

Captive Massasauga Populations and Conservation

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Introduction

The American Zoo and Aquarium Association (AZA), representing approximately 200 North American professionally managed zoological institutions, recognises that zoos play a role in conservation through public education, scientific research, professional training and support of in situ conservation projects (Hutchins et al., 1995). Further, zoos are in a position to preserve threatened species in captivity over long periods thus providing a reservoir of genetic and demographic material that can be used periodically to reinforce, revitalise, or re-establish populations in the wild. In the following paper I will describe how Toronto Zoo, an AZA member and a founding member of the Massasauga National Recovery Team, continues to work towards fulfilling this conservation mission for the captive massasauga rattlesnakes we maintain.

Conservation roles for captive wildlife

Toronto Zoo is currently maintaining two captive populations of massasauga rattlesnakes. One is the zoo's permanent population of snakes (long term captives for exhibit, public outreach/education, etc.) and the other is a special population of rescued snakes being maintained in hopes that it will contribute to the recovery of a threatened population near Windsor, Ontario. In 2003, faced with a small population threatened with imminent destruction as the result of a residential development project in the Windsor area (Pither, 2003), the Ojibway Nature Centre, Toronto Zoo, the Massasauga National Recovery Team and the Ontario Ministry of Natural Resources (OMNR) decided to rescue as many snakes as possible from this area. Four adult massasaugas were rescued and transferred to Toronto Zoo where they were placed into the zoo's quarantine facilities. The ultimate goal was not only to save the individuals, but also to return these snakes to the Ojibway Prairie complex in Windsor so that they could contribute to the recovery of this severely imperilled population. Two of the rescued rattlesnakes were gravid females and they gave birth soon after arrival. This rescued population remains isolated from, and is managed separately from, the zoo's permanent population of captive snakes. Maintaining these snakes in preparation for a release back to their home territory has, at times, been challenging. The time, space, supplies and effort required to maintain a large group of snakes in one location requires the commitment of substantial resources. More than one half of the available quarantine space for reptiles and amphibians at Toronto Zoo has been devoted to this captive population, and their presence at the zoo has necessitated that we modify our plans for the zoo's permanent collection. We have approached this as a collaborative rescue effort with the OMNR and the Recovery Team, and see our efforts in this situation as meeting our conservation mission.

Conservation ought to be the first priority for any captive population of threatened wildlife whether these animals are held in accredited zoos or in private collections. It is important that captive populations have a well defined conservation goal that is appropriate, realistic and of sound conservation value. As stated earlier, captive populations of threatened species should be managed to complement and improve the success of other conservation initiatives (education, enforcement, habitat protection and enhancement, population augmentation, research, repatriations, reintroductions, etc.). Wiese et al. (1994) defined four general conservation roles

for captive populations: 1- basic and applied research, 2- support for field conservation projects, 3- local and international education, and 4- long term maintenance of genetic variation for future supplementation of wild populations if needed.

Research

The first of these roles, research using captive populations, can be used to guide and develop recovery actions and adaptive management strategies. Research using captive wildlife usually takes place in captivity, but can also be conducted in the field using released captive animals. In captivity, populations of threatened species can be utilized in various research projects; species life history, physiology, biology, behaviour etc. Captive populations can also aid in the development of technologies and research techniques that will benefit wild populations. Further, databases from captive populations can complement research conducted on wild populations. Examples of this type of research include the development of microsatellite DNA markers for Amur tigers (Zhang et al., 2004), developing non-invasive molecular sexing technique for St. Vincent Amazon parrot (Russello and Amato, 2001) and developing alternative approaches to reversible contraception on wild cervids using captive animals (Baker et al., 2004). Research involving the experimental manipulation of released captive wildlife has also been conducted as is the case with the Bali Mynah, where researchers examined various medical treatments for birds that were part of a release program (Collins et al., 1998). Captive populations can also provide opportunities to study specific life-stages. For example, Schlaepfer (2003) used eggs obtained from captive lizards to assess the impact of human activities (forest to pasture conversion) on the egg life-stage of a Neotropical lizard. Such research projects provide a valuable opportunity to study threatened wildlife without placing wild populations at risk (Brook et al., 2003). A review of research in AZA institutions found that an overwhelming majority of institutions conduct research (88%), with over half of these conducting research on the wild counterparts to their captive population (Stoinski et al., 1998). Similarly, Wiese et al. (1996) state that in a four year period AZA institutions and their collaborators published over 1,300 research articles involving a variety of taxa. Card et al. (1998) reviewed research within the zoo herpetological community and found that in a ten year period zoo herpetology departments published 164 refereed technical papers and 101 non-technical papers and participated in 16 field studies.

