Recognizing and Mitigating Evolutionary Changes in Captive Animal Populations

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ABSTRACT

Studies have documented genetic evolutionary change taking place in a span of less than 100 years, and possibly even within the human lifespan (Ashley, 2003; McDougall, 2005). With documented accounts of the rapid evolution of an animal to its environment, concern can be quickly directed towards those animals in captive situations. Species in captivity are carefully managed to be sure that the highest levels of genetic diversity are maintained.

Although much consideration is made to avoid genetic loss, selective pressures do exist in captivity and can lead to situations of rapid genetic and behavioral evolution among captive animals (Lynch, 2001; McDougall, 2005). With a set number of individuals available for reproduction, there are factors impacting the genetic integrity of captive populations, including inbreeding depression and the lack of free mate choice. Managers of captive zoo populations employ various methods of combating these factors in an effort to minimize evolutionary impacts and maintain a level of genetic diversity as similar to that of the wild as possible.

INTRODUCTION

Evolution is often thought of as a process that happens over the course of millions of years, with slow genetic changes altering a species over time to be best adapted for ongoing environmental changes. While this gradual change is often the case, some evolutionary biologists present findings that suggest evolutionary change can take place in a much shorter time frame. Studies have documented genetic evolutionary change taking place in a span of less than 100 years, and possibly even within the human lifespan (Ashley, 2003; McDougall, 2005). With documented accounts of this rapid evolution of an animal to its environment, concern can be quickly directed towards those animals in captive situations.

Given the growing number of environmental pressures being placed on natural environments, many species are forced into captivity as a last effort to save them from a fate of mass extinction (Jimenez, 1994). Animal species brought into this captive situation are carefully managed and cared for, not only to ensure the individual health of the animal, but to be sure that the highest levels of genetic diversity are maintained as well. Maintaining strong genetic diversity in captivity helps to ensure that current and future populations are near self-sustaining and that selected species intended for reintroduction to the wild are best adapted for re-entry (Asa, 2011).

Although much consideration is made to avoid genetic loss, there is little question that some strong selective pressures do exist in captivity and can lead to situations of rapid genetic and behavioral evolution among captive animals (Lynch, 2001; McDougall, 2005). This paper explores not only how captivity can genetically affect animals through instances of inbreeding and mate selection, but also how captive zoo mangers work to mitigate these effects.

INBREEDING DEPRESSION

Tracking Genetic Diversity in Captivity

With a set number of individuals available for reproduction within a given captive population, inbreeding becomes a risk. While inbreeding can also occur in nature, it has been noted that the deleterious effects of inbreeding in captive environments has been worse, as additional stress can be a factor in captivity (Frankham, 2005). Captive population managers work to avoid inbreeding by tracking and monitoring the genetic lineages of individual captive animals (Leus, 2011). The most commonly used method of avoiding inbreeding in captive zoo populations is by tracking the Mean Kinship value of each animal (Lacy, 2000; Russello, 2004; Cosson, 2006; Asa, 2011; Leus, 2011). In the Mean Kinship (M.K.) method, each animal is assigned a numerical value that represents its genetic relatedness to the rest of the captive population. If an animal has a high M.K. value its genetic lineage is more prevalently found in the population than an animal with a low M.K. value. This makes those individuals with low values more genetically valuable than an individual with a relatively high value. By tracking this genetic relatedness, managers can better ensure that the average M.K value for an entire captive population stays as low as possible, maintaining a population genetically close to that of the wild (Asa, 2011; Leus, 2011).

While tracking the M.K. values of individuals has shown to be a successful means of minimizing instances of inbreeding, it also has factors for consideration. When an animal is obtained directly from the wild, some managers begin by merely assuming that it is not genetically linked to others already in the captive population, thus assigning the wild individual a low M.K. value. There is a chance, however, that the particular animal referred to may have a higher relatedness than assumed, as there is no way to readily tell genetic relatedness without genetic testing. This could lead to unintended instances of inbreeding. Willis (2001) presents the opposing practice however, stating that many managers are turning to use the “worst-case scenario” method in these instances, assuming that a wild caught individual, with a true genetic lineage that is unknown, is highly related to the rest of the population. This allows them to mange for the “worst-case scenario”, avoiding as much possibility of inbreeding as manageable. To be more certain of the true M.K. value, molecular DNA testing must be done, isolating significant markers. Selected microsatellite loci and specific alleles are targeted to reveal genetic links to others in captivity (Russello, 2004). Without this testing, assigning M.K. values to wild-caught animals can be skewed.

Managing Genetic Diversity in Captivity

Despite the best efforts of managers to avoid instances of inbreeding, still existent is the situation that there are only a limited number of individuals available for breeding in captivity. In time, genetic lines can grow closer together, quickly creating common gene lines, depleting genetic diversity and hastening genetic drift (Asa, 2011). This can be offset by occasionally introducing new individuals into the population, or by dividing the entire captive population into smaller subdivisions and monitoring for genetic variance across groups (Lacy, 1981). Both of these practices are common in the global zoo setting. Most zoos engage in animal loans and trades from one institution to another for long or short-term stays. In this way, new genetics can be introduced to one zoo population from another; and, when managed correctly, can have large effects on the health of captive populations. In captive binturongs (*Arctictis binturong*), for example, it is believed that periodic immigration of breeding animals between the subpopulations in Europe alone could almost eliminate genetic drift (Cosson, 2006). With the close genetic tracking and management of captive populations, genetic diversity can be well maintained, minimizing genetic drift and slowing the possible evolutionary changes brought on by captivity.

