An overview of the saiga antelope (*Saiga tatarica*) in captivity in Europe and the United States

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1. Introduction

This review is intended to collect, compare and analyse available knowledge on the management of the saiga antelope in captivity in Europe and the US for the purposes of saiga conservation. While preserving wild populations in their native habitat should always remain the highest priority, the species is once again critically endangered in the wild and we should make sure that captive breeding can be used effectively for regenerating saiga populations, if and when it becomes necessary.

The conclusions and recommendations made in this document are intended as a starting point for more critical thinking and joint efforts, and not least for a much needed dialogue between stakeholders in saiga conservation. It is hoped that further knowledge and experience can be incorporated into this document along the way, and that we will arrive at husbandry practices that produce reliable results.

2. Historical overview

2.1 Imports

Saiga first appeared in zoological collections in Europe in the middle of the 19th century, and reached US collections in the 1930s (DOLAN, 1977).

It was in the 1950s that larger numbers of saiga were first imported from Russia through Prague Zoo, then through Tierpark Berlin. This ended in 1989. Both of these institutions served as distribution centres, and saigas in zoological collections in Europe and the US were mostly acquired from these two sources. A further similar quarantine facility existed at Warsaw, Poland. (DOLAN, 1977)

Askania Nova in the Ukraine has also been an important source of animals up to the end of saiga breeding efforts in European zoos. The institution has a long history of exporting saiga from their growing semi-wild herd, and e.g. Cologne Zoo (DE) and Chomutov Zoo (CZ) both acquired animals from that source. Askania Nova is currently the only source of saiga for breeding efforts that does not put any pressure on wild populations. However, the genetic

diversity of the animals is not known, individual animals are not identified and no studbook is kept.

The only time when saiga can be captured in the wild with minimum stress is within their first 48 hours after birth, when they are not moving with the herd. It is no surprise therefore that all saiga imported from Russia were very likely captured during that period in the wild, and then hand-reared. The hand-reared animals arrived in Berlin mostly between October of the year of their birth and January of the next year. The youngest saiga ever transported to Berlin arrived in August of the year of its birth, i.e. probably at no more than 4 months of age (POHLE, 1974).

As a general rule, juvenile hand-reared saiga are assumed to be the safest and easiest to transport, preferably each in a separate crate. Based on past experience, this does not require sedation. Capturing adults in the wild and then transporting them without any chemical restraint puts the animals and potentially also the humans involved at risk.

2.2 Origin of animals

Which populations the animals exported to Berlin or Prague, and then transferred to other collections originally came from is not well-documented. From the 1950s a collection centre operated in Astrakhan, Russia, therefore a majority of saigas probably came from the Kalmyk population. Records at Nuremberg Zoo, Germany suggest that they also acquired saigas from the Aral region (DOLAN, 1977).

No effort was made by collections to separate animals from different regions, and it is highly likely that in at least some cases animals of different geographical origin interbred.

Saiga as referred to in this review is understood to mean the Russian subspecies (*Saiga tatarica tatarica*). The Mongolian saiga (*Saiga tatarica mongolica*) is not known in captivity (DOLAN, 1977).

2.3 Animal exchanges and coordination of breeding efforts

Although a great number of different institutions in Europe and overseas kept saiga at some point during their history, only a handful of them managed to maintain breeding populations for longer periods. Also, there was never a large number of institutions at any one time with stable breeding populations. Even if breeding was successful, the total number of animals kept usually stagnated and in many cases declined quickly due to losses to diseases and trauma. The last saiga in captivity in Europe was a male at Cologne Zoo, which died in 2009. During the last years of the saiga programme at Cologne there was no other zoo to exchange animals with. This also means that for any breeding to occur, inbreeding was inevitable, and females

sired by the only breeding male were allowed to mate with it when they reached maturity (source: personal communication with Vera Rduch). Importantly, this resulted in no immediately apparent defects. However, in Oklahoma City, reduced breeding success was tentatively attributed to inbreeding pressure (RAMSAY, 1992).

In the light of the above, we cannot speak of truly coordinated breeding efforts, and there has never been a centrally managed international studbook. The efforts to maintain the saiga in captivity were however still considerable, and even involved transatlantic exchanges as the following list from Cologne Zoo also proves (source: personal communication with Vera Rduch):

November 1976	4 animals (1.3) imported from Russia
March 1977	1 male arrived, origin not documented
October 1981	2 wild-caught animals (1.1) arrived
October 1981	Further 3 (1.2) animals arrived from ZooCenter Moscow and Tierpark Berlin, place of birth unknown
November 1984	2 females born at Tierpark Berlin arrived from Tierpark Berlin
October 1990	1 male born in Nuremberg arrived from Antwerp
November 1993	1 male arrived from Askania Nova via Warsaw
November 1994	1 male arrived from Askania Nova via Warsaw, was immediately sent on loan to Neumünster, came later back to Cologne
February 1995	1 male born in Cologne came back from Neumünster
May 1997	4 wild-caught animals (1.3) came from San Diego

A large number of North American collections imported saiga, and considerable efforts were invested in exchanging animals from the beginning even between collections in opposite corners of the continent. Winnipeg Zoo in Canada for example imported saigas from Dallas, Texas in the 1960s, and San Diego acquired saigas from Albuquerque, San Francisco, Oklahoma City and Dallas (DOLAN, 1977).

As of August 2017, the Zoological Information Management System (ZIMS) lists 2.5 saiga at Almaty Zoo in Kazakhstan. Further approximately 500 saiga are kept at Askania Nova in the Ukraine (source: personal communication with Askania Nova, August 2017).

