Accumulation of Deleterious Mutations Due to Inbreeding in Tiger Population

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Abstract

Biodiversity in a species is the amount of genetic variability within the species. Genetic diversity refers to the total number of genetic characteristics in the genetic makeup of a species. The loss of genetic diversity within a population can be due to inbreeding within the species. Inbreeding can lead to an increase in homozygosity in the population and cause an excessive amount of deleterious mutations. Tigers are one of the most inbred animals in captivity. Tigers carry a recessive gene that can cause some offspring to be white. For the white coloring to show, the tigers must be inbred. The constant inbreeding can lead to mutations such as immune deficiency, scoliosis, cleft palates, mental impairments, strabismus, and early death. Inbreeding of the tigers leads to a loss of genetic variation within the species which can diminish the chances of evolving if necessary. Current research shows the geneaology of all white tigers can be traced back to the very first white tiger. It can be proven that every white tiger is related to one another. Other research proves that inbreeding is the major cause of mutations in the tiger population and hopefully further research will be done on other possible mutations that could occur within the species.

Key Terms

Biodiversity, inbreeding, heterozygosity, homozygous, inbreeding depression, deleterious, mutation, phenotype, genetic variation.

Introduction

Conservation genetics is an interdisciplinary science that aims to apply genetic methods to the conservation and restoration of **biodiversity** (Conservation genetics, n.d.). Biodiversity is the variety of different **species**, the genetic variability of each species, and the variety of different ecosystems that they form (Glossary, n.d.). Genetic diversity is a level of biodiversity that refers to the total number of genetic characteristics in the genetic makeup of a species (Genetic diversity, n.d.). The genetic diversity of a species is always open to change; no matter how many variants of a gene are present in a population, only the variants in the next generation can contribute to the diversity of the species in the future (Conservation genetics, n.d.). The loss of genetic diversity is a major problem in today's world. If a species lacks genetic diversity, it could become extinct due to the fact that there are only specific gene combinations possible. If gene combinations are limited, many members of a population may have to breed

with relatives in order to keep the species alive, an act known as **inbreeding**. Inbreeding is breeding between close relatives, whether plant or animal. If practiced repeatedly, it leads to an increase in **homozygosity** of a population. A higher frequency of recessive, deleterious traits in **homozygous** form in a population can, over time, result in **inbreeding depression** (Inbreeding, n.d.).

Sometimes inbreeding is not due to the lack of population, sometimes inbreeding is purposely done to show specific traits of a species that is desirable. For example, many Bengal tigers are inbred because the species carries a very rare gene causing some of the offspring to be white. The offspring are then bred to each other or to the parents to create more of the white tigers. The constant inbreeding of these animals is declining the genetic diversity of the species and causing serious mutations to occur. The white tigers themselves serve no purpose to any ecosystem because they can never truly exist in the wild, yet people continually breed them for economic reasons and not for conservation reasons. Many organizations such as the Tiger Species Survival Plan are trying to stop the inbreeding of tigers to prevent any life-threatening mutations from staying within the **gene pool**.

Inbreeding in Tiger Population

Humans today are unaware of the problems of inbreeding within the animal kingdom. Inbreeding depression refers to the decreased biological fitness of individuals and populations due to mating between related individuals. The more closely related two individuals are, the more likely it is that they are both carriers of the same recessive **deleterious** or lethal gene, which means that if they mate their offspring may be born with the undesirable genetic condition (Refer to PLATE 1; Mettler, Gregg, 1969) (Arlington, 2009). Another problem with inbreeding is the affect it has on the evolution

of a species. The smaller the gene pool in a given population, the less genetic variation and the more likely it is that the population could be wiped out by an epidemic (Arlington, 2009). There are many animal species that suffer from inbreeding depression, mostly because of human influence.

