EAZA Pygmy Hippopotamus Best Practice Guidelines

Best Practice Guidelines for the Pygmy Hippopotamus (*Choeropsis liberiensis*)

Front cover: copyright Zoo Basel

Tapir and Suiform TAG
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EAZA Best Practice Guidelines disclaimer

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 husbandry of zoo and aquarium animals. For this reason, quite early on, EAZA developed the “Minimum Standards for the Accom- modation 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 countryto 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. Whilstsome 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.

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Contents

Summary

In the first section, the biology and field data of pygmy hippopotamus are presented. Pygmy hippos live in the rainforests of West Africa: Ivory Coast, Liberia, Sierra Leone and Guinea. Pygmy hippos are believed to browse, feeding on leaves, herbs, aquatic plants, fallen fruit, roots, ferns and tubers; the proportion of grass in their diet is very low.
They are mostly solitary and mainly crepuscular and nocturnal, but little is known about their behaviour in the wild because of their cryptic and secretive nature.

The second section deals with the management of pygmy hippos in zoos and how the information gained from the wild can be translated into species-specific husbandry that enables this breeding programme to maintain a healthy and sustainable captive population. It also summarises the experiences made in various zoos over many decades of keeping this species. The chapter includes sections on exhibit design, nutrition and health issues.
Pygmy hippo exhibits should be designed in a way that they resemble the natural habitat of the species and that they meet their species-specific requirements. Since the pygmy hippo spends a considerable amount of time on land, it is essential to provide an outside exhibit with a large and well structured land area that provides a lot of cover and retreat as well as a pool, moist and shady places for resting and a mud wallow. In cold climates, it is important to provide large and heated indoor areas. According to our vision, pygmy hippos should be kept in spacious mixed species exhibits with a large terrestrial area that offers shelter and retreat for all species kept and enables interesting interactions between the species.
The pygmy hippo is herbivorous and a non-ruminant foregut fermentor with low metabolic rates. The free-ranging diet of this species contains ferns, herbs, leaves, and fruit, with grass playing a minor role. Therefore, the pygmy hippo is considered to be more of an intermediate forager and browser. Anatomy and physiology require a fiber-rich diet.
A classic diet is composed of good quality grass hay ad libitum and ideally, a high fiber pellet containing minerals and vitamins (to compensate variable contents in hay). Pellets should be fed at reasonable amounts (maximal 1-2% of body weight) because obesity is frequently observed in adult and geriatric individuals.

Captive pygmy hippos are generally robust and require little veterinary attention if husbandry, enrichment and feeding practices are adequate.
Polycystic kidney disease is widespread in the captive population and further research into this problem is recommended even if it is often and incidental finding and does not seem to jeopardise the fertility of the population.
Neonatal mortality is high in this species and requires proactive veterinary care and investigative pathologic examination. Obesity is another widespread problem and may have negative effects on calf survival rates.

With the information provided in the first two sections, the holders will be able to design exhibits, structure them and manage the species according to its species-specific needs.

Finally, in section 3, a reference list can be found.

Section 1: Biology and field data

Biology

1.1 Taxonomy

For some time, the pygmy hippo was included in the genus *Hexaprotodon*, but a recent review of the taxonomy and phylogeny of *Hippopotamidae* (Boisserie, 2005)) restricted the definition of *Hexaprotodon* to extinct Asian hippos and revalidated *Choeropsis* for the extant pygmy hippo. An endemic subspecies, the Niger Delta or Heslop's pygmy hippo, was reported based on osteologic specimens obtained by Heslop in 1945 due to variations in cranial anatomy. As no complete specimen was ever brought into captivity, and the description of this subspecies is based on only one skull, mandible, and skin, the veracity of this subspecies is difficult to confirm. Despite this scarcity of literature, there is general agreement that if this subspecies existed, it is possibly extinct in Nigeria, as the last wild animal in that region was seen in 1943. Two subspecies recognised (Lewison, 2011).

Order: *Artiodactyla*
Family: *Hippopotamidae*
Genus: *Choeropsis*
Species: *Choeropsis liberiensis*
Subspecies
C. l. liberiensis, Morton, 1844
C. l. heslopi, Corbet, 1969 (possibly extinct).

1.2 Morphology

Length from head to body: Pygmy hippos measure about 150-175 cm, and the tail 20 cm.
Their shoulder height is 75 – 100 cm;
Weight of adults in captivity is 160 – 270 kg (weight of wild individuals is not known).

Pygmy hippos are more adapted to terrestrial living than common hippos. They have a barrel-shaped body with somewhat longer limbs and a more torpedo-shaped head than the common hippo. Their body is hairless except on snout and tail and the skin is grey and appears greasy. The feet have four toes; these are more moderately webbed in the pygmy than in the common hippo as an adaptation to walking on terrestrial substrate. The front incisor teeth grow continuously and the canine teeth elongate into tusks, and are used for defence rather than for feeding. The stomach has four chambers. The first three are covered with keratinised epithelium lined with finger–like papillae where microbial fermentation supports digestion through the production of volatile fatty acids. The last chamber contains glandular epithelial tissue. There is an elongated, triangular gallbladder, but no caecum. Pygmy hippos have strong muscular valves in the ears and nostrils that close for submersion (Lewison, 2011).

Nothing is known about pygmy hippo vocalisations in the wild. Bülow noted a roaring-snorting reaction of the female to the adjacent male, both captured for fitting with radio collars (Bülow, 1987).
A female in oestrus can utter "muffled cries", breathing loudly and grunting (S. Thompson, S. Ryan, unpublished US husbandry manual).

1.3 Physiology

According to Flacke, 2019,
The body temperature of an anesthetised female was 35.8 – 38.9°C and for an anesthetised male: 33.6 – 35.3°C.
At Basel zoo, the currently held female Ashaki was trained for taking body temperature (without anesthesia) and on three different days, her body temperature was 34.6°, 34.6°, and 34.0° Celsius while that of the currently held male was measured once and was 34.8°C.

Heart rates from immobilised animals: 96 – 106 beats/min (female), average 60 for a male and for immobilised adults: 34 +/-7 (Flacke, 2019).
The heart rate of the non-immobilised female at Basel was once measured and was 76/minute.
Flach et al., 1998, report a heart rate of 42 – 100/minute in a female immobilised with etorphine and xylazine.

Respiratory rate (breaths/min): 0 – 10 for an anesthetised female, 4 for an anesthetised male and an average of 14 +/-6 for immobilised adults.
Allometric scaling was used to estimate the heart rate (beats/min) of conscious animals at 60 – 65, heart rate data for conscious individuals has not been reported. Respiratory rate (breaths/min) for conscious pygmy hippos is reported at 10-16 (Flacke, 2019).

With regard to all these values and information, it has to be kept in mind that they are from a limited number of animals and are influenced by anesthesia protocol.

1.4 Longevity

According to the SPARKS software, the oldest individual in captivity was male "Hannibal" at Stuttgart (studbook number 241). He reached an age of 50 years, 1 month and 12 days.
The oldest wild born male died at Zurich at an approximate age of over 42 years.
The oldest females in captivity were all wild born with the oldest dying at Rum Creek at an estimated age of over 48 years (studbook number 253). The oldest captive born female was studbook number 96, she died at NZP Washington at the age of 41 years, 8 months and 13 days.

<u>Field data</u>

1.5 Conservation status/Zoogeography/Ecology

The nominate subspecies is endemic to the Upper Guinea Forest of West Africa, occurring in four countries, Côte d'Ivoire, Guinea, Liberia and Sierra Leone. The second subspecies, *C. l. heslopi*, formerly occurred in Nigeria from the Niger Delta east to the Cross River in Nigeria. There have been no reliable reports of this subspecies since 1943, and its continued presence seems unlikely.

The historic distribution of the pygmy hippo was far more extensive than the distribution today. Populations have disappeared from many sites and become fragmented across the landscape. There are confirmed recent records from localities in each of the four range countries and additional sites that have not been surveyed in recent years may still harbour pygmy hippo populations. Full details of the current distribution are therefore unknown but a best assessment based on the most recent data is provided by Mallon *et al*. (2011) (Lewison, 2011).

Pygmy hippos are associated with heavily forested lowland areas of West Africa that are remnants of country-wide forest complexes (Lewison, 2011). They live in lowland primary and secondary evergreen forests (Robinson, 2013), and also inhabit gallery forests that extend into the savanna regions of West Africa (Robinson et al., 2017).
Temperatures are on average between 25°C and 27°C all year round and air humidity is constantly very high. The habitat is characterised by a huge amount of rainfall and there is no dry season (Henschel, 1990).
The general behaviour of the pygmy hippo suggests that it avoids encounters with the larger rainforest mammals and that there are hardly ever interspecific conflicts (Roth et al., 2004).
Predators are leopards, Nile crocodiles and African rock pythons (Robinson, 2013), golden cats and civets (Robinson et al., 2017).

In the IUCN Red List, the pygmy hippo is classified as Endangered, and it is listed under Appendix II of CITES. Pygmy hippos survive in a number of fragmented populations in Sierra Leone, Liberia, Guinea and the Ivory Coast. The primary threats are widespread habitat loss to logging, settlements and clearing for agriculture. Opportunistic bush meat hunting has been reported in more fragmented areas and probably poses an additional threat to the species' viability. The range of this species has changed drastically in the past 100 years, but most acutely in the last 30 years. In addition, there have been negative effects from national and international conflicts in the countries where remnant populations are found (Lewison, 2011).

A population estimate in the early 1990s stated that there were less than 3000 individuals remaining. Although the true population size is unknown, even that estimate may be high and populations most likely are continuing to decline (Lewison, 2011).

1.6 Diet and feeding behaviour

Pygmy hippos are believed to browse, feeding on leaves, herbs, aquatic plants, fallen fruit, roots, ferns and tubers (Lewison, 2011), especially those species rich in sodium and protein. Their thick lips are used to tear and remove forage.

Pygmy hippos do not actively select their food. The respective availability of each plant species seems to determine what proportion of their diet is composed of each of the types of plants within their dietary repertoire. They consume a variety of food crops that are high in energy, namely protein and fat. Food plants. Zingiberaceae (Afromomum sp.), Marantaceae (Marantachloa congensis) and Cyperaceae (Hydrolytum sp).
Fruits and seeds are of particular importance in the pygmy hippo's diet, for example Anthonotha fragrans. Preferred ferns and herbs had a high protein and sodium content. Lasimorpha senegalensis, having a very high sodium content, accounted for a main part of the diet.
The proportion of grass in the food spectrum is very low.
Active digging or rooting for food was never observed. 17 ferns, 26 dicotyledonous plants, 16 monocotyledonous plants and the fruits of 24 trees served as fodder (Robinson et al, 2017)

1.7 Reproduction

Information comes solely from captive animals as nothing is known about reproduction in the wild. Please see chapter 2.4 for more information on reproduction in captivity (p. 46 ff).

1.8 Behaviour

Pygmy hippos are more solitary than common hippos, occurring alone or in pairs in forested regions. Far less information exists on this species because of its cryptic and secretive nature. They are believed to occur near water sources, e.g. rivers, but spend more time on land than common hippos. They are more active at night, but activity is not limited to night-time hours. They follow game trails or tunnel-like paths through dense forest vegetation and mark travelled areas spreading dung by rapidly wagging their tail. Their home range, based on a small number of individuals, is estimated 2 km^2 for males and 0.5 km^2 for females (Lewison, 2011).

Locomotion
Considerable time is spent travelling/foraging along meandering tunnel-like paths that they create in streamside vegetation and through forests and swamps (Robinson, 2013). The movements vary with the season, and in particular when low-lying forests are inundated during the rains, they occupy larger areas (Robinson et al., 2017).

Activity
Pygmy hippos are primarily, albeit not exclusively, nocturnal and crepuscular, spending the daylight hours resting; evidence from camera traps shows that they may be active throughout the night and also during the day (Robinson, 2013). Activity budgets seem to vary between individuals and can be adapted according to needs (Hentschel, 1990).

Predation
In various zoos, it was observed, that pygmy hippos feed on pigeons or ducks.

Golden cat, civet, African rock python, Nile crocodile and leopard are listed as predators (Robinson, 2013, Flacke, 2017).

Social Behaviour

The lesser species is essentially non-gregarious. The pygmy species occurs in numbers ranging from 1-3 animals. When found singly, it was reported, the animal may be an adult of
either sex. A group of two animals invariably consists of an adult pair or an adult female with a juvenile. Groups of three are reported to be normally composed of an adult pair and a subadult (Robinson, 1970). During her PhD, April Conway never observed a male and a female together at one time. Pygmy hippo calf and mother pairs were observed at all seasons (April Conway, PhD).

The general behaviour of the pygmy hippo suggests that it avoids encounters with the larger rainforest mammals and that there are hardly ever interspecific conflicts (Roth et al., 2004).

Home-ranges (pygmy hippos are residential) seem to depend the presence of small streams with submerged trees, root hollows, swampy depressions, and size and density of ground vegetation, rather than nutritional factors or proximity of rivers (Robinson, 2013).

Nothing is known about the dispersal of young in the wild or about intraspecific communication in wild individuals.

Weaning occurs at about three months of age (Stroman et al) and pygmy hippo youngsters stay with their mothers at least until the age of six months (Partridge, 1983) or more commonly, until they are approximately one year old.

Sexual behaviour

Courtship and mating have never been observed in the wild.

In zoos, it was observed that a female in oestrus often breathes loudly and the male becomes excited.

When a female comes "on heat" she will become very restless and relentlessly pace around her stall. When put outside in adjacent paddocks both the male and the female will blow loudly through their nostrils and crouch down low so that their bellies touch the ground. They will stay close to the gate that divides them. These are sure signs that a female is on heat and the pair can be safely put together (Partridge, 1983).

Signs of compatibility are deep and audible breathing of the female, rubbing noses and standing quietly. When both the animals seem receptive, the male, after some playful actions, mounts the female, usually at an angle. The female tries to assist by changing her position. When mating does begin, there is very little movement, but the deep breathing of the female is noticeable. Copulation usually lasts five or six minutes (2 -20), after which the male dismounts and tests the female by rubbing noses. Both animals then sleep for an hour or so before mating again. Some pairs mate five or six times in one day, others only once (Stroman et al.).

Section 2: Management in Zoos and Aquariums

2.1 Enclosure

Pygmy hippos live in the rain forests of West Africa. Zoo exhibits should be designed in a way that they resemble as closely as possible the natural habitat of the species and that they meet their species-specific requirements. Since the pygmy hippo spends a considerable amount of time on land, it is essential to provide an exhibit with a large land area as well as a pool, moist and shady places for resting, a mud wallow and a warm and spacious indoor facility, especially in those climatic zones where access to outdoor areas is limited due to weather conditions in the winter.

In current outdoor exhibits, pygmy hippos have been kept on grassy areas, forests composed of indigenous tree species, bamboo forest and marshy terrain. In any case, the land area should ideally be planted in a way to evoke the impression of a (tropical) rain forest and it should provide cover and enable the animals to retreat as illustrated by the following pictures.

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Bioparc de Doué la Fontaine, copyright Fabian Schmidt

Zoo Duisburg, copyright Fabian Schmidt

Dierenpark Wissel Epe, copyright Fabian Schmidt

Miami Metrozoo, copyright Fabian Schmidt (only non-toxic fern species must be used)

In addition, since aggressive behaviour can occur in this species, exhibits need to be designed so that introductions can be facilitated and that the individuals can be kept separate if and when required (also for longer periods).

In cold climates, it is important to provide large and heated indoor areas. Ideally, pygmy hippos should be kept in spacious mixed species exhibits with a large terrestrial area that offers shelter and retreat for all species/individuals kept and also enables interactions between the species and individuals.

2.1.1 Boundary

Pygmy hippos can climb but find it difficult to jump high, thus comparatively low barriers of approximately 1.2 m can be used to retain an animal within its exhibit. Such perimeter barriers can be made of any sturdy material, such as chain link, wire mesh fence, concrete, bricks, wooden barriers (preferably with vertical structures, as horizontal ones could provide steps for climbing. Consider this also when making wooden barriers out of roots), plastic palisades or artificial rock walls.

Bioparc de Doué la Fontaine, copyright Fabian Schmidt

Cerza Zoo Lisieux, copyright Fabian Schmidt

Nairobi Safari Walk, copyright Fabian Schmidt

No objects should be positioned in front of the barrier that would enable the pygmy hippos to step on. In addition, lush attractive vegetation ought not to be planted near the barrier as it would lure the individuals towards it. Rough substrate such as rock can be used to prevent the animals from moving closer to the barrier.
The material used for the barrier has to be such that the pygmy hippos do not hurt themselves when accidentally touching it. Any obstacles used as boundaries should be easy to see and not involve a risk for accidents.

Should the animals be prevented from approaching the main barrier, a second barrier can be put in front of the main barrier to prevent the animals to come close to the main one. Electric fences with wattage of 5 – 9 kV are used. Electric fencing should, however, not be used as the primary barrier.

Zoo Dvur Kralove, copyright Fabian Schmidt

Inside, glass and wooden barriers have been used to serve as a barrier towards visitors. A new animal may first have to get used to glass as a barrier and putting stickers or tape on the glass initially helps them to realise the glass is there.

Singapore Zoo, copyright Fabian Schmidt

2.1.2 Substrate

Pygmy hippos spend a considerable amount of their time on land, depending on the season. The substrate type chosen should thus provide the best comfort to the animal. In general, the animal ought to have the opportunity to choose between different substrate types.

Outside, soft, non-abrasive substrates are suitable, such as earth, grass, peat, bark or sand. Sand should only be used in areas where no food is offered, to avoid the risk of sand impaction.

