Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Faculty of Veterinary Medicine and Animal Science
Department of Animal Environment and Health

Challenges with ex situ programmes in zoos

Emelie Smith

Uppsala
2015

Degree Project 30 credits within the Veterinary Medicine Programme

ISSN 1652-8697
Examensarbete 2016:57

Challenges with ex situ programmes
Svårigheter med ex situ program

Emelie Smith

Supervisor: *Maria Andersson, Department of Animal Environment and Health*

Examiner: *Jenny Yngvesson, Department of Animal Environment and Health*

Degree Project in Veterinary Medicine

Credits*: 30*
Level*: Second cycle, A2E*
Course code*: EX0756*

Place of publication*: Uppsala*
Year of publication*: 2016*
Number of part of series*: Examensarbete 2016:57*
ISSN*: 1652-8697*
Online publication*: http://stud.epsilon.slu.se*

Key words*: reproduction, breeding in captivity, zoo, young mortality, reproduction problem, mammals*
Nyckelord*: reproduktion, avel I fångenskap, zoo, ungdjursdödlighet, reproduktionssvårigheter, däggdjur*

Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Faculty of Veterinary Medicine and Animal Science
Department of Animal Environment and Health

SUMMARY

Human activities are driving many species of wildlife towards extinction. The number of species regarded as threatened by the International Union for Conservation of Nature (IUCN) Red List of Threatened Species more than doubled between 2000-2015. This calls for future actions towards survival and recovery of endangered species.

Captive breeding in zoos is a commonly used tool for maintaining biodiversity and preserving demographically stable and genetically healthy populations. However, it is clear that zoos have failed to manage sustainable populations. The level of breeding success and ultimately reintroducing animals bred in captivity into the wild varies and there are a number of important factors that have to be considered. Behaviour incompatibility, domestication effects, disease outbreaks, inadequate enclosure design and inbreeding depression are some of the factors explaining limited breeding success in zoos.

A high young mortality rate and the limited breeding success seen in zoos raises concern regarding the health and welfare of zoo animals. This review illustrates the failure of getting captive populations to reproduce at rates comparable to wild populations. The results show that, this is primarily the result of species-specific socio-environmental conditions not being successfully met in captivity. Breeding success must be enhanced in breeding programs to maintain sustainable captive populations. In the future, more research is needed about which enclosure design and husbandry methods are the most beneficial as well as which social requirements need to be met in order to provide an environment that is well-adapted to the species physiological, mental and physical needs.

SAMMANFATTNING

Fram till idag har människan drivit många djurarter till utrotning. Antalet arter som listas som hotade på International Union for Conservation of Nature (IUCN) ”Red List of Threatened Species” har fördubblats under åren 2000-2015. Framtida åtgärder krävs som fokuserar på återhämtning och bevarande av hotade arter.

Avel i fångenskap har ansetts vara ett viktigt verktyg för bibehållandet av den biologiska mångfalden och bevarandet av demografiskt stabila och genetiskt friska djurpopulationer. Det är alltmer tydligt att djurparker misslyckats i att skapa hållbara och livskraftiga populationer. Reproduktionsframgången och återförandet tillbaka till det vilda varierar och det finns ett antal viktiga faktorer som måste tas i beaktande. Beteendeinkompatibilitet, domesticeringseffekter, sjukdomsutbrott, stress och inavelsdepressioner är bara några av de faktorer som kan förklara den begränsade avelsframgången som man ser i djurparker.

Hög ungdjursdödlighet och begränsad reproduktionsframgången väcker frågor angående bristande hälsa och välfärd hos djurparksdjur. Detta arbete illustrerar svårigheten med att få djur i fångenskap att reproducera sig i samma utsträckning som i det vilda. Resultatet visar att detta främst är en konsekvens av att artspecifika sociala- och miljöförhållanden som inte tillgodosetts i fångenskap. Avelsprogrammen måste börja ta mer hänsyn till just dessa faktorer för att att avelsframgången ska förbättras. I framtiden behövs mer forskning gällande utformning av hägn och vilka djurhållningsmetoder som är mest fördelaktiga liksom vilka sociala förhållanden som krävs för att skapa en miljö anpassad för att möta varje enskild arts fysiologiska, mentala och fysiska behov.

