AZA White Paper

Welfare and Conservation Implications of Intentional Breeding for the Expression of Rare Recessive Alleles

Association of Zoos & Aquariums
Animal Welfare Committee: Taskforce on Animal Breeding Practices
Approved by the AZA Board of Directors – June 2011

AZA Position Summary:

Breeding practices that increase the physical expression of single rare alleles (i.e., rare genetic traits) through intentional inbreeding, for example intentional breeding to achieve rare color-morphs such as white tigers, deer, and alligators, has been clearly linked with various abnormal, debilitating, and, at times, lethal, external and internal conditions and characteristics, which are outlined in this paper. Many of these conditions may seriously compromise the welfare of individual animals. In addition, such breeding practices are also problematic from a population management and conservation perspective, impairing our ability to develop and maintain sustainable captive populations for the future and to deliver appropriate animal welfare and conservation education messages.

Therefore such practices are not in adherence with AZA's Board-approved Policy on the Presentation of Animals (22 July 2008), which maintains that "… animals should always be presented according to the following core principles: 1. Animal and human health, safety, and welfare are never compromised; 2. Education and a meaningful conservation messages are integral components of the presentation; and, 3. The individual animals involved are consistently maintained in a manner that meets their social, physical, behavioral, and nutritional needs."

Based on the welfare, population health and management, as well as conservation and education concerns outlined in this paper, AZA-accredited institutions should not engage in intentional breeding practices for the purpose of producing anomalous phenotypes.

At times, inappropriate breeding practices by others (outside of AZA) may yield animals with anomalous phenotypes and adverse internal conditions, which may be in need of rescue. Providing holding and care for such animals and responding to rescue requests from local, state, or federal agencies are appropriate activities for AZA-accredited institutions, provided that the delivery of thoughtful educational messages about the unfortunate results of intentional inbreeding for rare genetic traits are part of any public display.

Interestingly, the very instinct that appears to draw humans towards novel patterns and diversity in general also seems to underlie our fascination with unusual and abnormal patterns and phenotypes expressed only rarely, or occasionally, in nature. The spectacle provided by displays of calves with two heads, five toed cats, and traits such as albinism, melanism, or dwarfism, continues, even today, to provide an attraction to many, unaware of the biology underlying such odd occurrences. Even among today's frequently well informed and educated zoo visitors, the interest in seeing white tigers, white lions, white alligators, or king cheetahs continues often in preference over the 'normal' looking individuals of the same species.

Of greater concern, in some cases, there exists the misconception that these unusual color morphs, or other phenotypic aberrations, may represent a separate endangered species in need of conservation. Various articles and education efforts over the years have tried to put this issue into a proper scientific perspective, at least for the tiger (e.g., Leyhausen & Reed, 1971; Latinen 1987; Schroeter, 1981; EAZA 2010). However, some of the myths persist and will require additional education and a clear stance on this issue from the AZA community.

The purpose of this White Paper, therefore, is to highlight some of the well documented welfare and conservation concerns involved in breeding, or support of breeding, for unusual and rare traits (in any species) and provide recommendation with regard to this practice for AZA accredited institutions and certified related facilities.

A precedent for such recommendations has been set in the area of pet and farm animal welfare in Europe and the UK, where various legislative efforts are under way, or have already been put in place, to discourage the intentional breeding for rare recessive alleles with known potential deleterious effects and welfare concerns. A long list of potentially harmful recessive traits exists for pet animals, from fish and hamsters to dogs and horses, that are associated with either substantial physical or behavioral impairment and/or even lethal outcomes such as a drastically shortened lifespan (e.g., Not et al., 2008; Stucki et al., 2008; Kirkwood et al., 2010). For example, taillessness in some duck breeds can lead to lowered reproductive rates and shorter lifespan as well as problems with copulation and egg laying (Stucki et la., 2008).

