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Review Article

Genetic Management in Conservation Programs: A Review

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ABSTRACT

Loss of local or native breeds occurs through breed replacement (primarily by imported or exotic breeds) or by dilution through cross-breeding (generally indiscriminate rather than planned). These losses in both cases generally occur for reasons unrelated to productivity. To assess the real genetic effects of breed loss or within-population selection, suitable measures of genetic variation must be available. The subject of this review is the genetics management of animal genetic resources, namely of domesticated livestock species and breeds. The conservation program itself, the necessity of identifying and prioritizing species that are threatened, and regular monitoring systems for detecting changes in the status of animal populations are all given attention. The necessity to combine preservation and better use is underlined as practical conservation challenges are assessed. The possibilities of using animal genetic resources in biotechnology are described. The institutional, financial, and administrative frameworks required for a conservation program, as well as its regional and national components, are discussed. The recommendations given are directed toward Institutional Infrastructures, Monitoring Practices, Breed Development and Conservation Programs, Biotechnology, and Legal Aspects.

Keywords: Conservation Program, Genetic, Management, Animal genetic resource

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INTRODUCTION

Livestock systems are ever-changing. The drivers of change in livestock production systems products; developments in trade and marketing, including increased regard for food quality and for safeguarding human health and animal welfare, as well as increased interest among consumers in niche products and sustainable use of resources; technological advances; environmental (including climate) changes; and policy decisions (FAO, 2013).

Henson (1992) wrote in FAO Animal Production and Health Paper 99 of- In situ, conservation of livestock and poultry that many different breeds and livestock populations have evolved and adapted over many centuries to the variety of environmental conditions found all over the world. Numerous breeds, types, and strains have evolved as a result of selection pressure brought on by factors such as climate, soil type, altitude, food supply, endemic illnesses and parasites, management practices, and market needs. Each has its own genetic makeup and has become adapted to a particular niche. This genetic variety, which is livestock's main resource, must be available in order for it to continue to develop and improve for agricultural use. The prerequisites for genetically regulated variation are uncertain and change throughout time. Changes in market needs, changes in the environment and climate, and the effects of new breeding technology and DNA editing techniques all have an impact on them (Henson, 1992). The requirement for concurrent animal genetic resource conservation, as the foundation for upcoming animal breeding initiatives, is also acknowledged and is growing in importance in global, regional, and national agricultural planning. In areas of rapid agricultural transition, when local livestock and farming practices are being replaced, conservation is especially important. Another top objective is to focus on regions where specific parasite problems or extreme climatic conditions have led to locally distinct and genetically modified stocks that can withstand extreme conditions. Since parasitic microorganisms and insects can adapt to modern chemical control techniques and the expected global climate change, such conservation efforts are especially crucial.

All human endeavors, including strategies, plans, policies, and actions taken to safeguard the diversity of animal genetic resources to support food production and agricultural productivity or to preserve other values of these resources (ecological, cultural), both now and in the future, are referred to as conservation. For conservation, the most critical process is to identify the breeds at risk. This section describes the methodology to identify breeds that are at risk because of censuses, surveys, and analysis; determine the conservation value, and prioritize the breeds for conservation. These guidelines address monitoring the population over a time interval, some time, and a baseline survey provides a starting reference point for monitoring the population in the future (Joshi *et al.,* 2013).

In conservation, genetic diversity is a prerequisite for genetic improvement and environmental adaptation. The diversity of Animal genetic resources has been in a continual state of decline (FAO, 2007). Because the conservation of all Animal genetic resources is not feasible, conservation priorities are imperative. Conservation is on the level of breeds and genetic characterization of breeds will be most essential (Boettcher *et al.,* 2010). In the context of animal breeding, conservation genetics addresses issues of the preservation of uncommon and endangered breeds or populations as well as the use of deliberate genetic alteration to increase viability, productivity, and production efficiency (Barker, 1994).

In the monitoring of Breed Population, when a target population is already known as a recognized breed, then the emphasis is given to the present status of breed; size and structure of the population, and their geographical and temporal change. However, main objective should be monitoring the population changes. Same time, it is also important to analyze threats to their survival. It helps in identifying the threats to AnGR, priority setting for conservation programs, and supporting strategic planning for sustainable utilization of Animal genetic resources. Maintenance of a database containing all relevant information on breeds of all species, population census, distribution status, and ecological data is essential for designing and implementing conservation strategies. For monitoring the status and trend of the breed, Breed wise census is highly necessary and should be conducted at the national level covering all livestock genetic resources (FAO, 2015).

The principles of Conservation in Animal genetic resource management are: determining population size (Stock should be maintained with optimum population size above the level of risk). Determine the characteristics of the stock (i.e. species or breeds to form pure breeding stock, having special traits, and select diverse stock). Environmental conditions are maintained and conserve the locally adapted breeds and that too in the same location. Identifying breeding which is the genetic merit and diversity should be maintained using an appropriate breeding program (Kumar, 2016). Immediate action should be taken to conserve any population, breeds, and species in imminent danger of extinction. All livestock populations should be identified, and steps taken to classify and characterize them to determine their genetic potential in both their native country and other countries, as well as to identify breeds that require protection Research attempts have been carried out concerning genetic management in conservation programs in countries of various national and international organizations (Universities, research institutions, and private organizations). The goal of this work is to review and evaluate the literature on genetic management in conservation projects, including historical and present research (option of population or breed, conservation techniques, preservation of allelic diversity or allelic richness).