CONTENT

INTRODUCTION

Human activities are driving many species of wildlife towards extinction (IUCN, 2007). The number of species regarded as threatened by the International Union for Conservation of Nature more than doubled between 2000-2015 (IUCN, 2015). Since expected extinction rates are rapidly increasing, concerns are raised for conservation strategies to ensure survival and recovery of species (Olney, 2012). Ex situ conservation refers to the conservation of biological diversity outside their natural habitat (Biodiversity, 2015). Captive breeding in zoos is a commonly used tool for maintaining biodiversity and preserve demographically stable and genetically healthy populations. However, it is in many cases clear that zoos have failed to manage sustainable populations (Lees & Wilcken, 2009). The fact that zoos are failing despite considerable resources, extensive research, organized and focused actions in the past years, illustrates the complexity and difficulty of succeeding to breed animals in captivity (Lees & Wilcken, 2009). Captive breeding should only be used for some species where there are no efficient alternatives in the short term (Snyder *et al.,* 1996). There are many potential causes for the limited breeding success seen in zoos that have to be considered, such as: inbreeding, unnatural social structures, symptoms of stress, lack of partner selection and inadequate enclosure designs (Snyder *et al.,* 1996). This review has looked more deeply into the detail of these factors that affect the reproduction and young mortality in captive animals. The review covers a variety of species, but to limit the scope only mammals are included.

Aim

The aim of this review was to describe the factors affecting reproduction and young mortality during captive breeding in zoos and to review the challenges facing ex situ breeding programmes.

LITERATURE REVIEW

Endangerment of animal wild life

To this day, human activities are driving many species of wildlife towards extinction (Lees & Wilcken, 2009). Life on earth is under serious threat (Vié *et al.,* 2009). The total number of species regarded as threatened by the IUCN Red List of threatened species (2015) has more than doubled between 2000-2015. The number increased from around 11 000 threatened species year 2000 to around 24 000 species year 2015. The IUCN Red List of Threatened Species is the most comprehensive information source on the global conservation status and give a useful picture of the current status of species. Although this number is a gross underestimate considering that only 2,7% of the world´s 1,8 million described species have been analysed (Vié *et al.,* 2009). This extinction and loss of biodiversity crisis is a result of many species facing extreme threat from climate change, overexploitation and habitat loss (Vié *et al.,* 2008). Other treats include invasive species, fragmentation, land use change and pollution (Biodiversity, 2015).

Climate change

Climate change impacts directly or indirectly biodiversity through a variety of complex interaction. Under new climate regime both structure of habitats and ecosystems will change. This results in species being forced to relocate or gradually disappear and eventually risk extinction (Biodiversity, 2015). The Intergovernmental Panel on Climate Change (2007), forecast that approximately 20-30% of plant and animal species risk extinction if the increase in average global temperature exceeds 1,5-2,5°C. Other studies tend to support this forecast scenario, including the model developed by Thomas *et al*., (2004). His model based on species-distribution to a range of climate-warming scenarios indicated a 15-37 % risk of extinction for species in various parts of the world by 2050. The average global surface temperature has risen by approximately 0, 8-0,9 (0.74°C ± 0.18°C) over the past 100 years (1906-2005) and continues to increase at a rapid rate. The major part of this increase has occurred over the last 50 years (IPCC, 2007). Although species throughout their evolutionary history have been able to adapt to climate change, there is an increasing concern regarding their ability to respond to the current rapid rate of climate change (IPCC, 2007; Olney., *et al.,* 1994).

Habitat destruction

Habitat loss is another major threat against animal wild life. Human expansion is destroying habitats at an alarming rate and the rate of regrowth is not enough (Huxel *et al*., 1999). Destroying animal habitats inflicts serious damage on biodiversity and ecosystems. Species natural co-existence with its natural environments is disrupted leading to a risk of extinction (Root *et al*., 2003). Of all factors leading to destruction of species habitats, clearing of the forest is by far the most serious. During the last 50 years, about half of the world´s original forest has been lost. The rate of this deforestation is increasing and today over 60% of the temperate hardwood and mixed forest have been lost, as well as 30 % of conifer forest, 45% of tropical rainforest and 79 % of tropical dry forest (Wilson, 2003). The consequence of this on biodiversity are severe. Habitat destruction exceeds habitat protection by a rate of 8:1 (Hoekstra *et al.,* 2004).

Invasive alien species

Invasive alien species are non-native species whose introduction or spread to a new geographic area or ecosystem outside of its natural distribution range is a threat to biodiversity by establish, thrive and dominate these new places (GISP, 2008). Invasive species occur worldwide including animals, plants, fungi and micro-organism (Biodiversity, 2015). Today, invasive species are considered, after habitat destruction, as the second most important cause of species endangerment and extinction (Lowe, 2000). International conservation concern and efforts, such as the Global Invasive Species Programme (GISP) have a major focus on invasive alien species to enhance awareness of the complexity and the harmful consequences they have on biodiversity (Lowe, 2000). Alien invasions are growing in number and disrupt and impact various aspects of native wild life both directly- by preying on and competing with them for resources such as food and breeding sites, spreading disease- as well as indirectly by altering habitat and other ecosystem processes (GISP, 2008). The loss of biodiversity and dramatic changes to ecosystems that alien species has caused is severe. Recent global assessment (GISP, 2007) show that alien species have affected 30% of threatened birds, 11% of threatened amphibians and 8% of threatened mammals.