Parc Animalier Branféré, Le Guerno, copyright Fabian Schmidt

Edinburgh Zoo, copyright Fabian Schmidt

Inside: In colder climates where the animals have to spend a lot of time inside, the substrate should be soft, so that their feet remain in good health. Good experience has been had with bark chips, wood chips (see photo below), coir or peat. These substrates can be added on top of a concrete floor (layer of about 10 cm). Peat is easy to clean and hosing keeps it moist. It is a suitable substrate, but not really recommended for reasons of sustainability.

Bioparc Valencia, copyright Fabian Schmidt

The quality of bark can vary and should be checked to avoid to harm to their feet due to splinters.
that the animals harm their feet due to splinters.
Concrete should only be used in areas where pygmy hippos do not spend much time.
Rubber has been used inside by several zoos. Relatex (www.relatex.de, Kantstraße 24, D - 49593 Bersenbrück, Germany, Tel. +49 5439 80 99 99 8 * Fax +49 5439 60 94 694) floor works better than loose rubber mats because the hippos may chew them or toss them around.
Depending on the amount of time the animals spend on rubber floor, foot problems such as cracks can develop as well.
When choosing the appropriate substrate inside, cleaning aspects need to be kept in mind.
Good experiences has been made at Zoo Basel with providing bark on top of concrete and to regularly change the substrate.

As pygmy hippos do not seem to be very susceptible to endo-parasites and have few health problems, hygiene needs not be of high priority but should not be neglected either. Dung spreading is an important marking behaviour in this species and should not be completely prevented. When cleaning, certain areas where the animals regularly defecate should thus remain to a certain degree. In addition, young pygmy hippos eat the dung of their parents to improve their gut flora, thus their access should not be denied.
A trade-off thus has to be found between meeting hygienic and visitors' aesthetic requirements and enabling the animals to perform their natural behaviour.

2.1.3 Furnishings and Maintenance

Both outdoor and indoor exhibits need to be well structured. This is achieved by using natural objects, such as plants, dead wood, roots, bushes, trees or rocks, or artificial materials. These structures, especially dense bushes and trees, convey a forest habitat, provide shelter and hiding places and allow the animals to retreat from each other and from visitors. They should be devised to create activity, encourage movement and other species-specific behaviours, such as lying in the shade, rubbing the skin etc. In addition, an exhibit should offer various comfort zones, so that the animal can choose where it wants to be. Such comfort zones can be grassy areas or areas with ample straw. This will enable the animals to use the outdoor exhibit also during colder seasons. To prevent new plants from being eaten, trampled or excessively defecated, a wooden barrier made out of thorny bushes will keep the animals away from and will allow the bushes to grow to a size that they are no longer of interest to the animals.

Copyright Zoo Basel. Especially young animals will play with bushes and trees

Copyright Zoo Basel, rocks and dead wood will protect plant islands and will allow them to grow

Zoo Rostock, copyright Fabian Schmidt

To prevent new plants from being eaten, trampled or excessively defecated, a wooden barrier made out of thorny bushes will keep the animals away from and will allow the bushes to grow to a size that they are no longer of interest to the animals.

Important structures in the outdoor exhibits

Outdoor pool

Each outdoor exhibit must have a pool or pond, which should be of sufficient size to allow the animals to swim and walk under water (see photos below for various options). If the pool is used by more than one adult animal, it should have at least one entry and one exit. Ramps that slope at approximately 25° are well suited and should not be slippery.

Barcelona zoo, copyright Fabian Schmidt

Parque de la Naturaleza Cabarceno, copyright Fabian Schmidt

Givskud zoo, copyright Fabian Schmidt

Bioparco di Roma, copyright Fabian Schmidt

Opole Zoo, copyright Fabian Schmidt

Plzen Zoo, copyright Fabian Schmidt

Stairs with long steps can also be used and can be covered with rubber.
Flat steps or shallow areas are readily used by the animals (adults and calves) to rest, laying down with the body submerged and the head posed out of the water. Preferred areas for resting in the water are underneath some overhanging vegetation that provides shelter and shade.

Copyright Zoo Basel

The animals enjoy lying on soft, rather shallow and not too deep surfaces.
Filtration systems are not necessary, except for human aesthetic requirements.
Pygmy hippos can live in murky water and it is sufficient if the pool is cleaned when needed throughout the year. A lot of zoos use the water of a river flowing through the zoo. Important considerations when emptying the pool is the size of the outlet and prevention of sticks and other objects going down the drain and obstructing the pipes. The spill over section of the pool needs to be shallow to avoid that a very young hippo can get trapped.

Mud wallow
An outdoor area must have some kind of mud wallow or muddy bank for wallowing, so that the animals can keep cool and for the comfort of their sensitive skin and feet. The wallows should measure at least 2 m x 1 m and be around 40 cm deep. In some exhibits, the pygmy hippos can create their own mud wallows.

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Bioparc de Doué la Fontaine, copyright Fabian Schmidt

Zoo Rostock, copyright Fabian Schmidt

Introduction area

It is recommended to have a safe area where male and female can meet and the male can assess the reproductive status of the female. This can be a physical barrier (fence, gate) composed of metal bars that enables visual, auditory and olfactory contact. The barrier should be operated by the keeper at a remote distance, so that the barrier can be removed when the animals are interested in each other.

Gates

All gates should have an appropriate size, so that animals can be unloaded and bulky furnishings be taken into the exhibits. The doors and gates should be designed in such a way that a keeper can easily operate them from a safe area (i.e. hands-off). Sliding gates are preferred over guillotines as the latter can harm or scare an animal when operated inappropriately.

Plastic strips keep the heat in while at the same time allowing the animals to choose when to go out and when to stay inside. This system is very easy and most animals refrain from chewing the plastic stripes.

Vertical bars are recommended (approximate width of 10 cm) because some individuals have broken their teeth in mesh wire when trying to get access to the exhibit of the other sex. There is also the risk that they get stuck in wire mesh.

Feeding areas

Areas on dry and hard ground or on a hardstand are easy to clean and suitable for feeding, especially for providing hay, while vegetables can also be scattered in the whole exhibit. Feeding sites may become overused with time and need to be maintained.

Important structures in the indoor exhibits

Pygmy hippos live in tropical rainforests and require heated indoor facilities in colder regions.

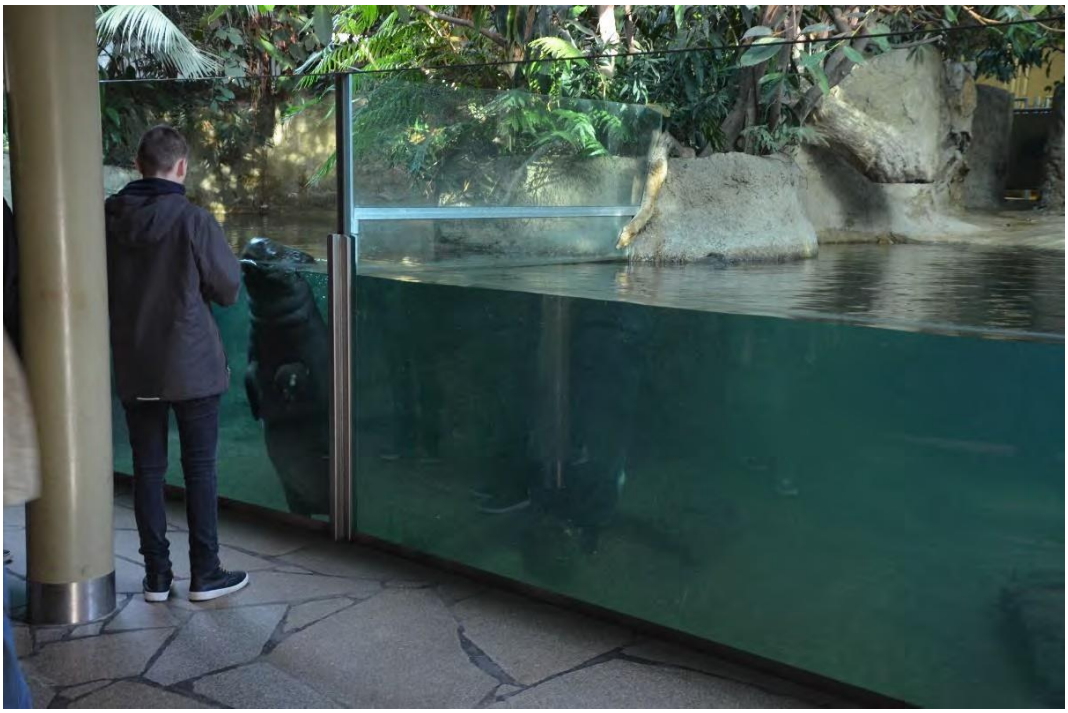
Any indoor areas should be sufficiently large, especially in cold climates where the animals will need to stay indoors for longer periods during winter. Ideally, this space can be used by several species in mixed species exhibits.

Indoor pool

A pool should always be available indoors. The water should be heated to a minimum of approximately 18 - 25°C.

Entrance: ramps are better than stairs and should be flat (maximum gradient 25°) and non-slippery, so that the pygmy hippos can lay there. The depth should be at least 80 cm, allowing the animals to submerge. It is good to have a separate entrance and exit.

Regarding the size, it is important to consider the size of the animal and the fact that they should be able to lay down and move in the water.



Zoo Berlin, copyright Fabian Schmidt

If more than one pool is used, independent management systems are recommended, so that at least one pool can always be used. If outdoor pools cannot be used all year round, the indoor pools should be larger and should be heated (18° - 25°C). Pygmy hippos prefer warm water (25°C) and if the water is cold, they may refuse to use the pool and the skin may crack.
(Although they have been known to swim in icy water briefly, so offer the choice). They also enjoy waterfalls and objects in the water, such as plants, dead wood or rocks.

Zoo Berlin, copyright Fabian Schmidt

When young pygmy hippos use the pool, certain objects where the youngster can get stuck need to be removed.

Filter Systems
Various options are available, such as sand filters (succeed in providing clear water), Ultramembrane filters (do not work well), ozone filters (good water quality), and UV desinfection in combination with other systems and fish pond filters with plastic brushes (not very successful).
Berlin Zoo uses a combination of a siff, sand filters, ozone treatment and carbon to neutralise the ozone. In addition, a reef bed reduces nitrates in the water. Although to our knowledge not yet realized with pygmy hippos but with other species, the addition of small amounts of Ozone (1000 mg/h) would also help increase visibility and does not harm animals or employees, so with such small amounts, carbon or any other deozoniser can be omitted).

Certain zoos keep pygmy hippos with several fish species (*Labeo* spp., West African Cichlids).
The fish feed on the faeces but do not succeed in clearing the water from debris. In addition, they can feed on the skin and wounds of the pygmy hippos. The downside of this is that the fish will keep wounds open for longer so careful monitoring is needed.

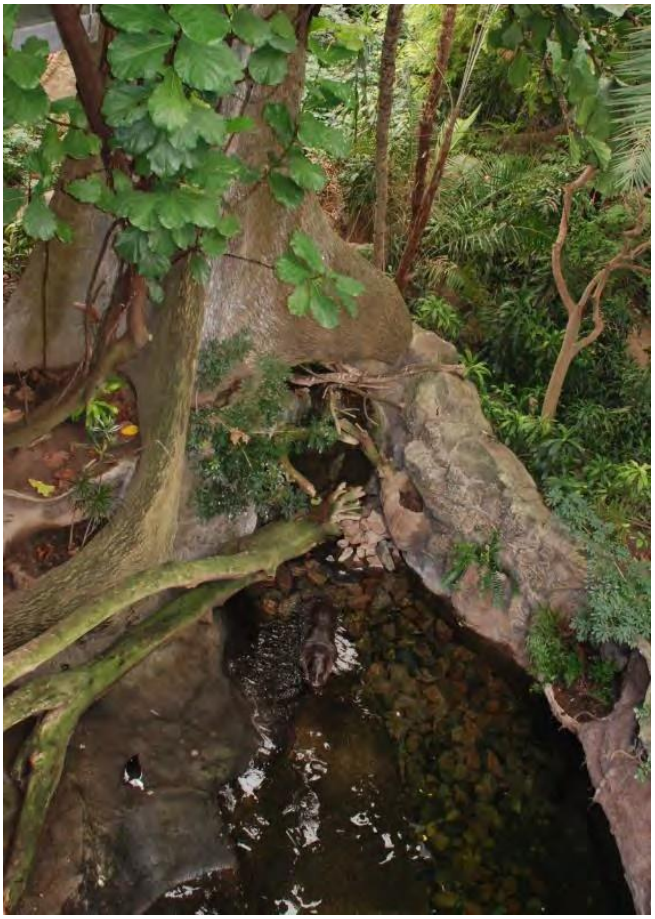
Singapore zoo, copyright Fabian Schmidt

Plants and other furnishings

As for the outside, the inside exhibit should also allow for ample space and be structured with plants, natural objects (wood, logs) and other items that provide shelter, encourage the animals to move and make the exhibit resemble a rain forest. This includes hiding places, comfort zones (beds with a big layer of straw), sprinklers or middens.

Zoo Leipzig, copyright Fabian Schmidt

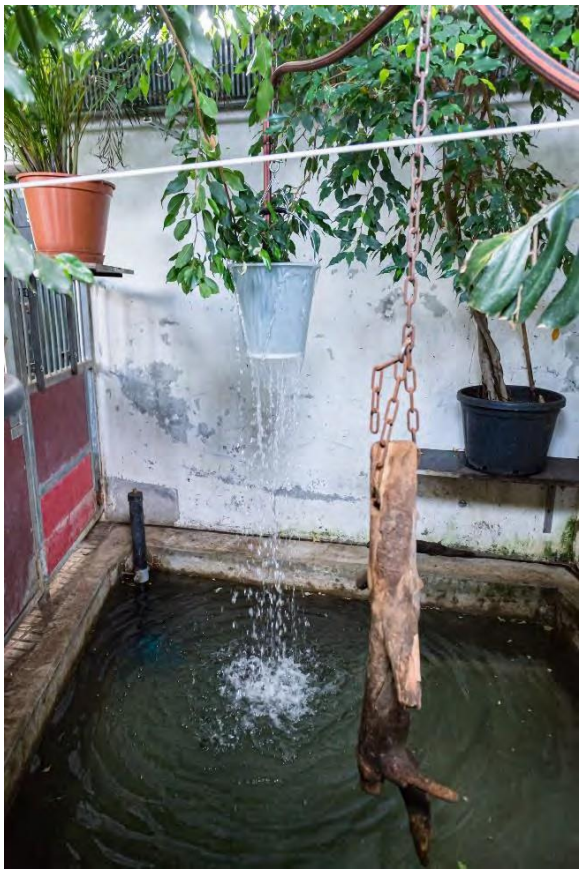
Omaha's Henry Doorly Zoo, copyright Fabian Schmidt



Omaha' Henry Doorly Zoo, copyright Fabian Schmidt

Basel zoo has had excellent experiences with innovative and (cheap!) ideas that encourage the animals to move in spacious circuits, move through structures made of living or dead plant material and make for uneven ground (obstacles). There is also a sprinkler offered for skin care. The following pictures illustrate some of these ideas.

Copyright Zoo Basel. A soft floor (bark) and structures to move between and hide behind are offered inside. A hinge allows the keeper to move them out of the way when cleaning. This section is not accessible to visitors.



Copyright Zoo Basel. A cheap and easy sprinkler system and enrichment in the pool.

A sprinkler system can be an additional way to keep the animal's skin moist. This very easy system is adored by the animals, indicating that a waterfall is not only nice to have for visitors, but will be used by pygmy hippos in an exhibit.

Training facility
Target training is suitable to teach the animals to show their feet and teeth.

A training chute is recommended, so that veterinarians can perform blood draws from legs or ultrasound for pregnancy testing. This can be a walk-through area or a gangway between the inside and outside exhibit. It can also be used for box training.
The chute should have a roof and a height of 1 m, a length of 2 m and the width should be 80 cm. The vertical bars should be 20 cm apart. One side should be movable, so that larger and smaller animals can walk through, but must not be able to turn around. It should be possible to stop the animals at the front and at the back.

Copyright Zoo Basel. This training 'chute' is very easy to build and highly efficient. The female is fed in front and from the side, the gap between the bars is large enough (10cm) for a hand to pass through and to touch the animal safely. Most pygmy hippos very much enjoy to be touched when done gently.
It is also advised to have a scale (with access from two sides).

2.1.4 Environment

Indoor housing

Room temperature
Should be kept at 15°- 22°C. Areas warmer than 22°C will provide comfort zones. When the house is kept at a lower temperature, it is important to provide additional heating devices for comfort zones. Heat bulbs should not be used as they may break and cause fire.
The houses should have natural light.

Water temperature
Outside
At Givskud, the pygmy hippos go into very cold water and will even enter pools that are covered with ice. It seems that they can cope well with it and use it only for a short while but it is important to make sure that the ice is easy to break when the animals swim underneath.

Inside
As most pygmy hippos prefer warm water, the indoor pool should be heated to around 20 - 25°C.

Lighting
Inside
Natural light should be provided.
Since pygmy hippos live in dense forests, artificial light sources should be placed with care. The animals should have the option to choose between lighter and darker areas.

Ventilation
Air circulation is required.

Humidity
It is advisable to have a humidity of around 85 – 90% because pygmy hippos' skin will crack when the air is dry.