Lack of pigmentation in snakes has been associated with detrimental changes in skin and eyes, such as reduced heat exchange ability and neural issues (Not, 1998). Dwarfism in rabbits has been associated with problems in teeth positioning and eating, as well as thermoregulation and reproduction. Indeed most dwarf forms of a variety of species seem to be more prone to general infections and may show compromised immunity (Not et al., 2008). In cats, breeds such as the Manx cat and tailless cat are associated with locomotive disorders, dispositioning of the vertebral column, difficulties defecating, and a loss of about a quarter of offspring when breeding for the trait of "taillessness". The "dominant white" trait in domestic cats (in spite of the word "dominant" in the trait's name the individuals are actually homozygous for this recessive color morph) has been associated with increased occurrence of deafness. Similarly in dogs, the "Merle factor" (e.g. Blue Merle Collie, or Merle Bobtail) has been associated with a disposition to deafness and eye disorders (Steiger et al., 2008). The list is

lengthy and several comprehensive reviews have documented the various problems associated with intentional breeding for rare and recessive alleles in a wide variety of species (e.g., Not et al., 2008; Steiger 2005, 2008; Steiger et al. 2008; Stucki et al., 2008; Kirkwood et al., 2010; Rooney and Sargan, 2010).

As a consequence of these findings, a declaration of intent was adopted in 1995 by the European Convention for the Protection of Pet Animals based on a multilateral consultation with stake holders. Some of the highlights of the declaration included an agreement to take necessary measures to control the breeding of animals that show genetic or phenotypic characteristics harmful to the welfare of the animals in order to prevent suffering, and to develop educational information for the public regarding these issues (website; Steiger et al., 2008).

Similarly, in 1999, the Federation of Veterinarians of Europe (FVE) urged its member countries and the European Commission to consider the introduction of measures designed to safeguard the welfare of animals with respect to the risks inherent in selective breeding for rare and recessive traits. It was stated that this form of selective breeding may cause welfare problems of the following types: offspring produced may be unable to express their natural behaviors and/or may be predisposed to a variety of hereditary, congenital, metabolic or infectious disease, disability, and early death (FVE, 1999; Steiger et al. 2008). Since then various European countries have indeed implemented legislative standards for animal breeding and have even gone so far as to outlaw breeding for some of the more extreme traits, such as intentional breeding of Manx cats or 'Merle factors' in dogs (e.g., Germany, 2000; Austria, 2005).

In exotic species hereditary problems associated with selective breeding have also been clearly documented. For example, most white tigers currently in captivity are Amur-Indian hybrids that have been highly inbred to achieve continued occurrence of the colormorph (Thornton et al., 1967; Thornton, 1978; Roychoudhury and Sankhala, 1979). Various abnormalities and deformities associated with such selective breeding practices have been documented, such as the occurrence of an abnormality of the visual pathways in the brain, resulting in visual impairments such as strabismus, a condition that involves a lack of proper alignment of the eyes, preventing binocular focus on any particular point or object, and thus negatively affecting depth perception (Guillery and Kaas, 1973). This congenital defect has been listed as a common abnormality also found in Siamese cats, and in albino ferrets, albino mink, and other albinos of various mammal species that have been studied (Creel and Giolli, 1972; Sanderson and Guillery, 1973; Guillery and Kaas, 1973; Guillery, 1986).

Vascular ring anomaly around the trachea and esophagus has also been reported. This abnormality leads to the inability to feed and swallow effectively and requires an operation for correction and survival (Ketz et. al. 2001). This type of abnormality similarly represents a common congenital problem in domestic dogs and cats (e.g., Fox, 1988) resulting from inbreeding. The same abnormality has also been reported in white lions (Goldin and Lambrechts, 1999). Other congenital defects, such as changes in cranial structures and skull development, as well as cleft palate have also been well documented in white tigers and other rare color morphs in other species. More generally,

albinism has been associated with a wide variety of health problems and congenital defects and is regarded as a hereditary defect rather than a desirable trait in wild and most domestic populations (Creel and Giolli, 1972; Guillery, 1986; Laikre, 1999).

The underlying cause for the multitude of the above cited health and welfare issues is a relatively simple one. Several of the traits such as albinism are located on recessive alleles that are only expressed phenotypically (in appearance) if two copies of the same trait are obtained by a given offspring (homozygous representation of alleles). For example, in the case of the white tiger one recessive allele has to come from each parent to allow for expression of the white striped color morph. While this has happened rarely in wild tiger populations, such as one in India many decades ago, and may occur in wild populations of various species occasionally (e.g., white deer, lion, ferret), such traits only rarely get expressed, and, when expressed, it is very likely that they confer a disadvantage resulting in reduced fitness for a given individual under most circumstances. Indeed, the very rarity of the traits in natural populations is itself strong evidence that they have deleterious consequences.