Examples of invasive species are the Feral Pig *(Sus scrofa)* that damage native vegetation and crops, spread weeds, disrupting ecological processes and also spread diseases such as Leptospirosis (GISP, 2007). Rats have a devastating impact on biodiversity by causing the decline of many small mammals, birds, reptiles and invertebrates (GISP, 2007). Rosy wolf snail (*Euglandia rosea*) is a snail that is native to the United States but was introduced in the Pacific and Indian Oceans as an attempt to biologically control another alien species- the giant African snail (*Achatina fulica*) but instead resulted in a significant loss of biodiversity (Lowe, 2000).

Current efforts on conserving wildlife

Because the expected extinction rate is rapidly increasing it raises the concern for conservation strategies significantly (Olney, 2012). Conservation strategies include in situ conservation which refers to the conservation of species in their natural surroundings and ex situ conservation which refers to the conservation of biological diversity outside their natural habitat (Biodiversity, 2015). Smithsonian Conservation Biology Institute (2015) states that research should focus on survival and recovery of species as well as ensuring health and welfare of animals. The fact that the IUCN Red List has dramatically grown in size the past years increase the pressure on conservation actions of governments and non-governmental organizations as well as scientific institutions (IUCN, 2015). Simon Stuart (2009), chair of IUCN species survival commission stated that “unless we address the fundamental causes of unsustainability on our planet, the lofty goals of governments to reduce extinction rates will count for nothing”.

World Association of Zoos and Aquariums is an international organisation where the world´s leading zoos dedicate their efforts to conserving wildlife. A key element in their action towards maintaining sustainable wild populations is organizing zoo breeding programs. The purpose of this is to preserve populations for future reintroduction into the wild (WAZA, 2015). Captive breeding in zoos is a commonly used tool for maintaining biodiversity and preserve demographically stable and genetically healthy populations (Lees & Wilcken, 2009). Despite

sustainable organized effort, significant scientific input and defined actions over the last 25 years, it is clear that zoos have failed to manage sustainable populations of wildlife. The fact that they have failed even with the considerable resources at their disposal, reflects the complexity and difficulty of succeeding with breeding animals in captivity (Lees & Wilcken, 2009).

Challenges with ex situ breeding

The level of breeding success and ultimately the reintroduction into the wild of animals bred in captivity varies (Jule *et a.,* 2008). Numerous important factors have to be taken into consideration. Behaviour incompatibility, high costs, domestication effects, disease outbreak, symptoms of stress, limited enclosure design and inbreeding depression are just some of the factors explaining the limited breeding success seen in captivity (Snyder *et al.,* 1996). Despite the fact that animals in captivity are free from predators, starvation and receive veterinary care (Watters, 2009; Snyder *et al.,* 1996), there are only a small percentage of species breed in captivity that manage to obtain consistent reproduction and survivorship. This suggests that the role of environment, behaviour, health and social effects in breeding programs has been underestimated (Snyder, 1996; Rahbeck, 1993).

It is important to understand the differences between species and how they adapt to captivity. Some species generally adapt well and some even thrive, for instance brown bear (*Ursus arctos*), snow leopard (*Panthera uncia*) and American mink (*Neovison vison*) show few signs of poor welfare when held in captivity. Other species such as clouded leopard (*Neofelis nebulosa*) and polar bear (*Ursus maritimus*) do not cope as well, resulting in breeding problems as well as poor health and welfare (Clubb & Mason, 2007). Understanding the reasons for these differences could lead to improved reproduction success rate (Clubb & Mason, 2007). Captive breeding has meant the difference between survival and extinction for species such as California condor (*Gymnogyps californianus*) and the blackfooted ferret (*Mustela nigripes*) (Snyder, 1995). However, recovery of species should only be used with those who benefit from it and only be used as a last solution in species recovery and not a long-term solution. This is because of the limitations that occur in captive environments (Snyder *et al.,* 1996). Captive breeding should only be used for some species where there are no efficient alternatives in the short term. It cannot replace the protection of habitat and ecosystems nor compensate from actions that maintain or restore populations in the wild (Snyder *et al.,* 1996).

