EAZA Best Practice Guidelines

RED PANDA (AILURUS FULGENS)

Drawing copied from Proceedings of the Zoological Society of Londen, 1869.

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EAZA Preamble

Right from the very beginning it has been the concern of EAZA and the EEPs to encourage and promote the highest possible standards for husbandry of zoo and aquarium animals. For this reason, quite early on, EAZA developed the “Minimum Standards for the Accommodation and Care of Animals in Zoos and Aquaria”. These standards lay down general principles of animal keeping, to which the members of EAZA feel themselves committed. Above and beyond this, some countries have defined regulatory minimum standards for the keeping of individual species regarding the size and furnishings of enclosures etc., which, according to the opinion of authors, should definitely be fulfilled before allowing such animals to be kept within the area of the jurisdiction of those countries. These minimum standards are intended to determine the borderline of acceptable animal welfare. It is not permitted to fall short of these standards. How difficult it is to determine the standards, however, can be seen in the fact that minimum standards vary from country to country. Above and beyond this, specialists of the EEPs and TAGs have undertaken the considerable task of laying down guidelines for keeping individual animal species. Whilst some aspects of husbandry reported in the guidelines will define minimum standards, in general, these guidelines are not to be understood as minimum requirements; they represent best practice. As such the EAZA Best Practice Guidelines for keeping animals intend rather to describe the desirable design of enclosures and prerequisites for animal keeping that are, according to the present state of knowledge, considered as being optimal for each species. They intend above all to indicate how enclosures should be designed and what conditions should be fulfilled for the optimal care of individual species.

Preface

The first official version of the husbandry and management guidelines for red pandas in zoos was published in the fifth edition of the red panda studbook in 1988. These guidelines had been compiled over the previous years and were refined at the first red panda conference, which was held in Rotterdam in 1987. Information and ideas from many people were compiled to create these guidelines. During the course of the panda conservation workshop held in Front Royal in 1991, the red panda husbandry and management guidelines was updated. Nevertheless, since these meetings there has been a lot of research into red panda diets, pathology, behaviour etc. AZA published the Red Panda Care Manual in 2011 (AZA Small Carnivore TAG, 2012). Because none of these publications had a focus on European standards, it was necessary to come up with the EAZA Best Practice Guidelines for the red panda.

Acknowledgements

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For the final editing process, the expertise of Angela Glatston (general), Joeke Nijboer (nutrition), Endre Sos, Guillaume Douay (veterinary) and Amy Humphreys (grammar) has been invaluable. My sincere gratitude goes to these colleagues.

Summary

This document reflects our current knowledge of the keeping of red panda (*Ailurus fulgens*) in captive environments. It provides Best Practice Information on successful captive management during the last 30 years.

Section 1., Biology and Field Data, reflects our current knowledge of the species in the natural environment using the most recent taxonomic information.

Section 2., Management in Zoos, covers housing, feeding, social environment, breeding and behavioural management. Managed programmes rely on the movement of animals between zoos and advice on capture, handling and transport is provided. A veterinary section provides information on current knowledge of medical care.

I want to draw your attention to an excellent book about Red Pandas that covers their biology and conservation. The title of the book is “RED PANDA, Biology and Conservation of the first panda”. This book is edited by Angela Glatston who is the former convener of the Red Panda Global Species Management Programme. The fist edition was published inn 2010 and the second edition in 2021.

This document is for all holders of red pandas to ensure the red pandas under our charge will get the best possible care. It is essential that all keepers of these wonderful animals frequently refer to the Guidelines and contact TAG members with any concerns or queries.

Table of content

1. Biology and field data

1.1. Taxonomy

1.1.1. Order

All carnivorous placental mammals are placed in the order of Carnivora. The name 'Carnivora' is derived from the word 'carnivore' and refers to all meat-eating organisms. The order Carnivora includes over 280 species of placental mammals such as: wolves, cats, dogs, raccoons, bears, hyenas, walruses, weasels etc. Suborders of *Carnivora* are: Feliformia (cat-like Carnivora) and Caniformia (dog-like Carnivora).

1.1.2. Family

Carnivora is divided into sixteen families. *Feliformia: Felidae, Herpestidae, Viverridae, Hyaenidae, Nandiniidae, Eupleridae. Caniformia: Procyonidae, Ailuridae, Ursidae, Canidae, Mustelidae, Mephitidae, Phocidae, Obenidae, Odobenidae, Otariidae.* The red panda is the only species that belong to the family of Ailuridae.

1.1.3. Genus

The genus of the red panda is *Ailurus*.

1.1.4. Species

The only species within *Ailurus* is *A. fulgens*.

1.1.5. Subspecies

There are two subspecies of *Ailurus fulgens*: *A. fulgens fulgens* and *A. fulgens styani.* (GROVES, 2011; FLYN ET. AL., 2000). According to Groves (2011), *A. f. styani* and *A. f. fulgens* should be treated as separate species. A recent genetic study (YIBO HUET.AL,2020) also suggest *A. f. styani* and *A. f. fulgens* should be treated as separate species. In this document the traditional nomenclature is used in line with the IUCN redlist (GLATSTON ET.AL. 2015).

1.1.6. Common names

Common names of red pandas are showed in table 1.

Table 1: Common names of the red panda in Latin, English, Dutch, German, French and Spanish.

Languages	Name(s)
Latin	*Ailurus fulgens*
English	Red panda, gold panda, bright panda, lesser panda, bamboo cat or fire cat
Dutch	Rode panda, kleine panda
German	Roter panda
French	Panda roux, petit panda
Spanish	Panda rojo

1.2. Morphology

Ailurus lives in the montane mixed deciduous-conifer forests of the Himalayas and the major mountain ranges of south-western China. It is well-adapted, both morphologically and physiologically to a consistently cool and moist environment.

1.2.1. Body size

Adult *Ailurus fulgens* have a head and body length of 45-60 cm and a tail length of 30-35 cm. Average weights for adult *A. f. fulgens* ranges between 4.5 and 5.5 kg, weight for *A. f. styani's* ranges between 6.5 and 7.5 kg. Females are generally smaller than males.

1.2.2. General description

Besides the size, the differences between the two (sub) species are minor. *A. f. styani* has more robust teeth and the skull is slightly bigger than *A.f. fulgens*. There are also some minor differences in pelage colour. *A. f. styani* has a darker red colour than *A. f. fulgens*. Juvenile red pandas have different body colours than adult pandas, as seen in figure 1. *Ailurus* have erect, triangular-shaped ears, covered with white hair on the ventral side and red or orange-brown hair of the dorsal side and rest of the body. The paws and soles of the red panda also have hair. The striped tail of the panda is a distinctive feature (GLATSTON, 2010), which is used for balance.

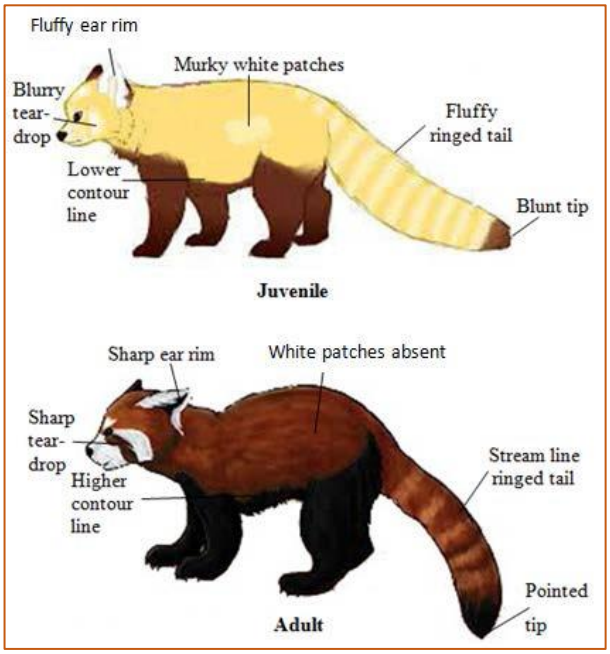


Figure 1. Difference in colours between juvenile and adult pandas (Shrestha et al, 2015) (Top art by Martina Tan and bottom art by Robyn Womack)

1.2.3. Basic anatomy

The dentition of *Ailurus* is similar to the general procyonid pattern but exhibits significant molar hypertrophy and inclusion of supernumerary molar cusps and cusplets that enlarge occlusal surface area presumably to aid in the mastication of bamboo (ROBERTS & GITTLEMAN, 1984). The dental formula is: incisors: 3/3, canines: 1/1, pre-molars: 3/3-4 and molars: 2/2. The red panda has 36 to 38 teeth.

The mandibles of the red panda are robust compared to their body size. Features of the skull and body of the red panda are adapted to the living environment and diet. Robust mandibles are needed for chewing bamboo and can reflect the size of the chewing muscles. Red pandas have less auditory sensitivity (HUNT, 1974)

1.3. Physiology

Morphological and physiological adaptations of *A. f. Ailurus* are specialized for a high-altitude, temperate environment and a bamboo diet. The red panda has dense fur (extending to the soles of the feet) and a low metabolic rate. It is capable of lowering its metabolic rate in cooler conditions. It also has the capability to reduce its metabolic rate without lowering its body temperature, apparently as a conservative energetic strategy.

While the red panda feeds primarily on bamboo, its diet is more seasonally variable than the giant panda (*Ailuropoda melanoleuca*), another bamboo specialist, in that berries, fruits and even young leaves bark, eggs, small mammals and birds are eaten (ROBERTS & GITTLEMAN, 1984).

1.3.1. Digestive system

Red pandas belong to the order Carnivora and are the only species in the family Ailuridae. Red pandas have a simple stomach, with no cecum and a short gastrointestinal tract (STEVENS & HUME, 1995). These are adaptations for the easily digestible foods that usually form the diet of carnivores (i.e. meat). However, in the wild red pandas have specialized in a diet of bamboo leaves and shoots that could account for ~95% of the total food consumed. In autumn, their diet also contains fruits, acorns, and mushrooms (WEI & ZHANG, 2011; WEI ET. AL., 2000;

In the wild, in order to thrive, it is suggested that the red panda selects high-quality portions of the bamboo like the tender leaves and shoots. However, due to a rapid passage rate they have to ingest large quantities (1.5 kg of leaves and 4 kg of shoots, as fed) to maximize nutrient intake and absorption (WEI & ZHANG, 2011; WEI ET. AL., 1999). The simple structure of their digestive system limits the ability to process this high fibrous diet. To cope with this, red pandas have developed several morphological, physiological, and behavioural strategies: 1) skull and teeth adaptations for effective mastication, 2) the ability to select the most nutritious parts of bamboo, 3) daily consumption of large amounts of food and rapid passage time of digesta to maximize the rate of energy intake, and 4) low metabolic rate that reduces energy requirements (WEI ET. AL., 1999).

