EAZA
Best Practice Guidelines
OKAPI

(Okapia johnstoni)

Illustration ©Natalya Zahn

ZOO ANTWERPEN

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Taxon Advisory Group: EAZA Antelope & Giraffid TAG

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EAZA Best Practice Guidelines

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EAZA Preamble

Right from the very beginning, it has been the concern of EAZA and the EEPs to encourage and promote the highest possible standards for the husbandry of zoo and aquarium animals. For this reason, quite early on, EAZA developed the “Minimum Standards for the Accommodation and Care of Animals in Zoos and Aquaria”. These standards lay down general principles of animal keeping, to which the members of EAZA feel themselves committed. Above and beyond this, some countries have defined regulatory minimum standards for the keeping of individual species regarding the size and furnishings of enclosures etc., which, according to the opinion of authors, should definitely be fulfilled before allowing such animals to be kept within the area of the jurisdiction of those countries. These minimum standards are intended to determine the borderline of acceptable animal welfare. It is not permitted to fall short of these standards. How difficult it is to determine the standards, however, can be seen in the fact that minimum standards vary from country to country.

Above and beyond this, specialists of the EEPs and TAGs have undertaken the considerable task of laying down guidelines for keeping individual animal species. Whilst some aspects of husbandry reported in the guidelines will define minimum standards, in general, these guidelines are not to be understood as minimum requirements; they represent best practice. As such the EAZA Best Practice Guidelines for keeping animals intend rather to describe the desirable design of enclosures and prerequisites for animal keeping that are, according to the present state of knowledge, considered as being optimal for each species. They intend above all to indicate how enclosures should be designed and what conditions should be fulfilled for the optimal care of individual species.

Preface

The okapi is one of the most elusive and unique animals in the world, hence its nickname the "African Unicorn". Native to the dense jungles of the Congo Basin it was completely unknown to modern science till the beginning of the 20th century – and it was only photographed for the first time in the wild in 2008! Unfortunately, the okapi is threatened by extinction and still very little is known about this species. Therefore, the *ex situ* okapi population has a high intrinsic value for the conservation, research and education of this unique creature for future generations. In that regard, zoological institutions must strive to provide and achieve the best conditions for animal welfare and husbandry using the best knowledge and expertise available. The first EAZA *Ex-situ* Programme (EEP) Okapi Husbandry Guidelines dates from 1989 and the Association of Zoos and Aquariums (AZA) published its Species Survival Plan (SSP) Okapi Husbandry Manual in 2004. Nearly 20 years later and with an increase in the number of current and future holders of the species, there was an increasing need to publish husbandry guidelines updated to the existing knowledge and practices with okapi and with a special focus on European standards. The backbone of these current EAZA best practice guidelines is the information present in the SSP Okapi Husbandry Manual (DeRosa *et al*., 2004) properly updated with the opinions and ideas of experts from European zoos and with most of the published research available about okapi. The EAZA husbandry and management guidelines for giraffes (EAZA Giraffe EEPs, 2006) were also of great help with some topics. With these best practice guidelines, each zoo should be able to learn enough about the okapi to create an environment for its animals that keeps them mentally and physically healthy and helps to achieve the EEP's goals and the conservation of this endangered species.

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We want to express special gratitude to the following people:

We are deeply thankful to Jennifer Wondergem who collected the opinions of several experts working with okapi in European zoos for her thesis. This valuable work was incredibly helpful for the development of this document.

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The editors would like to acknowledge that this EAZA Best Practise Guidelines for okapi took some useful inspiration and knowledge from the Okapi SSP which was simultaneously working on its AZA Okapi Husbandry Manual and thus thank all their contributors for the precious sharing of information to these EAZA guidelines. Any amendments made to content during the development of these EAZA Best Practise Guidelines have not been endorsed by those contributors.

Finally, the EEP coordinator would like to conclude with some good advice for EEPs that struggle to find the time to generate Best Practice Guidelines. Take help from motivated students! João Pedro Gomes Meireles is a Master Student of Environmental Biology: Behavioural Ecology, based at the Graduate School of Life Sciences at Utrecht University. If João had not been there, writing the BPG would have been an almost impossible task to combine with daily work. Thank you, João. You can be proud of this piece of work.

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Summary

1. Biology and Field Data

This chapter includes the best information we currently have about the biology and ecology of the okapi in its natural environment, including morphology, taxonomy, evolution, physiology, habitat, ecology, reproduction and behaviour. It also gives some insights into its current threats and the conservation efforts for the species. Due to its elusive nature, most of what is known was obtained from captive animals.

2. Management in Zoos

This chapter includes what in the view of the current knowledge and the professionals working with the species can be considered best practices and recommendations. It covers enclosure design, feeding, social group, breeding, hand-rearing, behavioural management, handling, transport and general veterinarian care. It also raises questions and necessary research that will help to increase our knowledge and fill the gaps we have about the okapi.

Abbreviations and Acronyms Glossary

AZA – Association of Zoos and Aquariums (North America)

AZF – Antwerp Zoo Foundation

CITES - Convention on International Trade in Endangered Species

DRC – Democratic Republic of Congo

EAZA – European Association of Zoos and Aquariums

EEP – EAZA *Ex situ* Programme

FZS - Frankfurt Zoological Society

IATA - International Air Transport Association

ICCN – Institut Congolais pour la Conservation de la Nature

IUCN - International Union for Conservation of Nature

JAZA – Japanese Association of Zoos and Aquariums

OCP – Okapi Conservation Project

OWR – Okapi Wildlife Reserve

SSP - AZA Species Survival Plan

TAG – Taxon Advisory Group

WCS – Wildlife Conservation Society

ZIMS - Zoological Information Management System

ZSL – Zoological Society of London

1. Biology and Field Data

Figure 1 – Wild male okapi with scarring most probably from a leopard attack. Leopards are the okapi's main predator - especially on young okapi. *©Okapi Conservation Project / Location: Democratic Republic of Congo*

1.1 Biology

Figure 2 - Illustration from an original painting by Sir Harry Johnston, who depicted the animal based on preserved skins. Lithograph by P. J. Smit - Proceedings of the Zoological Society, 1901, London, United Kingdom

1.1.1 Taxonomy

Scientific Classification and Binomial Name

The okapi (*Okapia johnstoni*) belongs to the Mammalia class and is classified among the even-toed ungulate order, traditionally known as Artiodactyla. New anatomical and DNA evidence on the relationship between Artiodactyla (even-toed ungulates) and Cetacea (whales and dolphins) recently led to a merging of the two orders into a new group; Cetartiodactyla (Kulemzina *et al.*, 2009) (Figure 4). The okapi belongs to the Ruminantia suborder, which is one of four suborders in the Cetartiodactyla order (Price *et al.*, 2005). Among the Ruminantia suborder, the family Giraffidae is found. This family, endemic to Africa, consists of the savannah-dwelling giraffe (Genus *Giraffa*) and the forest-dwelling okapi (Fernandez and Vrba, 2005). The okapi is the only species in the *Okapia* genus (Figure 4).

Philip Lutley Sclater gave the okapi the binomial name *Okapia johnstoni* in 1901. The generic name *Okapia* is either a borrowing from the Mbuba language name okapi or the related Lese Karo language name “o'api” with the specific name *johnstoni* being given in recognition of the first scientific discovery of the species by Sir Harry H. Johnston in 1901 (Mallon *et al.*, 2015; Lindsey *et al.*, 1999). Besides okapi, common names for *Okapia johnstoni* are forest or Congolese giraffe.

Scientific Classification

Figure 3 – Okapi. *©Wilhelma Stuttgart*

Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Cetartiodactyla
Suborder	Ruminantia
Superfamily	Giraffoidea
Family	Giraffidae
Genus	*Okapia*
Species	*O. johnstoni*

Binomial Name

Okapia johnstoni (P.L. Sclater, 1901)

Synonyms

Equus johnstoni (P.L. Sclater, 1901)

Common Names in English

Okapi
Forest giraffe
Congolese giraffe

Name in Other Languages

French: Okapi
Spanish: Okapi
Portuguese: Ocapi
German: Okapi
Dutch: Okapi
Polish: Okapi leśne
Czech: Okapi

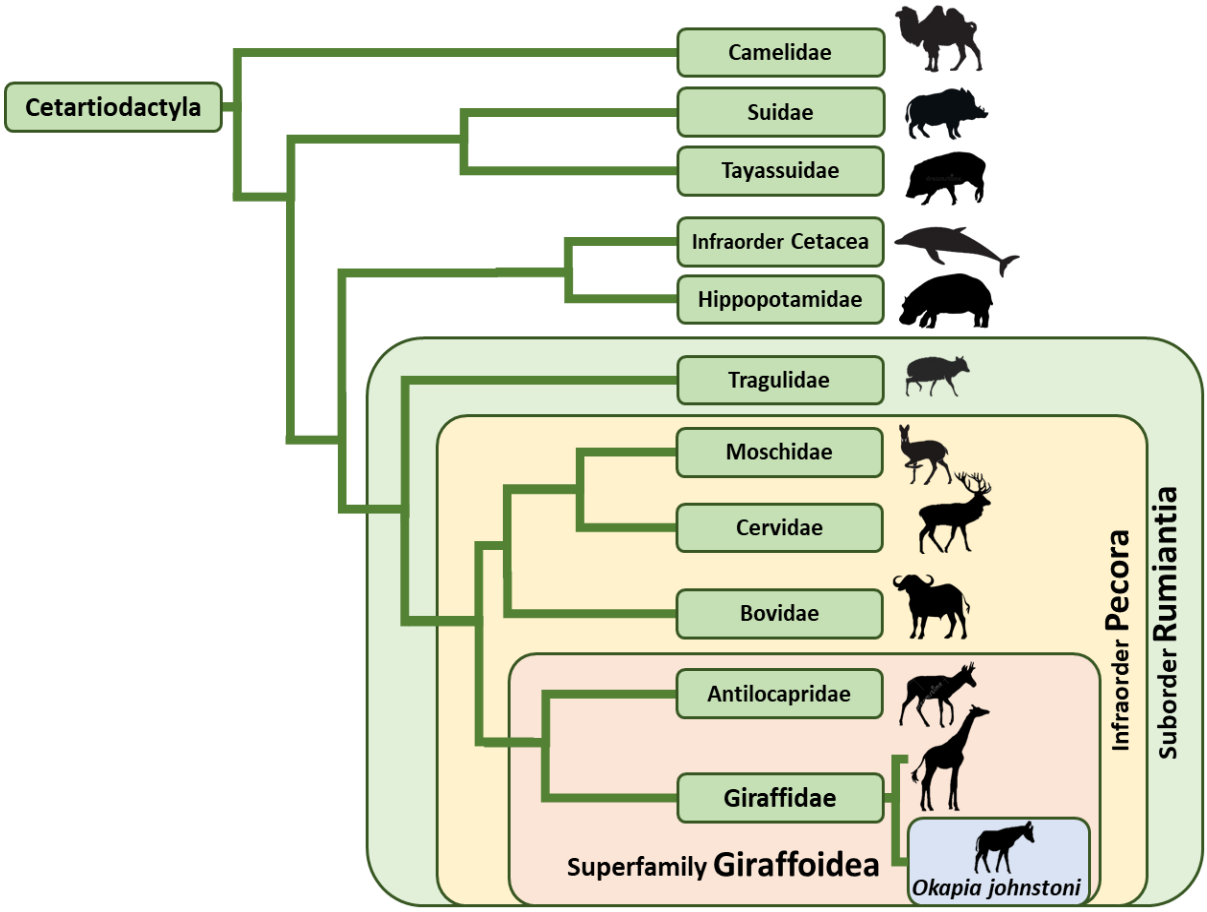

Figure 4 - The position of the okapi in the phylogenetic tree of the Cetartiodactyla order. Adapted from Prince *et al.* (2005). Branches' lengths are not proportional to time. *©João Pedro Meireles*

Figure 5 - Illustration of the Okapi together with its closer living relative, the Giraffe (*Giraffa spp.*) *©Liberty Shilton*

Evolutionary History and Close Relatives

The closest relative to the okapi is the giraffe (Genus *Giraffa*). The two animals look very different at first sight, with the giraffe being much larger and having a much longer neck and legs (Figure 5). Nevertheless, they share some common morphological features, including a long dark-coloured tongue, lobed canine teeth, and horns covered in skin that never shed, called ossicones. The okapi misses the specialised genetic and cardiovascular adaptations that are associated with the giraffe's longer neck (Agaba *et al.*, 2016). Genetic studies found that the last common ancestor of the giraffe and the okapi lived about 11.5 million years ago (Agaba *et al.*, 2016). With only the okapi and the giraffe as its extant members, the family Giraffidae was once much more extensive, with over 10 fossil genera described. The earliest members of the Giraffidae family first appeared in the early Miocene in Africa, around 20 million years ago, and were small and short-necked, resembling deer (Figure 6). From here, giraffids spread into Eurasia by the middle Miocene but today the group is restricted to Africa (Mitchell and Skinner, 2003). It has been suggested that the replacement of fossil giraffids in their niches by bovids and cervids was linked to the particularly slow reproduction (long gestation periods) of the giraffids (Clauss and Rössner, 2014). The closest living relative to both the giraffe and the okapi is the pronghorn (*Antilocapra americana*), being the three only living members of the superfamily Giraffoidea (Figure 4) (Chen *et al.*, 2019).

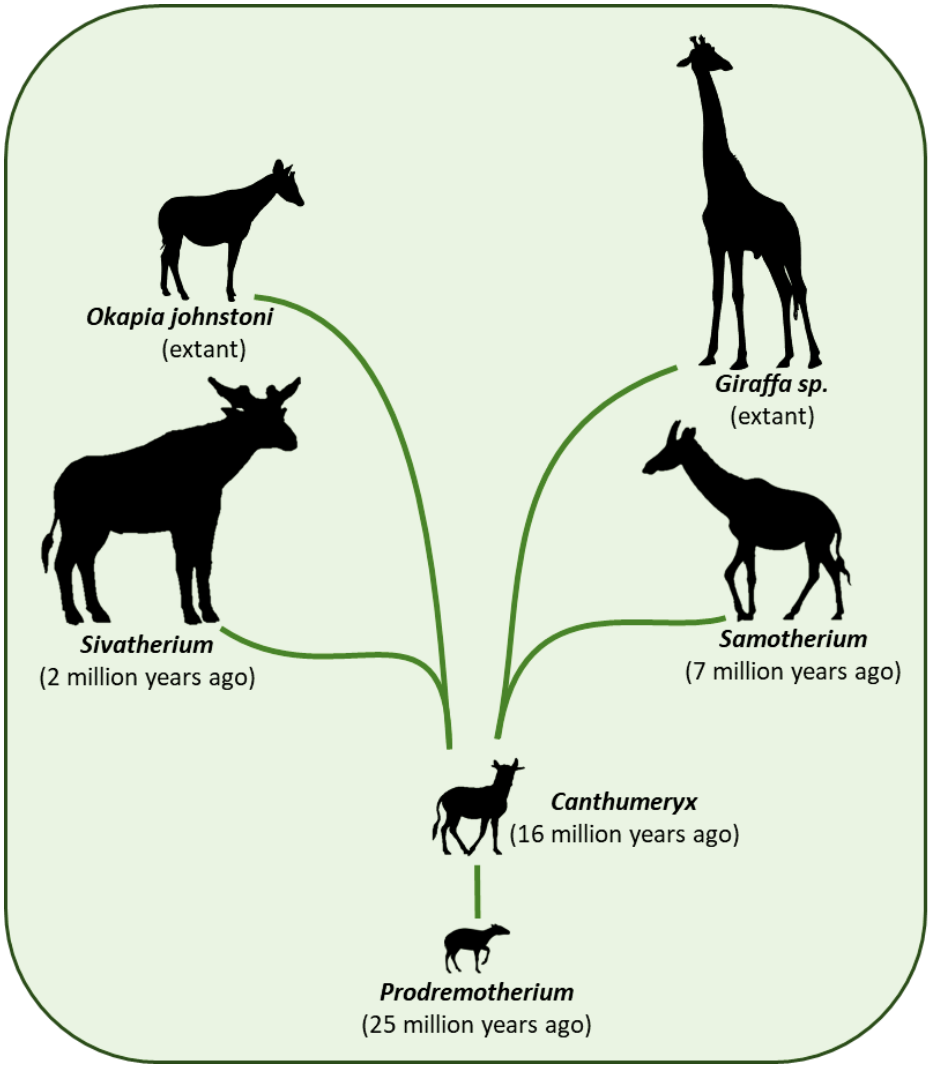

Figure 6 – Illustration of the evolutionary history of the Giraffidae with some fossil (extinct) representatives. Lines are not proportional to time and pictures do not represent the accurate real life size scale of the animals. *©João Pedro Meireles Adapted from Nikos Solounias/Melinda Danowitz. Pictures of ©Julio Lacerda, ©Meet the Fossyls and ©Nankeyike.*

1.1.2 Morphology

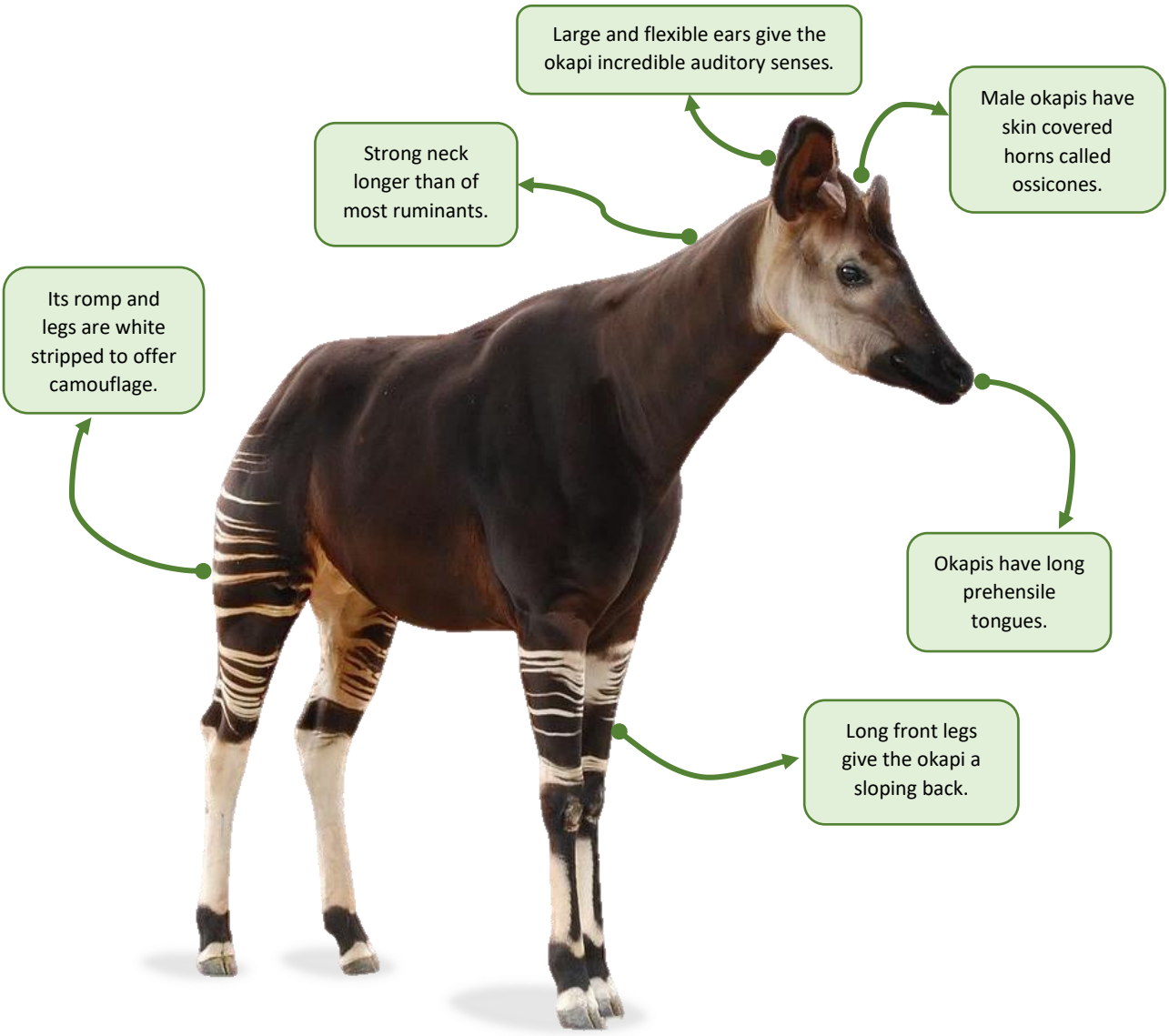

Figure 7 – Main morphological characteristics of the okapi.

Body Shape and Size

The okapi has long legs, a compact body with a sloping back, and a neck that is relatively long in comparison to other ruminants (Figure 7). The adult okapi height, as measured at the shoulders, ranges from 1.35-1.60m, with females being generally taller than males. Male body weight ranges from 180-260 kg and female body weight ranges from 240-365 kg (Hart, 2013). Infants weigh 14-30 kg at birth; a number that doubles by the end of the first month. Body length is 2.5 m on average for both males and females (Bodmer and Rabb, 1992). Sexually dimorphic characteristics found in okapi are the presence of two small horns (ossicones), which are solely found in males (Figure 10), and the slightly larger body size of the females. Okapis have two toes on each hoof that come to a slight point in the

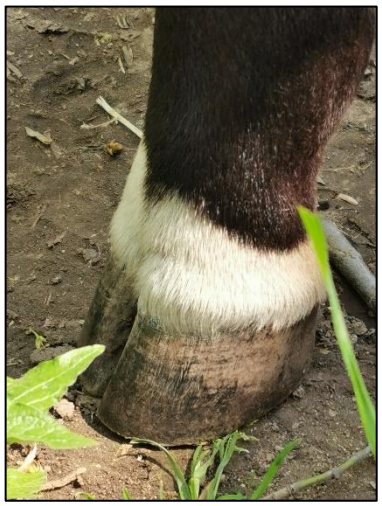

Figure 8 – Okapi foot. *©João Pedro Meireles / Location: Cologne Zoo*

front (Figure 8). Directly above and between the hooves is a small scent gland that is lined with hair (Figure 9).

Figure 9 – Blocked scent gland. *©Chester Zoo / Location: Chester Zoo*

Colouration and Coat

The okapi has a short velvety coat dark coloured in chocolate-like to reddish-brown on its body. Its coat is composed of oily hair which acts as waterproofing in the damp rainforest environment. (Skinner and Mitchell, 2011; Kümpel *et al*., 2015). It has white horizontal stripes on the legs and hindquarters and white stockings on the ankles. These stripe patterns are unique for each individual and are thought to act as camouflage by breaking up the outline of the body in the light and shade of the forest understory (Bodmer and Rabb, 1992; Skinner and Mitchell 2011). The cheeks and throat are whitish-grey or tan with a black muzzle and nostrils (Figure 11). Newborns have the same colouration and coat as adults (Hart, 2013; Bodmer and Rabb, 1992). Leucism was observed for the first time in December 2021 with a calf that was born at Al Bustan Zoological Centre (Sander Hofman, Pers. Obs.). Its coat is a light grey-brown colour with the white markings still visible. Both parents have normal colouration.

Figure 10 – Male and Female okapi. *©Antwerp Zoo /Location: Antwerp Zoo*

Ossicones

Characteristic from the giraffe family, the male okapi has at the top of the skull two ossicones, which are horn-like structures that do not shed, contrarily to the cervids' antlers (Figure 11). In the okapi, they grow from the male frontal bones while in giraffes, both sexes have ossicones on the parietal bones. These ossicones develop in okapi males after birth from cartilaginous knobs, which ossify, grow, and fuse with the skull between 1 and 5 years of age (Skinner and Mitchell, 2011). They can reach 10-15cm in length and are covered with skin and hair. Over time, male okapi may wear

Figure 11 - Male okapi. *©João Pedro Meireles / Location: Lisbon Zoo*

down their ossicones, shortening them and removing the hair, exposing the bone. Female okapis possess knobby bumps with hair whorls on the site of the ossicones, nevertheless, in rare cases, females can also develop minor ossicones.

Figure 12 - Okapi using its tongue to browse on leaves. *©João Pedro Meireles / Location: Lisbon Zoo*

Dentition and Oral Cavity

The dentition of the okapi is of the same type and arrangement as the giraffe. Totalling thirty-two teeth, the dental formula is 0/0/3/3 (incisor/canine/premolar/molar) in the upper jaw and 3/1/3/3 in the lower jaw. The premolars and molars are brachyodont (low-crowned). The canines have a lobed appearance, characteristic of the giraffe family. However, the number of lobes in the canines distinguishes the okapi from the giraffe. The okapi has two lobes, while the giraffe may have three or four lobes. There is a gap found between the front teeth and the premolars which is used to strip leaves from foliage (Lindsey *et al.*, 1999). The muzzle is elongated and tubular, with a long, muscular and prehensile tongue, allowing for the selection of particular plant parts (Hart 2013). The free part of the tongue is 42.5% of the total length, which is within the average range for a browsing species (Clauss *et al.,* 2006). The prehensile tongue of the okapi is even longer than that of the giraffe (Genus *Giraffa*), which is blue/purple darkly coloured and can be extended to a length of 25 cm, measuring in total up to 36-46 cm long (Figure 12). Some cases have been reported of okapi with a pink tongue. The long tongue allows the okapi to browse on foliage that stands up high in the forest canopy. It is also used frequently for grooming its body, ears and eyes (Skinner and Mitchell, 2011; Bubenik and Bubenik, 1990).

1.1.3 Physiology

Vital Signs

The rectal body temperatures for captive okapi calves average 38.07°C throughout the first ninety days of life (Bennett and Lindsey, 2005). The body temperature of an adult okapi is 38.5-39.2°C (Matern and Klöppel, 1995). The average heart rate ranges between 88 and 136 beats per minute (bpm) for an adult and between 100 and 112 bpm for a calf (Lindsey *et al*., 1999). The respiration rate of an immobilized sedated captive adult okapi ranges between sixteen and twenty-four breaths per minute, and that of a calf ranges between thirty-six and forty-two per minute (Lindsey *et al.*, 1999).

Sensorial Capacities

Okapi senses are particularly tuned for tropical forests; they have a high proportion of rod cells in their retina, which can be considered an adaptation for low-light vision. They also have a good olfactory system (Bubenik and Bubenik, 1990). Like with the giraffe, it has been suggested that okapi use their tongue to investigate novel stimuli and explore their surroundings similar to humans using their hands for touch (Bashaw *et al.,* 2001). Okapis also have well-developed auditory lobes in the brain, large

flexible ears, and large auditory bullae (hollow, thin-walled bony prominences), which suggest the okapi is equipped with a greater ability to perceive and locate sounds. Okapi's ears can move independently of each other (Lindsey *et al.*, 1999). Sound communication includes the use of chuffs, moans, snorts, bellows, and bleats. Okapi can also produce infrasonic vocalizations which reflect a range of hearing different from that of humans (Lindsey *et al.*, 1999).

Digestive Physiology

The okapi is a strictly browsing ruminant (Cerling *et al.*, 2003; Hummel *et al.*, 2005). Ruminant mammals have a complex, compartmentalised stomach (Figure 13), in which the plant matter consumed by the animal is fermented by micro-organisms in the rumen.

Browsing ruminants feed on the leaves and twigs of dicotyledonous plants, including trees, shrubs or herbs. Okapi do not include monocotyledonous plants (grasses) in their natural diet. Like in other browsers, short food retention times have been reported in okapi. This is an adaptation to the okapi's browsing diet in which energy is released quickly, requiring less fermentation time (Hummel *et al.*, 2005).

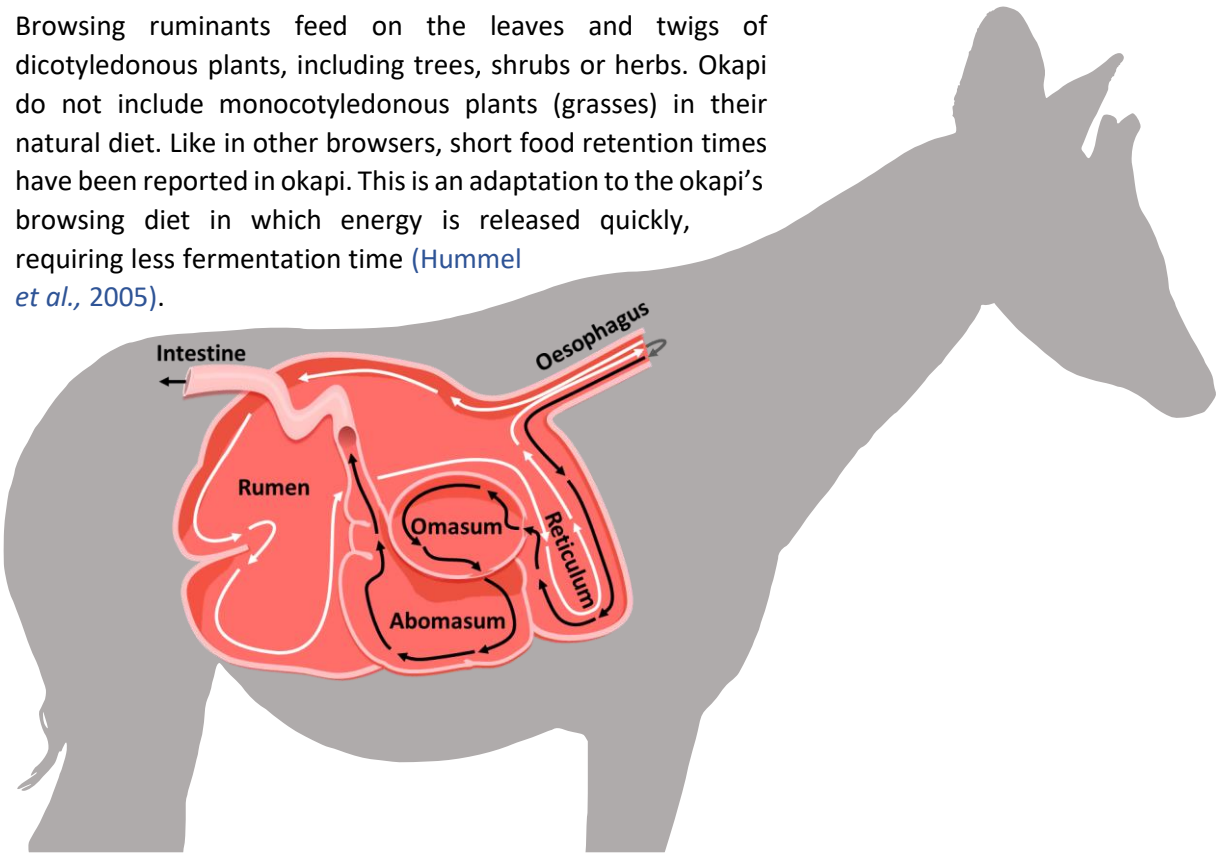

Figure 13 – Simplified diagram of an okapi's foregut, a typical ruminant. Black arrows represent the aftermath of rumination. *©João Pedro Meireles*

On the other hand, energy from grasses on grazers' diets is released more slowly, hence longer food retention times are observed. Because of the shorter length of food retention time in the gut, browsers such as okapi tend to have frequent feeding bouts (Hummel *et al.*, 2006d). Not facilitating this behaviour in captivity can result in the development of abnormal behaviour in okapi, such as stereotypies (Bashaw *et al.*, 2001).

|Mouth: The sizes of the parotid and mandibular glands (both salivary glands) are smaller in giraffids being more similar in weight to typical grazer species, rather than other browser species (Clauss *et al.*, 2006). It is speculated that these smaller salivary glands offer the okapi limited capacity to cope with secondary plant compounds and that might be one reason for its limited ecological range and the wide variety of plants consumed in its diet in the wild (Clauss *et al.*, 2006).

|Foregut: The volume capacity of the okapi's rumen and reticulum is typical of a ruminant browser. The honeycomb structure of the reticulum is relatively shallow (Clauss *et al.*, 2006; Clauss *et al.*, 2010).

The omasum is small and the reticular crest and omasal laminae are similar to that of other browser species, being lower than that of grazers (Clauss *et al.,* 2006). The protozoa community in the rumen is dominated by *Entodinium* spp. (Clauss *et al.,* 2006).

|Hindgut and other organs: The caecum and the colon assist in the microbial digestion of ingesta (Hart 2013). As in giraffes, the okapi does not have a gall bladder (Burne 1971).

Reproductive Physiology

The following section was edited by Katie Edwards and John O'Hanlon - Conservation Physiology & Reproduction team, Science, Chester Zoo.

In mammalian reproduction, the endocrine (hormonal) control of reproduction is regulated by the hypothalamic-pituitary gonadal axis. This involves the production of steroid and protein hormones that induce changes in function in target cells and promote appropriate behaviours for reproduction.

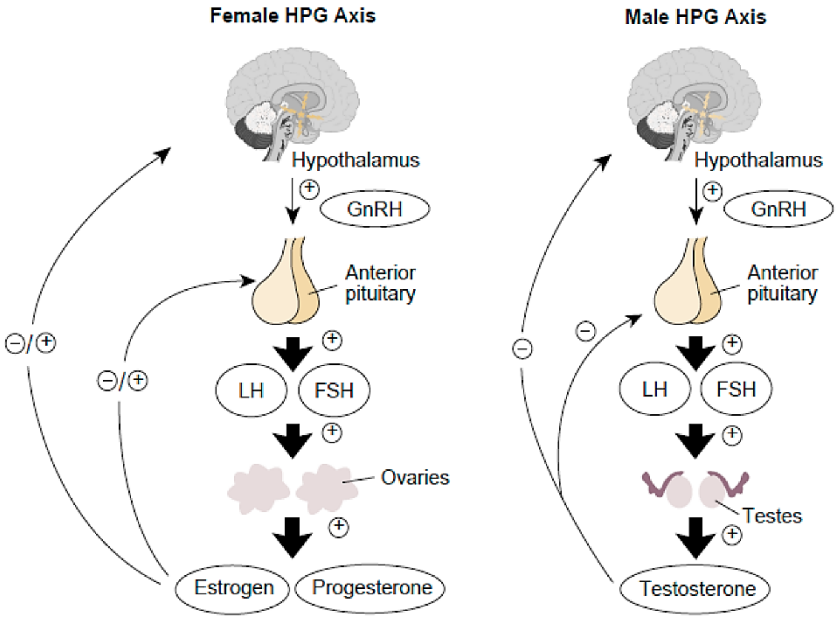

Figure 14 - Schematic representation of the hypothalamic–pituitary–gonadal (HPG) axes (Kong *et al*., 2014)

Gonadotropin-releasing hormone (GnRH) is produced in the hypothalamus, with a primary function to stimulate the release of luteinising hormone (LH) and follicle-stimulating hormone (FSH) from the anterior pituitary gland. These hormones then act on the gonads (ovaries in females and testes in males) to produce oestrogens and progesterone in females and testosterone in males (Figure 14).

|Male: In males, FSH is important for spermatogenesis (the origin and development of sperm cells), while LH stimulates testosterone production. Testosterone is important for secondary male sexual characteristics, physical behaviour and spermatogenesis. Male okapi reach sexual maturity at 2-4 years of age (Bertelsen, 2015). In males, the testes are scrotal, and the penis is fibro-elastic with a long urethral process (Bertelsen, 2015).

|Female: In mammalian female reproduction, the ovarian cycle (reproductive cycle) consists of two main phases, the follicular phase (when oestrogens are dominant) and the luteal phase (when progestagens are dominant) (Figure 15). During the follicular phase, a follicle (containing an ovum) matures due to increased concentrations of FSH. As the follicle develops, it causes an increase in oestrogens.

Peak oestrogen concentrations trigger a surge in LH which results in the release of an ovum from a follicle. The follicle then develops into the corpus luteum. The formation of the corpus luteum begins the progestagens production. Progestagens maintain the lining of the uterus in preparation for the

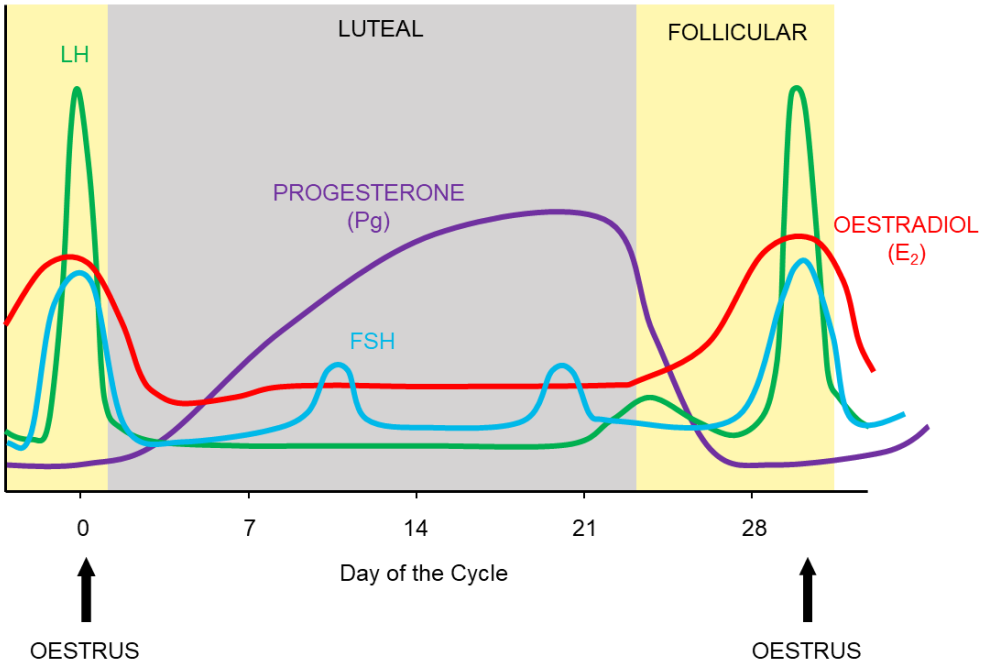

Figure 15 - Hormones involved in the ovarian cycle. Adapted from P.L. Senger, Pathways to Pregnancy and Parturition

implantation of a fertilised egg. If the egg is not fertilised, the corpus luteum will stop producing progestagens and will regress, resulting in the ovarian cycle beginning again (Figure 15). If the egg is fertilised, progestagens will continue to be produced, supporting the pregnancy.

Okapi in general are non-seasonal, polyoestrous spontaneous ovulators, meaning that they have multiple oestrous cycles a year and ovulate without the need of external stimuli. Females reach sexual maturity between 2-4 years of age (Bertelsen, 2015) and have a bicornuate uterus, and therefore, mostly have singleton pregnancies, with twins being very uncommon (Loskutoff *et al.*, 1988).

Table 1 – A summary of the reproductive characteristics of giraffids (Bertelsen, 2015)

PARAMETER		GIRAFFE	OKAPI
Karyotype (2n)		30	44, 45, or 46
Puberty, Age (Years)		Female at 3–4 Male at 4–5	Females at 2.5 Males at 2–4
Oestrus Cycle (Days)		14–15	15–16
Luteal Phase		8	11
Follicular Phase		6	5
Duration Of Copulation		Few seconds	Few seconds
Duration Of Gestation		420–468 days	414–491 days
Pregnancy Determination		- Urinary/faecal PdG - Transrectal ultrasonography	- Urinary/faecal PdG - Transabdominal ultrasound - Measurement of body weight gain
Placentation		Cotyledonary placentation	Cotyledonary placentation
Urinary Pregnanediol-3-Glucuronide (PdG), (ng/Ml)	**Nongravid Follicular**	3.6 ± 7 ng PdG/mg Cr	1.9 ± 0.1 ng PdG/mg Cr
	Nongravid Luteal	30.9 ± 1.7 ng PdG/mg Cr	27.2 ± 3.9 ng PdG/mg Cr
	Gravid	Persistent luteal levels - >250 ng PdG/mg Cr in late gestation	Persistent luteal levels - With levels >100 ng PdG/mg Cr
Semen Volume		4–6 mL	Unknown

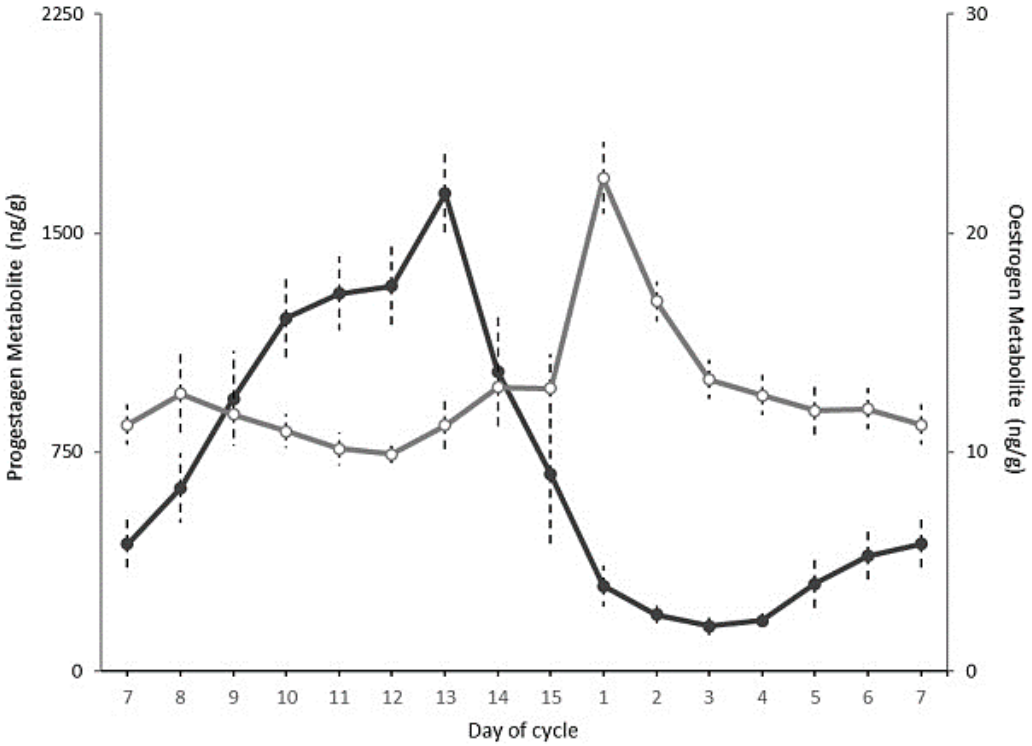

Figure 16 - The average faecal hormone metabolite concentrations of the oestrous cycle (n=17) for female okapi (n=3) with progestagen (●) and oestrogen (○) metabolite concentrations with +/- standard error. Day 1 of the oestrous cycle is determined by peak oestrogen concentrations as progestagen concentrations are decreasing (O'Hanlon *et al*., 2023).

Similar to other members of the Giraffidae family, okapi have an average oestrous cycle of approximately 14 days (Table 1); however, this can vary between individuals. Like giraffe, okapi lack a defined luteal and follicular phase in their oestrous cycle because the next wave of follicular development occurs while the previous corpus luteum is still present. Stages of the oestrous cycles are therefore referred to as luteal and inter-luteal phases, where peak oestrogens occur at the beginning of the inter-luteal phase, as progestagens are decreasing from peak luteal concentrations (O'Hanlon *et al*., 2023; Lueders *et al*., 2009) (Figure 16). It has been noted that matings occur as peak progestagens return to baseline, which corresponds to the period when peak oestrogens occur (Loskutoff *et al*., 1982; Schwarzenberger *et al*., 1993; Schwarzenberger *et al*., 1999; O'Hanlon *et al*., 2023), indicating that ovulation occurs around this time.

Following a successful mating, progestagen concentrations increase to peak luteal concentrations for approximately the first 150 days of gestation, before a secondary rise is observed (Schwarzenberger *et al*., 1999; Schwarzenberger *et al*., 1993; Kusuda *et al*., 2007; O'Hanlon *et al*., 2023), likely due to placental production. Progestagen concentrations will then remain elevated until parturition occurs. Okapis have an average gestation period of 440 days, with a range of 414 to 493 days (Hofman and Leus, 2015; Bodmer and Rabb, 1992) (Table 1). Compared to other ruminants, the gestation period of giraffids is surprisingly long (Clauss *et al*., 2019).

For further resources on general reproductive management, there is a link to the free online EAZA Reproductive Management course registration form (The registration form can also be found on the EAZA Academy and Reproduction Management Group websites respectively):
https://forms.office.com/pages/responsepage.aspx?id=N8XbY0Yc2EW0-qCY8AmOq8c3J_BS9JlNip5cOaUcDadUNUNSUTJQSlpIVlFSVTJLRTQ1VENCWjRDWC4u

- *For further details on reproduction, gestation and offspring see section* ***2.4 Breeding***

1.1.4 Longevity

Longevity or generation time for wild okapis is unknown and estimates are based on values from the *ex situ* population **(see section 2.4.7 Population management)**.