Shortcomings of captive breeding

There is a large number of species that have difficulties in reproducing or do not reproduce at all when held in captivity. Koher *et al.* (2006) found that the average infant mortality was 29 % during the first week when studying 12 different species of carnivores, ranging from fennec foxes *(Vulpes zerda)* to African lions *(Panthera leo).* They also found when looking at infant mortality in hoof stock such as Eld´s deer *(Celvus eldi)* that 49% died within the first week of age. Another example comes from breeding programs of the Black-footed ferret and shows that reproductive failure exceeded 50% in the male ferrets (Wolf *et al.,* 2000). Asian elephants *(Elephas maximus)* face global extinction due to limited natural habitat, low birth rates in captivity and high calf mortality. When looking at the 141 births in European zoos and circuses

between 1902-1996, 37% died within their first year, 48% were stillborn and 27% were killed by their mothers (Rees, 2003). A study on eight small felids (jaguar (*Panthera onca*), puma (*Puma concolor*), ocelot (*Leopardus pardalis*), margay (*Leopardus wiedi*), tigrina (*Leopardus tigrinus*), Geoffroy's cat (*Oncifelis geoffroyi*), pampas cat (*Oncifelis colocolo*), kodkod (*Oncifelis guigna*), Andean mountain cat (*Orealiurus jacobita*), and jaguarundi (*Herpailurus yaguaroundi*)) endangered in Latin America zoos (Swanson *et al.*, 2003) revealed that few male felids (lower than 20%) had ever reproduced during their time in captivity. The study also indicated that these individuals had an extraordinarily low number of sperms.

Zoo Animal Welfare

Zoo animal welfare has become an increasing concern both inside and outside zoo communities with the consensus that best possible welfare should be provided to all captive animals (Watters & Wielebnowski, 2009). There have been many attempts to define what animal welfare is. Ducan (1993) concludes that ”welfare is indeed all to do with what animals feel and the consequence of this conclusion is that methods to assess welfare should be aimed at asking animals what they feel about the conditions under which they are kept and procedures to which they are exposed”. Fraser (1995) presented a more philosophical prospective in assessing animal welfare. Others, Broom (1986) defined welfare of an individual as ”its state as regards its attempts to cope with its environment”. Both failure to cope with and difficulty in coping are indicators of bad welfare (Broom, 1991). Furthermore there are conflicts regarding what ”good” and ”bad” welfare refers to as well as to define situations in which animals ”suffer” and how to best measure it (Dawkins, 1990).

Studying animal behaviour provides information on how well the animal is able to cope with its situation as well as how it feels, its health and welfare (Broom, 1997). Comparing captive and wild animal behaviour and their environments can contribute to understanding variations in captive animal welfare and furthermore promote an understanding of which species adapts well to current captive environment and why (Clubb & Mason, 2007). Important issues to consider for future zoo welfare are, according to Watters (2009) to clarify welfare definition, establish collaborative ties inside and outside the zoo community, promote more research, identify technologies for monitoring animal welfare and establish cost effective welfare monitoring.

MATERIAL AND METHODS

Literature search

The literature was accessed by using databases such as Scopus, Web of Knowledge, Google Scholar for original articles and reviews published from 1987 to 2015. Search words included: *reproduction, captivity, zoo, juvenile mortality, young mortality, reproduction problem, infertility and mammals.*

Criteria for inclusion

All articles included wild animals in captivity in combination with problem in reproduction or reasons for juvenile mortality.

Criteria for exclusion

Articles that exclusively covered solutions (for example if an article covered artificial insemination in general) was excluded. Articles that only describes a certain species reproduction physiology or sexual behaviour unless there are clear connection to animal welfare, which in turn could affect reproduction or juvenile mortality was also excluded.

Data collection

The search for published papers on reproduction problems and young mortality gave a result of 90 scientific papers that met the criteria above. Out of these 90 papers: one was from the 1980´s, seven was from the 1990´s, 36 from 2000´s and 46 from 2010´s. The articles were found in 35 different journals. Fifty-one of the studies were experimental and 38 were not.

Study design and data analysis

A retrospective study based on information from articles on the subject reproduction problems and young mortality was conducted. The information was collated and presented with the help of descriptive statistic.

RESULTS

The 90 articles used cover 62 different species in 1059 zoos scattered around the world. The mean number of individuals in each article was 494. Fifty-six of the 90 articles studied herbivores and 25 articles studied carnivores.

