Success of large felines breeding in captivity, a studbook review

Framgång vid aveln på stora kattdjur i fångenskap, en granskning utav stamböcker

Lina Morein

Skara 2013

Etologi och djurskyddsprogrammet

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Abstract

In the past there has not been much concern about the breeding of exotic animals in captivity since many of the species kept could be replenished from the wild if needed. After years of collecting wild specimen for zoos the animals have begun to disappear from the wild and become threatened or endangered which makes it unsustainable to continue this practice. The number of techniques for captive breeding have increased tremendously over the years and research on breeding has progressed rapidly. The breeding of exotic species in captivity as a means of saving the threatened wild population has increased over the years. For many species reproducing under captive conditions has been difficult as well as obtaining surviving offspring. Although, of the three species chosen for this study, only the cheetah (*Acinonyx jubatus*) has had difficulty with breeding in captivity. This study was conducted to observe how the breeding of cheetahs (*A. jubatus*), tigers (*Panthera tigris*), and lynx (*Lynx lynx*) have been in the last ten years and see if any conclusion can be drawn. Although there has been some cubs which has died before six months of age, the statistics has gotten better as the years have progressed. For the future it would be recommended that more consideration be paid towards the animals' natural breeding behaviour. Many of the problems faced are due to inadequate housing or social environment. Efforts must also be put on evolving the modern zoo into something that not only preserves the animals but also improves on its work on educating the public.

Introduction

Breeding in captivity

In the early days of zoos the attempts to breed in captivity were limited since capturing animals from the wild often was the easier choice (Lasley *et al.*, 1981). After years of collecting wild specimen for zoos the animals began disappearing from the wild and many of them became endangered or threatened (Lasley *et al.*, 1981). The number of techniques for captive breeding increased tremendously and research on breeding progressed rapidly (Snyder *et al,.* 1996). In the early 90's captive breeding became one of the more popular methods for saving endangered species (Bowkett, 2009). As the captive breeding was used more and more, it was important to breed for genetic value so that the population stayed healthy and the genetic diversity was maintained (Wildt & Terri, 1997). It was when the list of limitations and problems grew that the captive breeding programs started to lose their appeal and soon the practice became seldom used (Bowkett, 2009). It was not until recent years the breeding programs made a comeback since more conservation actions are required for the successful preservation of endangered species (Bowkett, 2009).

To have a favorable outcome in ex situ conservation Mellen (1991) devised a list of factors that might influence breeding in captivity which fall into three groupings:

- Reproductive physiology: failure to reproduce might be due to nonviable sperm, lack of ovulation or other physical obstacles.
- Inbreeding and demographic planning: a good demographic planning where information about all the individuals are included, such as age, sex, relations to other individuals, is vital when planning pairings to avoid inbreeding.
- Physical and social environment: the housing is very important; with an enclosure too small or designed improperly the animals might become stressed or unable to reproduce.

Problems with breeding in captivity

Obtaining surviving offspring has been a challenge for many species when breeding in captivity (Snyder *et al.,* 1996). Although, of the three species chosen for this study, only the cheetah has had difficulty with breeding in captivity (Mellen, 1991). This problem with breeding could be due to many different aspects, some of which is listed below.

In 1991 Mellen did a study on small felids where she found significant relationships between numbers of litters produced and medical treatments, group size, latitude range and husbandry style. One of the things she recommends is that the keepers encourage friendly behaviour from the cats, such as cheek rubbing against the fence, to make the animals more content with their environment and so increase the chances of reproduction.

Another factor that influences the success of breeding is the amount of stress they have to be put through due to relocation in order to find suitable mates. Some animals have to be moved long distances to be mated with appropriate individuals; this stress can become too great and result in failed conception (Dan *et al.,* 2013).

As previously mentioned the enclosure design is an important factor when it comes to breeding exotic cats in captivity, not just the physical but also the social environment. When held in groups greater than two, solitary wild cats rarely produce any young (Mellen, 1991). Should any cubs be produced they often have to be hand reared (Mellen, 1991). On the other hand, if the female is kept under suitable conditions and manages to reproduce young, she is also usually successful in raising the offspring according to Mellen (1991). It is very important to respect the individual species behavioral needs, bobcats in captivity for example have proved to kill their cubs when disturbed during breeding (Stys & Leopold, 1993).

Preserving endangered species – the use of studbooks

The idea of organized breeding is nothing new; studbooks have been in use for over 200 years starting with thoroughbred horses (ne.se, 2013). It is an essential tool to avoid inbreeding and unfit pairings when you work with conservation of wild animals in captivity (EASA.net, 2013). A studbook contains useful information such as individual registration numbers, the sex of the animal, place and date of birth and registration number of the parents. It also shares the type of identifier, for example transponders, tattoos or/and tags (WAZA.org, 2013)

All the studbooks in Europe are managed by the European Association of Zoos and Aquaria, EAZA (EAZA.net, 2013). To organize all the studbooks they have two levels of breeding programs, European Endangered species Program (EEP) and the European StudBook (ESB) (EAZA.net, 2013). The cheetah and the tiger are classified as EEP, and the lynx as an ESB. For every species, there is a studbook keeper who is responsible for the specific studbook he or she is assigned to.