Research specifically involving captive massasaugas in AZA institutions is ongoing. In a cooperative project between the Milwaukee Zoo, Wisconsin Department of Natural Resources and USFWS, King et al. (2004) used captive born and raised massasaugas as a first step towards developing a repatriation method for this species. The population of rescued massasaugas currently at Toronto Zoo provides a tremendous opportunity for additional research. Two research projects, one in captivity and one in the field, have been proposed for this population. The first is a proposal to determine the feasibility of head starting (raising rattlesnakes in captivity to maximise growth) as a repatriation strategy, and to assess the utility of repatriation as a conservation management tool. The goal of this *in situ* proposal is to release and monitor some of the captive born rescued juveniles into a protected area that can support a population of rattlesnakes near Windsor, which is where these animals originated. Such habitat exists in the Ojibway Prairie Provincial Nature Reserve which had a population of massasauga rattlesnake until the 1970's. The conditions that led to the initial extirpation of rattlesnakes (human persecution, road mortality, and development) have been reversed or mitigated. This repatriation may be a significant step in the recovery of this species in south western Ontario. Plans for this repatriation were developed in 2004 and were being implemented in the first few months of 2005. This included the development of a detailed research project and securing funds to pay for

the repatriation, monitoring of the snakes post release, and costs associated with any habitat modifications required. Unfortunately, shortly before the planned release in the spring of 2005, the OMNR turned down this proposal because of political concerns regarding the impact on public safety of releasing venomous animals in an urban area. Following discussions with senior OMNR staff members, the proposal is being re-evaluated in light of the following specifics:

- 1- Massasaugas are already in Windsor and LaSalle neighbourhoods and, thanks to years of Ojibway Nature Centre's work, the public are aware of and mostly supportive of snakes.
- 2- The rescued snakes came from a residential area (one rescued male was 10 meters from existing housing). Snakes will be returned to an area within the nature reserve (approx 2km from the rescue site) and away from existing houses.
- 3- Returning these rescued animals to the Ojibway Population is the right thing to do for recovery of this provincially and federally listed threatened species.
- 4- The Recovery Team co-operated with MNR and participated in the rescue project with the intention of returning resulting animals to the Ojibway population where they belong.
- 5- The Recovery Team does not support permanently removing individuals from this highly threatened population.
- 6- The Nature Reserve is large enough to support a population of rattlesnakes: approximately 2 square km (1.2 km x 1.7 km) and will accommodate snakes which have been observed to move less than 0.4 km in a season. Rattlesnakes were found in the nature reserve until recently (extirpated by human activity in the mid-1970's). This habitat is now protected and recent surveys show that there are suitable hibernation sites available. A small mammal survey also shows that there is a prey base present to support rehab snakes.
- 7- There are adaptive management options for the method used to return these rehab snakes to Ojibway: we can monitor the animals and intervene if necessary by using transmitters in all animals; modifying the perimeter fencing to reduce chances of snakes leaving the reserve; soft release around good habitat in the centre of the reserve, etc..
- 8- Releasing rescued snakes in other parts of Ontario is not considered an ecologically viable option. For genetic reasons animals from a prairie adapted population should not be mixed with populations in other habitat types. Releasing elsewhere would also result in the further depletion of a very vulnerable population in Ojibway.

Since birth the juvenile snakes have been housed in a quarantine facility at Toronto Zoo. Their health status is being monitored so that the risk of exposing resident wildlife to novel pathogens is minimized. The release strategy also calls for close monitoring of released individuals using telemetry transmitter implantation (Austin, 2004). This will allow managers to react and change repatriation methodology and management strategies should any problems arise.