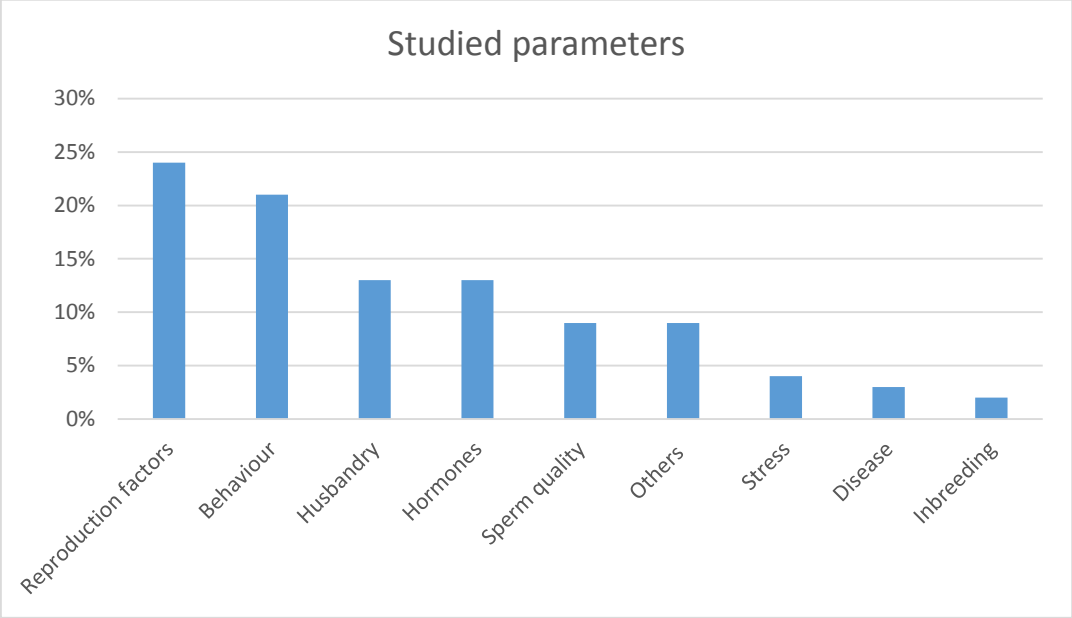

Figure 1. *Parameters the different articles were studying. This figure shows the distribution of the research done on the area reproduction and young mortality since the 80s. The Y-axis shows what percentage of articles covering each respective parameter on the X-axis.*

Figure 1, shows the distribution of the parameters covered by the articles. Each article is only included into one of the different groups. Therefore the percentage is out of the total of the 90 articles. If an article included more than just one of the parameters, only the major parameter was factored into the percentages above. For example, if the study covered both husbandry and behaviour, husbandry has been selected as the major parameter since behaviour was a result of husbandry method.

- 24% studied reproduction factors. This category includes many different factors from the age of the female, litter size, choice of male etc
- 21% studied different behaviours
- 13% of the articles studied husbandry, which includes a variety of different factors such as enclosure design and size, husbandry methods and enrichments
- 13% had studied hormones and these included only sex hormones such as oestrogen, testosterone and progesterone. Hormones such as corticoids are included in the stress category
- 9% of the articles studied sperm quality
- 9% studied "other" that did not fit any of the categories above
- 4% studied stress and corticoids to show its effect on reproduction and young mortality
- 3% studied in what way diseases can affect reproduction and young mortality
- 2% of the articles studied the effects inbreeding can have on reproduction and young mortality