LITERATURE REVIEW

Breed Risk Assessment

The degree of risk of a population is related to population growth trends; if populations are small there is a greater likelihood that adverse events or trends will lead rapidly to extinction. Population size as well as the rate of population decline is the most important factors in determining the breed status. The smaller population has a greater risk to be wiped out by many constraints like low fertility, and survivability, and is more prone to disease outbreak that arises due to low genetic variability within the breed. Current population trends are a factor to be considered in assessing risk status. Overall population size and growth rates, the risk status of a population is affected by other factors such as the number of herds, and the geographical concentration of the population, which influence exposure to threats such as disease epidemics; and by sociological factors such as the age of the farmers keeping the breed (Joshi *et al.,* 2013).

Population size and rate of change in population size are the most important criteria for determining a breed's risk of extinction and should be recorded regularly (FAO, 2015). The two aspects of breed extinction – loss of animals and loss of gene variants – are deeply interconnected. The loss of breeding animals and consequently a low number of parents available to breed the next generation increases the average relationship between parents and may lead to a higher occurrence of genetic defects and inbreeding depression. Once a breed's risk category has been assessed, different objectives for the management of its population can be considered. Four (non-mutually exclusive) means of strengthening the position of the breed can be distinguished: enlarging the population; managing diversity; selecting for improved productivity; and establishing a store of cryopreserved genetic material (FAO, 2015).

According to the report FAO (2013), determining the risk status of the population or breeds noted that to analyzing risk in terms of the loss of genetic variation. It is necessary to understand that breeding populations undergo random fluctuations in the content of the gene pool (genetic drift) from one generation to the next, depending on the sample of animals chosen as the parents of the next generation. When populations are smaller, the fluctuations tend to be larger. This process of fluctuation tends to reduce genetic variation because it increases the probability that alleles will be lost from the population. The current population size or population number in the breeding tract is an important criterion in determining risk status. Other criteria for evaluation of the degree of endangerment are Population trend, Number of breeding males, Number of breeding females; Effective population size. Risk status is generally considered the most important criterion for determining whether a breed should be subject to conservation activities. As a simple approach, breeds can be ranked according to their risk status, and those at the greatest risk are given the greatest priority for conservation. However, other factors may influence a breed's conservation value, and countries may wish to consider these as well. Factors that may influence the conservation priority of a breed include the following (Ruane, 2000; Cited by FAO, 2013).

Breed Risk Classification

The assessment of the risk status of livestock breeds or populations is an important factor in planning AnGR management, conservation, and genetic improvement. This will tell the policy planner and stakeholders whether, and how urgently, actions need to be taken for conservation. Considering various aspects, the following categories have evolved for the risk classification of a livestock breed (Joshi *et al.,* 2013). From a conservation point of view, one of the most important outcomes of a breed survey is the categorization of breeds according to their risk status (FAO, 2013). This facilitates the monitoring of livestock biodiversity at a national level, helps in the planning of conservation actions, and contributes to reporting and analysis at the international level (FAO, 2012). As noted above, a limited number of parameters are sufficient for obtaining an indication of risk, but the collection of additional information can refine the analysis by detecting underlying trends and causes.

Species differ greatly in their reproductive capacities, measured as the expected number of breeding females produced by each female during her life. Even if the census population size is equal, populations belonging to species with low reproductive capacity, such as the horse, are at relatively greater risk than those belonging to species with high reproductive capacity, such as the pig. This is because, in species with lower reproductive capacity, recovery from a population decline will take more time and more generations of breeding. Thresholds for the number of males (i.e. for ΔF) are the same for all species, as the reproductive capacity of a species is primarily determined by the reproductive capacity of the females.

The Breed Risk Status Categories or Classifications Are Defined as Follows

Extinct

A breed is categorized as extinct when there are no breeding males or breeding females remaining and any cryopreserved genetic material that may be available is insufficient for breed reconstitution (FAO, 2015). No breeding males (or stored semen), no breeding females (or oocytes) nor embryos remaining, and no longer possible to easily recreate the breed population (Joshi *et al.,* 2013).

Cry conserved

Breeds that have no residual living males or females but have enough cryopreserved material to allow for restoration of the breed are classified as cryoconserved exclusively. Depending on the quantity and type of saved germplasm, it may be possible to resurrect a breed that would otherwise be extinct.

Critical

A breed is categorized as critical if the total number of breeding females is less than or equal to 100 (300 for species with low reproductive capacity), if the overall population size is less than or equal to 80 (240), and if the population trend is increasing and the proportion of females being bred to males of the same breed is greater than 80 percent (i.e. cross-breeding is equal to or less than 20 percent), or the overall population size is less than or equal to 120 (360) and the population trend is stable or decreasing, or the total number of breeding males is less than or equal to five (i.e. ΔF is 3 percent or greater). If the population trend is unknown, it is assumed stable. Breeds that have active conservation programs (including cryoconservation) in place or populations that are maintained by for-profit businesses or research institutions are considered to be "critical-maintained" for reporting purposes (FAO, 2013).