2.1.5 Dimensions

Given that suggested dimensions and sizes for outdoor and indoor exhibits change over time and also vary in different countries (for example as far as minimum exhibit sizes are concerned) we prefer not to recommend certain sizes but refer holders to their respective national legal requirements, which need to be met.

Outdoor exhibit
Outdoor enclosures of EEP members range from 50 m2 to 2400 m2, but exhibits with a size of the lower end of this range are no longer recommended and should not be taken as a model for future enclosures. The suitable size also depends on the climate and how much time the animals spend inside and outside.

Indoor exhibit
Zoos in colder climates should provide large inside exhibits that can be used by various species. Ample space inside enables more flexibility in the management, will encourage activity in the animals and improve their welfare.
Pygmy hippos can be kept with various other animal species and large mixed species exhibits will prove highly attractive for visitors.

Individual boxes range between 2 m2 and 40 m2 in EEP members and the largest land area inside was 131 m2.

2.2 Feeding

2.2.1 Basic Diet (provided by Dr. Marcus Clauss, Zurich University)

The pygmy hippo is herbivorous and a non-ruminant foregut fermenter with low metabolic rates. The few studies suggest that the free-ranging diet of this species contains ferns, herbs, leaves, and wild fruit (that generally do not resemble commercial fruit, but green leafy vegetables in their nutrient composition), with grass playing a minor role. Therefore, the pygmy hippo is considered to be more of an intermediate forager and browser. Anatomy and physiology require a fiber-rich diet. Diet adaptations (e.g. from hay to fresh grass) and introduction of new food items have to be performed slowly, over several weeks.

An appropriate diet is composed of good quality grass hay or lucerne hay or a mixture of both, fed for *ad libitum* consumption, supplemented with a high fiber complete feed pellet containing minerals and vitamins (to compensate for variable contents in hay). The total amount of hay and pellets should be about 1.5-2% of body weight. Commercial fruits and colored vegetables should not be fed, as this species is especially prone to obesity in captivity due to a naturally low metabolic rate. Green leafy vegetables and salad can be added to the diet in reasonable quantities, as long as they do not reduce pellet intake, and can also be used for training purposes. Fresh grass, browse or branches can be offered for enrichment (be cautious to avoid toxic plants!). Mineral blocks should be offered to provide salt and trace minerals.

2.2.2 Special Dietary Requirements

Pregnant and lactating females do not usually receive a special diet.
Juveniles start to nibble on solid food quite early in life at the age of 3 to 4 months. Care should be taken that the food is in reach (very low trough or on the floor) and that the food is small enough, e.g. small cut/chopped pieces. Mineral blocks should be offered for salt and mineral supplementation.

2.2.3 Method of Feeding

In most zoos, food is offered in the inside and outside enclosure. The majority of zoos offers the food on the floor, with some using any kind of feeding trough.
Most zoos feed their pygmy hippos twice a day, some zoos only once and others three times or more.
Food is presented clumped or scattered. Most food is offered chopped, but some zoos present it whole.

2.2.4 Water

Inside, few zoos offer water in buckets or plastic containers; but in most zoos, pygmy hippos have access to water from a pool. In the outside enclosure, most pygmy hippos have access to water from a pool or creek.

2.3 Social structure

Little is known about the social structure of the pygmy hippo in the wild but it is assumed that the pygmy hippo is mostly a solitary species. Males and females will cross, meet and separate again in overlapping territories.

The female will tolerate her offspring at least until they reach sexual maturity, some even longer. A few zoos have held mother and daughter together over many years, especially when no male is kept.

In very large exhibits, such as at Rum Creek (USA), several females can be kept together but they also set up their territories and do not always lie next to each other.

Conservation Center for Tropical Ungulates, Rum Creek, Copyright Fabian Schmidt

Conservation Center for Tropical Ungulates, Rum Creek, copyright Fabian Schmidt

Many zoos keep male and female in separate exhibits except for breeding. If the exhibits are well structured, have no dead ends and offer various possibilities to retreat, male and female can also be kept together when the female is not in heat.

Zoo Leipzig, copyright Fabian Schmidt

Prior to parturition, a female will not tolerate a male and chase him away.

Separate exhibits for male and female should be available to separate the sexes when pairs have no breeding recommendation.

Basic Social Structure

Zoos usually keep one male and one female and the offspring.

Due to the lack of males in the population, no experiences exist with male groups.

2.3.1 Changing Group Structure

New individuals are introduced to each other only when the female is in oestrus.

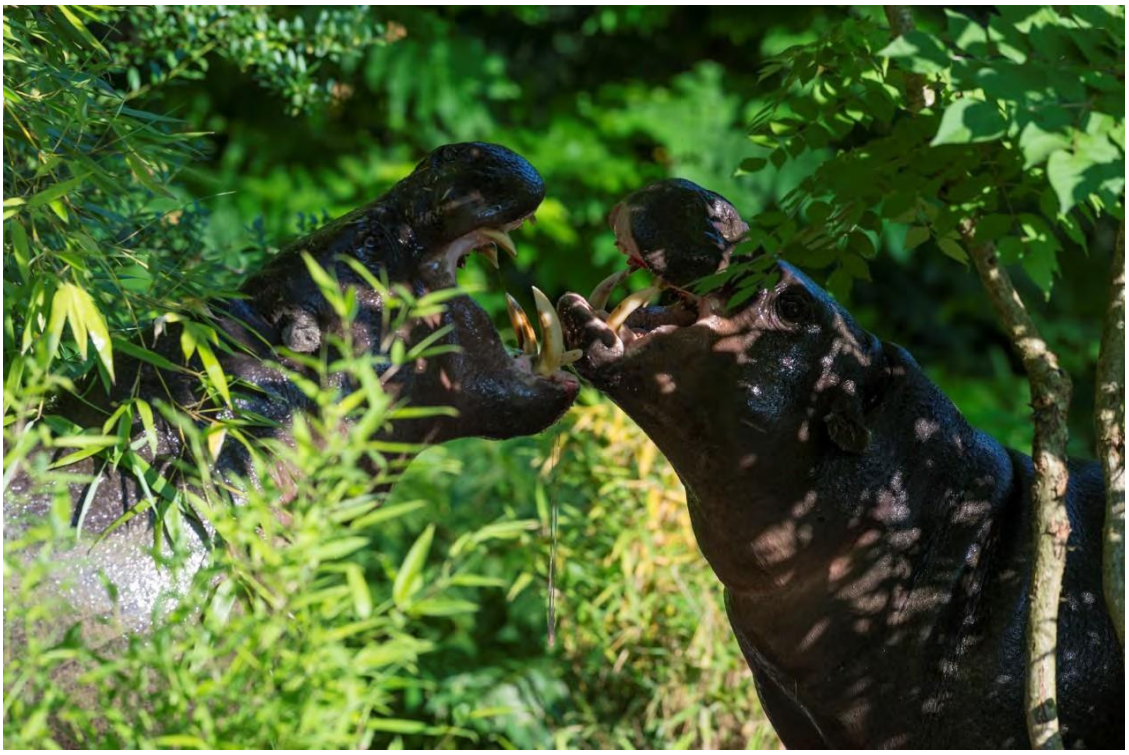
As male and female are usually kept solitary, no experiences have been had with introducing adult females to each other. However, if several females are kept in adjacent exhibits, aggression between them can occur at the boundaries.

Introducing a male to a female in oestrus
Oestrus is not always easy to detect in this species, but when sensing a female in heat, some males will grunt and honk and the female may respond. In other pairs, the female starts vocalising and the male reacts.
The two sexes will spend a considerable amount of time near each other, for example lying next to each other at gates or trying to reach each other.
Some individuals were observed going down on their front feet, puffing, huffing and swaying their heads.
In addition, the male will perform increased territorial marking behaviour with his faeces.
When such signs of oestrus are apparent, the two sexes are allowed to join each other.
This may happen inside as well as outside. It is important that the exhibit has no dead ends and provides circuits and possibilities to separate the animals when needed.
The encounter may become aggressive, so the keepers have to know which gate to operate and when.
When one sex is heavily chased by the other, keepers can also use fog horns or water hoses to separate them.

Copyright Zoo Basel. When meeting each other on the exhibit, they start by facing each other.

Copyright Zoo Basel. A female in oestrus followed by a male

Copyright Zoo Basel. Signs of heavy aggression, the whole expression of the animals changes, the head is held very high, the mouth showing the teeth. In this case, the female will run and should be given the option to retreat from the male.

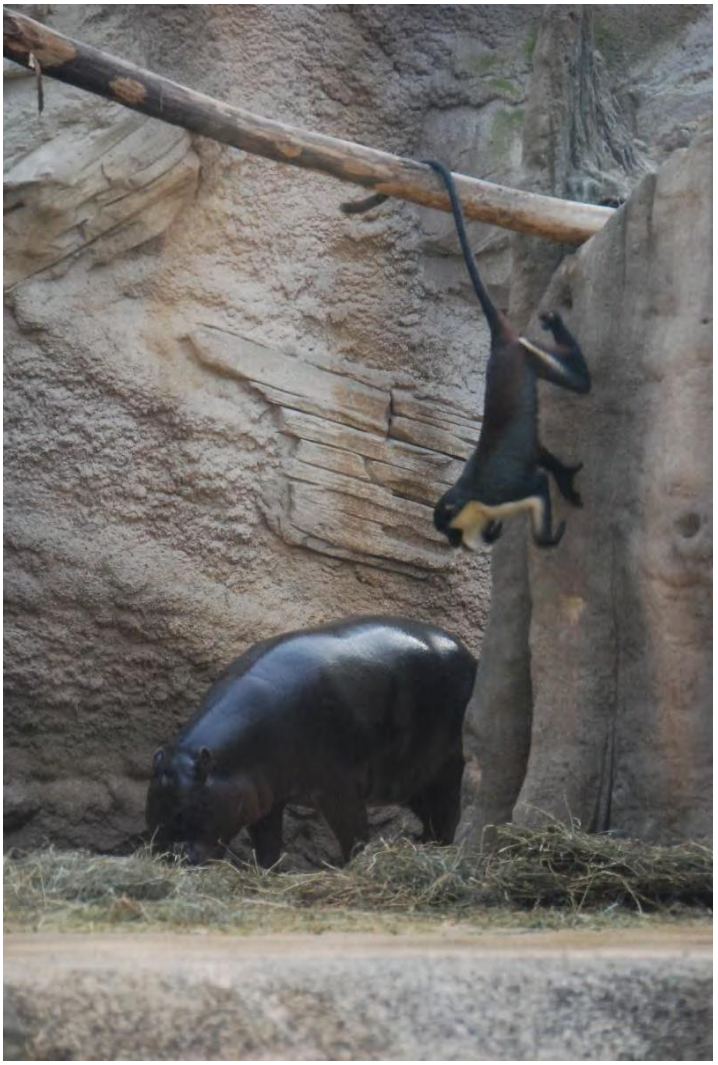


Copyright Zoo Basel. If the animals cannot be separated, they can inflict deep wounds. Usually this looks worse than it is and it may on certain occasions be important to allow the animals to settle their dispute and not to interfere. But this needs good observation and an exhibit that offers enough options to retreat when wanted.

2.3.2 Sharing Enclosure with Other Species

In this EEP, various mixed species exhibits exist with pygmy hippos and different bird species (marabous, duck, geese, egrets, ostriches, cranes, pelicans and others), monkeys (mandrills, Barbary macaques and others) and different antelope species.
Most holders report no problems, but the mandrills can be aggressive towards the pygmy hippos (especially the mandrill males).
Aggression also occurred between Stanley cranes and pygmy hippos and between a castrated male sitatunga and the pygmy hippos. In both cases, the other species were the aggressors.

When pygmy hippos are housed with bird species, the holders have to be aware of the fact that pygmy hippos killed and fed on several bird species, such as ducks, geese or egrets. As birds are often pinioned, this needs to be taken into consideration.



Zoo Leipzig, copyright Fabian Schmidt

Givskud Zoo, copyright Fabian Schmidt

Zoo de La Flèche, copyright Fabian Schmidt

Plzen Zoo, copyright Fabian Schmidt

Bioparc Valencia, copyright Fabian Schmidt

Mixed species exhibits seem to be popular in the US and several successful examples including pygmy hippos, various monkey species, zebras, duikers and other antelopes are described in the **OLD WORLD MONKEY TAG MIXED SPECIES MANUAL 2013** (Strange Honeycut, 2013).

Omaha's Henry Doorly Zoo, copyright Fabian Schmidt

Additional information on mixed species exhibits (for example with zebras and softshell turtles) can be found in the US mixed species institution document (anonymous, 2015, unpublished document), available from beatrice.steck@zoobasel.ch

Finally, various zoos keep fish species (*Labeo* spec., various cichlid species) in the pools used by pygmy hippos as the fish help to improve the water quality and to treat the skin of pygmy hippos.

Zoo Leipzig, copyright Fabian Schmidt

It is to be hoped that such mixed species exhibits will become more popular also for inside enclosures, so that all species involved can benefit from the ample space provided and interspecific interactions.

It is advised not to keep pinioned birds with pygmy hippos.

2.4 Breeding

The pygmy hippo breeds well in captivity and thus, natural breeding is encouraged. Artificial insemination has not been attempted in this EEP.

In captivity, pygmy hippos breed throughout the year and the estrous cycle averages 35,5 days with estrus itself lasting 24 – 48 hours. Mating occurs on land and in water. They gestate for approximately 6 – 7,5 months, after which time a single young (rarely twins) is born on land. Calves weigh approximately 5 kg at birth. Calves may be cached or hidden when first born but can readily swim shortly afterwards. Sexually maturity occurs between **2.5** to 3 years of age (Lewison, 2011).

Age at first reproduction according to SPARKS:
F: 2 years, 2 months, 28 days.
M: 2 years, 7 months, 2 days

Oldest males and females to have reproduced:
F: 35 years, 3 months, 26 days

M: 41 years, 8 months, 13 days.

2.4.1 Mating

Mating can take place either on land or in the water and is prolonged and noisy. It has been observed in some males that the male accesses the female from all sides. This may convey the impression that the animals do not know how to mate, so a certain amount of patience may be needed.
The mating itself is never violent and no serious aggression should occur.
It is suggested to leave the pair together for as long as they seem keen on each other. Once the female turns towards the male and shows aggression, the animals should be separated. If the female shows interest in the male again later, the pair can mixed again.
The female comes in heat every 25 to 39 days.

2.4.2 Pregnancy

The gestation length varies from 187 to 214 days.
Several methods and tools exist to detect pregnancy in a female:

- No more cycling. This is a useful indication in females that cycle regularly.
- Lack of interest in the female by the male. The male may still call her, but he is far less interested in her than when she is in heat
- Ultrasound can detect pregnancy at around 86 days
- A Doppler device can be used to detect the heart beat of the offspring (when 4 – 5 months pregnant)
- Certain females will seek more attention from the keepers

Approximately 3 to 4 weeks before birth, the vulva will begin to show swelling. In addition, a pear shaped swelling can be found below the vulva between the back legs. The female will start to push her bottom and vulva up against the walls of the exhibit. The udder will be noticeably larger and when touched, will produce a clear pre milk solution. Shortly before birth, the clear fluid will cease and milk will start to come from the udder. This would indicate that the female is about 3 days away from parturition. Before parturition, the female becomes restless and stomps around.

2.4.3 Details on contraception possibilities are highlighted.

The following table was received by Veronica Cowl (EGZAG), Chester Zoo.