The second research question that can be answered using this captive population of rescued snakes relates to the surgically implanted radio telemetry transmitters that will be employed to monitor this group when released. The surgical implantation of transmitters requires an invasive manipulation that may very well affect the behaviour and health of the study animal (Bridger, 2003). Knowing which, if any, changes in behaviour or physiology are artefacts of implanted transmitters will aid in the interpretation of data gathered in this project. This should improve management decisions that will aid in the recovery of this threatened species. Properly evaluating potential transmitter effects will require the use of control and treatment animals (Jemison, 1995; Millsbaugh and Marzluff, 2001). The cryptic nature of massasauga rattlesnakes means that a control group of free ranging rattlesnakes for such studies would be very difficult to monitor. For this reason, lab studies of captive snakes would best elucidate the effects of transmitters on rattlesnakes. To investigate these issues, a lab study has been

initiated at Toronto Zoo in collaboration with York University in Toronto. The extent to which results from a lab study of captive animals would reflect what is seen in wild snake populations is not known. However, there is some evidence that links lab study findings to field studies. Blouin-Demers and Weatherhead (2001) documented postprandial thermophily in black ratsnakes (*Elaphe obsoleta*). They found that both captive and wild snakes basked more frequently and thermoregulated more carefully after feeding, presumably to elevate body temperature and facilitate digestion. They argue that the response of snakes following feeding in a lab setting may accurately predict their response to feeding in the wild. Further, because habitat selection is one of the principle ways in which snakes thermoregulate, such lab findings from the study of captive snakes may predict habitat use patterns in wild populations. It is therefore entirely plausible that a rattlesnake in a lab setting may respond to both the surgery and associated healing, or the presence of the transmitter, the same as it would in the wild. In the current lab study, twenty-four of the rescued snakes are being used, and they were randomly assigned to three treatment groups. Twelve snakes, those that were destined to receive surgically implanted transmitters as part of the planned spring repatriation received surgically implanted transmitters in March 2005. Six other snakes received a sham operation (surgery without implantation) and six serve as a control. The sham surgery is required to separate the effects of the anaesthesia and surgery from the effects of the transmitter.

Rattlesnakes, as ectotherms, rely on thermoregulation to facilitate many other physiological processes, some of which may be affected by transmitter implants. Basking behaviour trials to determine substrate temperature selection took place in an experimental enclosure (fibreglass tub 45cm X 180cm) set up to provide thermal gradient (22°C to 34°C). Snakes were introduced to a test chamber individually and in a random order for a twenty-hour trial. An infra red video camera and time lapse video recorder were used to record each snake's activity patterns and the snake's position to determine temperature selection. Other parameters being studied are physiological responses such as inflammatory processes as a result of infection or the presence of a foreign body and increased stress which may be reflected in elevated stress hormone metabolite levels (Young, 2004). Blood collected during the physical exam before surgery, at 30 days post-op, 90 days post-op and 180 days post-op has been analysed. Feces produced has been collected and frozen for future analysis for concentration of excreted corticosterone metabolites to provide a non-invasive tool for monitoring stress in snakes. (Frigerio, D., 2004; Mathies, T., 2001). Potential effects on nutrition are being studied by examining feeding behaviour, growth (weight and length) , and bone density.

It appears that the delays this repatriation has already experienced are due to political pressures and not scientific and conservation reality. Should repatriation not be approved by the OMNR, research into the effects of transmitters will still be completed. Regrettably however, the opportunity to return rescued wildlife to natural habitat where individual animals can contribute to the recovery of the species will have been lost.

In situ support and education

The second and third roles for captive populations, supporting field conservation projects and education, are more traditional roles for zoos. However, each of these roles should be defined precisely and an action plan for implementation should be developed (Wiese et al., 1994). Actions that contribute to these goals include developing educational resources and displays; funding in situ research, habitat acquisition, and education programmes; professional training and transfer of technology developed in captivity to in situ partners. As an example of this we

can look at zoo involvement in massasauga rattlesnake conservation. There are currently twelve North American zoos exhibiting this species and many of them have well established public education programs and participate in and support field conservation and research. The Toronto Zoo is a founding member of the Canadian Massasauga Recovery Team and is in a position to respond to the conservation needs of this species. Like other professionally managed zoos, Toronto Zoo has the resources to reach a large audience (over 1.2 million urban visitors each year), the organizational structure to develop conservation partnerships, and skilled and dedicated staff. Over the years Toronto Zoo and the Recovery Team have produced a number of outreach and education resources that are being used across this province and throughout the range of this snake. These include posters, field identifiers, stickers, “Rattlesnake Tales”... a newsletter that celebrates people that share habitat with wildlife, a conservation video, and a comprehensive “Stewardship Guide” that helps people make the right choices that enable them to share habitat and be good stewards of the environment. Toronto Zoo has also developed and hosts workshops that demystify the snake and generate an appreciation of some of the fascinating aspects of its biology. Toronto Zoo is collaborating with the Michigan Natural Features Inventory and the Detroit Zoo to develop similar outreach and education programmes for massasauga rattlesnake conservation in Michigan.