Joshi *et al*., (2013) in cattle, buffalo, sheep, goat, horse, and camel breeds are categorized as critical if the total number of breeding females is less than 500 and the total number of breeding males is less than or equal to approximately 5. While in Pig and poultry breeds are classified as critical in any of the following conditions if the total number of breeding females is less than 250 and the total number of breeding males is less than or equal to approximately 5.

Endangered

If there are more than 100 breeding females (300 for animals with poor reproductive capacity) but fewer than or equal to 1000 (3000), the breed is considered endangered.; or the overall population size is greater than 80 (240) and less than 800 (2400) and increasing in size and the percentage of females being bred to males of the same breed is above 80 percent, or the overall population size is greater than 120 (360) and less than or equal to 1200 (3600) and the trend is stable or decreasing, or the total number of breeding males is less than or equal to 20 and greater than five (i.e. inbreeding rate (ΔF) is between 1 and 3 percent). Once again, if the population trend is unknown, then it is assumed to be stable (FAO, 2013). Endangered breeds will be assigned to the subcategory “endangered-maintained” if active conservation programs are in place or if commercial companies or research, institutions maintain their populations.

Vulnerable

A breed is categorized as vulnerable, the total number of breeding females is between 1000 and 2000 (3000 and 6000 for species with low reproductive capacity), the overall population size is greater than 800 (2400) and less than or equal to 1600 (4800) and increasing and the percentage of females being bred to males of the same breed is greater than 80 percent, or the overall population size is greater than 1200 (3600) and less than or equal to 2400 (7200) but stable or decreasing, or the total number of breeding males is between 20 and 35 (i.e. the Inbreeding rate (ΔF) is between 0.5% and 1%). Unreported population trends are assumed to be stable (FAO, 2013). Cattle, Buffalo, sheep, goat, horse, and camel are classified as vulnerable if: the total number of breeding females is between 10000 and 5000 and the total number of breeding males is approximately between 40 and 20 whereas Pig and poultry breeds are classified as vulnerable if the total number of breeding females is between 5000 and 2500 and the Total number of breeding males is approximately between 40 and 20 (Joshi *et al*., 2013).

The Breed Is Not at Risk

If the population status is known and the breed does not fall under the critical, endangered, or vulnerable categories (including any applicable subcategories), it is classified as not at risk (FAO, 2013). Additionally, even if the exact population size is unknown, a breed can still be deemed not at risk as long as it is known with certainty that the population size exceeds the corresponding thresholds for the vulnerable group. Countries are encouraged to enter estimated population sizes into DAD-IS if statistics from a formal census are not available to allow more such breeds to be accurately placed in the not-at-risk group (i.e. rather than classed as unknown). If the population status is known and the breed does not fall under the critical, endangered, or vulnerable categories (including any applicable subcategories), it is classified as not at risk (FAO, 2013). Additionally, even if the exact population size is unknown, a breed can still be deemed not at risk as long as it is known with certainty that the population size exceeds the corresponding thresholds for the vulnerable group. Countries are encouraged to enter estimated population sizes into DAD-IS if data from a formal census is not available to allow more of these breeds to be accurately assigned to the not-at-risk group (i.e., rather than categorized as unknown). However, it is strongly advised for such breeds to survey to get a more accurate estimate of population size (FAO, 2011). As the report of Joshi *et al*. (2013) summarized other factors for considerations that should be taken into account during the categorization of endangerment level (Gandini *et al.,* 2004; Alderson, 2010).

- A large population in a small geographical area-Presence of a large part of the population or breed found within a small geographical area should be taken into consideration.
- Degree of introgression-Degree of introgression per generation should be taken into consideration to fall a breed under the risk category.
- Rate of inbreeding in the population- Normally, a higher inbreeding rate for a population predisposes the breed to risk. Therefore, it should also be taken into consideration for risk assessment.

Table 1: Basic principles to assess the risk status of livestock breeds and arbitrary scores assigned to the different statuses

Status	Assigned score	Conditions on the number of breeding males (N_m) and females (Nf)	Other conditions
Not at risk	0	Nm > 20 and Nf> 1 000	The breed is maintained by an active public conservation program or within a commercial or research facility
Endangered – maintained	1	5 < Nm = 20 or 100 = Nf = 1000	
Endangered	2	5 < Nm = 20 or 100 = Nf = 1000	The breed is maintained by an active public conservation program or within a commercial or research facility
Critical-maintained	3	Nm = 5orNf < 100	
Critical	4	Nm = 5orNf < 100	

Adopted from; Verrier *et al*., (2015)

When the number of breeding females is close to one of the two thresholds (100 or 1000), other indicators such as the evolution of the actual population size or the proportion of crossbreeding may also be taken into account.

The studies by Verrier *et al*., (2015) on assessing the risk status of livestock breeds in France reported that breed risk status assessment methods are key components of country-based early warning and response systems and found in their studies, a multi-indicator method was developed to assess the risk status of livestock populations. Six indicators were used: (1) the current number of breeding females; (2) the change in the number of breeding females over the last 5 years or generations (depending on the species); (3) percentage of cross-breeding; (4) effective population size; (5) breeders organization and technical support; and (6) socio-economic context. To compare these indicators, observed values were transformed into scores on a six-point scale (from 0 to 5), with a different conversion method being employed for each indication. The various scores for each breed were graphically analyzed, and an overall score was determined by averaging the six individual indicator scores.