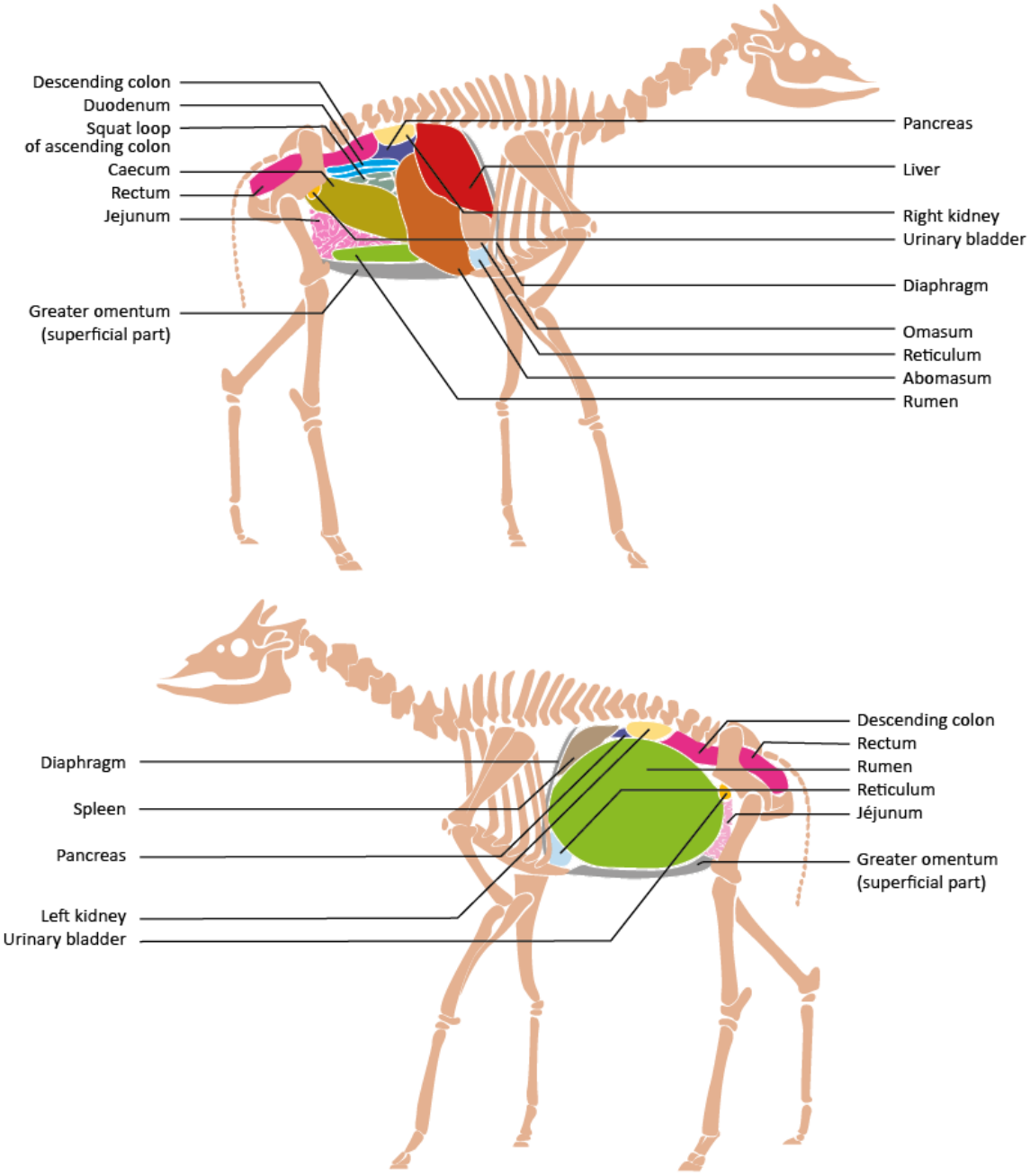

Figure 17 – Okapi internal anatomy. Top: Left lateral view. Bottom: Right lateral view. *©Mégane Noyée/David Di Paolo - Mulhouse zoo*

1.2 Field Data

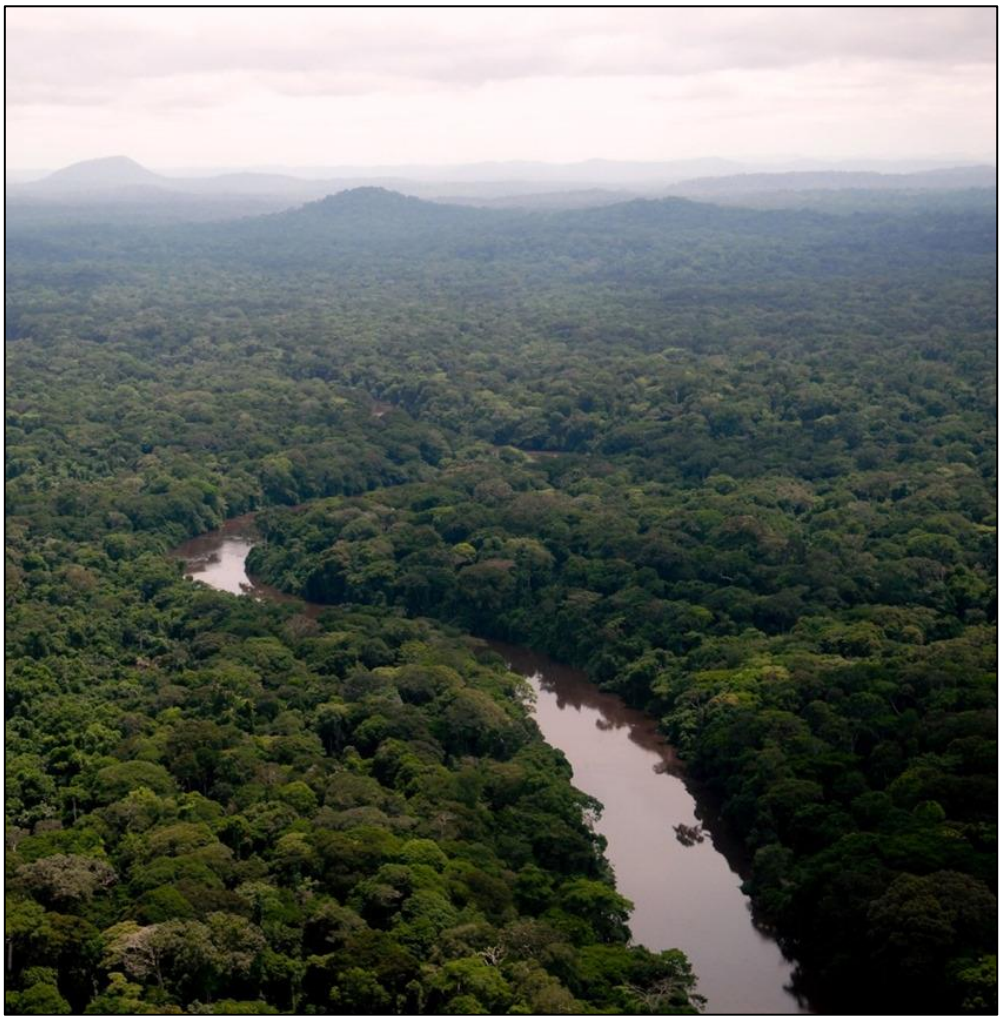

Figure 18 – Okapi Wildlife Reserve *©Okapi Conservation Project / Location: Democratic Republic of Congo*

"This UNESCO World Heritage Site has been protecting okapi and their forest home for 29 years now. That's 29 years of conservation for 1/6th the okapi population, 101 documented mammal and 376 bird species, and for 1/5th of the Ituri Forest - the best-preserved forest in the Congo basin."

(Okapi Conservation Project, 2021)

1.2.1 Zoogeography and Ecology

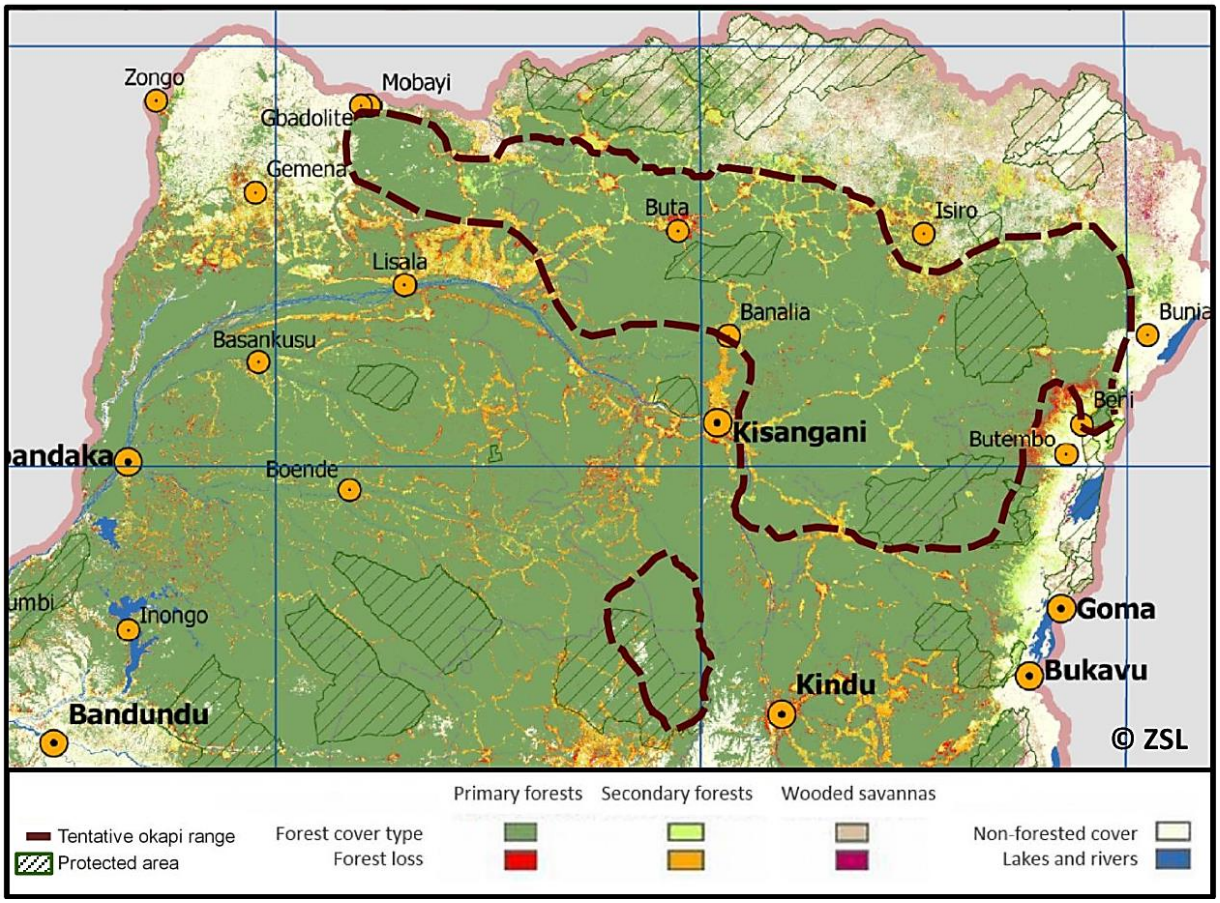

Figure 19 - The hatched area is the tentative current okapi distribution within DRC. Orange areas show loss of secondary forest, red areas show loss of primary forest. (Shapefile provided by John Hart). *©ZSL (Kümpel et al., 2015)*

Distribution

The okapi is endemic to the Democratic Republic of Congo (DRC), Africa. It is distributed across parts of the central, northern and eastern of the DRC. The okapi also has a much smaller range to the west and south of the Congo River (Hart, 2013) (Figure 19). In the recent past, okapi occurred occasionally in the Semuliki forest of western Uganda (Kingdon, 1979).

Its recorded presence is concentrated in and around protected areas, due to survey efforts. Survey activity of the species has been limited in the last decades and is logistically challenging to perform due to the political instability in DRC and the difficult accessibility of the okapi habitat. Therefore, vast parts of the potential okapi's range are poorly studied. Furthermore, okapis are secretive and their occurrence can easily go undetected.

The primary strongholds of okapi include the Ituri/Aruwimi and adjacent Semliki and Nepoko Forest, the forests of the middle Lindi, Maiko and Tshopo basins and the Rubi-Tele region in Bas Uele. (Hart, 2013). There are confirmed recent (2013) records of okapi in the Abumonbanzi Reserve in the Gbadolite district of North Ubangi at the northwest end of the distribution (Ngbolua *et al.*, 2014). Since 1980, expansion of human settlement, deforestation and forest degradation have eliminated important portions of the okapi range, particularly in the southern and eastern Ituri Forest where the species was at one time abundant (Hart, 2013). The okapi can be found in five protected areas (Figure 20).

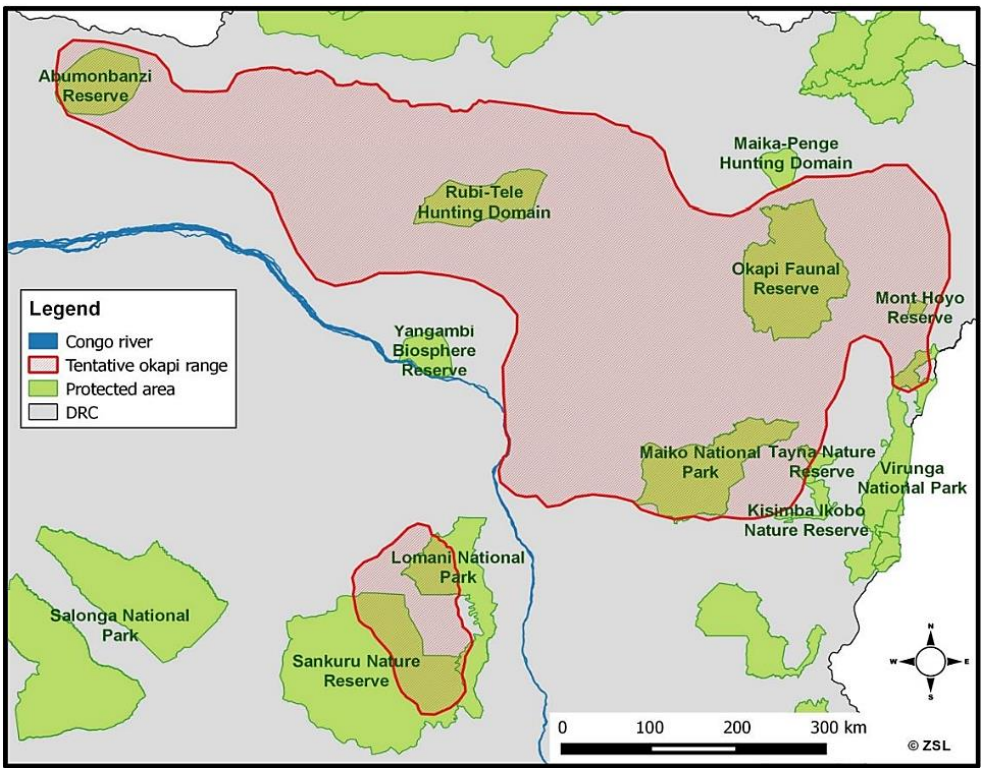

Figure 20 - Map of protected areas across the tentative current okapi range in DRC. *©ZSL (Kümpel et al., 2015)*

Habitat and Ecology

Okapi habitat is restricted to closed, high-canopy tropical forests (Figures 18 and 26) with an elevation between 450 m above sea level and 1500 m above sea level, occurring in a wide range of primary and older secondary forest types. These forests are supplied with over 1905mm of annual rainfall and the average temperature is 31°C. Okapis do not venture into gallery forests or pockets of forest surrounded by savanna and they do not stay in the disturbed habitats surrounding human settlements. They will live in seasonally flooded areas when the ground is still wet, but they are not present in truly wet or extensive swampy areas. Tree fall gaps are selected foraging sites for okapi during the early stages of regeneration (Hart and Hart, 1989). Due to the okapi's elusive nature, not much is known about the ecological role of the species. As a browser, it acts as a primary consumer and helps ensure certain vegetation is not too overgrown (Toon and Stephen, 2003).

1.2.2 Conservation Status

In situ Population and its Threats

The *in situ* population size was estimated to be between 35,000 and 50,000 individuals in 2013 (Hart, 2013). Current numbers are believed to be lower and declining, but there is no reliable estimate of the current population size (Kümpel *et al.*, 2015). The population trend has declined by over 50% over the last 3 generations (24 years) and continues to decrease at this rate. The *in situ* okapi population is experiencing several major threats, which are habitat loss due to logging and (illegal) human settlement, incursions, meat and skin hunting and the presence of illegal armed groups in and around key protected areas (Mallon *et al.*, 2015).

Relationship with Humans

The okapi evokes a strong sense of pride in the Congolese people and it is seen as the DRC's national animal. It features both on the logo of ICCN (Institut Congolais pour la Conservation de la Nature) and on Congolese Franc banknotes, and the national radio in the DRC is called "Radio Okapi". The okapi has always been revered and admired by locals, with pygmy tribes having many customs related to the okapi and even some considering it a sacred creature (Kümpel *et al*, 2015).

In situ Conservation Efforts

Although nationally protected since 1933, in November 2013, the okapi was officially transferred from the status of Near Threatened to the status of Endangered on the IUCN Red List of Threatened Species (Mallon *et al*., 2015). The okapi is a fully protected species under Congolese law (Hofman and Leus, 2015). The okapi is not included in the CITES appendices (Mallon *et al*., 2015). An effort is made by the Okapi Conservation Project (OCP) to protect the okapi in the wild (Figure 21). The OCP focuses on developing an economic and educational foundation on which the Okapi Wildlife Reserve (OWR) in Ituri Forest can operate to promote sustainable development with the local population and awareness of nature conservation (Okapi Conservation Project, 2022). In 2010, a conservation project by the Zoological Society of London (ZSL) and the ICCN was established on account of the declining population trend of the okapi population. The goal of this project is to obtain accurate and up-to-date information on the okapi population. In 2013 a multi-stakeholder workshop was hosted by ZSL and ICCN in Kisangani, DRC, to develop the first-ever species-wide globally coordinated conservation strategy for the okapi. In 2016 the okapi conservation strategy and status review were officially published (Zoological Society of London, 2016).

Figure 21 – Logo of the Okapi Conservation Project

The zoo community donates generously to *in situ* okapi conservation work, with a focus on the Okapi Conservation Project's activities in OWR. In 2019 Okapi EEP and Okapi SSP zoo partners donated US$236,830 to the Okapi Conservation Project, making up to 31% of its entire budget (Annual Report Okapi Conservation Project, 2019). The Antwerp Zoo Foundation (AZF) launched a project in 2022 that coordinates and contributes to conservation and development efforts in the province of Bas-Uélé in the DRC. The main goals of the AZF are to identify the hotspots of occurrence of the okapi in the region, define sustainable land and resource management, and promote engagement and education of the local communities about the conservation of the okapi's habitat (Antwerp Zoo Foundation, 2023). The Frankfurt Zoological Society (FZS) supports ICCN through a project in DRC within the okapi's range, in the Lomami National Park. FZS supports the management and protection of the Lomami National Park and local communities on the periphery and works to assess biodiversity within the park and then create strategies for protection and future monitoring (Frankfurt Zoological Society, 2023). The Wildlife Conservation Society (WCS) works extensively within the Okapi Wildlife Reserve, running a conservation research and training centre, monitoring human impacts and carbon stocks and working with local communities to restore respect for the reserve's protected status while alleviating poverty. Where possible, it seeks to conduct regular systematic surveys throughout the range of okapi and other mammalian species (Kümpel *et al*, 2015).

Ex situ Population

- *For further details on the ex situ population see section **2.4.7 Population management.***

The foundation for the okapi captive population was laid in 1919 when the first okapi arrived in Europe alive (van Dam and de Boer, 1980). The Okapi SSP and EEP have been established in 1981 and 1985, subsequently (Bell, 2001). In Europe, okapi falls under the Antelope and Giraffid Taxon Advisory Group (TAG). Okapis are housed in EAZA, AZA and JAZA institutions across Europe (as part of the EEP), North America (as part of the SSP), and Asia (ZIMS, September 22nd, 2021). The following mission statement for the *ex situ* population of okapi was formulated during the International Okapi Meeting in Berlin, in 2019:

"Maintain a cooperatively managed global ex situ population of okapi that inspires conservation action through education, fundraising and focused scientific research and serves as an insurance population for the wild."

Key areas of contribution of the *ex-situ* programmes to a viable *in situ* population:

- Education and awareness of the public: with all zoos producing a common message;
- Maintain a sustainable, cooperatively managed global *ex situ* okapi insurance population;
- Exhibit conservation messages and updates on *in situ* conservation initiatives;
- Research of the biology and behaviour of the species;
- Promote an increase in the number of zoos holding okapi to increase the species' visibility;
- Zoos with okapis to contribute to *in situ* conservation work with expertise and funds;
- Targeted fundraising promoting the okapi's role as a flagship species of the Ituri forest.

1.2.3 Diet and Feeding Behaviour

The okapi's diet in the wild is known from only one study (Hart and Hart, 1989). They are known to feed on over 100 plant species yet are selective feeders with a diet that consists mainly of leaves with some fruits, seeds, ferns and fungi. Faecal analysis shows that none of those 100 species dominates the diet of the okapi. This is probably an adaptation to reduce the intake of any one particular secondary compound in large amounts. In a day they consume 20 – 27 kg of fresh food. The daily dry matter intake of captive okapi is 4.3 – 5.0 kg. Hart and Hart (1989) showed that season did not have any effect on browse selection as many of the plants of the okapi's diet are available throughout the year. The okapi is mainly diurnal but has also been recorded feeding at night. It has feeding peaks at mid-morning and in the late afternoon. It moves about a kilometre a day to browse in small forest openings where fallen trees allow the growth of light-dependent young plants, which seem to be preferred by okapi. For its mineral intake, the okapi ingests clay, burnt charcoal and bat guano found in hollow trees. The okapi rumen anatomy fits with other ruminant browsers (Clauss *et al.*, 2006; Bodmer and Gubista, 1998; Bodmer and Rabb, 1992; Crissey, *et al*., 2001; Hart, 1992; Hart and Hart, 1989; Nixon and Lusenge, 2008; Lindsey *et al*., 1999).

- *For further details on diet and feeding in captivity see section **2.2.1 Basic Diet**.*

1.2.4 Reproduction and Development

Reproductive Behaviour

Sexual maturity is reached, on average at two years of age in both males and females (Kingdon, *et al*., 2013). In captivity, the youngest female to have conceived was 2 years and 5 months of age; the youngest male was 1 year and 11 months of age (Hofman and Leus, 2015). Female okapis have one calf at a time and will reproduce once about every 2-3 years. They can continue to reproduce throughout old age, although aged females may encounter health problems with pregnancies and/or deliver weak calves. There is no seasonal periodicity for the rut of males or the oestrus of the females and it means that the okapi reproduces year-round. However, some seasonality in breeding is seen in captivity (Hofman and Leus, 2015) though this seasonality is mostly due to management decisions instead of biological seasonality. Some institutions in the northern region of Europe, where winters are colder, prefer to have offspring born in spring or summer.

Through genetic testing, it has been determined that okapis are a polygamous and promiscuous species. This testing showed that the majority of okapis studied in the Okapi Faunal Reserve have high levels of genetic relations (Bodmer and Rabb, 1992; Stanton *et al*., 2015). Males enter female home ranges to mate, which is the primary reason for males and females to come together. During courtship, the couple stands head to tail, accompanied by circling, mutual sniffing of inguinal areas and flehmen. Thereafter, males go through a series of behaviours including head and neck stretches, head forward and upward positions, erect postures, nose lifting and leg kicking. The receptive female responds by a head-low posture, often with the tail shunted aside (Bodmer and Rabb, 1992). This is followed by mounting and copulation. After mating, the male and female part again (Grzimek, 1990).

- *For further details on reproduction, breeding and mating behaviour see section **2.4 Breeding***
- *For described breeding behaviours see **Appendix C – Mating Behaviour Ethogram***

Offspring Development

Figure 22 – Okapi calf with its characteristic dorsal mane that disappears when the animal reaches adulthood. *©Jenny Dierenfoto / Location: Rotterdam Zoo*

Females retreat into dense forest vegetation to give birth (Grzimek, 1990). Okapi females usually eat their placenta immediately after parturition. Okapi newborns are precocial; calves are usually able to stand after 30 minutes. They spend the first one or two days of life following their mother and exploring the environment. Thereafter, they find a suitable hiding spot and for the next two months spend 80% of their time in this nest and nurse relatively infrequently. This conservation of energy aids in rapid growth and weight gain. The general consensus is that okapi neonates do not defecate during the first two months after birth. They only secrete meconium. Meconium has another colour, consistency and form which distinguishes it from faecal pellets. The nesting or hiding behaviour and no defecation are perhaps an adaptation to reduce the chances of predator detection (Bodmer and Rabb, 1992). Weaning occurs at about six months of age, although young may continue to suckle for more than a year. While mostly resembling the adults,

newborn calves have longer eyelashes around the eyes, a dorsal mane (Figure 22), and the hair on their white stripes is longer. These features gradually disappear within a year. The development of ossicones in males begins at one year of age. Both males and females reach adult size at about three years (Bodmer and Rabb, 1992).

- *For further details on reproduction, gestation and offspring see sections **1.1.3 Physiology – Reproductive Physiology** and **2.4 Breeding***

Figure 23 – Newborn calf. *©Bioparc - E. Flautre / Location: Zoo Duoé de la Fontaine*

Figure 24 – Okapi calf 1.8 months of age. *©Jenny Dierenfoto / Location: Rotterdam Zoo*

Figure 25 – Okapi calves start ingesting solid food early on, while still nursing. *©Antwerp Zoo / Location: Antwerp Zoo*

1.2.5 General Behaviour

Figure 26 – Okapi in its wild habitat *©Okapi Conservation Project / Location: Democratic Republic of Congo*

Activity and Locomotion

Okapis spend 30-50% of their day resting and, despite being considered diurnal, okapi show some movement during the first few hours of darkness, mostly on moon-lit nights. They spend only about 10% of their total lifetime with conspecifics. Okapis have individual non-exclusive home ranges of about 2.5 – 5 km^2. Breeding females have the most stable home ranges averaging 3.5 – 5 km^2. Adult males often have undefined, wide-ranging home ranges (averaging 8 - 12 km^2) and move more often and over greater distances. Subadults have the most restricted home range, ranging from 2 – 3 km^2. The okapi pacing gait is about 16 km/h. Its foreleg and hind leg move forward together, followed by the legs on the other side, similarly to the giraffe's pacing gait. Gallop gait attains speeds of 56.3 km/h following the same left side/right side pattern. To reach the ground when drinking, the okapi must splay its legs the same way giraffes do (Figure 27) (Bodmer and Gubista, 1988; Dagg, 1960; Hart, 1992; Hart and Hart, 1988; Lindsey *et al*., 1999).

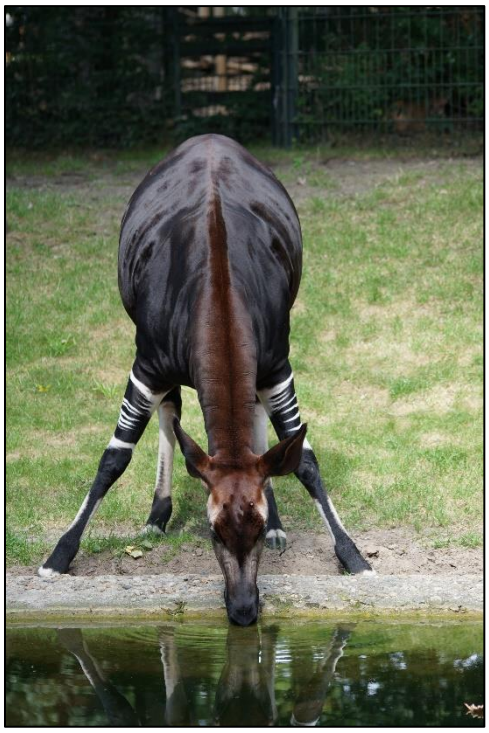

Figure 27 - The okapi splays its legs the same way giraffes do to reach the ground (e.g., drinking). *©Wolfgang Dreier / Location: Berlin Zoo*

Predation

Due to its size, the only predator capable of taking down an adult okapi is the leopard (*Panthera pardus*). The serval (*Leptailurus serval*) and the African golden cat (*Caracal aurata*) prey on young okapi (Bodmer and Rabb, 1992; Hart and Hart, 1988). Okapis are hunted for their meat and skin by humans (Hart, 2013; Kümpel *et al*., 2015). Several behaviours and strategies are utilized to prevent predation. Young okapis spend 80% of the first two months of their life in a nest. A disturbed calf lies motionless in its nest, and a female okapi will rush to aggressively defend her calf from danger. During the hiding stage, young okapis nurse relatively infrequently and do not defecate (Bodmer and Rabb, 1992).

1.2.6 Social Behaviour

Sociality

Okapis usually live solitarily. Males and females spend very little time together and only meet to mate. Okapi females and their offspring may remain nearby until the juvenile establishes its own home range. Okapis demonstrate male-biased dispersal, disperse large distances in the wild, and are genetically polygamous or promiscuous (Stanton *et al*., 2015). In the wild two adults, one juvenile and one young may inhabit the same home range but steady groups of more than three animals have never been recorded in the wild. Generally, okapis avoid other individuals in adjacent home ranges (Lindsey *et al*., 1999).

Agonistic Behaviour

Generally, the okapi is a tranquil and non-aggressive creature. Males competing for females engage in ritualized neck fighting, head butting, and charging (Prothero, 2002). Aggressive behaviours include kicking, head-throwing and slaps using the side or top of the head as a blow to flank or rump. Kicking is often symbolic without real contact. Dominant animals display an erect head and neck posture while subordinates may have their head and neck on the ground (Walter, 1979).

Territorial Behaviour and Communication

Territorial behaviour in males is expressed by olfactory signals. Both sexes have scent glands on each foot that leave behind a tar-like substance to communicate their passage and territory. Males mark objects (e.g., bushes, trees) with urine while crossing their legs in a dance-like movement. This kind of behaviour mostly occurs during courtship. Females mark their territory by using common defecation sites. Both males and females mark their territory with dermal exudate by rubbing their necks on trees. Males keep larger territories, overlapping the home range of many females, presumably to have access to multiple partners. Males are protective of their territory but allow females to pass through their domain (Bodmer and Gubista, 1988; Hart, 1992; Hart and Hart, 1988; Lindsey *et al*., 1999). The okapi only has rudimentary vocal cords (Bodmer and Rabb, 1992). The vocalization repertoire expressed within the human hearing range consists of chuffs, moans, snorts, whistles, bellows (when in acute distress) and bleats (Lindsey *et al*., 1999). Chuffs are used as contact calls for all ages and both sexes. During courtship, males express soft moaning sounds and infants use bleat alert vocalizations to provoke a response from their mothers (Bodmer and Rabb, 1992). Thereby the okapis are capable of producing and receiving infrasonic sounds whereof the source is hard to locate (Lindsey *et al*., 1999).

➢ *For further details on social structure and social group see section **2.3.1 Basic Social Structure***

2. Management in Zoos

Figure 28 – (Top Left) The first okapi at London Zoo, 1935 *©Sir George Grey Special Collections, Auckland Libraries*. (Top Right) Okapi at Copenhagen Zoo, 1949 *©Copenhagen Zoo*. (Bottom Left) Okapi Indoor enclosure at Rotterdam Zoo *©Rotterdam Zoo*. (Bottom right) Mixed co-habitation of an okapi with an yellow-backed duiker (*Cephalophus silvicultor*) in Zoo Beauval *©ZooParc de Beauval*.

2.1 Enclosure

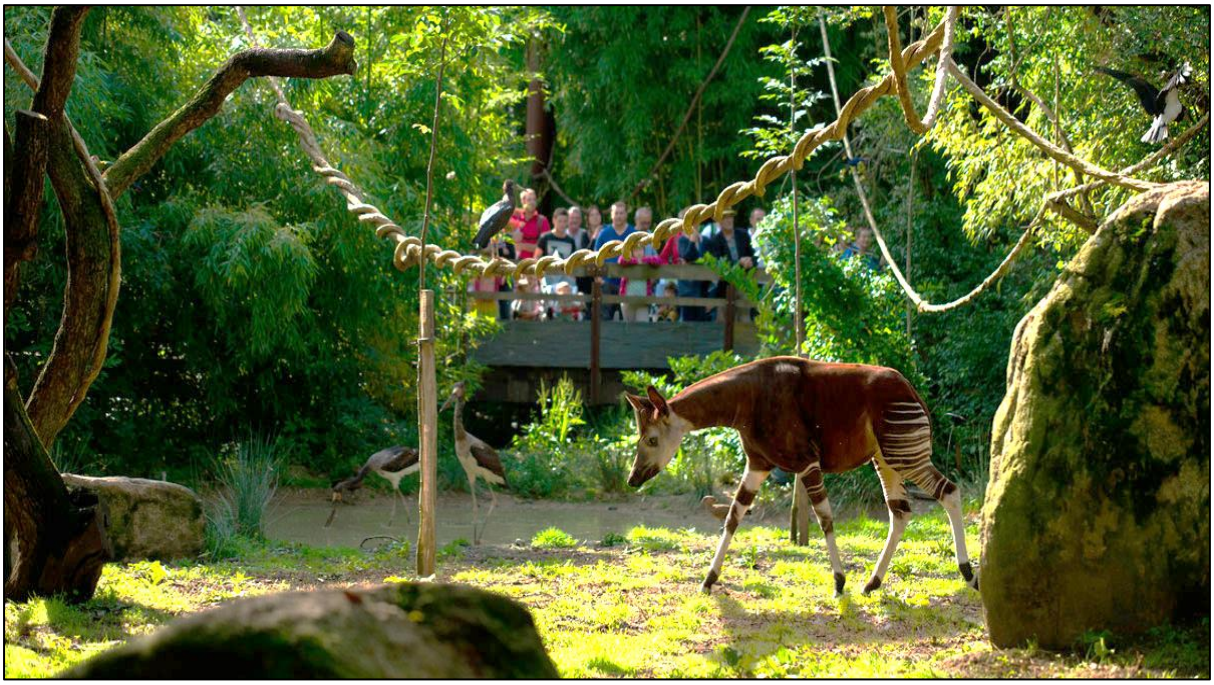

Figure 29 - Okapi outdoor enclosure at Bioparc Zoo de Doué-la-Fontaine *©Bioparc Zoo de Doué-la-Fontaine*.

EAZA members are expected to provide a high standard of accommodation for all the animals in their care, both on-show and off-show, permanent and temporary. Accommodation must take account of the welfare of the species, their space and social needs, appropriate management by staff and appropriate display to the public (EAZA, 2020).

2.1.1 Dimensions and Design

The design of the enclosure must address many issues to create a safe and easy-to-maintain space. The enclosure must attend to the biological and physiological needs of the animals but also ensure that the animal care staff can perform its work easily and safely. The safety of the public visiting the space must also be a top priority. The more accurately the enclosure recreates the animal's natural environment, the better it works to tell its educational message to the visitors. Also, an enclosure that has reduced usage of bars or mesh and has an immersive environment enhances the experience of the visitors (Hosey *et al*., 2009) (Figure 29).

The okapi is a species that requires both an indoor and outdoor enclosure due to weather restrictions. The available living space per individual okapi including indoor and outdoor areas should be a minimum of 500m^2. The optimal stable space per individual should be a minimum of 30m^2. However, the minimal living space must agree with the animal-holding laws of the country in question. Breeding facilities must consider space flexibility to accommodate dams with their calves or breeding pairs. Habitat complexity is as important as the living space given to individuals. This can be achieved by the addition of trees, shrubs, deadfall, rockwork, and furniture. These elements break up the open space creating complex pathways and providing natural and artificial elements with which to interact. Furthermore, open space does not provide the okapi with the illusion of security. Enclosures that offer visual screening and/or private and safe spots can reduce the severity of flight reactions. Large shade trees, as well as a mixture of shrubs and grasses, make up the ideal okapi habitat (Figure 30). Although okapi are generally not considered to be a dangerous species, the ideal enclosure design includes safe areas and escape routes for the keepers if they enter the enclosure with the animals within.

Some general recommendations when considering enclosure planning:

- Several feeding and watering stations must be available per individual animal;
- Each animal must be provided with a bedded area at an appropriate distance from visitors, keepers and neighbour enclosures;
- Absence of slippery floor surfaces and the exclusive use of non-toxic materials/paintings;
- Keepers must have the option to work with the animals in a protected contact system;
- A facility must be able to separate all individuals when necessary;
- Each animal must have the option to withdraw from others if wanted.

Figure 30 – Densely forested okapi enclosure. *©Bristol Zoological Society / Location: Bristol Zoo*

2.1.2 Indoor Facilities

Figure 31 - An okapi's indoor enclosure full of enrichment and complexity elements. *©Rotterdam Zoo / Location: Rotterdam Zoo*

Many okapis spend most of their time indoors due to weather constraints and concerns for animal safety overnight. Therefore, it is very important to guarantee that the indoor accommodation for okapi is as enriching and complex as possible to accommodate the animals' natural behaviour (Figure 31). Indoor facilities may also be visitable by the visitors (Figure 33).

The recommended stable space for a single okapi is around 30 m². Adjacent stables must have interconnecting doors that allow the combination of multiple stables to give the animals extra space when access to the outdoor enclosure is not possible due to weather or other constraints (Figure 32). In these circumstances, more than one stable is recommended for each okapi. This is also relevant when housing females with calves since they need to be able to stay away from each other during the nesting period of the calf to avoid over-grooming and restless mothers or calves. Two combined stables will allow the female to move away and stay out of sight from the calf but still give freedom to return at will for nursing. Okapi males housed across hallways without limited visual access may also display stressful or aggressive behaviours. Okapi males often require visual isolation from other males, especially when females are present in the same facility. Breeding facilities must take into account that an overhead space of a minimum of 2.7m is necessary to prevent a mounting male from hitting its head against the ceiling or any hanging object. A space to meet through the fence is important for the introduction of new animals and to prepare for breeding introductions. Also, a view from the stables on the outside exhibit reduces boredom in the animals. Stable walls should measure at least 1.8m tall. Animal door openings should ideally be 80cm wide at a minimum.

Figure 32 – Sliding doors that allow the combination/separation of multiple stables. *©Branféré Zoo /Location: Branféré Zoo*

The layout of the stables within the building must provide the okapi with both the choice to visually isolate from or avoid proximity to other okapi and the access to interact with

another okapi via mesh. Unrestricted visual access between individuals can cause stress or agitation in some cases with headbanging on walls or intensive pacing (Troxell-Smith and Miller, 2016). On the other hand, access to grooming other individuals can be very enriching for some okapi. This is achieved by offering okapi multiple stables with varying visual access, and/or strategically adding plywood or other materials to mesh, or the use of heavy-duty canvas curtain sheets.

Figure 33 – Individual stables with a visitation area allowing the public to see the animals when kept inside. *©Karol Mišovic/ Location: Wihelma Zoo*

Although the standard procedure in the EEP is to work in free contact with okapi, chutes or restraining boxes/lanes can be useful to perform veterinarian procedures that require protected contact. With the required training, the animal is capable of standing comfortably in these structures to be examined or manipulated. When incorporating a restraining box or chute in the facilities, it must fulfil the following conditions:

- The frame must be strong enough to withstand any kicking by the animal.
- The walls must be high enough (min. 1.8m), to not allow the animal to rear, jump, or fall over them.
- Removable restraining bars at the rear of the unit allow adjusting the length of the chute to the animal.
- One movable sidewall allows the animal to be firmly restrained and unable to turn around in the chute.
- Removable panels on the side walls allow access to all parts of the body.
- Flooring should have a non-slip surface (e.g., a rubber mat) to give the okapi secure footing.
- Ideally, a scale is incorporated for regular weighing of the animals.

➢ For further details on animal handling/restraining, see section ***2.6 Handling***

2.1.3 Outdoor Enclosure

Due to the solitary nature of this species, each okapi needs to have not only its separate stable but also an outdoor enclosure where it can be on its own. Animal welfare is promoted when the individual has the choice to access simultaneously the indoor or outdoor enclosure for extended periods. Whenever possible, this includes outdoor access during the night. Holders with multiple outdoor enclosures can also promote animal welfare by combining multiple outdoor enclosures to increase the

Figure 34 – Outdoor enclosure. *©Frankfurt Zoo / Location: Frankfurt Zoo*

living area or rotating the animals among them to offer them a constantly changing environment. Transfer corridors are recommended to be as short as possible and direct. Not all these outdoor enclosures have to be displayed to the public. Off-display enclosures are useful to isolate sick animals or calving dams from the crowds.

It is recommended that the perimeter of the outdoor enclosure should be curvilinear to avoid corners where animals can feel trapped by other animals, the keepers or other hazards. It is recommended that no more than 50% of the perimeter should be accessible to the public. A mixture of private and public areas gives multiple choices to the animal to retreat seeking privacy.

The enclosure should be generally flat terrain or gently sloping. However, it is recommended to include in the topography of the enclosure small gentle hills that will help the males to mount the females for breeding. It is relevant to remember that males are generally shorter than females, and short males might have difficulties mounting a very tall female. Water features such as small streams, waterfalls, and shallow pools (<1.2m deep) have been successfully included in okapi habitats. In general, okapis avoid deep water. Sediment in pools must be kept to a minimum. Easy outlet points and non-slippery borders are essential.

2.1.4 Barriers

The choice of barriers for okapi is not considered difficult, as the options are abundant. Barriers for okapi enclosures may consist of chain link or heavy-gauge mesh fencing, wood, concrete, brick, stone, artificial rock, and/or combinations of the above. Attention can be given to the safety and aesthetical components of the enclosure to enhance the public view. Both single barriers and combinations of barrier types can be utilized.

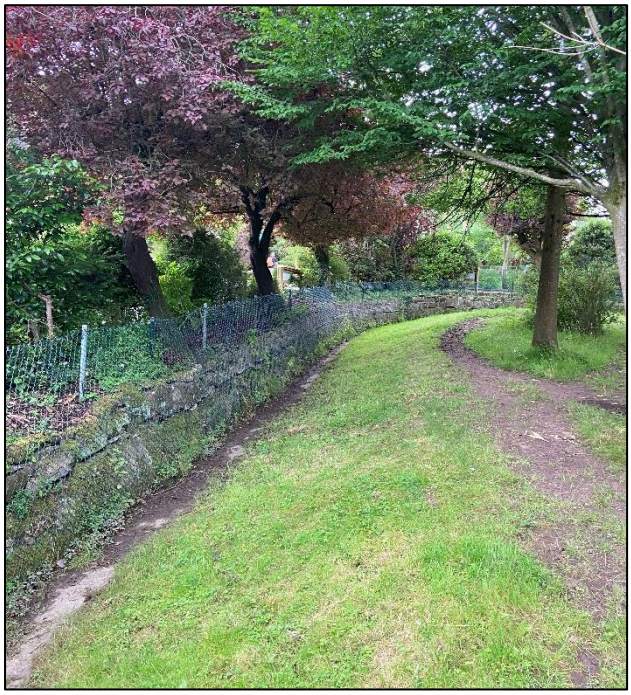

Figure 35 - Dry ha-ha moat. *©Chester Zoo / Location: Chester Zoo*

Barrier Characteristics

|Height: Okapis can jump over anything lower than 1.5 metres and up to 3 metres in length. Enclosure primary perimeter barriers must be a minimum height of 1.8 metres.

|Safety: prevention of public feeding, being free of protrusions and/or sharp edges, entanglement and preventing undesirable animals from entering the enclosure. All materials should be treated only with non-toxic compounds. Barriers should be easily visible to prevent animals from accidentally running into them. When an okapi gets spooked in the rainforest, it will run through the dense vegetation without hesitation. In a zoo setting it has happened that animals ran into walls or doors and tried to jump through windows.

|Visibility: Adjacent enclosures may need to have visual or non-visual barriers, depending on the needs of the collection or the inhabitants of the adjacent enclosure, etc. Okapis should have the ability to seclude themselves from humans and conspecifics when they feel the need to (Figure 40). Barriers in outside enclosures should not be completely opaque to allow the animal to see through. This

prevents the animal from getting spooked by approaching stressful stimuli (e.g., visitors, a working car, the vet) as the animal can see them long before they approach.

Figure 36 – Boulders as a solid barrier for the perimeter of the enclosure. *©Wolfgang Dreier / Location: ZooParc de Beauval*

Recommended Barriers

The most recommended barriers for outside enclosures are mesh fences, solid barriers, or partial barriers. For inside enclosures, the most recommended barriers are solid barriers and/or solid underneath with bars above. For holding pens, solid underneath with bars above, solid barriers and mesh fence are recommended. For stables, the most recommended barriers are solid underneath with bars above and solid barriers. For adjacent enclosures with conspecifics, mesh fences and partial barriers are the most recommended.