EAZA RMG

EAZA Reproductive Management Group

Fact Sheet Compiled by: Veronica Cowl, PhD

Last Updated: January 2020

Fact Sheet Reviewed by: EAZA RMG working group

We would recommend assessing any contraceptive bout with behavioural and hormone monitoring. For more information on this, please contact contraception@chesterzoo.org

Pygmy hippo (*Choeropsis liberiensis*)

Contraceptive methods	GnRH agonist (implant)	GnRH agonist (injection)	GnRH vaccine (injection)	Progestagen (implants)	Progestagen (injection)	Progestagen (oral)	Progestagen (oral)	PZP vaccine	Surgical/Permanent
Contraceptive Product:	Deslorelin acetate	Leuprolide acetate	GnRH protein conjugate	Etonogestrel 68 mg	Medroxyprogesterone acetate	Altrenogest	Chlormadinone	PZP vaccine main components are antigens derived from porcine zona pellucida glycoproteins and an adjuvant to stimulate the immune response (Freund's modified complete adjuvant for primary vaccination and Freund's incomplete adjuvant for boosters).	-
Commercial Names:	Suprelorin ®	Lupron ®	Improvac®	Implanon®, Nexplanon®	Depo-Provera®, Depo-Progevera®	Regu-mate®	Antiestrin®, Belara®, Prostal®, Lutoral®	Porcine Zona Pellucida	Vasectomy
Product Availability:	4.7mg (Suprelorin®) and 9.4mg (Suprelorin 12) widely available through veterinary drug distributors in the EU.	Leuprolide acetate licensed for human use.	Available through veterinary drug distributors.	Manufactured by Bayer Schering Pharma AG. Available through human drug distributors.	Manufactured by Pfizer. Widely available throughout Europe through human drug distributors.	Regu-mate® Equine 2.2mg/ml oral solution and Regu-mate® Porcine 0.4% w/v oral solution widely available through veterinary drug distributors.	Available through veterinary drug distributors.	Not commercially available in Europe. PZP is available to ship to Europe. It is advised that you check with the licensing authority that manages the import of veterinary drugs to obtain a permit to import PZP. Once all necessary authorisations and approvals have been completed, you can order PZP from: Kimberly M. Frank The Science and Conservation Center 2100 S. Shiloh Road Billings, MT 59106 phone 406-652-9718 fax 406-652-9720 e-mail sccpzp@hotmail.com	
Restrictions and/or permit required by Importing Country:	The EAZA RMG recommends: always check with your local licensing authority	Data deficient	Current knowledge: widely available throughout European countries. The EAZA RMG recommends: always check with your local licensing authority	The EAZA RMG recommends: always check with your local licensing authority	The EAZA RMG recommends: always check with your local licensing authority	The EAZA RMG recommends: always checking with your local licensing authority	The EAZA RMG recommends: always checking with your local licensing authority	License required UK and France; all other countries unknown. EGZAC recommends always checking with local licensing authority.	-
Mechanism of action:	GnRH agonist suppress the reproductive endocrine system, preventing production of pituitary and gonadal hormones. As an agonist of the GnRH initially stimulates the reproductive system, which can result in oestrus and ovulation in females or temporary enhancement of testosterone and spermatogenesis in males - therefore additional contraception needed during this time. Please see below and refer to Deslorelin datasheet for detailed information	GnRH agonist suppress the reproductive endocrine system, preventing production of pituitary and gonadal hormones	Production of anti-GnRH antibodies by the immune system, neutralising endogenous GnRH activity. This results in a reduction of FSH and LH production by the anterior pituitary and, ultimately, in a reduction of ovarian follicular development and /or inhibition of testosterone secretion from the testes and spermatogenesis.	Interference with fertilization by thickening cervical mucus, interrupting gamete transport, disruption of implantation, inhibition of LH surge necessary for ovulation.	Anti-estrogenic activity. Interference with fertilization by thickening cervical mucus, interrupting gamete transport, disruption of implantation, inhibition of LH surge necessary for ovulation	Interference with fertilization by thickening cervical mucus, interrupting gamete transport, disruption of implantation, inhibition of LH surge necessary for ovulation	Interference with fertilization by thickening cervical mucus, interrupting gamete transport, disruption of implantation, inhibition of LH surge necessary for ovulation	The PZP antibodies interfere with fertilisation by binding to the ZP glycoprotein receptors that surround the egg of the vaccinated female, blocking the binding and subsequent penetration of sperm.	Surgical procedure in which the ductus deferens are cut, tied, cauterized, or otherwise interrupted
Insertion/Placement:	Subcutaneous, in a place where it can be easily detected or seen for removal at a later date (i.e upper inner arm); refer Suprelorin fact sheet for effective method of implant placement (tunnelisation)	Injectable	Injectable Intramuscular or subcutaneously	Intramuscular or subcutaneous. The EAZA RMG recommends sub-cutaneous, upper inner arm for visibility (and for later removal)	Injectable intramuscular	Administered orally in feed or by syringe. Gloves must be worn when administering Regu-mate® (absorption through the skin can cause disruption to the menstrual cycle and prolongation of pregnancies in humans).	Administered orally	Injectable Intramuscular	Surgical
Females				**Data deficient**	**Data deficient**				
Dose:	2-3 implants are recommended depending on the body weight of the individual. As a guide 1 implant should be used per 100kg BW. 4.7mg is recommended for a minimum duration of 6 months and 9.4mg is recommended for a minimum duration of 12 months. Please contact the EAZA RMG for specific dosage advice.	There are various formulations available lasting from 1-6 months. Dosing information is not available: extrapolation from human literature is likely the best place to start. Please contact the EAZA RMG with specific dosage advice.	Two injections of 400ug are given 35 days apart and boosters are usually administered every 3-6 months, although duration can vary between species.	2-3 implants (0.68g) are recommended for successful contraception in this species. As a guideline 1 implant/100kg.	As a guide 5mg/kg BW every 45-90 days. Please contact The EAZA RMG for specific dosage advice.	Regu-mate® Equine: 0.044mg/kg daily; Regu-mate® Porcine: 5ml daily administered orally through feed or syringe.	½ a tablet should be administered daily (~10-12mg, although this varies depending on the product).	100 µg protein is recommended. The first injection would consist of 0.5mL PZP + 0.5mL adjuvant and the second injection should be given no less than 14 days after this. In species with longer breeding season, if the vaccine is given at a time other than prior to the breeding season the primary vaccination course should be given at day 0, day 21 and day 45; booster should be administered every 7-8 months. If a seasonal breeder with a well defined and short breeding season (2-3 months) then it is 1-2 months before the breeding season.	
Latency to effectiveness:	Deslorelin will have a latency to effect of 3-4 weeks during which a stimulation of the reproductive system will occur. For this reason separation of both sexes is recommended for approximately 3-4 weeks. If you cannot separate the sexes, in order to suppress the initial stimulation phase, the first contraceptive bout must be supplemented with an oral progestagen such as megestrol acetate pills (Ovarid) or altrenogest (Regumate®) daily, 7 days before and 8 days after the implant is inserted.	3 weeks average as GnRH agonists initially stimulate the reproductive system- **please refer to Deslorelin datasheet for detailed information** - separation of the sexes OR supplemental contraception is recommended during this time (see product data sheet. Megestrol acetate pills daily 7 days before and 8 days after implant insertion have been used to suppress stimulation phase. The dose for domestic dogs is 2mg/kg, but must be extrapolated for other taxa).	Latency to effectiveness can be up to 8 weeks so separation of the sexes is recommended if possible.	In general inhibition of ovulation after 1 day when inserted on day 1-5 of cycle or when replacing oral progestagen. As the right stage during oestrus cycle is often unknown, it is advised to use other contraceptive methods for at least 7-14 days after insertion of the implant depending on administration route (IM or SC).	1-2 days post injection. However, if the cycle stage is not known then extra time must be allowed; therefore, separation of the sexes or alternative contraception should be used for at least 1 week. Oral progestagen such as megestrol acetate pills (Ovarid) or altrenogest (Regumate®) can be used for this purpose to supplement the contraceptive bout.	In mares, 95% treated with Regu-mate will be suppressed within 3 days however separation of the sexes should be used for 7-14 days after contraceptive methods, if this not possible then other contraception methods should be used for this time.	Latency to effectiveness should be approximately 3 days; however it is recommended that the sexes are either separated for one week, or alternate contraception is used at this time.	Latency to effectiveness is approximately 2-3 weeks after the final injection in year 1 therefore separation of the sexes from the initial injection until 2 weeks after the final injection is recommended (primary course of vaccination 2 injections 2-4 weeks apart, preferable 3 injections).	-
Oestrous cycles during contraceptive treatment:	Initial oestrus and ovulation (during the 3 weeks of stimulation) then down-regulation. To prevent the stimulation phase, the megestrol acetate protocol described above is recommended.	Initial oestrus and ovulation (during the 3 weeks of stimulation) then down-regulation. To prevent the stimulation phase, the megestrol acetate protocol described above is recommended.	In a group of 57 mares, 50% were anoestrus after the primary vaccination and 100% after the booster vaccination, the interval from treatment to anoestrus was 2-3 weeks.	Oestrus behaviour may be observed. Cycling and even ovulation can occur in adequately contracepted individuals (but is unlikely and the degree of suppression is dose dependent).	Oestrus behaviour may be observed. Cycling and even ovulation can occur in adequately contracepted individuals (but is unlikely and the degree of suppression is dose dependent).	Oestrus is inhibited.	**Data deficient.**	PZP should not suppress oestrous cycles and may extend the breeding season beyond what is considered typical, resulting in additional oestrous cycles.	-
Use during pregnancy:	Not recommended as may cause abortion	Not recommended as may cause abortion	**Unknown**	Progestagens are not recommended in pregnant animals because of the possibility of prolonged gestation leading to dystocia, stillbirth and abortion in some species, although the effect may depend on dose.	Not recommended for use in pregnant animals because of the risk of prolonged gestation, stillbirth or abortion, etc. In some species, although the effect may depend on dose.	Not recommended for use in pregnant animals because of the risk of prolonged gestation, stillbirth or abortion.	Not recommended for use in pregnant animals because of the risk of prolonged gestation, stillbirth or abortion.	Does not interrupt pregnancy or effect foetus.	-
Use during lactation:	No contraindications once lactation established; however treatment during pregnancy may impede proper mammary development.	No contraindications once lactation established; however, treatment during pregnancy may impede proper mammary development.	**Unknown**	Considered safe for nursing. Does not affect lactation, but etonogestrel is excreted in milk.	Considered safe for nursing infant.	**Data deficient.** Considered safe for nursing infant.	**Data deficient.** Considered safe for nursing infant.	No known contraindications.	-
Use in prepubertals or juveniles:	**Data deficient** in this group, see product information sheet. Deslorelin may prevent epiphyseal closure of the long bones, resulting in taller individuals.	Leuprolide may prevent epiphyseal closure of the long bones, resulting in taller individuals.	**Unknown**	The use of synthetic progestagens in pre-pubertals or juveniles has not been fully assessed. Possible long-term effects on fertility are not known.	The use of synthetic progestagens in pre-pubertals or juveniles has not been fully assessed. Possible long-term effects on fertility are not known.	**Data deficient.** The use of synthetic progestagens in pre-pubertals or juveniles has not been fully assessed. Possible long-term effects on fertility are not known.	**Data deficient.** The use of synthetic progestagens in pre-pubertals or juveniles has not been fully assessed. Possible long-term effects on fertility are not known.	PZP-treated prepubertal white-tailed deer and feral horses were fertile as adults. Not associated with side effects in elephants. But there are no data for other species.	-
Use in seasonal breeders:	**Data deficient.** Should start at least 2 months before start of breeding season.	**Data deficient.** Should start at least 2 months before start of breeding season.	Unknown but if used should be done at least 8 weeks prior to the breeding season. Effective in the horse. Use before cycling starts at the onset of the breeding season.		Should be injected at least 1 week before the breeding season starts.	**Data deficient.** Treatment should begin at least one month before the anticipated onset of the breeding season.	**Data deficient.** Treatment should begin at least one month before the anticipated onset of the breeding season.	Can be used in seasonal breeders but initial treatment and annual boosters should be carried out 2 and 1 months before the start of the breeding season respectively.	-
Duration:	Duration of efficacy has not been well established. As a guide: 4.7 mg implants will suppress for a minimum of 6 months; 9.4mg will be effective for a minimum of 12months.	Lupron® is available in various formulations lasting from 1 to 6 months, but because the release of hormone from the depot formulation varies by individual, actual duration of efficacy can vary considerably.	Unknown for most of species. Improvac® induces an immune response that generates short-lived antibodies in the domestic pig (antibody production starts to decline ~7-8 weeks following second injection). Suppresses oestrus for a full season in mares after the first booster.	The duration of this product can last 2.5 to 3 years.	Dose dependent: 45-90 days in general. However, effects could last 1-2 years in some individuals.	No more than one dose each day. Regu-mate® must be given daily to maintain suppression of oestrus.	No more than one dose each day. Chlormadinone must be given daily to maintain suppression of oestrus.	Species -dependent: most species 1 year	Permanent

Reversibility	Deslorelin is designed to be fully reversible however there are no current cases of reversal in this species. Removal of implant may hasten time to reversal.	Lupron® is designed to be fully reversible however there are no current cases of reversal in bobcats.	It must be taken in to consideration that younger individuals will take longer to reverse in comparison to older individuals. Improvac is not designed to be reversible, although reversibility has been demonstrated in some wild animal species. We have one record of reversal in common hippos however, the date of offspring birth was not provided so time to conception could not be calculated.	Improvac is designed to be fully reversible however we do not have any records of reversal in this species.	Designed to be fully reversible but individual variations can occur. We have several records of reversal in common hippos, with time to conception ranging between 1 month and 7 years following the estimated expiry of the product.	It should be reversible after cessation of treatment. Signs of oestrus in equids have been observed 5 days after the end of treatment but will vary depending on the individual. We have one record of reversal in a common hippo, in which the female conceived approximately 3 months following the cessation of treatment.	Chlormadinone should in theory be reversible, however this has not been researched in this species. We have one record of a reversal in a common hippo, in which the female conceived almost immediately following the end of treatment that had lasted 6 months.	Species differences on reversibility. Reversibility differs between species, however the longer PZP is given the longer it takes for a female to become fertile again. Treatment for over 5 years has been associated with ovarian failure in some cases. The possibility of ovarian damage raises this method unsuitable for animals highly valuable to captive breeding programmes or where reversibility is important. It is therefore suggested that an individual is on PZP for no longer than 2 years if you want the female to breed. We have one record of an common hippo conceiving approximately 4 years after the cessation of treatment.	
Effects on Behaviour	**Data deficient**	**Data deficient**	Similar to surgical castration but short-acting (duration of antibody effect). No oestrus behaviour in males.	**Data deficient**	Effects on behaviour have not been studied, there may be individual variation in response. Medroxyprogesterone acetate (not an progestins are androgenic, so important to clarify) binds readily to androgen receptors and are androgenic, females may experience male-like qualities (increased aggression, development of male secondary sex characteristics, etc.). Further research in the subject is necessary.	Regumate® can be used to alleviate temperament changes and aggression. Synthetic progestins may not suppress follicle growth and some signs of oestrus behaviour may be present.	Effects on behaviour have not been studied, there may be individual variation in response.	Since usually the vaccine doesn't suppress oestrus cycles it has almost no effects on social behaviour, and no undesirable behavioural effects have been registered in free-ranging elephants treated for up to 9 years. In some species the failure to conceive can results in longer than usual breeding season and in some cases this can results in aggression and social disruption.	
Effects on sexual / physical characteristics	Similar to gonadectomy. GnRH agonists may cause the suppression of physical secondary sexual characteristics.	GnRH agonists may cause the suppression of physical secondary sexual characteristics.	Similar to surgical castration but short-acting (duration of antibody effect).		Because Medroxyprogesterone acetate binds readily to androgen receptors and is androgenic, females may experience male-like qualities (increased aggression, development of male secondary sex characteristics, etc.).	**Data deficient**	**Data deficient**	**Data deficient**	
Name	**Not Recommended as GnRH agonists are seemingly not effective in male ungulates**	**Not Recommended as GnRH agonists are seemingly not effective in male ungulates**		**Not recommended**	**Not recommended**	**Not recommended**	**Not recommended**	**Not recommended**	
Use	-	-	Two injections at 40ug are given 35 days apart and boosters are usually administered every 3-6 months, although duration can vary between species.	-	-	-	-	-	-
Latency to effectiveness	-	-	Latency to effectiveness can be up to 6 weeks so separation of the sexes is recommended if possible	-	-	-	-	-	Depending on species and individual, perhaps as long as 2 months or more
Use in prepubertals or juveniles	-	-	**Data deficient**	-	-	-	-	-	**Data deficient**
Use in seasonal breeders	-	-	Unknown but if used should be done at least 6 weeks prior to the breeding season. Effective in the horse. Use at the onset of the breeding season before cycling starts.	-	-	-	-	-	-
Duration and Reversibility	-	-	Unknown for most species. Improvac® induces an immune response that generates short-lived antibodies in the domestic pig. Antibody production starts to decline ~1-6 weeks following second injection). This lasts ~ 5 to 4 months in bull elephants when used for the control of musth. Improvac is designed to be fully reversible, there are currently no reversals on the database however, studies have shown reversibility in equids within a two year period. It must be taken in to consideration that younger individuals will take longer to reverse in comparison to older individuals.	-	-	-	-	-	The procedure should not be used to males likely to be recommended for subsequent breeding as reversal is unlikely
Effects on Behaviour	-	-	Similar to surgical castration but short-acting (duration of antibody effect). Decrease male aggression due to down regulation of testosterone synthesis. Can (mean) herniate or reduce aggression/musth behaviour in bull elephants.	-	-	-	-	-	Vasectomy will not affect androgen dependent behaviours.
Effects on sexual / physical characteristics	-	-	Similar to surgical castration but short-acting (duration of antibody effect).	-	-	-	-	-	-
General									
Side effects	In general weight gain as would be seen with orchidectomy or castration. Increased appetite will result in weight gain, especially in females. Males may lose muscle and overall weight if not replaced by fat. Males may become the size (weight) of females. Some dichromatic species may change colour. The KAZA RMG recommends always reading the manufacturer's data sheet	In general weight gain as would be seen with orchidectomy or castration. Increased appetite will result in weight gain, especially in females. Males may lose muscle and overall weight if not replaced by fat. Males may become the size (weight) of females. Some dichromatic species may change colour. The KAZA RMG recommends always reading the manufacturer's data sheet	Occasional swelling at the vaccination site - need to inject deep intramuscular in elephants and horses. The KAZA RMG recommends always reading the manufacturer's data sheet		Possible cancerous effects on the endometrium following prolonged use. Progestins are likely to cause weight gain in all species. In the human literature, Depo-Provera® has been linked to mood changes. Because it binds readily to androgen receptors and is anti-androgenic, females may experience masculinization (increased aggression, development of male secondary sex characteristics, in dichromatic species, aspects of male colouration, etc.). The KAZA RMG recommends always reading the manufacturer's data sheet	Progestagens likely cause weight gain in all species. Possible cancerous effects on uterine and mammary tissues vary greatly by species. Can cause endometritis in domestic horses and cystic follicles in sows at low doses. The KAZA RMG recommends always reading the manufacturers' data sheet.	Progestagens likely cause weight gain in all species. Possible cancerous effects on uterine and mammary tissues vary greatly by species. Can cause endometritis in domestic horses and cystic follicles in sows at low doses. The KAZA RMG recommends always reading the manufacturers' data sheet.	Treatment for over 5 years has been associated with ovarian failure in some species (precise differences). Significant ovarian disruption has been noted in dogs, rabbits, mice and domestic sheep. Cephalitis unknown if transient or permanent. In some species the failure to conceive can results in longer than usual breeding season aggression and social disruption)	
Warnings	Causes initial gonadal stimulation. Duration may be reduced if implant is broken. Do not cut the implant. If implant is not completely removed at the end of treatment, residue circulating levels of deslorelin may affect time to oestrus. **Should not be used in conjunction with DepoProvera.**	Causes initial gonadal stimulation	It should be handled with extreme care to avoid handler accidents. The KAZA RMG recommends always reading the manufacturer's data sheet		Interaction with other drugs are known to occur and may influence protection against pregnancy. In some diabetic animals progestagens can lead to an increased insulin requirement, it is advised that the product be used with caution in diabetic animals and that urine glucose levels are carefully monitored during the month after dosing. The KAZA RMG recommends always reading the manufacturer's data sheet.	This product is contraindicated for use in females with a previous or current history of uterine inflammation. The KAZA RMG recommends always reading the manufacturer's data sheet.	This product is contraindicated for use in females with a previous or current history of uterine inflammation. The KAZA RMG recommends always reading the manufacturer's data sheet.	The only adjuvant used with PZP is Freunds modified adjuvant, which DOES NOT CAUSE TH+ TEST REGULTS, and injection site reactions are less than 0.05%. Following the initial treatments, boosters are required, using only Freunds incomplete adjuvant	The procedure should always be carried out under sterile conditions, potential for infection of the surgical wound.