The method was used on 178 native varieties of ten distinct species-horse, donkey, goat, pig, chicken, turkey, goose, and Pekin duck-representing 10 different regions of France. Despite species-specific differences, it was discovered that a significant portion of the indigenous breeds were in danger of extinction due to farming. All local breeds of horses, pigs, and nearly all local breeds of chicken appeared to be in danger. Additionally, it was discovered that half of the local sheep breeds and almost 80% of the native goat and cow breeds were in danger (Verrier *et al*., 2015).

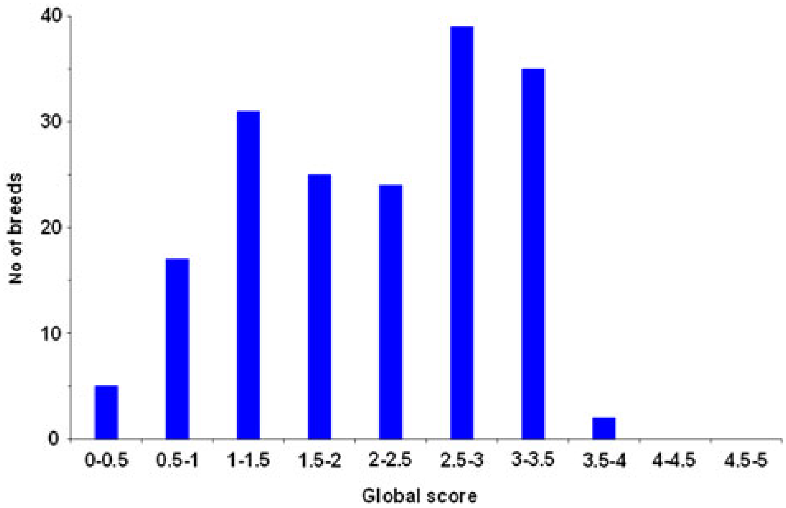

Figure 1: Distribution of overall risk assessment scores for the 178 local breeds examined / Source: Verrier *et al*., (2015)

Prioritization of Breeds for Conservation

When many breeds are assigned to risk classes, then there is a need to prioritize the breeds for conservation. It is always advisable to conserve as many breeds as possible, however, financial expenditure and available infrastructure force to restrict the number of breeds for conservation at a time. Assuming that not all animal genetic resources can be conserved, a process of prioritizing breeds is necessary (Joshi *et al*., 2013). For deciding which breeds should be prioritized for conservation, in general, many factors should be taken into consideration. The risk of extinction of a breed should be used as a primary criterion for conservation. Any breed under high-risk status should be given higher weightage or priority for conservation. Priority for conservation should be decided separately for each risk category. Genetic uniqueness/distinctiveness is another important criterion. Conserving the most genetically diverse breed will be the most efficient way to conserve the diversity of a species.

Breeds that are genetically superior for economically important traits should also receive priority in conservation. Breeds with unique traits should also give priority to conservation. The adaptation of breeds to specific environments is likely to be under some genetic control (Joshi *et al*., 2013). The breeds can be ranked by evaluating the total score or index for each breed after taking all the factors described above into consideration for that breed and giving due weightage to each factor for prioritization. Ranking of breeds for prioritizing for conservation can be done by calculating the conservation value as described by FAO (2013). Based on conservation values from highest to lowest rank, breeds are prioritized for conservation.

Prioritization of breeds with molecular genetic information; combining estimates of genetic diversity with data for other variables affecting conservation priority can also be utilized for prioritization of the breeds for conservation as per the Weitzman method (Weitzman 1992; Cited in Joshi *et al*., 2013; FAO, 2013).

Choice of Population or Breeds for Conservation Programs

The conservation of choice populations or breeds refers to an action to ensure the survival of a population of animals as defined by the range of genetically controlled characteristics that it exhibits. This method of conservation was created to guarantee the preservation of all the features inherent in a given population, including many that may not have been recognized, defined, documented, or monitored. It is used for both endangered species and breeds. Instead of the existence or lack of unique genes, breed differences may frequently be caused by variations in the frequency of quantitative genes. Concerning appearance and output in a particular habitat, such a change in gene frequency may produce drastically distinct populations (Henson, 1992; FAO, 2013).

Various methods for combining different criteria have been proposed for prioritizing breeds targeted by conservation programs. Ruane (2000), for example, proposed a method to be followed by a group of experts identifying breed priorities at the national level. The following seven criteria are included in the framework: species (i.e. breeds from which species are to be included in the priority setting exercise); degree of endangerment; traits of current economic value; special landscape values; traits of current scientific value; cultural and historic value; and genetic uniqueness (FAO, 2015). It is suggested that breeds with high degrees of endangerment should be given priority for conservation. If it is necessary to prioritize highly endangered breeds, it is then suggested that the extent to which the breeds meet the other listed criteria should be taken into account. It may be necessary to assign weights to the various criteria to allow further differentiation of priority ranks. The relative importance to be given to each criterion would be decided by the expert group (FAO, 2015).

