SUNDA PANGOLIN

Manis javanica

HUSBANDRY GUIDELINES

First Edition, 2014

Nguyen Van Thai, Leanne Clark and Tran Quang Phuong

CARNIVORE & PANGOLIN CONSERVATION PROGRAM
Chương trình Bảo tồn Thú ăn thịt và Tê tê

Cuc Phuong National Park, Vietnam

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Status of Sunda Pangolin

Vietnam	II B of 32/2006/ND-CP
IUCN	Endangered (A2d+3d+4d) (IUCN, 2010)
CITES	Appendix II, A zero annual export quota

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These husbandry guidelines for the captive care of Sunda pangolins have been a work in progress since the first three confiscated pangolins arrived in the Carnivore and Pangolin Conservation Program, Cuc Phuong National Park, on 9th October, 2006. Along the way we have made mistakes, but we have learnt from our experiences working with 41 pangolins in captivity. We have been privileged to work with such an amazing species.

These husbandry guidelines would not have been possible without the hard work and dedication of many different people and organisations.

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Chapter 1 - Taxonomy

1.1 Nomenclature

Class : Mammalia
Order : Pholidota
Family : Manidae
Genus Species : *Manis*

1.2 Common Names

English: Sunda Pangolin, Malayan Pangolin
French: Pangolin Javanais, Pangolin Malais
Malay: Tenggiling
Spanish: Pangolín Malayo
Vietnamese: Tê tê java, Trút, Trút Bò, Trút Cơm, Trút Mỡ

In 1998, changes to the taxonomy of the Family Manidae lead to a separation of the Philippine form. This species is now known as *Manis culionensis* (Feiler, 1998; Esselstyn *et al*., 2004; Gaubert and Antunes, 2005).

1.2 Subspecies

No subspecies known

Chapter 2 - Natural History

2.1 Morphometrics

The information in Table 2.1 was derived from the measurements of 20 adult male and 17 adult females held in the CPCP, from the wild in Singapore (Lim, 2008; Lim, *pers. comms*.), and Night Safari (Vijayan *et al*., 2008). Pangolins are sexually dimorphic so the data is shown for each sex.

Table 2.1 Morphometric measurements of males and females

Morphometric measurements	Males	Females
Head-Body length (cm)	52.44 ± 1.92 (n = 18)	45.29 ± 1.47 (n = 14)
Tail length (cm)	51.32 ± 1.89 (n = 18)	39.29 ± 0.93 (n = 14)
Weight (kg)	7.55 ± 0.39 (n =20)	4.17 ± 0.31 (n =17)

2.1.1 Diagnostic Features

Pangolins are anteaters and somewhat similar in appearance to the armadillos found in South America.

They are light brown in appearance with a creamy underbelly. With the exception of their neck and belly, they are covered with protective overlapping scales that have bristles in between them.

They are terrestrial but have adapted to an arboreal habitat with a prehensile tail. They use this tail for hanging, climbing and feeding in the trees.

All pangolins have a conical shaped head with a long snout. They have very small external ears, no teeth, and they have a very long sticky tongue which is used to lick up insects, particularly ants and termites (Payne and Francis 1998).

Their feet are powerful with long claws which are used to dig into termite and ant nests, and dig sleeping burrows underground (Lim and Ng, 2008). Both of the front and back claws are similar in length.

Distinguishing features between M. javanica and other pangolin species

There are eight extant pangolin species. Four species can be found in Asia and the other four in Africa.

Asian pangolins are easily distinguished from the African pangolins as they have bristles between their scales; while there are no bristles between scales of African pangolins.

The Asian species consist of Sunda *(Manis javanica*), Chinese (*M. pentadactyla*), Indian (*M. crassicaudata*), and Philippine (*M. culionensis*) pangolins. The Sunda pangolin (*M. javanica)* differs from the Chinese pangolin (*M. pentadactyla*) and the Indian pangolin (*M. crassicaudata*), because they have more than 20 scales along the edge of their tail and their claws on the hind feet are almost as long as their fore feet. Both Chinese (*M. pentadactyla*) and the Indian (*M. Crassicaudata*) pangolins have fewer than 20 scales along the edge of their tail, and the claws on their hind feet are much smaller than fore feet.

Expert knowledge is required to distinguish between the recently described Philippine pangolin species (*M. culionensis*) from the Sunda pangolin *(M. javanica*). In 2005, Gaubert *et al* published a paper describing the use of morphometric data to distinguish between the Philippine pangolin and Sunda pangolin (see Table 2.2 below).

Table 2.2: Diagnostic characteristics of the Philippine pangolin and Sunda pangolin taken from Gaubert *et.al*. (2005).

Species-diagnostic characters	***Manis culionensis***	***Manis javanica***
Total no of lateral scale rows	19-21	15-18
Size of scales in nuchal, scapular, and postscapular regions	Small	Large
Ratio of head-body : tail length (Mean ± SD)	1.11±0.03 (n = 5)	1.25±0.13 (n = 20)

However, analysis of measurements of 32 Sunda pangolins carried out by the CPCP showed that ratio of head-body and tail length is **1.09** ± 0.14 (Mean ± Standard Deviation) (unpublished data), which differs from the results published by Gawbert *et.al.,* 2005. This result suggested that there is no significant difference between the ratio of head-body : tail length of *Manis culionensis* and *Manis javanic*a.