The EEP include the animal species that are in more need of conservation. All the individuals within a species, kept in zoos associated with EAZA, are listed in the studbook as well as demographic and genetic analyses to plan for the future management of the species (EAZA.net, 2013). The studbook keeper in an EEP is assisted by a Species Committee and in consultation with the committee the keeper makes recommendations each year (EAZA.net, 2013). The recommendations include which animals should breed and which animals should be transferred and so on, this is later sent out to all the zoos and aquariums within the program (EAZA.net, 2013).

The ESB is a less intense program where the studbook keeper is not assisted by a committee (EAZA.net, 2013). Although the species classified as ESB are not as threatened as those classified as EEP, they still need assistance to avoid difficulties in the future (EAZA.net, 2013). In an ESB you find information about births, deaths, transfers, etcetera, and the keeper may give out recommendations about breeding and transfers for the coming year (EAZA.net, 2013).

Conservation conventions and organizations

There are several organizations that work with conservation and preservation of endangered species. The Convention on International Trade in Endangered Species of Wild Fauna and Flora, CITES, regulate trading and transportations across borders with endangered species, both alive and parts (cites.org, 2013).

The International Convention for Conservation of Nature (IUCN) Red List which lists species in categories according to level of how endangered they are (IUCNredlist.org, 2013). According to IUCN Red List the tiger (*Panthera tigris)* is the most threatened species and listed as endangered, the cheetah is close second as vulnerable and the lynx classified as least concern (IUCNredlist.org, 2013)

The Convention on Biological Diversity represents the conservation of biological diversity (cbd.int, 2013). Without these interventions and protection of wildlife, the future of threatened species would appear very dim (Goodrowe, 1992).

The chosen species for this study

Three species were chosen to represent one native species, which is supposedly easy to breed, and two exotic species, where one is supposedly difficult to breed and the other less difficult.

As the first exotic cat, cheetah was chosen to represent the more difficult cat to breed, while tiger was chosen as the cat which bred more easily. The lynx was chosen as the native feline which is easy to breed in captivity.

Cheetah (*Acinonyx jubatus*)

It is estimated that there are about 10 000 cheetahs left in the wild, spread over 20 countries in Africa (WWF.se, 2013).

Genetic studies have shown that cheetahs have a very small genetic diversity which appears to be the result of a ‘bottleneck’ that must have happened centuries ago (Dalton *et al.* 2013). As a result of this the cheetah has lots of problems, e.g. a weak resistance against diseases and a high mortality rate. As much as 90 % of the cubs dying within three months. Bad quality sperm and an overall difficulty to adapt to changes in the environment are other problems they face due to the ‘bottleneck’ (WWF.se, 2013).

There are some general threats to the cheetahs’ survival in the wild, one is illegal trading with live animals and another is the loss of genetic variation. The hunting of individuals that have attacked livestock, prey competition with lions and hyenas, as well as loss of habitats are other factors threatening their survival (WWF.se, 2013).

Tiger (*Panthera tigris*)

Today there are little more than 3 %, 3200 tigers, left in the wild if you compare with the population a hundred years ago when around 100,000 tigers roamed the world (WWF.se, 2013).

There are a lot of reasons why the tigers are near~~ing~~ extinction. One is that their bones are grinded to powder and used in traditional Asian medicine. This is a growing problem and illegal trading is flourishing all over the world (WWF.se, 2013). The loss of habitats and illegal poaching are considered the two biggest problems facing the tigers in the wild (Karanth, 1995).

Eurasian Lynx (*Lynx lynx*)

The Eurasian lynx was once common in Europe and parts of Asia but today they are not as numerous (Koordinierte, 2004). By the turn of the 20th century there were no lynx left in Sweden. Today the lynx has returned to the country and only the islands of Öland and Gotland is left without (WWF.se, 2013).

Even though the Eurasian lynx is protected, illegal hunting still exists and is most common close to the snowmobile tracks where tracking the animals are easier (WWF.se, 2013)

The studbook for Eurasian lynx is relatively young, it wasn't until recently that EAZA saw it fit to start one (Koordinierte, 2004). It was around the time when the lynx was beginning to be reintroduced into the wild that it was decided that a better management of the species was necessary.

Aims and questions

Reproduction in captivity has been a problem for animal keepers since we started keeping wild animals in captivity. The research has moved forward a lot in recent years and this study was conducted with the purpose to observe how well the chosen species have reproduced in captivity between 2002 and 2012 and if any conclusions can be drawn from the results.

The main questions of the study are;

What does the reproduction history look like for the cheetah, lynx and tiger in captivity during the last ten years?