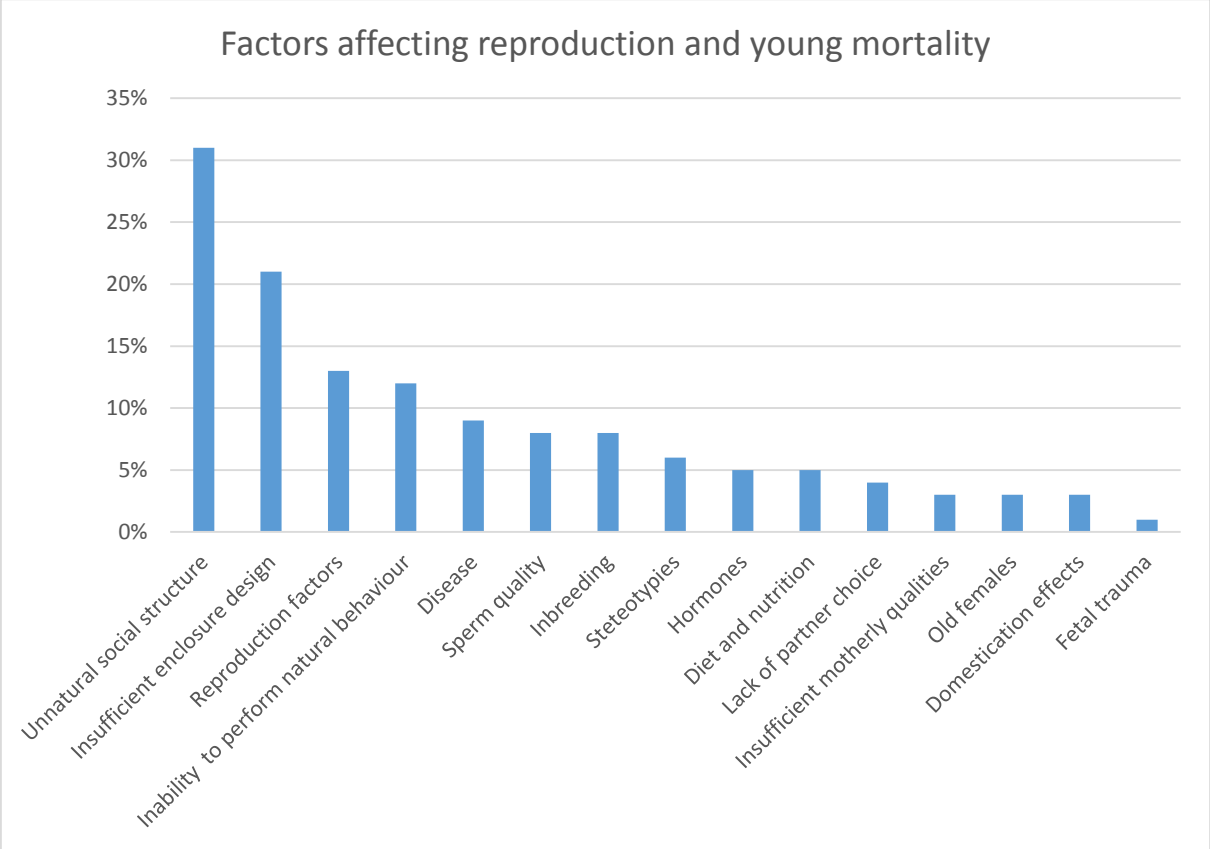

Figure 2. The factors affecting reproduction and young mortality that was found in the articles. This is a summary of the causes behind the described problem in each article. Each article can be included in more than just one category. The y-axis shows the percentage of articles that covered each of the different category in the X-axis.

Out of the 90 articles that were compiled into this review, 69% of these articles stated that they were trying to solve a problem and 31% that they were not. If the author was not solving a problem, the aim of their paper was to compare, investigate, evaluate, document or describe different aspects of reproduction. Out of the 62 articles that were trying to solve a problem, also found a cause to the particular problem. Out of these 62 articles that found a cause behind a problem, 24% found a problem linked with high mortality, 69% was about reproduction difficulties and 7% was about both. In this Figure, these causes are presented. If an article included more that one cause behind the problem they were addressing, the article was included in more than just one of the categories.

- 31% showed that the animals social structure was the reason behind the limited breeding success. An unnatural social structure means a social situation not well adapted to the species natural constellation in the wild
- 21% of the articles found that insufficient enclosure design, enclosure size, husbandry methods, enrichments and other limited environmental conditions caused limited breeding success
- 13% of the articles studied different reproduction factors as causes behind limited reproduction. Reproduction factors include many different parameters such as litter size, interbirth interval, ovulation number, birth weight, milk composition, infant growth, body weight, male presence and family group members
- 12% of the articles showed that inability to perform species-specific behaviour will limit the breeding success
- 9% studied the impact disease have on the limited breeding success. Most of the articles found infectious diseases to be the major threat to reproduction and young mortality among zoo animals
- In 8% of the articles, sperm quality was investigated as a cause behind the limited breeding success. Studies have compared seminal characteristics in animals maintained in zoos compared to free-living animals
- 8% have studied inbreeding and the effects its effect on reproduction
- 6% of the studies found stereotypies to be the reason for the limited breeding success.
- 5% studies how hormones can affect reproduction. Only sex hormones such as prolactin, progesterone, oestrogen and testosterone were included
- 5% showed that insufficient diet and nutrition also could be a risk factor for limited reproduction and high young mortality
- In 4% of the studies, lack of partner choice was concluded to be the reason for the problem with reproduction and young mortality
- 3% showed that the problem was due to mismothering or described as insufficient mother qualities

- 3% concluded that their problem described in the article was caused by the fact that the females were of high age
- In 3% of the articles, domestication effects were the reason for the limited breeding success
- 1% of the studies concluded that the problem was caused by fetal trauma during birth

DISCUSSION

A major challenge in ex situ breeding is getting captive populations to reproduce at comparable rates to wild populations (Lindburg & Fitch-Snyder, 1994). To achieve this a number of important factors have to be taken into consideration. This review illustrates the importance of creating environmental and social conditions for animals in captivity that resembles the wild. ”The use of captive breeding in species recovery has grown enormously in recent years, but without a concurrent growth in appreciation of its limitations” (Snyder, 1996). As the results show (see Figure 2), the major causes behind the limited breeding success are insufficient enclosure design and failure in creating a natural social structure. If zoos fail to successfully meet these socio-environmental conditions the situation will result in not only in limited reproductive success but also raises concern regarding compromised health and welfare (Clubb *et al.,* 2008). Furthermore, it causes difficulties for the animal to express highly motivated natural behaviours resulting in signs of stress and reduced welfare. This may reasonably be avoided if environmental and social requirements are met in the first place.

If the animals social structure and environmental conditions are not beneficial enough to meet the animals physiological and physical needs it will affect their reproduction (Mason & Veasey, 2008). Throughout evolutionary history, animals have adapted to live their lives in their natural habitat in the wild. If the captive environment they are placed in captivity does not reflect their natural habitat or social structure the animal will find it difficult or even impossible to cope with their new situation. When the animal is not provided with the conditions that allow it to express its natural behaviour it will experience stress and reduced welfare. Animals cope with stress differently and some develop abnormal behaviour such as stereotypies while others tend to be more introvert, passive behaviour and some even apathetic. The important thing is not how the animal expresses their stress but to understand why they express signs of not coping well with a situation, and further, how to provide the right conditions to prevent this (Mason, 2010).