Assurance Population: A genetic reservoir

The fourth role for captive populations, the long term maintenance of genetic variation, comes into play when standard conservation practices are not enough to prevent the extinction of vulnerable populations. This is particularly the case when immediate threats cannot be mitigated in a timely manner. In such cases, captive populations that will maintain genetically and demographically viable populations are an important tool for conservation and will maximize the opportunities for future recovery of imperilled wildlife. In some cases, the captive population contains more genetic diversity than remaining wild population. Examples of this are seen in the Amur leopard (Uphyrkina et al., 2002) and the bearded vulture (Gautschi et al., 2003). Individual animals that make up captive populations of threatened wildlife come from a variety of sources. These include specimens already in private and public collections, any rescued animals that faced immediate threats (habitat destruction, persecution), and individuals from confiscations of illegally imported or trafficked animals. A recent example of this is the large numbers of imperilled Asian turtles that have been amassed from confiscations that result from the large scale illegal harvest of turtles for food markets in Asia. Captive populations assembled for this purpose have been referred to as assurance colonies.

It has been recognised that captive breeding for reintroduction may not be appropriate for all species (Hutchins et al., 1995; Snyder et al., 1996). Moreover, given the limited space, human and financial resources available for captive breeding programs, it is possible to manage only a small percentage of the number of wildlife species at risk in this manner. For this reason it may be appropriate to select “flagship” species for captive breeding programmes; that is, high profile species that will attract public attention and help preserve habitat and other taxa as well as preserve genetic diversity of the target species. Ebenhard’s (1995) review of conservation breeding programs points out that the success of re-establishing wild populations has been limited. However, Ebenhard also states that much progress can be made if the wildlife management community and the zoo community cooperate more closely. Recent examples of cross sector cooperation in managing captive populations to benefit conservation include the St. Vincent Amazon Parrot Consortium, a group of zoos, private breeders and the government of St Vincent cooperating to manage the captive population and support in situ conservation; and the

AZA Puerto Rican Crested Toad Species Survival Plan (SSP) in which United States Fish and Wildlife Service (USFWS), AZA institutions, Puerto Rico Department of Natural Resources and private sector and academia in Puerto Rico collaborate for the recovery of this species.

An assurance colony, or any other captive population of threatened wildlife, should not be allowed to become an irrelevant collection of individuals; rather it must be responsibly managed in order to fulfill its conservation mission. Un-managed populations run the risk of becoming a collection of small fragmented populations that have a low probability of long-term survival and will likely never contribute to the recovery of threatened wild populations. Further, solely keeping these animals as a well managed captive population will not equal conservation for at-risk species. In the absence of the broader conservation roles for captive populations mentioned above, captive populations will not meet their full conservation potential.

Captive Management

Captive management of threatened species requires appropriate care of the individual (nutrition, housing, veterinary care, etc.) and appropriate care of the population as a whole. In order to care for the population's needs and maintain its long term health we rely on a systematic and scientific approach to animal breeding programs and population management. Managing populations and formulating breeding recommendations require genetic and demographic analyses that can only be carried out after basic pedigree and demographic information from the current and historic population have been compiled and organized. The costs associated with developing and maintaining the data bases required for responsible management must be acknowledged at the outset and accepted by those individuals and institutions holding threatened wildlife in captivity. Wiese et al. (1994) point out that just as veterinary expenses are justifiable for the short term health of an individual animal, the costs of population management are justifiable for the long term health of individuals and the population as a whole. Individuals and institutions that receive or keep threatened wildlife must ensure that their animals are included in the managed captive populations as a whole, and they should be committed to following captive population management practices and recommendations that will ensure the long term survival of the species.

Small Population Genetics and Demographics

Captive populations are by definition a small representation of the parent population. Small populations are unique in that they start with less genetic diversity (rare alleles are often not captured at the founding event) and they can lose diversity faster due to chance occurrence. Unlike large populations, captive populations cannot buffer against random setbacks and low probability outcomes without careful management. For example, the reproductive potential of a small captive population can be drastically reduced if all offspring from a single reproductive event are male. Management options that can help retain genetic diversity include increasing the carrying capacity of the captive population, maintaining a balanced sex ratio and increasing generation time. Demographic management of captive populations is directed at achieving a desired population size as quickly as possible (to prevent genetic loss from founders) and maintaining it over time. Population managers rely on data that are maintained in a species studbook to support the scientific foundations of captive population management. Studbooks are a record of the captive history of a species including pedigree traced back through generations to wild ancestors. The first studbooks were records of pedigrees of domesticated horses dating back nearly 5,000 years. In modern times, the first studbook for a wild species was written for the European wisent (*Bison bonasus*) in 1924. Currently AZA zoos and aquariums maintain