The effective population size, Ne, is a measure of fundamental importance for understanding the potential of species and populations to evolve and adapt to natural and artificial selection pressures. Quantitative genetic theory predicts that effective population size (Ne) is positively associated with the level of additive genetic variation and that the capacity of a population to respond to selection depends on the level of genetic variation for the trait(s) undergoing selection (Falconer and Mackay, 1996; Cited in Kristensen *et al.,* 2015). However, the association between Ne, genetic variation, and evolutionary potential is complex and depends on factors such as the number of loci underlying a trait, the presence of dominance or epistasis, the effects of new mutations, and selection mode and intensity (reviewed in Willi *et al*., 2006; Cited in Kristensen *et al.,* 2015).

Conservation Methods

In situ, (conservation through continuous usage by livestock keepers in the production system in which the animals arose or are currently often found and bred) and ex-situ (all other circumstances) are two categories for conservation programs. The latter can be further divided into ex-situ in vivo conservation (a limited number of animals kept outside their original production environment) and ex-situ in vitro conservation (cryoconservation in a gene bank) (FAO, 2015).

Livestock breeds or populations categorized under any category of risk will require urgent action. It is crucial to create a strategy plan for conservation and implement these development and conservation initiatives so that population growth can continue and any serious categories can be avoided. It is also important to monitor the population dynamics constantly and determine the genetic status and estimate the probability of recovering from the risk status at present (Joshi *et al*., 2013).

Three major strategies should normally follow in the conservation of farm animal genetic resources. The first involves the conservation of living population, i.e. in situ conservation as well as ex situ in vivo. The preservation of alive ova, embryos, semen, somatic cells, other animal tissue, DNA, etc. that have been cryogenically frozen in liquid nitrogen falls under the second category. However, there isn't a single conservation or preservation technique that works well in every circumstance. When a list of breeds is developed for conservation the applicability of these conservation options to choose become very important and critical (Joshi *et al*., 2013). For conservation purposes, it is the diversity between breeds, rather than between species, which is of crucial importance. Genetic variation at the population level consists of the differences in the types of alleles present and their frequencies across all members of a population considered together. Genetic variation is caused by changes in allele frequencies over time due to selection (environmental- and human-directed), random genetic drift, gene flow, demographic bottlenecks, founder effects, and mutation (Clamsen Mmassy & Røskaft, 2013). Conservation of animal genetic resources is the sum of all actions involved in the management of the animal genetic resources, such that these resources are best utilized and developed to meet immediate and short-term requirements for food and agriculture while maintaining the diversity they harbor to meet possible longer-term needs for future generations (Clamsen Mmassy & Røskaft, 2013).

Reasons for the conservation of animal genetic resources (AnGR) are: Opportunities to meet future market demands, insurance against future changes in production circumstances, present socio-economic value, and sustainable crossbreeding schemes require different viable populations, opportunities for research, cultural and historical reasons, and ecological value (Clamsen Mmassy & Røskaft, 2013; FAO, 2015; Kumar, 2016).

In situ Conservation

Conservation of a breed through continued use by livestock keepers in the production system in which the livestock evolved or is now normally found and bred (i.e. maintenance of breeds within their normal environment) (Joshi *et al*., 2013; Clamsen Mmassy & Røskaft, 2013; FAO, 2013). Successful in situ conservation usually requires changing the economic and market environment, allowing a breed to be financially sustainable (FAO, 2013). Operations for in-situ conservation include performance recording and breeding programs, and ecosystem management for sustainable production of food and agriculture a minimum number of animals to be maintained is 150 to 1500 breeding females in developed countries, but in developing countries, the number should not be below 5000 (Clamsen Mmassy & Røskaft, 2013).
According to Joshi *et al*., (2013), the in situ conservation of genetic resources will require information on:

1. Establishment of institutional structure and policies including specific measures to conserve breeds at risk
2. Population status of the breed in its native tract and outside the native tract
3. Communities responsible for maintaining the breed in its natural habitat along with the socio-economic status
4. Breeding management of the breed and the programs of government/ NGOs in the breeding of the animals for genetic improvement, and all kinds of expenditures on the maintenance.

In situ conservation is the most important factor of all conservation with genetic improvement projects and selection should carry out for its traditionally valued characteristics and in the environment to which it is adapted. The herds are managed within the natural environment for that breed and need to expose to conditions prevalent in the field. The government may establish a Nucleus herd in a native tract of the particular breed. Farmers maintaining the animals of that breed should give certain incentives for encouraging more rearing (Joshi *et al*., 2013; Clamsen Mmassy & Røskaft, 2013; FAO, 2013; Kumar, 2016).
The maintenance of healthy populations of the species in their natural habitats and, in the case of cultivated species, in the environments where they have evolved their specific characteristics is referred to as in situ conservation. In situ, conservation also refers to the preservation of ecosystems and natural habitats. In situ, conservation can be done in farmers' fields, pasturelands, and protected areas (Dulloo *et al.,* 2010; Cited in Kasso and Balakrishnan, 2013).

Advantages of In-situ Conservation

Animals are still being utilized, the performance characteristics can be properly recorded and evaluated and breeds have the opportunity to evolve (Clamsen Mmassy & Røskaft, 2013; Kumar, 2016).

According to FAO (2013) noted the advantages of in situ conservation allow the breed to continue to develop in the context of changes in production conditions. Offers greater research opportunities; facilitates breed evolution and adaptation to the environment and gives insight into breed characteristics; helps maintain the indigenous knowledge of livestock keepers; creates possibilities for sustainable utilization in rural areas; allows the breed to maintain its cultural roles and its contributions to nature management; and can be financially self-sustainable.