2.4 Regulations on trade

Regulations on the trade and transportation of wildlife have become considerably more complex in recent times, which also has an impact on shipments of animals between zoological collections. The international transportation of particularly ungulates has come under strict

regulation since the times when saiga were exported in large numbers, which makes potential animal exchanges between institutions difficult, and in some cases impossible.

The saiga was entered on Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) also known as the Washington Convention on 16 February 1995. After that date, the trade in live saiga intended for zoological collections is well documented. Records are publicly available online at https://trade.cites.org/.

Within the European Union, trade in saiga is subject to Council Regulation (EC) No 338/97 of 9 December 1996 on the protection of species of wild fauna and flora by regulating trade therein, which incorporates the CITES treaty into the body of EU regulations.

Under another applicable regulation, Commission Regulation (EU) No 206/2010 of 12 March 2010 laying down lists of third countries, territories or parts thereof authorised for the introduction into the European Union of certain animals and fresh meat and the veterinary certification requirements, live saiga antelopes may only be imported from third countries into the EU, if they are originating from and intended for an approved body, institute or centre, and have the required veterinary documents. The last saiga imported legally into the European Union arrived before this regulation entered into force.

Saiga may contract several diseases commonly found in livestock. Some of these diseases, such as e.g. the foot-and-mouth disease are critical for trade in live ungulates. The latest disease to impact shipments is the Schmallenberg virus found in Germany in 2012 and later in other EU member states. Several countries outside the EU banned the import of live ungulates and meat from the European Union (source: Wikipedia) as the virus became known, which may potentially affect ex-situ breeding efforts. The virus infects cattle, sheep and goats, and causes flu-like symptoms and birth defects if pregnant females are infected early in the pregnancy. As of now, the virus has not been found in wild saiga populations (ORYNBAYEV et al., 2016).

3. Captive management

3.1 Transportation

Records and experience suggest that transporting saiga over long distances is a difficult undertaking, and almost always involves losses either during transport or within a short time afterwards due to the stress and injuries suffered in transit, and the general difficulty of acclimatising saiga to new environments. 143 animals were imported to Berlin between 1958 and 1972, 57 (39.9%) of these died in Berlin. 45 out of the 57 imported animals that died at Berlin – 78.9 % – died within 6 months after arriving (POHLE, 1974). As losses at times exceeded 50% with wild-caught African ungulates in the same period and since then have improved (source: personal communication with Mátyás Liptovszky, Twycross Zoo, UK), it can be

assumed that the above figures would also be lower today with saiga given the progress in veterinary medicine and capturing techniques.

Although large trailers have been used in the past to transport several animals together, this method increases the risk of injuries and stress. Saiga cannot be safely herded onto a trailer because they generally do not flock, and herding them causes stress to the animals. For this reason they have to be caught one-by-one for any transportation. When chased, they flee in all directions often running into each other and any structure in their path, so care must be taken not to injure the animals. If cornered, they may however submit to being caught as it was found in Berlin (POHLE, 1974). In Cologne, they reacted to herding attempts by running in circles along the fence, and bumping into each other in panic. In small enclosures they may be caught by hand, and also transported this way over short distances while held by their legs and head and with their eyes covered. This was the case in Cologne, where saiga tolerated being transported (e.g. to the vet) by hand better, than in a crate. None of the saiga born there were hand-reared. When caught by hand and handled, saiga easily shed their fur (source: personal communication with saiga keeper Karl-Heinz Vogel at Cologne Zoo), which is however normal, and is an escape mechanism in the wild. In larger enclosures such as in Berlin (see Point 4 below for enclosure sizes) they may be caught individually by nets sprung up in front of them or with hoop nets. In very large enclosures, chemical immobilisation or drive nets may be used as in Oklahoma City. Subject to conditions, stress levels in captive saiga are potentially higher than in most other captive antelopes, which has to be taken into consideration when using chemical immobilisation.

Based on past experience, it can be assumed that saiga are best transported over long distances in individual crates not much larger than the animals themselves.

3.2 Stress

Based on previous experience, saiga can be assumed to be among the most easily stressed ungulates in captivity. They respond primarily to visual stimuli, while noise is not a significant factor.

The sight of larger groups of humans may cause considerable stress, which has to be taken into account when designing their enclosures. At Tierpark Berlin, saiga tolerated only smaller groups of visitors or single individuals at the boundaries of their large – and importantly off-display – enclosure, and if not stressed, were curious to investigate. In such situations they sniffed at people's hands reached out to them, and could even be petted. This behaviour became less and less expressed as the number of people increased, and the animals became more stressed. In Cologne, keepers reported that the sight of cranes moving above during the

construction of the nearby Asian elephant complex stressed the animals considerably, but they did not respond to the at times very loud noise of either the construction or the food stall close to their enclosure. They were also locked up in their stalls while at times noisy gardening work was performed in the enclosure, which they tolerated well (source: personal communication with saiga keeper Karl-Heinz Vogel at Cologne Zoo).

Care must be taken to prevent the animals from seeing predators including dogs, as it triggers a strong flight response.

Training has been known to reduce stress in captive ungulates in the past, and can be assumed to achieve the same effect in saiga (source: personal communication with Marc Enderby, ungulate keeper, Highland Wildlife Park, UK). Together with hand- or paddock-rearing, training should be considered for use in the captive management of saiga antelopes.