Furthermore, it is also important to understand that there is a variation not only between species but also between individuals. Each individual and species has its own specific needs that must be taken into consideration. For example black rhinoceros (*Diceros bicornis*) are solitary living animals who are not adapted to live together with other individuals. Zoos with two or more females showed lover reproductive success compared to those with only one female (Carlstead *et al.,* 1999). Other examples are gibbons *(Hylobatidae)* housed in large enclosures are more sexually active than individuals in small exhibits (Mootnick and Nadler´s, 1997) or cheetahs in zoos that have significantly higher levels of corticoids compared to wild cheetahs indicating chronic stress when held in captivity. This shows the importance of understanding the consequences social-environmental conditions have on animals in captivity and the impact it

can have on the breeding success. Zoos need to start providing an environment well-adapted to meet each species specific needs. By using functional enrichments and designed enclosures, zoos can help to create an environment more beneficial for the animal (Mason, 2010). Studies show that by using environmental enrichments such as decreased visitor visibility and increased enclosure size, gibbons showed improved reproductive success (Lukas *et al.,* 2002). Mason (2010) study also showed that by improving and species adaptation of enclosure size and housing conditions it provided a possibility for species to express species typical natural behaviour and therefore reproduce in a greater extent. Studies show that improving the environmental conditions could enable increased reproduction success since breeding success correlates positively with enclosure area. By making changes in the environment could enable expressing natural behaviour and lead to improved reproduction. Furthermore, articles describe the need to simulate natural conditions around the enclosure in order to achieve successful breeding.

It is important to understand that even closely related species can have vastly different specific needs that should not be generalised. What is beneficial for one species may not be beneficial for another. For instance, the Brown bear (*Ursus arctos*), American mink and Snow leopard (*Panthera uncia*) are species that generally adapt well in captivity while Polar bear (*Ursus maritimus*) and Clouded leopard (*Neofelis nebulosa*) typically adapt poor to captivity (Clubb & Mason, 2007). This illustrates that despite great resemblance there can be crucial differences in what needs the species has. In captivity, some species seem to adapt very well, live longer and are healthier, while for some species it is the complete opposite (Mason, 2010). They develop breeding problems, poor health and repetitive stereotypic behaviour. Understanding the differences could improve reproductive success (Clubb & Mason, 2007). More research is needed into investigate the fundamental biological difference between these species (Clubb & Mason, 2007). This would help in knowing how to improve husbandry and enclosure design and help understanding the species social requirements. Alternatively, species with relatively small ranges could instead benefit from other conservational strategies and focus could be on those species inherently more suited to the current or achievable enclosure sizes and enrichment regimes (Clubb & Mason, 2007).

Captive breeding can play an important role in preserving many endangered species, such as the loggerhead shrike (Parmley, 2015). However, captive breeding should only be used as a last solution in species recovery and not a long-term solution (Snyder *et al.,* 1996). This is because of the limitations that occur in captive environments (Snyder *et al.,* 1996). Captive breeding should only be used for some species where there are no efficient alternatives in the short term. Ex situ breeding cannot replace the protection of habitat and ecosystems nor compensate from actions that maintain or restore populations in the wild (Snyder *et al.,* 1996). When considering the endangerment to wild life biodiversity, we are facing today, the need for sustainable actions is of paramount importance for ensuring the survival of species. If ex situ breeding should benefit endangered species, we need a better understanding of the causes behind the limited breeding success so that extinction of species can be avoided. If the purpose of the breeding programmes is to ensure the survival of endangered species the focus must be be aimed at individualizing and creating environments well-adapted to meet each species need.

To summarize, this review illustrates the failure of getting captive populations to reproduce at comparable rates to wild populations. As the results show, this is primarily a result of species-specific socio-environmental conditions not being successfully met in captivity. If zoos can not provide an environment well-adapted to meet the species physiological, mental and physical needs, the survival of the species would reasonable be more beneficial from other conservation strategies.

REFERENCES

Biodiversity. (2015). *Biodiversity terms.* http://www.biodiversitya-z.org/content/ex-situ-conservation (2015-12-15)

Biodiversity. (2015). *Topics Section of the Biodiversity Information System for Europe.* http://biodiversity.europa.eu/topics/invasive-species

Brooks, T., M. (2002) Habitat Loss and Extinction in the Hotspots of Biodiversity. Conservation biology, Volume 16, issue 4, Pages 909-923.