When looking at the data from studbooks and the questionnaire, can any conclusions be drawn for future improvements on reproduction?

Materials and methods

Subjects

The subjects in this study were chosen as representatives of the captive exotic large cats in general kept in Sweden. The individuals suited for this study were those that had been kept sometime during the years 2002 until 2012, or were still being kept, in the zoos. The individuals used for reproduction were analyzed more closely. Five zoos were chosen to represent the zoos in Sweden; Borås Zoo, Kolmården Zoo, Nordens Ark, Ölands Djurpark, and Orsa Grönklitt Björnpark.

Lynx was the species held in greatest numbers during the years (see table 1). The sizeable numbers are the result of successful reproduction where many cubs were produced and cared for.

During the last ten years 47 cheetahs has been kept by Borås Zoo, and of those only four fit the criteria for reproduction, one male and three females.

Kolmården Zoo has had seven tigers in the last ten years, but only two of them have been used in successful reproduction, one male and one female. Ölands Zoo has during the last

ten years housed ten tigers, two of them have been reproducing. Borås Zoo has had four tigers, Orsa have had six and Nordens Ark have had three, but none of those have been able to reproduce.

Table 1. The total number of individuals of each species, including cubs, held by respective zoos sometime during the years 2002 until 2012.

Zoos	Cheetahs	Tigers	Lynx
Borås Zoo	47	4	19
Kolmården Zoo	-	7	27
Nordens Ark	-	3	11
Öland Zoo	-	10	18
Orsa Grönklitt Björnpark	-	6	22
Total	47	30	97

Studbooks

With the use of studbooks, information about the individual animals was collected and analyzed. The information about the animal's sex, age, birthplace, dates for respective event and the sires of each animal were registered and used. The animals chosen were those housed by the selected zoos during the years 2002 through 2012.

The questionnaire

A questionnaire was sent out to the respective zoos with questions regarding the reproduction of the concerned species. The questions were about the husbandry in general and more specifically regarding housing and breeding (see Appendix 1).

Out of the five zoos that the questionnaire was sent to only two answered, Nordens Ark and Borås Zoo, and due to this the answers could not be included in the study.

Results

The studbooks

The results are presented in the tables below (table 2-13). The sex of the cubs is specified as 0.0 where the first number symbolizes male offspring, and the second symbolizes female. In the few litters were cubs whose sex was not notified, there is a third number to symbolize these cubs.

The cheetahs

In the last ten years, only 8.5 % of the cheetahs has been reproducing (table 2), and in four of seven litters there were dead cubs (table 3). In the litter born 31th July 2011 there was one cub where the sex was unknown (table 3). In three of the litters there were living cubs,

the biggest litter produced in 2010 with eight cubs in the litter (table 3). One mating was performed at another zoo and the female, Luanga, was brought pregnant to Borås Zoo.

Table 2. The cheetahs held in captivity during 2002 until 2012 in the chosen zoos.

Zoos keeping cheetahs	Animals not breeding	Animals in successful breeding	Total number of animals
Borås Zoo	43	4 (8,5 %)	47

Table 3. Cheetah litters produced at Borås zoo during the years 2002 until 2012.

Sires	Date of birth	Living cubs	Dead cubs (within six months)	Total cubs
Paka (m) + Maeve (f)	28th April 2004	-	1.2	1.2
Paka (m) + Maeve (f)	28th May 2005	1.0	1.1	2.1
Richard (m) + Luanga (f)	20th May 2008	1.1	1.0	2.1
Paka (m) + Luanga (f)	19th February 2010	6.2	-	6.2
Paka (m) + Luanga (f)	31th July 2011	1.1	1.2.1	2.3.1
Paka (m) + Naki (f)	5th November 2012	5.2	-	5.2
Paka (m) + Luanga (f)	24th December 2012	3.2	-	3.2

The tigers

Only three out of five zoos holding tigers had been able to produce litters (table 4), and out of those three only 28,6 % (Kolmården Zoo), 66,7% (Nordens Ark), and 20 % (Ölands Zoo) of the animals were successful (table 5 and 6). Only Nordens Ark produced dead cubs (table 7).

Table 4. The reproduction of tigers held in captivity in respective zoos during the years 2002 until 2012.

Zoos keeping tigers	Animals not breeding	Animals in successful breeding	Total number of animals
Borås Zoo	4	0	4
Kolmården Zoo	5	2 (28,6 %)	7
Nordens Ark	1	2 (66,7 %)	3
Orsa Grönklitt Björnpark	6	0	6
Ölands Zoo	8	2 (20 %)	10
Total	24	6 (20 %)	30

Table 5. Tiger litters produced at Kolmården Zoo during the years 2002 until 2012.

Sires	Date of birth	Living cubs	Dead cubs (within six months)	Total cubs
Kazan (m) + 4731 (f)	16th July 2007	1.0	-	1.0
Kazan (m) + Taisha (f)	29th August 2008	0.2	-	0.2
Kazan (m) + Taisha (f)	7th June 2010	0.1	-	0.1

Table 6. Tiger litters produced at Ölands Zoo during the years 2002 until 2012.