There are certain species, such as tigers, that suffer from deleterious mutations caused by inbreeding within the species. There are two species of tiger; Siberian and Bengal. Both species are naturally orange with black stripes, but in the 1950s, a white tiger was found in a litter of Bengal tigers in India. Many people believe that the Royal White Bengal Tiger is a species, but in reality it is not a species at all. The Royal White Bengal Tiger is a genetic **mutation**. White Tigers can only exist in captivity by continual inbreeding, such as father to daughter, brother to sister, mother to son, etc (Baskin, n.d.). This is because the white color is the result of a double recessive **allele** and thus the white color can only be produced by inbreeding one tiger carrying the recessive gene for the white color to another tiger carrying the same recessive gene. The [white tigers] are merely a product of this practice of inbreeding for white coats as well and are not being bred for any sort of conservation program either. Private exhibitors have experienced **neonatal** mortality rates in excess of 80% because the recessive gene for the white color is a deleterious mutation and thus is co-linked to numerous other deleterious and often fatal characteristics such as **immune deficiency**, **strabismus**, **scoliosis** of the spine, **cleft palates**, **mental impairments** and early death (Refer to PLATE 2; Baskin, n.d.) (Laughlin, n.d.). Due to the inbreeding of tigers and many other animals, both federal and state governments have been passing acts against inbreeding such as Captive Primate Safety Act, Ban Contact with Big Cats (Haley's Act), Prohibit Import of Invasive Non

Native Species, Protect Great Cats in the Wild, Keep Elephants and Big Cats Out of Circus Acts, Bans Breeding & Possession of Dangerous Wild Animals, Stop Puppy Mills Senate Bill, Animals as prizes and gifts, and many others.

White tigers very rarely appear in the wild due to the fact that it is not in a tiger's nature to mate with close relatives. When a white tiger cub does appear in the wild, it is usually due to the fact that both parents were carriers of the **recessive** mutant gene. To find how often the mutant gene appears in the population requires the use of the **Hardy-Weinberg Law**. Conservationists believe that there are around 2,000 Bengal tigers left in the world (Tiger, 2009) and that there are 600 known white Bengal tigers in the world (White Tiger, n.d.); this means that there are a total of about 2,600 tigers in the Bengal tiger population. The percentage of Bengal tigers with the **dominant** gene (orange coat) is 76.9% and the percentage of Bengal tigers with the recessive gene (white coat) is 23.1%.

2000/2600 = .769 = 76.9% 600/2600 = .231 = 23.1%

For the rest of the equations, "**R**" will be used to show the dominant gene and "**r"** will be used to show the recessive, mutant gene in this population. By using these factors and statistics, it was found that 59.1% of the tiger population is "**RR"**, 35.6% are "**Rr"**, and 5.3% are "**rr"**.

.769 x .769 = .591 = 59.1%

.769 x .231 = .178 x 2 = .356 = 35.6%

.231 x .231 = .053 = 5.3%

From this it can be seen that 35.6% of the tiger population are carriers of the recessive gene, but this cannot be told by the **phenotypes** of these tigers because the dominant gene

is all that appears. Now that the **heterozygosity** of the Bengal tiger population is determined, the focus on how the white tiger gene came into the population can be shown. When the first white tiger (**rr**) came to the United States, it was bred with a normal Bengal tiger (**RR**). The probability that the any of the cubs would be white was 0%. The offspring (2nd generation) were all orange, meaning that each cub was **"Rr"** and carriers of the recessive gene (Refer to PLATE 3; Begany, 2009). The keepers of the tigers then bred one of these cubs (**Rr**) with the white father (**rr**). There was a 50% chance that any of the cubs would be white and a 50% that any of the cubs would be orange. All the cubs from this litter were white (Refer to PLATE 4; Begany, 2009). In order for the white gene to show in the generations after, the cubs were either bred with each other or with the white parent, causing a decrease in **genetic variation** within the species (Refer to PLATE 5; Begany, 2009). To maintain some genetic variation, many breeders breed a white tiger with a tiger carrying the mutated gene, then the offspring will be continually inbred.