We recommend that further research on the use of morphometric data to differentiate between these two species is required. In the meantime we discourage the use of the ratio of head-body: tail length for identification.

2.2 Distribution

The range of Sunda pangolins includes Central and Southern Vietnam, Laos, Thailand, Cambodia, Myanmar, Malaysia, Brunei, Singapore, and Indonesia (Sumatra, Java, Borneo). Sunda pangolin (*M. javanica*) is distributed across the forest of Southeast Asia except in the Philippines which has its own species of pangolin (IUCN 2008).

Figure 2.1 Distribution of Sunda pangolin (IUCN, 2010)

Sunda pangolins (*M. javanica*) have been recorded in Central and Southern Vietnam, but not in the North (Newton et al, 2008; Fig 2.2).

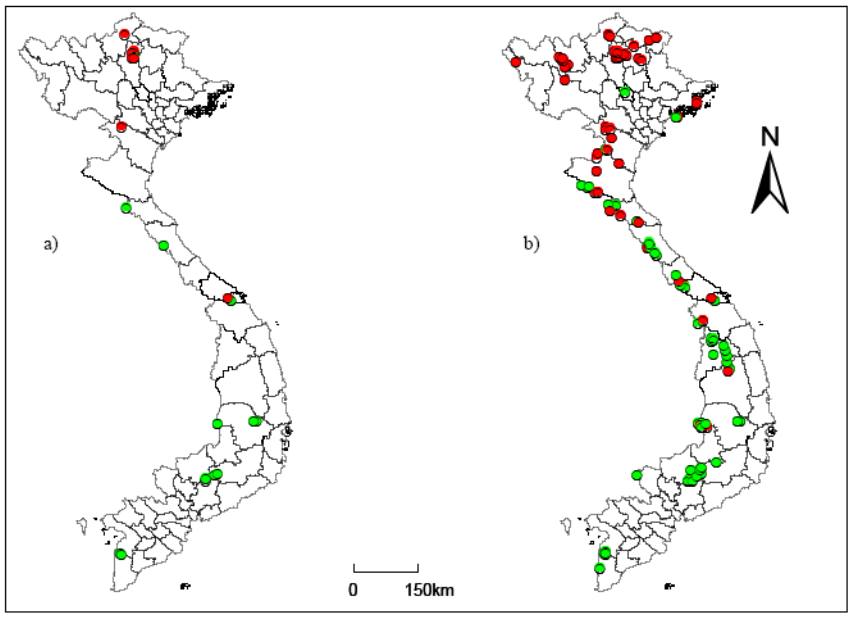

Figure 2.2: Distribution of *M. javanica* (green dots) and *M. pentadactyla* (red dots) within Vietnam. Based on a) scientific records and b) interview data and reports. Reprinted from Newton *et al.*, 2008.

2.3 Habitat

Sunda pangolins (*M. javanica*) are found in a variety of habitats including primary forests, secondary forests, thick bush, grasslands, and plantations (Duckworth *et al*., 2008; Lim and Ng, 2007; Newton *et al.*, 2008). This species has been recorded from sea level up to 1700 m (Duckworth *et al*., 2008).

Knowledge of the species habitat preferences is limited since there has been only one published field based study of Sunda pangolins (*M. javanica*) conducted in Singapore (Lim and Ng, 2008; Lim, 2008). In this study, one female *M. javanica* used tree hollows extensively, but was reported to feed in open areas. The size of trees in which the female was observed using as natal dens were tree hollows that had diameters of >50cm. The species also was found to dig burrows underground burrows beneath rotten logs, tree stumps, or rocks.

2.4 Wild Diet and Behaviour in the Wild

The following information is based on the studies by Lim and Ng (2008) and Lim (2008) and information from pangolin hunter interviews from Newton *et al*., (2008).

Sunda pangolins (*M. javanica*) are nocturnal mammals. They sleep during the day in tree hollows, burrows, amongst dense foliage on branches (e.g. amongst orchids and epiphytes), or in clumps of tall grasses.

Pangolins awake at night to hunt for ants and termites. They often sniff the air while walking which makes them very noisy as they move through the forest. They are excellent climbers using their claws and tails to grip bark and climb trees, and they are reportedly good swimmers (Sanyal 1892). They can also run surprisingly fast when threatened or can roll up into a ball to protect themselves from predators.

Pangolins have long, powerful foreclaws that are used to demolish ant and termite nests, to climb trees, and to dig burrows. They locate insects using a well developed sense of smell, and use their extremely long and sticky tongues to capture and eat them. Based on a radio-tracking study of 22 pangolins which were captured for a radio tracking study in Singapore, the species spent an average of 67% of their foraging time feeding on ants and 33% on termites (Lim 2008). Eleven ant genera were recorded as being eaten. The pangolins in the study showed a preference for *Polyrachis* spp. and *Anoplolepis gracilipes* and avoided *Philidris* spp. and *Myrmicaria* spp. (Lim, 2008). Hunters in Vietnam also reported that wild pangolins' diet includes bee larvae (Newton *et al*., 2008).