Reporting Requirements: In order to increase our knowledge of the efficacy of contraception methods in Elephantidae it is recommended that all fertilization or contraception be reported to the KAZA RMG

References:
N Asa, C.S. & Horton, J. (eds.) (2007) Wildlife Contraception: Issues, Methods, and Applications. The Johns Hopkins University Press: Baltimore

2.4.4 Birth

A deep layer of straw should be provided in various areas where the female likes to lay down, so that the female can choose. The female will generally prefer areas where she can hide from view and withdraw.
It is important that the substrate inside is soft and non-slippery.

Copyright Zoo Basel. : Females like to hide when giving birth. This can easily be accomplished by providing some areas that are filled with straw and used as shelter.

Parturition usually happens at night or early in the morning.
Labour can take several hours. Once the water is broken, delivery usually occurs within two hours. It is important not to disturb the female during labour and in general, they do not need help.
Usually, parturition does not cause any problems, but exception can happen. It may thus be useful to install a video camera, so that the keepers can observe the labour from a distance and more information can be obtained about calving in this species.
Where female pygmy hippos give birth in the wild is unrecorded. In zoos, births may occur in the water and on land. Even though some females have successfully given birth in water and infants at four days of age have swum adequately, many institutions recommend that females in late pregnancy only have access to a pool when constantly supervised by zoo staff. Others suggest that the water should be no more than 5 cm deep to avoid the risk of drowning.

2.4.5 Development and Care of Young

Healthy pygmy hippo infants weigh approximately 5 kg at birth and they will suckle for the first time within an hour of being born.

Copyright Zoo Basel. In rare occasions, the female will allow the keeper to enter the area of birth.

In the wild, the calf apparently does not follow its mother when she leaves the water to forage, but hides nearby. She returns at intervals and calls the calf out of hiding to suckle it. After bonding has occurred in the first two days, this behaviour seen in the wild can be put to good use in captivity to separate the female from the calf and give her the possibility to use the pool. During this time, the calf can be sexed, chipped, weighed and the umbilical cord can be checked.
It is recommended to have a nursery pool in addition to the main pool, but if no shallow pool is available, the calf should be bathed while the mother is in the pool.

The first faeces are passed at the first day, as was seen at Colchester while the baby was being weighed. Calves are regularly seen with at least their front feet in water whilst defecating, often using water drinkers to put their feet in if they have no access to the pool at the time.

It has been observed in several zoos that young pygmy hippos eat their mother's faeces from day two onwards. This is done by many ungulate species, this behaviour seems to be natural and needed to establish a sound gut flora at an early age in order to be able to digest plant material. This natural behaviour should not be discouraged.
The daily weight gain during an infant's first few months is approximately 0.45 – 0.7 kg.

Infants with their mothers have been successfully introduced to water at several days of age, where they were exposed to depths of water that gradually increased.
Infants may begin eating solid foods at 2 – 4 months of age and weaning occurs after about six to eight months.
Some zoos observed suckling behaviour even at the age of around three years, however, this behaviour may be more associated with seeking comfort than with milk intake.
Several institutions have successfully introduced sires back to the dams and their infants as soon as the infants reach three years of age and when the female shows no aggression towards the male. In general, males seem to be fairly gentle with their offspring, but sometimes show more interest than the female is willing to tolerate.

Problems
Parturition usually occurs without any problems.
Some institutions have experienced mothers crushing their infants. However, maternal experience, the use of creep areas and vigilant monitoring by zoo staff has reduced the latter.
Certain females can be rather clumsy and may accidentally hit their offspring, but usually, this does not harm the calf.
Few zoos have had problems with blocked intestines in the calf and with an open urachus.

2.4.6 Hand-Rearing

In general, we do not recommend the hand-rearing of pygmy hippos.
1. The species breeds well in captivity, hand-rearing is therefore not necessary to maintain a
healthy captive population.
2. With special reference to mammals, hand rearing may cause irreversible disorders in early ontogenetic socialisation; this complicates later integration into a group (or with a sexual partner) and puts stress on that particular individual (Stauffacher, 2003).
In exceptional cases, such as when a wild-caught pair has never successfully raised any offspring, the species coordinators should be consulted. If they approve, hand-rearing may be carried out according to the procedures described in the literature, i.e. Partridge, 1983, Stroman and Slaughter, 1972, Frost, 1996, and Langdon and Schmidt, 1981.

2.4.7 Population management

The captive management of the Pygmy Hippo has been going on for more than 25 years by now, and the population is well known. Because of a skewed sex ratio (more females than males) intensive management is important in order to keep a genetically and demographically healthy population. The programme is set as an EEP, its primary roles are in conservation and education (Quick Population Assessment 2017, to be found on the EAZA website, Tapir and Suiform TAG).

The programme has set a target population of 160 and a genetic goal of maintaining 90% genetic diversity for 100 years (QPA 2017).

2.5 Behavioural enrichment

The best enrichment for pygmy hippos is to have a well structured and diverse outdoor and indoor exhibit. Various suitable structures are presented in chapter 2.1.3.
In addition, the raising of a calf is an important "enrichment activity" for the female.

Feeding Enrichment
Most zoo animals spend less time foraging, processing food and feeding than they would do in their natural habitat. So a reduction in the accessibility of food and an increase in processing time seem to be promising ways to promote the welfare and the behavioural repertoire of the captive animals (Note: When more than one animal is present, the enrichment must not cause an increase in stress by aggression from monopolisation of the feeding items or overfeeding of one or more of the animals to the disadvantage of others). The natural feeding behaviour should be considered when designing the feeding enrichment schedule for the species. . Certain studies Gippoliti & Leoni (2005), Burchard (2018, unpublished), and Gippoliti & Leoni (2005) refer to the dispersal of food in the exhibit to increase activity and searching behaviour.

Sensorial Enrichment
Sensorial enrichment should be part of the daily routine of this species in captivity. As already noted, dung marking is an important way of communication for these animals. Therefore, dung marks should be left for as long as possible. Other options are to use dung, bedding material and small objects of furniture from other exhibits (e.g. logs, rocks, etc.), which may be moved from one exhibit to another. (Note: This can be done only following sanitary inspection and approval). Alternatively, exchange of material from exhibits with other species from the same geographical area (such as their predators: leopards, pythons and crocodiles) can be performed. Spices, herbs, piles of hay, leaves, bark or mud and artificial scents may also be used in order to stimulate the careful examination of the environment. These objects can also be hidden or buried.

Enrichment considerations (chapter taken from previous husbandry guidelines and revised by Melissa Broadway, EAZA Animal Welfare Coordinator)

The main aim of an enrichment programme is to promote positive welfare by providing the opportunity for an animal to perform its natural species-specific behaviours within the range of their natural activity time budgets. If given the opportunity to choose from different possible behaviours, the animal will be able to increase its behavioural repertoire in captivity, have more choice and control within the context of its environment and have more opportunity to fulfil its full range of behavioural motivations. Environmental Enrichment can also be a remarkable tool in the perspective of the education in zoos as any type of enrichment which promotes the natural behaviours of the animals in an engaging way can enhance curiosity in visitors and increase knowledge of the observed species and instil a greater respect for nature and wildlife.

To create an effective environmental programme, the following points should be considered:

- **Dynamic exhibit design:** It should include appropriate substrates and furniture that can be arranged in a way so that the exhibit remains dynamic and engaging for the animal. The structural part of the environmental enrichment resides in the complexity of the exhibit and its furniture (which will form the core of the 'habitat' of the animal). This includes vegetation, shelters, dens, logs, rocks, pools and stables. There should be adequate opportunities to exercise, find/choose shelter, manipulate the environment, engage with the exhibit, make territorial markings and to forage. The ability to change and alter the habitat frequently will allow for a dynamic environment that can offer continual stimuli for exploration.
- **Reflective of the animal's needs:** Aim to create not only an 'apparently naturalistic exhibit', but the exhibit must be really adequate to the animal's needs. It should incorporate the biology, ecology and behaviour of the species as well as the natural activity budgets of the animal and the constraints of the exhibit must be considered as thoroughly as possible. Specific information about the individual habits and stereotypes such as route tracing in the pigmy hippo (see section on stereotypes* below) will need to be analysed. You should aim to not only provide 'occupational therapy' for the animal, but provide all the items and stimuli necessary for an animal to be able to fulfil its ecological needs.
- **Tailored to the individual:** An environmental enrichment programme must be especially adapted to the individuals. This is necessary as an individual's behavioural needs will change over its lifetime, when there are changes to its environments, seasonally, if they have any particular medical conditions as well according to the individual's preferences (eg. Juvenile animals may require enrichment that promotes more play and high energy behaviours).
- **Organisation, Implementation and Evaluation:** The additions of specific enrichment to the exhibit can be applied according to a schedule. This will help to organise the delivery of the different categories of enrichment at appropriate time intervals in order to promote behaviours in accordance to the desired activity budget. One simple way of organising a daily enrichment programme and maintaining records of what is being done, is to plan a weekly or monthly enrichment schedule (see example in Table 1).

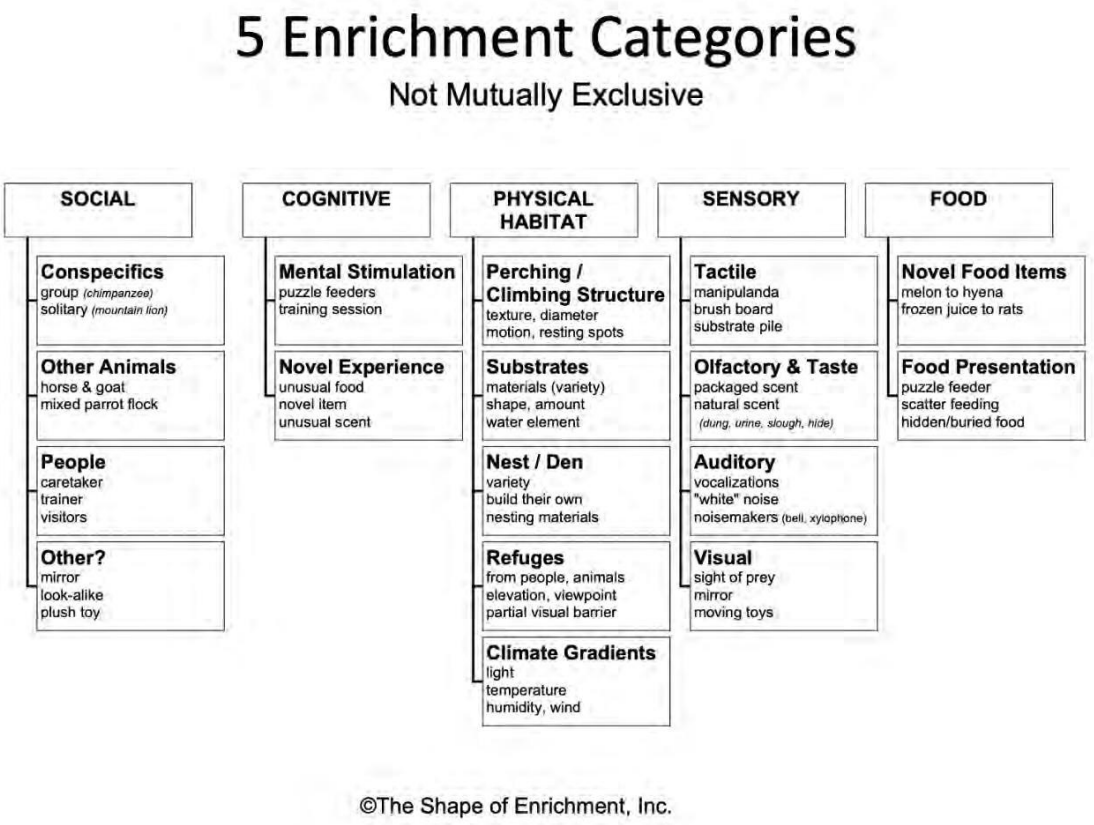
Table 1 Example of an Environmental Enrichment weekly schedule for Pygmy Hippopotamus.

Species: Pygmy Hippopotamus (*Hexaprotodon liberiensis*) **Order:** Artiodactyla **Family:** Hippopotamidae **Year:** 2005 **Month:** July **Week:** 27

DAY	TIME	EE CODE	*DESCRIPTION*	NOTES
MONDAY	Morning	Nill	Nill	
	Midday	IR	Ice rings	
	Afternoon	FS	Scattering food	
TUESDAY	Morning	FB	Burlap bag	
	Midday	IP	Popcicle	
	Afternoon	Nill	Nill	
WEDNESDAY	Morning	L	Small logs	
	Midday	Nill	Nill	
	Afternoon	B	Curtain of browse	
THURSDAY	Morning	Nill	Nill	
	Midday	IG	Pig-cicle	
	Afternoon	FS	Scattering food	
FRIDAY	Morning	BM	Broom heads	
	Midday	Nill	Nill	
	Afternoon	S	Scattering food	
SATURDAY	Morning	IB	Ice block	
	Midday	Nill	Nill	
	Afternoon	R	Rope of fruit	
SUNDAY	Morning	FT	Feeding tubes	
	Midday	T	Buoys, pneumatics	
	Afternoon	Nill	Nill	

➢ The non-mutually exclusive categories of enrichment are; feeding/foraging enrichment, sensory enrichment (eg. Smells, recorded sounds etc.), physical enrichment (e.g nesting materials, toys etc.), social enrichment and cognitive enrichment (eg. training) (See Image 1 below, The Shape of Enrichment INC, 2020). The success of any environmental enrichment programme depends on the continuous observation and

evaluation of results to ensure the desired behaviour is being promoted (Alligood, C., & Leighty, K. 2015).



For further discussion on environmental enrichment, see Kleinman et al. (1996), Field (1998), Maple, T., & Perdue, B. (2013) and Young (2003). The last publication also presents a very extensive list of sources of information on this subject.

**Stereotypies: Are defined as repetitive invariant behaviours that serve no apparent function. They can be established as a way for an animal to cope with the chronic stress associated with continually unfulfilled behavioural motivation (Maple, T., & Perdue, B. 2013). In order to address the abnormal stereotypic behaviour you can analyse the behaviour to determine the source of the issue and use enrichment as a tool to allow the animal to more actively engage in the behaviour that it was not previously able to fulfil, e.g. Route tracing in the pygmy hippo could stem from the animal not having the opportunity to perform adequate active exploration due to restrictions in its enclosure size and range. Therefore you could allow for more complexity of vegetation and routes within the given space and encourage more active exploration with different scents and provide a greater range of foraging opportunities to increase active food seeking behaviours. If you try to 'block' the stereotypy by simply putting something in the path of the pacing, this will not fix the underlying issue and the abnormal behaviour will adapt to the block and continue to be performed.*

5.1. Structural and physical enrichment

The home ranges of pygmy hippos comprise different habitats, several resting places and a network of trails, which are periodically used for feeding (Bülow, 1998 in Roth et al. , 2004). In the thick vegetation, the paths are like tunnels, while in swamp they are canals up to 2 ft (60 cm) wide, filled with water (Lang et al., in Grzimek, 1990). The most important elements of its home-range are the presence of small streams with submerged trees, root hollows, swampy depressions, as well as the size and density of ground vegetation. Pigmy hippos will be highly motivated to access water, therefore the more complex the water environments in captivity are, the more the animal will be able to fully engage with water related behaviours. The water quality is important to maintain, as poor-quality water may affect the health of the animal and restrict its ability to use this resource (see section 4.1.7). Availability of substrate and vegetation are highly important factors to consider as a staple to the exhibit but also as additional enrichment. For the Pygmy Hippo, although concrete allows for easy hygiene maintenance it is not an equivalent natural substrate for the species and can cause foot issues. By providing multiple substrates such as grasses, soil, loam, sand, marl, leaves, wood chips or gravel etc. as well as a variety of thick vegetation you allow the animal to interreact with these provisions as they choose, which can be enriching and allow the animal to control their comfort levels and habitat according to their preference (see section 4.1.5).

The habitat must offer well-hidden and protected places for resting, calving, nursing and hiding calves (Roth et al ., 2004). The young are born in these resting refuges and are nursed here during the first months of their lives (Galat-Luong 1981 in Roth et al., 2004). The design of the enclosure, the furniture and the structural elements should reflect this natural habitat, it should also allow for ease of manipulation and adjustments in order to keep the exhibit dynamic for the animal.