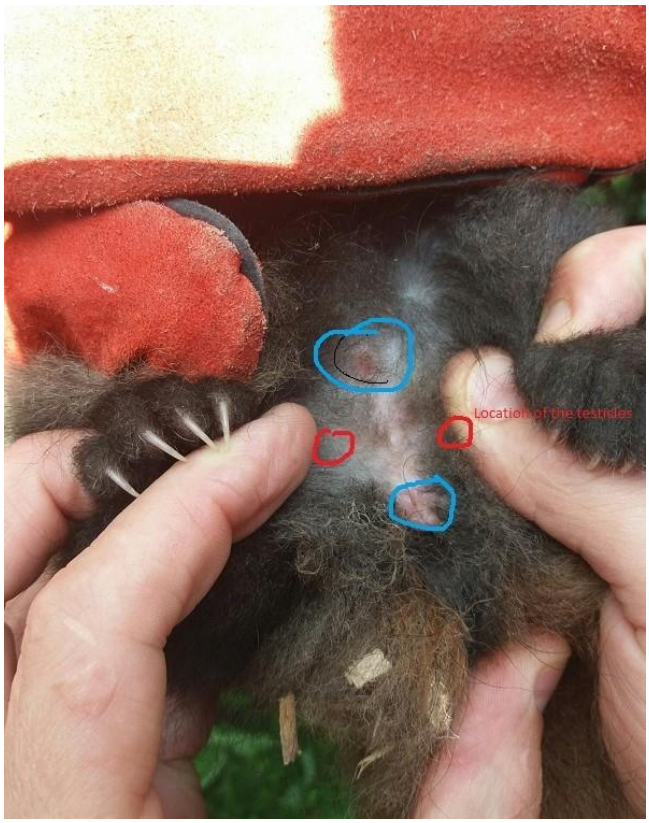
1.3.2. Reproductive physiology of female pandas

The reproductive system is the same as the giant panda, but there are also similarities of the reproductive system of raccoons and skunks (NORTHROP AND CZEKELA, 2011). The reproduction system includes the same organs as mammals, including a uterus and ovaries. Glands that are associated with the reproductive system are absent or reduced. The gestation time of red pandas is not exactly known because a fertilized egg does not implant directly onto the wall of the uterus but remains in the uterus for varying lengths of time. This is known as a delayed implementation.

1.3.3. Reproductive physiology of male pandas

The testes form rounded protuberances in the perineum. There is no scrotum present. The penis and baculum are relatively small, the baculum is only 23mm. Red pandas have a small prostate gland. The Cowper's gland is not present, as well as the glands of the ductus deferens and ampullae (FISHER, 2011).

See Pictures 1 and 2 for the difference between males and females. The distance between the anal and genital opening is shorter in females. The testicles of the male can be palpated quite early in a red panda cub's development.



Picture 1: Male *(photo by Janno Weerman)*

Picture 2: Female (photo by Janno Weerman)

1.4. Longevity

The lifespan of red pandas in captivity is longer than in wild. The average life span is suspected to be 8-10 years in the wild. Life expectancy from birth in captivity is 8,6 years. 25% of the captive red pandas live up to 12,4 years (info PMx 2020). The oldest captive red panda was 21 years. Captive red pandas will always have food available and diseases can be prevented or treated. Red pandas older than 12 years are considered geriatric pandas.

1.5. Zoogeography and ecology

Ailurus f. fulgens is found in the western part of the red panda's range, including India, Nepal and Myanmar. *A.f. styani* is found in the eastern part of the range in China.

1.5.1. Distribution

Red pandas have a large range that extends from western Nepal to northern Myanmar. The species also lives throughout mountainous areas of south-western China (Yunnan, Sichuan and Xizang provinces) at elevations between 2500 and 3800 meters. Figure 2 shows the distribution of the red panda on the map of East Asia.

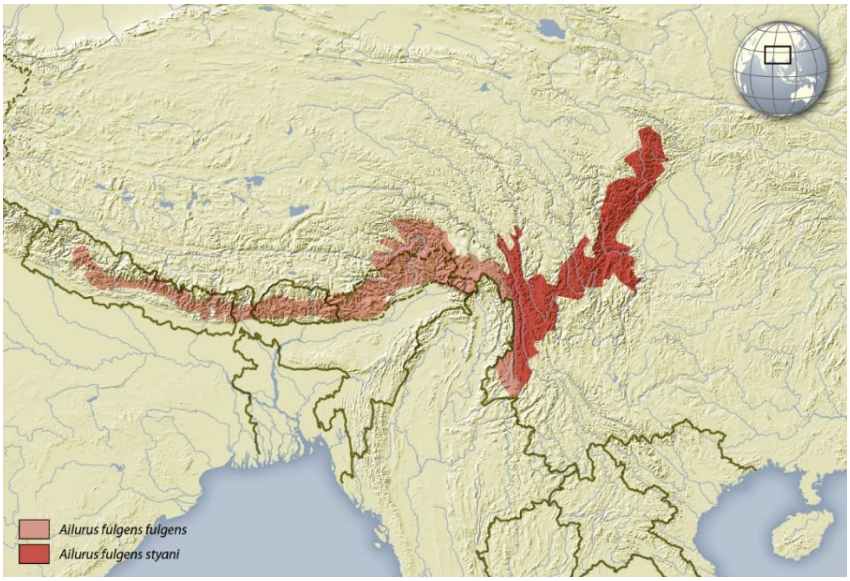


Figure 2. Distribution of *Ailurus fulgens fulgens* and the *Ailurus fulgens Styani (https://bg.wikipedia.org/)*

1.5.2. Habitat

Red pandas live in temperate forests in the foothills of the Himalayas. The temperature in this region is generally cool, and there is little annual variation. The southern slopes of the mountains trap the water from seasonal monsoons, supporting forests of firs, deciduous hardwoods, and rhododendrons. A bamboo understory grows in these forests and provides the bulk of the red panda's diet. However, these swaths of bamboo are only found in narrow bands throughout the red panda's range. Thus, although red pandas are distributed across thousands of miles of territory, they are restricted to these small, fragile areas because of their dependence on the bamboo plants (ROBERTS, 1992).

1.5.3. Population and conservation status

At the species level the red panda is currently listed as Endangered on the IUCN Red List of Threatened Species (GLATSTON ET.AL. 2015). Their actual numbers are far from clear, although it has been suggested that a maximum of 10,000 individuals, both (sub)species combined, may still survive. This estimate is probably optimistic.

The red panda has been classified as Endangered C1 by IUCN because its population in the wild has plausibly declined by 50% over the last three generations and continues to decline (GLATSTON ET.AL. 2015). The status was evaluated in April 2015. Although red pandas are protected by national laws in their range countries, their numbers in the wild continue to decline mainly due to habitat loss and fragmentation, poaching and a possible inbreeding depression (WEI ET AL. 1998). In captivity there were 188 males and 228 females with a total of 416 individual red pandas present in EAZA Zoos in 2020 (WEERMAN, 2020).

1.5.4. Threats

Despite protection, red pandas are still subjected to habitat loss, fragmentation, disturbance and illegal killing. These threats are not likely to disappear in the near future, particularly as the local human populations continue to move deeper into the mountain areas. As a result, the remaining individuals live in highly fragmented subpopulations, some of which are so small that they are vulnerable to stochastic threats.

1.5.5. Conservation actions

A well-managed global *ex-situ* programme for the red panda can therefore contribute to a more viable *in-situ* population in the following ways:

Directly contribute to the conservation of the species by:

- Providing a genetically and demographically sustainable and behaviourally competent backup population for the wild population.
- Holding the potential to supply individuals for genetic or demographic supplementation or reintroduction programmes.

Indirectly contribute to the conservation of the species by:

- Education and the raising of public awareness regarding the biology and conservation of the red panda
- Providing financial, technical, scientific and other support and expertise to the planning and implementation of in situ conservation and research work.

Since 2012 the WAZA Global Species Management Plan (GSMP) partnered with Red Panda Network (https://www.redpandanetwork.org/) to support conservation of red panda's in the wild. RPN is committed in protecting the red panda and their habitat. Local communities are key to red panda conservation. RPN work with the people who live among red pandas to secure sustainable livelihoods and live harmoniously with local wildlife. It is recommended that all in-situ conservation efforts are undertaken in cooperation with the RPN.

1.6. Diet and feeding behaviour

1.6.1. Food preference

The red panda is a vegetarian carnivore and is classified as carnivore by its jaws, teeth and feet. Around 95% of the diet of the red panda consists of bamboo. Primarily young, tender, green bamboo leaves (JOHNSON ET AL, 1988), but sometimes also berries, blossom, bird eggs, insects and fruit when the weather is warm. Because bamboo has a low nutritional value, red pandas have evolved a low metabolic rate which is comparable to sloths.

1.6.2. Feeding

Pandas have to spend to thirteen hours on foraging; searching and eating (NOWAK, 1999), mainly during dawn and dusk. Red pandas rest in trees during the day, but forage for food on the forest floor. Pandas have a small, bony projection on their wrists and sharp claws to grip bamboo. The panda chews the bamboo thoroughly, while the giant panda hardly chews at all.

1.7. Reproduction

1.7.1. Sexual maturity

Sexual maturity of the red panda is measured at the age when they can reproduce. Young become independent at approximately 8 months of age, after which the mother will start a new breeding season. Red pandas are sexual mature at an average age of 18-20 months for both males and females. The first age of birth is around 24-26 months (NORTHROP AND CZEKALA, 2011).

1.7.2. Reproductive cycle of females

The inter-birth interval of red pandas is around 12 months. The oestrus cycle consists of physiological changes by reproductive hormones. The ovarian cycle consists of two phases, which are separated by ovulation. The first phase is the follicular phase; a phase for follicular development. Subsequently, the luteal phase starts: increase in progesterone production signifies ovulation and sustains pregnancy (NORTHROP AND CZEKALA, 2011).

Females come into oestrus for around two weeks. Oestrus occurs during the breeding seasons from December until the end of March, but mostly in late winter. There is evidence that female pandas are poly-ovular because 48% of all births result in two cubs (HOWARD ET AL, 2006). Urinary oestrogens during the peri-oestrual interval show an increase in activity of oestrogen that can be detected 10 days before peak levels. Changes in hormones between pregnant and non-pregnant pandas are similar, which means that all behaviours that are driven by hormones are the same (KERSEY, 1999).

1.7.3. Reproductive hormones in males

During the breeding season some changes in urinary glucocorticoids and androgens are noticeable. Levels of androgen activity peaks prior to the breeding season (STEINMAN ET AL, 2006). Males have the choice to mate with different females, but it is unknown whether males mate with different females (KERSEY, 1999).

1.7.4. Gestation period and birth rate

The average time of gestation is 135 days but varies from 112 to 158 days (ROBERTS AND GITTLEMAN, 1984). There are no signs of pregnancy during the pre-implantations stage of the gestation period, but signs of pregnancy do become evident in the second stage. The female's weight increases, and they become noticeably larger in size. Females are very vigilant during this period, they are restless and there is an increase in food intake, water intake and urination.

1.7.5. Birth

Two weeks before birth starts the female begins to build a nest. Hay, grass, leaves and branches are used as nest material. The female is very active during this period. When birth starts, in late spring and summer, 1-4 cubs can be born, though there are usually two young. The ratio of sexes is equal (PROOIJEN, 1983).

1.7.7. Development

Young grow up with their mother and will remain with her until the next breeding season, when both parents are ready to mate and reproduce again. The male has no active role in caring for the young. The male can show some aggressive behaviour towards the young when the next breeding season starts.