3.3 Enclosure design

Although it is a generally accepted view that enclosure design is perhaps the most critical aspect of saiga husbandry, and one of the major causes of death in captivity has always been trauma, there is no consensus on ideal design. While a perfect solution may not exist, with more attention on the saiga's behaviour in the wild and on some key design aspects solutions may be found that offer satisfactory results. It is important to note that husbandry techniques have come a long way since the earliest saiga programmes mentioned here.

Enclosure size

As saiga have evolved to thrive in wide open grassland, it is a logical conclusion that the size of space available to them will be of the essence. This is true to a certain extent, but the impact of enclosure size cannot by evaluated without consideration to other conditions. Saiga have been kept in enclosures of very different sizes, and longevity does not show a direct correlation with enclosure size. It was common to see animals live much longer in small pens, than on very large enclosures. However, this may be simply due to the great variation in longevity generally observed in captive saiga and the differences in climate and husbandry. Based on past experience, we can assume that the area per animal is also a less significant factor, than overall enclosure size, and that it is the distance from the perimeter and stressful visual stimuli that will be decisive. It seems likely that e.g. a breeding group of 3 females and 1 male would require a similarly large enclosure – e.g. of approx. 2,000 m^2 – as a group of 10 females and 1 male.

The flight response of saiga is easily triggered, their flight distance is long, and they are unable to make quick turns or to quickly stop. This and the fact that they can also reach speeds of up to 80 km/h will have to be taken into consideration when planning enclosures.

For the least amount of management and intervention and for near-natural behaviour saiga require very large spaces, such as at San Diego Wild Animal Park. Inevitably, the 20 ha mixed exhibit in San Diego provided ideal conditions in terms of space. On such very large areas – if other necessary conditions are met – the typical hurdles of saiga husbandry can be eliminated. However, such large areas are rarely available and they have the consequence that if saiga need to be caught, the methods used have to be much like in the wild. An area of around 4000 m^2 (as at Oklahoma City Zoo) and upwards with suitable depth for distance from the perimeter has already proven to be large enough for leaving one breeding male in with a group of females for the whole year. It also allows for larger groups of females, which are more suited to the saiga's gregarious nature. The animals will be able to reach their maximum speed, but will be more likely to have enough space to slow down and turn before they collide with the fence.

Below a certain enclosure size – which still remains to be determined – the male will probably have to be removed for certain periods, but behaviour may otherwise be relatively natural. In Berlin (1,800 m^2), the breeding male attacked calves, and was later always removed before the calves were born (POHLE, 1974). The space was safe enough for females in the breeding season, when they were chased by the male. The animals will gain considerable speeds in enclosures comparable in size to the one at Tierpark Berlin, but may no longer be able to avoid collisions unlike in much larger enclosures. The fence design will have to take this into account. In Berlin, a pregnant female broke through the wood lattice fence on one occasion – which importantly did not have a visual barrier –, and had to be chased and captured. It survived without major problems, but aborted.

In small enclosures of a few hundred square metres – such as in Cologne – intensive management is required with males only allowed in for the breeding season, with constant supervision to ensure that the male does not injure or even kill any female. Behaviour will not be close to natural. This setup is ideally only suited for hand-reared animals. Hand-rearing reduces stress levels, which have been found to be far higher in saiga kept in small enclosures. Great care must be taken to reduce visual stimuli and all other stress factors to avoid regular injuries. Although animals will not be able to reach great speeds in smaller enclosures, they will more often jump into the fence. Fence design is therefore acutely critical. Saiga – at times seven females – were kept in an enclosure in Cologne, which was much smaller than the one in Berlin and other cited collections, yet the animals bred regularly and their longevity was not worse than elsewhere. Animals born in Cologne were never hand-reared, although the imports probably were.

Enclosure shape

Saigas not only need large spaces, but ideally need an appropriate distance from the perimeter of the enclosure in order not to be stressed. The sight and proximity of predators and groups of humans causes considerable stress to saiga even if they are hand-reared. For ideal use of space, this means either a square or better still, a hexagonal or circular enclosure. Past experience suggests that enclosures with curving sides and visual barriers reduce the likelihood of trauma. A small oval-shaped enclosure was used in Oklahoma City to house a breeding group of hand-reared saiga.

Fencing

Injuries suffered by saiga when colliding with fences were among the most frequent causes of mortality and injuries in zoological collections in the past, and finding a suitable fence design that minimises losses is key for the success of a breeding operation.

As DOLAN (1977) writes, the best solution would be moated enclosures, i.e. no fences at all. Water moats are probably the only solution that can gently slow down saiga without any physical impact involving a risk of injuries. As moats were not used in any documented saiga husbandry efforts, no specific design requirements are known. It is important to consider that saiga are good swimmers, and will readily enter the water. For this reason, it has to be ensured that saiga cannot leave the water on the external side and/or a fence needs to be built on the outer perimeter. This is also recommended against predators. Vegetation in and around the moat may offer grazing or browsing options and serve as a visual barrier. A potential risk factor here is the threat of infections and diseases generally linked to stagnant water in and around the moat.

All well-documented saiga breeding efforts used fences, and not moats. The fences used varied in design. Chain-link, wooden planks, diagonal wood lattice (Tierpark Berlin), or concrete and stockade (Oklahoma City), and game fence (Cologne) were all used. While all these fences were adequate for containing saiga, they did not minimise the risk of injuries or provide a visual barrier in every case.

