The concept of captive breeding biology essay

At a time when species extinction has become a serious global issue, conservation tools, such as captive breeding, play an essential role. The use of captive breeding for species conservation and recovery has become an integral part of the global conservation plan, but with too much emphasis. Its limitations far outweigh their benefits. Such limitations include domestication, loss of genetic diversity, increased transfer of diseases, bias of species selection, and the loss of perspective of the greater issue of habitat destruction. Politicians, the public and scholars alike must refocus their attention and resource allocation on conserving habitat, and likewise must understand that captive breeding is not a long term fix, and should only be used as last resort for species recovery.

At the onset of human expansion and global domination, the world began to experience monumental losses of biodiversity. These losses are continuing at a rate such that scholars are saying this may become the next great, or sixth extinction [1]. Although some may argue that the extinction of species is in fact natural, there is no doubt that humans are causing the fastest mass extinction in Earth history; largely because of the human destruction of ecosystems due to overpopulation, growing agricultural and urban use of land, increased rate of introduction of invasive species, overexploitation of species and natural resources and pollution [2]. The prospect of a biodiversity crisis is a reality and international concern, and the challenge here that biologists face, is how to respond to this crisis. Three priority areas of conservation biology are at the focus of biologists: identification, safeguarding and rescue and rehabilitation [3]. One of the major players who

address such areas, and who are fighting for the conservation of biodiversity, are zoos.

Zoos have undergone many transformations in the last century, moving from a tourist attraction, to what is now a global institution that advocates for and is directly active in wildlife protection [4]. Inside the zoo, there are successful and progressive captive breeding programs, unique exhibits and pavilions, improving education programs, advanced curatorial and veterinary services for animals and much more. But despite the good intentions and efforts of the World Association of Zoos and Aquariums (WAZA), zoos are overloaded by the rate and intensity of wildlife extinction [5].

Zoos are undertaking the global responsibility of wildlife conservation, and are facing tremendous challenges and controversies, especially concerning the efficacies of captive breeding. The arguments that centre around the problems of captive breeding in zoos are numerous. It is argued that species which are accepted into breeding programs within the zoos are often limited to a few charismatic species, including mammals such as polar bears, which are popular with the public and increase revenue through admissions to exhibits. Also, captive breeding may divert resources from the ecosystem and habitat conservation efforts, which are arguably more cost effective and said to be long term solutions. Additionally, captive breeding may lead to the erosion of genetic diversity if not properly conducted, and there is no guarantee that the native habitat from which the species was removed will exist or be restored in a reasonable time frame for the species to be reintroduced. The transmission of diseases in zoos are of concern as well, and in order to avoid this, zoos must invest large amounts of money to

isolate animals from those which are infected, to ensure the overall health of the zoos inhabitants, again a very cost-ineffective method of conservation [6].

There is also concern that animals bred in captivity will become domesticated, and in the case of reintroduction, will not be able to survive in the wild due to the absence of behavioural adaptations towards predators and their environment. Lastly, there is controversy over the fact that captive breeding and reintroduction programs may distract the public and government from the immense issue that is biodiversity loss, as caused by habitat destruction. It can give them the false sense that the battle against worldwide species extinction is being won, whereas in reality, the issue requires continuous awareness and resource input.

There is no doubt that zoos play an essential role in global wildlife conservation, but it is important to take an objective perspective and instill into the government, public and private organizations, that captive breeding should not be a first resort, as it does not directly address the source of species extinction. Of priority should be habitat conservation and protection, a battle that may eliminate the need for captive breeding programs, if successful.

Figure Graph ‘ a’ compares the distribution of threatened species of both non-mammals and mammals. It indicates that mammals are overrepresented in captive breeding programs relative to the percentage of threatened species. Graph b displays the distribution of taxa involved in

breeding programs. It indicates that captive breeding programs tend to host larger species [7].

Zoos are responsible for choosing which species they will conserve via captive breeding, but they are not objective in their choices. Currently, 90% of threatened species are non-mammals, and yet more than 60% of species within breeding programs are mammals [7]. Also, more than 50% of breeding programs are for only twenty three species of odd-toed ungulates, while more than 80% of breeding programs are for primates, carnivores and ungulates, which are classified as the largest mammals that inhabit this earth [7]. Zoos tend to represent and concentrate their efforts on mammals, but as a group (and including all vertebrates), they are poor representatives of total global biodiversity, only accounting for 0. 25% of the worlds known species [8]. Clearly, the efforts of wildlife conservation as being conducted by zoos, are not concentrating their efforts where the need is greatest (Figure 1). Captive breeding programs are more likely to host larger species than smaller species, as well as more mammals than non-mammals. Additionally, the investments of captive breeding on large mammals is very inefficient and cost-ineffective, as they breed more slowly, and are more expensive [7] (Figure 2). This bias may stem from the idea that having mammals, which are deemed to be popular with the public, would raise the revenue via increased public visitation to the zoo. But, it has been argued that larger mammals do not result in an increase of the mean percent of zoo visitors [7] (Figure 3). Therefore, captive breeding programs are focused primarily on mammals but at no significant advantage to global biodiversity, and at great cost.