Figure 37 – When introducing new animals to an enclosure with transparent barriers (e.g., glass) or poorly visible boundaries, tape can be used to signal the presence of these barriers. This way the animal will learn to recognise the perimeter of the enclosure faster and prevent potential accidents (e.g., running against a glass panel). *©Jasper van Rubio / Location: Antwerp Zoo*

Figure 38 – Glass can be used as barrier offering the visitors a clear visual access to the enclosure. *©Norbert Sdunzik / Location: Wuppertal Zoo*

Mesh fencing must be of a suitable size, it must not allow jaws, ossicones, a foot or leg to go through it. Vertical bars for outside enclosures are fine if the distance between the bars is not too close but also not too wide in order not to risk entanglement. The space gap between horizontal bars/frames should either allow the okapi to extend and retract their heads through it easily or should measure less than 8cm to prevent it completely. If allowing

the animal to extend its head through the space gap between bars, the distance should then not measure less than 25 cm to prevent the animal's head from getting trapped.

When using a ha-ha moat, one must make sure that the slopes are moderate (Figure 35). In the case of a ha-ha moat filled with water, one needs to know that okapi can swim. As such, the moat must not allow the okapi to escape through to the visitor's side (Figure 39). Electrical fencing can be used; however, it must be avoided as a primary barrier. In the case of glass as a barrier, the animals need to get used to it slowly and it is always recommended to have a visual barrier (like branches or bushes) in front of the window. One can use tape on the window temporarily to help the okapi to learn where the glass is (Figure 37).

Trench moats are not recommended for use with okapi as they are considered dangerous.

Secondary (public) Barriers

A secondary (public) barrier is important to prevent people from touching or feeding the animals. Public barriers may have a width of at least one meter to prevent people from reaching across. Every kind of barrier that is safe for the visitor and keeps visitors out of reach of the animals is suitable as a public barrier. For instance, stand-off barriers could be made from small tree branches and woven together to create a natural-looking barrier (Figure 40). This can be used on both the okapi and the visitor side of the enclosure. An example is a dry moat surrounding the whole exhibit, possibly with viewing platforms. Dense bushes could be placed in a part of the moat to both avoid the animals walking in and coming too close to the visitors.

Figure 39 – Water moat used as a barrier in an okapi enclosure. *©João Pedro Meireles / Location: Berlin Zoo.*

2.1.5 Substrate

Like most hoofstock species, the substrate of the enclosure plays an important role in hoof and joint health. The optimal way to keep okapis is on as natural substrate as possible, resembling the forest floor of their natural habitat. While in outdoor enclosures this can easily be offered, for indoor enclosures particular thought is needed. Soft deep substrate allows the hooves to sink into the material to properly wear off and maintain their shape. Inappropriate substrate may lead to

Figure 40 – Secondary barrier composed of small windows allowing the visitors to peek the enclosure while safeguarding the privacy to the animals. *©João Pedro Meireles / Location: Zoo Leipzig*

elongated, curved and very narrowed hooves. When planning which types of substrate to apply in an enclosure, other important attributes to take into account are the provision of sufficient traction, safe locomotion, good absorption or drainage of wetness, non-odour-retention, durability, and ease of cleaning and maintenance.

Figure 41 – Mulch as bio-floor substrate in a stable. *©Chester Zoo / Location: Chester Zoo*

Flooring Material

|Indoor Enclosure: The most important issue in the stables is to guarantee that the floor is non-slippery and provides good shock absorption. The floor should have a slight slope (maximum 5°) from the centre to the periphery to ensure proper drainage. Bio-floors are the best approach to offer a natural-like substrate that promotes good hoof and joint health. Bio-flooring can be mulch, pine pellets and shavings or wood chips both solely or in combinations (Figures 41 and 43). A 30-60cm thick layer of bio-floor substrate in any combination provides sufficient traction and facilitates urine drainage. Bio-floors require proper maintenance to work properly. They can become dusty if the environment becomes too warm and dry. A substrate with enough moisture that allows the hooves to be a little damp is helpful. However, a substrate that is too wet can lead to hoof rot and the growth of fungi or bacteria. Small areas of bare concrete (e.g., doorways, corridors or stable entrances) are possible as long as these are not the areas where the animals stand most of their time and are not slippery. Inappropriate concrete flooring (grooved, poured or slippery) must be covered with bio-floor or rubber mats. One should strive for natural flooring whenever possible, whether during the renovation of existing holdings or the construction of new facilities.

In instances where bio-flooring cannot be used other less optimal options are possible. Rubber mats are a good option for transfer lanes, corridors, transportation crates or temporary holding pens to increase traction and cushion. Rubber mats are also a good option for instances in which, for veterinary treatments (e.g. foot fungal infection), higher hygienic conditions must be provided in a temporary holding area with a concrete floor. When using rubber mats these must be large enough to prevent sliding (Figure 42).

|Outdoor Enclosure: For outside enclosures, grass, sand and soil are recommended. The outside area ideally must be a variety of various substrate types. It must be free of slippery or deep muddy surfaces to prevent potential injuries and unhygienic conditions. Good drainage is achieved by utilizing decomposed granite and limestone screenings. Slippery conditions can be solved with layers of mulch. Well-drained mulch will also keep hooves soft and will facilitate hoof wear. It is good to have a small patch of concrete in front of the stable's building or at feeding stations to keep these areas free from mud. Other abrasive materials such as a deep river sand layer can be employed on favoured pathways frequented by okapi to promote hoof wear.

|Unsuitable Substrates: Any material that is too dusty such as peat or sawdust is not recommended. Sand is not suitable near feeding areas due to the risk of sand impaction if swallowed when the animal is eating.

Substrate-related Health Problems

Like many other hoofed animals in human care, okapis often develop highly problematic hoof malformations, in which substrate is one of the major factors. In even-toed ungulates, the hooves spread out when they walk to improve traction. This is more notable when the animals are walking on a material that is soft and deep. The floor material will get in between the hooves, straighten them, and wear them in between. However, this does not happen when an animal is walking on a flat and hard floor material like concrete pavement. In zoos, the wide use of concrete pavement is also associated with traction and joint health problems because it does not offer shock cushion when the animal walks, and concrete without sand cover will exert excessive traction on the hoof when the animal is turning on its leg, straining the joints. In the wild, okapis live in a habitat that offers a large variety of substrate characteristics (e.g., soft, wet, hard, abrasive, etc.). It must be taken into account that concrete is always slippery, especially when an okapi is suddenly frightened. To reduce the existing coverage of concrete within an enclosure it can be covered with bio-flooring, or as less optimal options; rubber mats, sand, or shavings. The best way to prevent these issues is to provide a wide variety of substrates within the enclosure of the okapi.

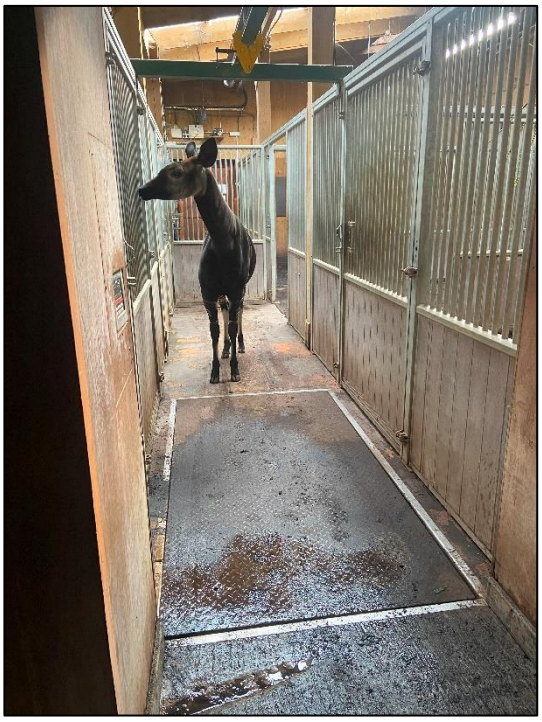

Figure 42 – Rubber mats covering the floor of a transfer lane between two stables. *©Chester Zoo / Location: Chester Zoo*

Having areas of different and appropriate substrates will help manage hoof growth but, in the end, it comes down to the total package: the correct diet, the right amount of space and exercise and having a good hoof care training plan (e.g., with animals trained to lift their feet and let them be examined) are all important parts of hoof care management.

➢ *For further details on hoof care, see section **2.7.2 Preventive Health Care - Hoof Care.***

Figure 43 – Okapi in typical sleeping position over wood chips substrate. *©Anna Pawlik / Wrocław Zoo*

Bedding

Okapi will remain active at dawn and dusk but will often find a place to lie down and sleep after sunset. They may remain in a lying position much of the night. Beds of hay or shavings placed in the stable will encourage the okapi to bed down in a convenient location (Figure 44). Okapi bedding should provide an adequate barrier between the okapi and its urine and faeces. The bedding materials that can be used in the stable are straw (pellets), wood shavings, bark mulch and wood mulch (Figures 41 and 43). Thick hay and shavings beds or shavings combined with mats have been successfully employed.

Figure 44 – Okapi on a bed of straw. *©Branféré Zoo /Location: Branféré Zoo*

2.1.6 Furnishings and Maintenance

Elements such as large rocks, deadfall, vegetation, shelters, hiding areas, and artificial trees act as furnishings. When appropriately designed and placed,

Figure 45 – Shelters or shadow structures can be added to the enclosure to offer more options to the okapi in the way it uses its outdoor enclosure. None of these structures can be considered or replace hard shelters (e.g., stables). *Left: ©Jasper van Rubio / Location: Rotterdam Zoo Right: ©João Pedro Meireles / Location: Leipzig Zoo*

it will increase the enclosure complexity and usage, enhance stimuli, and encourage a larger variety of behaviours (Figures 45 and 46).

Furnishings

Furnishings within the okapis' environment must be free from sharp objects; all items in the environment must have rounded corners/edges and prevent entangled. Keep tight passages like doorways or corridors free from furnishings, e.g. feeders or drinkers so do not obstruct the animal's passage. The placement of all furnishings must complement the layout of the overall space for the animal to make the most of the enclosure. For indoor enclosures, installing scratching branches, browse holders, puzzle feeders, or other enrichment devices increases the complexity of an environment that, compared to the outdoor enclosure, is much less stimulating for the animal.

➢ *For further details on behavioural enrichment, see section* ***2.5 Behavioural Management and Enrichment***

Weighing scales are a very important part of animal husbandry and veterinary care. A weighing scale does not necessarily have to be a fixed one. Holding pens may not be necessary in case there are enough stables. Cameras are a good addition to the fixed furnishings, especially in case of calving and introductions.

Figure 46 – Logs and small bushes can make the layout of the enclosure more complex. *©Benjamin Gilbert / Location: Wuppertal Zoo*

Enclosure Vegetation

Vegetation offers some aspects of enrichment for the animals such as shade, security or cover, browsing or urine marking. Trees and shrubs planted inside the enclosure or outside by a chain-link or mesh barrier will provide opportunities for the okapi to exercise their tongues. An important feature to reduce oral stereotypies. Plants that are unsuitable for the okapi and must therefore be avoided are plants that are known or thought to be toxic, plants that are too thick or thorny (thereby possibly causing entanglement or injury when running through them) and hard spiny plants.

Ingestion of the leaves of toxic plants might harm the okapi or even result in death. As the okapi will eat the leaves of any plant, it is recommended to use prickly shrubs and trees with high stems (with the leaves out of reach) in the exhibit design. Prickly shrubs seem to be able to withstand some browsing if browsed at all. Trees with high stems are particularly suitable as okapis, contrary to giraffes, do not feed on the bark. Besides avoiding toxic plants in the okapi enclosure, toxic plants must never be placed near the outside enclosure, as visitors tend to try and feed the animals with the plants that are the most nearby.

Figure 47 – Some types of vegetation might need to be protected against excessive browsing with barriers or mesh to allow their growth until they get out-of-reach from the animals. *©João Pedro Meireles / Location: Lisbon Zoo*

Specific plant species that must be avoided are yew, elder and oak (at least in large amounts). Particularly suitable plants are Berberidaceae and *Mahonia*, beech, ash, willow, oak (in small amounts), hazel, evergreen oak, and poplar.

Vegetation can also be used as a visual barrier or refugia by utilization of a variety of ornamental grasses, allowed to grow up to 1.2m, to offer areas of retreat or by using large stands of bamboo. It should be remembered that bamboo is not browse, but a grass, and that it contains a very high amount of silica phytoliths that wear down teeth (Martin *et al.*, 2019). Therefore, while bamboo can be used as a visual barrier, it should not be accessible to the animals to browse, or at least monitored so that

it is not heavily browsed. Bamboo is not a forage source for okapis or giraffes. It should also be noted that bamboo can provoke scratches on okapi.

- *For further details on diet and feeding see section **2.2.1 Basic Diet**.*

Cleaning and Maintenance

A clean and well-maintained environment is the primary measure to prevent disease transmission and dissemination. The cleaning of the facilities, especially the removal of faeces and stale hay must be done daily. The stable substrate will need regular changes. This includes substrate removal, cleaning the floor (e.g., with a high-pressure hose), cleaning the feeding and drinking furnishings, and total replacement of bedding material. Good drainage is essential to keep floors clean and allow pressure washing when required.

Since okapis use their tongues to explore their surroundings and interact with objects they may lick walls, food shelves, and floors. In some situations, this behaviour may develop into stereotypies (see **2.5.1 Stereotypical Behaviours**). In either scenario, for precautionary reasons, all non-porous surfaces/objects with which the okapi come into contact (including food bowls, water tubs, stable walls, and enrichment devices) should be hosed down and cleaned regularly. Disinfection every 7-10 days is sufficient if the animals are healthy. Stable floors should be scrubbed manually in areas where urine builds to prevent slippery conditions and should be dried before giving animals access. Deadfall branches and other debris such as leaf accumulation must be cleaned off in the outdoor enclosure to prevent trip hazards and slippery surfaces. When okapi eat too much fallen leaves this can be fatal to the digestive system!

Enclosure design, both indoor and outdoor, must facilitate the movement of large volumes in and out to facilitate enclosure renovations and maintenance such as adding substrate, moving, or replacing large trees, rocks, and other furnishings and loading and unloading animals from large crates and trailers.

Scent Marking

Okapi scent marking may be involved in the regular cleaning schedule. Scent marking is an important part of an okapi's behaviour so removing all substrate daily could create stress issues for the animal. Keeping an enclosure clean is important but leaving some scent behind is important to the animal.

2.1.7 Environment

Figure 48 – Plastic strips on the doors are a good option to keep the indoor facilities insulated from cold weather while still allowing the animals to enter and exit the facility. *©Antwerp Zoo / Location: Antwerp Zoo*

Temperature

The ideal facility temperature is within the range of 18–26°C. The health and age of the animals must be considered. The okapi may shiver when exposed to inappropriately low temperatures. Many facilities must routinely utilize some type of heating system during the colder months. In southern facilities, good ventilation indoors in the summer months is important to minimize high temperatures Air-conditioning and/or fans could be used inside to help to maintain the desired temperature range. Outside, okapi can tolerate temperatures up to 38°C if plenty of shade is provided. As the okapi is not cold-hardy, it can tolerate outside temperatures of 5–13°C for short periods if given free access to heated indoor space. Temperatures below 5°C must be avoided unless the weather is calm, sunny, and dry. When allowing the okapi outside during colder days the condition of the ground must be considered. The animals must not be allowed to go outside if there is a slippery surface (e.g., ice and frost). Okapi with a history of pneumonia, geriatric individuals, and calves under 3 months of age may be particularly sensitive to temperatures below 13°C. Since young calves (< 3 months of age) do not thermoregulate well, they must not be exhibited outdoors if the temperature range is out of the 18-26°C range (Lumpkin, 2007).

Light and Photoperiod

Whenever possible, utilise natural light sources in indoor facilities. The installation of windows or skylights will reduce the need for artificial lighting during the day. In indoor stables offering areas of different light intensity (through opening/closing of windows or skylights or different artificial light settings) gives the animals different areas to choose from.

Supplemental artificial lighting (that mimics natural daylight) must be available when required as it might be needed to observe the animals properly, for cleaning or veterinary work, or to extend the photoperiod. LED lights are the most recommended for being energy-efficient, long-lasting, and provide uniform illumination. Okapi must not be subjected to very bright lighting - okapis seem to prefer low-intensity illumination and their vision is adapted to low-light conditions. Artificial lighting that mimics natural daylight properties (Full-spectrum light) and allows proper observation of the animals is sufficient (100 to 200 lux – equivalent to the light during a thick cloudy day). Thus far, UVB supplementation is not considered necessary since vitamin D can be easily supplemented through diet. Lights must be positioned strategically to avoid glare. Use fixtures with diffusers or shades to soften the light and prevent direct glare in the eyes of the animals if needed. Artificial light equipment should be mounted in waterproof and shatterproof containers. All light fixtures (including wires) must be securely mounted to prevent them from falling and installed out of reach from the animals.

As okapis live near the Equator, a 12-hour photoperiod is the most appropriate to maintain a normal circadian rhythm. During winter months artificial lighting in indoor enclosures can be set to recreate this photoperiod. To prevent unnerving or startling the animals due to sudden changes in light conditions, when using artificial lighting, a timer with dimmable illumination using so-called “fade-in”

and "fade-out", that gradually increases/reduces the light intensity at the beginning/end of the photoperiod is recommended.

Air Quality and Humidity

Good ventilation is important to maintain good air quality. Enclosed facilities should always maintain good ventilation to minimize ammonia levels and to help alleviate extreme heat. Humidity levels must be monitored and maintained at a moderate level (50–60% minimum) year-round. Proper ventilation in stables should be applied to reduce the aerosol spread of pathogens.

Noise

Individual okapi may or may not respond to stressful sounds in an evident way. However, pacing, head-rolling, and standing inert with ears forward are behaviours observed by individuals exposed to disturbing sounds. The most sensitive management situations concerning sound include a female with a young calf, the acclimation of a new individual to the facility, and an individual acclimating to isolation. Okapis can acclimate to noise; keepers should familiarize individuals with routine voice levels and maintenance noises. Routine noise from hosing, raking, shovelling, work radios, opening and closing doors, equipment such as pressure washers and power tools, telephones, and even shouting are all acceptable with acclimation. However, the impact of sound should be monitored for each individual, and non-routine noises such as construction machinery equipment and small machinery should be avoided or mitigated. Ideally, the animals should have the option to avoid loud sounds within their environment. Sudden, unexpected noises are the biggest problem. A radio within the facility can be used to provide background noise and may minimize a startle response when unexpected noises occur. Nevertheless, it is not recommended to use a radio all day and keepers must be aware that certain music sounds can cause stress such as loud bass and trumpets or sharp high sounds.

Figure 49 – For indoor facilities, glass is an effective barrier to provide a quiet environment to the animals while still allowing the visitors to see them when kept inside. *©João Pedro Meireles / Location: Safaripark Beekse Bergen.*

Construction or maintenance work requiring machinery should be scheduled and planned for times when the okapi are properly housed as far away as possible from construction activities or are protected by a sound mitigating barrier (e.g. in indoor facilities). The okapi enclosure must not be located near sources of constant sound pollution such as concert venues, carousels, or regularly used sound systems. Sound-absorbing materials mounted in indoor facilities or added to walls or free-standing partitions located around outdoor enclosures can reduce the impact of sound pollution in and around the okapi enclosure. Glass is an effective sound barrier against visitors' noise for indoor facilities that offer access to visitation (Figure 49). Mechanical equipment, when installed within or near the okapi enclosure must be housed in rooms with appropriate sound and vibration isolation.

Any pipes, conduits, or fans throughout the okapi holding area should be monitored and evaluated routinely for rattling, squeaking, scraping, and other noises.

Weather Conditions

Special husbandry considerations may be utilized during unusual weather conditions such as heavy rain, snow, and ice. In case of rain, snow and ice, the okapi housing should be sufficiently big and warm enough to keep the animals inside for as long as required. Sufficient stable space must be available to move the animals to adjacent stables while cleaning. In summer it should be made sure the animals have access to plenty of shade. Some specific measures that could be taken during unusual weather conditions are:

- Putting grit on any area with the tendency to form ice and complete remotion of already formed ice before letting the animals outside;
- Keep the animals indoors if it is snowing;
- Open fewer outside doors when it is cold;
- Adjust the heating according to the temperature;
- Monitor the condition of the paddock in case of consistent rain;
- Keep consistent temperatures inside;
- Offering shadowy/covered locations outside.

2.2 Feeding

Figure 50 – Keeper offering browse. *©Reinaldo Rodrigues/Global Imagens / Location: Lisbon Zoo*

A diet is considered to be "nutritionally balanced" when it provides appropriate levels of known dietary essential nutrients based on current knowledge and information. A nutritionally balanced diet must be provided in a suitable form and correct proportion based on the most appropriate behavioural and physiological needs of the species and the individual (EAZA, 2020).

2.2.1 Basic Diet

The following section was edited with the consultation of Marcus Clauss (Zurich University), the nutrition advisor of the Antelope and Giraffid TAG (2023).

Nutritional requirements

Several factors affect the nutrient requirement of an individual. These factors include physiological state, health status, age, environment, activity level, and group dynamics.

|Energy: Energy requirement (in metabolizable energy) for average mammals are usually calculated as 1.5 to 2 times the basal metabolic rate (BMR) (Kirkwood, 1996); BMR is calculated from body weight (BW) as 293 kJ ME * $BW^{0.75}$, or 70 kcal ME * $BW^{0.75}$. Note that the typical energy unit used in Europe is joules (kJ = kilojoules), and calories (kcal = kilocalories) in North America. Multiplying this "basal metabolism" by a factor of 2 results in maintenance requirements of 586 kJ ME * $BW^{0.75}$, or 140 kcal ME * $BW^{0.75}$. With an even higher safety margin, the Ruminant Browser workshop (2009) estimated energy needs for browsing species (including okapi) to be 732 kJ ME*$BW^{0.75}$ or 175 kcal ME*$BWkg^{0.75}$. Life stage calculations have not been determined for okapi.

The figures have little relevance for practical feeding (except possibly for a rough initial estimation of how much food consumption one should account for), and are typically only used by animal nutritionists who also have access to reliable data on the metabolizable energy (ME) content of feeds, and that understand the difference in energy units between gross energy (GE, the data given on human feeds), digestible energy (DE, the data used for some domestic animals), and metabolizable energy (ME, the unit of physiologic energy requirements and used in some other domestic animals).

Like most zoo herbivores, okapis are fed important parts of their diet for *ad libitum* consumption (i.e., the amount eaten is usually not known) (Table 3), so calculating the maintenance ME requirement in terms of 'the amount required' is less relevant than estimating the nutrient composition of the overall diet. It will be more important to ensure that no feedstuffs with unsuitable nutrient composition or undesired properties are being used, and then adjusting the amount of that diet according to body condition or body weight monitoring.

|Carbohydrates: Okapi require the following quantities of carbohydrates in their diet:

> **|NDF (Neutral Detergent Fibre):** Okapis should receive at least 20-35% NDF in their captive diet (Crissey *et al*., 2001). Generally, fibres are those carbohydrates that are fermented relatively slowly by rumen microbes, even though differences in that speed may exist between grass and browse forages (see 1.1.3 – digestive physiology). Irrespective of whether a forage has a 'slow' or 'fast' fermentation compared to other forages, due to the high NDF levels this fermentation is always slower than that of NFC (see below).
>
> **|ADF (Acid Detergent Fibre):** Okapis require at least 13-18% ADF in their captive diet (Crissey *et al*., 2001). ADF is the least digestible part of a plant cell, including cellulose and lignin, and is included in the NDF fraction.
>
> **|NFC (Non-Fibre Carbohydrates):** Okapis might be able to manage 36-54% NFC in their captive diet (Huisman *et al*., 2008). NFC are highly digestible carbohydrates, including starches, sugars and pectin, which provide high levels of energy (Dupchak, 2014). The feeding of highly digestible NFC such as fruits and non-green vegetables is believed to be a contributing factor in the development of rumen disorders, for instance, acidosis, and other health issues that

are a direct consequence of acidosis, like the hoof problem laminitis (Clauss *et al.*, 2003; Huisman *et al.*, 2008).

|Protein: Okapis require 15% protein in their captive diet (M. Clauss - personal communication 2022). The protein requirements of ruminants are generally met through the digestion of microbial protein, so it is usually unnecessary to provide additional dietary protein (Cheeke and Dierenfeld, 2010b).

|Lipids: Okapis require no more than 5% of lipids in their captive diet. Ruminants generally have a low requirement for dietary lipids; a diet higher than 5% lipid reduces the gut microflora's ability to digest fibre (Cheeke and Dierenfeld, 2010a).

Table 2 – Nutritional recommendations for okapi.

Nutrients	Recommended Concentration (In % Dry Matter)
Protein %	15
Neutral Detergent Fiber %	30-45
Acid Detergent Fiber %	20-35
Non-Fiber Carbohydrate %	≤50
Lipids %	<5
Vitamin D, IU/g	0.55-1.11
Vitamin E, IU/g	120-350
Calcium %	0,70-0,97
Phosphorus %	0.36-0.40
Sodium %	0.055-0.17
Iron mg/Kg	126-139mg
Zinc mg/Kg	54-68mg
Magnesium mg/Kg	0.18-0.24mg
Selenium mg/Kg	0.077-0.199mg
Iodine mg/Kg	0.099-0.79mg

Table 3 – Suggested diet plan for an adult okapi of 270kg.

Food Items		Quantity (grams as fed)
Lucerne[1]	Hay	Ad-lib (minimum 2700)
	Fresh	Ad-lib (minimum 13500)
Browse[2]	Dried leaves	Ad-lib (minimum 600)
	Fresh leaves	Ad-lib (minimum 1800)
Browser pellet[3]		1000
Produce[4]	See Table 4 (below)	600
Unmollased beet pulp[5]		550

[1] When fresh lucerne is not available in such amount, the missing amount can be given as lucerne hay and calculated as follows: the missing amount of fresh lucerne divided by 5 = minimum amount of lucerne hay extra needed.

[2] Amount of fresh leaves is about the number of dried leaves multiplied by 3; browse silage is roughly equal in weight to fresh leaves.

[3] Should have forages (e.g., lucerne meal) as the main ingredient, the recommended fibre levels, and a buffer (e.g. sodium bicarbonate), as well as minerals and vitamins. Might ideally contain some linseed product.

[4] Can also be used for training.

[5] Beet pulp pellet (7% sugar) is soaked in water for at least 2 hours (25% pellet-75% water) and can be used if one has the impression that the animal requires extra energy; however, a better way to offer extra energy is to increase the amount of browser pellet used.

Nutritional Concerns

Diets that are high in carbohydrates or lacking fibres (e.g., fruits, wheat, oats, or pallets made from mainly starchy ingredients) are not recommended. Feeding browsers a diet low in fibre and high in easily digestible carbohydrates can lead to glucosuria, rumen acidosis and pathologies within the gastrointestinal tract (Clauss *et al*., 2003). A "minimal sugar" diet is recommended, which is carried out by offering only green leafy vegetables with no to low sugar levels and beet pellets with <7% sugar levels. Specifically, commercial fruits are not recommended, even though the animals like them (just as humans like sweets).

Food Items

|Browse and Alfalfa (lucerne): Browse is generally preferred over all other feedstuffs by okapi, even over feeds high in sugar. Since it most closely resembles the natural food of okapi, browse is the most desirable forage source for okapi. The following types of browse are identified as particular favourites with the okapi: Mulberry, elm, cedar elm, sweetgum, acacia (thorn-free variety), *Ficus* (multiple species), *Grewia*, willow, hackberry, wax myrtle, rubber tree, magnolia, ash (Lumpkin, 2007), and rose leaves. Other recommended favourites are beech, hazel, oak, nettles, crab-apple leaves, hazelnut tree, poplar, and fruit trees (e.g., apple, pear). During the winter months, as alternatives for fresh browse, browse silage, frozen browse, dried browse and branches with no leaves can be fed throughout winter (Hatt *et al*., 2006; Nijboer *et al*., 2006; Lachance, 2012; Watts, 2017). The feeding of branches without leaves gives little nutritional contribution to an okapi diet but is of high value from an occupational point of view. If no or less browse is available, it should be replaced by other forage sources, not by concentrates. It is recommended to offer browse for *ad libitum* consumption to the okapi, but at least 10% of its diet must be composed of browse (on a dry matter basis).

The alfalfa should have a high proportion of leaves and should have a high hygienic quality. In many European countries, acquiring high-quality alfalfa hay is challenging. When caring for okapi, there cannot be any excuse for having low or medium-quality alfalfa. Alfalfa comes in different varieties (long hay, chopped pressed hay, haylage) and can also be fed fresh. It is ideal to establish a long-term relationship with reliable suppliers.

The recommended diet should have at least 50% alfalfa in the total diet by weight (dry matter basis), but in practice, this means alfalfa must be offered for *ad libitum* consumption (Figure 52). This means that the okapi must always have access to an edible portion of alfalfa. In other words, an empty hayrack/haynet/barrel is a sign that *ad libitum* access was not provided. To facilitate selective feeding, one must never wait for a portion of alfalfa to be finished before supplying a new one. After the okapi has had access to an alfalfa portion, selecting from it those parts it prefers, the rest should be removed (and e.g., fed to less selective herbivores), and a completely new portion offered. The practice of 'topping up', with sometimes week-old material at the bottom of the hayrack/hay net/barrel, is not acceptable.

Some holders might have difficulties ensuring a constant supply of browse throughout the year, especially during the winter months. Several methods to obtain or offer browse (year-round and, if relevant, in winter) are:

|To Obtain:

- Regular browse delivery from an external source (year-round).
- Local production at the zoo grounds (year-round).

- Working closely with other organizations (e.g., universities, botanical gardens or greenhouse cultivation) to secure alternative sources of chemical-free browse (year-round).

|To Offer:

- Offering dried browse leaves or branches (winter).
- Cutting and freezing branches in the summer for offering in the winter months (winter).
- Trimming bare branches during the winter months for okapi to lick and chew (winter).
- Exposing willow branches placed in water to the proper temperature and light to stimulate the growth of leaves regardless of season (winter).
- Planting trees in okapi displays for consumption (year-round).
- Using commercial products (e.g., hay ball) or a variety of materials for hanging browse (year-round) (Lumpkin, 2007).
- Ensiling fresh browse over the summer months and feeding it to the animals in the winter (winter).

One important characteristic of browse (and other dicotyledonous plants like lucerne) is that, in contrast to grasses (including bamboo and other monocotyledonous plants), they do not contain silica bodies ('phytoliths' – leaf stones). Phytoliths increase the degree of tooth wear triggered by the food (Martin *et al*., 2019), and therefore, grazers usually have higher tooth crowns than browsers (Damuth and Janis, 2011). In zoos, browsers, including okapis, with their low-crowned teeth, are particularly susceptible to tooth wear (Kaiser *et al*., 2009). Therefore, due to the presence of phytoliths in grass and grass products (including not only grass and bamboo, but also leaves of other monocotyledonous plants such as maize, silvergrass, or the husks of grains from monocotyledonous 'grass' species such as wheat, oats, rice etc.), these items are not recommended for browser diets – neither to be fed directly nor to be included in larger proportions in pelleted feeds.

Figure 51 – An okapi eating unmollased beet pulp. Note: for this food container to be considered optimal, a grid or net on its top would force the okapi to use its tongue to reach the food instead of using its mouth, promoting its natural behaviours. *©João Pedro Meireles / Location: Safaripark Beekse Bergen.*

|Pelleted Feeds: Compounds or "pellets" (pelleted mixtures of different feedstuffs including important amounts of minerals and vitamins) should be preferred over separated "pure" energy concentrates like beet pulp and mineral/vitamin concentrates, since they best guarantee a balanced nutritional intake. Okapis must be fed pelleted feeds especially designed for browsing ruminants. Pellets designed for browsers should not contain grass forage or grass products (like grass meal, silvergrass, oat husks, rice husks, maize leaves etc.). In the declaration, the top listed ingredient (i.e., the one with the highest percentage in the pellet) should be a non-grass forage, like lucerne. Other ingredients particularly suitable are linseed products and fruit pomaces. At a protein level of about 15%, crude fibre levels of about 20%, and NDF levels of about 35%, such pellets can be offered for *ad libitum* consumption without risking an oversupply of "concentrate". If these

pellets contain a buffer, e.g., sodium bicarbonate, they have a second "safety net" against rumen acidosis.

|"Concentrates": Concentrates high in starch like pure grains, bread and also some pelleted feeds are known to result more easily in rumen acidosis and are not recommended. When there is an impression that an okapi requires more energy, the first measures should always include offering more browse, better alfalfa hay or increasing the amount of browser pellet, before resorting to additional feed items. Unmolassed beet pulp with residual sugar concentrations of 7-8 % of DM has been recommended for okapi (Hummel *et al*., 2006b, c) because it has been reported to have a more beneficial effect on the fermentation in the rumen than e.g., pure grains (Van Soest, 1987; Van Soest *et al*., 1991). Since beet pulp is reported to obstruct the throat in equids, it must be always soaked before feeding (Figure 51 and Table 3).

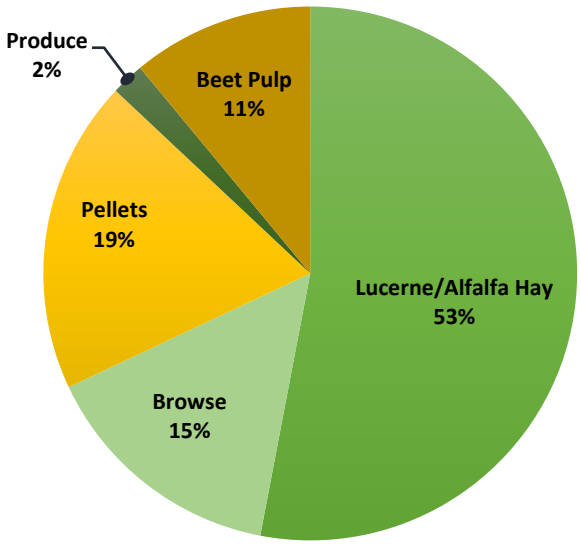

Figure 52 - Relative % of feed categories, on a dry matter basis, for a recommended okapi diet

|Produce: An important characteristic of ruminant food items is their fermentation rate. Fruits and many non-green vegetables have, besides 80-90% water, high amounts of very fast fermenting sugars. These sugars can promote rumen acidosis and therefore, must not be fed, and the offer of produce should be controlled and quantified. Table 4 lists low-sugar profile vegetables that can be offered and a recommended weekly plan. Green leafy vegetables do not need to be chopped. Other low-sugar vegetables that are fleshy are recommended to be offered roughly chopped to prevent potential throat obstructions. Note that the amount of green leafy vegetables can be increased without health danger, e.g., for management reasons (luring, training).

|Particularly Liked Food Items: Food items that are particularly liked by okapi are (pulp) pellets and barrelled browse. Depending on the individual, medication can be administered via soaked beet pulp or a handful of oat flakes (the latter should not be part of the regular diet).

|Problematic Food Items: Willow should not represent a major proportion of the browse offered, as it is debated that willow might cause kidney problems (Haenichen *et al*., 2001). However, some zoos have used willow without observing these problems.

Table 4 – Suggested produce weekly scheme in grams. Produce choices based on Clauss and Hatt (2011).

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Fennel				300			300
Endive		300				300	
Broccoli			300		300		
Chicory	300						
Leek			300		300		
Celery		300				300	
Chinese Cabbage	300			300			300

Vitamins and Minerals

Very little is known regarding the vitamin and mineral requirements of giraffids. The dietary plan must concern the supplementation of vitamin E, as it was found that some okapi might be at risk of vitamin E deficiency (Slifka and Raines, 2015). Just one source can be used to ensure supplementation for all vitamins and minerals; namely, the browser pellet. Additionally, both trace mineral and plain salt blocks have been provided to okapi without adverse effects. Not offering these blocks consistently every day, but randomly at only 3 days per week, potentially creates an enrichment effect.

Changes in Diet

It is important to gradually switch the diet to a new one (either in composition or quantity) and not offer the whole amount of a new item from one day to the next. This is important to allow the gut mucosa and microbiome to adjust and for the animals to develop a taste for a new item. Large changes in the diet should be extended over at least 14 days. It is also advisable to monitor the fibre intake for at least 3 days after changing the diet. Large daily changes are not recommended since too fast and too many changes might have negative effects. The body's condition must be closely monitored after any change in the diet so that it can be adjusted where necessary.

Nutritional Evaluation

Okapi's body condition can be assessed using a visual scoring gradient from emaciated to obese. The prominence of bony joints (hips, pelvis) or noticeable vertebrae, sunken flanks, noticeable ribs or bony heads, and poor coat condition are signs of poor health and nutritional condition. Acquiring regular weights helps assimilate seasonal or life-function weight variations for the respective dietary adjustments. Faecal condition examination provides insight into how an animal is digesting its diet as well as its general health status. Faecal scoring standards have not been defined for okapi. In particular, feed intake behaviour should be scrutinized for signs of dental issues, such as repeatedly spitting out pieces of hay, spitting out chewed 'wads', or a frequent occurrence of larger particles in the faeces.

- *The body condition score can be monitored according to* ***Appendix E – Okapi Body Condition Score***
- *For a faecal scoring table, see* ***Appendix F – Okapi Faecal Scoring***

2.2.2 Special Dietary Requirements

In most situations, acquiring weights regularly in addition to visual inspection provides animal care staff with the information they need to assess individual situations and respond accordingly.

|Lactation: Due to lactation being an energy-draining physiological state, an initial diet increase after parturition is necessary. A common practice for lactating females is to increase the diet by 20% after birth, then 10% increases every two weeks for a few months. Okapis in lactation have a greatly increased energy requirement. In lactating females, it is recommended to gradually double the amount of browser maintenance pellets and unmolassed beet pulp during the first month of lactation. If this measure does not yield the desired result, an additional offering of beet pulp represents the next step. It can gradually be reduced again from 3 months of lactation onwards or maintained until the calf is weaned depending on the physical state and needs of the female. As always, maintaining a good body condition score should guide any changes!

|Young and Geriatric animals: As in most animals, infants and juveniles expend more energy per kg body weight than adults. For geriatric animals, energy expenditure decreases from maintenance, though no studies are examining the exact percentage of decrease. As always, with any life stage, each individual is different, and body condition should be one of the guiding forces behind deciding how much food is offered. In old animals, in particular, that appear to have difficulties in chewing, offering a browser pelleted feed for *ad libitum* consumption may be a good option.

|Seasonal Variations: In colder climates, energy intake may need to increase to maintain body condition during the winter. The recommendation must be to guarantee a good supply of high-quality lucerne and browse and pelleted feed (appropriate for ruminant browsers) *ad libitum*. It is important to note that if individuals spend much of their time indoors during the winter it reduces their activity levels and consequently their energy requirements.

Figure 53 – Example of a meal for an okapi with produce and pelleted feed. Note: for this food container to be considered optimal, a grid or net on its top would force the okapi to use its tongue to reach the food instead of using its mouth, promoting its natural behaviours. *©João Pedro Meireles / Location: Safaripark Beekse Bergen.*

2.2.3 Method of Feeding

Husbandry Considerations

Food should be always made available throughout the day unless otherwise recommended by the veterinarian. It is recommended to provide/resupply food at least 3 times a day, each time giving the animals a portion of the pellet (unless this is offered for *ad libitum* consumption), vegetables and browse (Figure 53). Alfalfa hay must be renewed at each feed. There should be multiple feeding locations for each individual, to the extent that not all of them need to be used at a single feeding event.

Feeding should be observed to ensure that all animals receive the correct food intake. If feeding a group of animals, actions such as increasing the number of feeds per day, placing food in several locations or separating animals to ensure adequate consumption by subordinates may be necessary.

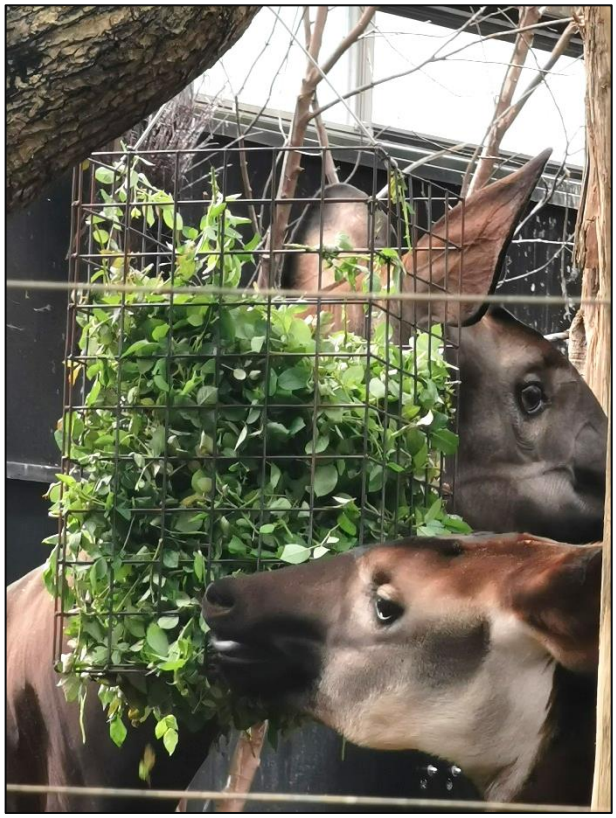

Figure 54 – "Slow feeder" that forces the okapi to use its tongue to get its food. *©João Pedro Meireles / Location: Rotterdam Zoo*

Food Containers

Food containers must be placed in several areas throughout the enclosure, located away from high-traffic areas to minimize the possibility of animals accidentally running into them. Their design should be smooth and rounded to minimize animal injury and minimize the risk of animal entanglement. Okapis rarely eat from the floor, as this is physically difficult for them and as such food containers must be placed away from the floor to a minimum height of 76cm. This height allows animals from different age groups to access food, especially in the case of calves. Additional hay and browse can also be placed at a higher height to accommodate adult animals when together with a calf. Ideally, each trough and rack or hay ball should contain a different feedstuff.

|Troughs: Food troughs for produce or pellets should be covered with a meshed lattice or a grid-like frame to make access to the food more difficult, stimulating the use of the tongue and extending the feeding time. If left open the okapi will use its mouth to eat instead of its tongue. Figures 51 and 53 are examples of a food container that does not follow this principle but can easily be optimised by including a net or grid on its top.

|Hay racks: Hay racks may have to be specifically designed since most used for domestic livestock are not appropriate to stimulate tongue use because bars are too wide apart. This can also represent a risk that the horns of males can get stuck in the hay racks or even the head of a juvenile or adult can get trapped. In giraffes, such hayracks are a common cause of jaw fractures. The distance between bars should not exceed 4.5 cm in width. It is recommended to further adapt the hay racks so that they function as a "slow feeder". The top must be covered in case adult animals can reach it with their mouths. The meshes/bars of the hay racks could be made even smaller so that the animals need more

time to eat the alfalfa; e.g. using several nets inside each other to create a small mesh. This allows the animals to spend more time eating and thus better stimulates their natural behaviour – using their tongues to catch the food (Figures 54 and 55). In case the alfalfa hay loses most of its leaves and since they are the most nutritious part of the hay it is recommended to provide a collection system under the rack (Figure 56). The leaf loss can also be swept up and mixed with the pellets so that the animals are stimulated to eat it. Sieving the alfalfa before the offer is also possible, but it is important to find a way, such as mixing in the pellets, so that the alfalfa powder is also eaten.

Figure 55 – Examples of devices to offer Alfalfa hay. The left is a bad example of a hay rack since it does not work as a "slow feeder".

All food containers should be scrubbed regularly to maintain sanitary conditions. Leftovers must be removed every day.

Feeding Enrichment Considerations

Offering the different components of the diet at different/novel times and locations or in dispensers will make the feeding time more stimulating and lengthier for the animal. In this way, natural behaviours are promoted as it must work to obtain food. Ideally, all regular diet items should be provided under conditions of difficult access (see above - food containers).

Offering browse is very important to encourage the animals to strip leaves from the branches, using their long prehensile tongue as they would do in the wild. This practice offers needed oral stimulation that in its absence might generate oral stereotypical behaviours. Positioning browse at higher positions will also encourage animals to stretch to reach the food. Alfalfa hay can be used as well to promote natural foraging behaviour when hanging or placed in tall feeding containers.

It should be noted that food items, such as produce, offered as enrichment or reward during training sessions should not exceed the recommended dietary amounts and food enrichment must be integrated into the dietary plan.

Figure 56 – Hay rack with a collector. *©Antwerp Zoo / Location Antwerp Zoo*

➢ *For further details on Feeding Enrichment see Section **2.5.3 Behavioural Management and Enrichment - Feeding Enrichment***

2.2.4 Water

Okapis need to have access to clean water *ad libitum* and the devices must not cause any trouble or danger to the animals. Fresh drinking water must be made available in both the inside and outside enclosures. All water containers should be scrubbed and cleaned regularly to maintain sanitary conditions.

Water can be offered through:

- **Automatic drinkers:** they are good for being an always fresh and clean water source (Figure 57).
- **Natural water sources:** The water in these types of sources might become contaminated and if its quality cannot be guaranteed throughout the year its use must be avoided. Safety must be taken into account to avoid animals sliding into water moats, lakes or streams.
- **Troughs or buckets:** These are good for monitoring the animals' water consumption, but water needs to be manually replaced daily.

Figure 57 – Juvenile okapi by an automatic drinker. *©Lisbon Zoo / Location: Lisbon Zoo*

2.3 Social Structure

Figure 58 - Two okapi socializing and sharing their enclosure with red duikers *(Cephalophus natalensis). ©Klaus Rudloff / Location: Berlin Zoo*

Facilities for keeping animals shall allow maintaining a social unit that reflects the life history of a given species in the wild, and thus may need to have sufficient flexibility to adapt towards changing group dynamics (EAZA 2020).