Independent of the size of the enclosure, a fence design is required that is strong enough to withstand the impact of a saiga colliding with it, and flexible and otherwise safe enough to stop the animals without causing severe injuries and without entanglement. The speeds the animals reach will vary e.g. depending on enclosure size, but so far no fence or enclosure design, or husbandry methods have managed to completely stop saiga from jumping or running into fences.

The solutions used in the most recent programme in Cologne appear to have eliminated some of the biggest problems. A loosely fastened, flexible game fence with large mesh-size was used with fence posts outside the enclosure, and vegetation on the outside as a visual barrier. This design has the potential to reduce injuries, but 29% of deaths were still caused by trauma (RDUCH et al., 2016). While this may have been due to the fact that the enclosure was small, which stressed the animals, it is important to note that the speeds that they could reach were far from the maximum. One obvious disadvantage of this solution was that it did not protect against predators.

The height of the fence is not critical from the point of view of containing saiga, as they do not jump over structures according to past experience. Several different heights have been used between 1.60 m (Cologne) to 2.1 m (Oklahoma City), and even the lowest were adequate. It is likely that fences lower than 1.60 m would be sufficient to contain saiga. For protection against predators however higher fences will be needed.

Saiga have evolved to spot predators in the steppes from great distances before they themselves are spotted, and their flight response to such visual stimuli is to run away at great speed in a straight line. In captivity, this means that if saiga are exposed to movement around the perimeter of their enclosure e.g. by visitors, they will have an increased tendency to run into the fences. This instinct is very strong, and only hand-rearing can tone it down to a certain extent (RAMSAY, 1992). For this reason, visual barriers are an essential part of every fence design in saiga enclosures. A solution used in Oklahoma City was to cover the lower part of the fence with e.g. wooden planks (1.2 m out of 2.1 m), which however is not safe for the animals. As the ideal saiga fence is itself flexible, the visual barrier used should either be solid and on the outside, or flexible, and installed on the inside of the fence. Installing a flexible visual barrier on the inside would be preferable, as it could also be used to reduce the likelihood of cuts and potentially add some padding. A solution used in Mexico at the breeding centre of the similarly flighty peninsular pronghorn antelope (*Antilocapra americana peninsularis*) was shade cloth installed on the inside of deer fence (source: personal communication with Jeff Holland, CCTU).

Substrate, vegetation and landscape

Based on past experience, it can be assumed that the use of a hard, dry substrate in saiga enclosures provides several benefits. One advantage is that it reduces the need for hoof trimming. An even more significant factor is that wet or waterlogged soil is more likely to have a high parasite and germ count, to which the saiga is particularly susceptible in captivity. Saiga

are naturally adapted to dry heat and frosty conditions, and may also get chilled on wet ground in colder weather.

In the mild, wet climate of Cologne, Germany, the use of dolomite and an area with sand proved beneficial in combination with appropriate cleaning and regular anthelmintic treatment.

It is recommended to provide saiga with a grassy area for grazing as would be natural, which is however mostly possible in much larger enclosures than the one in Cologne. As saiga are a steppe species, and need open landscapes, they do not require trees or dense vegetation.

Flat open spaces – as in the wild – are best to house saiga antelopes. A slight elevation in the middle can be assumed to give them more feeling of security by providing a good view over the whole enclosure, and may also serve as an internal visual barrier useful in enclosures where males are left in for long periods or the whole year. Steep hillsides are not ideal for saiga, although they have been kept in the past on more gently sloping terrain e.g. in Oklahoma City and in Los Angeles. A slight incline also has the benefit that excess water will flow off the enclosure's surface.

Stalls

Saiga are a naturally resilient species and can tolerate extreme weather conditions. They are generally reluctant to enter enclosed spaces, and will not voluntarily use stalls even at night and even in the coldest weather. In cases where they had to be locked in for the night for their own safety, it caused considerable stress to the animals, and not rarely they could not be made to enter their stalls. Keepers in Cologne tried to use food to attract them inside, but the animals were very nervous as they entered the stalls, frightened very easily and then darted out onto the enclosure. Calves can be carried inside without problems even if not hand-reared (source: personal communication with saiga keeper Karl-Heinz Vogel at Cologne Zoo). To avoid the animals running into corners, the stalls in Cologne for both the breeding male and the females had a circular design (RDUCH et al., 2016).

Structures open on one or more sides are more readily accepted, and will be used for resting, giving birth or feeding (RAMSAY, 1992).

3.4 Breeding

Breeding saiga in captivity as such is not difficult based on past experience; it is rather keeping them alive for the natural length of their lives that proved a challenge. That said, their breeding success in captivity did not reach the same levels as in the wild.

Females are sexually mature by the breeding season following their birth at less than 1 year of age, while males are sexually mature by the second breeding season following their birth.

Due to the aggression of the males, only one breeding male may be kept in the same enclosure in the breeding season with the females. When females are receptive, they show a typical tail-wagging, which is a sure sign that the male can be allowed in with the females. It was however common practice to allow the male in before the breeding season, if they were kept separately. In Cologne – where the climate is relatively mild and wet – it was found that a cold spell brought on the breeding season usually in late December (RDUCH et al., 2016).