Discussion

Due to the loss of genetic diversity and accumulation of mutations due to inbreeding within tiger populations, I believe that further research should be done to see what other mutations can be caused in the tiger population in the future. Research should also be done on other possible genetic mutations of tigers and other animals that are inbred. If research finds that the mutations appear to be getting worse generation to generation, the organizations and the government should begin to fault zoos, private breeders, and conservationists for the inbreeding of the animals. Currently, many

[sanctuaries and zoos] claim to be breeding cats to save them from extinction when in fact they are not involved in any real conservation effort and rather are justifying their breeding to have babies who will bring in paying visitors and or to sell. “If anything, they ruin real conservation because they’re screwing up bloodlines that are mix-matched… and this tiger is inbreeding with this tiger to get the few white cubs.” White tigers are “man-made animals that shouldn’t exist” (Baskin, n.d.). Many organizations today, such as the Big Cat Rescue, rescue tigers and other animals from these breeding centers and care for them. The organizations allow people to visit and guests are given information about inbreeding and harmful mutations. Due to public knowledge, many individuals have confronted both state and federal governments about inbreeding and cruelty of animals. Because of this action, both federal and state governments have been involved in trying to stop inbreeding and other forms of animal cruelty in both captive and wild animal populations. The federal government has passed the following acts over the past 30 years; Captive Primate Safety Act, Ban Contact with Big Cats (Haley's Act), Prohibit Import of Invasive Non Native Species, and Protect Great Cats in the Wild. Many state governments have passed bills such as Keep Elephants and Big Cats Out of Circus Acts, Bans Breeding & Possession of Dangerous Wild Animals, Stop Puppy Mills Senate Bill, and Animals as prizes and gifts. Other current research proves the geneaology of every white tiger can be traced back to the very first white tiger. This proves that all white tigers are inbred in order to create more white tigers. Other research proves that inbreeding is the major cause of mutations in the tiger population and hopefully in the future, it is hoped that the amount of inbreeding in animals will be declined and that genetic mutations will be diminished in the gene pool.

Pictures and Plates

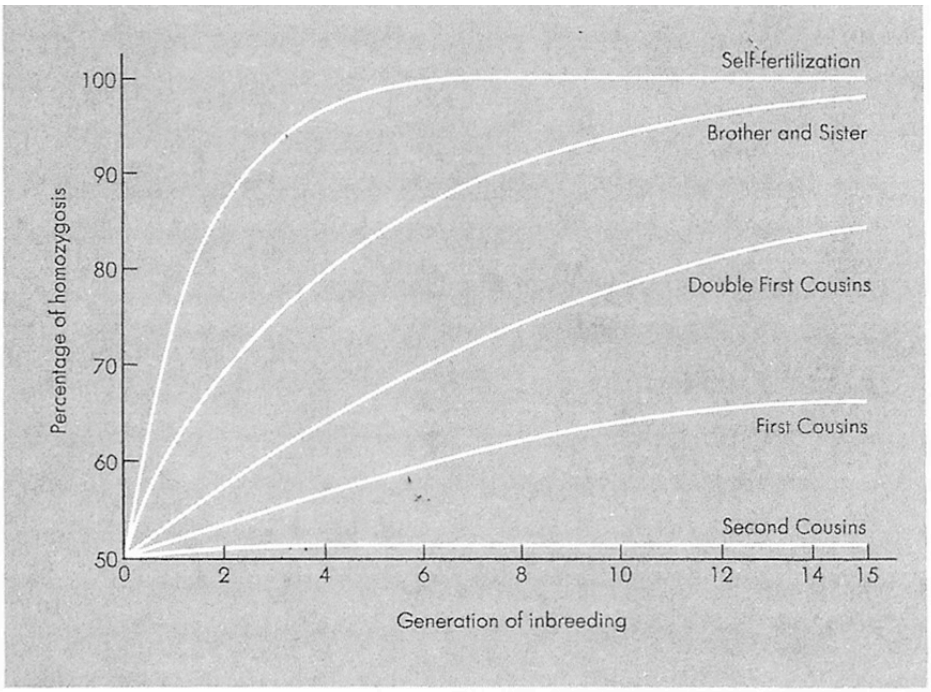

PLATE 1
(Mettler, Gregg, 1969)

The percentage of homozygous offspring from systematic matings with different levels of inbreeding.