2.3.1 Basic Social Structure

The okapi is considered to be solitary in the wild. However, our knowledge of their social habits or lack of them remains very scarce. Okapis have defined home ranges and it is thought that two individuals rarely interact with each other. Males and females come together for breeding but do not remain together. Mother-calf pairs live together until the subadult leaves in search of its own home range.

➢ *For further details on social behaviour in wild okapi see Section **1.2.6 Social Behaviour***

Okapis are solitary animals and holders usually choose to keep okapi in individual enclosures as this is how they are found *in situ*; however, there are many instances where pairing or grouping okapi proved to have a positive impact on the individuals involved. Experience shows that the animals seem to like each other's company and like to interact with one another (e.g., allogrooming is a common behaviour). A variety of social groupings can be successful, largely depending on the personality, age, and/or reproductive status of the individuals involved, and the size and quality of space provided. The availability of areas for the individuals to escape and hide as well as enough space and visual barriers is essential, giving the animals freedom of choice to interact or not with their conspecifics. All this means that different holders might have different results when recreating the same grouping combinations. The typical number of animals that should be held at a breeding institution is 2.2.2, comprised of the preferred breeding male for each female, a second male who acts as a backup breeder, and the most recent offspring of the females. Since this species is not highly social, it is not to be expected that a breeding male can easily be mixed with two females and their calves and it is expected that two males next to each other in the presence of a female will cause a lot of stress. Therefore, to have multiple enclosures for multiple combinations and/or solitary animals is the way forward. Flexibility is key!

Much of the success of okapi groupings relies on early socialisation, and some individuals will develop the ability to mix well with conspecifics. When grouping individuals, holders should be prepared to monitor the animals and must have the ability and space to separate if the introductions do not work. Some animals will be subordinate to more dominant animals, which is considered normal if not performed persistently and without aggressive behaviours. If otherwise not showing comfort and confidence, the submissive okapi might feel limited in space and activity in this dominant-submissive relationship and its well-being be compromised. The increase in behaviours such as pacing or aggressive behaviour are probably indicators of social-related stress (Troxell-Smith and Miller, 2016). However, keepers must be provided with time to monitor for other more subtle signs of stressful interactions and avoidance. It is important to separate when introductions become negative since okapi learn extreme submissive behaviour quickly, and negative experiences may greatly affect future interactions, even those involving novel individuals. This is particularly pertinent to breeding introductions as learned submissive responses may negatively affect future breeding success.

➢ *For further details on breeding introductions, see Section **2.4.1 Mating - Breeding Introductions**.*

Single-sex groups

Most of the time there are no issues associated with single-sex groups as long as the opposite sex is not within the vicinity, so they do not have partners to compete for. Grouping individuals of the same sex can even yield positive effects on their welfare. For instance, at one institution, two unrelated adult males were introduced successfully. Afterwards, a decrease in stereotypical behaviour was noticed in one of the individuals. However, it was also noticed that some dominant behaviour and mounting behaviour occurred.

Female Groups and calves

Female groups can be composed of related females or females who have been raised together from an early age. However, females do not necessarily have to be related to form a good social group. If the exhibit is well-structured, two females can be housed together (Figure 59). A female with a young calf may be housed alone in a location that is familiar and comfortable for the female. Once weaned, the pair may be re-introduced and monitored for behavioural indicators of stress. Two females with calves may be successfully maintained together if the females have had a positive relationship previously. It is noteworthy that in some cases, young okapi can be curious and approach and bother older animals, who can react aggressively. Okapi calves in the process of weaning from the mother may benefit from pairings with tolerant adults, subadults or other weaned calves to reduce stress and continue socialization. Weaned calves may do well together for up to two years as long as there are no breeding behaviours and few dominance/submissive displays.

Figure 59 – Two adult females and a calf sharing some browse. *©Basel Zoo / Location: Basel Zoo*

Male Groups

Two immature males can normally be introduced and housed together through maturity before their introduction or proximity to mature females (Figure 62). A possible problem amongst groups consisting of males is aggression (especially if females are in the vicinity, thus not recommended). Some male pairings can become more aggressive as the animals get older. It happens that some males continuously trying to dominate are overbearing with the second animal. In many other institutions, males were kept together successfully, which demonstrates that the success of the animal combination partially depends on the animals' characters. If aggression occurs between males, they should be kept separated.

Breeding Groups (mixed-sex groups)

Compatible male/female pairs can be kept together daily as long as their behaviour is monitored and separation is carried out if necessary. It must be considered that the proximity of other individuals may affect the behaviour of those nearby. Some individual females tolerate the presence of males very well throughout their oestrus cycle and even when pregnant. If the zoo facility houses two males and one female, it should be considered how to keep the males (e.g., out of sight of the females, in a separate building and not together) as this situation might result in stressed males. A zoo facility with one male and two females works very well in general. One could allow the male access to one female almost every day, for social enrichment and to help them get used to each other for mating. Some calm males can be good companions to females outside of oestrus periods. However, if another female in oestrus female is in close proximity, the male may show aggression toward his female companion female. If a certain male-female combination does not work, the animals should be separated. The EEP coordinator should be contacted for advice and resolution of the situation.

2.3.2 Changing Social Structure

Temporary Removal

Removing individuals from social groups should be avoided unless it is really necessary. There are several reasons to temporarily remove individuals from a social group, e.g., breeding males, females with young calves, after medical procedures, before transport, etc. If the animals are separated, the option to keep visual contact will probably keep them calm. Okapi will display stress-related behaviour when isolated. The reintroduction can be problematic. A change in group dynamics can alter the dominant position between individuals. Social interactions can decrease between certain individuals after reintroduction, though this depends a lot on the individual animal. Before a transfer, it is recommended to delay the separation to the last possible moment and at the same time get the animal accustomed to the crate.

Introductions and Reintroduction

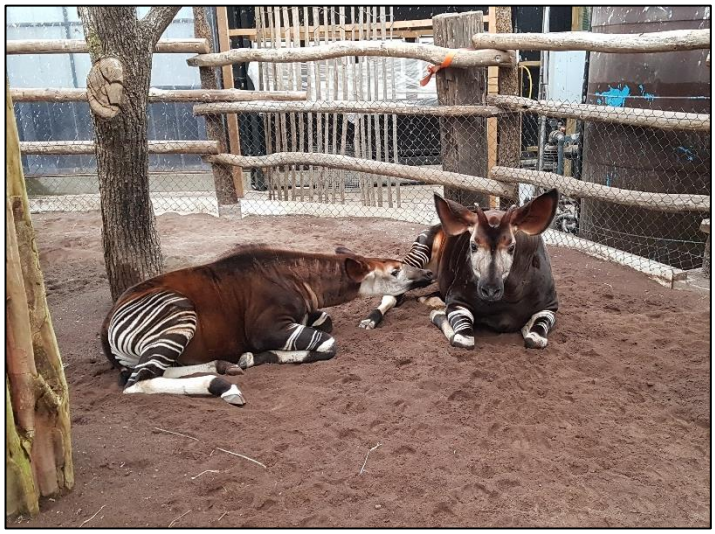

Figure 60 – Juvenile okapi and an adult male. *©Rotterdam Zoo / Location: Rotterdam Zoo*

Generally, okapis are not too difficult to manage and introduce to one another. The introduction success will strongly depend on the behaviours of each animal at a certain time and as such, every introduction is different. Introductions should always be observed by experienced keepers. Response flexibility and close observations of the behaviour of the individuals are key.

Animals must get the chance to meet through the fence before the actual introduction, for a period of 1-2 days to several weeks depending on the individual okapi's response. Allogrooming during this initial fence contact is a positive interaction; however, okapis that avoid contact, refuse to walk past the adjacent animal, or headbang at the fence may not be ready for introductions. Headbanging is commonly observed between males and unfamiliar females, but usually, it should subside after a while. A full visual contact fence line may provoke more initial excitement/aggression than fence lines with the bottom half blocked. Chain link fence covered with plywood or other soft material reduces the risk of serious injury to the male's ossicones during aggressive headbanging.

After the initial contact, the animals may be introduced to an area that will allow quick access for separation in case there are any major problems. As running may occur, okapi should not have access to slippery flooring or substrate, and trip hazards should be eliminated. The introduction enclosure should have a curvilinear perimeter with no tight corners to avoid any animal becoming trapped by potential aggressors. Unfamiliar noises and environmental disturbances should be removed before the introduction. Browse at multiple locations in the introduction enclosure may help animals divert their focus from each other initially and start making contact more gradually later on.

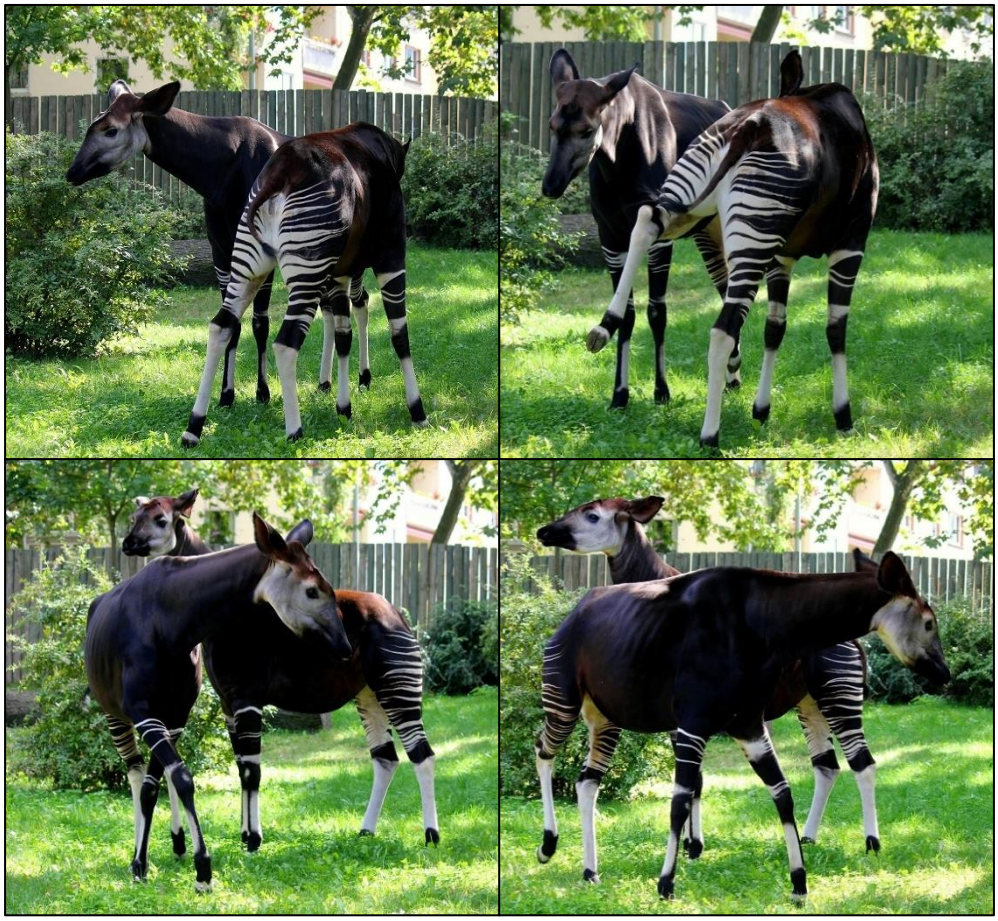

Figure 61 – Some behaviours between two female okapi. Top Right: Kicking. Bottom: Spin-in-place. *©Wolfgang Daum / Location: Frankfurt Zoo*

During a (re)introduction, the following behaviours might occur (Figure 61):

- Chasing;
- Submissive lay;
- Head butts/tossing;
- Kicks;
- Spin-in-place;
- Attempted nursing (in case of a weaned calf)

It is useful to collect video footage of the behaviours during the introduction of animals since new keeper staff members need to be acquainted with critical behaviours before they experience them in real life. The EEP coordinator and/or keeper staff from experienced zoos are also available to assist. Interference should only occur if it is really necessary. The severity and duration of any aggressive or submissive behaviours during the (re)introduction process will determine if separation needs to occur. The submissive lay is a key behaviour factor and should be judged by an experienced okapi keeper. Sometimes almost immediate separation is best when the submissive lay occurs, other times it is better to wait to see if the animal gets up again. Judging the behaviour of the standing animal is important as well. The animals should not be left unattended until they resume normal behaviour. There should be a clear plan for separation and all tools at hand to execute a sudden need for separation. During the initial introduction period, okapis are separated during the night to ensure safety. After several days, animals can be left together overnight as long as food intake can be

Figure 62 – Two male calves introduced to each other in the same enclosure. *©João Pedro Meireles / Location: Antwerp Zoo*

monitored. Adult males are generally not left with adult females overnight unless additional surveillance is provided, or the keeper staff is fully confident the pair is friendly.

Institutions that introduce mother-calf pairs to another animal may introduce them in a large area to allow animals to move away from each other. When introducing calves without the dam present it is recommended to introduce them in an area where it is easy to intervene. All individuals must always be familiar with the area where the introduction takes place.

Separation at night is usually best to allow the monitoring of food and water consumption. This does not apply to mothers and nursing calves (as long as there are no over-grooming problems. the animals must be only left together inside when the indoor situation is designed for this (e.g., run-arounds). Calves do not necessarily have to be introduced to another okapi for socialization at an early stage. Although there is no scientific evidence, the EEP does feel that it can be beneficial for the calf to meet more individuals besides its mother to learn social skills before it leaves for another institution.

2.3.3 Mixed Species Exhibits

Figure 63 – Okapi exhibit consisting of a large aviary where okapis share their enclosure with birds, duikers and small primates. *©Bioparc Zoo de Doué-la-Fontaine / Location: Zoo de Doué-la-Fontaine*

The potential advantages of a mixed-species exhibit are social enrichment/positive inter-specific interactions and environmental enrichment (as well as enhancing visitor experience). Okapis are a very curious species, so other species represent positive interactions. For example, one institution observed positive interactions between their okapi and duiker.

However, one must be aware of the potential risks of mixed-species exhibits, such as:

- Higher chances of disease transmission
- Injuries and stress caused by interspecific interaction.
- Competition for common resources (e.g., food, water, space, resting places)
- Harmful diets of other species (e.g., fruit and high-sugar vegetables given to other species must be avoided by the okapi (for more information see section **2.2 Feeding**)
- Attention should be paid when other species dig holes, into which the okapi can tread and stumble or break a leg.

Figure 64 – Okapi with a female sitatunga *(Tragelaphus spekii). ©Branféré Zoo / Location: Branféré Zoo*

Okapis have been successfully displayed together with birds and other hoofstock (Figures 63 and 64). Generally, curious species that engage or challenge the okapi may provoke incidents of aggression. In the case of the okapi, the fear response is typically freezing before fleeing, leaving it vulnerable to

hoofstock species that chase and challenge by attacking. These species utilize a completely different method of communication than that used by solitary forest hoofstock during interactions.

As stated previously for conspecific groupings, individual okapi may tolerate other species well, while other individuals may chase, kick/stomp, or flee, all of these depending on the personality, age or socialisation history of the individual. Usually, male okapis have proven more tolerant of mixed-species situations than females. Okapi females have fatally injured birds that approach their calves.

When housing okapi with other species, wide-open habitats (as opposed to long narrow spaces) allow the different individuals to avoid each other and prevent animals from trapping one another. Therefore, visual barriers and the complexity of the enclosure are essential. The mixed-species exhibit should be designed to be comfortable and safe for both species, providing enough feeding and resting places. When competition for browse between the okapi and other browsers occurs, it may justify feeding the animals separately. Separate gates and separate feeding stations for each species reduce the competition among the animals and may promote the use of different areas of the enclosure by each species (Figure 65). For instance, since an okapi is taller than most hoofstock, higher hanging baskets with browse are ideal. Harmful food items/diets of other species can be avoided by feeding each species separately or creating feeding stations inaccessible to the okapi.

A lot of observation should be carried out for each interspecific introduction with the okapi. The absence of negative interactions does not exclude existing stressors or issues. It is recommended to introduce each species alone into the habitat, so the individuals get acquainted with the entire area and potential refugia and escape routes. Within the EEP okapi have been housed successfully with mini antelope (duikers and dik-dik), female nyala and sitatunga, varied flying and terrestrial birds and small primates (e.g., Hamlyn's Monkey (*Cercopithecus hamlyni*)).
Mixing with duikers has been proven the most successful combination when considering other hoofstock, although there have been a few cases of aggression from mini antelope towards okapi and vice-versa. Mixing with other species should be considered very carefully. Horned antelopes are always a risk. Every single okapi in the EEP's breeding pool is very important; therefore, mixing with horned antelopes is not allowed. Female antelopes without horns should not be a problem (Figure 64).

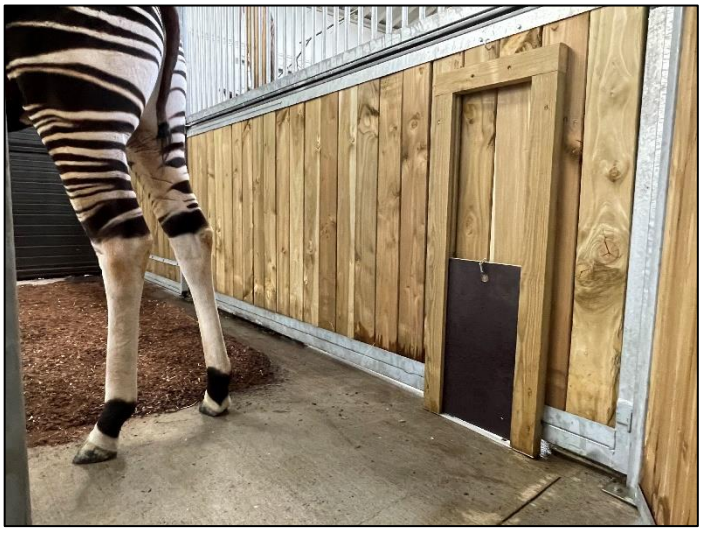

Figure 65 – Mini antelope gate within an okapi stable.
©Branféré Zoo / Location: Branféré Zoo

2.4 Breeding

Figure 66 – Neonate okapi calf nursing from its mother. *©Basel Zoo / Location: Basel Zoo*

Reproduction is an integral part of the quality of life and natural behaviour of each living animal (EAZA, 2020). EAZA Members strive to ensure that their animals are held in appropriate, species-specific circumstances that ideally enable the expression of as wide a range of normal behaviours as possible. It is therefore important that they should be able to exercise the full range of regular breeding behaviours on a natural cycle where rearing of juveniles forms part of that behaviour (EAZA, 2021).

2.4.1 Mating

Pair Compatibility

Occasionally, the breeding of two selected animals brings some issues. In such pairings, when introduced to breed, aggression from the male to the female escalates or the female is over-submissive towards it as an indicator of fear or lack of interest. In these situations, the keepers might be forced to intervene and separate the animals. Many times, these pairs never engage in normal courtship in future breeding introductions while others might get along if new attempts are made. Both situations are equally probable so a case-by-case decision must be made whether to keep trying to breed the pair or not (Meireles *et al*., 2023). Even pairs with previous breeding success may also raise issues in future introductions for no understandable reason.

The breeding success of pairs with such problematic behaviours is reduced or even null (Meireles *et al*., 2023). Since very little is known about the reproductive behaviour of the okapi in the wild, the underlying reasons behind these abnormal behaviours are mostly unknown and are often classified as incompatibility between the male and the female (Meireles *et al*., 2023). One factor that was linked to higher probabilities of a male displaying aggressive behaviour towards the female during breeding introductions was the regularity that the pair was introduced to each other and its linkage with the female's oestrus. Pairs that were only introduced to each other when the female was on oestrus (once every two weeks) had higher chances to display aggression than those pairs that were introduced regularly (e.g., every other day) regardless of the reproductive status of the female. The general recommendation is to provide as many opportunities as possible for the pair to interact and be introduced to each other, hence promoting familiarity between the two (Meireles *et al*., 2023). Other factors analysed such as age difference or social history did not appear to be significant in the probability of one pair displaying male aggressive behaviour during breeding introductions (Meireles *et al*., 2023).

Some other unexplored factors that are suggested to drive the compatibility of the pairs are breeding history and genetics. Animals with a history of being aggressive or submissive require extra precautions when paired with new animals (see further ahead **Aggressive Behaviour in Breeding Introductions**). Reactions and behaviours during breeding introductions can be highly variable between individuals. As such, every new pair, regardless of their breeding history or age, deserve close monitoring during their first introductions and husbandry precautions for any outcome must be prepared.

> ➢ *For further understanding of breeding behaviours see **Appendix C – Mating Behaviour Ethogram**.*

Another reason that has led to incompatible pairs is the size of the animals. Male okapis are generally shorter than the females and in instances of pairing taller-than-average females with shorter-than-average males, the male cannot mount the female. Often this challenge can be overcome if the enclosure has some sloping ground or small hills to provide the male with some higher ground.

Breeding Introductions

Breeding introduction of recommended pairs of okapis must be planned. Because the female's oestrus only lasts 1-2 days, missing it means one must wait two more weeks to get another breeding opportunity. The outcome of the introduction can be uncertain. Instances of highly aggressive males or distressed/submissive females may occur without notice and the animals might have to be separated. Proper monitoring of the animals' behaviours is the key instrument to evaluate the whole

process, make decisions and act accordingly. As such, the staff must be trained on which behaviours and indicators take part in okapi mating and courtship.

➢ *For further notes on the introduction of individuals see section **2.3.2 Changing Social Structure - Introductions and Reintroduction***

|Pre-introductions: For breeding introductions between new pairs and pairs with previous breeding experience, the intended pair must be placed adjacent to one another, or at least within visual access of one another, for some time before the actual introduction, the so-called "howdy" period (Figure 67). Behavioural observations during the "howdy" period may help the staff in the detection of the female's oestrus and pair compatibility issues. The female doesn't have to be in oestrus for an introduction to occur. Some adult pairs get along very well regardless of the female's reproductive state. Negative behaviour in the "howdy" period often translates to aggressive behaviour during introductions. However, a positive "howdy" does not predict a positive introduction. Introduction via adjacent pens is essential. Depending on the pairing's temperament and interaction through the barriers, it is recommended to introduce them when the female goes in oestrus. This way, she becomes more receptive and interested in the male in general. However, sometimes it is possible to leave a pair together in the enclosure all of the time (during the day) regardless of the oestrus cycle of the female. The presence of other conspecifics in the enclosure can cause problems.

Figure 67 – A pair of okapis interacting through the fence. *©Wolfgang Daum / Location: Frankfurt Zoo*

|Enclosure Considerations: Okapi breeding introductions have occurred successfully on-exhibit, off-exhibit, indoors and outdoors as the different holders vary greatly on enclosure design, space and weather conditions. Nevertheless, the ideal introduction enclosure must involve:

- The ability to easily monitor and separate the breeding pair (the more gates or doors the better);
- The best combination of even terrain and open space;
- Appropriate non-slip substrate;
- Lack of obstacles and tight spots or corners;
- The least potential for environmental stressors or distractions, including the presence of humans, conspecifics, non-routine noise, and other unpredictable stimuli.

Furthermore, the decision as to where to hold introductions relies upon the layout of the enclosures, space availability, weather restrictions, and display needs of the individual institutions.

Most breeding introductions are done using as much space as possible and are nearly always done on the outdoor enclosure. A gently sloping terrain can be an advantage to a male when paired with a particularly tall female. Access to indoor space is important especially if an introduction is taking place during wet or cold weather. On-exhibit introductions are normally no problem. Visitor areas can be closed if more privacy and silence are required.

Breeding introductions may also occur indoors because indoor holdings afford more keeper control for monitoring and separating breeding pairs, and provide a safer and less complex terrain. In some cases, indoor spaces are too small to be suitable for breeding introductions. However, it is not important to this species' holders to have an indoor enclosure for introducing a pair to each other. Mating indoors poses several safety issues unless the facility makes modifications to stable flooring (such as the use of mats, shavings, substrate, or a combination of the above) and as long as the stable layout provides appropriate space and shift door access. As such, an appropriate indoor holding for breeding must have non-slip flooring and especially plenty of clear height space so that a male can mount without hitting an obstruction on the ceiling.

Introductions should occur in areas with which the female okapi is familiar. As the territory of the okapi male intersects that of the female in the wild, scent-marking through pedal glands, urine, and faeces plays a role in communication between breeding pairs. The female's scent in her enclosure yard/stall may provide a positive partial distraction for the male during initial introductions. Animal care staff should also introduce browse, favourite enrichment items, and other positive additions to the breeding environment. This may distract and calm the animals to give them time to feel used to each other. Some holders even wait to feed the male until the time of the breeding introduction so it may feel more tempted to eat first while the female gets habituated to him (Lumpkin, 2007).

|Staff Considerations: The presence of humans is not a problem, as long as they will not disturb or provoke distracting/unpredictable stimuli. Experienced staff must be in the area for the duration of the introduction to closely observe and be prepared to separate the breeding pair if necessary. However, if the pair is familiarised or are compatible animals, periodic monitoring with minimal staff required is allowed. Keeper safety must be considered when separating breeding pairs. Although okapis are generally considered to be friendly towards keepers, enclosure design must include safe areas and escape routes as animals can react differently while paired up for breeding.

Figure 68 – Sometimes, when having lack of interest, females may lay in lateral recumbency. This position is dangerous for the female since she may regurgitate stomach content that may end up into the lungs. Keepers must separate the animals if the female remains in this position for too long. *©Antwerp Zoo / Location: Antwerp Zoo*

Oestrous Cycle Tracking

|Behavioural Indicators: The most common method to detect the oestrus on a female is by housing it adjacently to an adult male 24/7. Male behaviour is often the strongest evidence of oestrus in a female. However, it can still be difficult to detect oestrus in females, even if a male is in the vicinity. Okapis may show physical or behavioural indicators of oestrus (Table 5); but often, many animals do not. For example, naïve individuals are not as obvious and consistent in displaying sexual behaviour as experienced individuals. Allowing the animals time-limited access to adjacent space may also not result in accurate behavioural indicators. Occasionally, breeding behaviour can continue into the first few months of pregnancy, and this can create some difficulty for the animal care staff in determining accurate conception and subsequent parturition dates.

Table 5: Behavioural or physical indicators signifying possible oestrus

Female Indicators	Male Indicators
Tail standing or diverting (Figure 122)	Flehmen reflex (Figure 119)
Changes in faecal consistency	Increased level of general activity (pacing or agitation)
Increased level of general activity (pacing or agitation)	Laufschlag kicking and head butting while in howdy to a female
Slightly swollen vulva (Figure 69)	Head raising
Posturing (lordosis)	Honking
Repetitive tail swishing	Loss of appetite due to focus on an oestrous female
Stiffened front legs	
Pacing just before and during oestrus	
Accentuation of already present behaviours (e.g., head rolling or tail “pulling”)	
Breeding behaviour among female conspecifics housed together (including laufschlag kicking, chest resting, and head raising) in which the oestrous female more typically assumes the male position (Lumpkin, 2007).	

|Hormonal Monitoring: Hormone analysis can be a useful tool in determining ovarian cycles, periods of oestrus, acyclicity, irregular cycles and pregnancies. Using this method to track a particular female allows staff to compare observed behaviours with endocrine changes to provide more insight into which particular behaviours of the individual animal are associated with oestrus or periods of irregularity or acyclicity.

The hormone monitoring of okapi has been documented in a number of sample types including blood urine and faeces. The determination of oestrous cycles and pregnancy non-invasively was first established

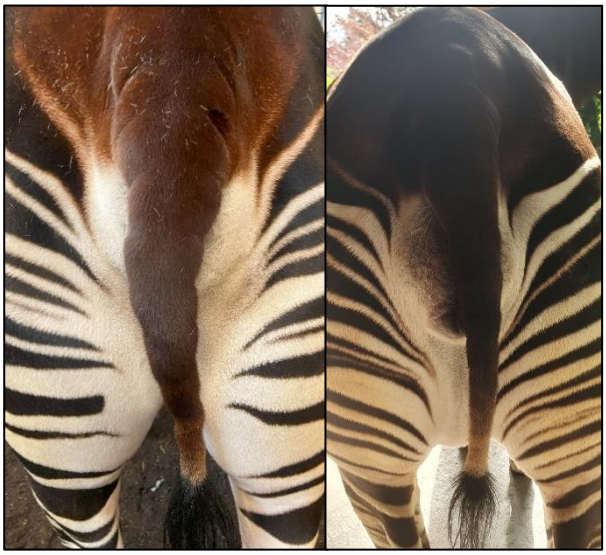

Figure 69 – Comparison between a non-swollen vulva (left) and a swollen vulva (right). *©Chester Zoo / Location: Chester Zoo*

using urine and later with faecal samples (Loskutoff *et al*., 1982; Schwarzenberger *et al*., 1993; Schwarzenberger *et al*., 1999; Kusuda *et al*., 2007; O'Hanlon *et al.,* 2023). More recently, methods testing blood samples to determine pregnancy is a relatively novel method of detection (Kinney *et al*., 2021).

Due to their non-invasive nature, faeces and urine are preferred sample matrices, with faecal samples being easier to collect and more reliable (Schwarzenberger *et al*., 1999). Both non-invasive methods do require frequent sample collection, however.

Sample collection frequency is dependent on the sample type and the question being asked i.e., research project, pregnancy detection or reproductive assessment. It is recommended to always discuss with the testing facility what is the optimal sample collection frequency before collection starts. Samples must be clearly labelled with relevant information, such as institutional name, individual ID and date of collection (Figure 70).

Figure 70 – Example of faecal sample collected and labelled in a sample bag. *©Chester Zoo*

For institutions that conduct reproductive hormone testing, please contact the EEP coordinator.

Through routine sample collection (at least 3 samples per week) clear hormone profiles for individuals can be produced (Figure 71). Hormonal results will always provide a retrospective answer, but this can be overlaid with husbandry observations such as changes in behaviour to provide a greater insight into individual okapi reproductive status. Samples can be analysed in collection periods of six to eight weeks to allow for changes in reproductive state to be observed. To understand if a female okapi is

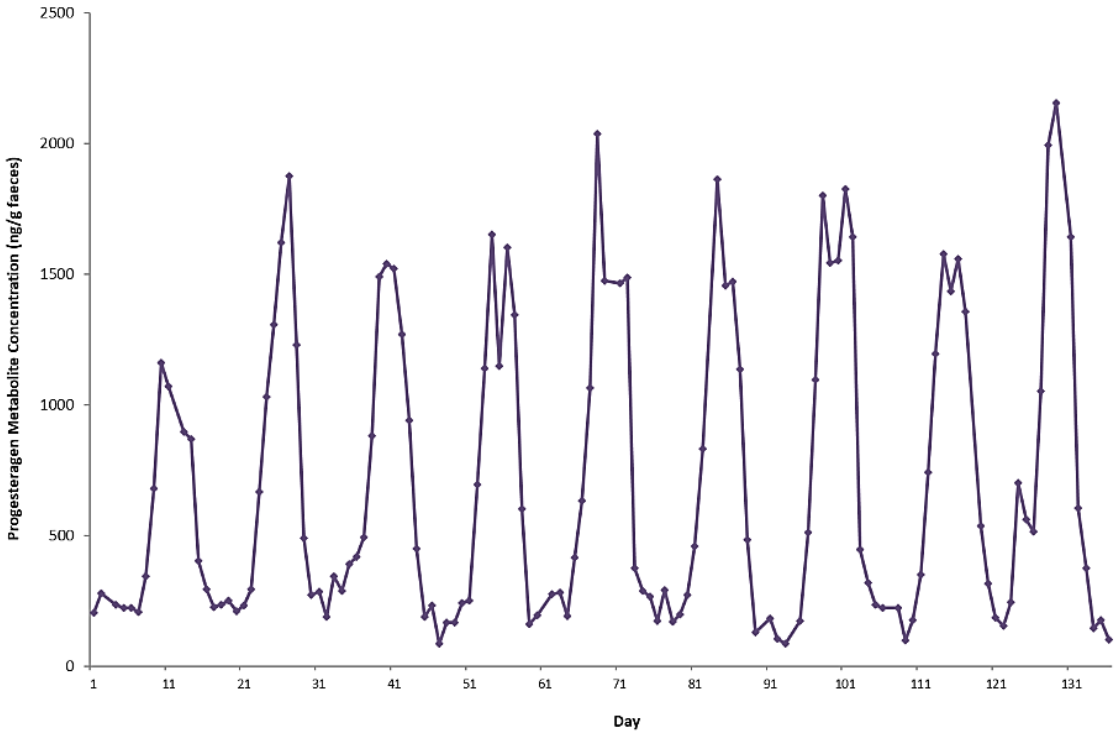

Figure 71 - Example of faecal progestagen concentrations during multiple oestrous cycles from a female okapi. *©Chester Zoo*

cycling or pregnant progestagens are often measured, however, oestrogens can also be beneficial in determining the reproductive state of females. The profile of a regularly cycling female will show progestagen concentrations rising and falling approximately every 14 days, corresponding to changes that occur during the ovarian cycle. Oestrogens will peak at the time of oestrus; this is when the female will be most receptive to the male. Pregnancy will be indicated by a sustained elevation in progestagens for longer than the 14-day cycle, and they will remain elevated throughout the 14-month gestation.

➢ *For further information on the female's reproduction physiology see section **1.1.3 Physiology – Reproductive Physiology***

Courtship and Mating Behaviour

Some elements of courtship and mating behaviours are:

- Flehmen;
- Chin-resting;
- Neck-thrusting;
- Laufschlag;
- Mutual circling.

During courtship, the okapi pair may initially stand head to tail in a reverse parallel position. The pair may circle each other while sniffing, nosing, and licking each other's anogenital regions. Both male and female okapi may flehmen (this will occur during periods of non-oestrus as well). When the female is in oestrus, she may stand and allow the male to position himself behind her. She may or may not tail divert depending on the individual. The male okapi will stand behind the female with his head up and neck stretched. He will laufschlag kick and honk before attempting to mount. Copulation spans less than 3 seconds and is repeated during the introduction almost continuously when a female is in full oestrus.

Often the male will vocalize a soft coughing or moaning sound ("chuffing"), which is not heard at any other time. Sometimes the ejaculatory thrust is noticeable. Breeding behaviour can vary a great deal depending on the individuals involved. In some cases, a male could be heard chuffing via the introduction fence and before he is allowed in with the female.

As the oestrus period does wax and wane, an increase in submissive behaviours by the female may indicate she is not in full oestrus. If the pair is calm and no serious aggression is displayed, they may remain together without the threat of injury or learned submissive behaviours. Some individual females, particularly naive or more submissive females or a female in a new pairing, will kneel briefly or assume a sternal position even when in full oestrus. These behaviours are typically brief and are displayed between more extended periods of standing and allowing the male to mount.

➢ *For described breeding behaviours see **Appendix C – Mating Behaviour Ethogram***

Mating Management

Ideally, breeding pairs should be monitored continuously until the risk of aggression is small. Remote camera monitoring is an excellent option for animals that are easily distracted by human presence.

The female comfort level in the presence of the male during breeding introductions should be carefully evaluated. She must not be overly stressed at the introduction. It can be beneficial if multiple pre-introductions are carried out for short periods to habituate the female to the presence of the male.

Two or three short introductions can be undertaken during the day as long as the female is confident and relaxed.

Besides cases of serious aggression, a breeding pair must be separated:

- After the female ceases standing for one hour (Figure 68)
- When the female begins to show signs of frequent submission (for a normally cooperative
- female)
- When the female begins to display minor agitation as in kicking or head butting
- If it is determined that tension is increasing between the two animals
- If no sexual interest or mating has occurred within 90 minutes of pairing

The need for separation depends on the individual breeding pair. There can be a fine line in deciding whether or not to separate a pair due to the observation of some aggressive/distressed behaviour.

Leaving a female lying for too long before separating is not recommended unless the male is ignoring her completely (Figure 68). If minor agitation is being observed it is recommended to persevere; however, knowing the individuals and being able to estimate if the situation will turn for better or worse is a key factor.

Browse can be used as a separation technique to lure one or both animals away from each other. As a general rule, the more doors available in the breeding introduction space, the higher the chances of separating the animals successfully and safely.

In case of major difficulties in separating the animals or aggression among the animals occurs more extreme measures are required. Those could include the use of a spray bottle, water hose, and various sound devices. In the case of using these more extreme measures, one should not exaggerate to prevent injuring the animals. In case of major aggression, boards or a broom can be used to push a male away. Boards will offer some protection to the keepers while not being too heavy to move around. With a broom, a distance can be created between the keeper and the animal. The animal can hurt itself badly on a hard object or sharp edges. Free-contact approaches must be exercised with caution, as okapi not normally aggressive toward keepers may become so in a breeding situation (Lumpkin, 2007).

For record-keeping or data collection purposes, the behaviours observed during okapi breeding introductions can either be recorded as (Lumpkin, 2007):

- the number of mounting attempts;
- confirmed mounting with intromission;
- The success or failure of the attempts and the possible reasons for failed attempts;
- Incidents of aggression;
- timeframe of introductions, courtship or certain behaviours;
- other behavioural notes

Aggressive Behaviour in Breeding Introductions

Aggressive behaviour as an outcome of a breeding introduction may occur occasionally among some pairs with or without previous breeding history or aggressive behaviour history. First-time pairs require extra precautions as it is not possible to predict what might happen during the introduction. Aggressive behaviour is more commonly seen in males but it can also happen for a female to be aggressive towards a male. Some forms of moderate aggression, including raking (male to female)

and rear leg kicking (female to male), are not a sign of concern and do not require immediate separation of the breeding pair.

The aggression displayed by the male during breeding introductions seems to intensify in the presence of specific female behaviours, particularly the submissive sternal or recumbent positions (Figure 68). Inexperienced males are likely to be more impatient with a female, especially when she sits down. Females most commonly assume this position when not in oestrus and not during the peak of the oestrus when the female is more receptive to mate. The compatibility of two unique temperaments should be taken into consideration, as the combination may produce a chain of behaviours, positive or negative, which feed off of one another. It must be taken into account that some females learn to submit immediately during breeding introductions, even during oestrus, after previous aggressive experiences which reduces future breeding success. Familiarity of the pair with each other may be considered. Pairs well known to each other will show better results. The previous experience of the male is particularly important (Lumpkin, 2007).

The separation of the pair must happen before behaviour begins to reach a level unproductive to the goal of successful breeding or the safety of the animals. Some levels of aggression, such as repeated raking of the female while in the sternal or full lie position, stomping, and head swinging/slamming prompt intervention or the separation of a breeding pair. However, female submission may be allowed for brief periods if the male appears calm. Sometimes a female may assume the sternal position briefly and be gently encouraged by the male to stand by gentle leg kicking. If a female responds to this by standing up, the introduction can continue. If the male shows aggressive behaviour or is being aggressive then instant separation is required if the female is lying down.

It can happen that the male does not show prior aggression with other females, and the "howdy" period was uneventful. An experienced male known to be aggressive should be monitored closely during introductions. Even if that male is introduced to a female he has bred before, he may still attack her. There have been instances of aggression worsening with each introduction between individual pairs with an aggressive history.

Using any sort of medication to aid pair compatibility should be avoided if at all possible or should only be considered as a last resort in consultation with the veterinarian.

2.4.2 Pregnancy

Pregnancy Confirmation

Okapis have an average gestation period of 440 days, with a range of 414 to 493 days giving birth to one calf and very rarely to twins. As a rule of thumb, this means that birth will occur two months later than breeding in the next year.

Early detection of pregnancy is important for husbandry and veterinary care. A pregnant female might have to be relocated to a quieter area and before parturition, a calving area must be prepared in the stable. The female must get used to these changes well in advance before calving, hence the necessity to confirm pregnancy early on. From a veterinarian's perspective, confirmation of pregnancy status helps to anticipate assisted reproductive care such as hormone treatments or monitor other health problems such as pregnancy-induced congestive heart failure.

Pregnancy can be determined by:

- Daily or weekly weight measurements (Figure 73);
- Non-invasive hormone analysis;
- The use of transabdominal ultrasound (Figure 74);
- Observations of behavioural changes in the female, specifically a decrease in activity beginning two to three months after the last known oestrus

Other indicators might hint at pregnancy, however, these vary from one individual to another. Not all females appear pregnant since this species does not exhibit an extended abdomen. Pregnant females may increase alfalfa consumption. Urine production may increase. Pregnant females may appear more reluctant to do allogrooming or be near adjacent male okapi. Motor skills remain consistent before and during pregnancy. Often, foetal movement can be observed during the month before parturition. Closer to term the perineal area (vulva, tail base) may become more relaxed and pink in colour.

Figure *72* – Measuring the abdominal circumference of a pregnant female okapi. *©Reuters / Location: London Zoo*

The pregnant okapi's weight gain begins early in the first three months of pregnancy. Weight gain is rapid for the first 40 weeks then slows in the final 20 weeks of pregnancy (Boylan *et al*., 2003). Okapi dams typically gain up to 13% more body weight during pregnancy. A strong increase in weight occurs from the 4th through the 8-9 months of gestation (100-200 days) (Figure 73).

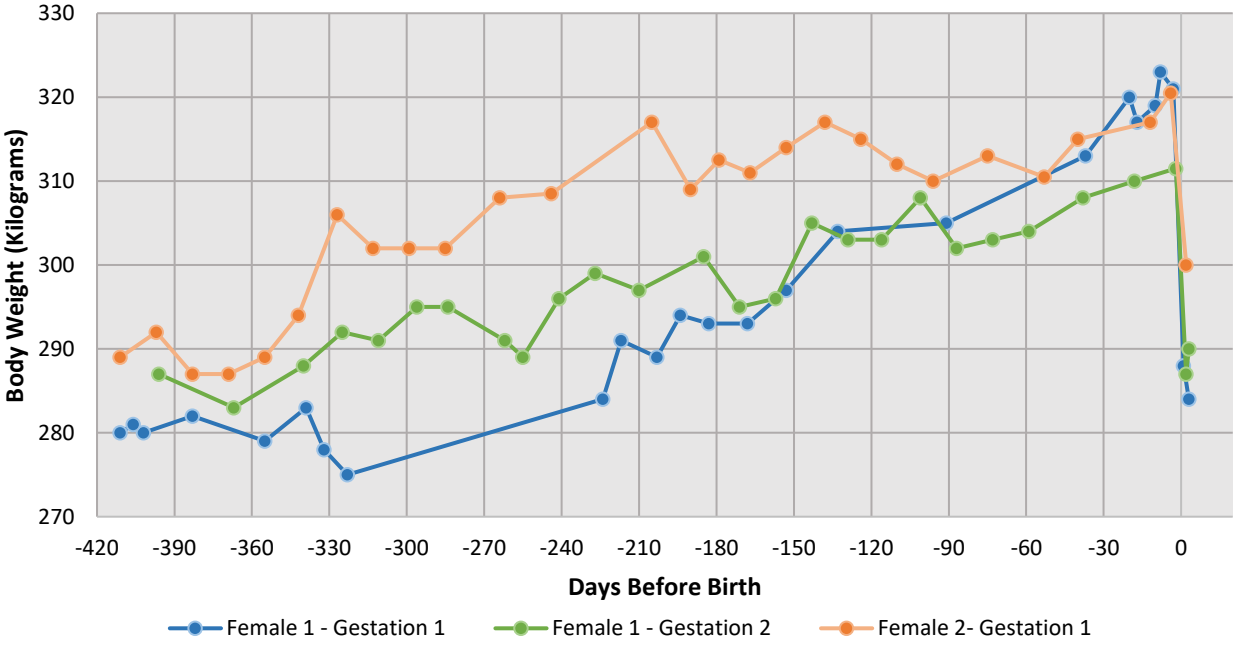

Figure 73 - Body weight during two pregnancies of one female and during the pregnancy of a second female. Data source: ZIMS.

The use of hormones to determine pregnancy has been well-established in okapi. Sampling types include non-invasive methods such as urine (Loskutoff *et al.*, 1982) and faecal (Schwarzenberger *et al.*, 1993; Kusuda *et al.*, 2007; O'Hanlon *et al.*, 2023). It has been found that faecal analysis has higher reliability than urinary analysis (Schwarzenberger *et al.*, 1999). With routine monitoring of faecal progestagens, pregnancy diagnosis can be confirmed within the first 20 days following a known mating (O'Hanlon *et al.*, 2023) (Figures 75 and 76).

Figure 74 - A vet and keepers carry out an ultrasound through target training and free contact on a pregnant okapi. *©ZSL / Location: London Zoo*

In a study performed in 1999, pregnancies were diagnosed using faecal progestogen analysis. From this study, it was concluded that faecal analysis has higher reliability than urinary analysis (Schwarzenberger *et al.*, 1999). A study done in 2007 suggests that faecal analysis is useful for evaluating luteal activity and, again, diagnosing pregnancy. According to Kusuda *et al.*, (2007), oestrogens might have some role as a trigger of parturition as well.