Males relentlessly drive and buck females in the breeding season. For this reason, it was common practice to cover the tips of the males' horns with a piece of rubber hose or a knob for more safety. During that time males often vocalise, their nose is swollen, and they move with a typical gait that makes the swollen nose wobble. In small enclosures of a few hundred square metres the chasing may increase the risk of injuries, and to allow females some rest, the male should be separated at night. With increasing enclosure size the problem becomes less expressed. Copulation may take place during the day or night, and is brief. If the females become pregnant, the tail-wagging stops, and the male stops driving and bucking them. If they do not become pregnant, they will come into oestrus a second time in the same season. In Berlin the observation was made that females still receptive were herded into a separate group within the enclosure by the male, with all chasing and bucking only directed at them. Females assumed already pregnant took no notice of the chase (POHLE, 1974). As males may attack calves, it is advisable to separate them before the birthing season in the spring/early summer in smaller enclosures. Only in large enclosures such as at San Diego – 20 ha – or at Oklahoma City Zoo – 4,197 m^2 and 8,998 m^2 – can one male be left with the females all year round. Unlike in the wild, males may continue feeding during the breeding season, but will show signs of exhaustion when driving females in large enclosures.

In their first breeding season, females usually give birth to a single calf, while later births are mostly twin births in the wild (BEKENOV et al., 1998). The regularity of twin births seems to be lower in captivity. The observation was made in Oklahoma City – where saiga were kept in enclosures of different sizes – that smaller enclosure sizes result in a lower number of twin births and an increased incidence of birth complications (RAMSAY, 1992). Twin births were also rarer in Cologne than in the wild (RDUCH et al., 2016). This is of potential significance for future breeding programmes.

At an average length of 138 days, twin pregnancies were found to be slightly shorter than single-calf ones (average 143 days) in Cologne (RDUCH at al., 2016). On the whole, only a small ratio of births involved complications at any collection. Births were recorded both during the

day and the night. In Oklahoma City and Cologne, about half of the offspring were males, and half of them females.

3.5 Hand-rearing

Hand-rearing of saiga in captivity is not considered difficult and is well-documented. It has both risks and benefits for management in captivity.

On the one hand, there is a risk in hand-rearing due to the potential of males for extreme aggressiveness. The character of males varies, but there is a definite potential for them to become dangerous even to their keepers. Adult male saiga may attack keepers in the breeding season even if dam-reared, and hand-rearing may further increase aggressiveness towards humans. As saiga are fragile, keepers protecting themselves (e.g. with shields) may inadvertently injure the animals.

However, hand-rearing increases tolerance towards humans and hand-reared saiga also tolerate smaller enclosures as was found in Oklahoma City (RAMSAY, 1992). Another great advantage is that hand-rearing reduces stress. In such a highly strung species, this is of the essence, and can reduce the number of collisions with fences and the resulting injuries, will make day-to-day work with the animals and in the enclosure safer, and makes for easier and safer transportation. Reduced stress levels also make chemical immobilisation safer.

It is important to note that hand-rearing as referred to in this section is understood to mean hand-rearing at the place or institution of birth for later management at the same place, or in the same environment. Marked differences were namely found between imported and hand-reared animals e.g. in Oklahoma City, whereas – as reported by POHLE (1974) – all saiga imported from Russia, therefore also those imported by Oklahoma City Zoo were hand-reared, only not there, but at or close to the site where they were captured soon after birth in Russia. This means that these animals were transferred to a new location, a new environment in a new climate zone as juveniles, and whatever differences were observed, were due to the change in environment, and not hand-rearing. A trend observed at Cologne Zoo also seems to confirm that a change in environment has a significant impact on saiga. It was namely observed there, that in females born in Cologne and dam-reared, the ratio of twin births was 43%, and 78% of their offspring were twins. In contrast, the ratio of twin births is females born elsewhere and transported to Cologne was only 12% with 21% of their offspring twins (RDUCH et al., 2016). This is a significant difference, and confirms the general belief that saiga are difficult to establish in new environments.

To eliminate the detrimental effects of a change in the environment and the possible delay it may cause in breeding efforts, it should be considered to transport saiga to new locations

– if necessary – before weaning. Also more research is required into the potential impact of hand-rearing successive generations of saiga on the nursing behaviour of females. It can be assumed that paddock-rearing, when animals have contact with and are also fed by keepers, but raised with their mother in the herd could potentially reduce the impact on social or reproductive behaviour.

In the light of the obvious benefits and trends, it is recommended to incorporate hand-rearing into captive breeding efforts, although more research will be needed on its long-term impacts.

3.6 Separation of males due to aggression

Saiga males are very aggressive and capable of causing fatal injuries to each other and females during the breeding season. In the wild, they often become so weakened by the fights with other males, by chasing the females and protecting their harem that they die at the end of the breeding season. They also often stop feeding for this period, which also weakens them. In captivity, the management of males therefore requires particular attention from the keepers. Saiga males have been known to attack and cause injury even through a wire-mesh fence. For this reason, it is recommended to physically and visually separate males from each other during the breeding season to avoid stress and losses. The males' horns were often trimmed and capped for protection in the past (RAMSAY, 1992; RDUCH et al., 2016), which is recommended in most captive setups.

Most institutions that kept saiga had to separate breeding males from females for long periods during the year. The length of separation varied depending on the character of the given male and the size of the enclosure. In small enclosures, males were usually allowed in with the females only immediately before or at the beginning of the breeding season and removed before the calves were born. In Cologne, the male was also separated during the night in the breeding season to allow the animals some rest. Even in Berlin, on a 1,800 m^2 enclosure, the male had to be separated after it attacked new-borns. Only in the largest enclosures – e.g. as seen in Oklahoma City and San Diego – can males be left with the females, and only one of them. In such a setup, male offspring has to be moved to a different enclosure in the autumn following their birth.