studbooks for more than 300 species. Studbooks include information on genealogy, provenance and demography. They are used to monitor captive populations and to make breeding recommendations to ensure genetic diversity is maintained and inbreeding avoided and to ensure that population size does not exceed the carrying capacity of co-operative breeding and management programs. An extensive body of theory and research into the best practices for making pedigree based breeding recommendations exist and is being expanded (Russello and Amato, 2004). The goal of these recommendations is to retain the genetic variation seen in the founding wild population. Demographic information from studbook life tables is used to calculate the target population size required to maintain genetic diversity and how many births are required each year to maintain the target population size. Demography also allows managers to understand how a population functions numerically; how fast it can grow, how quickly it ages and this can help predict long term changes that can be expected and offers options to mitigate those changes if they are undesirable. Demographic information can also be used to determine the number of individuals that can be harvested from a captive population for reintroduction or repatriation projects without compromising the genetic and demographic integrity of the captive population.

Multi-institution cooperative captive population management

Due to the limited space available for managed captive breeding populations, a co-operative strategy for managing captive populations needs to be used. Such co-operative strategies have been developed by the American Zoo and Aquarium Association (AZA) and the Canadian Zoo and Aquarium Association (CAZA). There are two strategies employed by AZA members: the Population Management Plan (PMP) and the Species Survival Plan (SSP). A PMP is a less intensive management option than a SSP. PMPs are designed to establish stable, self sustaining captive populations for the future and do not necessarily contribute to the conservation of species at risk. SSPs on the other hand are meant to preserve the entire species, not just the captive population. Both management options provide full scientific analysis and result in recommendations that will benefit the captive population (long term survival and fitness of individual animals). However the more comprehensive approach of the SSP ensures that captive populations have the best chance of fulfilling their conservation potential. SSPs are directed by a SSP Coordinator and a Management Group. Captive population management recommendations are developed by Population Managers who have been trained in studbook data management and population management at AZA population management training courses. AZA's Small Population Management Advisory Group and the AZA Population Management Center have been established to provide support and expertise to each Population Manager. In addition to population management recommendations, the Management Group also develops a Maser Plan that focuses efforts for conservation through research, education, reintroduction and habitat preservation. SSPs require the full participation of all members so that the captive population can be treated as a single biological population. In this way a large number of institutions share the substantial commitment of space, financial and human resources required for a viable and self sustaining population. SSPs also facilitate recovery of threatened species by collaborating with many partners in situ. A recent example of this is the cooperation between the USFWS and the AZA Puerto Rican Crested Toad SSP. USFWS and AZA have published a joint recovery plan for this species. This plan combines both captive and in situ actions that will lead to the recovery of this threatened species; a prominent part of the plan is captive propagation for reintroduction.

Conclusion

Conservation of threatened species and habitats require multifaceted approaches to be successful. Captive populations can and do contribute to species conservation. Thanks to the mechanisms set up by professional zoo associations such as the AZA, captive populations in modern zoos are in a position to assist in recovery of wild populations. Preservation of what already exists in situ is important but cannot be considered the only, or even an adequate, strategy for preserving biodiversity on its own (Ayyad, 2003). In many cases we are faced with altered and depleted habitats and ecosystems and there is a need to mitigate losses and detrimental changes. For some species with limited dispersal ability, such as the massasauga (King et al., 2004; Pither, 2003) recovery may depend on repatriation. Using captive wildlife populations in these cases may be a viable and important tool in recovery and is one example of how captive populations can contribute to conservation.

Current status of the captive massasauga population

There are currently 62 animals in 12 institutions that submit data to the International Species Inventory System (ISIS, current to 12 June 2005). The total number individuals of this threatened species including those being held in private collections is unknown, but may be much larger.

Buffalo: 1.0

Columbus: 0.0.2

Detroit: 3.2

Fort Wayne: 0.1

John Ball: 1.1

Milwaukee: 1.1

Philadelphia: 1.0

Racine: 0.1

Rochester: 2.0

St. Louis: 1.0

Toledo: 3.2

Toronto: 21.17 (16.17 owned by the Ontario Ministry of Natural Resources)

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