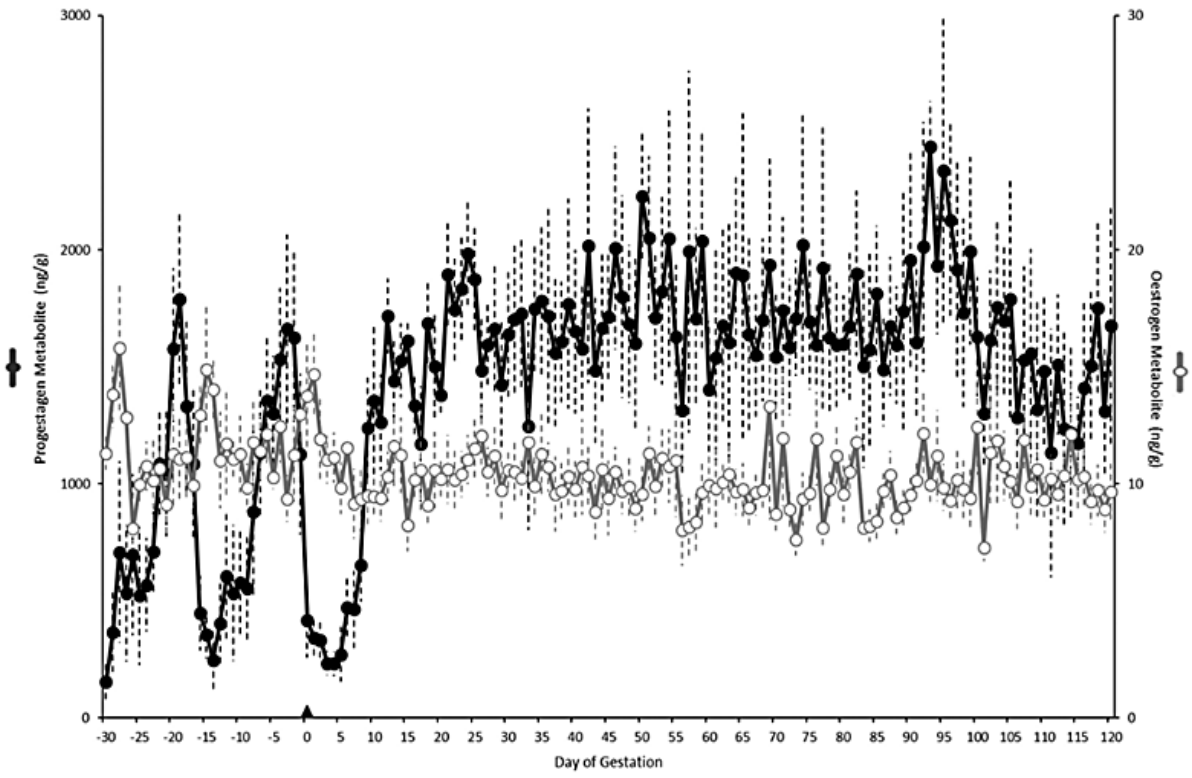

Figure 75 - The average daily hormone (progestagens (●) and oestrogens (○)) concentrations with +/- standard error in female okapi for 30 days prior to mating (▲) and first 120 days of gestation (n=7). Mating occurred at day 0 of gestation. (O'Hanlon *et al.*, 2023).

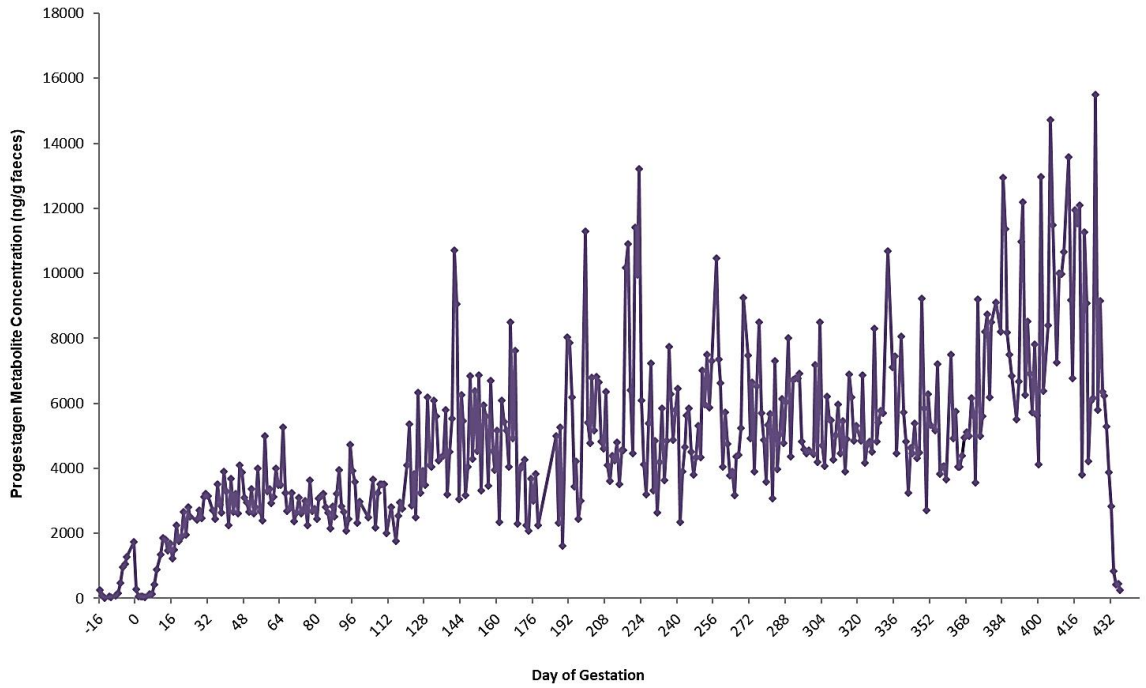

Figure 76 - Full pregnancy profile including oestrous cycling before mating (at day 0) of a female okapi.

Pregnancy can also be confirmed using invasive sample types such as blood, where pregnancy-specific proteins can be used. Kinney *et al*., (2021) analysed pregnancy-specific protein B (PSPB) in pregnant okapi with a sensitivity of 88% and specificity of 100%. Pregnancy could be detected as early as 21 days of gestation but with lower sensitivity during this early stage of gestation. Sensitivity improves to its maximum after 116 days of gestation.

Pregnant females have stimulated breeding interest from males at roughly another 14-day interval after conception occurs. Breeding behaviours are normally not seen after this period which makes the behaviour of a male a potential indicator of pregnancy as well; however, lack of lack of breeding behaviour may also be due to other factors such as a period of anoestrous in the female.

> ➢ *For further information on the female's reproduction physiology see section **1.1.3 Physiology – Reproductive Physiology** and for hormonal monitoring see section **2.4.1 Mating - Oestrous Cycle Tracking***

Pregnancy Husbandry Considerations

Once a female is confirmed pregnant, particularly if the female has experienced difficulties in the past, it is recommended that progestagens continue to be monitored for at least the first five months so problems early in the pregnancy can be documented and possibly even mitigated. Around the fifth month of pregnancy, it is sometimes possible to detect a secondary increase in progestagen concentrations when the placenta begins to take over progesterone production from the ovary. Upon parturition or if a pregnancy is lost, measured progestagens concentrations will decrease back to basal levels.

Along with regular weights, okapi females may be trained to allow abdominal ultrasound. Also, training the female to allow measurement of her abdominal circumference can measure growth through time. Photo documentation taken at regular intervals during pregnancy from the rear, side, and udder area may be useful when compared with other pregnancies.

Health problems associated with pregnancy include abnormal hoof growth due to nutritional deficits caused by the growing foetus, suspected links to chronic heart failure, and excessive weight gain or anorexia. A carefully monitored diet alleviated most of the issues above. More research is required concerning the incidents of chronic heart failure (CHF) linked to pregnancy in several SSP females. Whether the cause is genetics, high blood pressure, multiple births, or other factors is currently unknown. Any nasal discharge, coughing, or lethargy should be investigated immediately. In the case of miscarriage, the condition of the foetus will determine what type of follow-up medications the female will require if any.

Pre-partum vaccinations are not recommended but the veterinarian of each institution may decide to vaccinate taking into consideration the institutional prevalence of rotavirus and coronavirus. So, a risk assessment of each institution will be an important tool for vaccination. Rota/coronavirus vaccinations should be carried out 4-6 weeks before parturition to boost colostral and lactogenic antibodies.

Re-breeding

The calf should be fully weaned at the time of re-breeding the dam. The right moment for re-breeding differs per female and depends on when the female is back to her normal weight and is in good health.

2.4.3 Contraception

Contraception is not used in okapi in the EEP. Unless for veterinary or management reasons, to date, there are no breeding restrictions. The easiest way to prevent breeding is by keeping the individuals separated or housing single-sex groups.

2.4.4 Birth

Parturition Husbandry Adjustments

Before parturition, some adjustments are required regarding the physical and social environment of the pregnant female. It must be taken into account that females have been known to injure or kill the newborn if in an excited or confused state. The female must be in familiar surroundings, without the distraction of other animals or people in the immediate surroundings. Then, any changes that need to be made in the area must be accomplished well in advance (+/- 2 months) of the calf's arrival, allowing time for the female to become familiar with these changes.

If a pregnant female is to be moved to a different stable/enclosure, this should be completed as early in the pregnancy as feasible. When isolation is not possible, a compatible female conspecific could be housed together/adjacently with the dam. However, the pregnant female should be separated to give her time to adjust well before parturition. In this situation, it is recommended to use a visual barrier between the dam and the adjacent okapi. Adult males should preferably not be directly housed next to expectant females.

In case of needed infection control around the birthing stable, the staff must prepare a separate set of tools and footwear in addition to supplying a birthing stable footbath to service the area. Dams should be acclimated to the smell of unfamiliar disinfectants well before calving so the smell is not new. Inside temperatures must be regulated (21-27 °C), as okapi calf thermoregulation is not well functioning until they are about 51 to 60 days of age. Fans or air-conditioning are required if ambient temps are higher than 24 °C. Staff should check both day and night ambient temperatures daily.

The flooring of the okapi dam/calf stable must be modified to provide traction for the calf to stand and walk; fine-grade limestone or a very thick layer of absorbent bedding has provided good footing

for newborns in facilities where the permanent floor does not provide adequate traction. Any additional substrate must be added to the interior flooring approximately 3–4 weeks before the parturition. To provide traction for the calf, one could use thick bark mulch (23 – 25 cm) with straw on top as substrate, for comfort and warmth. The fatal risk of okapi calves splaying is high with bare floors even if a layer of hay is added. It must be paid attention to any material or flooring that the calf might ingest when investigating its surroundings. The substrate must also prevent the mother from ingesting dirt or shavings when tending the neonate and consuming the placenta. When present, water levels in tubs should be lowered and eye-level branches and other furniture removed.

The method for weighing the dam/neonate should be included in the birthing stable for the habituation of the female. If a facility has a dedicated scale for the calf, the scale may be moved into place and covered with a mat and/or hay.

Parturition Indicators

The physical and behavioural indicators of impending parturition vary considerably among individual dams but appear relatively consistent within subsequent pregnancies of the same individual. Installing monitoring equipment (e.g., CCTV) will help document behaviour. The udder development and vulva oedema are the two most observed **physical pre-parturient signs**. These changes observed in the appearance of the udder and vulva may occur several weeks before parturition. More frequently lying down position, increased agitation and reduced feeding are the three most observed **pre-parturient behavioural changes**. The changes in behaviour can be observed hours before the beginning of labour (Lobko, 2022).

The most typical signs of **imminent parturition** are pelvic ligament relaxations (occurring about 6.3 ± 1.2 days before birth), restlessness (1.4 ± 1.1 days prior birth) and pacing (0.83 ± 0.58 days prior birth) (Lobko, 2022).

The physical and behavioural indicators of parturition are:

- A decrease in appetite among certain individuals
- An increase in activity and agitation among certain individuals (pacing, tail swishing, head rolling, and/or repeated lying down and rising, squinting of eyes, and licking back at sides)
- A palpable drop in body temperature (with the skin feeling cool to the touch)
- Leaking udder (although this may occur days before parturition)
- Redness surrounding the vulva,
- Viscous discharge from the vulva

Labour

While the duration of labour varies considerably, especially among primiparous females, most normal births occur within two hours of the presentation of the calf's hooves at the vulva (which happens within 1.5 to 2.5 hours). The calf's hooves presentation is referred to as the beginning of the second labour stage. If a female is uncomfortable in her surroundings, she may delay the progress of her parturition for some time. Work routine activities must subsist around the female during labour. Abnormal or sudden noises must be avoided. During active labour, the female will raise her tail and stretch frequently. Contractions should be regular once the front hooves are visible.

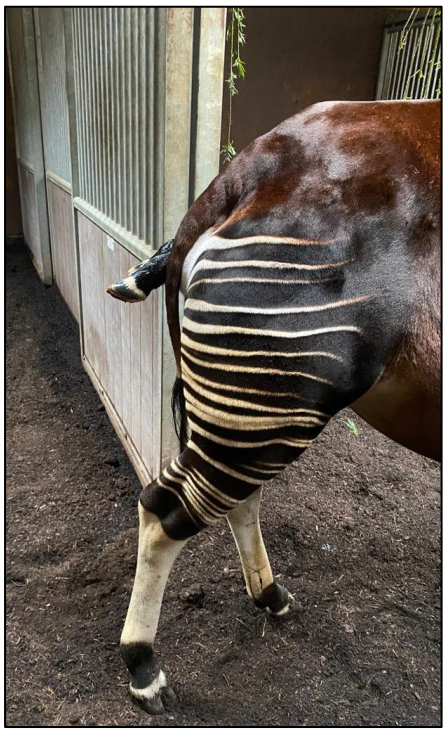

Figure 77 – Okapi dam at the second labour stage with the calf's hooves already visible. *©Chester Zoo / Location: Chester Zoo*

Abnormal progression of labour may be due to the abnormal presentation of the calf or dystocia; dystocia resulting from uterine inertia and posterior presentation. In cattle, intervention is recommended about two hours after the onset of the second labour stage (defined here as the appearance of foetal hooves at the vulva) (Mee, 2004) (Figure 77). Okapi calves born in less than 150 min had a statistically significantly greater rate of survival at birth than calves delivered in 150 min or more (Lobko, 2022). The length of the second phase of labour in the parturient female is therefore essential to monitor, to determine when assistance is required for the delivery since this is the most critical stage for the survival of the calf (Lobko 2022). In several situations, this has been solved by keepers (familiar with the dam) following veterinary directions and thereby assisting the dam, or by a veterinarian performing standing anaesthesia, to facilitate staff to assist in pulling the calf safely.

The placenta should pass within 2-6 hours following birth but it can take as long as 24 hours. Retained placenta occurs with some frequency particularly when the calf is stillborn or dies within the first day (Bertelsen, 2015). The mother should be allowed to consume the placenta. If the placenta is not passed, staff may note persistent contractions without the production of material or the placenta may be visible and there is no progression on the expulsion with persistent straining and abnormal discharge. Other post-partum complications for the mother include metritis, mastitis, and uterine prolapse.

2.4.5 Development and Care of Young

Neonatal Husbandry Adjustments

Husbandry practices that minimise stress around the dam and the neonate reduce issues such as nursing problems and the occurrence of maternal aggression. In the first few days following parturition, limited interactions with the dam and no interactions with the calf must be exercised. Ideally, the most familiar keepers may be selected to work near the dam and calf during these days and visitations and other activities or disturbances in the nearby area must be limited. Cleaning work must follow the nursing patterns of the mother and calf. In general, staff can catch a nursing session and take the opportunity to clean the empty stable, then may use outdoor access for the mother to quickly clean the extra stable.

Extra attention should be exercised when entering a stall with the dam and the calf. Staff may offer a rub, a scratch or food to calm and distract the mother while entering to perform cleaning and care routines. Keepers must avoid staying in between the mother and the calf and keep their distance from the calf for the first weeks. Staff should not force the calf or the mother to change to another stable during cleaning work.

During lactation, it is important to increase the food intake of the mother. For this, the mother's feed is gradually increased following the body weight gain of the calf. This increment must stop at the calf's

4th month of age and gradually reduce once the calf starts to ingest solid food. The mother should have access to water and alfalfa hay at all times

➢ *For further dietary requirements of a lactating female see section* ***2.2.2 Special Dietary Requirements*****.**

Mother-Calf Management

Extensive maternal grooming and high-frequency contact between the dam and calf are characteristic of the period immediately following parturition (Figure 78). Short nursing bouts are frequent, averaging two bouts per hour during this initial phase. This initial phase of mother-infant bonding lasts from 2 to 7 days. After day 3, nursing should occur between 3 to 5 times a day for 8 to 15 minutes at a time for the first 3 months. After, the frequency of nursing decreases to 2 or 3 times per day. The use of any drugs is not recommended as they could pass to the calf through the dam's milk.

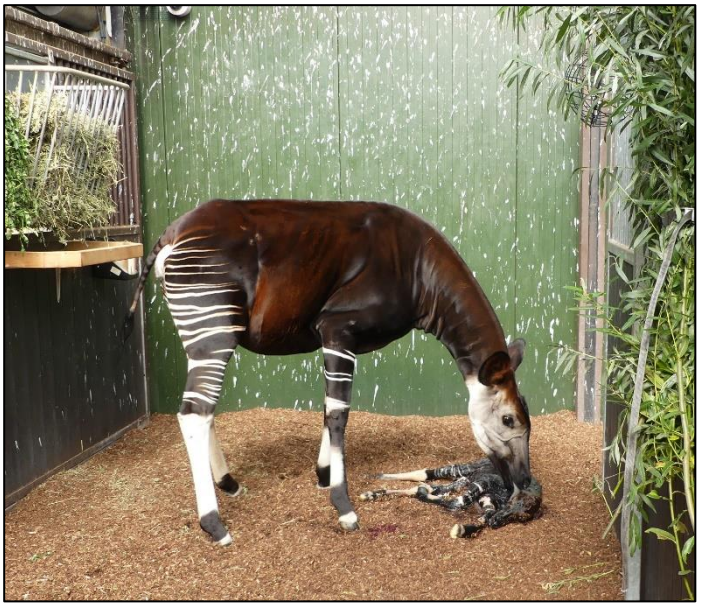

Figure 78 – The dam starts grooming its calf following the parturition. *©Rotterdam Zoo / Location: Rotterdam Zoo*

Okapi neonates are intensive nesters during the first 3 months of life. They only leave their nests to nurse and for occasional play behaviour or try solid foods. As the calf ages, time spent on the nest will decrease, but they might remain strongly attached to their nesting site to rest till 6 months of age. They will typically choose a corner of one of the stables to use exclusively as a nest during the first few months. Staff may place bedding in every accessible birthing stable to allow for the mother and calf to choose individual areas for nesting/resting. Not providing adequate conditions to allow nesting behaviour at this early age might cause strong distress to the calf and the dam. In nature, females leave their calves in their "nests" alone for twelve hours or more. In captive situations, the dam is likely to be seen as distant as possible from her calf while it is in the nesting stage. If given 2 stables, after the calf has chosen its nesting site in one stable, the female will choose the other stable to spend most of her time eating, resting and to defecate.

Calves that do not have the chance to have any separation time from the mother may not nest normally resulting in abnormal nursing patterns and low weight gain in the calf. The constant stimulus of the calf's presence may also trigger stress behaviours observed in the mother such as aggression, overgrooming or tail-biting. To promote nesting behaviour, the dam must be allowed to spend time physically separated, locked away or out of visual contact with the young calf. This temporary separation may provide a solution to the issues mentioned before.

It is advised to wait until the dam and calf are voluntarily reunited for nursing to clean the calf and/or dam stable, instead of forcing the dam and calf together for this purpose. If relevant, beds may be provided for both the calf and the dam in both stables (Lumpkin, 2007).

Different approaches to promote the temporary separation between the dam and the calf are suggested by several institutions:

- **Enforced Prolongated Separation** - the dam and calf are separated during the day for up to 8 hours after the first nursing or separated overnight. This approach is commonly seen to be too restrictive, as the animals have no free choice and the time they spend separated is very long.
- **Enforced Short Separation** – separate the dam from the calf for one to three hours between the nursing sessions and only allow four monitored nursing sessions of 30 minutes to 1 hour long per day. This approach should only be carried out if there are issues presented such as overgrooming.
- **Multiple Stables and Yards** – Offering multiple options to the animals gives them the free choice to be together or separated according to their will and needs. The calf will need several days to find its "nest place", thereafter it will stay there. The mother will intentionally keep her distance and stay in a different stable.

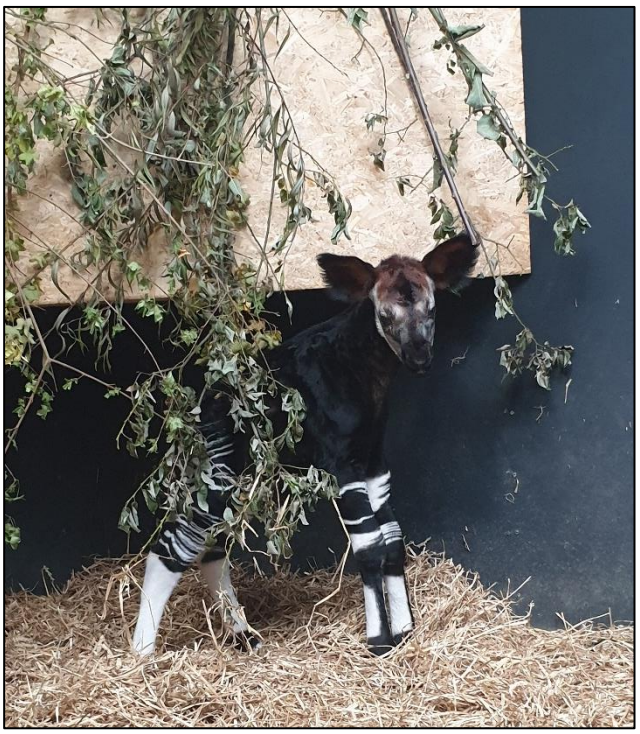

Figure 79 – Creating a creep are with some hanging branches help to promote nesting in a certain area and help the calf to feel more secluded and comfortable. *©Yorkshire Wildlife Park / Location: Yorkshire Wildlife Park*

- **Visual Barriers** - Adding a visual barrier within the enclosure: a barrier of approximately 1.2 metres high is sufficient to visually block the calf while it is on its nest (for instance by using the construction of hay/straw bales). It should be kept in mind that the female might try to climb over or tear down the barrier.
- **Calf Door** - Using a creep partition/gate to allow the calf into a stable or small yard, without giving access to the dam (for instance by removing lower panels of stable walls, placing a strip of wood diagonally across a corner of the stable and hanging vegetation secured by hooks from the strip (Figure 79). This allows the calf to be able to go out and meet the dam, but without the dam being able to approach the calf when the calf is hidden in this reserved area for itself.

If the weather is warm enough, the female could be given access to the outside enclosure and be given the choice to come in and go out later again if she wants to see her calf. Because calves do not thermoregulate well, the keeper staff has to ensure the calf will go inside again and not nest outside.

Special Mother-Calf Considerations

|Maternal Aggression: These maternal aggressive behaviours can range from subtle bumping of the calf (from under the belly) to head slamming, kicking and stomping of the calf. CCTV systems are a good option to monitor since some dams may have a negative reaction towards the calf when being directly observed. Maternal aggression may disappear by removing staff presence, disturbances, and other unfamiliar stimuli or by offering sufficient space. Plans must be in place to observe primiparous and problematic females and intervene if aggression to the calf begins or is suspected after the labour. Calves from "repeat offender" females may have to be pulled for hand-rearing immediately after birth to prevent trauma.

Figure 80 – Neonate okapi nesting. *©Leipzig Zoo / Location: Leipzig Zoo*

|Overgrooming: It is by definition grooming that causes hair loss and/or sores. In okapi dams, it is usually a response to the stress caused by the permanent presence and visual proximity of the calf in the absence of normal nesting behaviour. It has more chances to occur during the winter months, when the dam spends more time indoors, in closer proximity to the calf. Overgrooming is particularly dangerous if the dam is licking the anal-genital area excessively (causing tail sloughing and rectal and vaginal trauma/infection). This can cause calf mortality. Overgrooming must be reduced or disappear if visual and/or time separation is provided between the dam and the calf. The calf can be separated from the dam during the whole night when it is one month old to prevent overgrooming or tail biting. If necessary, in the absence of other options to overcome this issue, a small jacket can be created to place over the bodies of over-groomed calves. However, the reaction of the female must be monitored closely (Lumpkin, 2007).

|Maternal Neglect: It is recommended to document dam-calf interactions and to ensure that good maternal care is exhibited by the dam and document nursing bouts and early development of the calf. If the dam does not interact with the calf within one hour after birth or is reluctant to allow nursing it maternal neglect must be suspected. It might be difficult to document all nursing bouts as the calves do not nurse very often. Nevertheless, calves that nest and appear calm are most likely receiving sufficient milk from the mother. If the calf follows the mother around for extended periods or appears restless, staff should suspect nursing problems. If the dam is not allowing the calf to nurse, and the calf is otherwise in good health, the calf can manage for around 24 hours without needing nutritional support. It is plausible that the calf can go longer than this with fluid and dextrose supplementation. It is important to determine why the dam is reluctant to nurse the calf (e.g. insufficient milk production). If the dam remains reluctant to allow the calf to nurse, hand-rearing or early weaning must be considered (dependent on the age of the calf).

|Assisted Births: Careful consideration should be given to the reintroduction of calves born through assisted births to their dams and to monitor their health, as these calves are at higher risk of maternal neglect or trauma and neonatal problems.

|Disturbed Nesting Behaviour: If the calf suffers strong distress or is scared while in the nest, it will relocate to another site. In case the calf moves to its mother's sleeping location or her stable, she will adjust its sleeping location by shifting to another stable or location. This shifting may take a couple of days during which the female may display stress behaviours like pacing or excessive grooming of the calf since they are sharing the same space. Since the move of the calf to abandon its nest leads to increased stress in the calf and mother, keepers should abstain from disturbing the calf in its new nest during cleaning routines.

Neonatal Exam

There is no need to restrain the calf for injections/blood draw/transponder placement. Only if the calf is showing signs of disease, an intervention may be necessary. If the mother and calf allow the keepers to touch and walk the calf onto a weighing scale, that should suffice.

Calf Development and Health

Normal birth weights range from 14.6 to 31.6 kg with a mean of 22.5 kg. Low birth weight calves or calves exhibiting evidence of immaturity have a much higher prevalence of neonatal problems and may be evaluated and closely monitored. Neonates commonly double their birth weights in 3 to 4 weeks and triple it by 8 weeks (Bennett and Lindsey, 1992) (Appendix H). Rectal temperatures vary from 37.0° to 39.2°C with a mean of 38°C for the first 90 days of life. Behavioural landmarks can be used to assess the health of a neonate (Table 6) (Rabb, 1978; Bennett, 1989). Neonates that take too long to reach these behavioural landmarks must be carefully evaluated and monitored. Monitoring equipment such as CCTV can monitor behaviours 24/7 without disturbing the mother.

- For a graphic depiction of okapi calf weight gain see ***Appendix H – Calf Growth Graph.***

Appendix H – Calf Growth Graph

Table 6 – Behavioural landmarks to assess neonatal health and expected times (maximum and average) (Rabb, 1978; Bennett, 1989).

Behavioural Landmarks	Maximum Expected Time Since Birth	Average Time Since Birth
Sternal recumbency	within 15 minutes	8 minutes
Attempts to stand	within 18 minutes	12 minutes
Standing	within 45 minutes	29 minutes
Attempts to nurse	within 2 hours	38 minutes
First successful nurse	within 6 hours	77 minutes

Weak calves with difficulty standing can be assisted by assisting the calf in standing for nursing whenever the calf attempts to rise (Lumpkin, 2007). However, it might be difficult to get a calf to nurse successfully when offering such assistance. Maintenance of the birth substrate must continue until the calf becomes comfortable and stable walking. After, the substrate can begin to be removed gradually during routine cleaning.

Table 7 – Behavioural and physiological landmarks to assess calf development and health and their expected ages (range and average) (Rabb, 1978; Bennett, 1989).

Behavioural Landmarks	Age Range	Average age
Water Ingestion	After one week	
First ingestion of solid food	14 to 25 days	20 days
First rumination	27 to 41 days	33 days
First defecation (meconium passage)	28 to 70 days	43 days
Thermoregulation	51 to 60 days	
Regular defecation (daily or every other day)	101 to 135 days	120 days

Calf development must continue to be tracked beyond the neonatal phase by recurring again to key behavioural and physiological landmarks (Table 7). Nursing should never be assumed since changes can happen over time even after established patterns. Nursing should be confirmed via camera recording or, in the impossibility of doing video observations, via normal growth curve monitoring (

Appendix H – Calf Growth **Graph**). Body weight gain is the best indicator of successful nursing and weight data will highlight any potential nursing issues. To achieve this calves must be weighed

anywhere from daily to once a week, depending on the calf's stress level with the process as well as the ease of scale set-up. Data from other holders might be a good frame of comparison. Calves that defecate earlier must be observed closely for signs of illness. Bleating is a vocal indicator of severe stress from the calf. Listlessness is a concerning sign of illness.

Calf Socialization

Calf habituation to human contact is important for its welfare and husbandry and, once started, must be a daily practice. The goals of early calf habituation include; full-body touching and examination, ultrasounds, radiographs, blood collection, lifting the legs for hoof care, weighting routine and introducing early shifting techniques. Animals early habituated to humans also have lower tendencies to be aggressive towards keepers. Calf habituation must be initiated in the days following the birth. It is recommended to wait until the dam consistently begins to spend time outdoors or away from the calf (the fourth day or after). The number of keepers performing habituation may be limited to no more than two during the first month. Two different approaches to calf habituation could be practised:

Figure 81 – Calf habituation to body touch with use of gloves and straw. *©Antwerp Zoo / Location: Antwerp Zoo*

- Slowly approaching the calf's nest to touch the calf, thereby working with a constant evaluation of the calf's comfort level and avoiding distress of the calf while in the nest;
- Waiting until the calf approaches the keeper (more time-consuming).

The habituation should progress slowly starting with the keeper sitting quietly with the calf, then starting soft speaking, moving a hand close to the nest area, to finally starting to light touching the ear or the head of the calf (Figure 81). Always without triggering distress on the calf in its nest. If a calf becomes alarmed, it may bleat which also may leave its mother alarmed. Keepers must leave the calf until both animals have settled down again. Turning off the lights to the calf and offering some browse or enrichment to the dam might help in this process.

The decision as to when to exhibit the calf to visitors is based on a variety of factors including weather, facility design and the calf's behaviour/developmental stage. If it is offered free choice to the calf to go outdoors or remain inside, it can be displayed at a very young age (1-2 weeks old). It is advised to not display calves earlier than the age of four months old in situations that do not provide the choice

of going outdoors or remaining inside. Since young calves do not thermoregulate well, they must not be exhibited outdoors if the temperature range is out of the 22-27°C range (Lumpkin, 2007). If a holder wishes for visitors to view very young calves, possible options are facilities designed with one-way glass and sound isolation or the installation of cameras in the birthing area and TV screens in the visitor area. This may allow the public to view the calf and its behaviours.

When introduced to conspecifics, calves must be old enough to be out of their nest. Also, introductions to either adult males or adult females may occur only if the dam has been housed with the other adult before pregnancy and calving. The age of 6 months would be the standard to start introducing the calf to conspecifics. When introducing a mother-calf pair first re-introduce the mother without the calf and after a couple of sessions when all is relaxed add the calf to the mix. All introductions regarding calves need to be closely monitored by animal staff. After weaning, a calf can usually be introduced to any okapi including a mother-calf pair, adult female, adult male or similarly aged conspecific. Adult males can work as social companions for weaned calves up to 2 years of age. A possible problem when introducing weaned calves is attempted nursing. These nursing attempts usually do not occur until after the initial day of introduction. If the calf is persistent in its nursing attempts, the other animal may become aggressive which could result in the need for separation. To avoid certain problems, males must not be housed in the vicinity of cycling females as this can result in aggressive and/or breeding behaviour directed towards the calf.

> ➢ *For further notes and details on the introduction of individuals to conspecifics see section **2.3.2 Changing Social Structure - Introductions and Reintroduction.***

Calf Feeding

Foods that are included in the regular adult okapi diet should be available to the calf early on (e.g. through low food shelves, low hay feeders and browse hanging low) to introduce the calf to these items and eventually prepare for weaning. The dam and calf may be allowed to share feeding time, as most calves learn to consume pellets and other foods by food sampling directly from the dam's mouth.

If the calf begins to consume a cup or more from the dam's diet, more food should be added to the female ration. If the young calf begins to heartily consume large amounts of pellets (whether of its ration or from the mother), the calf's access to pellets must be limited to avoid potential health problems. The age difference among calves in their first consumption of pellets ranges from less than 2 months to 5 months of age.

A salt block must be made available but, if usage is high, access should be limited to 2–3 days per week. Clean water must be available at all times beginning at birth.

Calf Weaning

Weaning can either be allowed to occur naturally or weaning can be forced by separating the dam and the calf. The decision to separate calves from their dam is usually based on the declining body condition of the female as older calves continue to nurse and/or the dam over-grooming the calf. Each female and calf needs to be monitored individually to determine the necessity of the separation. It is recommended to wean calves at about 10 months of age. At that age, the weaning process does not have to be very gradual. After weaning is completed, the calf can be re-introduced to the dam.

The method of weaning depends very much on the age of the calf at the beginning of weaning. When it is very young as it still drinks a lot of milk the risk of mastitis in the dam is high if the weaning is carried out suddenly. If the calf is older this risk is lower. In the case of forced weaning, the age of calves may range from 5 – 10 months, with a mean of 8-9 months. Calves must be separated during

the day or at night during the weaning process, which must be carried out gradually. Calves may have visual contact with dams during the separation, but this should be limited contact.

Another method follows a scheduled plan and takes several weeks: one day together and one day apart for three occurrences, one day together and two days apart for three occurrences, and then one day together and three days apart for three occurrences. Once full separation occurs there must be as much physical (and visual) distance between the pair as possible. Stress caused by separation is not more excessive than the stress caused by natural weaning.

Pellet and lucerne consumption by the calf may be considered if weaning will occur before 8-9 months of age. After weaning, there is likely to be a decrease in consumption by the calf, but that decrease must not be more than 60% and must not last for more than three days.

Neonatal Mortality

In the captive population, abortion, stillbirths and perinatal deaths remain an important risk estimated at 27.54% (n = 19/69; 2012 - 2022) over the last ten years (Lobko, 2022). The most reported causes of abortion are twin pregnancy, progestogens insufficiency, and dam severe illness (Schwarzenberger *et al*., 1999), while stillbirths are mostly due to dystocia (Bois *et al*., 1992). Okapi calves born in less than 150 min had a statistically significantly greater rate of survival at birth than calves delivered in 150 min or more (Lobko, 2022). The corpse of the neonate can be safely removed once the dam loses interest in it.

Contributing factors to neonate mortality following birth to the first anniversary include general weakness, congenital defects, septicaemia, pneumonia, viral or bacterial infections, maternal neglect or aggression, and trauma. The first 10 to 14 days are critical for calf survival. Maternal neglect or inadequate maternal care can lead to failure to nurse and failure of passive transfer of maternal immunoglobulins. Such calves will be prone to infectious disease, and if intake remains inadequate, these calves will quickly become hypoglycaemic and dehydrated. Measures must be in place to prevent environmental dangers including extremely high or low ambient temperatures, choking hazards, the aggression of the mother toward the calf, or overgrooming of the calf by the mother.

2.4.6 Hand-Rearing

Due to the small population size and limited breeding of this species, all planned births are important to the population. Therefore hand-rearing, if necessary, is warranted. However, the hand-rearing procedure is advised for only strictly necessary situations due to the high possibility of imprinting with the keeper, difficulties with future introduction back to its conspecifics and the possibility of rejection by that individual of its own young in the future. Any guidelines for hand-rearing may always be developed with the intention of reintroducing the animal back to members of its own kind with the minimum of stress incurred to the animal.

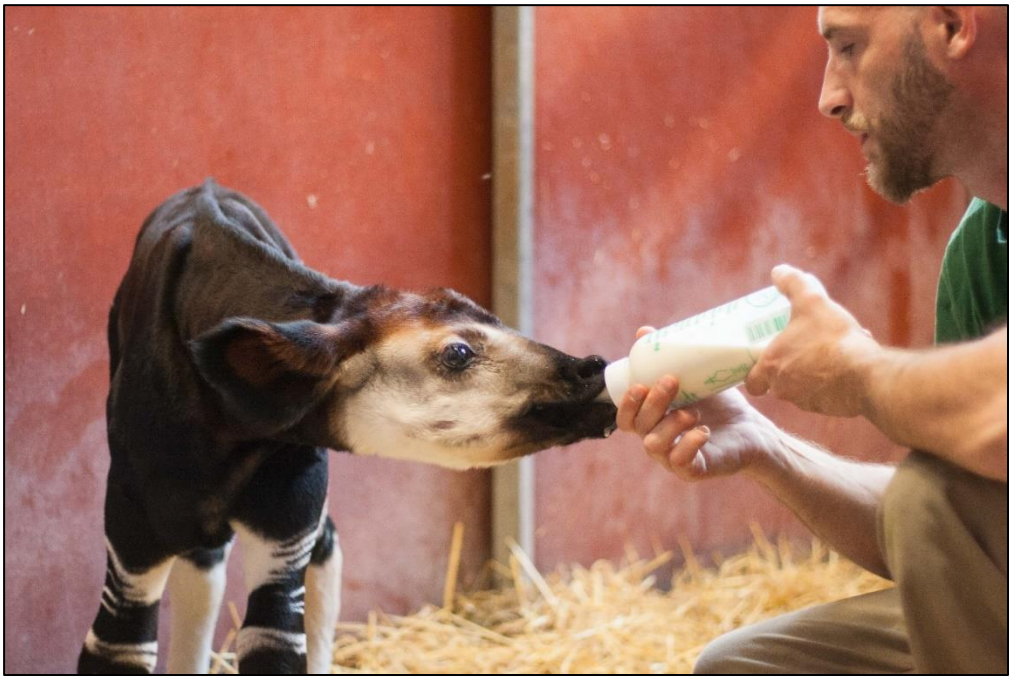

Figure 82 – Bottle feeding of an orphan neonate female *©Wilhelma Press Photos / Location: Wilhelma Zoo*

Hand rearing is recommended in the following instances:

- **Maternal aggression:** Separate immediately in the case of serious maternal aggression or the case that moderate aggression does not subside after some time.
- **Maternal neglect:** Separate within 24 to 48 hours after the birth if the mother does not interact with the calf or does not allow nursing.
- **Poor Calf development:** Separate if the calf is born prematurely, appears weak, does not stand well for nursing, does not settle into nesting patterns after day 3, does not thrive and/or increase weight normally, or becomes ill.
- **Maternal severe illness/mortality:** In case the dam is incapacitated to provide maternal care for an extended period or dies after the parturition or a few days/weeks later. Depending on the age and development of the calf it can be weaned instead of hand-reared.

Assisted Rearing

Taking into account that hand-rearing must be a last resource option, in instances where okapi calves are not nursing or thriving normally they may receive assistance from the keepers with no need for separation and replacement of the dam's maternal care. Pending the decision to fully hand-rear, okapi calves may receive supplemental hydration via subcutaneous fluids if dehydrated. If required, the calf may receive colostrum and initial feedings via gastric tubing-- with care not to introduce fluid into the rumen-- as it does not compromise the nursing /suckling response of the calf. The neonatal exam will help to indicate potential issues and which will be the best approach to take. If the neonatal exam indicates that no colostrum was received, the calf has a limited window of 48 hours to be offered colostrum, or banked plasma, to then receive the benefits of passive immunity absorption. Supplemental bottle feeding should not be done if there is any chance of introducing the calf back to the mother for nursing. Once bottle-feeding starts, one must be ready to commit to hand-rearing the calf full-time. Conversely, commitment should be made to hand-rearing early and before the calf is nursing from the mother.

Milk Formulas and Supplementation

It has been documented in several species that milk composition and output change over time and with the sampling method (Oftedal, 1984). Thus, published values are greatly dependent on the time taken during lactation as well as the methodology used. This may be the reason for the variation in published values. Since relatively few samples of okapi milk have been published; it is necessary to consider general trends at this point. Below are the nutritional values for okapi milk (Table 8).

Recent successful hand-rearing procedures have utilized a Zoologic® Milk Matrix (PetAg, Inc; USA) and non-fat, dry milk-based formula and diluted the entire formula for the first few days (**Option 1**). Before this, some zoos had success with an evaporated milk-based formula with varying levels of Esbilac® powder (PetAg, Inc; USA) (**Option 2**). Details for the recommended substitution formulas are presented in Table 9.

Table 8 - Nutrient composition of okapi milk and replacement milk formulas.

Source	% Solids	% Of Solids			% As Fed		
		Fat	Protein	Lactose	Fat	Protein	Lactose
Faust (1968)	24.1	39.4	24.9	unk	9.5	6.0	Unk
Crandall (1964)	18.5	10.8	54.1	27.0	2.0	10.0	5.0
Senft (1978)	20.1	19.9	48.3	20.4	4.0	9.7	4.1
Gregory (1965)	28.2	15.6	58.9	?	4.4	16.6	?
Ishwwada *et al* (2008)	17.8	27.5	41.6	24.7	4.9	7.4	4.4
Kawasaki (2012)	20.8	40.8	36.0	17.3	8.5	7.5	3.6
Power (2017, pers. comm.)	22.18	30.8	39.6	17.2	6.85	8.8	3.82
Formula Option 1	17.97	20.0	42.1	12.6	3.6	7.6	2.3
Formula Option 2	19.3	34.9	29.8	29.9	6.7	5.7	5.8

Table 9 – Recommended milk substitution formulas and supplementation that should be added.

FORMULA OPTION 1			FORMULA OPTION 2		
	%	g/L		%	g/L
Zoologic® Milk Matrix 42/25	12.2	122g	**Evaporated milk**	46.25	463g
Non-fat dry milk	6.3	63g	**Esbilac® powder**	7.5	75g
Water	81.5	815g (ml)	**Water**	46.25	463 (ml)

SUPPLEMENTATION FOR THE FORMULAS	
Lactase enzyme	Per package directions
Human infant vitamin drops	10 drops/L
Human infant iron drops	1 ml/100g of formula

|Preparation of the Formulas: A conservative approach to avoid possible diarrhoea is to offer a more diluted formula in the first few days. To prepare the formula it is required to use refrigerated water from a bottled source or previously boiled. In case the calf shows signs of dehydration and to promote a good sucking response water can be replaced by electrolytes solution (Pedialyte® (Abbott Laboratories; USA) or equivalent) on the first feeds. Use a food thermometer to check the temperature of the formula. The temperature that the calf prefers must be determined and then consistently be offered at that temperature. The preparation of the formulas presented in Table 9, their required administration timeline, amount (ratio of calf's body weight) and respective dilutions are described in Table 10. Other product-specific storage or preparation indications displayed in the packaging must be followed.

For **Formula Option 2**, previous holders utilizing this formula have kept the calf on a pre-formula for the first 9 days to help prevent early stool passage. The difference between the two formulas is an increase in the percentage of Esbilac® (and calories) in the final formula. The transition from pre-formula to final formula must be done slowly.

If the calf is removed for hand-rearing and has not received colostrum by nursing, colostrum must be administered via bottle-feeding. This feeding should replace one of the six formula feedings within the first 48 hours after birth.

For the first several weeks of hand-rearing, the increments of volume (calculated following the calf's weight) should not exceed 30 ml per feeding (180 ml per day). The increases must only occur every 3 to 5 days even if the calf is gaining weight well. It is extremely important not to increase the volume too much too fast as it may cause early defecation or gastrointestinal distress. A consistent weighting routine of the calf and control of its caloric intake will be the tools to adjust the volume of the formula across time. Past weight graphs will determine if the calf is having the expected growth. Most calves are expected to initially lose weight when transitioning to bottle-feeding. The increase in calories to reach weight gains must always be achieved by increases in the volume of the formula while maintaining the percentage and concentrations of its solids.

Table 10 – Preparation of milk substitution formula Options 1 and 2 and their administration timeline.

FORMULA OPTION 1			
Preparation (final formula)	12.2% **Zoologic® Milk Matrix** + 6.3% **Non-fat dry milk** + 81.5% **Water**		
Timeline	**Dilution**	**Amount**	**Notes**
Day 0-2	50% final formula/50% water	**10%** of the calf's body mass (divided into **6 feeds per day**)	
Day 2-3	75% final formula/25% water	**10%** of the calf's body mass (divided into **6 feeds per day**)	This dilution provides 0.54 calories per ml.
Day 4-28 (4 weeks)	100% final formula	**10%** of the calf's body mass (divided into **6 feeds per day**)	
Day 29 (+) – after the 4th week	100% final formula	decreased slowly to **6%** of the calf's body mass (divided into **5 feeds per day**)	

FORMULA OPTION 2			
Preparation (final formula)	46.5% **evaporated milk** + 7.5% **Esbilac®** + 46.25% **water**		
Preparation (pre-formula)	48.5% **evaporated milk** + 3.5% **Esbilac®** + 48.25% **water**		
Timeline	**Dilution**	**Amount**	**Notes**
Day 0-2	Pre-formula	**10%** of the calf's body mass (divided into **6 feeds per day**)	This formula provides 0.85 calories per ml.
Day 2-8	Pre-formula	**10%** of the calf's body mass (divided into **6 feeds per day**)	This formula provides 0.85 calories per ml.
Day 9-28 (4 weeks)	Final formula	**10%** of the calf's body mass (divided into **6 feeds per day**)	Slowly transition to the final formula using intermedium concentrations.
Day 29 (+) – after the 4th week	Final formula	Decreased slowly to **6%** of the calf's body mass (divided into **5 feeds per day**)	

|Nutritional Supplementation: Most calves can go up to 48 hours without receiving any supplementation if they are ingesting some formula via bottle feeding. This is especially true if the calf has received colostrum supplementation at the beginning of the process.