BOX 1 Pygmy hippopotamus exhibit in Melbourne Zoo

Melbourne Zoo has developed a naturalistic West African tropical rainforest exhibit for pygmy hippos and mandrills (Arnott et al ., 1994). This habitat immersion type exhibit was inaugurated in 1992 and has proved popular with visitors since then. The design of the exhibit was based on thorough research to determine natural habitat, behaviour repertoires and captive requirements of the species. The design was then applied to the constraints of the Zoo (Arnott et al. (1994) and Vaartjes (pers. comm ., 2005). The design of each exhibit comprises a large body of water surrounded by artificial river banks and land areas planted with vegetation, dominated by tropical grasses, sedges and wetland plants. There is also a mud wallow. Artificial rock walls, 1-2 m high, which resemble river banks, form a nonobtrusive barrier. Some of the species of plants used are: Cyperus papyrus , Dietie s sp., Carex sp., Ficus hillii , Waterhousia sp. Arnott et al. (1994) supplies a very useful planting list for the exhibit. The majority of the plants (except the advanced trees) were grown at the zoo's plant nursery. Some vegetation is surrounded by an electric fence, so that the hippo has no access to these plants. However, the animals have access to some trees but they don't eat them (these were based on a 'trial and error' basis). For safety reasons, all plants used are non-toxic to the animals.

The environmental vegetation of the exhibit is important for the welfare of the animal, in that the vegetation should be non-toxic, where possible it should reflect vegetation that they would naturally encounter, it should provide appropriate seclusion from sight and it

should be dynamic. Vegetation also will allow for visual, aesthetic and educational benefits for the visitors. Additional vegetation that the animal is able to actively engage with should be provided and consistently replenished.

General view of the Pygmy hippo outside exhibit in Melbourne Zoo (Melbourne, Australia, 2005) (Photos by Sjoukje Vaartjes).
To date, the major difficulties with regard to the display of the pygmy hippos in this exhibit have been:

1. The maintenance of water quality – due to the fibrous nature and sheer volume of the hippo's faeces in the water;
2. The maintenance of the vegetation health and density – because if the plants are not protected, the animals will readily feed on them without allowing sufficient time for recovery; and
3. The viewing of the animals by the visitors – the animals may sometimes conceal themselves in the thick vegetation of the land habitat. However, the ability to retreat from sight in order to promote feelings of safety and security is very important for the animal's welfare and should be maintained.

With the appropriate environment achieved according to the pigmy hippo's ecological needs, the provision of allowing for a dynamic exhibit should be considered. In general, the animal will behave in a way that this becomes a necessity for the general maintenance of the exhibit, ie. The Pigmy Hippo will interact with vegetation so that it is a requirement that the staff must continually adapt by offering new vegetation, re-planting, rearranging vegetation etc. Other ways to allow for the easy manipulation of the environment is to consider branches, substrates, vegetation, logs, rocks etc. that should be easy to re-arrange and replace.
It is important to note that in climates that do not match the warm condition of the natural range of the Pygmy Hippo (Central Africa), the ability of the animal to use its outdoor enclosure for a significant amount of time throughout the year may be limited. Therefore, when this is the case, the indoor heated facilities should be as complex as possible and allow for the animal to continue to complete its full range of behavioural motivations despite the restricted use of its full enclosure.

5.2. Behavioural enrichment

Social Enrichment

Unlike the common hippo, the pygmy hippo is solitary and strictly residential (Roth et al., 2004). Therefore, social interactions with conspecifics are of less importance for this species. However, the rearing of young is considered a part of natural behaviour repertoires for females of the species and therefore we can assume there will be motivations to perform such behaviours. For more information on their social structure, group size and composition and breeding recommendations, see chapter 2.8, 3.1 and 3.3.6 respectively.
The benefits of human-animal contact have been described as a potential way to increase the welfare of an animal in solitary housing (Young, 2003), however Pygmy hippos are non-social animals that have the capability to become very aggressive, therefore, the manual handling of pygmy hippos is not recommended (see also 3.3.2). Alternatively, non-contact training using positive reinforcement may be beneficial when the animal has thechoice to engage in the training and when it does not promote aggressive tendencies.
Training in this way can be considered as social and cognitive enrichment for the animal. Training can also be used to minimise stress of the animal when human-animal contact is necessary, for example during certain husbandry and medical procedures.

Feeding Enrichment

Most zoo animals spend less time foraging, processing food and feeding than they would do in their natural habitat. So a reduction in the accessibility of food and an increase in

processing time can be ways to promote the welfare and the behavioural repertoire of captive animals (Note: When more than one animal is present, the enrichment must not cause an increase in stress by aggression from monopolisation of the feeding items or overfeeding of one or more of the animals to the disadvantage of others).
In the wild, the pygmy hippo's diet appears to consist exclusively of vegetable matter, including the leaves and root stocks of a variety of semi-aquatic and forest floor herbs as well as various fallen fruits from forest trees (Robinson, 2005). Roth et al. (2004) refer to the work of Hentschel (1990), in which he has identified a wide spectrum of fodder plants, mainly dicotyledons, fruit and ferns that occur in primary and secondary forests (see also appendices 3 and 4 in chapter 7). It is also commonly seen that where grass becomes available, pygmy hippos will use this resource readily and this was confirmed by observations in the wild (Roth et al., 2004). London zoo also provides fresh cut grass and clover soaked in water for enrichment.
According to Lang et al. (in Grzimek, 1990), the pygmy hippo prefers to seek for food in dry terrain. It obtains food in various ways: low grasses are grazed; branches are completely stripped of their leaves; woody fruits are broken with the strong teeth; swamp plants are pulled out of the ground by the roots; and to reach the higher branches, the animal stands on its hind legs and supports itself with its forelegs on the tree trunk (see also chapter 2.7. "foraging behaviour"). Therefore, all these behaviours should be encouraged through feeding enrichment and the appropriate placement of food according to the natural nutrient intake of the species (see 2.2.1) For example, Gippoliti & Leoni (2005) refer to the dispersal of certain kinds of food, e.g. apples, all over the paddock area in order to encourage foraging activity. See Table 2 for a list of enrichment items, which may be used as part of a feeding enrichment schedule.

Sensory Enrichment
Sensory enrichment should be part of the enrichment routine for this species in captivity. As already noted, dung marking is an important way of communication for these animals. Therefore, dung marks should be left for as long as possible (keeping sanitary requirements in mind). Other options are to use dung, bedding material and small elements of furniture from other pygmy hippo exhibits (e.g. logs, rocks, etc.), which may be moved from one exhibit to another. (Note: This can be done only following sanitary inspection and approval). In this way the use of scents can also be considered a form of social enrichment. Alternatively, exchange of material from exhibits with other species from the same geographical area (such as their predators: leopards, pythons and crocodiles) can be done. Spices, herbs, piles of hay, leaves, bark or mud and artificial scents may also be used in order to stimulate the careful examination of the environment. These objects can also be hidden or buried. Further auditory and visual enrichment may also be considered.

In the following table, there is a list of enrichment items, which may be used as part of a feeding enrichment schedule.

Table

Enrichment item	*Description & goal*	Location	Type of enrichment
Broom heads	Set in a fixed position for the animals to scratch against. The broom heads made of thin wood branches are functional and more naturalistic. May also be rubbed with scents.	L	P, S, F
Big logs or branches	Useful for the animals to rub on and scratch against.	L	P,S
Rubbing posts	Vertical wood posts cemented on the floor. The animals will rub and scratch against. May also be used as browse hangers and/or rubbed with scents then promoting the exploring behaviour and scent marking.	L	P, S, F
Curtains of browse	The browse may be settled on specific structures on the ground or in height (rubbing posts or in tress). They will serve as visual barriers (to break sight lines) and food dispensers; may be scented with spices or other foods (e.g. fruit).	L	P, S, F
Rope of fruit	Hung fruit and vegetables on a rope fixed on the two ends. This may be put over land or water. Beware of the possibility of tangling in rope or its ingestion.	L, W	F
Mobiles/wind chimes	These can be made with cardboard tubes, rope and produce. They may be adapted to the rubbing posts.	L	F
Roots or logs with holes	These are good for hiding food. Promotes the foraging behaviour and extends the feeding time.	L	F
Small logs	Put them in the water for the hippos to play with and push them around the pool.	W	O
Produce	This is adequate for all herbivores. It may be given whole (such as pumpkins, maize tops, growing corn) or cut. Promotes the foraging behaviour and extends the feeding time.	L	F
Scattering food	Scatter fruit and vegetables on the soil in different parts of the exhibit. Floating food can be offered in pools.	L	F
Feeding tubes (puzzle feeder)	PVC/acrylic tubes with drilled holes and lids on ends. Stuff the tubes with food through the lids and close the tube. The animals must roll the containers to obtain the food items inside them. Other structures with holes and food (e.g. big acrylic boxes, etc.) may also be used. Stuffed bread, pumpkins or marrow also proved successful. These may be hung on trees in different heights - some very accessible, others not. The animals must "work" on the structure to obtain the food. Promotes the foraging behaviour and extends the feeding time. Beware of the possibility of tangling in ropes or its ingestion.	L	F
Burlap bags	Fill in the bags with substrate as hay or wood wool and food items. The bag may be open or partially sewn to increase the difficulty. It can also be hung. Promotes the foraging behaviour and extends the feeding time. Beware of the possibility of tangling in rope or its ingestion.	L	F
Pig-cicle	Bucket filled ¼ with water; add chopped produce and freeze. When frozen repeat with a new layer of water and produce until the desired size is reached. Then remove the bucket and provide to the animals. Enables playing behaviours and extends the feeding time.	W, L	F, O
Popcicle	Freeze food items in water in containers of different size. Then provide to the animals. Enables playing behaviours and extends the feeding time.	W, L	F, O
Ice rings	Freeze chopped produce in a small tub (7 cm deep) with a can or other round container placed in the centre of the tub during freezing. The rings may be hung or put in the water. Enables playing behaviours and extends the feeding time. Beware of the possibility of tangling in rope or its ingestion.	W, L	F, O
Ice block	Freeze big blocks of water with or without produce (chopped or whole) and provide to the animals. Enables playing behaviours and extends the feeding time.	W, L	F, O
Toys	pneumatic tyres, sailing buoys, entire pumpkins (these are good for water.) Boomer balls, tires (the tires must not be steel belted). Enable playing behaviours.	W, L	O
Items from other exhibits	Scents from other animals (e.g. predators) and bed material from conspecifics or other ungulates. Any item from other animal/ exhibit must be submitted to sanitary inspection and approval prior to use. Promotes exploring behaviour and scent marking.	L	S

Legend: L – Land; W – Water; P – Physical; F – Feeding; S – Sensorial; O – Ocupational

Further ideas suggested by Melissa Broadway are:

- Buried food
- Browse feeding poles, which would encourage the pygmy hippo to stand on two feet and reach for the appropriate forage

- Inclusion of different appropriate vegetation (could even have this on its own rotational system)
- Inclusion of different substrates (eg. Pile of leaves potentially from another enclosure or pile of sand etc.)
- Training could also be included

Pygmy hippos will use the presented objects and chew them, but swallowing has so far not been observed.
Caution should be taken when offering paper or cardboard as these materials may be chewed for a long period and can get stuck in their mouths or block the animals' intestines. In addition, they can block the filtration system when pulled into the water.
Car tyres are not recommended as the metal inlay can be harmful and the tyre itself can get stuck on the animal's head.

Several pygmy hippos seem to show abnormal behaviours regarding nose pressing on glass. This behaviour is thought to be associated with a motivation to expand their tunnelling systems. Anecdotally, there has been a reduction in this behaviour when zoos have removed larger fish and took steps to restrict public viewing of the hippos underwater. One way viewing glass *could* result in the reduction of the behaviour (Melissa Broadway, pers. Com.).

2.6 Handling

Adult pygmy hippos can be dangerous and aggressive. They are very fast and move quickly when disturbed. In addition, they bite when they feel afraid or uneasy. So it is recommended that keepers use hands-off procedures and do not work inside the enclosures along with the animals.
Calves can usually be handled safely until they reach the age of one year. However, young animals that feel stressed can also turn and bite.

2.6.1 Individual Identification and Sexing

In general, adult pygmy hippo females are smaller than males.
However, in captivity, overweight is a widespread problem and may result in females resembling males in size. A body condition scoring system is available from the coordinator and should be used.
Sexing the calves is easy.

2.6.2 General Handling

When a pygmy hippo needs to be moved between enclosures with the keeper walking behind, a board can be used. The board should be kept tightly to the ground, so that it cannot flip. Nevertheless, caution needs to be taken as pygmy hippos can turn quickly and

jump when stressed. When 'driving' a pygmy hippo with a board, one should never stress the animals and be patient. It is much easier to work with a relaxed pygmy hippo.

Pygmy hippos are easy to train because of their curious nature and their preference for certain food items and they love being scratched. Target training works well.
In EEP zoos, pygmy hippos are trained to enter crates, go on a scale, tolerate ultrasound, lift feet, take the body temperature, open their mouths and to move between exhibits.

2.6.3 Catching/Restraining

Pygmy hippo babies can be caught by hand but they can easily slip away. The use of a towel will facilitate capture. Adult animals should never be caught by hand due to their potential danger to humans.
Pygmy hippos only ought to be restrained when they have been trained to tolerate it.
If the animals have not been trained to accept restraining and are not sedated, they will fight seriously, putting the safety of the keepers at risk. In addition, the stress caused by the procedure can cause serious health risks to the individual, even more so if the specimen is overweight.

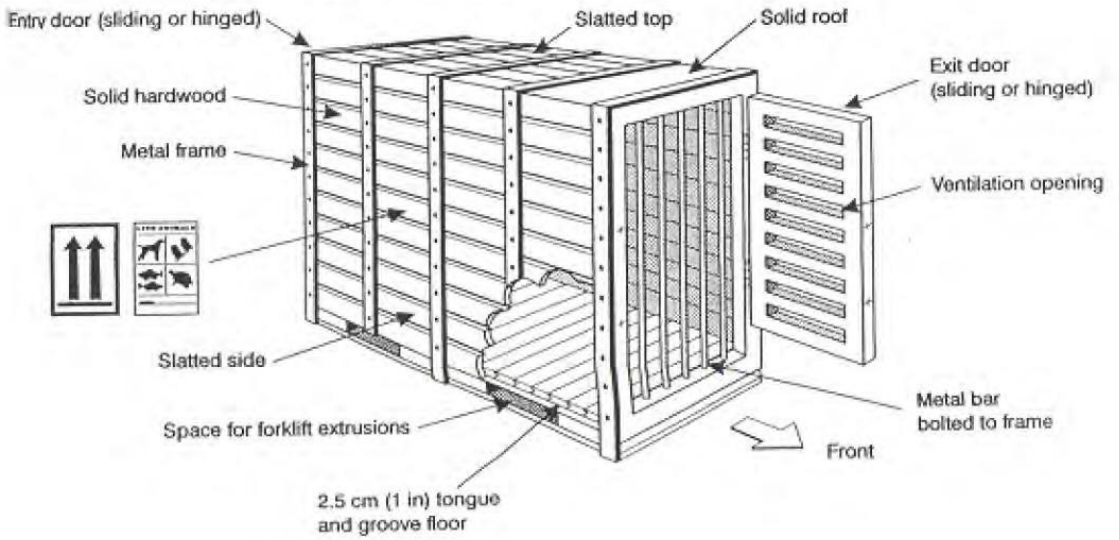
2.6.4 Transportation

Design of crate (according to IATA regulations, IATA (2019). Live Animal Regulations, 45th Edition. International Air Transport Association, 2019)

Transport crates should allow the pygmy hippo to stand upright and lie down. Details of an appropriate container for air transportation is provided by IATA. These containers should either restrict movement to a degree so as to prevent the pygmy hippo from turning around which might lead to injury. Or alternatively, the containers should be large enough to enable the pygmy hippo to turn around without the risk of an injury. We would be interested to hear of zoos that have transported pygmy hippos in such large containers as we have no experience with it.

International Air Transport Association
Live animal Regulation

Container for transport Hippopotamus (including pygmy hippo)



Container construction

Materials: metal and hardwood or other safe materials

Dimension: In view of the diversity in size, strength and temperaments of this species, the size and strength of the container must be sufficient to restrict the movement as well as restrain the animal in question. The animal must be able to stand naturally without being cramped but must not be able to move freely.

Frame: Must be made of strong metal welded or bolted together depending on the weight of the animal

Sides: Solid hardwood sides, with no internal projections, must line the outer framework for extra strength. All woodwork must be secured with either bolts or nuts that face the exterior so that they can be easily tightened from the outside. Spring steel weld mesh can also be used in combination with strong metal corner posts, together with a rigidly braced top and sides.
In either case, the lower part of the sides must be solid and leak-proof. A heavy plastic foil or tarpaulin covered with sufficient absorbent material which is tied up half a meter around the crate, can be used.

Floor: Must be made of thick tongue and groove of at least 2.5 cm thickness or its equivalent and have a non-slippery surface. It must be completely leak-proof.

Roof: Must be solid over the animal's head and shoulders and slatted over the loins and hind quarters to give good ventilation.

Doors: A series of metal bars must be bolted to the top and bottom of both the entry and exit of the container. Exterior to these bars, sliding or hinged solid hardwood entry and exit doors must be made to completely cover the entry and exit. The door must be fastened by a sufficient number of strong bolts, which must be able to resist the weight of the animal. The upper third of both doors must have ventilation openings. These openings could also be used for showering the animal. Entry and exit must be clearly marked as such.

