

Ground-hornbills in American zoos: a case study of the challenges to *ex situ* population sustainability for conservation

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Abstract: Modern zoos pride themselves on their ability to maintain healthy captive populations as *ex situ* conservation resources with the potential to be used for future *in situ* conservation support and prevent harvest from wild populations under threat. This premise, however, is dependent on the ability of zoos to maintain sustainable populations, which are genetically and demographically viable. The Association of Zoos and Aquariums (AZA) in North America has established a management system of Species Survival Plans (SSPs) to ensure that conservation priority species are managed in a sustainable manner. However, for species where the population management is challenged by more complicated atypical factors such as social systems, reproductive biology and/or captive management costs, population sustainability can be difficult to achieve in reality. Both species of ground-hornbills are kept as captive populations in North American zoos and both are managed as SSP's. Achieving true population sustainability for these species has been challenging and the author conducted a case study assessment to better identify the challenges preventing the achievement of population sustainability, and to design strategies to overcome each of the challenges. Some of the challenges identified included the SSP not always being able to respond to institutional requests, recommended transfers not always taking place or being slow to be implemented, some genetically valuable birds not being available for transfer, low breeding success from some pairs identified as being high priority for breeding, and a concern over the breeding potential of some captive bred birds due to rearing method. Further analysis suggested that some of the root causes for these challenges included underestimation of the importance of social learning within an extended family cooperative breeding system for juvenile Southern Ground-Hornbills, the cage space and holding facilities of some zoos being a limiting factor to their success with ground-hornbills, the use of ground-hornbills in education programs (bird shows) preventing recommended pairings, and possible lack of staff experience with ground-hornbill behaviour limiting the breeding potential of some priority captive birds. Each of

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the challenges has been assessed and recommendations are presented to improve the success of the SSP captive populations to make them a more sustainable and credible conservation resource for the future.

Keywords: population sustainability, genetic diversity, demographic stability, husbandry, conservation, ground-hornbills.

INTRODUCTION

Ground-hornbills are large impressive birds, which are typically very active and highly visible as zoo exhibits. There are two species of ground-hornbill, the Abyssinian *Bucorvus abyssinicus*) and Southern Ground-Hornbills *B. leadbeateri*. Both live on African savannahs and lead a mainly terrestrial existence. Ground-hornbills differ from true hornbills by having an additional neck vertebra, elongated tarsi and a special tendon between pelvis and femur that allows them to walk and run with a long stride, enhanced by long legs and the ability to walk on the tip of the toes. Ground-hornbills also differ from most other hornbills in being predominantly faunivorous. They have black plumage over most of the body, except for white primary feathers that are hidden except when they take flight or extend their wings to jump. The tail is relatively short, nares are covered with a tuft of bristly feathers, eyelashes are well developed and flattened to form screens above the eyes. They breed in rock or tree cavities, not sealing the nest, showing no nest sanitation, the female being fed at the nest while incubating and brooding. Food is carried to the nest, often as a bundle of several items held in the bill that can include nest litter material as well as food. The female does not moult flight feathers simultaneously while breeding. The chick's skin turns from pink to black a few days after hatching, and the chick is often left alone in the nest well before fledging (Kemp 1995).

The Abyssinian Ground-Hornbill, also known as the Northern Ground-Hornbill, ranges through sub-Saharan African savannahs north of the equator. It is usually found living as adult pairs, sometimes with current offspring living with them. Breeding appears to be initiated by nest-site inspection, courtship feeding; and beak slapping between mates. Vocalization consists of a series of deep booming notes that may continue for lengthy periods (Kemp 1995).

The Southern Ground-Hornbill was formerly widespread across African savannahs south of the equator. Southern Ground-Hornbills live in extended family cooperative breeding units, where juvenile males can stay with the parents living as a family social group and acting as 'nest helpers' for up to 20 years. Female juveniles by comparison usually stay with the family for only one to three years after fledging. All members of the family unit coordinate their activities and remain closely together throughout the day. Social organization is maintained by allopreening

and complex interactions involving giving and withholding food. Vocalization consists of a main loud call that is a deep, resonant, four-note booking, accompanied by three body contractions the last of which produces a double note. This call is given by all family group members throughout the day, but most frequently at dawn and dusk. Adult male and female will often “duet”, with the male calling at a lower pitch than the female, but any family member may call at either pitch (Kemp 1995).