1.8. Behaviour

1.8.1. Activity

Pandas are less active during the day and more active during dusk, dawn and at night. The level of activity depends on temperature, feeding regimes and the breeding season. Red pandas communicate with different vocalizations such as; snorts, huffs, barks, bleats, short whistles and squeaking. After waking they clean their fur, back and belly and subsequently patrol their territory. The pandas curl up like a cat when sleeping and generally sleep in evergreens or tops of limbs.

1.8.2. Locomotion

Movement on the ground is bear-like, characterised by slow, cross-extension movements and also faster bounding or trotting. Red pandas travel a few hundred metres per day. Tree climbing is extremely agile, because red pandas have flexible pelvic and pectoral girdles. They always climb head-first, gripping the trunk with their hind claws. The tail is used for balance.

1.8.3. Predation

The primary predator of red pandas is the leopard. Pandas climb in trees when threatened. Pandas have killed fawns of muntjac (GLATSTON, 2015).

1.8.4. Social behaviour

Red pandas are solitary animals. Males show more territorial behaviour than females. Males have a larger range than females and spend more time on protecting and patrolling their territory, while females mostly stay within the middle of the territory. Both mark their territory with fluid that is released from their anal glands and glands on the base of their feet.

1.8.5. Sexual behaviour

Red pandas rarely interact with each other, except during breeding seasons. This season starts during winter and lasts four months. The scent-markings increase during this season, by urinating or rubbing their anogenital area on trees. Aggressive behaviour occurs mainly in breeding seasons, by fighting over rest or nest places. Females will invite males for sexual interactions.

After sexual interaction pandas will groom each other, but the male leaves the female after mating. The female carries nest materials and builds a nest several days before parturition.

2. Zoo management

2.1. Housing

Careful consideration should be given to exhibit design to make sure that all areas meet the physical, social, behavioural, and psychological needs of the species. Animals should be displayed, whenever possible, in exhibits replicating their wild habitat and in numbers sufficient to meet their social and behavioural needs.

Zoos which are planning to hold pandas for the first time should submit plans of their proposed enclosure to the EEP coordinator for discussion and advice before approval before they receive the animals.

2.1.1. Environment

Temperature and humidity: temperatures at the upper range are of more concern with red pandas than thermal lows, therefore, 50 % of the enclosure should be in shade throughout the day, particularly when temperature is above 24°C. Indoor housing or access to an insulated nest box should be provided where winter temperatures drop below -10°C. Ideally, the temperatures in these areas should be maintained between 2°C and 24°C. The red pandas should always have access to their outdoor exhibit (ROBERTS, 1980). Heat stress in red pandas is greatly exacerbated by high humidity. Air-conditioned indoor holding or nest boxes should be provided where temperatures get above 28°C combined with a high humidity for prolonged periods. This is especially important for pregnant females and cubs. Infant mortality increases at higher temperatures. Zoos subject to hot summer months should provide mist sprays or air-conditioned inside accommodation to keep the animals cool.

The animals must be provided with one nest box more than the number of red pandas in the enclosure. So a minimum of three nest boxes per two animals should be provided which should be situated at different locations within the enclosure. Therefore, the number of nest boxes can be determined by the number of red pandas in the enclosure plus one (n+1). At least two of these nest boxes should be well insulated and placed in shaded locations in the enclosure to maintain an interior temperature not exceeding 20°C. Cool nest boxes should be available in countries where summer temperature is regularly above 23°C for prolonged periods. (GLATSTON, 2015; 2.1.2. Habitat Design DESIGN; 2.5.3. Birthing Facilities).

Light: red pandas should be housed in outdoor exhibits with access to inside quarters if climactic conditions (e.g., extreme heat) warrant it. Natural light is preferable in indoor enclosures.

Water and air quality: red pandas are a terrestrial species that do not require water systems. However, fresh water should be available to all animals at all times of day. Care should be taken so that sufficient water is available and freezing is avoided. When there is no fresh potable water available in the exhibit, sturdy bowls that are not easily overturned are usually suitable for providing water. Animals with restricted water intake will also decrease food intake, so the availability of fresh water is very important (ROBERTS & GLATSTON, 1994). Air exchange rate needs are not generally applicable .

Sound: at this time, it is unknown for red pandas what the tolerances are for sound and vibration; however, as with any wildlife, those disturbances should be kept to a minimum. Noise should be minimized before and after parturition. If air conditioning is used, the unit should be on at least one month prior to parturition to allow for acclimation.

2.1.2. Habitat Design

In captivity red pandas are nocturnal and crepuscular and exhibit a polyphasic activity pattern throughout the night. Their activity patterns change throughout the year in response to temperature, feeding regimes, and the presence of young (ROBERTS & GLATSTON, 1994). Their gross behavioural repertoire includes scent marking, a preference to maintain personal distance except during breeding season, the tendency to climb and hide from disturbing/frightening elements such as loud noises, natural foraging feeding activities, breeding associated activities, young rearing behaviours, and sleep. To accommodate these behaviours and others, enclosures should follow these guidelines (ROBERTS & GLATSTON, 1994).

Environment: red pandas should be housed in outdoor enclosures (indoor enclosures should also be provided where extreme weather conditions indicate that these are required). Where indoor quarters are provided the animals must always have access to the outdoor facility (24 hours/day).

Enclosures should have natural substrate planted with edible grasses and contain a variety of elevations. Red pandas prefer to rest on elevated perches above the level of the viewing public, so the attention should be given to furnishing the animals with this possibility by providing a variety of climbing structures and resting perches at various locations and heights in the enclosure.

Pictures 3: Different examples of natural planted enclosures (photo by Wietse Verwer).

As animals will graze grasses and herbs, it is recommended that at least 50% of the enclosure be planted with (edible) grasses. *Carex* is a grass-like plant that is eaten by most pandas. Red pandas prefer to rest on elevated perches above the level of the viewing public, this should be taken into consideration when furnishing their enclosure to allow the animals this option. Providing a variety of climbing structures and resting perches at various locations and heights in the enclosure is recommended. Living trees are preferable as these provide shade and climbing opportunities. The environment should include rocks, trees, pools, logs, clumps of vegetation etc. These will provide both adequate shade and facilitate the animals' need to withdraw from the direct gaze of the general public at times (UNKNOWN, 2008; ROBERTS & GLATSTON, 1994).

Enclosures require a floor area of at least 150 m^2 but preferably more and should have sufficient climbing structures. The climbing possibilities in the enclosure are more important than the floor area.

Having live, full-grown trees in the enclosure is ideal because of the shelter and shade they provide. It would be preferable to have an enclosure which is 100 m^2 but fully planted with trees and shrubs than a 300 m^2 meadow with no vegetation or climbing possibilities. The required enclosure size is also related to the situation of the enclosure within the zoo. It is recommended that the minimum enclosure size should only be used in very quiet situations where the public is separated from the perimeter of the enclosure by a stand-off barrier, such as a fence or a plant border (UNKNOWN, 2008).

Public access should be restricted to one, or at most two, sides of the enclosure so that animals can retreat from public disturbance. The size of the enclosure and its location within the zoo should be taken into account when planning public access: a large enclosure in a quiet location can have access around a greater proportion of the perimeter, whereas a small enclosure in a busier area should have less public access for viewing. Following parturition red panda females become increasingly intolerant of public disturbance and provision should be made to reduce public disturbance after birth (UNKNOWN, 2008; ROBERTS & GLATSTON, 1994).

Enclosures should not be located near aggressive animals, which could disturb the red pandas: a distance of at least 50 m between a red panda exhibit and that of a large carnivore is recommended. Also, red pandas should not be situated close to busy traffic routes or noisy gathering places. However, enclosure size is an important parameter: animals housed in large enclosures can probably tolerate more disturbance from traffic or the public than those in small ones (UNKNOWN, 2008; ROBERTS & GLATSTON, 1994).

Pandas generally prefer to rest and sleep alone, except during breeding season. Exhibits should be designed with this behavioural norm in mind. Pairs of pandas should not be housed closer than 10 m from one another. Visual barriers should be placed between adjacent pairs (UNKNOWN, 2008; ROBERTS & GLATSTON, 1994).

Scent marking is important for this species. Scent-marking anal glands are present in most carnivores, and red pandas possess a pair that empty into the distal aspect of the rectum. Also on the plantar surface of the feet there are a series of small pores from which small amounts of clear, colourless, and odourless fluid appears of uncertain function (FISHER, 2011). Because of the tendency to mark their environment, furniture/substrate, red panda enclosures should be allowed to build up scent posts. However, these areas should be monitored and cleaned on a rotating basis.

For a more natural feeding scenario mechanisms to fasten bamboo to trees, or other upright structures should be incorporated into the exhibit. PVC pipes that are one inch or less in diameter are recommended for this purpose.

Nest boxes: a minimum of the number of pandas plus 1 nest boxes should be provided to allow hiding and sleeping options for the animals within the enclosure. These should be constructed of insulating material and be placed in different shaded locations around the enclosure. Some part of the enclosure should be in shade throughout the day to provide animals relief from the radiant heat of the sun (ROBERTS & GLATSTON, 1994).

Nest boxes with different shapes and designs have been used in zoos, with measurements ranging from 61 cm wide x 91 cm long x 51 cm high, up to 92x127x76 cm.

Pictures 4 (Bioparc Doué la Fontaine) and 5 (Lille Zoo): Different shapes of next boxes.

Zoos should have two enclosures, or the ability to split one enclosure into two parts. This will enable separation of the male from the female or allow separation of a single sex pair/group. This can be achieved by having an extra enclosure or by having the enclosure split in two parts by a removable bridge (as can be seen in red in the picture below of Rotterdam's exhibit). This extra enclosure should be big enough for one panda as the animal will have to stay in the exhibit for three months (from December to March).

Picture 6: Enclosure Rotterdam with possibility to split (log) in red (camera picture observations camera Rotterdam Zoo)

2.1.3. Barriers and Containment

Barriers may be constructed of mesh, solid walls, moats and fences, glass screen or any combination of the above that does not endanger the health and safety of the animals. Red pandas are not only very good climbers, but they can also swim very well so enclosure barriers should be constructed with this in mind. Barriers should be at least 1,5 m in height, and the surface should be very smooth or be topped with a smooth overhang. Water moats should only be used in combination with other barriers because pandas will be likely to get out of the enclosure if just a water barrier is in place. In the winter, moats should be drained to avoid freezing unless the surrounding barriers meet the criteria outlined above. It is important that branches of climbing trees are not allowed to overhang or be too close the boundary fence. At least 1,5-2 meter between the branches and the boundary fence is recommended. (UNKNOWN, 2008). Beware: red pandas are escape artists.

Picture 7: Wall with overhang Zoo Zurich (photo by Wietse Verwer)

Picture 8: Concrete wall with hotwire Heidelberg Zoo (Photo by Wietse Verwer)

Picture 9: Concrete wall Heidelberg Zoo (Photo by Wietse Verwer)

Hotwire/electric fences is not an effective barrier. Evidenced so far is that pandas ignore hot wire. However, hotwire could be used in some cases to keep wildlife from entering the red panda enclosure. If used, it should be considered a secondary barrier which is more of a defence against intruders and should have an alternating current that is no higher than 6,3 khz. If there are cubs in the exhibit, the hotwire should be turned off or reduced.