Disadvantages Of In Situ Conservation

Leaves the breed exposed to risks associated with catastrophic disasters and disease outbreaks; and does not protect (founder) alleles from genetic drift when the population is small (alleles with a low frequency in the population can easily disappear because of low numbers of breeding animals) (FAO, 2013). Animals are at risk from diseases and other natural disasters. Genetic drift may result in unfavorable genetic changes if the population is small, there is a risk of increasing inbreeding and hence homozygosity, which is associated with reduced fitness. The animals may be less productive and so more costly to maintain (Clamsen Mmassy & Røskaft, 2013).

Ex-situ Conservation

Ex-situ conservation means literally, “off-site conservation". The preservation of biological diversity components away from their natural settings is known as ex-situ conservation. It involves taking a portion of an endangered species' population from a habitat that is in danger and relocating it to a new one, which could be in the wild or under human supervision. This makes use of a variety of tools and approaches and involves the preservation of genetic resources, along with wild and domesticated animals. Some of these include Gene banks, e.g. seed banks, sperm and ova banks, and field banks. Ex situ, in vivo conservation refers to conservation through the maintenance of live animal populations in farm or zoological parks or other collections including government farms. It involves the preservation of a sample of a breed in a situation removed from its normal production environment or habitat (Clamsen Mmassy & Røskaft, 2013; Kumar, 2016). Ex-situ conservation: In situ conservation may not be feasible for the breeds which economically not viable and hence they may lose due to economic pressure. Ex situ, conservation can be done to handle this situation (Kumar, 2016). Ex situ preservation of genetic material stored in cryogenic storage is one method of conservation, whereas in situ preservation of living populations is another. This latter point is crucial for species or areas of the world where cryogenic conservation procedures are underdeveloped or unavailable. Additionally, it permits populations to keep evolving, adapting, and being chosen for usage in their natural surroundings.

Ex-situ conservation may be by conserving live animals away from the habitat (ex–situ in vivo) or cryopreservation of the germplasm in the form of semen, ova, embryos, or tissues (Ex situ in vitro). Maintenance of the genetic diversity of the breed is very difficult in ex-situ in vivo. It is, always recommended to combine this method with cryoconservation. It is possible now to store a wide variety of living cells for long periods (Joshi *et al*., 2013).

Ex-situ conservation means, "Off-site conservation". It is the process of protecting an endangered species, variety or breed, of plant or animal outside its natural habitat; for example, by removing part of the population from a threatened habitat and placing it in a new location, which may be a wild area or within the care of humans (IUCN, 2014; UN, 1992). The degree to which people influence the managed population's natural dynamics varies greatly, and this may involve changing living conditions, reproductive cycles, resource access, and protection from mortality and predators. Ex situ management can take place both inside and outside of a species' native range. Ex-situ individuals exist outside of an ecological niche. This indicates that they are not subject to the same selection pressures as wild populations, and if kept ex-situ for many generations, they may be subject to artificial selection (Rao, 2001).

Genetic management for animal species or populations in ex-situ conservation methods; animal species can be preserved in gene banks, which consist of cryogenic facilities used to store living sperm, eggs, or embryos. It is a potential technique for aiding in the reproduction of endangered species in interspecific pregnancy, implanting embryos of an endangered species into the womb of a female of a related species, and carrying it to term (Niasari-Naslaji *et al*., 2009). Genetic management of captive populations in ex-situ conservation techniques or methods is managing problems such as inbreeding depression, loss of genetic diversity and adaptations to captivity, minimizing mean kinship, and managing genetic disorders.

Minimizing Mean Kinship

Increasing genetic diversity and preventing inbreeding among confined populations can frequently be accomplished by managing populations based on decreasing mean kinship values. (Frankham *et al.*, 2002*).* The likelihood that two alleles will be identical by ancestry when one allele is randomly selected from each mated individual is known as kinship. The average degree of kinship between a particular person and every other person in the population is known as the mean kinship value. Mean kinship values can help determine which individuals should be mated. Choosing individuals for breeding it is important to choose individuals with the lowest mean kinship values because these individuals are least related to the rest of the population and have the least common alleles The mean kinship value is the average degree of kinship between a specific individual and every other person in the population. Which individuals should be paired off can be determined using mean kinship values.

Because they are least connected to the rest of the population and have the fewest shared alleles, it is crucial to select breeding individuals with the lowest mean kinship values (Frankham *et al.*, 2002).

Avoiding Loss of Genetic Diversity

Due to the founder effect and ensuing small population numbers, genetic diversity is frequently lost within captive populations (Frankham et al., 2002). Since more diversified populations have better adaptation capacity, minimizing the loss of genetic variety within the captive population is a crucial part of ex-situ conservation and is essential for successful reintroductions and the long-term viability of the species (Kleiman et al., 2010). By making sure the founder population is sufficiently large and genetically representative of the wild population, the founder effect's loss of genetic diversity can be reduced (Frankham et al., 2002). This is frequently challenging since removing sizable numbers of people from natural populations could significantly limit the genetic diversity of a species whose conservation is already under threat.