Sires	Date of birth	Living cubs	Dead cubs (within six months)	Total cubs
Tim (m) + Mi (f)	26th February 2003	0.1	-	0.1
Tim (m) + Mi (f)	3th July 2003	1.1	-	1.1
Tim (m) + Mi (f)	15th October 2007	2.0	-	2.0

Table 7. Tiger litters produced at Nordens Ark during the years 2002 until 2012.

Sires	Date of birth	Living cubs	Dead cubs (within six months)	Total cubs
Uri (m) + Sparta (f)	26th October 2010	-	3.0	3.0

The lynx

All the zoos in this study have been able to reproduce at least two litters during the years observed (table 8). 14,4 % out of all the lynx managed to breed, and the highest percentage was Borås Zoo with 21 % (table 8). Nordens Ark was the only zoo that managed to keep all their cubs alive over six months (table 9). One remark is that all but four litters were born in the month of May (table 9 -13).

Table 8. The reproduction of lynx held in captivity in respective zoos during the years 2002 until 2012.

Zoos keeping lynx	Animals not breeding	Animals in successful breeding	Total number of animals
Borås Zoo	15	4 (21 %)	19
Kolmården Zoo	24	3 (11,1 %)	27
Nordens Ark	9	2 (18,2 %)	11
Orsa Grönklitt Björnpark	20	2 (9,1 %)	22
Ölands Zoo	15	3 (16,7 %)	18
Total	83	14 (14,4 %)	97

During the years 2002 until 2012 Borås Zoo produced nine litters of lynx using four individuals, two pairs. On the cub born 25th May 2011 the sex was unknown (table 9). There were also cubs with unknown sex produced at Kolmården Zoo, born 29th May 2002 (table 10). The first litter at Ölands Zoo didn't have any registered sires, and further two litters didn't have any registered dame, they are listed as unknown (table 13).

Table 9. Lynx litters produced at Borås Zoo during the years 2002 until 2012.

Sires	Date of birth	Living cubs	Dead cubs (within six months)	Total cubs
Flackis (m) + Lovis (f)	20th May 2004	1.0	-	1.0
Flackis (m) + Lovis (f)	11th May 2006	1.1	-	1.1
Flackis (m) + Lovis (f)	21th May 2007	0.2	-	0.2
Gustaf (m) + Blanka (f)	31th May 2007	-	0.l	0.1
Gustaf (m) + Blanka (f)	2th June 2008	2.1	-	2.1
Gustaf (m) + Blanka (f)	28th May 2009	2.1	-	2.1
Gustaf (m) + Blanka (f)	24th May 2010	0.1	-	0.1
Gustaf (m) + Blanka (f)	25th May 2011	-	0.0.1	0.0.1
Gustaf (m) + Blanka (f)	21th May 2012	-	1.0	1.0

Table 10. Lynx litters produced at Kolmården Zoo during the years 2002 until 2012.

Sires	Date of birth	Living cubs	Dead cubs (within six months)	Total cubs
Lomax (m) + Losanne (f)	29th May 2002	-	0.0.3	0.0.3
Lomax (m) + Losanne (f)	19th May 2004	1.1	0.1	1.2
Lomax (m) + Losanne (f)	22th May 2005	0.1	-	0.1
Lomax (m) + Losanne (f)	19th May 2006	0.3	-	0.3
Lomax (m) + Lorie (f)	17th May 2009	2.0	-	2.0
Lomax (m) + Lorie (f)	16th May 2011	1.1	-	1.1
Lomax (m) + Lorie (f)	24th May 2012	2.0	-	2.0

Table 11. Lynx litters produced at Nordens Ark during the years 2002 until 2012.

Sires	Date of birth	Living cubs	Dead cubs (within six months)	Total cubs
Raipe (m) + Loka (f)	18th May 2005	0.1	-	0.1
Raipe (m) + Loka (f)	18th May 2009	2.0	-	2.0

Table 12. Lynx litters produced at Orsa Grönklitt Björnpark during the years 2002 until 2012.

Sires	Date of birth	Living cubs	Dead cubs (within six months)	Total cubs
Diodoros (m) + Paloma (f)	2th June 2002	0.1	-	0.1
Diodoros (m) + Paloma (f)	18th May 2003	2.1	-	2.1
Diodoros (m) + Paloma (f)	14th May 2004	2.1	-	2.1
Diodoros (m) + Paloma (f)	19th May 2005	0.1	1.0	1.1
Diodoros (m) + Paloma (f)	17th May 2006	1.1	-	1.1
Diodoros (m) + Paloma (f)	25th May 2007	2.1	-	2.1

Table 13. Lynx litters produced at Ölands Zoo during the years 2002 until 2012.