2.2. Capture and Transport

Animal transportation must be conducted in a manner that is lawful, safe, well planned, coordinated, and minimizes the risk to animal(s), employees and general public. Safe animal transport requires the use of appropriate means of transportation and equipment that is in good working order.

The equipment must provide for the adequate containment, safety, physical, behavioural and psychological needs of the animal(s). Transport protocols should be well defined and clear to all animal care staff.

Red pandas should only be transported in spring or fall, ideally in temperatures between 5–16°C.

Capture: prior to capture it is helpful if the trees can be made inaccessible to the animals. This can be achieved by tacking a flexible sheet of plastic, 50 cm wide around the trunk of the climbing trees. Hand restraint is not recommended. Red pandas can be safely and easily captured using a net. Another easy way to catch a panda is to use cat doors in the indoor enclosure or nest box. Cat doors with switches that allow doors to swing only out, only in, both in and out, and fully lock give you control of the panda.

After capturing red pandas should always be weighed. When animals are transferred to a new exhibit/zoo, its identification chip should be checked. Pandas are often miss-sexed, especially as infants. It is strongly recommended that, whenever a red panda is transferred to your zoo from the outside, or even when it is transferred between exhibits in your own zoo, that its sex is checked.

Shipping: red pandas should always be shipped individually. Red pandas should be transported in an IATA recommended crate (50 cm long x 40 cm wide x 45 cm high) (IATA ,2020).

One of the short sides of the crate should be made of cage wire for ventilation. Sky kennels or similar airline-approved plastic pet carriers work well. Modifications should be made to prevent airport personnel from accidentally opening crates. Any doors of the sky kennel should be secured with zip-ties on all four corners. Mesh ventilation panels and doors should be loosely covered with an open weave fabric such as burlap to provide privacy without overly restricting airflow.

Each crate should contain a layer of wood wool or similar bedding material. In the event of a longer journey the animal's normal diet can be sent along during transport to provide familiar foods. If being transferred to another institution, sufficient food to transition to an alternative diet should be provided as well. Food and water containers should be securely fastened to the door of the crate with access from the outside to add or refill. Red pandas do not need to be sedated during transport.

Picture 10: Example of a transport crate (photo unkown).

2.3. Feeding

A formal nutrition program is recommended to meet the nutritional and behavioural needs of all red pandas. Diets should be developed using the recommendations of nutritionists, veterinarians as well as EAZA Taxon Advisory Groups (TAGs), and European Ex-situ Program (EEP). Diet formulation criteria should address the animal's nutritional needs, feeding ecology, as well as individual and natural histories to ensure that species-specific feeding patterns and behaviours are stimulated.

2.3.1. Requirements

Energy: animals require energy for basal metabolic functions, in a resting, unstressed, post-absorptive state, in a thermo-neutral environment (no shivering or special activity to maintain body temperature). Basal energy expenditure is related to body surface; Kleiber (1975) concluded fasting homeotherms produce 1,000 kcal of heat per square meter body surface. Kleiber (1975) used previously published research to establish the equation RMR = 70 * (W 0.75) to express kilocalories needed per day for basal metabolic functions. RMR stands for Resting Metabolic Rate and the W for weight in Kg.

Red pandas vary their intake of shoots and leaves relative to seasonal changes both in the wild and in zoos. It was noted by McNab (1988) that the red panda has a low rate of metabolism, which is only 39% of the value predicted by the Kleiber equation at ambient temperature of 25–30^{o}C.

Seasonal influence: red pandas have a higher energy requirement in the winter months and during late gestation, lactation and especially during growth. During these times the animals should always be fed *ad libitum* or enough that at least 3% of the total food offered is left uneaten (NIJBOER & DIERENFELD, 2011).

Body condition: diets should be formulated considering an animal's size, activity level, age, and over-all health. Target weights should be set for each animal and diets formulated to maintain that weight. Red pandas have been noted to become obese from overfeeding, lack of exercise, or a combination of the two.

"Goal weights" for individuals should be established (ideally, general, and seasonal), and body weight checked frequently, so that diet adjustments can be made in a timely fashion to avoid over or under-condition. Wild red panda (*Ailurus fulgens fulgens*) weights range between 3–5 kg, Adult *A. f. fulgens* (in captivity) with a body weight of between 5–6 kg has been found to consume between 145–200g of nutritionally complete hi fibre biscuits/pellet as fed) each day. Examples of appropriate biscuits are leafeater biscuits from Mazuri or DK leaf eater small. This represents intake of animals in a maintenance situation, (e.g., when the animals were under little stress from the weather, not pregnant or lactating, and in the absence of any other food item) (NIJBOER & DIERENFELD, 2011). Due to their dense hair coat and body shape, it is difficult to determine a standard body condition score for red pandas. Photos taken periodically in the same position, over time, may be helpful to pair with weights, as an assessment of body condition. Red pandas can be easily trained to climb on to platform scales and frequent weighing and adjustment of the biscuit portion of the diet is recommended based on weight, condition, intake, and behavioural observations. Careful weight management of breeding pairs, especially the females, is very important. Red pandas have been noted to easily gain weight in zoos and aquariums. This can be managed by regularly monitoring their weight and adjusting diets according to the results.

Nutrients: In Table 4 the target nutrient levels for the red pandas are presented. These requirements are calculated for one adult animal of average weight, per day (taken from Unknown, 2008). Be aware to look at the animal itself and its BCS, nutritional requirements always vary per individual.

Table 2: Target nutrient levels for red pandas (Unknown, 2008).

Nutrients	Recommended minimum level (dry matter basis)
Crude protein (CP)	18.0%
Fat (EE)	5.0%
Fibre (ADF)	10.0%
Calcium (Ca)	0.75%
Phosphorous (P)	0.6%
Sodium (Na)	0.15%
Potassium (K)	0.65%
Magnesium (Mg)	0.1%
Iron (Fe)	100.0 ppm
Copper (Cu)	8.0 ppm
Manganese (Mn)	40.0 ppm
Selenium (Se)	0.18 ppm
Zinc (Zn)	50.0 ppm
Thiamine	2.5 ppm
Riboflavin	5.0 ppm
Vitamin B6	2.0 ppm
Vitamin B12	30.0 ppb
Niacin	30.0 ppm
Folate	600.0 ppb
Biotin	100.0 ppb
Choline	1250.0 ppm
Pantothenate	15.0 ppm
Vitamin A	8000 IU/kg
Vitamin E	220 IU/kg
Vitamin D	800 IU/kg
Linoleic Acid	1%

2.3.2. Diet

Dietary ingredients should be fresh and of good quality. Fresh water should always be available. Every effort should be taken to avoid spoilage of the food during warm weather and freezing during cold. Offering bamboo with a dry biscuit should help eliminate these kinds of problems. To further reduce this problem it is suggested that the animals are fed at least twice per day; at these times fresh food should be provided and the old food removed (NIJBOER & DIERENFELD, 2011). This will help minimize the impact of desiccation of the food items. When animals are housed together it may be important to offer food in more than one bowl and in several locations. This will ensure that all animals will have access to the same food items and will help prevent one animal from potentially dominating the food and excluding others from the more nutritious components of the diet (ROBERTS & GLATSTON, 1994).

In order to monitor food uptake and prevent diseases it is recommended that food be presented in such a way that it is inaccessible to vermin (UNKNOWN, 2008).

Bamboo: If possible 300g of fresh bamboo leaves should be offered daily to each animal. Preferably presented as branches. The preferred species of bamboo are *Pseudosomas* spp., *Phyllostachys aureosulcata*, *P. Japonica*, *P. bissetii*, *P. nuda* etc.

If bamboo is unavailable or only seasonally available, then fibre must be incorporated into the concentrate portion of the diet (the biscuit). If an appropriate biscuit is not provided then an additional fibre source such as ground beet pulp must be provided in some acceptable form (possibly unsweetened gruel) or through an adequate source of grass and plants in the enclosure (NIJBOER & DIERENFELD, 2011).

Biscuit/gruel: Based on current feeding ecology information, red pandas should be offered apart from a large quantity of bamboo, a nutritionally balanced diet of good quality nutritionally complete biscuits. The nutrient profile of this biscuit should consist of roughly: protein 23%, fat 4.5%, acid detergent fibre 13%, Calcium 1.0%, Phosphorus 0.6%) (ERIKSSON, 2012; PRADHAN, 2001; WEI ET. AL., 1999; WEI ET. AL., 2000). Frequent weighing and adjustment of the biscuit portion of the diet is recommended based on weight, condition, intake, and behavioural observations.

Red pandas that are “off” their food (this can occur in varying circumstances) can be tempted to eat by soaking their biscuit in water or apple juice, making a sweetened gruel or by smearing their biscuits with a sweet product. It is important that the sweetener/gruel is withdrawn from the diet as soon as possible to avoid dental problems (NIJBOER & DIERENFELD, 2011).

Young pandas around the time of weaning are susceptible to death due to starvation. Such deaths have been reported in young pandas between 5 -7 Months. It is important to check young pandas regularly at this time. Young animals which are not accepting the normal diet adequately should be provided with a sweetened gruel and extra bamboo during this time. They can be weaned onto the normal diet gradually.

Fruit: can be harmful, especially in large quantities as they will dilute the nutrients in the biscuit thus lowering the nutrient content of the diet (FULTON, 1987; NIJBOER & DIERENFELD, 2011). In addition, fruits provide readily fermentable carbohydrate and little fibre, which is not appropriate for the gastrointestinal health of the red panda.

Fruit can be useful in small amounts as a training reward or when providing medications to the animals as undesirable substances can be presented in a palatable form (NIJBOER & DIERENFELD, 2011). Many

red pandas readily accept apples and bananas, but all produce should be fed very sparingly as it can cause the animals to become overweight.

Provision of food and water: fresh water always needs to be available to all animals. Care should be taken so that enough water is available and freezing of the water is avoided. Where there is no fresh potable water available in the exhibit, sturdy bowls that are not easily inverted are usually suitable for providing water. Animals with restricted water intake will also decrease food intake so the availability of fresh water is very important.

2.3.3 Example diet

According to the nutrition chapter of Red Pandas Care Manual created by AZA Red Panda Species Survival Plan® in association with the AZA Small Carnivore Taxon Advisory Group (AZA Small Carnivore TAG, 2012), the diet ratio should be the amount that is present in figure 3.