Avoiding Adaptations to Captivity

There may be adaptations that are advantageous in captivity but harmful in the wild because selection favors different features in captive populations than in wild populations. It is crucial to manage captive populations to lessen adaptations to captivity because this lowers the success of re-introductions. By increasing the number of migrants from wild populations and reducing the number of generations raised in captivity, adaptations to captivity can be reduced (Frankham et al., 2002). Another way to reduce adaptations to captivity is to minimize the selection of captive populations by creating an environment that is similar to their natural environment, but it's crucial to strike a balance between an environment that minimizes adaptation to captivity and an environment that allows for adequate reproduction. By controlling the captive population as a collection of population fragments, adaptations to confinement can also be reduced.

Managing Genetic Disorders

Because captive populations are typically founded on a small number of individuals, genetic diseases are frequently a problem (Frankham et al., 2002). The frequencies of the majority of harmful alleles are often low in large, outbreeding populations, but when a population experiences a bottleneck during the establishment of a captive population, previously uncommon alleles may survive and become more prevalent (Kleiman et al., 2010). The risk that harmful alleles are expressed in the captive population may also rise with further inbreeding due to the population's rising homozygosity.

Table 2: Summary of some of the key differences between in-situ and ex-situ conservation

In-situ conservation	Ex-situ conservation
It means on-site conservation.	It means off-site conservation
It is the conservation of wild species in their natural habitats to maintain and recover endangered species.	It is the conservation of species in man-made habitats that imitate the natural habitats of species
It is more dynamic as it involves the natural habitats of organisms.	It is less dynamic as it involves man-made habitats.
It protects endangered species against predators	It protects against all hostile factors
It is suitable for animals that are found in abundance	It is suitable for animals that are not found in abundance
It is not suitable in the event of a rapid decline in the number of a species due to environmental, genetic, or any other factor	It is an ideal option in case of rapid decline in the number of a species due to environmental or any other reason
Wildlife and livestock conservation involves in-situ conservation.	It can be used to conserve crops and their wild relatives
Examples include national parks, wildlife sanctuaries, biospheres reserve, etc.	Examples include zoos, aquariums, and botanical garden
It involves designation, management, and monitoring of the target species in their natural habitat.	It involves sampling, storage, and transfer of target species from their natural habitats to manmade habitats.
It helps maintain the ongoing process of evolution and adaptation within the natural environment of the species.	It separates the animals from the ongoing process of evolution and adaptations within their natural environment

Adopted from: https://www.javatpoint.com/in-situ-conservation-vs-ex-situ-conservation

Ex situ In-vivo Conservation

This implies keeping animals (often a very limited number) outside their natural habitat if reconstruction of a population with frozen semen is required, it might be very helpful to use the few purebred *ex-situ in vivo* conserved females as founders. The young males from elite females should be selected and procured. The males should be reared to maturity under intensive management (Joshi *et al*., 2013).

Ex situ in-vivo Conservation is the maintenance of live animal populations in environments that are not their normal management conditions (e.g. in zoological parks or governmental farms) and/or outside the area in which they evolved or are now normally found. For financial and practical reasons, animals are often kept in very limited numbers. Because the animals are kept outside their normal production environments and their numbers are small, natural selection is usually no longer effective in its role of ensuring the adaptation of the population to these environments.

It is strongly recommended that ex-situ in vivo conservation be complemented with cryoconservation (FAO, 2013).

The Advantages of Ex-Situ in Vivo Conservation

The advantages of ex-situ in vivo conservation are that it offers insurance against changes in production conditions and offers research opportunities; allows for strict control of selection and mating decisions; and offers an opportunity to reconstitute a breed quickly from the limited number of females available (with ex-situ conserved semen) without applying a cross-breeding strategy.

Ex-Situ In-Vitro Conservation (Cryopreservation)

Once the decision has been taken as to which breeds and populations should be collected for the gene bank and the type of germplasm to collect, the next step is to determine the amount of germplasm needed. In general, the goal of reconstituting extinct populations will require the greatest amount of germplasm. Material for cryoconservation (gametes, embryos) must meet high sanitary requirements, and animal disease might disturb or inhibit the collection of this material. Freezing, maintenance, and thawing of frozen material require special skills and reliable equipment and infrastructures. To avoid risk, professional gene banks often store the material of an individual animal at two different locations (Joshi *et al*., 2013).

Gene Banks

A gene bank is a place for the storage of germplasm. Types and quantities of germplasm for a range of species and breeds to place in gene banks will decide the size and capacity of the banks, and similarly different equipment is needed for the storage operation. Germplasm should be collected under high sanitary conditions. The specialized workforce as well as the security of the gene bank is also important.

Countries created gene banks as a way to preserve their resources due to the global decline of animal genetic resources. Establishing a set of guidelines to make sure that gene banks are abiding by national laws is a good idea. The relationship between gene banks and the owners of the cattle from which they are obtaining samples and the pertinent national or international health regulations are the two main factors to be taken into account. Private property rights are the most frequent legal concern that will be taken into account while creating collections and dispersing stored material while dealing with animal breeders to acquire germplasm (Joshi *et al.,* 2013). The animals that may or may not be gathered, as well as the scope of the usage of the germplasm, may be governed by national animal health standards.

Gene Bank is a physical repository where samples of a genetic resource which being preserved (e.g. live animals, embryos, oocytes, semen, tissues, DNA) are kept. A data bank is a collection of information on characteristics (including production system, production levels, adaptive traits, and physical characteristics), status, husbandry, users and uses, etc, of genetic resources, stored in a systematic manner (usually electronic) and with provisions for editing and retrieval for viewing and analyses (Mmassy, 2013).