A wide variety of heritable defects and abnormalities have been found associated with recessive alleles, and the occurrence of these detrimental and/or lethal recessive traits is termed the genetic load of a population and species. Since these alleles are generally rare in a given population, some level of inbreeding (i.e., breeding of closely related individuals, which increases the chance that the same two rare and recessive alleles will be present in the two parents and therefore can be transmitted to and expressed in offspring) has to be practiced to achieve phenotypic expression of the trait with greater than a miniscule frequency of occurrence. Selective breeding for such traits will therefore usually lead to a variety of negative consequences also documented for severe inbreeding, such as increased expression of the genetic load, congenital defects, such as cleft palate, and overall decline in fecundity and increase in morbidity (e.g., Falconer, 1981). In summary, the welfare concerns associated with intentional breeding for rare (and thus usually detrimental) traits are therefore twofold:

1. Health and welfare problems directly associated with the trait itself, such as visual and neural problems associated with albinism, or gait and elimination problems associated with taillessness.

2. The sometimes more indirect, but just as problematic, health and welfare consequences related to intensive inbreeding to accomplish expression of rare and unusual traits, such as congenital deformities, decline in overall fitness and fertility, increased susceptibility to disease and infection and shortened lifespan or still birth.

Furthermore, in terms of effective conservation management and population health, selective breeding for specific phenotypes is in direct opposition to standard zoo population management goals of maximizing genetic diversity by minimizing inbreeding. Recessive alleles (or any particular alleles) should neither be selected against nor selected for, since doing so would lead to a loss of overall genetic diversity (Lacy, 2000).

Selection for specific traits will hasten a population's loss of gene diversity, lead to higher inbreeding levels more quickly, and create a domesticated form of the species that no longer represents or resembles the wild population.

Occasional expression of a rare and deleterious allele may occur by chance, but should not be 'forced'; rather, these traits should be allowed to appear at their naturally occurring frequencies. Retaining all alleles at their naturally occurring frequencies helps retain genetic diversity and provides populations with adaptive potential in the face of environmental change. The standard genetic management strategy in zoos, using mean kinship rather than phenotype to select breeding animals, is specifically intended to maintain gene diversity and minimize inbreeding (Ballou & Lacy, 1995). The mean kinship genetic management strategy aims to efficiently equalize all founder lineages in small populations, whereas preferential breeding of rare or abnormal phenotypes within the limited space in zoos causes over-production of a few lineages at the expense of known-pedigreed animals from genetically valuable lineages. Inequality of founder lineages will lower genetic diversity at the population level and will eventually lead to individual genetic problems associated with inbreeding.

Modern zoos are concerned with future sustainability of wildlife populations. Problems for many captive populations arise from the small genetic base (i.e., few founder individuals) from which zoo breeding programs often are started, the difficulty of obtaining breeding activity reliably and successfully, and the small populations that can be maintained with the resources available for most programs. It is especially counter-productive therefore, to allocate breeding program resources toward practices that rapidly degrade the genetic variation with which the program was started, cause reduced reproductive fitness, shorter life spans, and reduce the resources that can be allocated for animal management programs that do serve bona fide conservation and education purposes.

From an education perspective, intentional inbreeding for the production of anomalous phenotypes is in direct contrast to the mission of modern zoos. Propagating animals that specifically do not represent the normal characteristics and variation of the species creates a confused educational message. If animals in zoos and aquariums are to be ambassadors for their species then the exhibition of phenotypic aberrations creates difficulty in properly interpreting what modern zoos are about. Further, it is counter-productive to the overall conservation message of preserving essential characteristics of a species and ensuring genetically healthy and sustainable populations both in zoos and aquariums and in the wild.

Primary roles of modern zoos are to help protect wildlife and natural habitat, educate the public about conservation efforts, and directly engage the public in these efforts. These commendable goals are forfeited when intentional inbreeding is practiced to create or abnormally augment the occurrence-frequency of anomalous phenotypes outside of the natural variation in the species. Such practices cause rapid depletion of the normal genetic variation, the maintenance of which is a stated goal of the professional zoological community, while simultaneously subjecting some of the animals that are produced to, now documented, poor welfare, poor health, and reduced fitness.

Breeding practices that increase the phenotypic expression of single rare alleles through intentional inbreeding cause abnormal or aberrant external and internal conditions and characteristics. The predictability of such outcomes from intentional inbreeding to produce phenotypic anomalies indicates that these practices are not in adherence to AZA's Board-approved Policy on the Presentation of Animals (22 July 2008). Thus, AZA-accredited institutions should not engage in intentional inbreeding practices for the purpose of producing anomalous phenotypes from the perspectives of welfare, education, population management, and conservation.

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