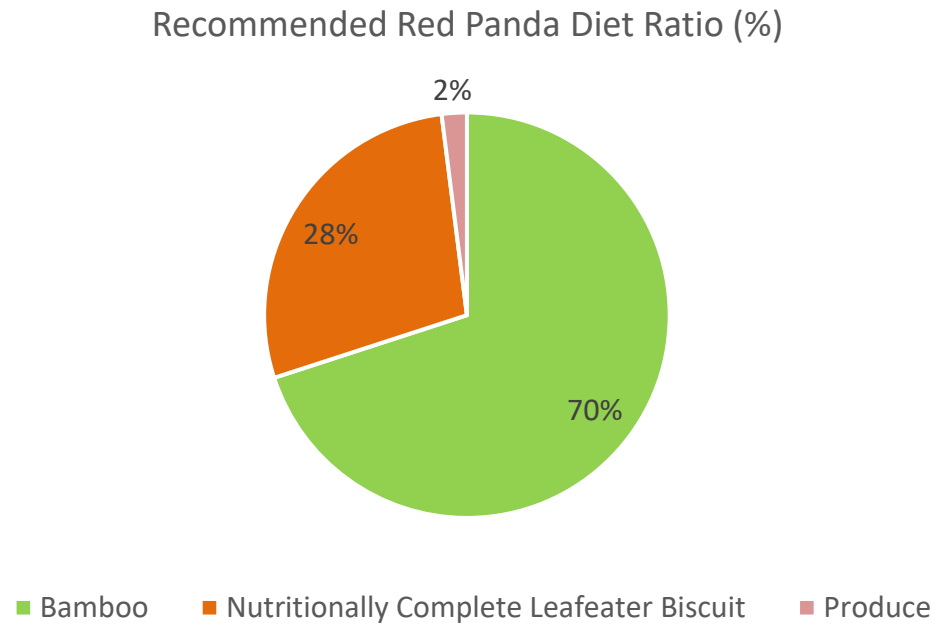


Figure 3: Recommended red panda ratio.

The main component of a red panda diet should be bamboo and completed with leafeater biscuit.
If the bamboo it's not growing inside of the facility, it should be always delivered fresh. Examples of suitable ingredients for a red pandas diet are shown in table 3 and an example of a diet is given in table 4.

You should use the panda cake when, for example, it's an old individual which has problems eating hard food (like the biscuits). If it's a healthy individual you should use the leafeater biscuit because it's better for their teeth compared to the panda cake.
Fruits should only be used for training and medical procedures or only in an insignificant amount in their diet. The fruit can dilute the nutrients of the biscuits and down the nutritional value of them. Food that can be used for extra purposes are shown in table 5.

Table 3: Examples of suitable ingredients to include.

Bamboo	Leaves/ plants (80-90%)	Commercial feeds (5-10%)	Vegetables (5-10%)
Phyllostachys japonica	*Poa pratensis*	Leafeater biscuit	Walnuts
Phyllostachys aureosulcata	*Agrotis alba*	Red Panda's cake	Acorns
Phyllostachys bissetii	*Alopecurus pratensis*		
Phyllostachys nuda	*Lolium perenne*		
	Phleum pretense		
	Trisetum flavescens		

-Fruit can be used as a reward during training, however this should not be in their daily diet

Table 4: Diet example – adult.

	Hour	Food	Amount
Breakfast	8:00	Bamboo	100 g (of leaves)
		Pellets	100g
Lunch	13:00	Bamboo	150 g (of leaves)
Dinner	18:00	Bamboo	150 g (of leaves)
		Pellets	100 g

Table 5: Example of extras for the red panda.

Extras	Food	Regularity
Animal products	Boiled egg Mouse	1 or 2 times per week
Vegetables	Nuts Acorns	1 or 2 times per week
Fruits	Apple Berrys Banana	Training Medical treatment Appetite stimulation

2.3.4. Diet evaluations

Increased or decreased requirements for illness, thermoregulation, or activity can be met by offering diets ad lib and monitoring body weight and condition over time. In general, diets should be offered so that a small amount of food is remaining at the end of the feeding period; however, this should be managed on an individual basis to avoid obesity.

Analysis of weight fluctuations can be a valuable tool for managing individuals and populations. Weight changes can reflect nutritional problems (e.g., obesity and under-conditioning), illness (e.g., cancer, organ failure, etc.), changes in reproductive condition (e.g., pregnancy or weight loss during lactation), and hormonally or environmentally induced changes in metabolism (e.g., prior to dormancy and the

onset of the breeding season). Observing and recording weight changes that correlate with key life history parameters will enable animals to be managed much more effectively and efficiently.

2.4. Social Environment

Dates of the formation of a pair and/or separation of animals and dates of mating are to be recorded and made available on request to the EEP Coordinator. Changes in pairings are to be discussed with the EEP Coordinator before they can go ahead.

2.4.1. Group Structure and Size

Careful consideration should be given to ensure that animal group structures and sizes meet the social, physical, and psychological well-being of those animals and facilitate species-appropriate behaviours.

Breeding pairs should remain together 24 hours per day throughout the year. The male should remain in the enclosure with the female after birth unless there are obvious signs that he is interfering with or inhibiting normal maternal care.

Young may remain with the parents at least through the next breeding season and up to one month prior to the next anticipated birth. Juveniles should not be separated from their parents earlier than about 7 months of age (February in Europe) to ensure proper socialization and weaning. To avoid inbreeding, young should be separated from their opposite sex parent at no older than 18 months (UNKNOWN, 2008). The young should remain together after separation until they are placed in breeding pairs, juveniles of more than one litter can be housed together. Singletons should be housed with other young to ensure socialization, every effort should be made to locate other similar aged young for this purpose.

Adult males (>18 months old) are not to be housed together in the presence of a female. Even when no female is present, all male groups can be difficult and are best only attempted in large enclosures and should be monitored closely. Male siblings who have been together since birth can usually be maintained successfully as groups in the absence of females.

Single sex pairs and single sex groups have been formed to slow down population growth. After 7 years of forming single sex pairs and groups, there are no major issues encountered. It is noted that pandas from 8- 9 months of the same sex are fine when put together. Females appear to be put together more easily than males. A study which has been conducted in Gaia Zoo shows that there were more agonistic behaviours than affiliative ones between the members of their bachelor group (4 males of which 2 were related) (De Feijter, 2017) Moreover, if affiliative behaviours occurred, most of them were taken place between two siblings, which suggests that it is better to house siblings together to avoid agonistic behaviours as much as possible (De Feijter, 2017).

2.4.2. Influence of Others

Red pandas are typically maintained in single species exhibits. In 2010, the zoos that were holding red pandas at that time were asked if they were or had held pandas with other species. The following table shows which species have been exhibited with red pandas and any considerations or problems that occurred. This information was mixed with the data on mixing carnivorans VII by Krisztián Svábik (SVÁBIK, 2020). More information can be found on the following website: http://zoorope.hu/en-mixed-exhibit-procyonidae-ailuridae/

Table 6: Species successfully exhibited with red pandas.

Common Name	Scientific Name	Considerations / problems
Chinese Muntjac	*Muntiacus reevesi*	• Both species share the exhibit during the day; the pandas are closed into their shelter and separated from the muntjac overnight. • Need a nice slow intro- then non-breeders seem to do fine. • A muntjac ended up breaking its leg trying to get out of the exhibit and panicking with people around. • During breeding season for the pandas, pandas sometimes became aggressive. Pandas were aggressive towards muntjac fawns and can kill muntjacs. • Separate feeding in a mixed species enclosure with 4 different species can be difficult.
Michie's Tufted Deer	*Elaphodus cephalophus michianus*	• Similar to Muntjac (above)
Urial	*Ovis orientalis vignei*	• Species ignore each other.
Chinese Goral	*Naemorhedus griseus*	• Species ignore each other.
Blackbuck	*Antilope cervicapra*	• No problems stated
Southern Cassowary	*Casuarius casuarius*	• Very peaceful couple of cassowaries, might be different with other individuals.
Crane spp.	*Grus spp.*	• White-naped, black-necked and red crowned crane. • They all get along very well. Pandas stay up in the tree 90% of the time.
Indian Peafowl	*Pavo cristatus*	• No problems stated
Bewick's Swan	*Cygnus bewickii*	• Separate feeding in a mixed species enclosure with 4 different species can be difficult.
Common Shelduck	*Tadorna tadorna*	• Separate feeding in a mixed species enclosure with 4 different species can be difficult.

2.4.3. Introductions

Red panda introductions rarely result in aggression, but should be done gradually nonetheless. It is better to introduce a male to a female once she is established in the enclosure. Gradual introduction (e.g., olfactory, followed by visual, followed by physical contact) in neutral territory is preferred. Providing distractions (e.g., bamboo or treats spread through the introduction area) can help ease introductions. Care should be taken not to provide areas where one animal can corner another

Pair formation should occur no later than the end of November, 6 weeks prior to the onset of the breeding season, which occurs in the late winter months in captive populations of the northern Hemisphere (December – March).

2.5. Breeding

It is important to have a comprehensive understanding of the reproductive physiology and behaviours of the animals in your care. Hand rearing red pandas is generally not practised in European zoos; however, if the EEP coordinator finds it is necessary from a population management perspective and this can be agreed upon with the respective institution, information about hand rearing of red pandas is presented in appendix 2.

2.5.1. Reproductive Physiology

As per studbook data, both male and female red pandas will reach sexual maturity at approximately 1 year and 7 months of age (in the second breeding season after birth). In Europe, red pandas breed in the late winter months, between December–March. Red pandas give birth from May – July after a gestation of from 114 to 145 days (NORTHROP & CZEKALA, 2011).

2.5.2. Pregnancy and Parturition

It is extremely important to understand the physiological and behavioural changes that occur throughout an animal's pregnancy. The average gestation varies from 114 to 145 days (NORTHROP & CZEKALA, 2011). Ultrasounds have been successful in determining pregnancy. Ultrasounds can easily be done with training. It is not advised to anesthetize for ultrasounds.

Picture 11: Ultrasound Rotterdam Zoo (picture Rob Dolaard)

Some research is occurring on running faecal assay hormones to determine pregnancy and more research in this area is required.

There are very few signs of impending parturition, decreased activity about 1 month before birth has been observed. Increased appetite is common, and diet increases are recommended. A change in gait will be noticed, such as a distinctive waddle, within a week of cubbing. The female may build nests in the nest boxes with any available material, but this is not always the case. Nests can be elaborate with multiple materials, or simple with just a few leaves. Nest materials should not be removed, if faecal material is present, the faeces should be removed. Within one or two days of birth, grumpiness, restlessness and decreased appetite may be noted. Females will occasionally give birth outside of the nest boxes. In these cases, the females will usually move them into the chosen nest box on their own, but if they don't, monitor the situation and decide whether intervention is necessary.

Normally, red panda mothers spend nearly all their time in the nest box during the first weeks after parturition; cubs should be evaluated if mothers are spending excessive amounts of time out of the nest box. Red panda mothers will move cubs between nest boxes but moving cubs excessively or constantly carrying cubs around enclosures can indicate that the female is not comfortable with nest boxes or the environment and can result in injury to cubs or cub abandonment. If temperature is too hot the female spends less time with cubs, this is probably the reason for higher infant mortality in hotter conditions Additionally, mothers will sometimes cause injury to cubs due to excessive grooming.

When the occasion occurs that cubs are not getting enough milk form their mother, supplemental feeding can be a better alternative than hand rearing.

2.5.3. Birthing Facilities

As parturition approaches, animal care staff should ensure that the mother is comfortable in the area where the birth will take place.

The provision of at least three, insulated nest boxes located in shaded or air-conditioned areas is recommended. Nest boxes from 60.1 cm wide x 91.4 cm long x 50.8 cm high to 91.4 cm wide x 127 cm long x 76 cm high have been used in zoos. Wood wool, straw or other appropriate bedding should be provided for all nest boxes.

The female should be left in her familiar enclosure with the male. Following parturition red panda mothers become increasingly intolerant of public disturbance and provisions may have to be made to ensure disturbance is kept to a minimum. Since containment may be altered for the cub's safety, other measures may need to be taken.