MATE CHOICE

Forced Mate Choice and Selective Breeding

Other than to avoid the deleterious effects of inbreeding and genetic drift, the goal of breeding and genetic management in captivity is also to ensure that reproduction is managed in a way to best maintain the genetic diversity of a captive population at large. Where in the wild, mate selection is left up to the individual animals; in captivity possible pairings are studied and mindfully chosen with the best genetic intentions. Breeding pairs are recommended based on location, age, reproductive history, and, largely, genetic relatedness (Asa, 2011). When these pairs lead to successful copulation, the genetic goals for the population are further met. However, there are many evolutionary considerations to be addressed about the practice of forced mate choice and selective breeding.

The importance of free mate choice among animals can be dated back to 1871 when Charles Darwin proposed that mate choice, composed of competing males and choosy females driving genetic fitness through their selections, was a major selective force in evolution (Darwin, 1871). Darwin's claims have been and continue to be supported through related studies. The importance of mate choice has been documented in almost all classifications of animals. In mammals, studies of wild chimpanzees (*Pan troglodytes*) showed that mate choice was almost entirely left up to the female (Stumpf, 2006). Despite the fact that male chimpanzees are dominant in most other roles, the female exhibited resistant behaviors towards males she did not wish to mate with and only mated with the males of her choosing, indicating the existence of highly preferred qualities in mate selection. Further behavior indicating the importance of mate choice was observed in mallards (*Anas platyrhynchos*). A 2004 study pairing females with mates, half were paired with mates previously documented as being preferred and half were paired with non-preferred mates. The eggs from the preferred matings were significantly more successful than the eggs from the non-preferred matings (Bluhm, 2004). This also indicates choice for highly preferred qualities in mate selection and suggests the ability of females in some species to control the success of resultant offspring (Asa, 2011).

In captivity, however, there exists a limited number of individuals available for mating; and, when taking in to account the need for mating that maintains or furthers genetic diversity, that available number becomes even smaller. Selected pairings are chosen using the best possible criteria, many of which do lead to successful copulations; but, it is thought by some that when the element of free mate choice is removed, so are the processes that go with it, thus altering the natural mating behaviors and, over time, creating animals that are adapted to man-made environments rather than to natural ones (Asa, 2011).

Free Mate Choice in Captivity

It has been suggested by some to have zoos allow free mate choice among a group of captive individuals rather than simply choosing the specific mate (Lacy, 1979). In this manner, the individual still maintains an element of participation in the selective process. Lacy showed in his 1979 study that allowing mate choice in captivity could actually prove to be beneficial in situations where the individuals are of unknown genetic lineage and managers are unable to identify the best possible pairings. This situation does run the risk of allowing matings that are not genetically ideal, but the belief is that the individual's instinctive selective behaviors will deter it from pairing with an ill-suited mate (Lacy, 1979).

Allowing mate choice within a captive population has its concerns as well. While there is still much to be known about the driving factors influencing mate choice among various species, it is well supported that individuals choose mates displaying qualities seen as beneficial to survival in the environment. The concern here is that captivity provides selective pressures that may differ from natural selection pressures and may actually discriminate against some of the very traits and behaviors that help species survival in the wild. The nature of captivity favors animals that are more laid-back, less aggressive, and sometimes even lazy (Frankham, 2005; McDougall, 2005). While these qualities would not contribute to the animals' natural fitness in the wild, in a captive setting, they are among the most desirable. In this way, mate choice, while still being left up to the individual animal, could be skewed into choosing individuals best suited to survive in captivity, possibly leading to the depletion of wild characteristics in the population over time, making them "less wild" and less suited for their natural environment. On the contrary however, individuals well adapted to captivity may not *always* be ill suited for the wild. In a 2003 study with black-footed ferrets (*Mustela nigripes*), even after several generations spent in captivity, captive born individuals that were released into the wild were able to successfully find wild mates and produce genetically rich offspring (Wisely, 2003).

CONCLUSION

Although evolution is thought to be a slow process, with gradual changes taking place over thousands, often millions, of years, there is evidence to suggest that some instances of evolution are taking place under much shorter time spans. The parameters involved in the captive animal setting make it ideal for rapid evolutionary change to take place. The set number of individuals making up these populations, as well as the environmental pressures of a captive habitat, are the driving forces behind this rapid evolution. With evolution in captivity proving to be a real concern, captive population managers must work to mitigate these evolutionary changes.

Instances that greatly affect the genetic integrity of a population, such as inbreeding and forced mate choice, need to be monitored and managed so as to avoid the deleterious effects of such mating. Through the use of tracking the Mean Kinship value of individual animals, and by managing mass populations through creating subdivisions and regulating subpopulation breeding, many instances of inbreeding and the genetic drift that accompanies it can be avoided. Issues surrounding mate choice, and the lack of free selection among captive animals, is a field that still needs much exploration as there is documentation of the evolutionary importance of free choice in many animal species , while other studies suggest that any changes brought on by generations spent in captivity would not influence the animals natural fitness levels. There is still much to be studied in the field of captive evolution. While the evolutionary changes themselves may be labeled as rapid, the instances of these changes must be monitored over lengthy periods of time in order to properly draw conclusions.

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