Two bachelor herds – the only documented ones – were maintained at Oklahoma City Zoo in small enclosures (slightly above 300 m^2), with some males removed for breeding each year, and reintroduced at the end of the breeding season. This meant that the hierarchy had to be re-established after every re-introduction, when breeding males were in a weakened state. Temporary visual barriers were installed for this period inside the enclosures. Young males

raised together tolerated this setup better than males of different ages in the same group. However, experience suggests that creating bachelor herds of saiga involves considerable risks, and as aggressive behaviour will inevitably occur, close supervision is required to avoid fatal incidents. Losses are to be expected.

3.7 Population management

The saiga's high reproductive rate and short lifespan may represent a difficulty in captivity in the sense that a large number of unrelated founders, very frequent animal exchanges and large numbers of animals at single institutions are needed to avoid inbreeding and to keep the populations going despite potentially significant losses. The aggressiveness of the males however makes keeping sufficient numbers of breeding males for acceptable levels of genetic diversity at any one collection difficult. Even in large enclosures as in Oklahoma City – which are ideally required even for small herds – only one breeding male may be kept with a group of females. The shorter lifespan of males further complicates things. Rotating males between collections before every breeding season would be a possible solution, but it would require a large number of institutions with successful breeding groups, and close, potentially centralised cooperation and a studbook. This was never the case in the past. In Cologne, e.g. there were several years, when there was no breeding male in the herd.

One potential solution to the difficulties related to keeping large numbers of the aggressive males at any one facility would be artificial insemination. More research is needed as regards the harvesting and storage of the semen of wild saiga males for the purpose of introducing new bloodlines into captive populations without any pressure on wild populations. Harvesting semen from captive males, and storing and exchanging samples between breeding operations would enable single facilities to keep smaller numbers of males, as the females could still be bred from even if critical losses occur. This would also help avoid transporting potentially very aggressive adult male saiga over large distances, which is considered risky for both the animals and the humans involved. Another advantage is that genetic material can be cleaned of any pathogens, and can be transported even if adult animals cannot be due to trade regulations and diseases (source: personal communication with Dr Derek Clelland).

If breeding operations manage to achieve birth rates close to wild levels in captivity with a high number of twin births, and losses are successfully reduced to minimal levels, the problem of excess males will become acute within just a few years, even if individual breeding groups at any one facility remain small, and we assume that no females will be lost before they can breed. One solution to this issue could be to allow the culling of excess males. In order not to lose genetic diversity, semen could be harvested from males before culling, and stored as

necessary. In the range states, the carcasses could be handed over to local communities, which would probably increase the acceptance of breeding operations in local communities and reduce hunting pressure on wild populations. The horns will have to be removed in each case and disposed of in a manner that does not encourage the illegal trade in saiga horn.

3.8 Predation

Both adult and juvenile saiga have been known to be killed in captivity by predators.

At Cologne Zoo, the red fox (*Vulpes vulpes*) was the only threat and a single attack put an end to decades of saiga husbandry. Females and new-borns refused to enter the stalls one night – which is a general problem – and were killed or chased to death by a fox that broke into the enclosure in May 2006. At Los Angeles, coyotes (*Canis latrans*) killed two females in November 1990 under similar conditions. The breeding male survived in both cases as it was separated in Cologne and locked in for the night at Los Angeles Zoo.

New-born saiga are also apparently vulnerable to attack by corvids in the first 48 hours of their lives. Such fatal attacks have been reported from Chomutov Zoo (Czech Republic) and Askania Nova (Ukraine). At Chomutov, the breeding programme ultimately failed as a result, because the herd had to be moved into a smaller netted enclosure, which they did not tolerate (source: personal communication with Klaus Rudloff). At Askania Nova, crows have been known to attack a new-born while its mother was giving birth to a second lamb a few metres away (source: Saiga News, Summer 2009, Issue 9). Controlling corvids or other aerial predators may be necessary if they threaten the success of breeding efforts, as netting large enclosures is not practicable.

3.9 Diet

Saiga are grazers, their diet in the wild consists of more than 80 different plant species (BEKENOV et al., 1996), and includes grasses, herbs, shrubs and even plants that are toxic to other animals. Although this variety is impossible to reproduce in captivity, feeding saiga is not considered a challenge. They will readily graze grass or weeds in their enclosure, and accept browse, such as weeping willow (*Salix spp.*) or poplar (*Populus spp.*) leaves, as was seen in Cologne (RDUCH et al., 2016). They were fed different combinations of hay, pellet food, cereals, fruits and vegetables in the past. It is important to chop harder fruits or vegetables into smaller pieces, as saiga cannot seem to bite pieces off, and there are documented cases when larger pieces lodged in the animals' throat and killed them (DOLAN, 1977).

As some of the plants that saiga feed on in the wild are known to be toxic and/or have medicinal, such as anthelmintic properties (e.g. *Artemisia spp.*), it should be considered to offer such plants so captive saiga for disease control purposes.

3.10 Disease management and veterinary care

Enclosure cleaning and hygiene

On very large and natural or near-natural enclosures, regular cleaning of the whole area is neither required, nor is it practicable. It is however important to provide an area for feeding that is easy to keep clean at all times. In smaller enclosures under intensive management, the thorough daily cleaning of the whole enclosure is absolutely necessary, and is key for the health of the animals. Regularly disinfecting feeding and other structures and troughs is also recommended in all setups.