Maintenance of allelic diversity

Genetic diversity is an important aspect of the dynamics of populations, as it is directly related to the evolutionary potential of the population and the deleterious effects of inbreeding (Hughes *et al.*, 2008; Cited in Greenbaum *et al.*, 2014). There are, however, several different types of measures of genetic diversity, most notably measures based on heterozygosity and measures based on allelic richness (defined as the number of alleles). The formulations, ecological and evolutionary interpretations, and the mathematical contexts in which these groups of measures can be used vary (Toro *et al.,* 2009; reviewed in Greenbaum *et al*., 2014).

Allelic Diversity

The quantity of alleles, also known as allelic diversity or allelic richness, is a genetic diversity indicator of a population's potential for long-term adaptability and persistence. Due in part to the greater mathematical difficulty involved in accounting for the stochastic process of genetic drift when calculating allelic richness, allelic diversity is employed less frequently as a measure of genetic variety than heterozygosity (Greenbaum *et al*., 2014).

The allelic richness of a newly founded population experiencing genetic drift and gene flow, according to studies by Greenbaum *et al.*, (2014) on allelic diversity (Allelic richness) using stochastic modeling by incorporating gene flow and genetic drift in a source population and newly founded population. The model replicates the impact of gene flow on the preservation and restoration of allelic richness and tracks the dynamics of alleles lost during the founder event. The likelihood that an allele will exist in the population, has been recognized as the crucial statistical characteristic for a valid interpretation of allelic richness. Measures of allelic diversity, or the number of various allelic types segregating in the population, are also frequently used, especially in studies of conservation genetics. For instance, it was acknowledged that the proportion of segregating alleles in a population provides rudimentary data on historical variations in population size (Caballero & García-Dorado, 2013). Additionally, the number of unusual alleles can be used as a gauge for the degree of gene flow among subpopulations.

According to Caballero and Rodriguez-Ramilo (2010), the partitioning of diversity into gene-frequency-diversity and allelic-diversity components results in somewhat distinct conservation strategies. This suggests that the two separate diversity measures complement one another. The effects of allelic variety on evolution, however, are not well understood. The reaction to selection for adaptation to a changing environment is

one area where allelic diversity may have significant effects. Long-term response and selection limits may be more closely tied to the number of alleles initially available for selection than short-term response to selection, which depends on additive genetic variance and, consequently, on the predicted heterozygosity.
Caballero & García-Dorado Statistics based on population gene frequencies are typically used to estimate genetic variation empirically, but alternate statistics based on allelic diversity (number of allelic types) can offer additional information. The evolutionary consequences of allelic-diversity measurements, particularly in structured populations, are not well understood. We determined which diversity characteristics had stronger correlations with both short- and long-term adaptation to the new optima after forcing a worldwide change in the ideal. While allelic-diversity measurements are more highly connected with long-term and overall response to selection, quantitative genetic variance components for the trait and gene-frequency-diversity measures are often more strongly correlated with short-term response to selection. As a result, allelic-diversity variables are superior to gene-frequency variables as predictors of long-term adaptation (Caballero & García-Dorado, 2013).

CONCLUSION
Conservation can refer to the ex-situ preservation of genetic material that has been cryogenically preserved or the in situ preservation of living populations. This latter point is crucial for species or areas of the world where cryogenic conservation procedures are underdeveloped or unavailable. Additionally, it makes it possible for populations to keep evolving, adapting, and being chosen for usage in their natural surroundings. Any population, breed, or species that is at immediate risk of going extinct needs to be saved. To determine the genetic potential of all livestock populations and to identify the breeds that require conservation, it is important to identify all livestock populations and take steps to classify and characterize them. Populations can be maintained as distinct breeds, breed pools, or composites. A breed composite or pool should contain no more than three or four breeds, and effort should be taken to ensure that each breed is thoroughly defined before being combined. Only breeds with comparable traits ought to be put in the same pool. Although populations may recover from much smaller founder groups, the foundation of a conservation effort should be the smallest population sizes of an effective population (Ne) of animals. The size of very tiny populations should be swiftly expanded. The conservation and breeding of considerably larger populations, comprising several thousand animals, is necessary for the most efficient breed conservation. Breed conservation is required to cope with changes in consumer preference or productive environment, to supply genes for disease resistance and other simply inherited characteristics, and for aesthetic reasons. The necessity to combine preservation and better use is underlined as practical conservation challenges are assessed.

Cryopreservation is the most cost-effective means of conservation. Maximum retention of genetic variation within populations occurs when initial variability, population size, and Ne/N ratio are maximized, and the number of generations is minimized. The possibilities of using animal genetic resources in biotechnology are described. The institutional, financial, and administrative frameworks required for a conservation program, as well as its regional and national components, are discussed. The advice given is focused on institutional infrastructures, monitoring procedures, programs for the breeding and conservation of breeds, biotechnology, and legal considerations.

AUTHOR'S CONTRIBUTION

The authors equally contributed to the data collection, reviewed information, and write up the manuscript. The authors read and approved the final manuscript.

CONFLICT OF INTEREST

The authors declare that no conflict of interest concerning the research, authorship, or publications of this article.

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