Ground-hornbills were first seen on display in North American zoos in 1922 when the Philadelphia Zoo acquired wild caught specimens of the Southern Ground-Hornbill. Ground-hornbills started to appear more regularly in North American zoos over the ensuing 50 years with the first captive breeding successes being recorded during the 1970s. The first records of captive breeding in North American zoos began in the 1970s when the San Diego Wild Animal Park (now called San Diego Zoo Safari Park) achieved captive breeding of the Abyssinian Ground-Hornbill in 1973 and a few years later the Jacksonville Zoo achieved captive breeding of the Southern Ground-Hornbill in 1979.

Both species of ground-hornbill are currently managed by the AZA as Species Survival Plans (SSP), with the author acting in the role of species coordinator for both species since 2008. A North American regional studbook has been published annually since 2008 and a population analysis, breeding and transfer plan document has been produced for both ground-hornbill species (Sweeney and Lynch 2011, 2012).

Key tasks for the role of an SSP coordinator include maintaining a genetic studbook for the population and undertaking periodic population analysis, leading to transfer and breeding recommendations with a view to manage the captive population as sustainable as possible while meeting four main objectives: (1) maintain demographic stability of the population, (2) maintain genetic diversity in the population, (3) maintain population at the recommended target population size, and (4) meet institutional needs within a cooperative management system.

Populations are generally assessed against risk definition parameters including:

- Is current gene diversity high (the proportional gene diversity, as a proportion of the source population)?
- Is the projected gene diversity over 100 years viable?
- Are there enough breeding age birds in the population?
- Are a sufficient number of zoos keeping the species?
- Is current husbandry and breeding management successful?
- Is disease in the captive population a factor?
- Is behavioural quality of captive bred birds a concern?
- Is the history of the animals in the captive population known?

Background

Soon after taking over the task of coordinating ground-hornbill SSPs in 2008, the following programme performance concerns with these populations became apparent to the author.

The SSP had not always been able to meet institutional requests from zoos looking for birds to pair up single birds or establish new exhibits; often there can be a time delay in managed populations between institutional requests for birds and being able to match, but this population seemed to have some requests that were not being met. Some of the recommended transfers that were made were very slow to be completed or were not happening at all. This was partially because some genetically valuable birds were not available for pairing, often because they were trained to perform in education demonstrations with zoos not being prepared to move the bird because of their education/performance value.

In addition to the problems with transfers to form new pairings, there was also relatively low success with breeding from priority potential founders. The population data for the Southern Ground-Hornbills showed only 21% of wild caught potential founders in zoos had successfully bred and raised offspring, while for Abyssinian Ground-Hornbills 31% of wild caught potential founders had raised chicks.

Finally there was growing concern about the breeding potential of first generation Southern Ground-Hornbills, with an obvious lack of breeding behaviour from many mature birds compared to the Abyssinian Ground-Hornbill. Both ground-hornbill species had demonstrated captive breeding in North America zoos since the 1970s, with both species now having significant numbers of mature first generation birds. For the Abyssinian Ground-Hornbill, 54% (37 of 68) of the first generation birds had become reproductively successful while for the Southern Ground-Hornbill that number was just 3% (2 of 61), with both examples being first generation males that had been paired with wild caught males and which had been through a long series of breeding attempts before becoming successful. While captive offspring of the Abyssinian Ground-Hornbill, with a basic monogamous pair bond and short period until chick dispersal, appeared to respond well in zoo population management parameters, there was significant concern that captive management for the Southern Ground-Hornbill, with a more complicated extended family cooperative breeding system, seemed to produce first generation birds that were showing a significant lack of breeding potential.

METHODS

From summer 2009 through early 2010, a number of steps were taken to investigate the status and potential problems with the captive populations

of both ground-hornbill species. In preparation for upcoming population analysis for both of the ground-hornbill populations, a needs and wants survey was conducted of all North American zoos. An extensive literature search was conducted. A detailed husbandry was prepared covering three main knowledge areas: (1) cage space and physical environment requirements, (2) husbandry parameters, and (3) breeding information. Two months after circulation of the survey, a reply rate of over 80% was achieved and the results analysed (Table 1, Figure 1). In addition to the quantitative written surveys the author also conducted a series of qualitative interviews with zoo avian curators managing collections where long term successful breeding had been achieved with ground-hornbill species. The author also conducted first hand behavioural observations of a number of captive ground-hornbills, particularly comparing Southern Ground-Hornbills between zoo exhibits of adult pairs without chicks and examples of zoo exhibits of well-established extended family groups of this species.