- **Colostrum:** Calves older than 48 hours will not benefit from colostrum replacer and this step should be skipped. Supplementation of the calf with colostrum must be via bottle. Banked blood serum (from the mother or okapi donor taken in advance) is the best recommendation. It can be administered orally, intravenously, or subcutaneously. It can be administered orally, IV, sub-Q or IP. Considerations to add glucose or electrolytes to the colostrum tube feeding must be taken if

dehydration is noted. A colostrum replacer commercial product can also be used as an option. Feed at 10% of the calf's body mass (one time only) for either the blood serum or the commercial replacer.

- **Lactase supplement** (Table 9): Added to the formula to break down lactose and aid digestion.
- **Hydration:** Consider drawing blood daily in the morning (after taking body weight and after first feeding) to guide what hydration supplementation is needed. Supplement hydration via subcutaneous fluids can be done as needed to sustain the calf until it is bottle-feeding well.
- **Vaccinations:** Administration of oral Rota/coronavirus vaccination (Calf-guard) orally via syringe or subcutaneously (not during bottle-feeding).
- **Vitamin and mineral supplements** (Table 9): They must be included with the milk substitution formula from the beginning. In this way, taste changes are kept to a minimum. Access to salt/mineral block and fresh alfalfa and browse around the nest area must be provided as early as possible.
- **Oral probiotics:** To offer to older calves once rumination has started. Probiotics are not added to the bottle formula initially. As an alternative, the introduction of adult okapi faeces in the enclosure when the calf is older if isolated from other individuals.

Bottle-Feeding

Okapi calves do not accept bottle-feeding readily especially if they have been nursed by the mother. It may take up to 3-5 days to establish consistent bottle-feeding behaviour, so some supplementation may be needed to sustain the calf. Only tube feed needed nutritional supplements as a last resort as this will very likely interfere with establishing normal bottle-feeding behaviour. The volume of feedings given by gastric tubing should be based on the body weight of the calf, and the frequency of tube feeding should be kept to a maximum of once every 24-48 hours.

|Husbandry: Disturbances and the handling of the calf must be kept to the required minimum until the calf is nursing well from the bottle. Veterinarian procedures must be planned with the bottle-feeding schedule. The hand-rearing team must be of reduced size (2-3 experienced keepers).

|Feeding intervals: Feeding calves should occur 5-6 times per day mostly in daylight hours – between 6 AM and 8 PM until the calf is completely weaned. After 19 weeks the milk volume stops to increase but the number of feedings remains the same.

|Type of bottle and nipple: Starting with a small black "lamb's nipple" and a small size bottle. Important to make sure the nipple is securely attached to the bottle as calves can accidentally pull the nipple off the bottle when suckling. As the calf grows, a larger red "goat's nipple" with a base is used with a larger bottle. It is not recommended to change to a larger bottle size until the calf is much older. Starting with a larger bottle size than is needed minimizes any changes in the bottle-feeding routine that might disturb the calf.

|Bottle-feeding technique: Poor bottle-feeding techniques or poor suckling response can cause serious complications for rumen health. Calves that gulp and swallow from a bottle instead of suckling are prone to depositing the milk in the rumen and developing rumen acidosis. Similarly, tube-feeding milk directly into the rumen can cause rumen acidosis and as such it is not recommended. However, there is one exception; if the calf is not suckling the colostrum on the first day, then colostrum is given by tube feeding, but after that, no more tube feeding should be used.

Recommendations for a correct bottle-feeding technique:

- Only one staff member should enter the stable with the calf for feeding. The feeding can be observed from outside the stable.
- Gently encourage the calf up off the nest and to come to a regular location in the stall for feeding. Dams initiate nursing bouts, so calves need to be encouraged to stand and get out of the nest site to nurse.
- A consistent side of the animal's body (right or left) to bottle feed must be established and never changed. The keeper must keep a consistent posture when feeding. Once this is established, it must be described to the rest of the team members.
- Staff must wear a common unit of uniform shirt when feeding. The familiarity of smell and appearance will help the calf to accept the change of staff member when it is required. If the calf had experience with the mother, use her scent on the uniform.
- The nipple must be placed and kept straight on into the mouth (not to the side). The calf should not be allowed to chew on the nipple.
- The bottle should not be squeezed to force milk into the mouth. The calf must suckle instead of just passively swallowing the milk. Trying different nipple openings might help the calf to suckle.
- Defecation and urination must not be stimulated after bottle feeding. New calves will initially urinate on the nest while lying down and then stand to urinate later in their development. They do not produce meconium and should not defecate for 4-10 weeks.
- Use a dedicated platform scale in the stable to keep the movement of the calf to the scale a more positive interaction.
- When transitioning between staff, have the new staff member stand next to the current staff member for a few feedings before trying the new person. Wear the same type of uniform.
- Take daily body temperature at a consistent time with an ear thermometer. Preferably take the body temperature after feeding not right when the calf gets up off the nest. Rectal thermometers should not be used until the calf is defecating daily.

|Record keeping during Bottle-feeding: From each feeding session the following information should be recorded:

- Time.
- Calf's weight (taken in the morning).
- Calf's body temperature.
- Amount of formula offered.
- Amount of formula consumed.
- Any changes to the regular formula (added vitamins or crushed calf pellet).
- Urination.
- Defecation.
- Behavioural or physical condition observations.
- Notes.
- Staff.

Husbandry and Care

Calves must be weighted at the same consistent time before the first feeding. This way changes to the supplementation plan or formula changes can be determined for the day. A review of previous weight graphs will determine if the calf is growing normally. Most hand-reared okapi calves initially lose weight when transitioning to bottle feeding, so this should be expected.

The hand-reared okapi calf must be "wet groomed" over its body with a wet, warm cloth after each feed to recreate the grooming provided by its mother. It is not recommended to stimulate calf urination and defecation. Hand-reared calves may start defecating earlier than parent-reared calves. This is not a cause for concern if nursing behaviours are normal, and the calf is nesting well.

The hand-reared calf must have shelter and must be held in moderate temperature conditions. A nesting area bedded with hay must be provided, with floor substrate that is safe for consumption (as most calves lick the floor while they nest). If the calf needs to be hospitalized after establishing a nest site, the nest material must be moved with the calf.

As okapi neonates do not thermoregulate well till 2 months of age. Heat is essential and temperatures must be able to hold at 21-27 °C. Fans or air-conditioning are required if temperatures are higher than 24 °C. Calves may suffer from overheating if they are allowed access to direct sunlight. Alternately, calves are prone to hypothermia if they nest directly on a bare floor or near open doors during colder periods. A good ambient temperature in the stable with a good nest site underneath the calf should not require a heat lamp or supplemental heat source unless the calf is ill.

During the first two weeks, the calf is not recommended to be allowed outside. After the calf may be encouraged to exercise outside once or twice per day for about 10 minutes per session if the weather permits. While getting older these sessions' duration can be extended.

Weaning and Solid Foods

The weaning process possibly must require an individualized assessment for each hand-reared calf. The calf's ability to be weaned must be based on solid food consumption, weight gain and general health of the individual. At about 19 weeks, weaning may be performed by keeping the milk formula at a constant amount, instead of increasing it along with body weight gains, while the calf continues to grow and consume more of its adult diet. Once the calf is consuming additional solids and is gaining weight, the quantity of formula can be gradually decreased. The calf must be completely weaned by 6 to 8 months of age. Care must be taken to ensure that the calf is consuming its nutritionally complete pelleted diet so that it obtains the nutrients it needs. Familiarity with pellet, green leafy vegetables, browse, and high-quality alfalfa hay early in their development is necessary to help transition the calf to solid food. Place high-quality alfalfa hay chaff and select hay around the nest area when the calf is a few weeks old to encourage hay consumption. Okapi calves should also be offered browse as soon as they are observed consuming alfalfa. Any non-leafy green vegetables offered must be chopped into manageable-sized pieces.

Introduction Back to Conspecifics

Depending on the personality of the individuals involved, hand-reared individuals could be introduced to conspecifics normally as early as 6-8 months. However, it is favourable to mix in calves that are hand-reared with other females much sooner than after 6-8 months. When mixing in hand-reared calves with conspecifics, supervision is required as past experiences have not always been positive. Consideration may be given to the finding that some hand-reared youngsters are very persistent in attempting to nurse from their companions.

2.4.7 Population management

The following section was edited by Kristin Leus, the International Okapi Studbook Population Management Advisor (EAZA Population Management Centre).

Goal: Maintain a sustainable, cooperatively managed global *ex situ* okapi insurance population.

Demography

On the 31st May 2023, the International Studbook for okapi registered 82 living individuals in the EEP (all in EAZA member institutions), of which 40 were males and 42 were females (Table 11). Another 106 individuals are living in other regions and the global living population thus counts 188 okapi.

Table 11: Number of living okapis in the International Studbook on 31st May 2023. (not EAZA = total of okapis in other regions of the world) Data Source: ZIMS

Region	Total	Male.Female.Undefined	λ (2000-31May2023)
World	188	101.86.1	1.015
EAZA	82	40.42.0	1.025
Not EAZA	106	61.44.1	1.003

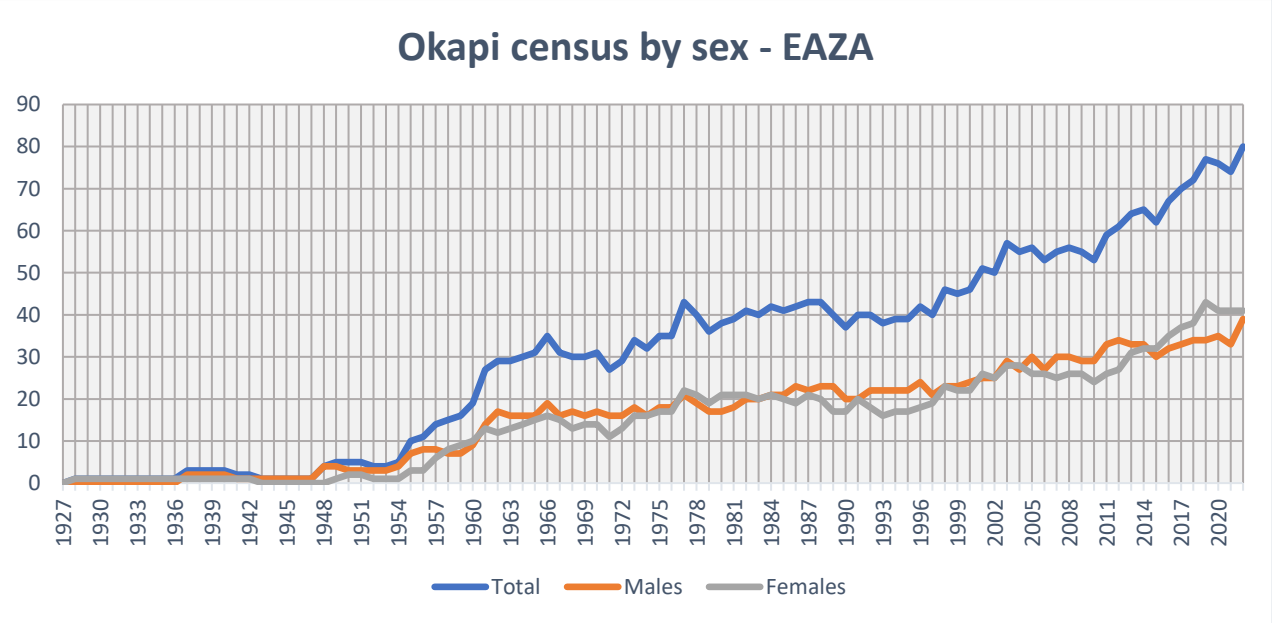

Figure 83 - Census (by sex) of the okapi population in EAZA member institutions. Data Source: ZIMS

Lifetable analysis shows that since 2000, the EEP okapi population had an average yearly growth rate of 2.5% (Table 11), with most growth having taken place since 2010 (Figure 83). The census-based average yearly growth rate since 2010 was 2.9%. In contrast to the situation in the 1990s, the EEP is currently responsible for the growth of the world population, with the totality of the populations in the other regions having stagnated during the last decade (Figure 84).

Over time, the EAZA population had a fairly even sex ratio at birth, though there were periods with a slight deviation from 50/50 among the living population (Figure 83), which, especially when the population was still very small, did provide some challenges for mating combinations and reproductive output. Of the 15 calves born between 1 January 2022 and 31 May 2023, 12 were males (and 1.1 did not survive), causing a male-biased age pyramid in the pre-reproductive age classes. However, there are more females of breeding age (Figure 85). The world population currently has a slightly male-biased sex ratio among living individuals (Table 11).

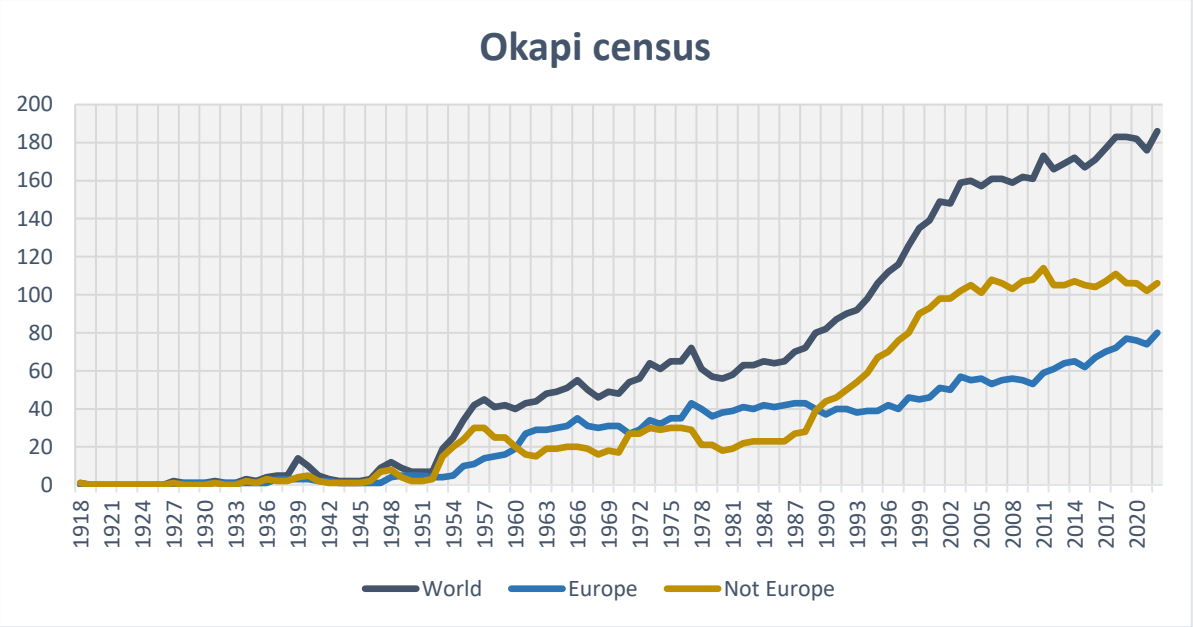

Figure 84 - Census of the okapi population: globally, in Europe, and outside of Europe. Data Source: ZIMS

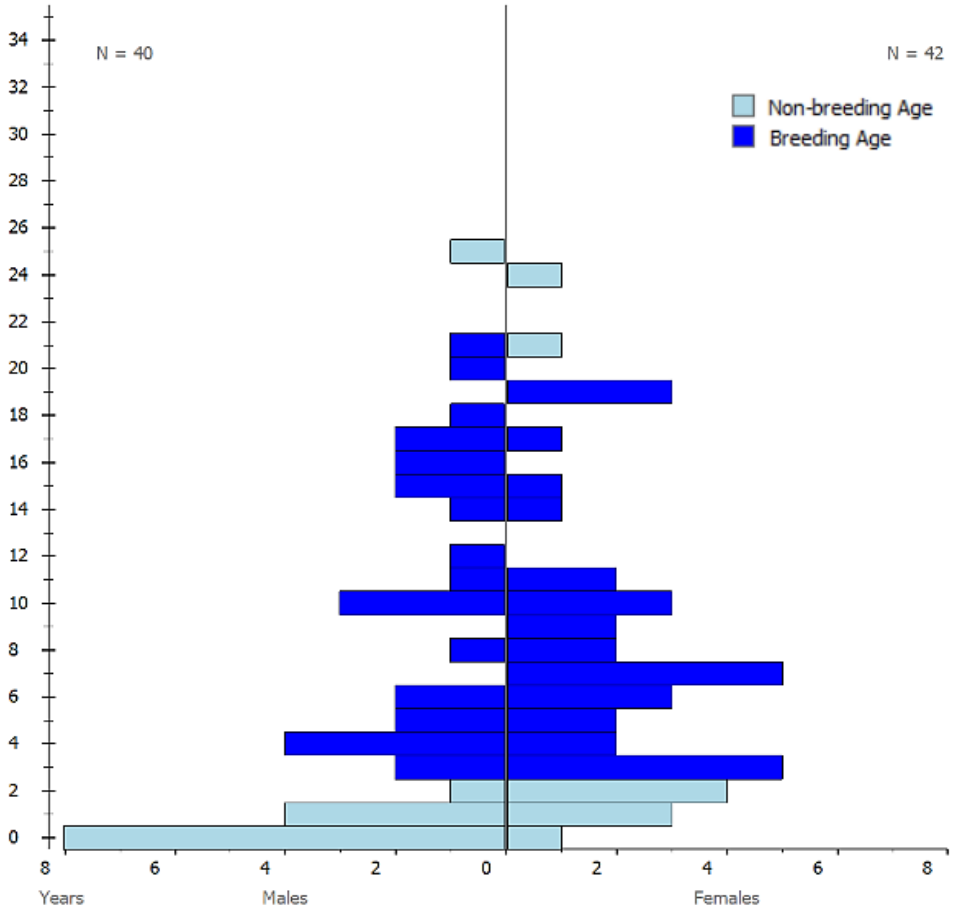

Figure 85 - Age pyramid of the EAZA okapi population on 31 May 2023. Males on the left, females on the right. The pre- and post-reproductive age classes (light blue) are determined by the ages at which animals bred during the period 1 Jan 2000 – 31 May 2023. Data Source: ZIMS

Between 1990 and 31 May 2023, first-year mortality for EAZA okapi was 31% for males and 28% for females (Figure 86). For both males and females, adult mortality is low until about 10 years and increases a little bit until the late teens, when it increases more rapidly. From the age of 17 onwards, sample sizes per age class are less than 20 and results are sensitive to sample size effects – explaining

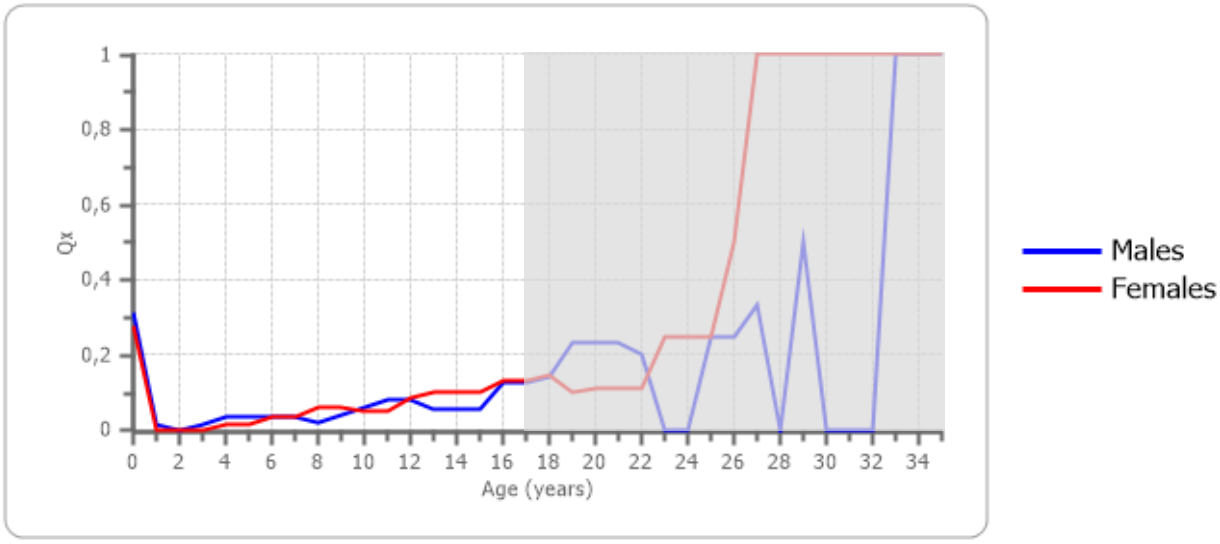

Figure 86 - Age and sex specific mortality (Qx) for EAZA okapi during the period 1 Jan 1990 – 31 May 2023. Data smoothed once. Data Source: ZIMS

the erratic results in these later age classes.

Fifty per cent of EAZA okapis survived from birth to the age of 12 (Lx = 0.50), 25% survived to the age of 19 (Lx = 0.25), 10% to the age of 23 (Lx = 0.10) and 5% to the age of 27 (Lx = 0.05). The oldest EAZA individual living on 31 May 2023 was 25.2, and the oldest EAZA individual recorded in the analysed period was 33.5 years old.

Figure 87 shows the age and sex-specific fecundity of okapi during the same period. For both males and females, the first reproduction occurred at 3 years of age. As was the case for the mortality calculations, from the age of 17 onwards, sample sizes per age class are less than 20 and results are

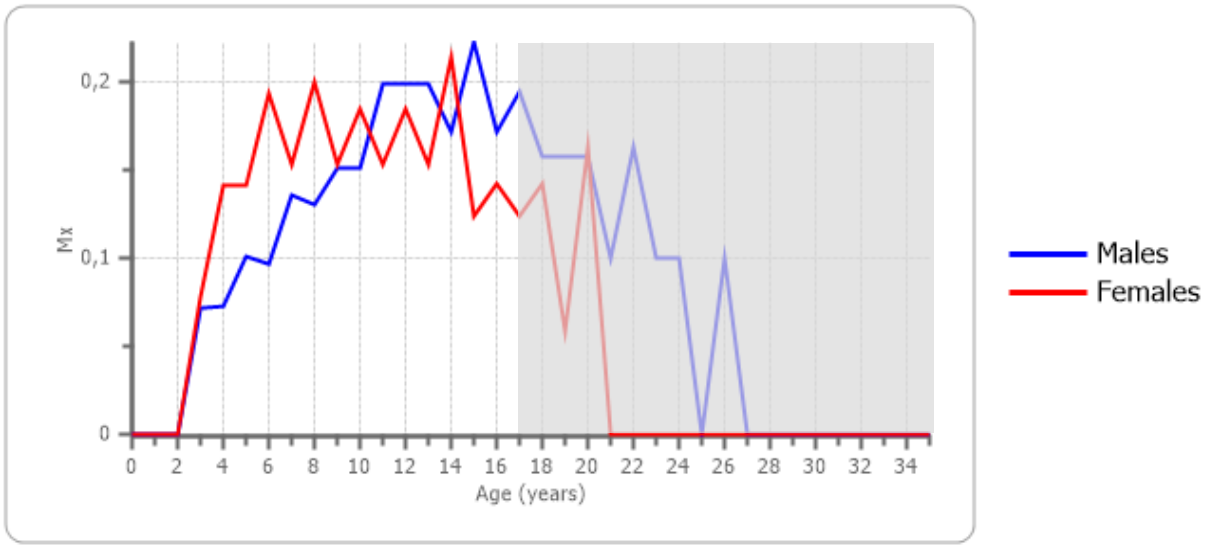

Figure 87 - Age and sex specific fecundity (Mx) for EAZA okapi during the period 1 Jan 1990 – 31 May 2023. Data smoothed once. Data Source: ZIMS

sensitive to sample size effects. For females, the main reproductive age classes are between 3 and 15 years of age, after which the probability of reproducing drops. The oldest females reproducing in this time window were 21 years of age. Young males (<10 years old) had lower reproductive outputs than old males (>10 years), whereby it should be remembered that this is mostly a result of management. Young males are commonly transferred to new holders or male-only holders and have to wait for an available female, delaying their first breeding.

Genetics

The genetic status of the current living okapi population can be found in Table 12. A total of 16 individuals, of which seven were from EAZA, were excluded from genetic analysis because they were considered unable to reproduce (again). All but one of the 29 founders of the global okapi population are also represented in EAZA. However, the percentage of gene diversity of the wild source population that is retained in the current living descendant population is lower in EAZA (90.4%) compared to the rest of the world. This is explained by the EAZA population having stayed smaller for longer and thus losing its gene diversity faster. This also results in fewer founder genome equivalents and a higher average inbreeding coefficient and population mean kinship compared to the rest of the population and the global population as a whole. The improved growth rate over the last decade and the potential gene diversity suggest that with careful pairing based on mean kinship, the rate of loss may be slowed in the short term future.

Table 12: Genetic status of okapis globally, in EAZA, and in the totality of the remaining world population (= Not-EAZA), on 31st May 2023 Data Source: ZIMS

	World	EAZA	Not EAZA
Population size (N)	188	82	106
Population size after exclusion	172	75	97
Founders	29	28	29
Potential Founders	0	0	0
Founder Genome Equivalents (FGE)	8.96	5.2	7.2
Potential FGE	13.94	8.1	10.7
Gene Diversity (GD) %	94.4	90.4	93.1
Potential GD %	96.4	93.7	95.3
Mean Inbreeding (F)	0.0369	0.0506	0.0263
Population Mean Kinship (MK)	0.0558	0.0962	0.0694

Founders: An individual obtained from a source population (often the wild) that has no known relationship to any individuals in the living descendant population (except for its own descendants).
% Gene Diversity: % of Gene Diversity of the source population (often a wild population) retained in the living descendant population.
Founder Genome Equivalents: The number of unrelated wild-caught individuals (founders) that would produce the same amount of gene diversity as is present in the living, descendant population.
Mean inbreeding: Average of the inbreeding coefficients of the living descendants.
Population Mean Kinship: Average of the mean kinship values of the living descendants. Equals the proportional loss of gene diversity of the descendant population relative to the founders and also the mean inbreeding coefficient of progeny produced by random mating.

The *ex situ* okapi population has been informally managed at the global level since 1977 (Hofman and Leus, 2015). The participating regions come together every ≈7 years to set and review global and regional targets and exchange experiences and expertise. The regional coordinators are in regular contact and when necessary and possible, individuals are transferred between regions for regional and/or global genetic and/or demographic benefit. Objective 12 of the IUCN and ICCN Okapi Conservation Strategy (Kümpel *et al.*, 2015) also states *"The okapi captive population is managed to maximise its contribution to the conservation and survival of okapi in the wild"* and Activity 12.2 asks to *"Ensure the genetic management of ex situ and in situ okapi populations to ensure the long-term survival of the species and its genetic diversity as well as a representative genetic reservoir for the species."* The commonly agreed target for the *ex situ* population is to maintain 90% of the gene diversity of the wild source population in the living descendant population for 100 years, at the global level. Table 3 shows that this is possible if the global population grows by 1-2% per year to a size of ~210 okapi. This is a realistic growth rate and a target size that is close to the current size of 188 individuals and thus deemed possible in terms of space capacity. Table 3 also shows that neither EAZA nor the totality of the remaining world population can achieve self-sustainability (retaining 90% of gene diversity for 100 years) on their own. Continued global collaboration, therefore, remains necessary to achieve the *ex situ* population goals.

Table 13: Potential genetic futures of the world population, EAZA and the totality of the remaining world population (= not EAZA). NP = not possible with these parameters. Data Source: ZIMS

	Total	EAZA	Not EAZA
Current N	188	82	106
Current Gene Diversity (GD)	94.4	90.4	93.1
Current Effective size/true size (Ne/N)	0.47	0.51	0.43
FUTURE			
Projected growth rate	1.02 / 1.01	1.02	1.02
Generation time	10.5	9.9	10.9
% Gene diversity at 100 years	90	85.7	89.0
Population size required	210 / 212	NP	NP
Population size at 100 years		580	750
Years to 90% GD		3	53

Effective population size (Ne): the size of a "genetically ideal" population that would have the same rate of loss of gene diversity, or would result in the same mean level of inbreeding as observed in the real population.
Ne/N: This ratio of the effective population size and the true population size indicates how "effective" the true population size can be in maintaining gene diversity.

2.5 Behavioural Management and Enrichment

Figure 88 – Okapi using a suspended ball as a browsing enrichment.
©Simona Jiřičková / Location: Safari Park Dvůr Králové

Animals kept in EAZA collections should be encouraged to perform as much of their natural behavioural repertoire as possible and acceptable. Whenever possible, unnatural behaviour should be prevented or actively discouraged. An important element in achieving this is behavioural enrichment (EAZA 2020).

2.5.1 Stereotypical Behaviours

Stereotypical behaviours refer to behaviours that are repetitive, morphologically identical and with no obvious goal or function (Mason 1991). These behaviours are considered 'abnormal' as they are only displayed by animals subjected to barren environments, scheduled or restricted feedings, social deprivation and other cases of frustration, but do not arise in animals in their natural environments. These behaviours may be maladaptive, involve many times self-injury, and are associated with high or chronic stress levels. Stereotypical behaviours are thought to be caused by artificial limitations in the environment that do not allow animals to satisfy their normal behavioural needs. For instance, when animals are highly motivated to do something but are unable to do so (lack of control over their environment), such stereotypies as pacing may appear.

Licking of non-food objects and pacing are the most common stereotypical behaviours reported in okapis and giraffes. Other less common stereotypies may include head tossing, head rolling, and tongue play (Bashaw *et al*., 2001).

Stereotypies related to the mouth and tongue are associated with feeding motivation. In okapi, they might be related to reduced stimulus and the requirement to use their long tongue. To prevent or reduce this issue it is recommended to increase the feeding complexity through the offer of browse and alfalfa hay. More complex environments are also associated with a decrease in oral stereotypies. It was found that giraffes and okapis that spent more time in their indoor enclosure were more prone to perform licking behaviour, and limited data in okapi suggest that the lower the structural fibre intake (via browse or alfalfa hay), the more oral stereotypies (Hummel *et al*., 2006a). Because indoor enclosures are usually less complex and stimulating than outdoor enclosures it is recommended to extend the time animals spend outdoors and also offer as much space and complexity to the indoor enclosures as possible (Bashaw *et al*., 2001).

Social stimulus in their environment, either from conspecifics or from humans, may affect stereotypies. Usually, opportunities to socialise decrease the frequency of stereotypies however some individuals might not cope well when opportunities to avoid social interactions are not available (e.g., visual barriers or separate stables or enclosures) (Troxell-Smith and Miller, 2016). Pacing is commonly seen in males when they perceive that an oestrus female is in the vicinity, but they do not have access to each other. Females may also pace when in oestrus.

Individual variation in the occurrence of these behaviours must be taken into account since under the same conditions some animals might develop stereotypies while others do not. Individual assessments and action plans might have to be designed. Age, sex or previous history are potential factors that influence the probability of developing stereotypies. For example, it was described that pacing was more prevalent in males than females while oral stereotypies are equally likely to occur in both (Fripp *et al*., 2013; Bennett *et al*., 2015). This is in line with the natural history of the species since males have larger home ranges and travel to meet the females to mate. Bennett *et al.* (2015) suggest that increasing the time the okapi has access to their larger and more complex enclosure (usually the outdoor enclosure) can prevent or diminish the occurrence of pacing.

2.5.2 Stress Indicators

Fear response in the okapi typically begins with an alert stance with ears forward. A frightened okapi may remain in a frozen position for hours. When the perceived threat is great enough, the okapi will display a flee response that is not always mindful of physical barriers, obstacles or boundaries.

2.5.3 Behavioural Enrichment

Behavioural enrichment refers to the presence or offer of stimuli and opportunities in an animal's environment to increase physical activity, stimulate cognition and promote species-specific natural behaviours. Behavioural enrichment is crucial for optimal psychological and physiological well-being (Young 2003; Maple and Perdue, 2013; Mellor *et al.,* 2015). The main pillars for good behavioural enrichment practice are:

- **Natural history:** Understanding of the species' natural behaviours that one needs to try to recreate and promote within the enrichment programme.
- **Variety:** Even the most stimulating and inventive enrichment can become predictable and boring for an animal, and that predictability can be very detrimental to the animal's well-being. Variety comes in many forms such as feeding at different times, feeding in different ways, getting new enrichment items, moving exhibit furniture around, etc.
- **Individual variation:** Each animal's individual needs, tastes and unique behaviours must be accounted for within an enrichment programme. Enrichment that works for one individual might not work for the other.
- **Safety:** Evaluation of the safety and correct use of the enrichment must also be included. Some individuals might use enrichment devices to injure others or injure themselves.
- **Evaluation:** Enrichment given to an animal needs to be monitored continuously to ensure that it still elicits the desired outcome. Just because an enrichment item was enriching in the past does not mean the animal always finds it enriching. Monitoring the effectiveness of an enrichment item can be extremely important as it will give real data on how that enrichment is performing and will help keep the success of an enrichment programme for a long time. Some enrichments might have opposite outcomes and promote even more certain stereotypical behaviours.

Enrichment Devices

An enrichment device is every artificial object installed in the animal's enclosure that has the goal of promoting natural behaviours. An enrichment device is considered successful if at least one individual spends extended time expressing natural behaviours while utilizing the device. Enrichment devices must be safe for the animals using them and easily serviced within the husbandry routine, and ideally reusable. When using such devices, the okapi must be rewarded for carrying out a natural behaviour. By offering 'non-reward' enrichment objects the behaviour is not encouraged and the enrichment device becomes ineffective. It is recommended to use devices where the reward is the okapi's normal food (e.g., leaves, lucerne), territorial marking or physical comfort (e.g. grooming). Generally, feeding containers with difficult access (slow feeders) to offer the items of the normal okapi diet – except for browse – should not be considered "enrichment devices" such as a hayrack with difficult access, a trough with an overlaying grid, a feeding barrel etc. These should be the standard and not an extra stimulation.

The most popular artificial devices for okapis generally involve objects that provide the opportunity to exercise the tongue. To be effective, each food item must be presented in such a way that only the tongue (not the lips and mouth) can reach the food. These devices are ideal to prevent stereotypical behaviours. Other natural behaviours that are encouraged through artificial enrichment devices are self-grooming and scent marking (Lumpkin, 2007).

The placement or instalment of any enrichment device in the enclosure must always meet the safety of the animal. Attention must be taken to objects that may block the passage of the animal or cause

potential entanglement, stumbles or slips. Artificial materials or toxic paints must be avoided as much as possible, especially in cases where the animal might lick or chew (and swallow parts of) the object.

Artificial enrichment objects/devices that could be offered are:

- A jolly ball (preferably suspended);
- Likit product (consisting of a plastic rotating ball with flavoured inserts);
- Presentation of low shrubbery or bunches of browse mounted into the ground with PVC: used to walk over and urine mark;
- Mounted brush heads and/or cocoa mats; used for self-grooming;
- Attaching natural-fibre floor mats to walls, trees or posts; used for rubbing necks;
- Hanging baskets for browse/lucerne;
- Scent containers
- Solid boxes mounted on the wall with different-sized holes in them for food to be manipulated out with their tongue;
- Firehose curtains for self-grooming, touching and covering.

➢ *For pictures of devices and other examples of enrichment see **Appendix D – Enrichment Examples***

Like many species of ungulates, okapis are sensitive to unfamiliar stimuli. Therefore, the gradual introduction of new devices and objects may be necessary. Partially covering foreign objects with something familiar such as straw, browse or bramble can reduce stress or even help stimulate curiosity. As the animals become familiar with the introduction to new objects regularly, and those interactions are positive, their nervous reactions will likely diminish and give way to the desire to investigate and explore the new item. However, for the staff, knowing when to back off and remove the object entirely is essential. Some animals have such an overwhelming flight response that ensuring there is ample space for the animals to avoid the object may be necessary for their safety.

Feeding Enrichment

Feeding enrichment refers to the promotion of the natural strategies and behaviours that an animal performs in its wild environment to obtain food, by mimicking the same challenges and conditions in captivity. Feeding enrichment can be promoted by frequently changing the feeding times, feeding

Figure 89 – Okapi eating alfalfa hay from enrichment devices. *©ZSL / Location: London Zoo*

locations, maintaining a high difficulty and complexity to obtaining the food, increasing the variety of food items and changing the presentation or method of provision of food. Only recommended food items should be used. For example, hanging a watermelon in the exhibit is not desirable, as feeding enrichment should follow the species-specific nutritional requirements.

Okapis are browsers and they almost exclusively use their long prehensile tongue to strip off leaves from branches. This browsing behaviour needs to be promoted extensively in captivity to prevent oral stereotypies. Browse branches are the most popular feeding enrichment item among okapis. Browse branches should not be counted in daily rations and therefore can be eaten at will by the okapi. Browse branches must always be offered to overhang since the okapi has difficulties browsing from the floor. Striking differences exist among individual okapi concerning what types of plants they appreciate or reject for browsing. Therefore, it should be considered that okapi might develop their taste for favourite plants according to exposure, either at a young age or through more frequent exposure. To prevent this, it is important to always feed a variety of food items in order not to fix the animal's taste to one particular item, especially at a young age.

Novel presentation of both regular and novel food items has met with varying success; as with other forms of enrichment, okapi often learn to enjoy new food items after repeated exposure. Variation in food items can be achieved by varying the browse and the green leafy vegetable part of the diet. Variation should not be introduced via commercial fruit or non-green vegetables, and not using different types of grain, bread, or non-browser pellets.

Some ways of presentation of both regular and novel food items are:

- Puzzle feeders.
- Stringing produce on branches to maximize the amount of time spent foraging regular produce items.
- Offering frozen leaves in 'leaf-feeders', of which the mesh needs to be dense enough for the frozen leaves not to fall out.
- Logs with drilled holes, in which different feed items can be placed.

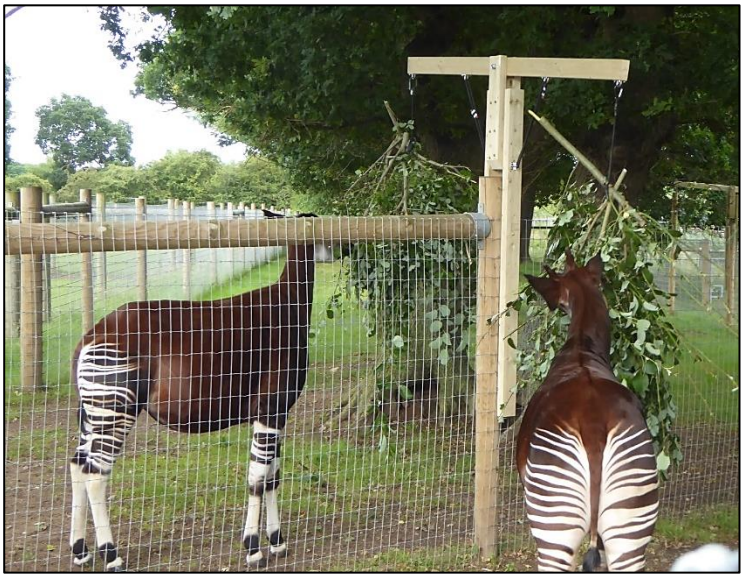

Figure 90 – Okapis eating from a bungee browse feeding device. *©Team Building with BITE / Location: Yorkshire Wildlife Park*

The method of stringing produce on branches may not be carried out but could be used for putting scents on branches instead.

> ➢ *For further details on how to guarantee a proper diet for the okapi see section* ***2.2 Feeding*****.**

Structural Enrichment

It describes every object or structure that mimics the natural environment of the animal and/or promotes exploration and physical activity, as well as the design of the enclosure itself. It usually refers to the size, complexity and furniture of the enclosure and its variation across time to offer

opportunities to exercise, find/choose shelter, manipulate the environment, make territorial markings and forage. Appropriate substrates and furniture can be re-arranged regularly in a way that the exhibit becomes dynamic and engaging for the animal. When holders have multiple enclosures, rotating the animals among these offers new stimuli to the individuals to explore new environments and more room to travel in case of simultaneous access to multiple enclosures. This method of changing among different enclosures or enclosure sizes recreates the constantly changing and diverse environment that the okapi encounters in the wild. Vegetation is the main structural enrichment within an okapi's enclosure, working as furniture. Vegetation is occasionally browsed but mostly enriches the environment by offering shade, security, or cover. Hanging browse (see feeding enrichment) a little higher than the comfortable okapi's reach forces the animal to elongate its neck and use its tongue as well, to reach it. Vegetation also promotes territorial behaviour through scent and urine marking (Lumpkin, 2007).

➢ *For further details on the furniture and structure of enclosures see section **2.1.6 Furnishings and Maintenance**.*

Sensorial Enrichment

Sensorial Enrichment focuses on the stimulation of the animal's senses. It can be divided into olfactory, visual, auditory and tactile.

Figure 91 – A brush attached to the wall of a stall gives the chance to the okapi to scratch different parts of its body, especially those hard to reach. *©João Pedro Meireles / Location: Safaripark Beekse Bergen.*

Olfactory enrichment can be offered by allowing okapi the opportunity to explore the urine, scent and faeces of healthy conspecifics by shifting animals through stables before cleaning and/or even rotating animal stables and enclosures regularly. Males are particularly responsive to the olfactory signs of another individual okapi. Another way to provide olfactory stimulation that still requires further exploration and use among okapi holders is by the introduction of other novel scents such as herbs, plants, spices or perfumes. It can be done by installing scent containers (PVC pipes, wood boxes, etc.) throughout the enclosure. It is not recommended the application of scent substances (powders or liquids) over surfaces since its remotion will be much harder in case it reveals to be distressful for the animals. Removable scent containers are preferable. The provision of novel scents has had varying success; one institution noted particular success with vanilla scent; the former has been met with a high level of response including some negative reactions. While some individuals appear apprehensive and fearful, an aggressive response has been noted as well (Lumpkin, 2007). It is important to guarantee that the okapi does not ingest any potentially toxic scent product. Direct access must be approved by the veterinarian.

Visual enrichment can be offered by providing opportunities for the okapi to hide and seek refuge. Vegetation, visual barriers and walls allow the okapi to keep its privacy and security. Vegetation, brush heads or doormats offer opportunities for the okapi to groom and scratch its body (Figure 91). The touch of dense vegetation seems to calm the okapi and the tips of branches supposedly are used by okapi to scratch the inside of their ears. Mixed-species enclosures may offer not only social interaction

with other animals but also a more complex sensorial environment, with the sounds, movements, and odours of the other species. Offering different food items and their presentation also offers new sensorial stimuli, such as different textures (e.g. cooked or liquid), flavours or temperatures (e.g. frozen items) – see feeding enrichment.

Social Enrichment

Social enrichment can be provided through interaction with conspecifics or other species. Human-animal interactions can also be very enriching for certain animals. Social interactions can happen through a fence line or by introductions of another okapi. It has been noted that stereotypical behaviours such as pacing were reduced when offering adjacent access to conspecifics and/or other species. Human/animal interactions (ranging from formal training to behind-the-scenes tours) constitute a form of enrichment that offers interesting stimuli into the okapi's environment. Participation in training offers the okapi the opportunity to make choices that affect its environment (Lumpkin, 2007). Behind-the-scenes tours may be arranged with caution. Too many strangers can distress the animals. Very small numbers of behind-the-scenes visitors may be fine.