Sires	Date of birth	Living cubs	Dead cubs (within six months)	Total cubs
Unknown	15th June 2004	-	1.1	1.1
Lothar (m) + Unkown	30th June 2004	0.1	1.0	1.1
Lothar (m) + Unknown	27th May 2007	2.2	-	2.2
Lothar (m) + Etti (f)	15th July 2008	1.2	-	1.2
Lothar (m) + Tilda (f)	25th May 2009	-	1.1	1.1

Discussion

What has happened during the ten years?

The overall conclusion of this study was that there are a lot of individuals of feline species which did not breed. Why these individuals did not breed is difficult to determine.

Because all the answers to the questionnaire weren't returned, only the studbooks were used as the information source. That made it difficult to understand why fertile individuals did not breed. In the studbooks there were only information such as birthdates, transfers and deaths, no specific information regarding breeding or illnesses. Many of the individuals listed in the studbooks during the examined timeframe were the cubs born in the zoo. This made many of them too young to breed and others were moved when they were old enough. Without taking that into account the numbers could be misleading when looking at the breeding statistics.

Another aspect that could be misleading would be a comparison between animals in the wild and animals in captivity regarding the number of reproducing adults. To avoid inbreeding and genetic bottlenecks zoos have to make the most of the genetic material they have (Witzenberger & Hochkirch, 2011). Since the populations in captivity are restricted and many populations in the wild are slowly going extinct, the animals in zoos need to be successful in breeding in order to secure the survival of their species.

Information about breeding large cats in captivity is from the 80s and 90s when the subject was at its peak and therefore might not be up to date. This made it difficult to attain information from more recent years that was relevant for this study. What was also important was that much of the information gathered were from studies on other feline species (Lasley *et al.*, 1981. Mellen, 1991. Snyder *et al*., 1996. Stys & Leopold, 1993), which must be taken into consideration when applying the results to the species in this study. If the results are based on one species, it could be difficult to apply the results on another species due to the differences between them. In the study on reproductive success in small felids by Mellen (1991), she looked at several different species of felids to get a picture as broad as possible. In doing so she made it easier to adapt the findings and apply them to other species of feline. Take enclosure design and breeding techniques for example, she could compare the different variables between the species, how they related to each other and present recommendations for most of the small felines kept in captivity. These recommendations are applicable to many different species since the data was gathered from several objects making it more dependable than other studies with just one species as an object. The study was also performed in several zoos and using numerous variables, making the data more credible. The description of the study is also meticulous and well written which would make it possible to repeat the study with new species such as the big cats in this study.

One study which was less meticulous was Stys & Leopolds (1993). They did not specify how long the cats were kept, if they were wild caught or captive bred. These are important parameters, because depending on how long the cats were kept and where they came from they had different conditions for successful breeding in the mentioned pens. It would be difficult to repeat the study due to the fact that much of the information was left out. The bobcats in Stys & Leopolds (1993) study were not held under the most suitable conditions and many of the animals probably suffered from stress due to the inadequate housing. They were kept in relatively small pens, 6x6x3m, were no shrubbery or trees were described as being present, just ramps, tunnels and scratching pads.

The future of endangered flora and fauna are threatened not only by human influence but also the impending climate change, as a result ex situ conservation would be needed now more than ever (Pritchard *et al.* 2011). That is why this paper is an important contribution to the future work and research on captive breeding. The information presented is an important beginning since they show a summary of the animals studied which have not been done before. As their existence in the wild are becoming more and more threatened we need to look into how we keep them in captivity.

Aspects that might affect breeding

There can be many different aspects that can affect breeding, many more than are brought to light in this paper. Here is a small sample of issues which can cause problems.

Due to the unnatural situations that can arise in zoos, many of the captive felids have been placed in social environments that differ from the wild (Miller *et al.*2013). In some situations this might have posed as a problem, but it did not always have to be disadvantageous or stressful for the cats. Research has shown that tigers in captivity, who have sufficient amount of food, could adapt from a solitary lifestyle to sociality (Dan *et al.*, 2013).

Another aspect that have affected the behaviour of captive carnivores have been the differences in activity budgets. Compared to the wild cats, the cats in captivity live a relatively uneventful life with little to no exercise. Wild cats' primary activity is hunting while in captivity almost no opportunity is given to express this behaviour (Lindburg, 1988).

Not surprisingly, what has been negatively correlated with successful reproduction has been the number of medical treatments (Mellen, 1991). An animal that has health problems probably won't be fit for breeding.

Possible solutions to the problems

If more litters have been what the zoos have been striving for, then maybe artificial breeding is a probable solution for the more difficult species. There has been much research done on the subject over the years and some data can be found (Goodrowe, 1992; Wildt & Terri, 1997; Farstad, 2000). With the help of assisted reproduction those animals that would otherwise not breed in captivity could be breed which could result in offspring of genetically important animals that would otherwise be impossible. The cheetah would be one animal whose breeding program in captivity has benefited from this research. Several offspring has been produced repeatedly with the help of artificial insemination, AI (Wildt & Terri, 1997). According to Wildt & Terri (1997) there has even been a record of one wild-caught cheetah who never displayed any interest in natural breeding in captivity but using AI she managed to produce offspring.