Ventilation: Through the slatted or louvered upper third of both wooden doors and slatted portion of the roof.

Feed and Water Containers: The water container must be fixed in the front of the container, it must be made of strong metal and must be wide enough so that the animal's muzzle can enter.
Outside access is from a low wooden flap, clearly marked **FEEDING**, at the base of the door. Food can be placed between the bars and the door, the access flap must be securely closed when not in use.
During transport, water containers will usually be covered with dirt and can cause problems. As pygmy hippos love to eat lettuce, the lettuce can be dipped into a bucket of water before feeding, thus allowing the hippo to ingest water when needed.
It is also very important to have the possibility to shower the animals during a break to make sure that the skin does not get too dry and does not crack.

Forklift Extrusions
Must be provided as an integral part of the design.

Preparations before dispatch
An ample quantity of absorbent material such as wood shavings is required for bedding. The animal must be watered before shipment.

Feeding and watering guide
The animals do not normally require additional feeding or watering during 24 hours following the time of dispatch. If feeding or watering is required due to an unforeseen delay, instructions supplied by the shipper must be followed.

Crate training
It is recommended that all shipments be accompanied and go through crate training well before dispatch.
To lure a pygmy hippo into the transport box, it is suggested that the box be placed, one end open, against the door. The door at the back end should be open, too, to allow as much light as possible in the crate. Then, keepers should advance toward the hippo, walking behind sheets of solid plywood.
The hippo will see the door as the only means of escape and use it. Then the box door can be shut. A much easier way of crating is to train the animal to use the crate as a sleeping box.

You could also place the transport box in the night quarters, with the usual bedding material

removed from the bed area. By placing the bedding in the transport box, the hippo will naturally sleep in the crate over the next few nights. A keeper can then close the door in the morning, limiting stress to the individual.
Training by positive reinforcement can be used if you offer the pygmy hippo titbits for walking into the transport box for up to a month before the move date.

Crating with chemical sedation / tranquilisation
Crating with chemical sedation is not generally needed.

Transport
The use of tranquillisers during transport can reduce the ability of the animal to respond to stress, heat and cold. Each case has to be evaluated by a veterinarian according to the respective situation (distance, means of transport, individual animal, etc.). We would be interested to hear of zoos that have used tranquillisers successfully for transport.
Pygmy hippos should not be transported during the hot summer months.
Their skin ought to be kept moist during transport and whenever possible, they should be showered during transportation. Beware of overheating. Never leave the box in the sun!
In colder seasons, the animal has to be kept warm in a heated container.

2.6.5 Safety

Escapes have not been reported so far, but contingency plans outlining suitable measures to be taken need to be in place.
In the past, keepers were injured by pygmy hippos in various zoos, so hands-off management is seriously recommended. In this respect it is important to keep in mind that pygmy hippos can be very fast and are able to jump. They also have very long and sharp teeth.

2.7 Veterinary: Considerations for health and welfare

VETERINARY CONSIDERATIONS FOR HEALTH AND WELFARE OF THE PYGMY HIPPOPOTAMUS (*Choeropsis liberiensis*)

Christian Wenker, Tim Bouts and Gabriella L. Flacke

INTRODUCTION

Scientific studies of veterinary health issues of the pygmy hippopotamus, hereafter referred to as pygmy hippo, are rare in the literature and many recommendations here are based on case reports or empirical knowledge of the species. Any contributions of activities concerning clinical veterinary medicine and pathology from zoo veterinarians and people involved with the species are greatly encouraged and will be added to future editions of these guidelines.

Good record-keeping using standardized databases (e.g. Species360 medical) are essential to increase medical knowledge and improve preventive health measures of the pygmy hippo.

In addition, institutions are strongly encouraged to perform systematic and comprehensive necropsies using the SSP/EEP standardized protocol for all pygmy hippo mortality events (see Appendix).

It is worth noting that captive hippos are generally robust and require little veterinary attention if husbandry, enrichment and feeding practices are appropriate.

1. Identification

The recommended identification method is subcutaneous microchip placement behind the left ear. Microchips can easily be placed under manual restraint of the newborn hippo few days after birth (e.g. at the time of the neonatal exam).

Routine observation and procedures

Every pygmy hippo should be checked daily for:

- General behavior and demeanor
- Appetite
- Respiratory rate and character
- Eyes, ears, nostrils, mouth and anogenital regions for abnormal discharge or excretions
- Quantity and quality of physiologic excretions (feces, urine)
- Locomotion and posture
- Skin for any lesions, cracks, wounds, abscesses, or evidence of dermatitis.
- Nails for cracks and soles of feet for abrasions.
- Oral cavity for any dental pathology, broken teeth, mucosal lesions, malocclusion, or canine tooth overgrowth.

Every pygmy hippo should be checked monthly for:

- Body condition and weight (see BCS sheet, Appendix).

Keepers can perform these checks and inform the veterinary staff if concerns arise. Training the animals to allow tactile exams of the skin and feet and to perform an 'open-mouth' behavior is advised if logistically possible.

Adult pygmy hippos weigh between 180 and 250 kg. Animals above these weight ranges are likely to be overweight and a diet modification is indicated (see chapter nutrition).

Although endoparasites are rarely observed in captive pygmy hippos, fecal samples should be examined (parasitology and microbial culture) minimally once year, and whenever abnormal fecal excretions are seen. Assessment of normal feces can be difficult because defecation can take place in water.

Anthelminthic drugs that have been used in hippopotamids include avermectins and benzimidazoles (equine paste formulations).

There are currently no recommendations for routine vaccinations.

Recommended drug doses for hippopotamids are available in the Zoo and Wild Mammal Formulary (Hahn 2019). Some antimicrobial, anthelminthic, and anesthetic dosages are listed in the hippopotamid chapter in Fowler's Zoo and Wild Animal Medicine 5th Edition (Miller 2003) and 8th Edition (Walzer and Stalder 2014). Anatomical and physiological characteristics point towards empirical pharmaceutical choices and dosages based on ruminant, suid, or equid doses.

If animals are anesthetized for any reason, EDTA and serum samples should be obtained for routine haematology and serum chemistry analysis, and aliquots stored at -20° Celsius. Ideally, all haematology and serum chemistry results, especially from healthy animals, should be entered in the Species360 database to expand the number of healthy pygmy hippos for the establishment of reference ranges.

Punch-biopsies of the skin and/or EDTA-samples should be stored for genetic analysis and bio banked at -20°Celsius or preferably -80° Celsius.

Trans-rectal ultrasonography can be performed in an anesthetized pygmy hippo to evaluate the kidneys for polycystic kidney disease (PKD, see non-infectious diseases). Results, negative or positive, should be reported to the SSP and EEP veterinary advisor(s).

Handling and clinical examination

Physical restraint or handling is not recommended because the species can be unpredictably dangerous. For any procedures that require closer contact to the animal, chemical restraint is necessary.

A valuable alternative for minor examinations and procedures is medical training in protected contact. Procedures that can be performed using protected contact include oral examination, obtaining rectal body temperature, blood sampling, and trans-abdominal ultrasound, disinfection of skin wounds, walking onto a scale to obtain body weights, injections, and foot care.

A walk-through passageway or tunnel helps to position a pygmy hippo sideways adjacent to a training wall or bars where an examiner can access different body parts (Figures 1, 2). Most individuals learn to accept this installation in a few training sessions.

Copyright Zoo Basel. Simple construction of a walk-through training tunnel where the animal can be approached after desensitization via the bars on the right (in protected contact). Note: No confinement or squeezing is necessary. Animal is trained to enter tunnel from both sides.

Copyright Zoo Basel. Side view of the training tunnel from the handler's side. Keeper offers food while examiners perform transabdominal ultrasound for pregnancy diagnosis.

Blood sampling can be challenging in pygmy hippos. The medial saphenous vein may offer a suitable venipuncture site (Figure 3). The cephalic or ventral tail vein may also be used. In anaesthetized animals, the sublingual veins and superficial digital veins are also accessible. Warm water bathing before attempting blood sampling and/or ultrasound can be helpful to identify cutaneous vessels.

Copyright Zoo Basel. Localization of the medial saphenous vein on the medial aspect of the hind limb (arrow).

A possibility for non-invasive monitoring of reproduction of female pygmy hippos is the analysis of fecal estrogen and progesterone metabolites (Flacke et al., 2017), e.g. as provided by Prof. Franz Schwarzenberger, Dept. of Biomedical Sciences - Endocrinology University of Veterinary Medicine (Vetmeduni Vienna), Veterinärplatz 1, 1210 Vienna, Austria, Phone: +43-1-25077 4104, Fax: +43-1-25077 4190, www.vetmeduni.ac.at. Franz.Schwarzenberger@vetmeduni.ac.at

Pregnancy diagnosis can be achieved by transabdominal ultrasound with the probe placed in the inguinal area starting at about the 80th day of pregnancy on the left side. Later, the pregnant uterus also becomes accessible from the right inguinal area. From the left side, the spleen (triangular shape) serves as cranial - and the mammary gland as caudal landmark. Any fluid-filled structure between those two organs is supportive of pregnancy (Wenker et al. 2018).

Neonates can be separated from the mother in the first week after birth for few minutes and handled with minimal physical restraint. A basic neonatal exam includes body weight, oral inspection to assess for the presence of a cleft palate, examination of the umbilicus, auscultation of the heart and lungs, rectal body temperature (lower than in most other mammals), sex determination and microchip placement (subcutaneously behind the left ear) for permanent identification.
Pygmy hippo neonatal body weights are in the range of 4-8 kg at 1 to 4 days after birth, and calves that weigh above 5 kg at birth are more likely to survive.

Animal transfer and quarantine

Before transfer, the receiving institution should obtain the complete medical history of the individual including age, sex, identification, rearing, diet and medical records. Transport crates offer the opportunity to calculate the animal's weight using loaded and empty weights.

A visual exam should be performed prior to transfer. Health examination under general anesthesia is not recommended for pre-shipment or quarantine exams unless specific health concerns require immobilization.

Routine fecal examination for endoparasites and *Salmonella sp*. should be conducted prior to the transfer. The usefulness of routine intradermal tuberculin testing is debatable and results should be interpreted with caution (see Bouts et al. 2009). Zoo-transfers to or from areas with high encephalomyocarditis virus (EMCV) prevalence (e.g. southeastern USA) should include serological pre-shipment testing for EMCV.

Crate training works well and should be used whenever possible.

Specific sedatives or long-acting tranquilizers for transfers of pygmy hippos are not known.

Quarantine facilities should ideally be completely separate to the exhibit and holding areas for the species. However, some zoos will need to quarantine pygmy hippos in exhibit holding areas. A situation-specific protocol based on a risk assessment should be established to manage the quarantined hippo given the logistical and facility limitations.

At arrival, each pygmy hippo should be isolated from other animals and the following examination should be carried out or repeated: identification, general health check via visual examination, bacteriological and parasitological analysis of feces for pathogens (*Salmonella sp*., endoparasites).
A separate set of tools and equipment for cleaning and feeding should be used for the quarantined animal. Disinfecting footbaths should be used for entering/exiting the quarantine stall or holding area, and a separate set of boots should be worn by husbandry staff entering the quarantine area. Ideally assign a separate husbandry staff member to work with the quarantined hippo versus the collection animals each day. If not logistically possible, always deal with the resident animal(s) before handling or working with the quarantine animal. A 30-day quarantine period is considered to be sufficient for most zoo to zoo transfers.

Vaccination

There currently is no recommendation for routine vaccination of pygmy hippos, but vaccines against rabies, West Nile virus, encephalomyocarditis virus, leptospirosis and clostridial disease, including tetanus, can be considered in specific situations.

Immobilization

Anesthesia of pygmy hippos can be challenging. A detailed review of hippopotamid anesthesia considerations can be found in Zoo Animal and Wildlife Immobilization and Anesthesia, 2nd Edition (Miller et al. 2014).

Preparations include pre-anesthetic fasting for 24 hours to reduce pressure of the gut on the diaphragm during recumbency. Individuals have to be kept away or separated from water and pools to prevent accidental drowning. Pygmy hippos have thick skin. Therefore, recommended intramuscular injection sites are either the medial or caudal aspect of the thigh or the area in the neck immediately caudal to the ear using a high-pressure blowpipe or dart gun with long (5.0 cm) or large-gauge needles (14 to 16 G). A pressurized pole syringe can also be used.

A recommended protocol is a combination of

Ketamine (1.2 mg/kg) and Medetomidine (0.08 mg/kg) IM

for induction followed by endotracheal intubation (12-14 mm ID, cuffed) for oxygen supply or maintenance using isoflurane in oxygen. For intubation the mouth can be kept open by placing two ropes behind the canine teeth of the upper and lower jaw.

Visualization of the epiglottis is hindered by a ventral position of the distal soft palatine border into the glosso-epiglottic angle. A long-blade laryngoscope (55 cm) helps to solve this situation. The veterinarian is referred to the publication of Bouts et al. (2012) for details. In the author's (Flacke) personal experience, a combination of

Ketamine (0.5mg/kg), Medetomidine (0.04mg/kg), Midazolam (0.15mg/kg), and Butorphanol (0.15mg/kg) IM

also followed by intubation for oxygen/isoflurane administration, is another reliable option.

Opioid-only immobilization has historically resulted in unacceptably high mortality rates for pygmy hippos. Furthermore, extensive safety precautions are necessary to prevent human exposure whenever handling potent opioids. Protocols focused on ultra-potent opioids are thus not recommended.

Monitoring the immobilized pygmy hippo is essential. Cardiac auscultation can be challenging. Positioning of an ultrasound Doppler pad fixed on the closed eyelid may help to monitor cardiac activity. An ECG can be placed by clipping the leads to small needles inserted in the skin. Keeping the animal in a sternal position may facilitate respiration; ETCO2 should be monitored when possible and the hippo may require IPPV. SpO2 monitoring probes can be placed on the tongue, prepuce, or trans-rectally. Peripheral IV access is also challenging. The sublingual vein is consistently accessible for catheterization, blood sampling or intravenous emergency drugs.

Surgery

A laparotomy for a caesarean section was accompanied by substantial bleeding of the fat and abdominal muscle layers, and the closure with braided nylon sutures resulted in dehiscence and slow second intention healing with persistent infection (Flach et al., 1998). In this animal, surgery was followed by nine immobilizations over a period of two months for wound management. It is concluded that a surgical approach to the skin of this species has to be carefully planned including the management of hemorrhages and the evaluation of the suture material.

Euthanasia

Deep chemical immobilization should always be the first step followed by intravenous or intracardiac application of barbiturate drugs (pentobarbital).

Post mortem examination

Every pygmy hippo that dies should undergo necropsy including histology, serology, virology and microbial culture for definite diagnosis when indicated. A standardized SSP/EEP necropsy protocol is available (see Appendix).

Neonatal deaths should be examined for lung ventilation, any congenital malformations, omphalophlebitis (including the urachus), and stomach contents for milk. Mesenteric and ileocecal, lymph nodes should be collected for bacterial culture.

Common causes of mortality in pygmy hippos, including neonates, are described by Flacke et al. (2016).

Polycystic kidney disease (PKD) has been diagnosed in several pygmy hippos and it is imperative to look carefully for such lesions in every animal regardless of age (Nees et al. 2009; Flacke et al. 2017). PKD is defined as at least three cysts in total, distributed between both kidneys. Cystic lesions are mostly present in the kidney, but have also been described in the liver, duodenum, pancreas, and ovaries.

2.8 Specific problems

Problems with regard to population management
The EEP has a serious problem with the skewed sex ratio: 40% male births versus 60% female births. In addition, male juvenile mortality seems to be higher than female juvenile mortality.

Given the fact that the EEP holds and breeds more females than males, it would be advisable that new holders build exhibits that have three enclosures: one for a male and two for two females.

A few zoos have kept females in adjacent exhibits and encountered problems with aggression and lack of breeding. At Rum Creek, young females are kept together in very large enclosures. However, this works only when the females have known each other from weaning onwards. At some point, one female will become dominant and may prevent the others from using the pool. So exhibits with various females may possibly work only in enclosures with several ponds (David Love, pers. Com.).

It would be valuable to gain more experience in the EEP with keeping females in adjacent or in the same exhibit (with the possibility to separate them when necessary), and this could lead to new ways of keeping pygmy hippos in zoos and safari parks.

Specific health problems

Noninfectious Disease

Dental

Canines and incisors grow continuously in hippos and may reach impressive length, in some cases predisposing to tusk fractures, oral lesions, penetrating wounds, and persisting fistulas. Various forms of malocclusion, including teeth growing in a wrong direction with

inability to masticate, have also been reported. These conditions require general anesthesia and endodontic therapy (if there is pulp exposure) and/or trimming.

Dermal

The skin heals remarkably well when injured, which may be attributable to anti-bacterial and anti-inflammatory properties of the skin secretions. In colder climates, abscesses and dermatitis can occur in winter due to low humidity and cold water temperatures. Frost bite has also been reported. For fly-induced dermatitis see the 'Parasites' section.

Further investigations are encouraged with regard to skin lesions in pygmy hippos.
A salt bath was successful for treatment of idiopathic dermatitis in two captive common hippos (Helmick, 2017).

Feet

Several zoos reported pododermatitis, cracks in soles and nails causing lameness. Flooring and substrate of enclosures have to be evaluated in these cases (see 'Husbandry' section).