Problems identified

Upon review of the information collected through the investigation steps, five main problem areas were identified.

- 1) The importance of extended family cooperative breeding behaviour had been significantly underestimated for the Southern Ground-Hornbill.
- 2) For some zoos, the exhibit cage space and holding facilities were a potential limiting factor for successful breeding. Also, clearer guidelines for nest site provision could improve the chances for successful breeding.
- 3) Some individual birds were being used in education presentation programmes and holders were unwilling to move them to meet breeding recommendations.
- 4) There were examples of zoos trading their captive bred ground-hornbills outside of the SSP population.
- 5) Many recommended pairings were not breeding successfully with a variety of causes (including pairing criteria, recognizing key behaviours, etc.) contributing to this lack of success.

Recommendations

The husbandry and cage space requirements survey produced a large amount of useful information that is now used for the development of husbandry guidelines and an animal care manual, as well as being shared in several publications still being prepared on different specific aspects on the management of ground-hornbills in zoos (Sweeney 2013). However, the most important results were quickly identified and the following recommendations were set out in a presentation about the challenges

of these populations during a sustainability challenges workshop at the national AZA conference in 2010 (Sweeney 2010).

- 1) Encourage zoos to prioritize exhibit space and holding facilities for Southern Ground-Hornbills, given their conservation status and population sustainability challenges compared to the Abyssinian Ground-Hornbill.
- 2) Encourage zoos keeping Southern Ground-Hornbills to form family groups. This became an expectation for all zoos participating in the SSP from 2011 forward (Sweeney and Lynch 2011).
- 3) As an extension to the recommendation for zoos breeding Southern Ground-Hornbills to form family groups, it was also stressed that juveniles should remain with the parents and not separated into young pairings too early in order to avoid potential sibling effect relationships being formed. Female juveniles should remain within the group for two years, or until any signs of displacement are observed, male juveniles should remain within the group for at least five years and ideally gain experience acting as a nest helper before being separated and moved into a pairing situation.
- 4) Information gathered from the above actions was used towards producing a draft Animal Care Manual for ground-hornbills.
- 5) Continue research to identify key aspects of behaviour, pairing and breeding success. Certain key behaviours related to courtship display and maintaining social organization within a family group have been poorly understood in the past. The development of the animal care manual should help resolve this.
- 6) If Southern Ground-Hornbills need to be hand-reared, SSP participants should consider supervised re-introduction of those juveniles back to the parents pre-weaning using the protocol developed by San Antonio Zoo.
- 7) Seek solutions to valuable birds being lost or made unavailable for SSP breeding recommendations.

RESULTS

Since the recommendations in 2010 (Sweeney 2010) more zoos have moved towards keeping Southern Ground-Hornbills in extended family cooperative systems. The 2011 Southern Ground-Hornbill population analysis, breeding and transfer plan (Sweeney and Lynch 2011) clearly stated that it is now an expectation for zoos keeping Southern Ground-Hornbills to try and establish a family group.

The successful protocol developed by San Antonio Zoo, for the introduction of parent-reared chicks back into the parent's enclosure, has

now been very successfully replicated at the Potawatomi Zoo. Here, four hand-reared chicks have now been successfully introduced back to the parents pre-weaning and are now all part of a successful family group there.

Additional potential founders have now initiated breeding, becoming founders and contributing to the number of first generation birds. Some of the non-productive first generation birds have started to show increased breeding potential since they have become the focus of increased behavioural work.

Several projects to help test and quantify the significance of social learning are planned or implemented, including an important attempt to encourage breeding behaviour from a very genetically valuable first generation hand-reared female who has now been paired to a first generation male that was parent-raised and has observed breeding behaviour as a nest helper in a cooperative breeding family group.