Assisted reproduction could be used to breed animals that would not be sexually compatible, move genetic material between populations without the risk of infections and make full use of the genetic diversity (Wildt & Terri, 1997).

Using assisted reproduction the focus must be on producing healthy individuals, both physically and mentally. In many cases assisted reproduction might be a good option, but in other cases the reason for failed natural mating must be considered. Did the natural mating fail because the individuals were not suited for breeding? It is important to consider

both the behavioral and genetic aspect when contemplating assisted reproduction instead of natural mating.

One zoo that would not need to consider artificial reproduction would probably be Borås Zoo, they have been very successful in their cheetah breeding program. They have been one of the most successful zoos in Europe regarding the breeding of cheetahs. Many zoos have been unable to reproduce these cats at all in captivity (Cheetah studbook, 2010). In 2010 only 11 out of 83 zoos participating in EEP were able to breed, but over 50 of them hade the ambition to reproduce (Cheetah Studbook, 2010).

Only 20 % of all the tigers in this study managed to breed successfully. From all the litters produced, only one had any stillborn or infant deaths and according to the zoo this was the result of euthanasia because of improper breeding. This could mean that when tigers do manage to reproduce they also manage to successfully raise their young and keep them healthy and alive. Studies have been done on bobcats that show that yearling females who have been used for breeding perform more poorly than older females; the reason is thought to be their smaller size and their higher energy expenditure due to their own growth (Stys & Leopold, 1993).

This study only looked at the cubs up until they were six months old, what happened after that could be an idea for a new study. It would be interesting to know how long the cubs live, and how well they manage in captivity, how many of them are able to reproduce? Is there a pattern in which animals are able to breed? Does success in breeding have much to do with the way the individual was raised?

Critique on the experimental design

This study has mostly been based on the species studbooks and the articles collected.

The lack of information from the questionnaire makes the information more susceptible to misleading or missing data. It was not possible to verify if the data in the studbooks was missing or wrong.

The cause for the delay with the questionnaire was that the first version that was sent out could have been better outlined and the questions better phrased. One zoo sent back some feedback about the survey and after that the questions were rewritten and the questionnaire sent out again. This time the questions were more clear and easier to understand, and fewer in numbers. All this took time and resulted in many zoos being unable to answer in time.

Since only one zoo answered the whole questionnaire it was difficult to incorporate the answers in the study and so the answers were left out completely.

The articles compiled were mostly older than 15 years and this poses a dilemma; either the information is not ~~be~~ up to date or it is still current and not in need of updating. Deciding which information falls under which category was difficult and sometimes impossible without further research.

In the process of compiling the data, some of the numbers could be misleading since both fertile (adults) and infertile (cubs and castrates) animals were included. When the numbers were as small as in this study, percentages could also be misleading and show an incorrect picture. With this in mind, all the individuals were included in the study anyway, since the purpose of the study was to show how many individuals are bred out of the entire population in the specific zoo.

The studbook information about the cheetahs was based on only one zoo; the results gathered can’t be hastily applied to other animals outside the zoo. The group was too small

to get any viable results but it gave a hint on what might be of interest in further studies on the subject.

Thoughts for the future

Should we breed animals in captivity? An important question we must ask ourselves.

Most of the animals bred in captivity cannot be reintroduced back into the wild in the foreseeable future. The captive breeding might result in different degrees of behavioral changes that might make them unfit for reintroduction (Snyder *et al.*, 1996). For some species the behavioral changes are drastic enough to make them unfit for the wild within only a few generations, sometimes as few as one (Snyder *et al.*, 1996). The risk of progressive domestication during long term breeding programs makes reintroduction difficult and as such we might have to rethink our strategies of captive breeding for several generations before reintroduction (Snyder *et al.*, 1996).

When choosing animals to breed much emphasis have been on the genetics and not much on the individual's behaviour, this might have dire consequences in the future if the offspring in future generations are to be reintroduced into the wild and some of the natural behaviors have been changed through progressive domestication (Snyder *et al*., 1996). Individuals in captivity which are not fit for reintroduction might not be fit for breeding either due to this risk.

This poses a problem when all genetic material is vital in the threat of genetic bottlenecks. Do we want individuals in captive breeding programs that won't be able to live in the wild, when the main purpose of the programs is to reintroduce the offspring when the habitats are stable enough?

One important aspect of captive breeding is that large carnivores have higher reproduction rates in ex situ breeding programs than in in situ programs (Balmford *et al*,. 1995). The reason for the higher reproduction rates could be that large carnivores usually have rather large litters and in the wild there is quite a high neonatal mortality. In captivity most of the cubs survive their first year. Despite the higher reproduction rates Balmford *et al*, (1995) came to the conclusion that it costs less to maintain populations in the wild than in captivity, which is an important point since money is one of the biggest problems when it comes to conservation programs.