➢ *For further details on the social group and mixed-species management see section **2.3.3 Mixed Species Exhibits**.*

2.5.4 Animal Training

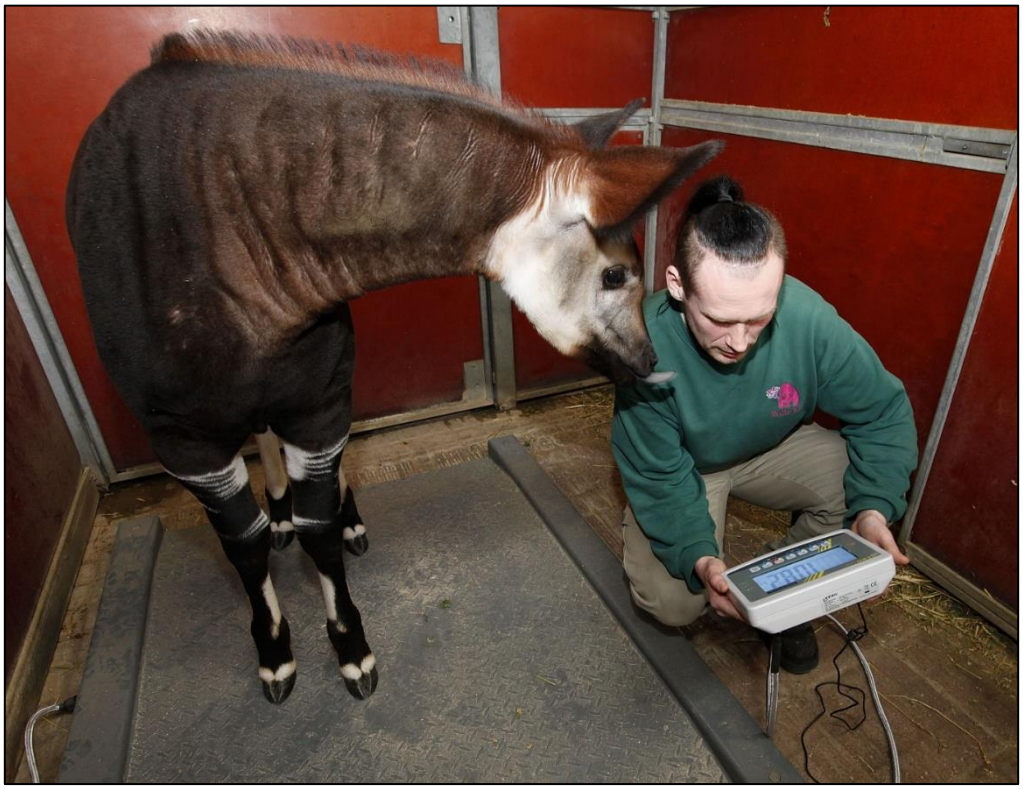

Figure 92 - Young okapi being weighed by its keeper *©Wilhelma Press Photos / Location: Wilhelma Zoo*

Animal training through operant conditioning is an important tool for animal welfare, husbandry, and enrichment. Since training must be voluntary, it gives the animal a sense of control over its environment. It also promotes faster progress and faster response from the animal. Training strengthens the relationship between the animal and the human and reduces stress associated with husbandry and veterinarian procedures. Training must be incorporated into the various aspects of the

facility design, husbandry plan, staff training and daily operations. The use of operant conditioning in okapi has had great success and the individuals have been trained for a varied set of behaviours and procedures. Training these behaviours will facilitate and improve the keeper's daily routine, the animal's comfort and help to early diagnose and treat health problems. The progress of training will depend on the individual. Some animals will progress faster than others. Some individuals are calm and easy, while others never get habituated to a chute or the presence of veterinarian staff. This needs to be recognized and training methods adapted to each individual.

It is important to emphasize that training cannot be effective when done opportunistically. Success can only be achieved when working with the animals regularly and consistently. Even after the individual has learned something this needs to be practised regularly, as the animal might forget or get dishabituated again to the training/procedure it once learned. All members of the zoo staff must understand the goal and importance of animal training, from keepers to management, even if one primary keeper may be the only person working with the animal initially. When training is first initiated, preferably only one keeper will do the training, because different keepers can have slightly different methods, and this can confuse the okapi and slow the progress of training. Naturally, later all keepers must be able to work with the animals. This must happen, each time a new keeper begins, after an adjustment period to introduce the new trainer to the animal. Always closely guided and supervised by a more experienced keeper/trainer.

The training methods should follow the following principles (EAZA, 2020):

- All animals need to have the freedom to participate (or not) in the training.
- Only positive reinforcement techniques should be used.
- None of the training goals can be detrimental to the individual's welfare or the keeper's safety.

Figure 93 – Height measurement (at the shoulders) of a calf. *©Antwerp Zoo/ Location: Antwerp Zoo*

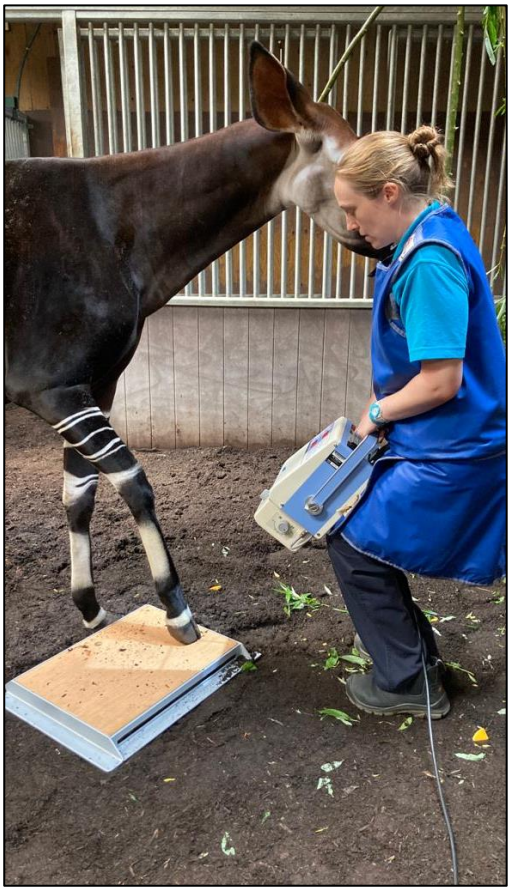

Figure 94 – X-ray procedure in free contact with a trained animal. *©Chester Zoo / Location: Chester Zoo*

Behaviours or procedures that are useful to train with okapi include:

- Target and call training;
- Manipulating feet for inspection and minor hoof trims;
- Rectal temperatures;
- Tactile habituation and body inspection;
- Standing on a scale for routine weights;
- Allowing growth measurements to be taken;
- Trans-abdominal ultrasounds and radiographs;
- Collecting urine or milk samples;
- Acceptance of a crate or transport trailer;
- Mouth and eyes exam;
- Voluntary blood draw.

Okapis are mostly food-motivated. Browse or other favoured food items are a common reward during training (Figure 97); positive keeper interaction (e.g., in the form of tactile, particularly ear cleaning/rubbing) (Figure 101) or the presence of a favoured conspecific are effective as well in some cases. Individual preference, reward delivery techniques and availability/ease of obtaining the reward item must be considered in choosing an appropriate reward.

Okapis respond well to a variety of verbal cues and soft sound cues used as commands for desired behaviours. In positive reinforcement training, when the animal responds correctly, a sound is paired with the correct performance to communicate to the okapi that it has responded correctly. This sound called the bridge, can be a spoken word, whistle, or click. The bridge must be followed by positive reinforcement (reward). The only type of punishment recommended to give to an animal is the so-called "time out". It is a brief period in which the trainer simply ignores the animal by walking or looking away from it to communicate to the animal that it responded incorrectly (McLaughlin *et al*., 2007). In general, it is advised to have many short positive sessions when desensitizing okapi to negative sensations.

Training facilities

Okapi training may allow free contact, protected contact, on exhibit, or in the stables. Most behaviours are safely performed with free contact, including hoof care and ultrasound. However, for more invasive or painful procedures (e.g., blood draws and injections) or those involving multiple staff members, to be safely performed with some individual animals they should be trained through a barrier or a chute. Some holders have specifically designed training chutes that restrict space and facilitate access to okapi for the training of veterinary procedures. The okapi must be fully habituated to confinement in this chute space before the training of other behaviours begins. Okapi should never be squeezed with a wall or towards a barrier. However, in the absence of properly designed training chutes, simple modifications to existing facilities can be equally successful. Window cuts into existing walls or removable training walls constructed from cattle panels, mesh fencing or fire hoses provide flexibility.

General Husbandry Training

|Target training: Target training may be learned rather quickly once trainers employ a bridge signal (e.g., a word, or a whistle). Target training will become the auxiliary for many other procedures and operations such as shifting, scale training, injection and blood draw training (among others). It is recommended the use of a target stick or a similar object (Figure 95). The target provides a task for the okapi to focus upon during desensitization to painful stimuli and may also help hold the okapi in position whether in a training chute (protected contact) or during free contact (Lumpkin, 2007).

Figure 95 – Target training of an okapi through protected contact. *©ZSL / Location: London Zoo*

|Shifting training: The degree of difficulty encountered during shifting is mostly determined by individual okapi temperament and facility design. The difficulties of shifting can be overcome with positive reinforcement, most commonly in the form of browse. Browse can either be used to lure the okapi through the shift or to train the okapi to expect and receive the full reward after shifting. Another method is the use of an auditory signal to prompt the okapi to shift inside for its meal (Lumpkin, 2007). More success can be achieved by training a bridge with a reward. It is recommended to also use a target during shift training, to provide the okapi with a clear and visible goal to focus upon while overcoming aversions or distractions.

The challenges that are met during shifting are mostly caused by both positive and negative distractions. The positive distractions (e.g., the presence of another okapi, vegetation along the route, and other attractive variables) may be eliminated to facilitate the shifting. Negative distractions can be water-related stimuli (e.g., a wet floor, puddles, keepers hosing holding areas, window washing, precipitation, etc.), to which okapi seem to show an aversion. Rather than forcing an animal into or over a wet area, the problem can be solved or avoided, for instance by drying the area and placing hay, shavings, substrate or mats over the trouble spot. In some cases, an animal-specific negative distraction during shifting can be pinpointed to the previous experience during which the okapi formed the negative association (e.g., incidents of falling, experiencing traction issues, startling, etc.). (Lumpkin, 2007)

|Hoof care training: Hoof care is one of the most valuable trained behaviours and can be carried out both in a free-contact manner (Figure 96) or with the okapi in a training chute. Training the okapi for hoof work at an early age significantly increases the chances of successful hoof work into adulthood. The training process proceeds as follows:

- The keepers habituate the okapi to tactile of the upper, then lower leg;
- Then, before asking the okapi to raise its leg, keepers train the okapi to allow manipulation of the digits and heel while the okapi stands;
- Thereafter, the okapi is trained to lift its leg, by either picking up the okapi's foot or tapping the okapi's foot and cradling the hoof once raised.

Operant conditioning by bridging and rewarding the okapi for lifting its leg and tapping its hoofs with trimming instruments can be utilized as well. Working with familiar staff members is recommended as okapi generally will allow leg lifting for longer periods. Okapis respond best to short sessions repeated over several days for rasping or clipping work. Training for daily hoof care consists of lifting the leg, rubbing under the hooves, touching between the toes, and using a hoof scratcher to clean hooves (Lumpkin, 2007).

➢ *For further details on hoof care, see section **2.7.2 Preventive Health Care - Hoof Care**.*

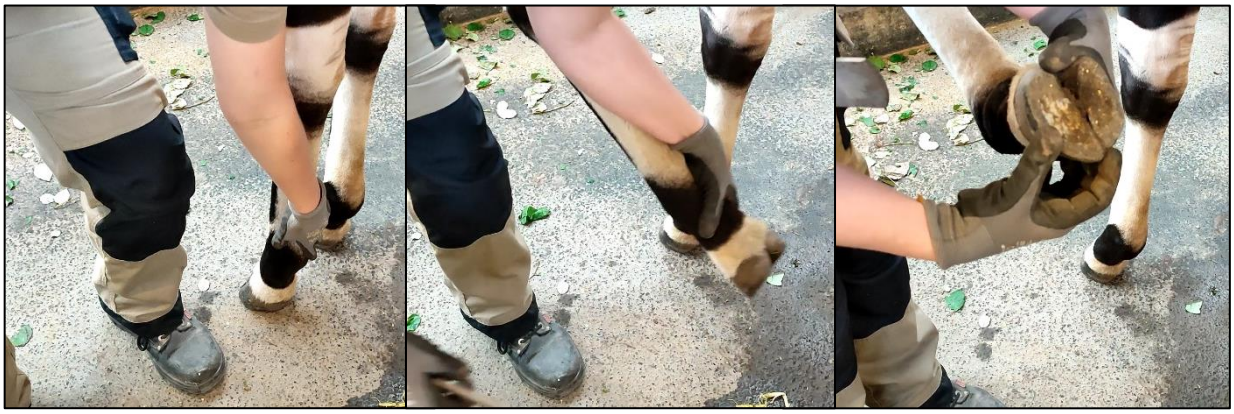

Figure 96 – Hoof care training using free contact. *©Antwerp Zoo / Location: Antwerp Zoo*

|Crate/Trailer training: Okapis must be acclimated to their transport trailer or crate before shipment. This can be done by initially luring the okapi into the trailer or crate with food, loading the trailer or crate with browse and allowing the okapi free access to the trailer or having the staff lead the okapi into the trailer or crate. An example of a method is to place a food tray on a hay bale in front of the crate and gradually move the tray into the crate as the okapi's comfort level increases. The door to the crate or trailer preferably may not be closed during training. To encourage exiting down out of the trailer a familiar substrate may be used to transition the okapi from the trailer to the new stable.

➢ *For further details on protocols for transport, see section **2.6.4 Transportation**.*

|Scale training: Scale training could be done by either targeting the okapi or luring the okapi onto the scale with browse (Figure 97). Scales could be recessed into flooring or placed within frequently accessed corridors. Scale equipment usually requires a step up; in case this poses a problem, it could

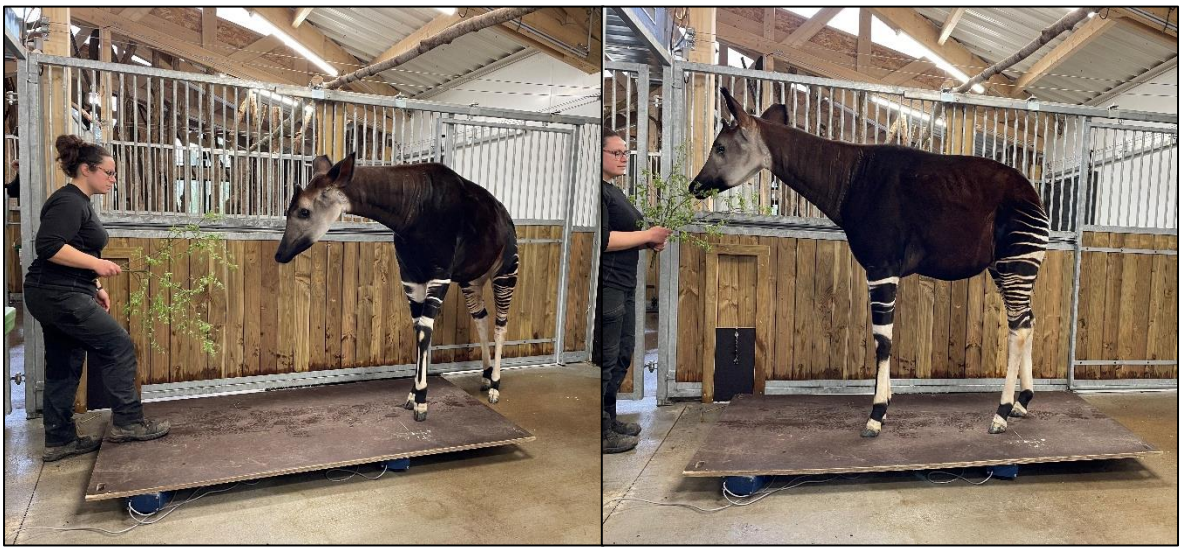

Figure 97 – Scale training using browse to lure the okapi. *©Branféré Zoo /Location: Branféré Zoo*

be solved by building gradual ramps of plywood or substrate. Scales preferably must be covered with matting to provide proper traction (Lumpkin, 2007).

Veterinarian Care Training

|Injection and blood draw training: For injection and blood draw training it is advised to train through protected contact, like in a chute. Target training is considered one of the most effective training tools to maintain the animal focused and stationary during these procedures. The keepers must start by asking the okapi to touch the target while they touch the jugular area of the upper part of both sides of the neck with their hands. Bridging must be given and the animal rewarded with food if the hand contact on its neck is accepted while still focused on the target. Some individuals might be frightened during the first few days of training but soon they will associate the touching with the reward. Then, the next step should be the presentation of gauze, first without alcohol, and later with alcohol. The okapi should get habituated to the smell of alcohol. As soon as the animal accepts the gauze with alcohol along its neck, the keeper can introduce a blunt needle and a syringe simulating a needle entering the skin. The first contact with the needle must be with very light pressure if any at all. The okapi must be continuously bridged and rewarded each time it accepts touching and manipulation while still focused and stationary. As the animal becomes more comfortable the keeper increases both the pressure and the time length of contact of the needle with the skin. It is advised to train okapi to tolerate extensive movement of the needle as a blood drawing procedure may require frequent adjusting to find the vein. When the keeper feels the animal is completely comfortable with the blunt needle on both sides of the neck, a sharp needle is introduced into the procedure. Once the keeper can place the needle into the skin for a short time it becomes possible to draw blood. Working closely with veterinary staff during the training is beneficial since the okapi needs to get habituated and comfortable with specific elements of the procedure associated with veterinarian staff well in advance of any negative perceptions.

Figure 98 – Keeper training ultrasound desensitization using a cloth with ultrasound gel. *©Copenhagen Zoo / Location: Copenhagen Zoo*

|Non-invasive veterinary procedures: Non-invasive veterinary procedures commonly performed on the okapi through training include ear-cleaning (with swabs and cleanser); dental inspection; examination of the heart, lungs, and gastrointestinal tract via stethoscope; rectal temperatures; X-ray and ultrasound. Some simple training tips for the above behaviours include rubbing the anus of the okapi until the tail relaxes for rectal temperatures and tail manipulation; warming the tip of the stethoscope before placement; and using ear-cleaning as a reward for other behaviours. Mock ultrasound devices could be designed for desensitization and the animal acclimated to the procedure using alcohol and ultrasound gel (Figure 98).

Training of okapi calves

Figure 99 – A vet and keepers carry out an ultrasound through protected contact using a training chute. *©Bristol Zoological Society / Location: Bristol Zoo*

Early training and socialization with humans of calves while still in the nest is the best practice to increase the success of future behavioural management. Behaviours that should be trained with calves within the first year include scale training (Figure 92), full-body touch and examination, hoof care, injection, blood draw, and response to call – the latter facilitates shifting and prepares the calf for future interactions. The keeper must find where the calf enjoys being touched and utilize this as positive reinforcement. With each step, staff should closely monitor the calf for signs of stress. Staff should always quickly cease interactions if the calf makes a move to rise or flee from the nest. One must strongly limit negative interactions. This is important for not communicating mixed signals to the calf. Staff should not push the calf or force movements for the first few days of scale training or hoof care.

➢ *For further details about calf socialisation, see section **2.4.5 Development and Care of Young - Calf Socialization***

2.6 Handling

Figure 100 – Okapi with its keeper in free contact. *©Marie Nussbaumer/ Location: Mulhouse Zoo*

Animals are to be handled only by, or under the supervision of, competent, trained, and authorised staff; and this is to be done with care, in a way which will avoid unnecessary discomfort, behavioural stress or actual physical harm to animals (EAZA, 2020).

2.6.1 Individual Identification and Sexing

Individual okapis are easy to identify without any external markers. Each okapi has a unique pattern of stripes on its legs which allow the identification of the individual. Adults have sexual dimorphism with males having ossicones that are absent in females. Microchips are mandatory for transport. It is recommended that the transponder should be placed at the base of the ear. This may be performed during a good calf exam or any sedation.

For the trained eye the sex of a newborn calf can be determined with quite some certainty by observing the stripe pattern on the back legs (Table 14). To get 100% certainty the sex of the calf can be determined during the first weighing, which needs a hands-on approach anyway.

Table 14 – Sexing of okapi calves through stripe pattern. Pictures: *©Antwerp Zoo*

Calf Sexing through stripe pattern	
MALE	**FEMALE**
The black stripping extends to the inner legs "connecting" with the tail.	The black stripping fades before reaching the inner legs and does not "connect" with the tail.
	
	

2.6.2 General Handling

Figure 101 - Okapis are of a general calm nature and even appreciate physical contact, such as sessions of coat brushing. *©Yorkshire Wildlife Park / Location: Yorkshire Wildlife Park*

Most okapis easily adapt to daily routines, to contact and interaction with their keepers, to shifting among enclosures and to training to allow health check-ups and care. As such okapis are mostly worked in a free-contact management system. Positive reinforcement and consistent practices are essential to building up the relationship of trust and comfort between the okapi and its keepers for this kind of system. However, depending on the individual okapi's comfort and level of habituation, staff usually does not conduct the cleaning in the same space as the okapi. The animal is shifted to a different area before the cleaning. If the facilities allow it and a certain individual is more aggressive or bold, a more protected contact management system can be practised. Negative reinforcement must never be applied to handle the animals – except in rare emergencies.

Okapis are mostly unaggressive, and they can develop a high level of comfort with humans. However, it must be kept in mind that okapis are a large hoofstock species with a lot of strength and the ability to kick fast and hard and under a free-contact management system there is a likeliness for accidents to happen. To reduce the risks the following guidelines must be followed when working in a free-contact system with the okapi:

- When standing behind the okapi, one must keep a distance of at least 1 meter (within the kick range). The okapi may not kick the keeper as a form of agonistic behaviour but instead, kick as an automatic response for being frightened or touched (e.g. insect). Among okapis, a rear leg kick is a minor form of aggression but can be sufficiently strong to injure a human.
- Keepers must always move slowly (no sudden movements), be calm and lower their voice when being around okapi.
- Okapis may become easily startled (e.g. by an unexpected noise) and run or flee without deviating from objects or obstacles. As such, the keeper should not stand directly in front of the okapi but should stand just to the side, keeping the path free in case the okapi starts running. Okapi may attempt to avoid running into staff but may not have time to change course if suddenly startled. The keeper can approach an okapi lying in a sternal position (e.g. hoof inspection) but should not stand directly in front because the okapi lunges forward when taking off running.
- Caution must be taken when entering an area to separate a male from a female and when entering a space with a mother and calf. Staff should not position themselves between the mother and the calf until the mother appears comfortable with routine interactions.
- An okapi will display a warning if it is uncomfortable or intends aggression. Typically, staff should exit an okapi's space if they hear a loud exhale of breath from the nose (usually coinciding with a lowered head) or if the okapi begins to stomp or display a "stiff-legged" walk. The stomp is a warning and will begin some distance away from the perceived threat.
- During food preparation or touching the okapi, clean hands or gloved hands help prevent the transmission of zoonotic diseases.

Technical skills and competencies needed by animal care staff to promote safety and good handling of the animals must include:

- An understanding of the natural history, physiology, behaviour, and social structure of the okapi, both in the wild and in the zoo setting.
- An understanding of the basic principles of operant conditioning and training, and the need to integrate these into routine operations.
- Familiarity with an understanding of the basic facility design, its operation and safety protocols, and the ability to develop a rapport with the individuals in their care.

2.6.3 Catching/Restraining

The okapi can be easily trained for most preventative medical and care procedures (e.g. vaccination, blood collection, hoof trims, and basic measurements). Through operant conditioning, the animal participates voluntarily and with little to no stress response. As such, restraining, immobilization or sedation can be reserved only for the last resource. Okapis can also be habituated to a chute, providing extra protection if necessary for those performing such procedures.

➢ *For further details about animal training, see section **2.5.4 Animal Training**.*
➢ *For further details about restraining facilities (e.g., chutes), see section **2.1.2 Indoor Facilities.***

Physical restraint is not recommended as it is very difficult if not impossible on adult okapi, staff can get very badly injured, and it is very stressful for the animal.

However, in extreme situations where immobilization is needed, there are multiple options for chemical immobilization (sedation) in okapi. Anaesthetic complications are one of the primary causes of mortality in adult okapi and these include hypoventilation, regurgitation and subsequent aspiration of rumen contents, and post-anaesthesia gastrointestinal ileus. With opioid combinations, poor anaesthesia inductions (falling backwards/stumbling, opisthotonus, paddling on recumbency) can also occur. Therefore, they are considered a high-risk species to anaesthetize (McFarland *et al.*, 2019).

Figure 102 – Okapi sedation for hoof trimming. On the Left: Keeping the head elevated to prevent aspiration. *©Zoo Antwerpen / Location: Antwerp Zoo*

Immobilization can range from standing sedation using Medetomidine combined with Butorphanol or Xylazine on their own. Full immobilizations (anaesthesia) have been based on narcotic use with either Etorphine or Carfentanil in combination with Xylazine, which has been successful (Table 15). However, there is an increased risk of regurgitation with aspiration in Etorphine immobilizations, so extra measures against regurgitation must be taken. Thiafentanil is another narcotic showing promise in okapi with quick time to effect and clean reversal. Chemical restraint may only be carried out with experienced vets.

Standing sedation works well, with the possibility of ataxia developing, so it is important to be prepared for the animal to go down unexpectedly (Bertelsen, 2015). When sedating okapi, the procedure must occur in areas where the floor has sufficient traction. Substrate, ribbed mats, or combinations of mats and hay, shavings, or decomposed granite are recommended. It is strongly preferable to sedate the okapi in a small stable with its walls covered with hay bales or mattresses (Figure 103) and ensure a low light and low noise environment. The animals must be blindfolded and given oxygen by nasal insufflation (Citino and Bush, 2014). Okapi tend to regurgitate while under the influence of certain restraint agents, which can lead to morbidity and mortality from aspiration pneumonia, as such, this risk must be treated as a serious concern (Citino and Bush, 2014). For anticipated full immobilizations, individuals may be put on fasting from food and water for a specified amount of time as directed by the veterinarian to reduce the risk of regurgitation. After the sedation has taken effect it is important to position the okapi's head upwards (above the rumen) and the nose pointed down. This is critical in the prevention of aspiration of potential regurgitation that can lead to pneumonia (Figure 102). If the okapi is placed in lateral recumbency, padding should be adequately placed under pressure points. As the okapi tend to become hypothermic it should be kept warm during anaesthesia. After the reversal agent is administered, experienced staff should closely monitor the animal to prevent injuries until it is standing (Citino and Bush, 2014).

Figure 103 – Walls covered with mattresses to prevent the animal to get injured during sedation. *©Antwerp Zoo / Location: Antwerp Zoo*

Table 15 - Okapi Sedation and Anaesthesia Protocols. (Bertelsen, 2015; Citino And Bush, 2014)

OKAPI STANDING SEDATION			
Generic name	**Dosage**	**Reversal agent/dosage**	**Comment**
Xylazine	X: 0.50–1.20 mg/kg IM	Yohimbine 0.1-0.2 mg/kg IV/IM or atipamezole 0.05-0.1 mg/kg IV/IM	
Xylazine + Butorphanol	X: 0.4–0.8 mg/kg, IM B: 80–200 µg/kg, IM	Yohimbine 0.1–0.2 mg/kg, IV/IM; or atipamezole 0.05–0.1 mg/kg, IV/IM	If indicated, reverse butorphanol with naltrexone 1–2 times the dose of butorphanol, IM/IV
Detomidine + Butorphanol	D: 40–100 µg/kg, IM B: 80–200 µg/kg, IM	Yohimbine 0.1–0.2 mg/kg, IV/IM; or atipamezole 0.05–0.1 mg/kg, IV/IM	If indicated, reverse butorphanol with naltrexone 1–2 times the dose of butorphanol, IM/IV
Medetomidine + Butorphanol	M: 60–90 µg/kg IM B: 45–55 µg/kg IM	Atipamezole 5 mg/mg medetomidine IV/IM	If indicated, reverse butorphanol with naltrexone 1–2 times the dose of butorphanol, IM/IV
Xylazine + Ketamine	X:0.4–0.6 mg/kg, IM K: 0.4–0.6 mg/kg, IM	Yohimbine 0.1–0.2 mg/kg, IV/IM; or atipamezole 0.03–0.6 mg/kg, IV/IM	Normally, the animal will stay standing but may lie down
Detomidine + Butorphanol + Acepromazine + Midazolam (Mid)	D: 40–60 µg/kg B: 40–60 µg/kg Ace: 30–40 µg/kg Mid: 30–40 µg/kg	Atipamezole 0.03–0.06 mg/kg, IM/IV Naltrexone 40–60 µg/kg, IM/IV	
OKAPI ANAESTHESIA			
Generic name	**Dosage**	**Reversal agent/dosage**	**Comment**
Xylazine + Carfentanil	X: 0.12 mg/kg C: 5 µg/kg, IM	Naltrexone 0.5 mg/kg, IM	Allow 10–20 minutes after xylazine before giving C Add azaperone 50 mg/adult in stressed animals
Xylazine + Etorphine	X: 0.1–0.2 mg/kg, IM E: 8–15 µg/kg, IM	Atipamezole 0.05 mg/kg, IM/IV Naltrexone 0.2–0.3 mg/kg, IM/IV	Allow 10–20 min after xylazine before giving etorphine Do not use Immobilon because of the risk of regurgitation from acepromazine
Xylazine + Thiafentanil + Ketamine	X: 0.12 mg/kg IM T: 5.3 µg/kg IM + K: 0.6 mg/kg IM	Yohimbine 0.1-0.2 mg/kg IM; or atipamezole 0.125 mg/kg IM Naltrexone 30 mg/mg thiafentanil IM	Allow 15-20 min after xylazine before giving thiafentanil Rapid induction after T+K injection Shorter working time than with C+X
Medetomidine + Ketamine	Med: 60–120 µg/kg, IM K: 1–3 mg/kg, IM	Atipamezole 0.3–0.6 mg/kg, IV/IM	

2.6.4 Transportation

Container Size and Design

The type of shipment container depends on the length of travel, type of transportation, availability of air flights, and personality and size of the animal being moved. It can be either a crate or a trailer.

|Size: For trips longer than 12 hours in duration, the animal must be able to feel comfortable while standing up, and have space to lie down, get up again or turn around. Larger crates appear to be more comfortable and easier for the okapi as these resemble small stables. Narrow crates (61 cm interior width) are not recommended for long travels.

Recommended measurements for okapi transport crates are a minimum interior space of 122 cm wide. The ideal height is 210 cm. The ideal length is a minimum of 223 cm. The door width should measure a minimum of 210 cm wide.

|Design and Materials: Okapi crates should be constructed of 2.5 cm solid wood and/or metal parts bolted or screwed together. Bracing constructed with metal or 5 cm solid wood should be present around the whole container. The interior should be completely smooth and free of potential hazards to the animal. Okapi crates should have doors on both ends. At least one of the sides should feature a removable guillotine door panel to facilitate unloading in a variety of spaces. The other end may feature a matching guillotine door or may have a larger swing door that facilitates crate training and loading. This swing door can be bolted and locked once the okapi enters for transport. When using a trailer, the step up to the trailer is a major challenge and could be made easier by providing a ramp for the okapi to enter the trailer. For long-distance transport, the crate must include a small opening (that can be closed) for a feeding/water tray to re-supply the animal with water and food (Figure 104).

Figure 104 – Small opening in a transportation crate. *©Crossborder Animal Services*

Various okapi crate designs feature different options for offering food and water during transport. If the crate space is sufficient, elevated shelves can be constructed in corners adjacent to the guillotine door. A small, latched door in the exterior wall allows for water to be refreshed. Rubber tubs bracketed to the corner on the floor of the crate also work well with small holes cut through which to offer water or food.

The crate design should minimize direct contact between the okapi and its urine and faeces. All crates should have water-tight pans, built into the subflooring area, to catch okapi urine. The floor itself may feature wooden planks with small spacing between them to allow for drainage but narrow enough to prevent hooves from passing through. Forklift extrusions must be provided as an integral part of the design. Regarding ventilation, crates should have numerous ventilation holes with a maximum diameter of 5 cm along the top and above eye level. Holes should be at a safe height to prevent males from accessing them with their ossicones.

International Air Transport Association (IATA) live animal regulations should be met or exceeded when the transport is done by air. IATA regulations require containers to be closed, properly ventilated (on at least three sides and covering 16% of the total surface area of the container), escape-proof,

reinforced appropriately, labelled with animal identification and care instructions, leak-proof, and made of safe, non-toxic materials (IATA, 2022).

Preparation for Transport

Figure 105 – Transportation crate being placed inside of a truck. *©Antwerp Zoo /Location: Antwerp Zoo*

|Planning: Okapis are solitary and must be transported separately and only when the individual is considered fit; which includes good health and correct age (EAZA 2021). The transport of calves not weaned is not recommended. The ideal age for transport is between the ages of 2 and 3 years. If the container space is sufficient, okapi can comfortably travel long distances within the transport container for up to two days, as long as an attendant is monitoring the animal and can offer food and refresh the water. Usually, okapis are only transferred in mild spring or autumn if trailers are not climate-controlled. Some okapi holders, particularly those in colder climates, opt to only receive in the Spring as adjustments to winter routines and dietary limitations may result in a more challenging adjustment period for the animal that comes from warmer climates. The date of shipment should depend upon the okapi's comfort level with the crate. It is advised to begin crate/trailer training one to two months in advance of shipment. Pre-shipment tests may be carried out before the transfer of the animal.

Routes and schedules must be predetermined and reviewed to minimize the length of the trip as much as possible. Planned or emergency stop locations must be planned. The animal must not be removed from its container unless it can be contained in another acceptable area if extreme circumstances demand it. It is recommended to have a keeper familiar with the animal during the shipment to assist with its acclimation.

|Supplies: It is recommended that holders transferring okapi supply a sealed bag of the okapi's normal browser pellet for the okapi's diet to transition gradually to the receiving holder's pellet. As hay quality also varies greatly bringing alfalfa from the sending institution will also allow for a smoother transition. Other supplies should travel with the okapi as necessary, including extra keys to any locks used on the crate, extra copies of the okapi's transfer paperwork and health certificate, extra food bowls if needed, a funnel for refreshing water, a flashlight, a thermometer, extra rope, pliers, and a cordless drill/screwdriver for fastening and unfastening any screws.

|Flooring/Bedding: Ideally, a thick layer of wood shavings covered with hay is offered as bedding during transport. A 15 cm layer of sand covered heavily with hay is acceptable as well. Bedding must provide good footing and traction, isolation, absorb moisture during transport and give the animal a cushion on which to rest. Uncovered shavings or sand are not recommended, as issues may arise with it getting in animals' eyes during the move.

|Crate/Trailer Training: Okapi should not be immobilised for transportation and must be trained to their transportation trailer or crate before shipment. During training, while leaving the container in the okapi's enclosure for habituation, the doors of the container should be secured in the open position and any doors on the opposite end should be secured with a lock. Any potential things capable of frightening the okapi, such as noise or rattling, must be anticipated and mitigated.

➢ *For further details on crate/trailer training see section **2.5.4 Animal Training**.*

Care During Transport

|Food and Water: Browse must be available during the shipment. If possible, it is recommended to follow the animal's normal feeding/watering schedule. pellets can be fed at a reduced rate (1/4 ration) but they can also be absent during shipment. Fresh leafy green vegetables may be offered and refilled as necessary during shipment to encourage eating and provide moisture. Small amounts of water can be offered. Funnels with extended nozzles serve well to add water from the outside of the crate through trap doors or holes. If feeding the okapi browse during transport, the browse should not be placed directly in contact with the crate's substrate, especially if it is made of shavings or sand. A layer of bedding/grass hay placed under the alfalfa will guard against the ingestion of debris. Animals may need to be acclimated to the presence of unfamiliar animal care staff (belonging to the transportation company) if the animal needs to be observed, fed and/or watered during travelling.

In some cases, for short travels, it is best to leave the animal and its crate alone during transport. The offering of some soaked lucerne hay is enough to provide some water and food without the need to stop for feeding or watering the animal and eventually spooking it.

|Temperature: Temperatures may be maintained within the normal husbandry range. Ambient and crate/trailer temperatures should be checked and recorded to ensure proper conditions. Supplemental heat must be provided if the temperature falls below 13°C and cooling must be provided if the temperature rises above 29°C. It's important to consider that even if ambient temperatures are not considered extreme, the temperature inside a trailer or crate can average 10 degrees warmer and transports should not be undertaken under those conditions. Extreme temperatures in either direction pose a serious risk to animal health.

|Sound and Light: Crated animals waiting to be loaded onto a transport vehicle must be placed in an environment as quiet as possible; a radio may be utilized to mitigate unusual noises that cannot be eliminated. Trailers and crates must be constructed to minimize strong light and direct views.

Arrival and Unloading

After arriving at the destination, it is preferable to release the animal into an interior space where locomotion, light, and visibility can be controlled. It is recommended to reduce the unnecessary presence of humans in the first 24-48 hours upon arrival since the okapi might be nervous and tense and can be easily frightened. The animal care routine must be instituted to aid the animal in acclimation to its new environment. The animal must be monitored for the first couple of hours after release.

2.6.5 Safety

Human Injuries

There have not yet been any reported severe human injuries. However, some kicks and shoving, especially during veterinary acts or loadings have occurred. Despite a lack of serious injuries, enclosure design including restraint chute usage may be carefully considered to support keeper safety.

Animal escape

Procedures and the appropriate response should be clearly defined in the case of animal escape. While okapis are not considered dangerous in normal situations, a frightened animal can easily become a danger to staff, members of the public, and itself. Depending on the area of escape, staff may be

required to clear the public and form a perimeter around the okapi to block its path to potentially dangerous areas. However, an okapi will not perceive a line of humans as a barrier alone, and shade cloths or solid panels should be utilized at a safe distance. All responding to the emergency must remain calm so as not to spook the okapi, and staff trained to work with the okapi should be the only persons qualified to approach the animal. Most often the animal can be lured back into holding with browse if the situation remains calm.

Figure 106 – Okapi in a transportation trailer. *© Bristol Zoological Society / Location: Bristol Zoo*

2.7 Veterinary Care

Figure 107 – Eye exam in free contact with a trained animal. *©Chester Zoo / Location: Chester Zoo*

A programme of veterinary care must be established and maintained under the supervision of a veterinary surgeon or practitioner. The condition and health of all animals in the zoo are to be checked daily by the persons in charge of their care for that particular day. Any animals which are noted to be unduly stressed, sick or injured must receive immediate attention and, where necessary, treatment (EAZA 2020).

2.7.1 General Veterinary Management

Holders must always contact the veterinary advisor of the EEP and the EEP coordinator when issues or unfamiliar illnesses arise.

Okapis are susceptible to many of the diseases common to domestic ruminants. Digestive disorders, viral and bacterial infections jaw abscesses, trauma and overgrown hooves are a few of the most common problems encountered in the zoo community.

Medical management of the okapi is similar to other medium/large ruminants. To perform medical procedures, two approaches can be used successfully – Operant conditioning training or immobilization. If the procedure is relatively non-invasive (ultrasound, blood draw, etc.) and the individual has an approachable temperament, a standing immobilization in a chute with training can be undertaken. If the animal is not approachable or not acclimated to direct contact or the procedure is more involved, a full immobilization is warranted. Many management practices are designed to reduce the risk of spreading pathogens from other species to the okapi and vice versa. Illness is prevented by increasing disinfection, reducing traffic to okapi areas, practising preventive medicine, limiting the access of keepers to various working areas on a given day and practising footwear disinfection.

Figure 108 – An X-ray exam performed to an okapi foot using a training chute and protected contact. *©Bristol Zoological Society / Location: Bristol Zoo*

Okapi calves are very susceptible to infectious diseases. Veterinary neonatal care is recommended to identify health problems early, guard against specific pathogens known to affect okapi and build a database of available okapi neonatal information. Since okapi dams have been known to traumatize calves following handling, any procedure involving a calf must be carefully thought out, discussed, planned and considered worthy of the risk.

- *For further details about Veterinarian care training, see section **2.5.4 Animal Training**.*
- *For further details about Immobilization, see section **2.6.3 Catching/Restraining**.*
- *For further details about Neonatal care, see section **2.4.5 Development and Care of Young**.*

2.7.2 Preventive Health Care

The best way to prevent illness and medical intervention is to exercise preventive medicine. Many health problems can be avoided, prevented or managed through routine health checks and care. In addition to the indications listed below, nutrition also plays a role in preventing health problems.

- *For further details about Nutrition, see section **2.2 Feeding**.*
- *For the vital signs of the okapi, see section **1.1.3 Physiology - Vital Signs**.*

Observations

Every individual must be assessed every day for eventual signs of illness, trauma or distress. Observable signs of health issues are abnormal breathing, nasal discharge, lethargy, abnormal locomotion, loss of appetite, skin problems, absence of rumination or sudden changes from normal behaviour. Okapi showing any of these signs should be closely monitored and examined as necessary.

Figure 109 – Deterioration in coat condition. *©Chester Zoo / Location: Chester Zoo*

Biosecurity and Hygiene

Humans may be a vector of transmission of common viruses, particularly rotavirus, from a sick okapi to another individual. As such, high levels of biosecurity are particularly important when working around this species. During food preparation or touching the okapi, clean hands or gloved hands help prevent the transmission of zoonotic diseases. Staff should not work around okapi if suffering from stomach flu, vomiting, and/or diarrhoea. Footbaths and dedicated boots, coveralls and utensils are recommended to prevent enteric viruses from spreading from enclosure to enclosure.

Figure 110 - Rectal temperature measurement using a training chute and protected contact. *©Bristol Zoological Society / Location: Bristol Zoo.*

General Exam

Okapis are typically examined only on an opportunistic basis – rare occasions of general anaesthesia. When this occurs, the procedure includes:

- Physical exam
- Blood sample for CBC/chemistry panel
- Intradermal comparative tuberculin test
- Cardiac ultrasound to establish the expected normal
- Rectal temperature (Figure 110)
- Anti-parasitic medication if necessary
- Vaccinations: Rota-coronavirus if the veterinarian deems it necessary after an institutional epidemiologic assessment; Clostridial 7-way vaccine and ImRab opportunistically.

Weighting and Body Condition

Body weight should be measured for each individual regularly, at monthly or bi-monthly intervals. Weight changes can be the first indication of a health issue. However, the weight alone can be misleading, especially if no previous values are present to compare with. The evaluation of the body weight should always be combined with body condition scoring for a good assessment of health

condition. The diet should be reviewed and adjusted when required in response to weight changes in individual okapis. If changes persist the animal must be evaluated by a vet and further analysis such as blood or urine must be undertaken to detect the cause of weight loss.

➢ *For a body condition score table, see* ***Appendix E – Okapi Body Condition Score***

Hoof Care

Figure 111 – Left: Example of poor hoof condition. *©Chester Zoo /Location: Chester Zoo*. Right: Overgrowing in one toe of an okapi's hooves. *©Antwerp Zoo /Location: Antwerp Zoo*

Like many hoofstock species, okapis are susceptible to overgrown hooves in captivity mainly because of lack of movement, dry environments, lack of sufficiently abrasive surfaces, and possibly an acidosis-inducing diet (Figure 111). Apart from simple overgrowth, excessively steep stances, crossing over of the tip of the claws, and flaring hoof walls are the most common problems in okapis (Bertelsen 2015).

➢ *For further details about Hoof Care training, see section* ***2.5.4 Animal Training - General Husbandry Training*****.**

Figure 112 – Examples of hooves in good condition. *©Chester Zoo / Location: Chester Zoo*

Figure 113 – Hooves before and after hoof care. *©Antwerp Zoo / Location: Zoo Antwerp*

Figure 114 – Hoof trimming in a training chute and through protect contact.
©Bristol Zoological Society / Location: Bristol Zoo

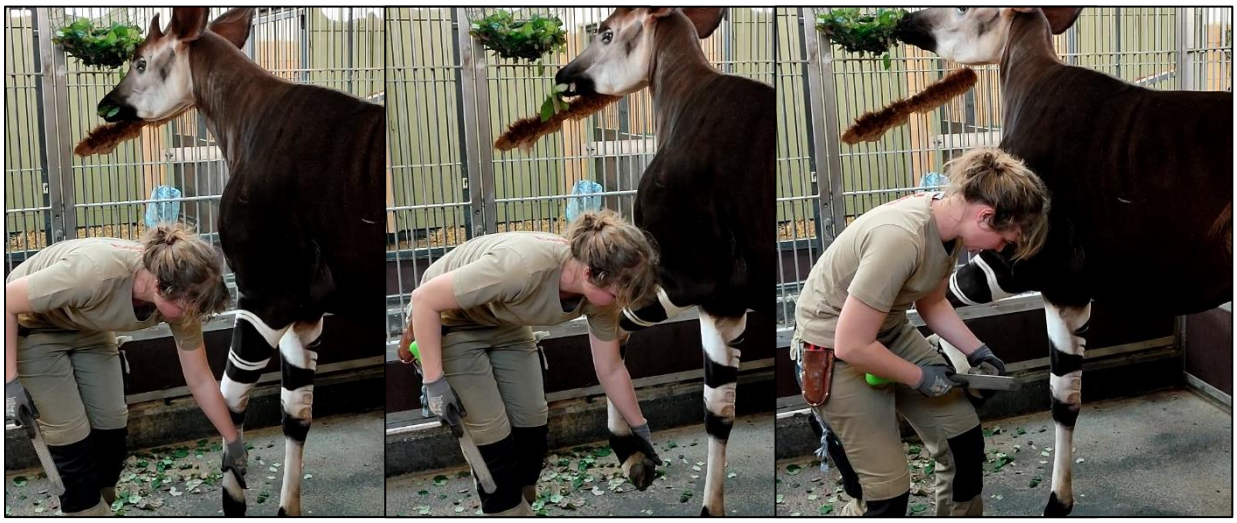

Figure 115 – Okapi hoof care performed in free contact with a trained animal.
©Antwerp Zoo / Location: Antwerp Zoo

Blood Sampling

Blood samples in adult okapi must be taken opportunistically or at least once a year to create a database of normal values for each individual. Blood sampling with more regularity might be necessary if the clinical state of the individual requires so. Anaesthesia for blood collection is not recommended. The animals can be trained to allow blood collection. Blood draws must be taken from the jugular (Figure 116). It is not recommended to collect blood from the ears since the vessels collapse very easily and cannot hold the large volumes of blood needed for tests. Subtle changes in the blood can be very informative when trying to diagnose a disease. Breeding holders should create a bank of plasma and serum at -20°C to help newborns with difficulties.