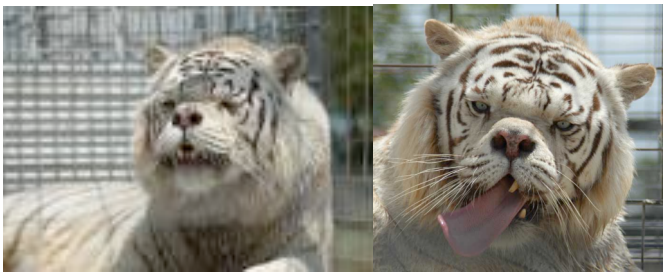

PLATE 2 (Baskin, n.d.)

Picture of white tiger with cleft palate and strabismus , two of the many mutations caused by inbreeding in tiger population.

	.769 **R**	.769 **R**
.231 **r**	.178 **Rr**	.178 **Rr**
.231 **r**	.178 **Rr**	.178 **Rr**

PLATE 3 (Begany, 2009)

Decimal form of how prevalent each gene is in the gene pool in the first generation. Possible genotype/phenotype combinations of offspring are shown.

	.5 **R**	.5 **r**
.5 **r**	.25 **Rr**	.25 **rr**
.5 **r**	.25 **Rr**	.25 **rr**

PLATE 4 (Begany, 2009)

Decimal form of how prevalent each gene is in the gene pool of the second generation. Possible genotype/phenotype combinations of offspring are shown.

	.5 **r**	.5 **r**
.5 **r**	.25 **rr**	.25 **rr**
.5 **r**	.25 **rr**	.25 **rr**

PLATE 5 (Begany, 2009)

Third generation. Notice that there is only one gene present. Due to the inbreeding the recessive trait is all that is left for these offspring to pass on to the generations to come.

Glossary

Allele – Either of a pair of genes located at the same position on both members of a pair of chromosomes and conveying characters that are inherited in accordance with Mendelian law.

Biodiversity - The variety of different species, the genetic variability of each species, and the variety of different ecosystems that they form

Cleft palate – A cleft from front to back along the middle of the palate, or roof, of the mouth, caused by the failure of the two parts of the palate to join in prenatal development.

Deleterious – Harmful to health or well-being; injurious.

Dominant - describes the effects of the different versions of a particular gene on the phenotype of an organism.

Gene pool – The total of all the genes of a species.

Genetic variation - A level of biodiversity that refers to the total number of genetic characteristics in the genetic makeup of a species.

Hardy- Weinberg Law – A rule which relates the frequencies of genotypes at a locus in a population to the frequencies of the alleles at that locus.

Heterozygosity – The state of being heterozygous; having two different alleles of the same gene.

Homozygous - Having two of the same alleles of a particular gene.

Homozygosity - the state of being homozygous; having two identical alleles of the same gene.

Immune deficiency – Impaired ability of the body's defense mechanisms to combat infections by bacteria, viruses and fungi.

Inbreeding – The continual mating of individuals of the same or closely related stocks.

Inbreeding depression – is reduced fitness in a given population as a result of breeding of related individuals.

Mental impairments – A lack of normal development of intellectual capacities.

Mutation – A sudden variation in some inheritable characteristic in a germ cell of an individual animal or plant, as distinguished from variation resulting from generations of change.

Neonatal - Of or pertaining to the period of time immediately following birth, or to the newborn.

Phenotypes – The manifest characteristics of an organism collectively, including anatomical and physiological traits, that result from both its heredity and its environment.

Recessive – Designating or relating to that one of any pair of allelic hereditary factors which, when both are present in the germ plasm, remains latent.

Scoliosis – Lateral curvature of the spine.

Species – A naturally existing population of similar organisms that usually interbreed only among themselves, and are given a unique, latinized binomial name to distinguish them from all other creatures.

Strabismus – A disorder of the muscles of the eyes, as cross-eye, in which both eyes cannot be focused on the same point at the same time.

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Additional Links

http://www.youtube.com/watch?v=8VnvjGInpzs

http://www.youtube.com/watch?v=_5_mzz-9i3g

http://www.bigcatrescue.org/index.htm

http://www.bigcatrescue.org/000news/0articlesbybcr/2001white_tigers.htm