Figure 3 This graph shows the mean percentage of zoo visitors as dependent on animal type. Body size increases from the left to the right, and there is no indication that larger animals result in more visitors [7].

Figure 2 The above three graphs portray the varying costs of breeding invertebrates, reptiles and amphibians, birds, and mammals. The first graph shows the rate of population increase of these groups, with mammals being the slowest, and invertebrates the fastest. The second graph shows the cost of maintenance for these groups, with invertebrates the least costly and mammals the most costly. The last graph shows the total value of breeding programs for these groups, with mammals being the most expensive [7].

The erosion of genetic diversity as a result of captive breeding and inbreeding is a serious threat to the survivability of reintroduced species. When captive breeding programs become an option, usually a species is already on the brink of extinction. Small populations mean low mate selection, and over time, if not already, inbreeding becomes inevitable. Of course, with limited options, inbreeding is necessary, but it results in the reduced fitness of a species' and thus lowers their chance of survival in the wild.

An example of a reduction in genetic diversity is of the red wolf, who has been involved in a managed captive breeding program for three decades. In order to determine the rate of loss of genetic diversity, Lockyear et al. [9] used the number of actively breeding individuals within a population (Ne). They found that in captive red wolves, the effective population (Ne) with respect to the whole population, had decline from 1990 to 2005, as a result

of inbreeding depression through biparental inbreeding, or close cousin mating. This is apparent in a progressively larger breeding coefficient from 1990 to 2005 (Figure 4).

Figure 4 This graph shows the inbreeding coefficient in captive red wolves from 1980 to 2005. As indicated, the inbreeding coefficient gets progressively larger, a result of biparental inbreeding [9].

Similarly, Fraser [10] found that in some populations captive-bred salmonoids (trout and salmon, an economically crucial fish group), allelic diversity decreased from 4. 8-8. 2% per generation, despite thorough management practices. Likewise, in a captive breeding program of Atlantic salmon, a loss of alleles of 4. 7% per generation was reported [11]. Jiang et al. [12] also conveyed the same message. In comparing captive individuals and wild individuals of Elliot' Pheasant (Syrmaticus ellioti), a species of bird, they found that the genetic diversity was significantly higher in wild individuals.

Again, captive breeding programs are an essential tool in conservation biology. There are very advanced methods to ensure the maintenance of a significant level of genetic diversity in captive populations, but there is no way to completely control or understand how an introduced species will react in the wild, as affected by the artificial selection conducted in the captive breeding program. Losses in genetic diversity of a population can lead to a compromise in their ability to cope with possible environmental changes, and thus reduces their chance of long-term existence.

Evidence suggests that endangered species are more susceptible to diseases because of reduced population sizes and resulting loss of genetic diversity [13, 14], and this may be a contributor to the increased frequency of disease outbreaks in captive collections. Other causes of increased disease outbreak in captive collections can include enhanced exposure to exotic pathogens, caused by inter-species interactions in zoos. The endangered species in question may not have any resistance to these diseases and parasites [15] and their captive populations can suffer as a result. The possibility for research in wildlife diseases is poor, and diagnostic and treatment capabilities are not widely available [16]. Also, standard quarantine periods are not long enough for a dependable detection of slow acting diseases, which can remain dormant in carriers and suddenly become induced by animal stress [17].

The presence of dormant pathogens in captive populations (for example equine encephalitis in the whooping crane, inclusion body disease in red-crowned and hooded cranes, herpes and hepatitis in the Mauritius kestrel and pink pigeon (etc.) [18] also put at risk wild populations, in the event that they undergo reintroduction. For example, in the Midwestern U. S, many restored populations of Wild Turkeys are infected with a hematozoan parasite (Plasmodium kempi), possibly from the translocation of infected birds [19]. Likewise, in wild desert tortoises and gopher tortoises the upper respiratory mycoplasma disease is present, possibly a result of the release of infected captive individuals [20]. There have been many cases of accidental introductions of diseases into wild populations [21], and the American Zoo and Aquarium Association has responded to these issues with the

development of health screening protocols for reintroductions [22]. Unfortunately this does not completely eliminate the risk due to their ineffectiveness in slow-acting pathogens and new diseases. Thus, zoos must ensure the intense screening of diseases and ensure that animals to be reintroduced into the wild have not been exposed to potential disease carriers. These procedures are both time and resource consuming, and complete isolation of species is almost impossible in zoos [23].