Polycystic Kidney Disease (PKD)

Pygmy hippos affected by advanced PKD can show clinical signs of renal insufficiency and uremia including weight loss, lethargy, anorexia, and polyuria/polydipsia. Rarely PKD may present as acute pain, lethargy, and recumbency due to a renal infarct or hypertension-associated vascular event (stroke). However, in the majority of cases, there are no clinical signs, and PKD is considered an incidental finding at necropsy.

PKD remains a significant finding in pygmy hippos and further investigations are strongly recommended including ultrasound of kidneys, monitoring of renal function through serial serum chemistry analysis, establishing a database for renal function tests, and further investigation into the heritability of the condition.

Renal Disease other than PKD

Mortality due to renal disease was diagnosed in adult and geriatric pygmy hippos and was primarily degenerative in nature (glomerulosclerosis, glomerulonephritis, interstitial fibrosis and tubulointerstitial nephritis), leading to chronic renal failure.

Degenerative Musculoskeletal Disease

Adult and geriatric pygmy hippos are commonly affected by osteoarthritis and neuromuscular disorders. Obesity is an important factor and contributes to the severity of the disease. Affected individuals should be managed with analgesics and inflammatory mediators as indicated by clinical signs of pain and/or lameness.

Obesity

Maintaining ideal body condition is strongly recommended for individual animal health and welfare. Obesity may be linked to stillbirths and poor calf survival rates. Obesity also exacerbates degenerative musculoskeletal conditions in older animals.

Geriatric Animals (30+ years)

Pygmy hippos in this age range are often affected by multiple comorbid conditions affecting multiple organ systems. Many animals are affected by degenerative joint disease. Clinical signs are exacerbated by obesity. Further affected organ systems affected by degenerative changes include the renal/urinary and cardiovascular systems (see Flacke et al. 2016). Neoplasms are uncommon; a list can be found in Flacke et al. (2016). McCurdy et al. (2014) describe a case of lymphoblastic leukemia.

Neonatal Morbidity and Mortality

The current neonatal mortality rate is high and a cause of concern for the captive breeding programmes of this endangered species. Mortality rates are higher for male calves, both through still births and in the first year of life. This situation requires proactive veterinary care and investigative pathologic examination. Neonatal weights should be monitored daily for the first few weeks, and it is important to maintain the calf's environment above 20° Celsius with adequate humidity to mimic the species' natural tropical habitat.

Pygmy hippos have sometimes drowned within the first days of life, leading to the recommendation that pools are drained when parturition is impending, or that pregnant females are isolated from the pool(s). Specifically, pools with steep drop-offs and vertical walls have contributed to this problem in contrast to pools with shallow waters and gently sloping sides. Pygmy hippos give birth on land!

One institution reported several cases of juvenile gastro-intestinal impaction caused by ingested substrate (sand colic).

Infectious Disease

There are no specific pathogens reported for pygmy hippos.

Bacterial

Various bacteria were isolated from pygmy hippos including *Mycobacterium tuberculosis* and *Mycobacterium bovis*, non-tuberculous mycobacteria (NTM) (Bouts et al. 2009), *Pasteurella multocida*, *Salmonella spp*., *Clostridium perfringens* (enterotoxaemia) and *chauvoei* (toxemia, myositis) and *Leptospira interrogans* serovar *icterohaemorrhagiae* (Cracknell et al. 2011). A list of microbial pathogens cultured from pygmy hippos at necropsy can be found in Flacke et al. (2016).

Anthrax caused by *Bacillus anthracis* is a specific concern in free-ranging common hippos (*Hippopotamus amphibius*). This species seems to be highly sensitive to anthrax. It is currently unknown if free-ranging pygmy hippos are also similarly susceptible to anthrax.

A commonly used broad-spectrum antibiotic for infected wounds or other suspected infections has been trimethoprim-sulfadimethoxazole (20 to 30 mg/kg SID-BID PO), but other large animal antibiotics have been used in equine or bovine doses.

TB testing is sometimes required by veterinary authorities but the interpretation of intradermal test results is difficult.

Viral

Encephalomyocarditis virus (EMCV) infection resulted in the acute death due to cardiovascular collapse of several pygmy hippos in the southeastern United States and Australia. Serological screening for EMCV is recommended in endemic areas. Cases of acute death should be submitted to a reference laboratory for serological testing and virus isolation whenever post-mortem findings indicate a cardiovascular etiology.

Commercial vaccines for EMCV are not currently available, but experimental vaccines have been used in clinical trials and outbreak situations. EMCV is transmitted by rodent carriers. Therefore, rodent control and facility hygiene have to be addressed.

Parasites

Certain flies (*Hydrotaea irritans* – sheep head fly – reported in Denmark) have been observed to be very aggressive and have caused serious ulcerative dermatitis in individual pygmy hippos. These ectoparasites disappear when an animal is moved indoors. A variety of insecticides/repellents was tested with poor success.

No specific endoparasites have been reported in pygmy hippos.

2.9 Recommended research

- Research into the causes of the skewed sex ratio and means to remedy it.
- The role of stress and obesity in reproduction and in particular in the biased sex ratio.
- Research into the genetic variability of the captive population, also in comparison with that of the wild population.
- Research into the causes of male mortality and means to improve it.
- Research into the clinical significance of PKD, its potential heritability mechanisms and influence of environmental factors in the development of PKD (Polycystic Kidney Disease) (PKD Flacke et al, 2017, Flacke mortality 2016).

- Research to systematically analyse risk factors associated with stillbirth and early mortality and the higher mortality rate in males (Flacke mortality 2016).

- For suggestions of research regarding the anatomy, morphology and physiology of pygmy hippos, please consult the former husbandry guidelines for this species.

In her research review: The Pygmy Hippopotamus *Choeropsis liberiensis* (Morton, 1849): Bringing to Light Research Priorities for the Largely Forgotten, Smaller Hippo Species (Flacke, 2015), G. Flacke and her colleagues review, analyse and provide a synthesis of the pertinent literature, aiming to identify and prioritise focal research topics for optimising ex situ management:

As a result of this comprehensive review, it is concluded that further research in the following key areas is essential to guide collaborative, integrated conservation efforts for the pygmy hippo and to help optimise health, husbandry, welfare, and reproduction in captivity:

1) Elucidating in situ social structure, behavioural ecology, feeding strategies, and nutritional requirements such that husbandry practices in captivity can be adjusted accordingly;

2) Establishing and comparing baseline stress levels for both wild and captive populations;

3) Assessing the potential for captivity-induced stress to alter normal physiology, behaviour, or contribute to disease processes;

4) Determining the prevalence and demographics of PKD to guide future population-wide breeding recommendations;

5) Examining the potential influence of external factors, including diet, hormones, and microbial pathogens, in the development of PKD;

6) Developing standard, consistent, non-invasive methods for monitoring oestrous cycles and diagnosing pregnancy;

7) Refining and streamlining the processes for collecting and preserving semen;

8) Clarifying underlying reasons for the lack of breeding success experienced by many zoos;

9) Elucidating the influence of obesity on reproductive physiology and general welfare;

10) Determining underlying mechanisms and potential ecological significance of the female-biased sex ratio;

11) Developing a 'family tree,' using molecular genetic tools, to guide captive breeding efforts and maximise the representation of unique genomes.

Most importantly, prospective in situ research is needed to deduce the 'normal' parameters for a wide variety of ecological and physiological phenomena, ranging from morphometrics and reproductive physiology to habitat use and population demographics. Knowing whether wild pygmy hippos also have polycystic kidney disease or a biased sex ratio willinfluence hypotheses about these phenomena in captive animals. Meanwhile, continued investigations with the captive population through carefully considered, step-wise, hypothesis-driven analysis is crucial, especially for elucidating the degree to which captive husbandry conditions affect various physiological and pathological processes.

Humans have kept wildlife species in captivity for millennia – we can never perfectly replicate a natural ecological environment for these animals, but our desire to optimise their welfare while under our care should never fade (Flacke et al., research priorities 2015).

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Necropsy protocol for Pygmy Hippopotamus (*Choeropsis liberiensis*)

Animal identification (Studbook n°, transponder, etc)	
Sex	□ male □ female □ unknown
Date of birth	
Date of death or euthanasia	
Euthanasia/Death	□ Death □ Euthanasia □ unknown

Dam identification (Studbook n°)	
Sire identification (Studbook n°)	
Weight at birth (if available)	
Weight at death	
Date of necropsy	

Gross necropsy performed by (name of prosector(s), institution):

Photography (yes / no):

History (briefly summarize clinical signs, circumstances of death; death / euthanasia; number affected; evidence of struggling; environmental conditions, etc…):

Gross examination worksheet:

- Description of lesions and abnormalities seen:
  1. **Degree**: mild, moderate, severe
  2. **Distribution**: focal, multifocal, locally extensive, disseminated, diffuse, …
  3. **Localisation**: cranial, caudal, ventral, dorsal, proximal, distal, …
  4. **Duration**: acute, subacute, chronic
  5. **Tissue** affected
  6. **Modifiers**: describe surface, consistency, shape, colour, size, smell ……
  7. **Process**: inflammation, fibrosis, tumour, abcess, granuloma …..
- Obtain samples for bacteriology before contaminating carcass with intestinal content, etc…
- Cut samples of tissues for histopathology (no more than 0.5 to 1 cm in thickness, in 10% buffered formalin at ratio of **1 part tissue to 10 parts formalin**)
- **Polycystic kidney disease (PKD**) has been diagnosed in several pygmy hippopotamus and it is imperative to look carefully for such lesions in every examined individual. Cystic lesions are mostly present in the kidney, but have also been described in the liver, in the duodenum and in the pancreas.

GENERAL CONDITION: (nutritional status, physical condition)
! Neonates: examine for malformations (cleft palate, deformed limbs, etc)

INTEGUMENTARY SYSTEM: (skin, ears, feet, parasites, hydration)
! Neonates, juveniles: examine ombilicus
□ without special findings

MUSCULOSKELETAL SYSTEM: (Bones, joints, muscles)
□ without special findings

BODY CAVITIES: (fat stores, abnormal fluids)
□ without special findings

HEMOLYMPHATIC SYSTEM : (spleen, lymph nodes, thymus)
□ without special findings

RESPIRATORY SYSTEM: (nasal cavity, larynx, pharynx, trachea, lungs, regional lymph nodes)
! Neonates: determine if breathing occurred (do the lung tissues float in formalin?)
□ without special findings

CARDIOVASCULAR SYSTEM: (heart, pericardium, great vessels)
□ without special findings

DIGESTIVE SYSTEM: (mouth, teeth, oesophagus, stomach, intestines, liver, pancreas, mesenteric lymph nodes)
! Neonates: is milk present in the stomach? Meconium in large intestine?
□ without special findings

URINARY SYSTEM: (kidneys, ureters, urinary bladder, urethra. **Check for cystic lesions**)
□ without special findings
Please cut both kidneys lengthwise and check for cysts.

PKD is defined or "reached" when at least three cysts, distributed between both kidneys, are identified.

Because of different definitions of PKD being used in the literature, if you cannot send us the kidneys, **please indicate in the report how many cysts were found in each of the kidneys.**

In addition, please send us both kidneys, even if no cysts were detected; i.e. send

- one half of each kidney, preserved in 4% formalin, and
- the other half of each kidney, deep-frozen, to

Dr. Christian Wenker, Zoo Basel, P. O. Box, CH – 4011 Basel, Switzerland.

REPRODUCTIVE SYSTEM: (testes/ovaries, uterus, vagina, penis, prepuce, prostate, mammary glands, placenta)
□ without special findings

ENDOCRINE SYSTEM: (adrenals, thyroids, parathyroids, pituitary)
□ without special findings

NERVOUS SYSTEM: (brain, spinal cord, peripheral nerves)
□ without special findings

SENSORY ORGANS: (eyes, ears)
□ without special findings

PRELIMINARY DIAGNOSES (summary of macroscopic

findings)

LABORATORY STUDIES (list bacterial, viral, parasitological, toxicologic investigations submitted and results if available)
□ Bacteriology: organs: ……..
□ Virology: organs: ……
□ Parasitology: organs: ……
□ Toxicologic investigations: ……
□ others:

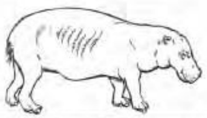
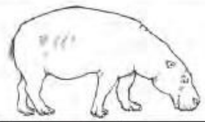
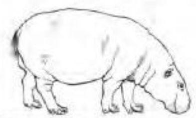
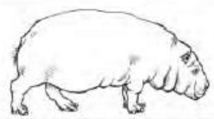
Often, the zoos receive the reports of laboratory studies after the main necropsy report. Please remember to send us copies of these reports as well (they were often missing in past reports).

Histology:
FIXED TISSUE CHECK LIST: **include section of all lesions**, and if possible samples of following tissues:
Cut samples of tissues for histopathology (no more than 0.5 to 1 cm in thickness, in 10% buffered formalin at ratio of **1 part tissue to 10 parts formalin**) and send the histological slides and/or paraffin blocks to Dr. Christian Wenker, Zoo Basel, P. O. Box, CH – 4011 Basel, Switzerland.

- ☐ Lung (sections from several lobes, including a major bronchus)
- ☐ Heart (transverse sections from right and left wall and septum, longitudinal sections including atrium, ventricle and valves from right and left sides)
- ☐ Thymus (may not be present in adults)
- ☐ Trachea
- ☐ Thyroids / parathyroids (leave intact)
- ☐ Liver (sections from 2 or 3 lobes)
- ☐ Adrenal (transverse incision)
- ☐ Kidney (cortex and medulla from each kidney; check for cystic lesions)
- ☐ Urinary bladder, ureters, urethra
- ☐ Spleen (cross section including capsule)
- ☐ Lymph nodes (cervical, mesenterial, bronchial, mesenteric, prescapular, popliteal)
- ☐ Tongue / tonsils
- ☐ Salivary glands

- ☐ Oesophagus
- ☐ Stomach (sections from fundus, cardia, pylorus)
- ☐ Small intestines (duodenum, jejunum, ileum)
- ☐ Large intestines (caecum, colon)
- ☐ Pancreas
- ☐ Reproductive tract (entire uterus and ovaries with longitudinal cuts into lumen of uterine horns. Both testes/epidymis with transversal cuts, prostate)
- ☐ Diaphragm and skeletal muscle
- ☐ Brain (if possible entire brain with longitudinal incision, incl. pituitary gland)
- ☐ Spinal cord (if neurologic disease, sections from cervical, thoracal and lumbal cord)
- ☐ Eyes (intact, remove extraocular muscles and periorbital tissues)
- ☐ Bones (opened rib or longitudinally sectioned ½ femur (marrow must be exposed for proper fixation)
- ☐ Skin (abdominal skin, lip, ear pinna)
- ☐ Neonates (umbilical stump, including surrounding tissues)

Body condition score chart

SCORE	1. Emaciated	2. Underweight	3. Ideal	4. Overweight	5. Obese
					
Head & Neck	• Loose skin sagging around the neck • Sunken, hollow appearance to facial structures	• Thin, narrow neck • Reduced subcutaneous tissue around facial features	• Neck has minimal ventral skin folds • Neck narrower than back of head when viewed from above • Face appears full	• Visible rolls of skin and fat at ventral neck behind angle of jaw. • Neck similar diameter to back of head; no tapering apparent	• Rolls of fat prominent and full on dorsal and ventral neck • Neck is much thicker in diameter than the head
Ribs	• Individual ribs prominent	• Rib cage is apparent but individual ribs not discernable	• Rib cage is not visible, but ribs can still be felt underneath	• Rib cage is not visible, ribs cannot be felt	• Thick fat cover, rib cage is not visible and ribs cannot be felt
Back & Scapula	• Dorsal spinous process of vertebrae visible and prominent along the back • Top of scapula visible • Generalized lack of subcutaneous fat	• Dorsal spinous processes are not visible but can be readily palpated • Top of scapula not readily visible but palpable	• Dorsal spinous processes are not visible and can only be palpated with firm pressure • Top of scapula not visible or palpable	• Dorsal spinous processes not palpable • Scapula not apparent or palpable • Skin rolls noticeable behind the elbow	• The area directly above the spine is indented between layers of back fat on both sides along the length of the spine • Fat rolls quite apparent behind the elbow
Abdomen	• Abdomen tucked up in appearance • Loose skin may be noticeable at ventral aspect	• Abdomen slightly tucked; belly not rounded	• Abdomen full but not sagging; belly slightly rounded	• Abdomen very full; moderate sagging • Skin starts to fold or roll above fore and rear limbs at the elbow/knee	• Abdomen very rounded and noticeably sagging • Fat rolls prominent above the fore and rear limbs at the elbow/knee
Flank	• Flank area sunken and narrow when viewed from above • Transverse spinous processes readily apparent	• Flank area is slightly hollow but not sunken • Edges of the transverse spinal processes visible but not prominent	• Flank is full • Edges of the transverse spinal process not visible but palpable with firm pressure	• Flank appears full and rounded • Edges of transverse spinal process not visible or palpable	• Flank very full and rounded, flank area not discernable
Pelvis &Tail Base	• Pelvic bones are very prominent • Deep, sunken cavity around the tail base (viewed from behind)	• Pelvic bones are visible but covered • The tail base is covered but flat (viewed from behind)	• Pelvic bones not visible, and are only palpable with firm pressure • Tail base full but not rounded	• Pelvic area rounded, pelvis cannot be palpated • Tail base rounded, set within prominent fat	• Pelvic area very rounded, hippo becomes barrel-shaped • Tail base bulging, set deeply in surrounding fat

taken from Flacke, G. L. et al. 2016.