As with other sensitive ungulates in captivity, keepers should maintain good standards of hygiene at all times, and avoid carrying infections from other domestic or wild ungulates to saiga. This could e.g. involve changing clothes and disinfecting shoes before entering a saiga enclosure. It is also highly recommended to keep a distance between saiga enclosures and those of other – also domestic – ungulates.

Hoof trimming

Hoof growth varied greatly among captive saiga in the past, with some animals needing regular trimming and others none at all. The general rule also applies here that a hard, dry substrate in the enclosure reduces, although does not eliminate the need for hoof trimming. Based on past experience, it can be assumed that on a softer, sandy substrate saiga will be more likely to require regular hoof trimming even in larger enclosures, as was the experience in Berlin (POHLE, 1974).

Immobilisation

Saiga are nervous animals and easily stressed, which will have an impact on chemical immobilisation. It is best to use products proven effective and safe with agitated ungulates. Hand-rearing reduces the need for chemical immobilisation and by lowering stress levels, improves its efficiency.

Due to the flightiness and fragility of saiga, darting is not recommended in captivity. If injections have to be administered, it is best to catch the animals and then inject them by hand (source: personal communication with Jeff Holland, CCTU).

Anti-parasitic treatment

Besides the treatment of injuries caused by trauma, anti-parasitic treatment was the most frequently performed veterinary procedure in the past. Gastrointestinal parasites are reported to be very common in wild saiga, and captive saiga are similarly susceptible. As parasitic infestation weakens the immune system, infested animals may be more susceptible to infections (POHLE, 1974). It is assumed that parasitic infestation also played an important role in the high mortality rates of saiga in captivity. In the most recent saiga programme at Cologne Zoo the following active agents were used for regular anti-parasitic treatment: *Fenbendazol, Ivermectin, Febantel, Mebendazol, Sulfamethoxazole, Trimethoprim. Toltrazuril* was used against coccidia (RDUCH et al., 2016).

Although never described in any documented programmes, the use of slow-release anthelmintic regimes should be considered in the light of the saiga's susceptibility to parasites. Such solutions can achieve better results at lower, strategically timed dosages. No ungulates should be kept on the intended location of saiga enclosures for at least a year before introducing saiga, and the anti-parasitic treatment of the animals should begin before introduction to a new area to increase their resistance. (source: personal communication with Dr Derek Clelland)

It is important to monitor the consistency of faeces for early detection of parasites or infections, and routine screening for parasites should be included in the veterinary regime (source: personal communication with Mátyás Liptovszky, veterinarian, Twycross Zoo, UK).

3.11 Climate

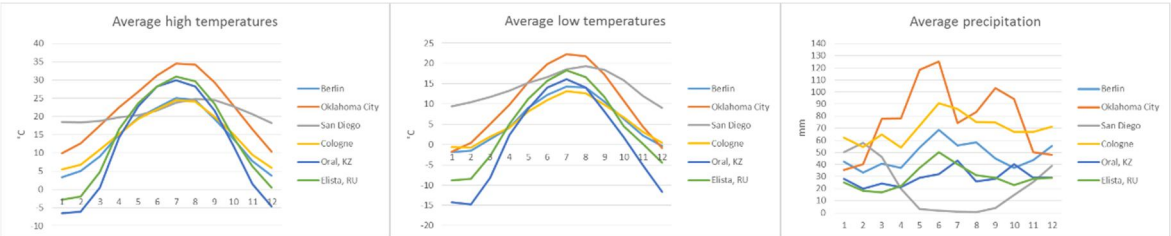
Saiga can tolerate an astonishing range of temperatures and weather conditions from severe frost to scorching heat in the wild and in captivity. They have been kept under very different climates, and – even extreme – temperatures alone did not cause any problems. There have been differences in the start and length of the breeding season, and therefore the birth of the calves, but that had no ill effect on either the adults or the offspring. In Cologne cold weather often triggered breeding behaviour in the late autumn or winter (RDUCH et al., 2016).

The amount of precipitation in combination with temperatures however is of key importance. Saiga are adapted to hot, dry, and often dusty conditions in the summer and frosty and snowy conditions in the winter. Most precipitation falls in the warmest months in their natural habitat, and the amounts are very low. Experience suggests that without intensive management, they do not tolerate mild, wet winters in captivity. The inevitably wet, muddy and soft ground in larger, natural enclosures under such climates is not suited to

their needs. They will sink into the mud when moving, and their thick winter coat will be soaked when they lie down or are in the rain for extended periods. This increases the likelihood of respiratory diseases. Wet ground under mild climates also has a greater potential for a high parasite and germ count than the soil in the saiga's natural environment, which increases the risk of diseases in captive saiga. In enclosures with a specifically prepared hard, dry substrate, good drainage, meticulous daily cleaning, and an effective anthelmintic regime they may be maintained in good condition under mild climates, as the successes of the saiga programme at Cologne prove.

In the light of the above, it is recommended to restrict breeding efforts to either the saiga's current range where conditions are known to be suitable, or choose ex-situ locations with generally low precipitation levels and dry cold or frosty winters. Breeding programmes can be successful under mild climates, but will require a much more significant investment of time and effort.

The charts below show climate data from the location of four previous well-documented saiga programmes, and reference data from Elista, the capital of the Republic of Kalmykia in Russia, and Oral (or Uralsk) in Western Kazakhstan. It is clearly visible that both winter temperatures and winter precipitation levels are lower in the saiga's native range than at the cited zoological collections (source: Wikipedia).