Of course, disease risk assessment has developed considerably over the years, reducing the chance of disease spread in zoos and into the wild, but at a heightened cost and at no guarantee. This again lends to the argument that captive breeding is expensive, risky, and should only be a last resort for biodiversity conservation, coupled with more invested habitat and ecosystem preservation.

Figure 6 This chart compares the aggressive and submissive behaviour of wild and captive bred bank voles. As shown, captive bred bank voles demonstrate more submissive behaviour, and less aggressive behaviour than do the wild bank voles [24].

Figure 5 Chart a compares the success of captive-bred and wild bank voles. Wild bank voles are much more successful at opening hazelnuts than are captive-bred bank voles, indicating domestication of captive-bred bank voles [24] .

Despite the best efforts of the zoos animal and captive breeding managerial staff, the evolution of captive animals (including behaviour and physical changes) is almost impossible to avoid, even if the most advanced genetic and behavioural management is practiced. For example, in an experiment done involving bank voles, it was found that the bank voles bred in captivity lost their ability to open hazelnuts by their own means. Wild bank voles were able to open hazel nuts with a success rate of approximately 56%, whereas captive-bred bank voles had a 0% success rate [24] (Figure 5).

Additionally, it was found that captive bred voles were significantly more active than the wild voles; engaging in natural but more extensive and rather wasteful burrowing behaviour, which did not result in the creation of useable burrows. This is maladaptive because they are allocating energy and time to a rather useless activity that could be better used in other activities such as foraging or mating. Captive-bred voles were also found to be significantly less dominant than their wild counterparts, a disadvantage when competing for mates and defending their territory [24] (Figure 6). Although this study is not entirely conclusive, it demonstrates that behaviour changes in captive bred animals are hard to control, and it is even more difficult to try and mimic their native environment, for the purpose of reducing behavioural and evolutionary changes in captivity.

Another example of an evolutionary change occurring in captive breeding was shown by Kelley et al. [25]. In an endangered Mexican fish, Kelley et al. [25] showed that the captive bred individuals sought refuge less often than did wild fish, hence putting them at a higher risk of predation. Other studies

convey a similar message, whereby captive environments encourage domesticated behaviour of wild animals that can affect predator recognition [26], reproductive behaviour [27], and foraging. Such behaviour changes have been observed in old field mice [28], mussels [29] and in steelheads [30].

It is possible to try to imitate the native environment in order to minimize domestication and evolutionary and behavioural changes in captive-bred animals. Nevertheless, there is no guarantee that these changes won’t happen, and they can result in a reduction of fitness in captive-bred animals, thus decreasing the chance of survival in the wild.

Captive breeding does play a role in contributing to the protection of international biodiversity, although at a very high cost. An example of this is with the Arabian oryx, which is considered as one of the most successful captive breeding and reintroduction programs to date. Originally the Arabian oryx occupied the entire Arabian Peninsula, but they experienced population declines leading them to numbers between 100 to 200 individuals [31], as caused by severe hunting pressures. After a successful captive breeding program conducted by Phoenix Zoo, the Arabian oryx was reintroduced into the wild in the early 1980s [32].

Despite the success of this conservation effort, the cost was immense. The conservation project of the Arabian oryx included a veterinary program at all stages of the program [33], constant monitoring of the animals by rangers with four-wheel drive vehicles post-release, and currently forty individuals of the population are constantly being monitored with radio-tracking equipment

[33]. Not only do the reintroduced populations require post-management, but local human populations must also be consulted and negotiated with in order to discuss the competition of domestic herds. Thus, like all captive breeding and reintroduction programs, this one has required an enormous amount of resources to ensure its success, and also continuous management and commitment is still necessary.