2.5.4. Contraception

Institutions without a breeding recommendation have several options to avoid offspring. One of those is to contracept an animal before the breeding season. Surprelorin is an implant which can be used on males and females. It is recommended to use it on the female, because it takes 3 weeks to work, whereas males may remain fertile for two months or more after insertion.

A survey conducted on the effect of Surprelorin supports existing literature that the contraceptive effects of Suprelorin implants are longer than the minimum effective time of the contraceptives (e.g. 3 years rather than 6 months for 4.7mg implants). Therefore, if recently implanted animals receive breeding recommendations, it is feasible to expect that the recommendation may only be fulfilled a minimum of 3 years after the implants have been inserted; provided they have not been removed.

We would recommend removal of the implants to facilitate reversals as the source of reproductive suppression is removed. As locating and removing Suprelorin implants can be difficult if placed intrascapularly, we would advise *placing* the implants in an alternative site where the skin is thinner therefore making them easier to locate e.g. inner thigh, base of ear, around the navel area. This also facilitates the removal procedure. Placing implants in these alternative sites has been shown to be effective (EGZAC, 2017).

2.5.5. Population management

The European red panda population has grown significantly over the past years; from 276 individuals in 2012 to 431 individuals in 2021. Population growth had been exclusively due to captive birth, since Europe has consistent reproductive success. The number of births has increased from 27 births in 2004 to 78 births in 2014. In 2013, single sex pairs and groups were introduced to slow down population growth. Since 2014 breeding recommendation are send out annually. This decision resulted in a stabilized population. Since 2018, breeding is slowly increased, because of an increased demand (WEERMAN, 2020).

When formulating breeding recommendation the following guiding principles are used; reducing the rate at which inbreeding is accumulated and gene diversity is lost within the population. With 28 founders, the mean inbreeding coefficient was 0.0675 and the genetic diversity had a rate of 91,32% in 2020 (WEERMAN, 2020).

2.6. Veterinary Care

Medical care must be provided at all institutions by qualified veterinarians either on a full-time or a consulting basis. The institution's veterinarians are encouraged to contact the vet advisors and the coordinator of the EEP to discuss medical practices.

Holders need to notify the EEP coordinator of any significant medical problems.

Blood and other tissue samples should be made available (at the zoo veterinarian's discretion) on request of the EEP Coordinator, for genetic analysis or for the monitoring of physiological parameters. Please contact the EAZA biobank when samples are taken and can be shared.

2.6.1. Routine Health Inspections

Routine health observations of red panda are no different from any other "small carnivore" species. Any nonspecific clinical signs such as diarrhoea, vomiting and lethargy should be investigated and treated as per other carnivore species.

Animals which appear to lose weight or do not look in optimal condition need diet enhancement or medical attention. Obtaining regular weights is essential for good management of these animals. Red pandas are easy to train and can be weight on demand. Forethought in the nest box design by integrating a weighing scale will minimize the potential disturbance of monitoring infants in the nest or when obtaining cub weights.

Parasite checks should be conducted at least twice yearly and include:

- Direct smear for the detection of protozoa (e.g., amoeba, ciliates) or motile larvae.
- Flotation methods for nematodes, cestodes, and coccidia.
- Sedimentation techniques for identification of lungworm larva.

Reported lungworms species in red pandas are *Crenosoma* sp., *Troglostrongulus* sp., *Angiostrongylus vasorum* and *Metastrongyloides* sp. Most parasites are easily identified and treatment with appropriate parasiticide is efficient. An animal should be considered free of parasites only after two successive examinations post-treatment.

Red pandas are susceptible to heartworm disease (*Dirofilaria immitis*) and preventative measures needs to be taken in the geographical range of the parasite (southern Europe).

Red pandas are reported to be affected by fleas, especially in warm weather. The infestation can be severe, and on some occasions have led to death, especially in cubs during nesting period. The animal can present hypersensitivity lesions as observed in domestic animals. Flea infestation prevention and control is necessary during warmer months of the year. Regular changing of bedding material, environmental treatment with appropriate and safe insecticides and oral or topical medication for the animal at risk.

Red pandas are highly susceptible to canine distemper virus (CDV), which is always fatal. The typical signs, catharal pneumonia and acute necrotizing inflammation of several organs, are found in panda and the animal often dies within few days. Prevention of exposure to canine distemper and vaccination against the disease is critical. Red panda should never be vaccinated with live or modified live virus vaccine to avoid vaccine-induced disease. Killed virus vaccines need to be use such as Purevax® (Merial) but provision is difficult and need importation from North America. Red pandas in Europe are only vaccinated against Feline Panleucopenia (FPLV) with vaccine such as Fel-o-Vax® (Boehringer Ingelheim).

Several studies are ongoing about vaccination and canine distemper in red pandas. Ideally animals should be vaccinated against CDV with three injections, one month apart then yearly.

Recently, a new virus, Amdoparvovirus has been isolated from red panda causing peritonitis, pancreatitis and myocarditis. More studies are needed to understand the extent and importance of the disease within the captive population.

Ideally, an initial series of vaccinations should start at eight weeks and be repeated every three weeks for 16 weeks; red pandas should be vaccinated once to twice a year, depending on the epidemiological context for protection (ROBERTS & GLATSTON, 1994). However, depending on the situation it may be relevant to delay the first vaccinations to avoid disturbing maternal behaviour.

Rabies vaccination with a killed vaccine is used in endemic rabies areas. Red pandas develop titres comparable to protective titres in domestic carnivores following vaccination with a 1 ml dose intramuscularly (IM) (ROBERTS & GLATSTON, 1994). Similarly killed vaccine products should be administered when vaccinations against feline enteritis are considered necessary by the attending veterinarian.

As a potential source of pathogens, rodents need to be controlled as part of the overall preventative medical program. Special precautions should be taken to ensure that pandas do not have access to any rodenticides.

2.6.2. Capture and Immobilization

Red pandas can be safely and easily captured using an appropriate net and protective device for the manipulator. It is essential to usher the animal into an enclosed space before restraining and avoid any capture at height. A swinging pet door link to the den or the nest box is an easy way to capture a panda. Also, this species is easily trained for entering crate voluntarily. Minor procedures such as vaccinations or injections can be achieved without sedation either by manual or squeeze cage restrain or even by operant conditioning. (ROBERTS & GLATSTON, 1994).

Red panda are not a difficult species to sedate and a wide range of technics and protocols have been used. Prior to sedation a fasting period of 12 hours is recommended, and the animal should be in a familiar and comfortable place to decrease any unwanted stress.

Volatile drugs such as isoflurane have been used either by mask or in an induction chamber but should be reserve to young or debilitated animals.

Injectable anaesthesia is the safest technique in adult panda and several protocols have been used so far. Dosages are informative and need to be adapted to each situation and animal (see table 7 for some protocols)

Table 7: Drugs protocols for capture and immobilization.

Drugs protocol	Mean Dosage (mg/kg)
Tiletamine - Zolazepam	5
Ketamine	5
Medetomidine	0.06
Dexmedetomidine	0.025
Ketamine	3.5
Midazolam	0.2
Ketamine	10
Xylazine	1.5
Ketamine	4
Medetomidine	0.05
Midazolam	0.2
Medetomidine	0.03
Butorphanol	0.1
Tiletamine - Zolazepam	1
Tiletamine - Zolazepam	3
Medetomidine	0.025

It is advisable to use a protocol for which some drugs are reversible in case of emergency or for a faster recovery. For prolonged procedures such as major surgery and when available, the anaesthesia should be maintained with an inhalation anaesthetic and the animals intubated (ROBERTS & GLATSTON, 1994).

Opportunistic measurements should be taken during any sedation, including total length (tip of nose to tip of tail), tail length (base to tip of tail), chest girth, waist girth, hind foot length. For lactating females, a milk sample should be collected and analysed to better understand the milk composition and aid the development of possible milk substitutes (UNKNOWN, 2008).

2.6.3. Quarantine

Quarantine duration and testing needs to follow local and regional legislation (BALAI and national legislation).

If a full health examination is needed during the quarantine period, a complete physical examination, including dental examination, blood parameters and radiographic examinations should be performed. Animals should be evaluated for ectoparasites and treated accordingly. Vaccinations should be updated as needed.

2.6.4. Diseases, disorders and/or injuries

Red pandas are generally robust animals, but there are some health conditions this species should be closely monitored for.

Dental diseases we're common in red pandas and most of the time attributed to inadequate diet (not enough bamboo and too much soft food). Animals fed soft gruel diets or high quantity of fruits are prone to periodontal disease characterised by tartar accumulation, gingivitis leading to lose teeth causing

severe pain and malnutrition. The major form of prevention is to offer the recommended diet and reduce or even remove high sugar items.

Alopecia is commonly found in red pandas. The seasonal moult can be pronounced, especially on the flanks and the tails. This usually occurs in spring, but some individual exhibit it during fall. Any abnormal hair loss outside of the moulting seasons or abnormally prolonged moult should be thoroughly investigated with a full dermatological examination including ectoparasite check, skin scrap up to skin biopsies. Endocrinopathies such as hypothyroidism or hyperestrogenism are hypothesised as well as poor nutrition. (ROBERTS & GLATSTON, 1994). The origins of uncontrolled hair loss at random moment of the year being not still fully understand, more research is needed on this topic. Self-plucking cannot be excluded.

A frequent dermatologic condition affecting young pandas is dermatophytosis or ringworm. The animals exhibit focal crusty alopecia associated with flaky skin on the face, head and under the neck and feet. In severe case the lesions are ulcerated. When not treated on time, lesions can lead to severe scars or even amputation of the tail. Treatment consists of clipping the affected area and applying topical iodine and anti-fungal agents. Systemic treatment with anti-fungal is needed for severe condition.

Mucoid stools is frequently reported by holders in North America. It never used to occur in the EAZA region but is becoming more common. The animal exhibits lethargy, dysorexia and abdominal discomfort 24 to 48 hours before passing mucoid faeces, the animal will immediately go back to normal after. Frequency is dependent on the individual and can vary from every other week, up to once a year and seem not to be related to the diet. In rare cases, the animals will present vomiting. The cause is still unknown, and several studies are ongoing to better understand this condition.

Geriatric animals above 12 year old should be checked regularly for aging conditions such as spondyloarthropathies, kidney and liver failure and dental condition.

In the literature several cases of infectious disease in red panda have been reported: tuberculosis, erysipelas, salmonellosis, Chagas' disease, Tyzzer's disease, and toxoplasmosis. Neoplasia’s seem to be a rare or underreported condition is this species.

For more detailed information on Red panda medicine, please refer to Glatston, A.R. ed., 2010. Red Panda: Biology and Conservation of the First Panda (chapter 15; Captive Red Panda Medicine)(PHILIPPA & RAMSAY,2010).

2.6.5. Individual Identification

ID/identification is a necessity in all species. Red pandas need to be permanently identified with a passive integrated transponder subcutaneously in the interscapular region. The corresponding ID number needs to be communicated to the coordinator and recorded on ZIMS.

2.6.6. Post-mortem Provisions

All red pandas that die need to undergo a full necropsy by a qualified veterinarian to determine the cause of death. The post-mortem should be conducted in accordance with the standardised protocol found in the Appendix 1.