4. <u>Saiga programmes at a glance</u>

4.1 Tierpark Berlin, Germany

- Enclosure: off-display, rectangular, 30 m x 60 m = 1,800 m^2; 70 m^2 adjacent enclosure with feeders under a roof and two doors to the main enclosure, also for separating the aggressive male while cleaning and for catching animals
- Quarantine enclosure (transit): rectangular, approx. 1,000 m^2
- Stalls: none
- Fence type: 1.80 m tall diagonal wood lattice, no visual barrier
- Substrate: sandy soil, vegetation: weeds, no trees
- Programme duration: 1958 – 1989, 34 years

A population of European rabbits (*Oryctolagus cuniculus*) inhabited the enclosure, their dens caused no problems. One female saiga broke through the wooden fence one night, and when chased achieved speeds in excess of 65 km/h. High mortality rates, by the time diseases were apparent, it was often too late. Tierpark Berlin was a quarantine station and trading hub for wildlife from the USSR, and by 1986, 332 saigas were received. Part of this number was intended for other institutions (DOLAN, 1977).

4.2 Oklahoma City Zoo, USA

- Enclosures: altogether seven; 1969 importation herd: grassy 3,375 m^2 rectangular pen; 1977/78 importations in 2 pens, Herd 1: 4,197 m^2 (109 m x 39 m) rectangular grassy yard, Herd 2: 8,998 m^2 (170 m x 58 m) rectangular grassy yard; Hand-reared 1: 1,880m^2 flat, rectangular, grassy yard; Hand-reared 2: 297 m^2, oval-shaped, dirt surfaced yard; two bachelor herds in dirt-surfaced enclosures, like the oval enclosure of Hand-reared 2, but slightly larger
- Stalls: unheated barns, rarely used; pole barns enclosed on 3 sides, more often used
- Vegetation: bermuda grass (*Cynodon dactylon*) in grassy enclosures
- Fence types: combinations of the following: 2.1 m chain-link fence, concrete with chain-link on top, 2.1 m chain-link with the lower 1.2 m covered with wooden planks, 2.1 m wooden planks, 1.8 m chain-link, 1.65 m stockade
- Programme duration: 1969-1974, 1977 - ?

The only documented programme with two bachelor herds and several different enclosures. An outbreak of Johne's disease required hand-rearing all offspring of infected adults to prevent their infection, and the euthanasia of several adults (one whole group among others).

4.3 San Diego Wild Animal Park, California, USA

- Enclosure: 20 ha mixed exhibit
- Stalls: none

Interspecific conflict on one occasion: a male blackbuck (*Antilope cervicapra*) injured a male saiga.

4.4 Cologne Zoo, Germany:

- Enclosure: rectangular, 20 m x 32 m = 640 m^2; smaller adjacent pen for the breeding male separated by a sliding door
- Stalls: round stalls with no internal separation; separate round stalls for the breeding male
- Fence type: 1.60 m tall loose game fence, vegetation on the outside for visual barrier

- Substrate: dolomite with a patch of sand; vegetation: sparse grass and weeds, two weeping willow trees (*Salix spp.*)
- Programme duration: 1976 – 2009, 33 years
- Total number of animals kept: 99 (51.48)

The saiga were herded in each night for protection against foxes, but were very reluctant to enter the stalls. Excess males were kept off-display. The enclosure is surrounded by vegetation on all sides, visitors look down on it from the path. The enclosure still exists unchanged, and houses goitered gazelles (*Gazella subgutturosa*).

5. Key figures

PLEASE NOTE that the data for Oklahoma City Zoo is not directly comparable due to the great number of different types of enclosures and groups of animals. It is hoped that missing data can be added in the future.

	Tierpark Berlin (up to 1974)	Oklahoma City Zoo (1977-78 import, breeding groups)		San Diego Wild Animal Park (mixed exhibit)	Cologne Zoo
Enclosure size, m2	1800	8998 (i)*	1880 (hr)**	200000	640
		4197 (i)*	297 (hr)**		
Average age, m (y)		1.3 (i)*			2.6
Average age, f (y)		3.1 (i)*			4.3
Longevity record, m (y)					8.8***
Longevity record, f (y)		10.5 (i)*			10.05
Earliest birth	3 May	16 April			April
Most births	May	May		May	May
Latest birth	2 June	21 July			June
Cause of death: trauma					29%
Cause of death: gastrointestinal disease					21%

*i – imported **hr – hand-reared *** minimum, exact date uncertain

6. Conclusion

Although zoos and the captive management of ungulates have come a long way since the first documented saiga breeding efforts also cited here, the saiga antelope remains one of the most difficult ungulates to maintain in captivity. Its unique characteristics demand husbandry practices specifically adapted to the species' needs. Based on the above described previous

experience, the combination of the following factors are decisive for successful breeding programmes:

- Appropriate number of founders in several breeding groups at any one location taking into account potential initial losses, and the short-lifespan of particularly the males
- Adequate solutions for managing the aggressiveness of males towards other males, females and keepers
- Eliminating sources of stress as much as possible
- Incorporating hand-rearing and/or paddock-rearing into long-term breeding efforts
- Maintaining good standards of hygiene
- Regular and effective anti-parasitic treatment
- An integrated approach to designing enclosure systems at breeding facilities and zoos with consideration to the combined impact of enclosure size, enclosure shape, fence design, substrate, and moving males between enclosures safely and with the least amount of stress
- Protection from both land and aerial predators
- Setting up breeding operations under suitable climates
- Potential use of culling and artificial insemination to manage captive populations

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