Comparatively, just a fraction of the time and monetary resources used for the Arabian oryx program could have made a considerably larger impact if it were used in another area of biodiversity preservation. For example, let us consider Podocarpus National Park in southern Ecuador. Spanning over 1450 km 2, this park is estimated to host as many as approximately 800 of the 9200 known bird species in the world, making it, on these terms, one of the five richest national parks in the world [34]. The park is relatively self sufficient, being protected by less than 10 poorly paid park wardens and managed by one administrator, under a small budget. Currently, it is threatened by anthropogenic activity, and although money and manpower alone may not solve these problems, they are essential for the development of employing a sustainable management plan for the area [35].

This example serves to show that any captive breeding and reintroduction program requires a tremendous, long term commitment, but this can only be done for a limited number of species due to resource restraints. Due to the restricted application of captive breeding to a few select species (primarily mammals) [36], these programs can only make a limited contribution to the preservation of biodiversity. Conversely, if these resources were invested

into a habitat restoration or preservation program, many more species could be preserved with a small fraction of the cost.

Today, there is too much effort and too many resources being allocated towards saving a small handful of endangered species via captive breeding, where as each year an area of tropical forest larger than the size of Costa Rica is being cut down, possibly leading to the extinction of hundreds of species [38]. Captive breeding is extremely costly, and these resources can be more efficiently used in habitat and ecosystem preservation, solutions which would address the issues of species extinction directly [38].

It has been claimed that there is consistent competition for funds between in situ and ex situ efforts. For example, the California condor is one of the most popular successes in captive breeding, and has received, easily, funding of almost $1. 0 million dollars annually. Yet, the U. S Fish and Wildlife Service continually rejected to fund a proposal for a project on toxicity studies of alternatives to lead bullets, which could solve the problem of lead poisoning in Condors in the wild [40]. Eventually they accepted the proposal, but this struggle demonstrates the diversion of resources from more effective in situ initiatives towards captive breeding programs, which act as a ‘ quick-fix’ in species conservation but yet fail to address the original causes of the population decline. An example of just this issue, concerns the black-footed ferret, a highly publicized captive breeding and reintroduction program. But, this arguably has distracted the public from the continuous destruction of the ferret habitat through government initiated Prairie dog eradication campaigns [40].

In these cases, captive breeding has saved these two species from extinction, but only in the short term. It has effectively ignored and diverted attention away from the real issues at hand; habitat and ecosystem destruction. Captive breeding, as argued, is an essential tool in conservation biology, but not the first priority and not the ‘ be all and end all’ solution. It acts as a short term fix, does not solve the initial problems and only prolongs the uphill fight against species extirpation. Long term solutions may be more politically difficult than captive breeding solutions, and thus the government will tend to put less emphasis on initiatives for wild populations, once captive populations are assured.

Figure 7 A depiction of the principal threats to the following groups: a. primates, b. carnivores, c. ungulates. The main threats to primates and carnivores are habitat loss.

There is no doubt that zoos are contributing to the protection of global biodiversity, but captive breeding programs themselves are giving the public and politicians the wrong impression of a dire situation. The battle against extinction has just begun, and captive breeding programs signal to the authorities that there is hope for disappearing species, as they are able to be readily reintroduced from captivity [41]. Captive populations wrongly indicate that a species is safe, and that the destruction of habitat and wild populations can proceed. In the rare cases that captive breeding is successful, what is the guarantee that there will be suitable habitat available for reintroduction? Zoos can become hosts to the ‘ living dead’, species which will have no hope of ever being able to proliferate again in the wild. With habitat loss as the main cause of species extinction, the possibility for relocation is very small. A captive breeding program is useless if habitat conservation is not implemented first and foremost. For example, many primates and carnivores which are being sustained by captive breeding are termed the ‘ living dead’, because their habitat has been destroyed, and in the hopes that they will be restored, they are kept alive ex situ [42] (Figure 7).

The argument is not against captive breeding, but more a warning that it should not become a substitute for habitat protection and conservation. Captive breeding is an important tool in conservation biology, but it should only be implemented when there are no feasible alternatives. As discussed, there are many disadvantages in relation to captivity. These include the erosion of genetic diversity, the detraction of resources from more cost-efficient and effective initiatives (such as habitat and ecosystem preservation), the bias of zoos to choose mammals in captive breeding

programs, the increased chance of disease transfer in captivity and also from captive animals to the wild, the possible chance of captive animals becoming domesticated, and lastly, the false impression given to the public and government that captive breeding can save all endangered species.

With all of the aforementioned taken into consideration, it is clear that captive breeding must only be taken as a last resort, in order to save a species that is on the brink of extinction. In the case that captive breeding is used, it should always be combined with recovery goals for wild populations and should not be used as a long-term solution, as this does not solve the fundamental problem.