A detailed post-mortem report needs to be sent to the EEP Coordinator. Tissues are to be submitted to the owner's institution for special projects upon request. Disposition of the skin, skeleton and all other tissues is to be determined by the facility and in accordance with local legislation. Neonatal post-mortem: special attention is needed for neonatal deaths. The following list includes information needed from neonatal animals (including aborted foetuses, stillbirths and neonates up to 30 days of age). Examine all specimens submitted including partially consumed carcasses.

1. Body weight, sex and estimate degree of maturity/ immaturity.
2. Crown-rump and other morphometric measurements.
3. Examine skin and umbilicus (fix section of stump and surrounding skin in formalin); pelage – texture, colour and amount (if any) of fur.
4. Examine external malformations (check for cleft palate, hare lip and other facial, skull, trunk and limb abnormalities)
5. Assess state of hydration (subcutaneous and serosal surfaces dry or moist) and nutritional status (record subcutaneous and body cavity fat stores as: none, moderate of abundant).
6. Examine internal malformations (e.g. diaphragmatic hernia, cardiac abnormalities etc.)
7. Determine if the animal had breath before dying with the lung float test Place a segment of lung in water if lung floats animal probably breathed; if the lung sinks the animal had probably not breathed (if no proof of pneumonia).
8. Determine sex by examining gonads
9. Determine nursing activity by looking for and estimating amount of milk curd (white cottage cheese like substance) present in the stomach and the presence of "milk stool" (yellow-white semi-solid material in the colon) with absence of meconium (greenish-brown pasty material throughout the gastro-intestinal tract).

Proceed with the standard red panda post-mortem protocol as seen in Appendix 1. If available, collect samples from the placenta or any foetal membranes.

2.6.7 Safety

Human Interaction: to a large extent, red pandas are not dangerous; however, they are more than capable of protecting themselves. Red pandas have strong, sharp claws and a very strong bite. They can cause injury when trying to climb a person like a tree. There have been a few cases of red pandas that have exhibited aggression towards keepers, most commonly with hand raised individuals. In case of aggression, the ability to move the animal to another area for cleaning is recommended. Red pandas have been successfully trained to enter holding areas or crates, to station on scales and even to hold for injections, palpation, and vaginal swabs.

2.7. Behaviour Management

2.7.1. Animal Training

Classical and operant conditioning techniques have been used to train animals for over a century. Classical conditioning is a form of associative learning demonstrated by Ivan Pavlov. It involves the presentation of a neutral stimulus that will be conditioned (CS) along with an unconditioned stimulus that evokes an innate, often reflexive, response (US). If the CS and the US are repeatedly paired, eventually the two stimuli become associated and the animal will begin to produce a conditioned behavioural response to the CS.

Red pandas are easily trained to move, target, crate up, tolerate close visual inspection, medicate, and perform many other routine procedures. Red pandas can easily be trained to enter a nest box or shipping crate for food (ROBERTS & GLATSTON, 1994).

It is recommended not to use red pandas in animal encounters or feeding sessions with visitors. It is unknown what influence the animal encounters/visitor feeding sessions have on their normal behaviour. Because we don't know the long-term impact of animal encounters/visitor feeding sessions the EEP coordinator discourages these animal encounters/visitors feeding sessions. The main concerns are: Do we unintentionally select pandas with a certain personality fit to cooperate in animal encounters? Are these "selected" lines in the long term suitable to reintroduce in the natural habitat?

Keeper talks combined with food distribution can be used, however no visitors should enter the enclosure on a regular basis or during these talks.

2.7.2. Environmental Enrichment

Environmental enrichment refers to the practice of providing a variety of stimuli to the animal's environment, or changing the environment itself to increase physical activity, stimulate cognition, and promote natural behaviours. Stimuli, including natural and artificial objects, scents, and sounds are presented in a safe way for the red pandas to interact with. Some suggestions include providing food in a variety of ways, using the presence or scent/sounds of other animals of the same or different species, and incorporating an animal training (husbandry or behavioural research) regime in the daily schedule.

2.7.3. Staff and Animal Interactions

A keeper/animal association based on trust and consistency is important with red pandas and can pay off at extremely critical periods (McMillan et al., 2002). For example, females with offspring are very sensitive to environmental disturbances during the nesting season. Resulting maternal stress may increase the likelihood of cub mortality through such means as excessive carrying or grooming, or milk suppression. If a female is comfortable with keeper presence and has a working routine, she is more likely to be calm and cooperative during cubbing season.

Animal training and environmental enrichment protocols and techniques should be based on interactions that promote safety for all involved.

Red pandas have been successfully trained to enter holding areas or crates, to station on scales and even to hold for injections, palpation, and vaginal swabs. Keepers generally work in enclosures with red pandas, taking care to give the animals opportunity to avoid keepers. Red pandas should, however, be regarded with caution as they do have sharp claws and extremely strong jaws, and will defend themselves and their young.

2.8 Recommended research

Breeding

- Research on running faecal assay hormones to determine pregnancy is required.

Veterinary care

- Origins of uncontrolled hair loss at random moment of the year being not still fully understand.

References

AZA Small Carnivore TAG (2012). Red panda Care Manual. Association of Zoos and Aquariums, Silver Spring, MD. pp. 90.

Choudhury, A. (2001) “An overview of the status and conservation of the red panda *Ailurus fulgens* in India; with reference to its global status”. Oryx 35, pp. 250-259

Conway, K.(1981) “Supplemental feeding of maternally reared Red pandas (*Ailurus fulgens*)” International Zoo Yearbook 21, pp. 236-240 The zoological society of London, UK

Eriksson, P., Zidar, J., White, D., Westander, J., Andersson, M. (2010) “Current husbandry of red pandas (Ailrurus *fulgens*) in Zoos”. Zoo boil 29, pp. 1-9.

Fisher, R., (2011) “Red panda anatomy”, A.R. Glatson, (Ed.). Red panda: biology and conservation of the first panda (pp. 89-100) Academic press; London, UK

Flyn, J., Nedbal, M., Dragoo, J., Honeycutt, R. (2000). “Whence the Red panda?” Molecular Phylogenetics and Evolution 17(2), pp. 190–199.

Fulton, K., Crissey, S., Oftedal, O., Ullrey, D. (1987). “Fiber utilization in the red panda”. Proceedings of the 7th Dr. Scholl Conference on the Nutrition of Captive Wild Animals.

Glatston, A. (2010). Red panda. Norwich, N.Y.: William Andrew.

Glatston, A., Wei, F., Than Zaw & Sherpa, A. (2015). "Ailurus fulgens". IUCN Red List of Threatened Species. Version 2015.2. downloaded 01-03-2020, from www.iucnredlist.org

Groves, C. (2011) “The taxonomy and phylogeny of *Ailurus*” A.R. Glatson, (Ed.). Red panda: biology and conservation of the first panda (pp. 101-124) Academic press; London, UK

Howard, J., Huang, Y., Wang, P., Li, D., Zhang, G., Hou, R., Zhang, Z., Durrant, B.S., Spindler, R.E., Zhang, H., Zhang, A., Wildt, D.E., (2006). Role and efficiency of artificial insemination and genome resource banking. In: Wildt, D.E., Zhang, A., Zhang, H., Janssen, D.L., Ellis, S. (Eds.), Giant pandas: biology, veterinary medicine and management. Cambridge University Press, Cambridge, U.K., pp. 469-494.

IATA. (2020). “*Container requirement 82*”. Live Animal Regulations 46th Edition. IATA.

Johnson, K.G., Schaller, G.B. and Hu, J. 1988. Comparative behaviour of the red and giant pandas in the Wolong reserve, China. Journal of Mammalogy 69, 552-564.

Kersey, D.C. (1999). Reproductive and Adrenal Endocrinology of the Giant Panda (Ailuropoda melanoleuca): A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at George Mason University. George Mason University: Fairfax, VA.

Kleiber, M. (1975). “The Fire of Life: An Introduction to Animal Energetics; 2nd ed.”. Melbourne, FL: Kreiger

McDonald, D. (Ed.) (2001) “The encyclopedia of Mammals” Oxford university press, UK

McMillan, G., Drummer, L., Widner, K., Glass, S. (2002). “Establishing a Behavioral Management Program for the red panda (*Ailurus fulgens*)”. Knoxville Zoological Gardens. Red Panda SSP Keeper Workshop, Knoxville Zoological Gardens, October 18 – 20, 2002.

McNab, B. (1988). “Energy conservation in the tree kangaroo (Dendrlolagus matschiei) and the red panda (*Ailurus fulgens*)”. Physiological Zoology 61, pp. 280–292.

Nijboer, J., & Dierenfeld, E. (2011). “Red panda nutrition: how to feed a vegetarian carnivore”. A.R. Glatson, (Ed.). Red panda: biology and conservation of the first panda (pp. 257–270). Academic press; London, UK

Northrop, L. & Czekala, N. (2011) “Reproduction of the Red panda”, A.R. Glatson, (Ed.). Red panda: biology and conservation of the first panda (pp. 125-145) Academic press; London, UK

Nowak, R. (1999) “Walkers mammals of the wild; 6th ed.” The Johns Hopkins University Press, Baltimore and London; MA

Hunt, R.M., (1974) The auditory bulla in carnivora: an anatomical basis for reappraisal of carnivore evolution, J.Morphol, 143 (21-76).

Philppa, J & Ramsay, E., (2010) “Captive Red Panda Medicine”. A.R. Glatson, (Ed.). Red panda: biology and conservation of the first panda (pp. 271-285) Academic press; London, UK

Pradhan, S., Saha, G., Khan, J. (2001) “Ecology of the red panda (Ailruus *fulgens*) in the Singhalila National Park”. Biology of Conservation 98(11). Darjeeling, India

Prooijen, van, E. (1983). Gedrag van de kleine panda. Temperatuursinvloeden op het gedrag. (unpublished)

Roberts, M. (1980). “Breeding the red panda (*Ailurus fulgens*) at the National Zoological Park”. Zoologischer Garten, 1980, pp. 253–263.

Roberts, M. (1992). Red panda: the fire cat. ZooGoer, March/April, National Zoo

Roberts, M. & Gittleman, J., (1984). “*Ailurus fulgens*”. Mammalian Species 222, pp. 1–8.

Roberts, M. & Glatston, A. (1994) “Management and Husbandry Guidelines for red panda”. As adopted by the AZA Red Panda SSP, Red panda Studbook, and International Red panda Management Group. National Zoological Park, Washington, D.C.

Shrestha, S., Bahadur, S. Bista, D. and Baral, H.M. (2015). Photographic Identification of Individual Red Panda (*Ailurus fulgens* Cuvier, 1825). Applied Ecology and Environmental Sciences, vol. 3, no. 1: 11-15

Steinman, K., Monfort, S.L., McGeehan, L., Kersey, D., Gual-Sil, F., Snyder, R., Wang, P., Nakao, T., Czekala, N., (2006). Endocrinology of the giant panda and application of hormone technology to species management. In: Wildt, D.E., Zhang, A., Zhang, D., Janssen, D.L., Ellis, S. (Eds.), Giant pandas: biology, veterinary medicine and management. Cambridge University Press, Cambridge, pp. 198-230.