DISCUSSION

From 2010 onwards the managed captive populations of ground-hornbills show improved performance against the population sustainability criteria currently used to assess zoo populations (Lacy 2009), although when considering these sustainability criteria, we should continue to look harder into the true purpose behind our decisions for maintaining captive populations and what zoo population sustainability truly means (Lacy 2013). Increasingly, an argument is made for zoological collections to prioritize resources towards selecting species to focus on where there is realistic opportunity to merge *ex situ* populations with in field conservation management, with such populations being managed based on the criteria that captive management is a short-medium term objective as a meta-population strategy that integrates with conservation management for the wild population; rather than attempting to maintain closed zoo populations indefinitely (Conway 2011; Leader-Williams et al. 2007).

Recent research (Kotze et al. 2012) now suggests that there may be enough differences between the southern population of Southern Ground-Hornbills from South Africa and the eastern population from Tanzania, potentially meaning that from a conservation standpoint they would be better managed genetically as separate populations. This raises several questions about how the zoo populations of Southern Ground-Hornbills in North America and Europe could best contribute to future field conservation management.

In addition to reassessment of the potential that zoo populations could contribute genetic and demographic benefit towards reinforcement of the wild populations under a future meta-population conservation management strategy, there is also potential for behavioural and biological research objectives from zoo populations. In the case of the Southern Ground-Hornbill, the significance of social learning of juveniles within an extended family cooperative breeding system has been noted in both zoo management and by field researchers with the Mabula Ground Hornbill field conservation program. As the Mabula Ground Hornbill Project builds upon a successful reintroduction program, the potential exists for zoo populations to help test experimental parameters as future research questions are developed to further assess social learning and adaptive behaviour in juveniles, as well as providing easy access to build knowledge on basic biological values.

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Table 1. Data from 2010 assessment of the ground-hornbill populations in North American Zoos.

Species	Abyssinian Ground-Hornbill	Southern Ground-Hornbill
SSP living populations in 2010	70 (35♂♂, 35♀♀)	105 (48♂♂, 56♀♀, 1 unsexed)
Founders/potential founders in SSP	45 (2 still alive)	92 (42 still alive)
Founders that had bred	14 (31%)	20 (21%)
Captive bred birds	68	61
Captive bred birds that have bred	37 (54%)	2 (3%)

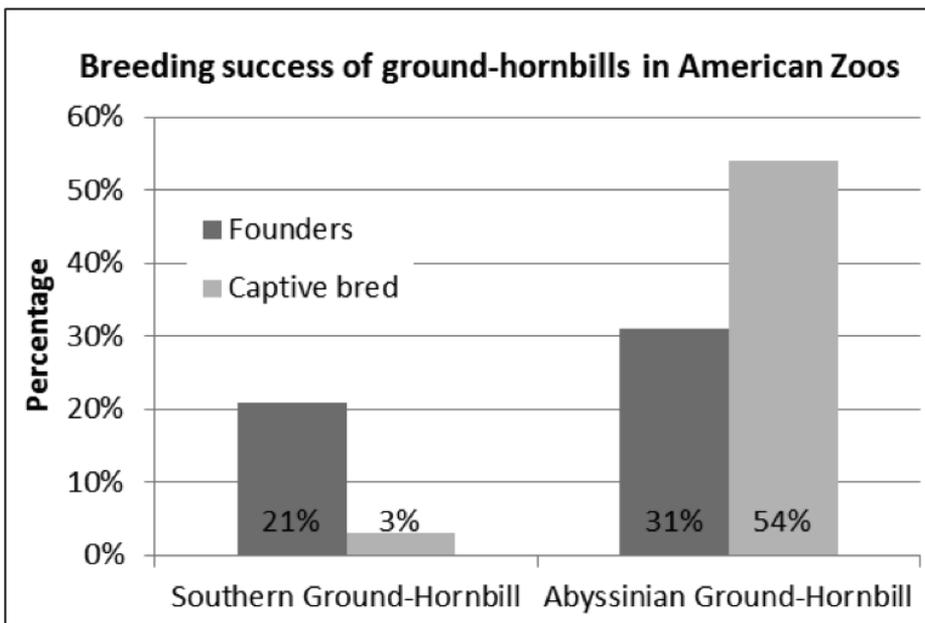


Figure 1. Percentage of founders and first generations birds in North American zoos that had demonstrated successful reproductive behavior for both Abyssinian and Southern Ground-Hornbills, assessed in 2010.