As the breeding programs become more and more successful and produce healthy living cubs, what are we to do with them? The limited space in the parks poses a problem when the animals start to increase in numbers and the possibilities of reintroduction are not yet a viable solution. Should we refrain from breeding as much as we do or should we build more arks for the animals?

This study is an important contribution to the study of captive breeding and the reproductive behaviour of cheetahs, tigers and lynx. The captive breeding programs have been at a standstill the last few years due to the lack interest and need, but as the environment is changing we need the programs to save many of the world's endangered species. The captive breeding programs are becoming more and more important due to this problem and this study can assist with the successful reproduction of wild felids. As this study compiles data from ten years of breeding, which has not been done before, it provides the future of captive breeding with new insights and inspiration towards the future. The prospects of ex situ conservation, especially breeding techniques, need to improve in the coming years if we are to sustain populations that can be reintroduced into

the wild in the future. This paper contributes to that future by compiling data and analyzing how we can improve the captive life of wild animals. If we are to continue keeping wild animals captive for breeding purposes this study is a vital tool in its success. No other study gathers information from the studbooks of these species as this study has, that makes this valuable information which can help in improving the breeding success of felines in captivity.

The consequences of this study would be that more people see the importance of this subject. Much more research is needed on the subject of ex situ conservation. Captive breeding is just a small part of that, but this study has shown we can improve the breeding and what we need to learn more of. The breeding of cheetahs at Borås Zoo is one of the most successful in EAZA, why so few manages to produce young when Borås manages so well is not something we can speculate from this study but an educated guess can be made. It might be that not enough information is shared or taken heed to between the parks and the animals have to suffer for it. The limited funding and means to which the parks have access to makes improving the recourses a difficulty. With this study it is hoped that the parks with fewer litters might rethink their strategies where breeding cheetahs are concerned.

An effective way of spreading information about the importance of conservation is through the zoos. A first step would be to change the way zoos are viewed by the public, raise their status to make people more interested in the survival of endangered species. Families go to the zoos and animal parks to be entertained, not taught. Perhaps that is something in need of change if zoos are ever to be taken as a place of sustainable conservation. People should still be entertained, as long as the main purpose of the visit is about learning. Entertainment is important for the public if they are to be interested in conservation. No one is motivated to save something that does not give them joy in some way or other.

Conclusions

The reproduction history for the cheetah, tiger and lynx looks good but can still be improved. Although there has been some cubs which has died before six months of age, the statistics has improved over the years.

For the future it would be recommended that more consideration has to be paid towards the animals' natural breeding behaviour. Many of the problems faced could be due to inadequate housing or social environment. If the breeding programs continue to improve we need more planning about what to do with the produced animals.

A recommendation would be that more effort should be put into the evolution of the modern zoo. We need somewhere to keep animals where we can avoid progressive domestication as well as an educational system that inspires people to see the importance of conservation biology. The awareness among people is growing as the threat of environmental changes is becoming more and more dominant.

The results are inconclusive and much information is still needed, many variables are not included and many more zoos need to be incorporated. The study is a fair beginning into the subject and other questions will need to be answered; how does early rearing affect the animal's breeding possibilities later? Which aspects are most vital when breeding large felids in captivity? How do we continue breeding wild animals in captivity for reintroduction later on without the risk of too much progressive domestication? Or the risk of too much inbreeding?

Sammanfattning

I djurparkernas tidiga historia fanns inte många tankar kring avel på de exotiska djuren i fångenskap eftersom de lättare kunde förnya bestånden från den vilda populationen. Allt eftersom jakten på levande djur och troféer fortsatte så minskade antalet vilda djur tills flera knappt fanns att hitta i vilt tillstånd. När det inte längre gick att samla nya individer från det vilda fick man börja avla istället, och de senaste 30 åren så har forskningen om avel i fångenskap gått framåt och nu krävs nästan inga vilda individer alls längre för överlevanden utav arterna.

I den här studien valdes tre arter ut för att representera de större kattdjuren, gepard (*Acinonyx jubatus)* för att representera de lite mer svår avlade arterna, Tiger (*Panthera tigris)* de lite mindre svår avlade, och lodjur (*Lynx lynx)* som den inhemska arten.

Syftet med studien var att titta på aveln av dessa arter och se hur framgången varit de senaste tio åren och om några slutsatser kan dras för att förbättra eventuella problem i framtiden.

För att kunna svara på dessa frågor skickades en enkät ut till fem djurparker för att få mer information om hur individerna hålls, och stamböcker användes för att få information om vilka individer som fanns i varje park under tiden som granskades. Utav de fem parkerna var det endast en som svarade på hela enkäten och en park som svarade delvis, dock fanns tillräckligt mycket information i stamböckerna och samlade artiklar för att svara på frågeställningarna till studien.