Stevens, C., & Hume, I. (1995). “Comparative Physiology of the Vertebrate Digestive System; 2nd ed.” New York, NY: Cambridge University Press.

Svábik, K. (2012). Mixed-species exhibits with Raccoons (*Procyonidae*) and Red Panda (*Ailuridae*). Budapest Zoo and Botanical garden, Hungary.

Unknown (2008), “Husbandry and management guidelines”, downloaded 17-6-2013, from www.eaza.net

Weerman, J. (2020). Red Panda Annual Report 2020 and recommendation 2021, downloaded 31-12-2020, from www.eaza.net

Wees, M. van (2012) “Red Panda EEP studbook report 2012”, downloaded 17-6-2013, from www.eaza.net

Wei, F., Feng, Z., Wang, Z., Hu, J. (1998) “Assessment on the current status of the Red panda in China”. Small Carnivore Conservation 18: pp. 1-4

Wei, F., Feng, Z., Wang, Z., Zhou, A., Hu, J. (1999). “Use of the nutrients in bamboo by red panda (*Ailurus fulgens*)”. Journal of Zoology, London 248(4), pp. 535–541.

Wei, F., Wang, Z., Feng, Z., Li, M., Zhou, A. (2000). “Seasonal energy utilization in bamboo by the red panda (*Ailurus fulgens*)”. Zoo Biology 19(1), pp. 27–33.

Wei, F., & Zhang, Z. (2011). “Red panda ecology”. A.R. Glatson, (Ed.). Red panda: biology and conservation of the first panda (pp. 193–212). San Diego, CA: Academic Press.

Yibo Hu, Arjun Thapa, Huizhong Fan, Tianxiao Ma, Qi Wu, Shuai Ma1 , Dongling Zhang, Bing Wang, Min Li , Li Yan, Fuwen Wei (2020) Genomic evidence fortwo phylogenetic species and long-term population bottlenecks in red panda. SCIENCE ADVANCES.

Appendices

Appendix 1: Red Panda Post-Mortem Protocol

INSTITUTION/OWNER .....

ADDRESS ..... COUNTRY .....

SUBSPECIES ..... ID#..... ISIS#..... STUDBOOK .....

BIRTH DATE/AGE ..... SEX ..... WEIGHT (KG) ..... (ACTUAL/ESTIMATE)

DEATH DATE ..... DEATH LOCATION ..... DATE OF PM .....

WILD CAUGHT/ CAPTIVE BORN (delete as appropriate)

HISTORY (Include clinical signs, circumstances of death, lab.work, diet & housing)

GROSS EXAMINATION

(If no abnormalities are note mark as normal, N, or not examined, NE)

GENERAL EXAMINATION (Physical and nutritional condition, pelage, subcutaneous fat stores, body orifices, superficial lymph nodes)

MUSCULOSKELETAL SYSTEM (Bones, marrow, joints, muscle)

BODY CAVITIES (Fat stores, pleura, thymus, lymph nodes)

RESPIRATORY SYSTEM (Nasal passages, pharynx, larynx, trachea, bronchi, lungs, lymph nodes)

CARDIOVASCULAR SYSTEM (Heart, pericardial sac, great vessels, myocardium, valves, chambers)

DIGESTIVE SYSTEM (Mouth, teeth, tongue, oesophagus, liver & gall bladder, pancreas, stomach, small & large intestine, anus)

SPLEEN

URINARY SYSTEM (Kidneys, ureters, bladder, urethra)

REPRODUCTIVE SYSTEM (Testes/ovary, uterus & cervix, penis/vagina, accessory sex organs, mammary gland, placenta)

ENDOCRINE SYSTEM (Thyroids, parathyroids, adrenals, pituitary)

CNS/SENSORY ORGANS (Brain, meninges, spinal cord, eyes, ears)

ADDITIONAL COMMENTS AND OBSERVATIONS:

Prosector:..... Date:.....

SUMMARISE PRELIMINARY DIAGNOSES:

LABORATORY STUDIES (Results of cytology, fluid analysis, urinanalysis, serum chemistries, bacteriology, mycology, virology, parasitology, X-ray photography)

TISSUE CHECK LIST

Where possible freeze 3-5 cm blocks of tissue from major organs (e.g. lung, liver, kidney, spleen) in small plastic bags, preferably in liquid nitrogen to be kept ultra-frozen at -70°C; freezing at conventional temperatures is acceptable if there is no access to an ultra-freezer.

Preserve as many of the following tissues as possible in 10% buffered formalin at a ratio of 1 part tissue to 10 parts solution. Tissues should be no thicker than 0.5 - 1.0 cm.
NOTE: There is generally no need to fix and label each tissue separately. Take two sets of fixed tissue, one for the Primary Pathologist and the other for the Regional Pathologist. Send tissues required for diagnosis to the Primary Pathologist and request a duplicate set of slides for the Regional Pathologist who should be contacted for further instructions. Also freeze post-mortem serum (from the heart), urine and any abnormal fluid accumulations. Consult regional breeding programme coordinator for a Special Projects Protocol for any special instructions about specimens requested by a Designated Researcher.

- Brain
- Nerve (Sciatic)
- Spinal Cord
- Eye
- Tongue
- Oesophagus
- Trachea
- Thyroid
- Parathyroid
- Pituitary
- Heart
- Muscle
- Diaphragm
- Liver
- Gall bladder
- Spleen
- Pancreas
- Stomach
- Small intestine
- Large intestine
- Caecum
- Skin
- Aorta
- Bone with marrow
- Testis/ovary
- Uterus
- Mammary gland
- Ureter
- Urinary bladder
- Urethra
- Kidney
- Adrenal
- Thymus
- Prostate
- Lymph node
- Salivary gland

PRIMARY PATHOLOGIST:

Name .....

Lab. .....

Address .....

(Please attach final pathology report and send a copy with this protocol to the EEP coordinator)

Appendix 2: Hand-Rearing

1. Due to a powerful sucking response that could result in aspiration of liquid, animals should be initially fed by stomach tube (size 5-10 French, depending on animal size). A measured volume is delivered by syringe. The procedure is simple and easily taught to handlers by veterinary staff. Attempts at bottle-feeding should be delayed until animals are well stabilized to milk formula (one week longer, depending on animal age and condition). Initial bottle-feeding attempts should utilize a sterile solution of 5 % dextrose and 0.9% NaCl in case of aspiration. For young pandas the small teats designed for premature human infants may be appropriate. Bottle feeding can be adopted when controlled sucking is obtained. The size of the hole in the teat is important for regulation of milk flow rate and should be monitored periodically to avoid excessive milk flow.

2. The milk formula used is a solution of powdered Esbilac (Borden, Inc.) in boiled water to which a lactase enzyme preparation (Lactaid; Lactaid., 600 Fire Rd, P.O. Box 111, Pleasantville, N.J. 08232) is added at rate of 1 drop per 100g formula (Lactaid is available is a product used by persons with lactose intolerance). The formula should be pre-digested with the enzyme for 24 hours in a refrigerator or for 90 minutes at 90-95^F (e.g. in a water bath). Due to possible bacterial contamination we use the 24-hour formula for one day only (discard at 48 hours after initial preparation). 90-minute formula is kept for only 12 hours prior to being discarded. Formula is kept refrigerated after the predigestion period and only the amount required for each feed is warmed prior to feeding.

3. For the first few feeds the formula should be very dilute (7% Esbilac by weight, i.e. 7g Esbilac, 93g boiled water, 1 drop Lactaid) to allow acclimation to formula constituents. Formula concentration is gradually increased in stepwise fashion (10%, 12%, 15%, 18%, 20% Esbilac) according to animal performance and age. Thus the formula concentration might reach 15% strength in one week and 20% in three weeks. Formula is kept at this strength until weaning. In some instances paediatric vitamins (ABDEC, Parke-Davis, Morris Flains, N.J. 07950) or iron supplements have been given to hand reared red pandas but these not be necessary in most cases as Esbilac contains generous levels of these nutrients.

4. Animals are initially fed at 3-hour intervals (8x per day). As the animals stabilize and get stronger the interval can be increased to 4 hours (6x per day). The amount fed per day is based on body weight; therefore, it is essential to weigh the animals each day. A typical regimen for the first week would be 25-30% of body weight distributed over 8 feeds (3.1-3.8% of body weight per feed). The amount to feed is recalculated at 3-4 days intervals based on body weight changes. As the animal ages the percentage of body weight fed per day is gradually reduced, e.g. at about one month old the panda is fed 20-25% of its body weight per day, at 2 months old 16-18% per day and at 3 months old about 15% per day. These amounts are modelled after milk intakes of mother-reared carnivores; small (undersized) animals should be fed at the upper end of these percentage ranges.

5. Weaning is commenced at approximately 3 months by adding panda gruel (see below) to the formula (e.g. 1 tsp. per bottle). Then animals must be taught to feed from a bowl, which can prove difficult. In one case the teat had to be placed in the bowl of formula to initiate feeding. The amount of gruel added is gradually increased such that animals are fully weaned by 5 to 6 months. Red pandas resist rapid dietary change. Bamboo and salad (apple, carrot, green bean) are offered separately from about 70-90 days to allow

manipulation and investigation, they may not be eaten at first. Water should be made available as solids are introduced.

6. The gruel to which animals are weaned is prepared daily, kept refrigerated and the excess discarded after 24 hours. A batch of about 760g is composed of the following: 114g Gerber's mixed cereal, 276g evaporated milk, 57g applesauce, 1 tablespoon vitamin-mineral supplement (Pervinal, Pet Products & Co., Brentwood, N.Y. 11717), 1/2 tablespoon honey, 2 egg yolks and 284 g boiled water.

7. Hand reared red pandas gain weight at a rate equal to or above that of mother-reared young. Weights of hand reared animals are provided below. Early weights of animals pulled due to small size are excluded (i.e. animals much smaller than those below are underweight).

- birth ca. 100 g
- 10 weeks 0.9 - 1.4 kg
- 2 weeks 160 - 210 g
- 4 weeks 260 - 360 g
- 6 weeks 460 - 650 g
- 8 weeks 650 - 960 g
- 3 months 1.3 - 1.9 kg
- 4 months 1.8 - 2.6 kg
- 5 months 2.4 - 3.7 kg
- 6 months 3.2 - 4.8 kg

8. Additional considerations:

- Animals should be reared as a group to prevent abnormal socialization as they mature. Since young animals tend to suck on each other, they may need to be housed separately for an initial period.
- Stimulate young animals to induce elimination. Older animals may develop soreness in the anal region from frequent scent marking (anal rubbing) of objects in the enclosure
- The normal range for rectal temperature appears to be 35.2- 36.6°C. Rectal temperatures above 37.2-37.8 °C may indicate a medical problem. Rectal temperature should be monitored once or twice a day in young animals.
- Young pandas are initially kept in an incubator or warm box at 29.4-32.2degrees Celsius. As they mature, they are prone to heat the stress. Fans can help in hot weather.
- Provide climbing apparatus for older animals but beware: red pandas are escape artists.
- Nails will require periodic trimming, even so it may be necessary to wrap older animals in a towel for feeding to avoid scratches. Handlers, will need heavy trousers when animals start to climb on them.

9. In order to aid the development of a new milk substitute, any zoo which has to sedate a lactating panda is asked to obtain a milk sample for analysis.