Broom, D.M. (1986). Indicators of Poor Welfare. Br. Vet. J. 142, 524-525.

Broom, D.M. (1991). Animal Welfare: concepts and measurement. J Anim Sci. 69:4167-4175.

Carlstead, K., Fraser, J., Bennet, C., and Kleinman, D.G. 1999. Black rhinoceros *(Diceros bicornis)* in U.S. Zoos: II. Behaviour, breeding success, and mortality in relation to housing facilities. Zoo Biology 18:35-52

Clubb, R. (2008). Compromised survivorship in zoo elephants. Science 322, 1649.

Clubb, R., Mason, G.J. (2007). Natural behaviour biology as a risk factor in carnivore welfare: How analysing species differences could help zoo improve enclosures. Applied animal Behaviour Science, Volume 102, Issue: 3-4, Pages 303-328.

Dawkins, M., S. (1990) From an animal´s point of view: Motivation, fitness, and animal welfare. Behaviour and Brain Science 13. 1-61

Duncan, I.J.H. (1993). Welfare is to do with What Animals Feel. Journal of Agricultural and Environment Ethics; 6 (Suppl 2): 8-14.

Fraser, D. (1995). Science, Values and Animal Welfare: Exploring the 'Inextricable Connection'. Animal Welfare, Volume 4, Number 2, 103-117(15).

Fraser, A.F., Broom, D.M. (1997). Farm Animal behaviour and Welfare. Third Edition. CAB International, 1997 pp ix+ 437 pp.

Global Invasive Species Programme (GISP) (2008). Marine Biofouling: An Assessment of Risks and Management Initiatives.

Global Invasive Species Programme (GISP) (2007). Invasive Species and Poverty: Exploring the links.

Hoekstra, J.M, et al., (2004). Confronring a biome crisis: a global disparities of habitat loss and protection. Ecology letters, Volume 8, Issue 1, Pages 23-29.

Huxel R, H, et al., (1999) Habitat loss, fragmentation and restoration. Restoration Ecology Vol. 7 No 3, pp 309-315.

IPCC 2007, Summary for Policymakers, in Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK, p. 17.

IUCN (2015). The IUCN Red List of Threatened Species. http://www.iucnredlist.org/about/overview

IUCN (2015). *Wildlife crisis worse than econimic crisis* http://www.iucn.org/news_homepage/?3460/Wildlife-crisis-worse-than-economic-crisis

Lees, C.M & Wilcken, J (2009). Sustaining the Ark: the challenges faces by zoos in maintaining viable populations. International Zoo Yearbook. Volume 43, issue 1, pages 6-18.

Lindburg, DG & Fitch-Snyder, H (1994). Use of behaviour to evaluate reproductive problems in captive mammals. Zoo Biology 13: 433-445.

Lowe, S., et al (2000). 100 of the world´s Worst Invasive Alien Species A selection from the Global Invasive Species Database. Published by The Invasive Species Specialist Group (ISSG), a specialist group of the Species Survival Commisstion (SSC,) of the worl Consrrvation Union (IUCN).

Mason, G.J. (2010). Species differences in respons to captivity: stress, welfare and the comparative method. Trends in Ecology and Evolution. Vol. 25, No. 12.

Olney, *et al.*, (2012). Creative Conservation. Chapman and Hall.

Root, T.L,. Price, J, T,. Hall, k, R., Schneider, S, H,. Rosenzweig, C,. Pounds, A, J,. (2003). Fingerprints of Global Warning on Wild Animals and Plants. Nature 421, 57-60.

Snyder et al., (1996). Limitations of Captive Breeding in Endagered Species Recovery. Conservation Biology Vol. 10, Issue 2, Pages 338-348.

Smithsonian Conservation Biology Institute (2015). http://nationalzoo.si.edu/scbi/default.cfm

Tayler, V.J and Poole, T.B. 1998. Captive Breeding and Infant Mortality in Asian Elephants: A Comparison Between Twenty Western Zoos and Three Eastern Elephant Centers. Zoo biology 17:311-332

Terio, K, A., et al. (2004). Evidence for Chronic Stress in Captive but not Free-ranging Cheetahs Based on Adrenal Morphology and Function. Journal of Wildlife Diseases 40 (2): 259-266

Vié, J.C., et al (2009). Wildlife in a Changing World. An Analysis of the 2008 IUCN Red List of Threatened Species. https://portals.iucn.org/library/efiles/documents/RL-2009-001.pdf

Watters, J. V., Wielebnowski, N. (2009). Introduction to the Special Issue on Zoo Animal Welfare. Zoo Biologi 28: 501-506.

Wilson, E, O. (2003). The future of Life. First Vintage Books Edition, United states, New York.

Zachos, F,E & Habel, J,C (2011) Biodiversity Hotspots. Distribution and Protection of Conservation Priority Areas. Springer- verlag Berlin Heidelberg.