Geparden som skulle vara den svåravlade arten visade sig inte vara så svåravlad i den park som var med i undersökningen. I Sverige hålls geparder i två parker, endast en av dessa var med i denna studie. Borås djurpark är en av parker som lyckats bäst med avel på gepard vilket gjorde att målet att ha en mer svåravlad art och en mindre svåravlad art blev missvisande. 20 % utav tigrarna i studien lyckades i avel. Hos lodjur så var det 14,4 % som lyckades, men det som räknas med är alla avkommor som senare flyttades eller avlivades och på så sätt inte senare var delaktiga i aveln. Detta gäller även för gepard och tiger, där alla avkommor räknats med i det totala antalet djur. Att avkommorna räknats med är för att vissa utav avkommorna har senare varit med i avel och därför varit värdefulla för studien. 8,5 % utav geparderna lyckades med aveln, men som nämnt så är det även avkommor räknade i det, och i deras kullar var det upp till sju ungar per kull.

Genom att endast titta på stamböckerna kan vi inte se varför vissa djur lyckats med avel och andra inte, eller om vissa djur aktivt inte används i avel och möjliga skäl till detta. Då endast en park svarade på hela enkäten kan inga riktiga slutsatser dras från den, utan endast appliceras på just den parken.

Vad som skulle kunna vara ett potentiellt problem för katterna är att samtliga utav de arterna i detta arbete lever ett solitärt liv i det vilda, men i parker är det svårt att tillgodose samma solitära livsstil. Det är även svårt att tillgodose samma aktivitet som i det vilda, bland annat blir jakten betydligt kortare i fångenskap än i det vilda, detta skulle kunna vara ett problem.

Om problem med aveln fortsätter så bör alternativa metoder tas i beaktning, artificiell insemination är en möjlighet för djur som inte lyckas med naturlig parning att ändå få avkommor. Det har visats på bland annat gepard att även om honan inte lyckas med naturlig parning så kan hon lyckas med artificiell insemination och då få ungar som hon uppfostrar tills de lämnar henne.

Ett stort problem med denna studie var att inte tillräckligt många djurparker svarade på enkäten i tid vilket gjorde att de mesta utav datan fick samlas in via stamböckerna och artiklar där liknande studier gjorts. Problemet med det är att slutsatserna kan vara svåra att tolka då inte information om hur omständigheterna är kring djuren och varför vissa djur inte avlats.

När det kommer till att avla vilda djur i fångenskap är det en viktig aspekt som vi måste ha i åtanke hela tiden; borde vi avla i fångenskap? De flesta utav de exotiska arterna som vi avla har inget habitat där de kan släppas ut inom den närmaste tiden. Att avla i fångenskap medför risker för viss domesticerings effekt vilket visar sig i individer som inte är lämpade för liv i det vilda genom bland annars minskad jakt- eller flyktinstinkt. För vissa förändringar krävs endast en generation för att se stora skillnader.

Det finns en sak dock som talar för avel i fångenskap utav utrotningshotade arter, stora rovdjur har högre reproduktion i fångenskap än i avelsprogram i det vilda. Anledningen till de högre antalet avkommor i fångenskap är att i de vilda är det inte många utav ungarna som överlever sitt första år medan i fångenskap hålls de i liv längre.

För framtiden rekommenderas dock att mer hänsyns visas till den specifika artens naturliga parnings beteende och behov.

Den här studien väcker fler frågor som skulle behöva svaras; hur påverkas individens uppväxt dess möjligheter till avel senare i livet? Vilka aspekter är viktigast när man avlar stora kattdjur? Hur fortsätter vi aveln på vilda djur i fångenskap utan risken för beteendeförändringar vilket resulterar i individer som ej överlever i det vilda? Hur ska man gå vidare för att undvika inavel när man har ett begränsat antal friska individer när många avelsprogram inte har någon tidsbegränsning?

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Appendix 1

The Questionnaire

Individual; XX (age and sex)

How is/was the social grouping for this individual?
How is/was the individual kept? Group or solitary?

How socialized is the animal?
According to your judgment, how socialized is/was this individual towards people on a scale of 1 to 5. (1=very little and 5=very well socialized)

Hiding places/birthing dens? *(In the enclosure where the animal is/was held during mating, pregnancy or with cubs)*
How many hiding places is/was there in the enclosure? 0-2, 3-5, 6-8, more.

What does/did the enclosure design look like? *(In the enclosure where the animal is/was held during mating, pregnancy or with cubs)*
How big part of the enclosure has/had insight from visitors? 0-25%, 25-50%, 50-75%, 75-100%

How is/was the food presented in the enclosure? *(Several alternatives can be chosen)*
□hidden in something
□hung from something
□always put in the same place
□given in the form of hunting possibility
□demanding problem solving from the animal

What type of enrichment is/was the animals given?

Is the individual bottle-fed or mother-raised?

Has the individual been mated without success?
If the animal has been mated without success, which years and how many times?

How many of the cubs died before reaching six months? *(Please answer per littler)*

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