➢ *For normal values of an okapi hemogram and biochemistry, see* ***Appendix A – Okapi Haematology and Biochemistry*****.**

Figure 116 – Blood draw in an anesthetised okapi. Blood collected at the jugular. *©Antwerp Zoo / Location: Antwerp Zoo*

Faecal Sampling

Faecal samples can help to diagnose infections or digestive disorders. Diarrhoea may indicate rotavirus (Raphael *et al*., 1986) and it should be tested accordingly. In the case of diarrhoea, as a preventive measure, quarantine protocols must be initiated, which may include separate tools, boots, disinfection, and limited isolation. Regular faecal sampling of the females allows the tracking of their oestrus cycle. The tracking of faecal oestrogen and progesterone metabolite levels allows the detection of eventual reproductive problems, including progesterone insufficiency that leads to loss of pregnancy. Routine testing for parasites is recommended followed by treatment as needed.

For hormone tracking, each sample (about eight pellets from a single defecation) should be collected into a small plastic sampling bag. The sample should be as fresh as possible and not more than 12 hours old if defecated in a weather-protected area (e.g., defecation left in a stable overnight). The sample bag should be labelled with the animal's identification information and the date, and it should be frozen (-20 to -80 °C) immediately after collection. Similarly, if an in-house laboratory is not available at the zoological facility, samples should be shipped to a lab for analysis on ice packs. Cortisol levels can be measured on faecal samples to assess stress levels (Othen and Jarsky, 2004).

➢ *For a faecal scoring table, see* ***Appendix F – Okapi Faecal Scoring***

Urine Sampling

Urine sampling can be useful to track reproductive cycles, stress hormones, monitor dietary parameters or even detect infections or other health issues. Urine can be either collected opportunistically or by the animals trained to realise the collection. The earliest possible urine in the morning is preferable. Urine should be collected mid-stream into a sterilised stainless steel or plastic collection cup attached to a pole or immediately aspirated off the ground with a syringe. Then samples must be labelled with the individual's identity, date, and time of urination, and immediately frozen at -20ºC, if for hormone analysis. If the samples aspirated from the ground are cloudy due to debris they might have to be centrifuged before being analysed (Bertz, 2004; Othen and Jarsky, 2004; Bennett *et al*., 2008; Fleming *et al*., 2006; Vercammen *et al*., 2014).

Vaccination

The veterinarian of each institution may decide to vaccinate taking into consideration the institutional prevalence of rotavirus, coronavirus, *E. coli* and *Clostridium*. So, a risk assessment of each institution will be an important tool for vaccination since some animals react strongly to vaccination.

Figure 117 - Okapi with a vaccination dart. *©Basel Zoo/ Location: Basel Zoo*

2.7.3 Infectious Diseases

Parasites

Captive okapis do not appear to be more susceptible than any other ruminant to endo or ectoparasites. Parasitic nematode worms are often found in okapi. Captive okapis may succumb to infection from *Monodontella giraffae*, a parasitic nematode that damages their bile ducts and is hosted by giraffes as well *(Bertelsen et al., 2009)*. There have been no reports of adverse reactions to anthelmintics at standard bovid dosing regimens. Anti-parasite preventive treatments must be done once a year unless faecal sampling suggests a different plan of treatment.

Gastrointestinal disorders

Diarrheal diseases can cause severe problems in okapi calves, with rotavirus as the main pathogen that is endemic in the captive okapi population (Raphael *et al.*, 1986). Other common causes of enterocolitis (inflammation of the digestive tract) in okapi calves are *E. coli* and coronavirus. Morbidity and mortality in okapi calves have also been caused by: meningitis, meningoencephalitis, pneumonia, septicemia, and enterotoxemia. Early defecation in a sick calf can be a sign of septicaemia and medical intervention is warranted. Although one-time early defecation can occur in healthy calves (Clancy and Raines 2014). The severity of the risk of severe disease or death from diarrheal disease decreases as the calf grows older.

To prevent the transfer of pathogens to a calf and dam, they may be kept as isolated as possible from other okapi and other species, and an increase in hygiene and sanitation may be instituted. Calving enclosures must be cleaned (and supplied with feed) first before keepers enter other enclosures; entry into calving enclosures may be reduced as much as possible. Keepers may concentrate on preventing

the introduction of pathogens into the calving enclosure rather than over-cleaning or sanitizing the calving enclosure.

Footbaths and dedicated boots, coveralls and utensils are recommended to prevent enteric viruses from spreading from enclosure to enclosure. If other animals in the collection are infected with rota-coronavirus, staff and facilities should be isolated. Calving environments must be kept warm and the air may be humidified to reduce rotavirus and coronavirus survival in the environment. Proper ventilation in barns should be applied to reduce the aerosol spread of pathogens. Phenolic disinfectants are most effective against rotavirus—dams may be acclimated to the smell of these disinfectants well before calving so the smell is not new.

Otitis

Okapi otitis externa is a rare, but significant disease described by Allender *et al.* (2008) in nine okapis at the Chicago Zoological Society during the summer months. The most common symptom was the dropping of the ear and frequent head shaking. The microbiological culture of ear swabs might aid in identifying the potential cause of the infection. Treatment of okapi with otitis appears to be successful by using chlorhexidine-based ear cleaners daily in combination with appropriate antibiotic or antifungal treatment. The factors leading to the development of otitis externa in okapi are suspected to be high levels of humidity and/or excessive licking of the ear canal by the okapi with its long tongue.

2.7.4 Non-Infectious Conditions

Failure Of Passive Transfer (FPT)

Calves with evidence of Failure of Passive Transfer of Maternal Immunoglobulins (FPT) (based on neonatal blood work) may be observed closely for evidence of illness during the first month of life. These “at-risk” calves may be considered for plasma transfusion to boost serum immunoglobulin levels; institutions breeding okapi may consider maintaining a frozen plasma bank for such occasions. Calves with FPT will need anywhere from 50 to 200 ml plasma/Kg body weight to raise immunoglobulins to acceptable ranges. The success of plasma transfer in raising serum globulins can be evaluated by measuring serum globulins and performing serum electrophoresis before and after transfusion.

Heart Diseases

Congestive heart failure (CHF) has been diagnosed in three adult female okapis in a single collection. Clinical signs included lethargy, loss of appetite, rapid breathing, shortness of breath, flared nostrils, and productive coughing with copious foamy nasal discharge (Warren *et al*., 2017). Whether the causes of CHF are linked to genetics, reproductive or cardiovascular factors is still unknown. Clinical signs were managed with oral furosemide and enalapril. Interestingly, cardiac hypertrophy or dilatation was a frequent (11 out of 67 reports) finding in a survey of postmortem findings (Students *et al*., 2008).

Laminitis

Like many other captive ungulates, the okapi regularly experiences hoof problems. These hoof problems can be a serious problem in captive ungulates. When the situation reaches a severe level, the animal might have to be anesthetised for the trimming of its hooves. Anaesthesia can have complications and/or result in mortality. Laminitis is the result of damage to the blood vessels that supply nutrients to the hoof and results in overgrowth of the hoof. The factors associated with Laminitis are high proportions of easily digestible carbohydrates in the diet, deficiencies in dietary

trace elements, and hard flooring in the okapi's enclosure (Engelhart *et al*., 2007; Clauss *et al.*, 2009). Easily digestible carbohydrates in abundance in the okapi's diet result in acidosis of the rumen, which is directly associated with laminitis. Therefore, preventing rumen acidosis (through diet) is the main focus to prevent laminitis (Clauss and Kiefer, 2003; Engelhart *et al*., 2007).

> ➢ *For the management of substrate-related health problems, see section **2.1.5 Substrate**.*

Specific Diseases and Illnesses

2.7.5 Quarantine

Quarantine for okapis can be accomplished in a large animal quarantine facility if such a facility exists. Alternatively, the animal should be isolated from other ruminants for the duration of the quarantine period. Quarantine should last a minimum of 30 days (unless otherwise directed by the staff veterinarian).

Keepers should be designated to care only for quarantined animals if possible. When this is not possible keepers should care for the non-quarantined animals first and only after, care for the quarantined animals. Risks of biosecurity must be minimised for those keepers that have to care for non-quarantined later again. As such, designated boots and clothing must be indicated for quarantine facilities, and footbaths should be at the entrance of all quarantine facilities ideally containing an approved disinfectant. Additional footbaths may be provided at the entry of individual holding stables if deemed necessary. All footbaths are changed and brushed once daily or after intensive use. Equipment used for feeding, caring for, and enriching objects of animals in quarantine should be used only with these animals. If this is not possible, then all items must be appropriately disinfected. Quarantine and exhibit facilities must not share the same waste disposal containers.

2.7.6 Geriatric Animals

Many animals experience physical and behavioural changes when they reach advanced age. This is particularly notorious in zoo animals since they live longer lives than their wild counterparts. These changes can negatively impact their well-being and keepers and veterinarians must pay extra attention to these individuals regarding their nutrition, care, and health (Krebs *et al*., 2018). An animal can be considered geriatric when it has reached 80% of the expected life span for the species. Under human care, okapis are considered geriatric after 16.5 years of age. However, some individuals can reach over 30 years of age. Geriatric okapi have been seen to have lower overall activity levels, increased resting, decreased appetite and changes in social behaviour towards conspecifics and humans (Krebs *et al.*, 2018).

Geriatric okapis generally suffer from age-related issues similar to those of bovids. Arthritis is relatively common. Medication can offer some pain relief. Solid flooring with good traction is important. Rubber flooring or thick bedding can also be necessary. Extra hoof care should be warranted to prevent hoof malformations. Also, closer monitoring of the dietary needs of these individuals is necessary with regular feeding plan adjustments and assurance of consumption of enough fibre and browse. Further attention must be given to the thermic comfort of geriatric individuals. Old okapi might be sensitive to low temperatures.

2.7.7 Adult Mortality

Due to their skittish nature, adult okapis can in the course of accidents, such as running against obstacles or panicking, suffer from serious trauma that leads to fatalities. Avoiding strong or sudden noises that might spook the okapi is the most important way to prevent these accidents. All the recommendations for enclosure design and husbandry presented in this guide provide mindful advice to reduce the chance of accidents (e.g., slippery floors or poorly visible barriers). Fatalities have also been recorded from strange objects being swollen by the okapi and causing gut obstructions. It is important to prevent visitors from feeding the okapi or monitor if the individual is repeatedly chewing potentially dangerous objects such as ropes or nets. During breeding introductions, if the female lays down in a lateral recumbency (on their side), content from her stomach is regurgitated and can enter her lungs, leading to potential death. In such a situation it is imperative to separate the pair and position the head of the female above her stomach in case she remains lying.

➢ *For information regarding noise disturbances, see **2.1.7 Environment**.*

When an individual dies (juvenile or adult) a full post-mortem protocol must be followed as standardized for the whole EEP.

➢ *For the post-mortem protocol, see **Appendix B – EEP Okapi Necropsy Protocol**.*

2.8 Recommended Research

The okapi is still a very mysterious species due to our reduced knowledge about it. Furthermore, its study in the wild is very difficult due to its elusive behaviour and the remoteness of its habitat. As such, one of the greatest potentials of the *ex-situ* population is its use for research on the species.

Any research which focuses on the husbandry, disease management, behaviour, and well-being of the species in captivity will greatly increase the health and welfare of the individuals and increase the efficiency of the breeding programme. Reproductive physiology and behaviour, and prevention of stereotypies are the main areas of concern in the captive population.

It is also greatly recommended to every holder to support okapi conservation and research projects in its native habitat. Expanding our knowledge of the wild population will also contribute to providing the *ex-situ* requirements that more correctly match the wild environment of the species.

Listed below are the main research questions/points that are relevant to investigate in the okapi captive population:

Breeding Programme and Genetics

- Reproductive biology studies such as the preservation and importation of semen to auxiliary the breeding programmes and the storage of genome material.
- Assisted reproductive techniques such as artificial insemination, contraception, sperm or egg collection and hormonal treatments have the potential to increase the efficiency of the breeding programme and the management of the captive population.
- Further improve the reproductive techniques for monitoring the species regarding the detection of oestrus, pregnancies, and parturition.
- Genetic studies to improve the management of the breeding programme and/or to assist the *in-situ* genetic monitoring of the wild population.
- More investigation on pair compatibility factors (genetic and behavioural) and techniques to promote mate choice or pair familiarity (e.g., allow female/male urine sampling before transfer/introduction to a new partner or allow a female to choose among different males' urine samples).

Behaviour

- The social behaviour and structure of okapi are still poorly understood, and it may impact its reproduction in captivity. Evaluation of the negative and positive impacts of the different social housing systems can be achieved using stress hormones and behavioural studies.
- The study of stereotypical behaviours and their mitigation and prevention. Evaluation of new enrichment devices/plans.
- Studies on the assessment and effects of stress in okapi on different environments and husbandry schemes via stress hormones and behavioural studies.
- Behavioural studies on personality and aggressive behaviour during breeding would greatly assist the breeding programme and prevent wrong matches. Understand the factors linked to aggressiveness in males during breeding and its prevention.

- Studies on the sensorial capacities of the species, notoriously the auditory and communication capacities via infra-sound.
- Utilising the captive population for testing, validation, and improvement of field techniques for studies in the wild such as radio-collaring or faecal DNA sampling among others.

Husbandry and Well-being

- Veterinarian studies in general, also focus on problems already described in okapi such as heart congestive failure, glucosuria, hoof care issues, kidney disease, etc. Improvements in testing, validation, treatment, and prevention of infectious diseases require improvement.
- The well-being and care of geriatric animals.
- The evaluation of the impact of cold and/or arid climates on the health of the individuals.

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Appendixes

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Appendix A – Okapi Haematology and Biochemistry

Reference ranges for haematological parameters for Giraffidae from composite ZIMS records, adapted from Bertelsen (2015).

Haematological Parameters Note: Values represent mean ± standard deviation (n = sample size).			
PARAMETER	**UNIT**	**GIRAFFE**	**OKAPI**
Leukocytes or white blood cell count	10^9/litre (L)	12.6 ± 4.8 (479)	8 ± 3 (91)
Neutrophils: bands	10^9/L	0.86 ± 1.2 (181)	0.11 ± 0.1 (14)
Neutrophils: segmented	10^9/L	9.2 ± 4.2 (446)	5.1 ± 2.5 (81)
Lymphocytes	10^9/L	2.3 ± 1.4 (451)	2.4 ± 1 (81)
Eosinophils	10^9/L	0.40 ± 0.40 (266)	0.16 ± 0.11 (32)
Monocytes	10^9/L	0.41 ± 0.37 (370)	0.29 ± 0.31 (70)
Basophils	10^9/L	0.29 ± 0.22 (255)	0.15 ± 0.09 (18)
Haematocrit or packed cell volume	Liter per litre (L/L)	0.35 ± 0.06 (550)	0.36 ± 0.08 (92)
Erythrocytes or red blood cell count	10^{12}/L	10.5 ± 2.4 (350)	10.0 ± 2.7 (80)
Haemoglobin	Gram per litre (g/L)	119 ± 18 (376)	124 ± 27 (90)
Mean corpuscular haemoglobin	Picogram per cell (pg/cell)	11.7 ± 2.7 (340)	12.7 ± 1.7 (79)
Mean corpuscular haemoglobin concentration	g/L	348 ± 35 (373)	347 ± 29 (89)
Mean corpuscular volume	Femtoliters (fL)	34.1 ± 8.4 (346)	36.7 ± 4.1 (78)
Platelets	10^{12}/L	0.42 ± 0.17 (93)	0.38 ± 0.11 (20)

Serum Biochemical Parameters Note: Values represent mean ± standard deviation (n = sample size).			
PARAMETER	**UNIT**	**GIRAFFE**	**OKAPI**
Total protein	Gram per litre (g/L)	74 ± 14 (312)	71 ± 10 (77)
Albumin	g/L	31 ± 5 (282)	31 ± 8 (61)
Globulin	g/L	42 ± 14 (280)	40 ± 10 (59)
Fibrinogen	g/L	2.3 ± 1.8 (135)	0.4 ± 0.9 (33)
Glucose	Millimole per litre (mmol/L)	7.7 ± 3.3 (434)	7.2 ± 2.4 (83)
Alanine aminotransferase	Unit per litre (Unit/L)	13 ± 11 (237)	17 ± 20 (73)
Alkaline phosphatase	Unit /L	522 ± 476 (388)	397 ± 547 (77)
Aspartate aminotransferase	Unit /L	96 ± 55 (393)	66 ± 36 (77)

Creatine phosphokinase	Unit /L	1356 ± 1677(198)	615 ± 612 (77)
Gamma glutamyltransferase	Unit /L	61 ± 82 (207)	58 ± 101 (57)
Lactate dehydrogenase	Unit /L	864 ± 650 (235)	522 ± 296 (41)
Blood urea nitrogen	mmol/L	7.1 ± 2.5 (417)	7.5 ± 2.9 (80)
Creatinine	Micromole per litre (µmol/L)	159 ± 44 (373)	194 ± 71 (39)
Iron	µmol/L	16.7 ± 12.5 (28)	25.1 ± 9 (14)
Calcium	mmol/L	2.50 ± 0.45 (404)	2.58 ± 0.40 (80)
Phosphorus	mmol/L	3.0 ± 0.8 (372)	2.6 ± 0.7 (74)
Magnesium	mmol/L	1 ± 0.2 (63)	1 ± 0.3 (7)
Potassium	mmol/L	4.8 ± 0.6 (379)	5.0 ± 0.5 (77)
Sodium	mmol/L	145 ± 4 (381)	142 ± 5 (76)
Chloride	mmol/L	104 ± 6 (358)	103 ± 6 (74)
Triglyceride	mmol/L	0.45 ± 0.3 (245)	0.37 ± 0.3 (35)
Bilirubin: Total	µmol/L	17 ± 15 (377)	7 ± 5 (75)

Appendix B – EEP Okapi Necropsy Protocol

When an okapi dies at your institution, please consult the instructions below and contact the EEP coordinator. If you need more information about these instructions, please contact the Okapi EEP Vet Advisor. Also please share your ZIMS Medical using "External Sharing" and choose "OKAPEEPVA/Okapi EEP Vet Advisor". If you are not using ZIMS Medical, please send the necropsy results to the Okapi EEP Vet Advisor.

The full necropsy includes the macroscopic examination of the following and a microscopic examination of the abnormal with ancillary tests, if necessary:

External examination

- Body weight
- Nutritional status (body condition score)
- Hydration status
- Nostrils
- Eyes
- Ears
- Skin and subcutis
- Claws
- Umbilicus (foetus/neonate)

Musculoskeletal system

- Skeletal muscle
- Joints
- Bones

Body cavities

- Oral cavity
- Nasal cavity
- Pharynx
- Sinus cavity
- Thoracic cavity
- Abdominal cavity

Cardiovascular system

- Heart (including weight and wall thickness of left ventricle, septum, and right ventricle)
- Pericardium
- Blood vessels

Respiratory system

- Larynx
- Trachea
- Bronchi
- Lung
- Mediastinum
- Pleura
- Diaphragm

Alimentary system

- Salivary glands
- Tongue
- Teeth
- Oesophagus
- Liver
- Pancreas
- Rumen (including pH)
- Reticulum
- Omasum
- Abomasum
- Small intestine
- Large intestine
- Omentum
- Mesentery
- Peritoneum

Urinary system

- Kidneys
- Ureters
- Urinary bladder
- Urethra

Reproductive system

- Penis
- Testes
- Epididymis
- Accessory sex glands
- Ovaries
- Oviducts
- Uterus
- Cervix
- Vagina
- Mammary gland

Haematopoietic and lymphatic system

- Bone marrow

- Thymus
- Spleen
- Lymph nodes

Nervous system

- Peripheral nerve
- Spinal cord
- Meninges
- Brain

Endocrine system

- Thyroid glands
- Parathyroid glands
- Adrenal glands
- Pituitary gland

Additional research requests

Blood/tissue for DNA analysis

- For molecular studies, blood/tissue samples should be sent to your designated EAZA Biobank Hub. See sampling protocol at: *https://www.eaza.net/assets/Uploads/Biobank/Biobank-docs/2021/EAZA-Biobank-sampling-protocol-English-final-2021.pdf*

Blood/tissue for chromosome analyses

- Because of the varying chromosome number in okapi, we try to determine the chromosome number of each animal. Possibly, local universities and laboratories will be able to do this. Ideally, you would get in touch with the local genetics lab or university beforehand, so they can provide you with the correct protocol.

Serum

- For metabolomic studies, we need 1 ml serum (-20°C).

Sperm

- When an immature male calf dies, put testis tissue in different tubes (5 % DMSO, 10 % DMSO and 10 % glycerol) at -80°C for possible future xenografting.

Urine

- Collect 5 ml and store at -20°C for glucosuria research. We also need urine from non-glucosuric okapis.

Kidneys

- We need kidney samples of every okapi that dies to learn more about nephritis. Please, collect 2 small pieces from each kidney for histology (10% formalin).

Rumen

- To obtain more information on the subject of subacute rumen acidosis, please take 2 small pieces of the rumen wall for histology (10% formalin).

Claws

- To obtain more information on laminitis, please take radiographs and 2 small pieces of the corium of the medial and lateral claw of the foreleg and hind leg of one side for histology (10% formalin).

Skin/skeleton

- We would like as many okapis as possible to be collected in museums. If the okapi is on loan from another institution, contact this institution to check if they have a preference for a museum where the specimen should be kept. If your institution is the owner of the okapi, ask your local museum if they are interested.

Please send all these additional tissues for histology (10% formalin), serum and urine (frozen) to:

Dr Francis Vercammen
Tel. +32 3 202 45 48
e-mail: francis.vercammen@kmda.org
Royal Zoological Society of Antwerp
Koningin Astridplein 20-26 2018 Antwerp, Belgium

Appendix C – Mating Behaviour Ethogram

Based on the Mating Behaviour Ethogram by Megan Lumpkin from Dallas Zoo

The following ethogram intends to describe the most typical behaviours observed in okapi during breeding introductions. It is important to note that each individual will have its particular repertoire of behaviours possibly including behaviours not described here. Although classified as male or female behaviours many of these are not exclusive to one sex or the other but just more commonly associated with one sex. It is also specified when a certain behaviour indicates the female is on oestrus or not.

The second part of the appendix consists of a list of pictures that illustrate some of the behaviours on the ethogram.

Male Behaviours				
Behaviour	**Description**	**Gender Exclusivity**	**Oestrus indicative**	**Figure**
Flehmen response	The male curls back its upper lips, displays the teeth and inhales through the mouth for a few seconds after sniffing an object, particularly faeces or urine.	Not exclusive to males	Not indicative of oestrus, but more frequent in males in the presence of a female on oestrus or its faeces	119
Circling	Two okapis walk nose to tail, or a male okapi repeatedly walks around a female.	Not exclusive to males	Not exclusively indicative of oestrus	121
Urine sample	The male licks the urine of a conspecific either in mid-stream or from a puddle.	Not exclusive to males	Not exclusively indicative of oestrus	
Groom/lick/ nose perineum or genital area	The male licks or noses the anus or the vulva of the female. Not exclusive to males	Not exclusive to males	Not exclusively indicative of oestrus	
Laufschlag kick	Standing behind/beside the female, the male raises a foreleg to repeatedly tap the female between the rear legs or on the flank. The foreleg is extended fully or bent at the knee. It usually precedes a mounting attempt.	Male exclusive	**Indicates possible oestrus in the female.**	118
Chin or chest resting	Male standing behind/beside the female with head and neck extended over the female's rump, the male lowers his head and neck into a position of rest upon the female's flank area	Male exclusive	**Indicates possible oestrus in the female**	120
Head raise	The male extends his head high with his neck stretched forward and nose pointed upward. Also indicative of dominance.	Male exclusive	**Indicates possible oestrus in the female**	120
Vocalize ("honk")	Male okapi emits a low-pitched moan (often accompanied by the Laufschlag	Male exclusive	**Indicates possible oestrus in the female**	

	kick). This vocalization signals a high level of arousal.			
Mount	The male rears up on the hindquarters and rests the abdomen on the female's hindquarters.	Male exclusive	**Indicates possible oestrus in the female**	
Copulate	The male okapi successfully mounts the female with the intromission of the penis into the vagina. Lasting up to 3 seconds.	Male exclusive	**Indicates oestrus in the female**	120
Female Behaviours				
Behaviour	**Description**	**Gender Exclusivity**	**Oestrus indicative**	**Figure**
Groom/lick perineum or genital area	Female licks the male's anus or penis. (the latter often occurs in the reverse parallel position).	Not exclusive to females	Not exclusively indicative of oestrus	128
Low head posture	The female stretches her head and neck out at either a downward angle from the shoulder or at an angle parallel to the ground (often assumed when standing for the male to mount). Also often performed as submissive behaviour between females	Female exclusive	It signals receptiveness to breed, especially if accompanied by tail diverting but it is not exclusively indicative of oestrus	124
Head bunt	Giving small and gentle headbutts on the body, normally on the flanks or abdomen, of the male.	Not exclusive to females	Not exclusively indicative of oestrus	
Tail divert	The female either raises or points her tail to the side exposing the vulva area to the male.	Female exclusive	**Indicates oestrus in the female**	122
Nose perineum or genital area	Female noses the male's anal or genital region.	Not exclusive to females	Not indicative of oestrus	
Antagonistic Behaviours				
Behaviour	**Description**	**Required separation**		**Figure**
Head raise	Okapi extends its head high with its neck stretched forward and its nose pointed upward.	No separation required		
Kick back	Okapi female kicks back at the male with rear legs as he stands behind her. Kick-back may also occur while the female assumes a submissive position. It also occurs in non-breeding introductions with animals of the same sex.	No separation required		123
Foreleg kick	Okapi raises forelegs to kick (may threaten by orienting to or may make contact with).	No separation required		

Rake	The male scrapes the female with horns while arching the neck and back, lowering the head, and then thrusting upward.	Must be separated	
Head slap or slam	Okapi swings head/neck to the side (may threaten by orienting to or may make contact with).	Must be separated	
Stomp	Okapi orients toward a perceived threat and lunges toward it while kicking out and beating both front feet on the ground. Stiff-legged walking is a dominance display related to the stomp.	Must be separated	
Submissive Behaviours			
Behaviour	**Description**	**Separation**	**Figure**
Submit sternal	The female assumes a sternal position in the presence or approach of the male. In this position, there is a greater probability of the male becoming aggressive. It also occurs in non-breeding introductions with animals of the same sex.	May require separation	126
Kneel	The female lowers herself onto the front knees with her rear legs bent, then immediately rises again. It also occurs in non-breeding introductions with animals of the same sex.	No separation required	
Submit lie	The female assumes a full lie position in response to the male. It also occurs in non-breeding introductions with animals of the same sex.	Must be separated	68

Figure 118 - Laufschlag kick. *©Wolfgang Dreier / Location: Berlin Zoo*

Figure 119 – Flehmen response. *©Marek Velechovský / Location: Safari Park Dvůr Králové*

Figure 120 – Left: Copulation. Right: Head raise and chest rest. *©Wolfgang Dreier / Location: Berlin Zoo*

Figure 121 – Circling behaviour. *©Bioparc Zoo de Doué-la-Fontaine / Location: Bioparc Zoo de Doué-la-Fontaine*

Figure 122 – Chin rest and Tail divert. *©Afrikaonline.cz / Location: Frankfurt Zoo*

Figure 123 – Female back kicking. *©Anna Pawlik / Location: Wrocław Zoo*

Figure 124 – Female Low head Posture and tail divert. *©Afrikaonline.cz / Location: Frankfurt Zoo*

Figure 125 – Tail divert, chin rest and Laufschlag kick. *©Afrikaonline.cz / Location: Frankfurt Zoo*

Figure 126 – Laufschlag kick with the female in a submissive position. *©Antwerp Zoo / Location: Antwerp Zoo.*

Figure 127 - Stand with head low posture. *©Megan Lumpkin*

Figure 128 - A female licking the male's genital area (in reverse parallel position). *©Megan Lumpkin*

Appendix D – Enrichment Examples

Figure 129 – Feeding Enrichment devices. *©Bristol Zoological Society / Location: Bristol Zoo*

Figure 130 – Feeding Enrichment devices. *©Branféré Zoo / Location: Branféré Zoo*

Figure 131 – Feeding Enrichment devices. *©Yorkshire Wildlife Park / Location: Yorkshire Wildlife Park*

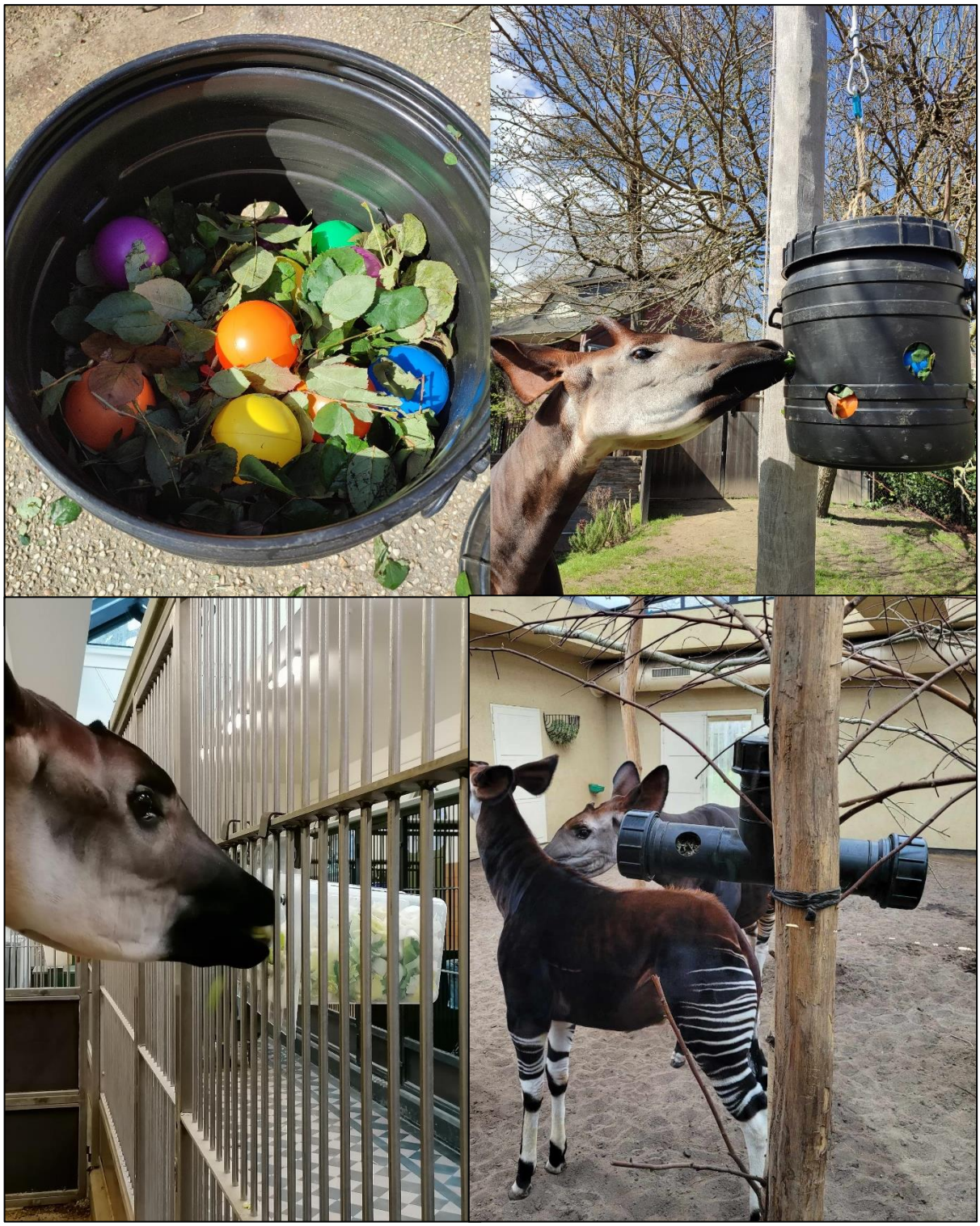
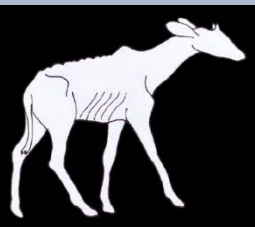
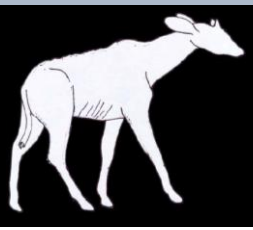
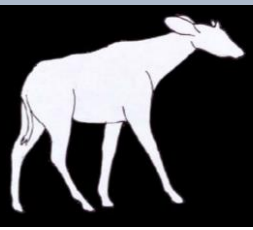
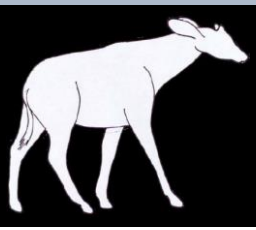
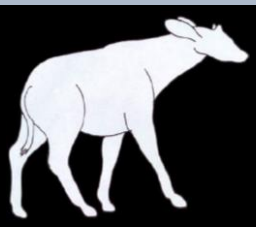


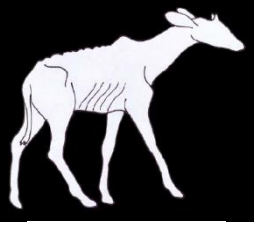
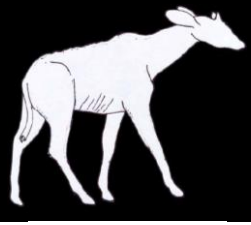
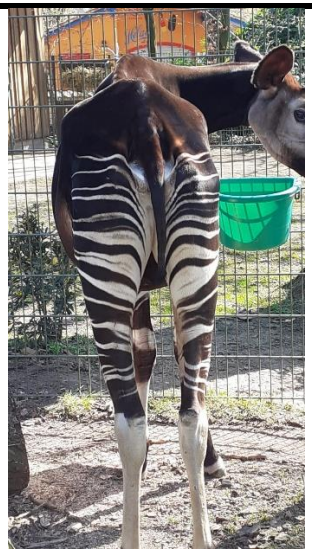
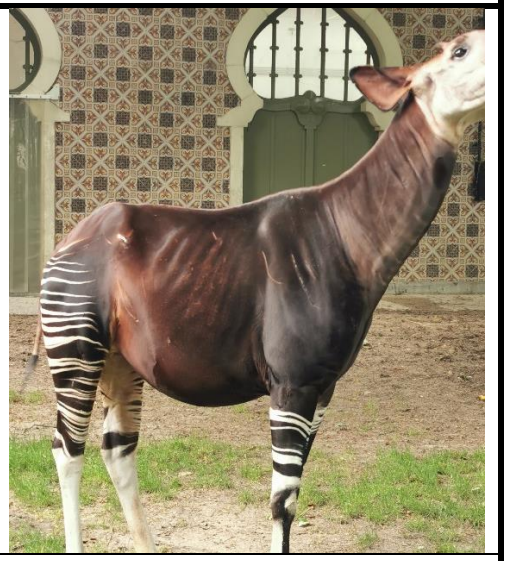
Figure 132 – Feeding Enrichment devices. *©Antwerp Zoo; Bottom right: ©Karol Mišovic / Location: Antwerp Zoo*

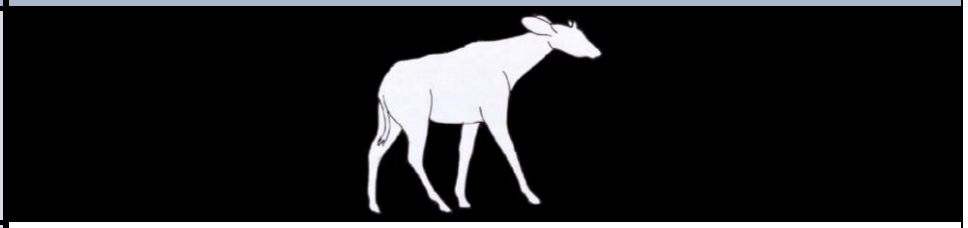
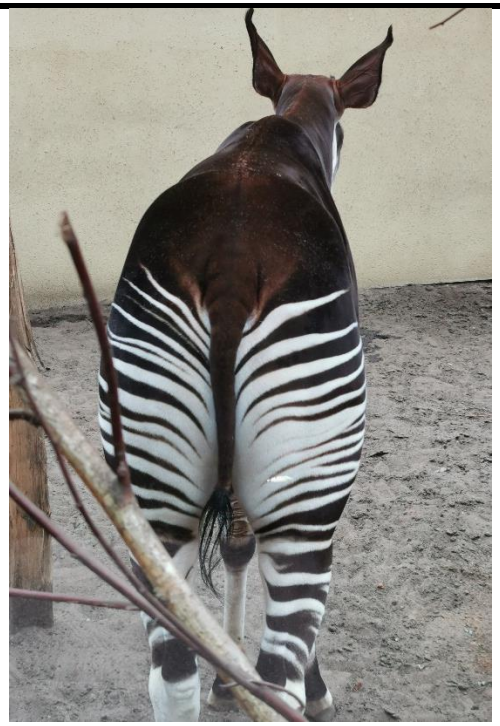
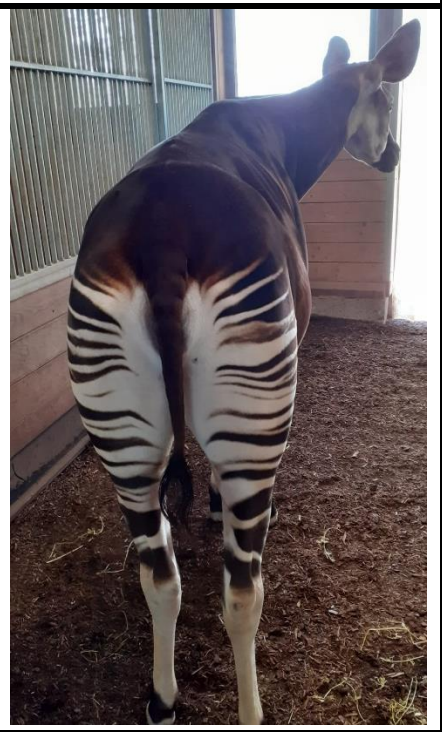
Figure 133 – Enrichment devices. In the lower left corner: Scratching Brush *©Chester Zoo / Location: Chester Zoo*

Appendix E – Okapi Body Condition Score

Based on Okapi BCS Disney's Animal Kingdom (2005) and Hip depictions are from giraffe in Clavadetscher *et al*. (2021).

Score	Emaciated	Thin	Good	Fat	Obese
Outline Depiction					
Hip Depiction					
Neck & Shoulders	• Emaciated • Bone structure is easily identifiable • No fat	• Ventral portion of neck is thicker than dorsal portion	• Neck is thick • Blends into shoulder	• Fat deposits present • Fat wrinkles present at bend of neck	• Fat is evident along neck • Bulging fat • Neck is thick
Withers	• Emaciated • Bone structure is easily identifiable • No fat	• Withers are less emphasized, but still identifiable	• Withers appears flatter	• Fat deposits are present	• Fat deposits make withers unidentifiable • Withers are flat
Loin & Back	• Emaciated • Spinous processes are easily identifiable	• Spinous processes are not individually visible, but the spine is still prominent • Transverse processes are faintly visible	• Back is flat	• Fat deposits are present and back appears flat	• Wide Back • Patchy fat
Tailhead & Hips	• Pelvic bones are very prominent	• Pelvic bones at point of hip are rounded, but still evident • Pelvic bones at rump may be slightly visible	• Fat is around tailhead • Hips are flat	• Hips are rounded	• Hips/thighs are very round
Ribs	• Emaciated • Ribs appear wide and depressed	• Ribs are discernible, but fat is evident by touch	• Ribs are not visible, easily discernible by touch	• Fat deposits over ribs are wide and unevenly spaced	• Fat deposits may be present, easily evident

Score	Emaciated	Thin
Outline Depiction		
Hip Depiction		
	 	 
	Female emaciated due to its advanced age (27yrs)	Thin Female due to lactation

Score	Good	
Outline Depiction		
Hip Depiction		
		

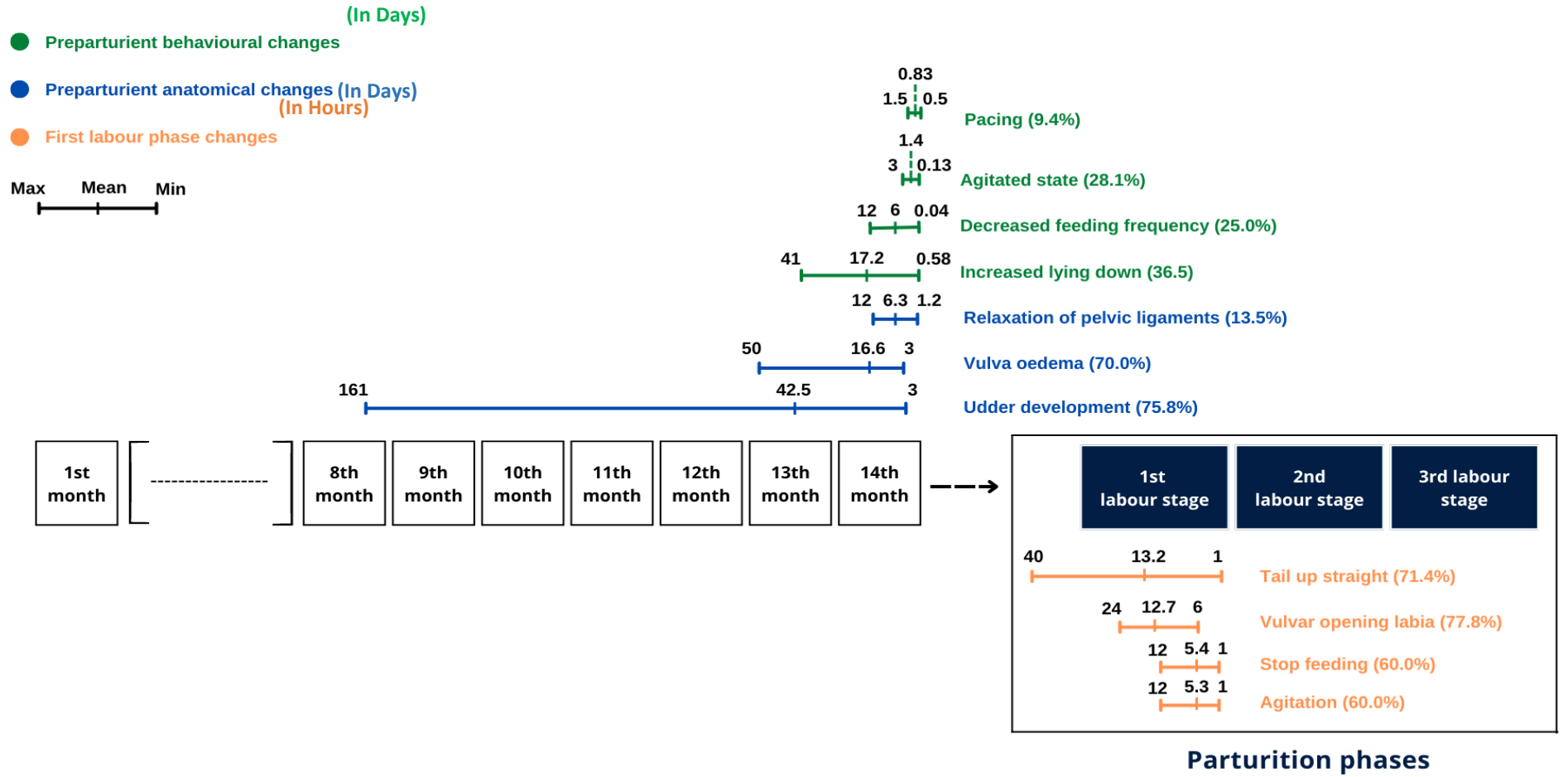
Appendix F – Okapi Faecal Scoring

Adapted from the Bristol Zoological Society Okapi Faecal Scoring and Mulhouse Zoo Faecal scoring. *©Pictures: Bristol Zoological Society. Drawings: ©David Di Paolo-Mulhouse Zoo*

	Type 1	Type 2	Type 3	Type 4	Type 5
	Completely liquid and without a distinct shape	Flat shaped dung	Big ball with a soft texture.	Big ball with texture and the formation of some pellets	Big ball with big pellets
					
Notes					
	Type 6	**Type 7**	**Type 8**	**Type 9**	**Type 10**
	Pellets aggregated in a ball	Good-sized pellets. Some aggregate others do not.	Pellets separated, sometimes bonded	Variable-sized pellets all separated	Shinning pellets of uniform size
					
Notes					

Appendix G – Practical Timeline of Okapi Gestation and Parturition

From Lobko (2022).



Appendix H – Calf Growth Graph

Body weight of 4 okapi calves from birth to around 2.5 years of age. Data source: ZIMS