2.5 Longevity

2.5.1 Longevity in the Wild

Longevity of wild pangolins is currently unknown

2.5.2 Longevity in Captivity

One Chinese pangolin (*M. pentadactyla*) has survived in captivity for over 23 years at Ueno Zoo in Japan. It is unknown how long Sunda pangolins (*M. javanica*) can survive but this species was first kept in captivity in 1929.

Table 2.3: Longevity of Sunda pangolin (*M. javanica*) in captivity

Days survived in captivity	**Name of institution/organisation**	**Time**	**Source**
2023	Angkor Centre for Conservation of Biodiversity, Cambodia	04 Jun 2005 – 18 Dec 2010 (still alive)	Handschuh (2008)
1531	Carnivore and Pangolin Conservation Program, Vietnam	9 Oct 2006 – 18 Dec 2010 (still alive)	CPCP records
915	San Diego Zoo	01 May 1966 – 02 Jan 1969	Heath, *et al*. (1988)
368	Washington National Zoo	03 Oct 1966 – 06 Oct 1967	Heath, *et al*. (1988)
363	Houston Zoo	02 Sep 1966 – 31 Aug 1969	Heath, *et al*. (1988)

Chapter 3 - Housing Requirements

3.1 Quarantine Enclosure Requirements

3.1.1 Quarantine Enclosure Design

The quarantine enclosure is typically used for *Manis javanica* for the first 30 days after arrival in the CPCP. Within the centre, animals which are unwell are also commonly moved to the quarantine for treatment and observation, in order to separate them from the main resident population.

On arrival, pangolins are typically stressed, may be very active and may try to escape. Enclosures with thick, smooth walls are required to prevent the animal from escaping, and to reduce the risk of injuries.

The CPCP suggests:

- The floor surface area of each enclosure should be at least $4m^2$ and the walls at least 2m high.
- Each enclosure should have one small pond as a water source and for bathing (described in more detail in section3.1.6)
- Concrete flooring should be at least 10cm in depth to prevent the animal digging and escaping. The floor should be smooth and sloped to make it easy to clean and to keep the enclosure floor dry.
- The walls should be made of concrete and very smooth to prevent the animal from climbing.
- The doors should be made of solid metal and the door must be well fitted to the walls so the pangolins cannot put their claws in the door/wall gap to climb up.
- The ceiling should be made with small wire mesh (2cm x 2cm) to let sunlight through to dry the enclosure and to provide fresh air.
- A solid roof should cover 40% of the ceiling (described in more detail in section 3.2.1)
- *Manis javanica* have very powerful forefeet, so if the wire mesh overlaps it needs to have at least a 10cm overlap, and joins must be adequately secured to prevent escape – we recommend a minimum of 10cm between any wire ties.
- Outside of the main enclosures, an enclosed service corridor should be in place in case the animal escapes during feeding, cleaning or while carrying out treatment.

The CPCP has a quarantine area with 18 separate enclosures, covering $144m^2$. This area has been divided into three separate blocks of six enclosures each. Enclosures were specifically designed to keep pangolins, but can also be used to keep small carnivore species.

Each enclosure in this facility has a floor area of 2 x 2.5m, and a height of 2m. All enclosures have concrete walls and a wire ceiling with mesh of 2 x 2cm. This small mesh size is important as larger size mesh can allow the animal to put its head out of the wire, causing superficial skin trauma. One wall includes a metal door and also two openings (30 x 30cm) which lead to two bedboxes. Outside of the enclosure is a fenced service corridor.

3.1.2 Position of Enclosures in Quarantine

Enclosures should be built on flat ground in an area of good drainage. Planting of trees around the enclosures can help keep the enclosures cool and provide wind protection.

3.1.3 Quarantine Weather Protection

Pangolins are strictly nocturnal mammals, so sunlight is not an issue unless it affects the temperature within bedboxes or other sleeping areas. However, enclosures do require a dry area for feeding the animals during wet weather. A solid roof over at least 40% of the enclosure's ceiling provides an element of protection from sun, wind and rain.

The service corridor outside of the enclosure also needs to be roofed to provide weather protection for staff and equipment.

In the CPCP, the total floor area of each enclosure is $4m^2$. This area is completely covered by wire mesh. However $1.6m^2$ of each enclosure also has a solid tile roof for protection. The service corridor outside the enclosures is totally covered by a roof to protect the bedboxes from rain and heat, and to provide a protected area for staff.

Figure 3.1: Quarantine service corridor

3.1.4 Quarantine Substrate

Walking on a concrete floor can cause abrasions to the feet of pangolins. If the pangolin appears healthy, and has tested negative for the presence of gastrointestinal parasites on faecal floatation, leaf litter and logs can be added to the enclosure floor. If animals have health problems, or have not previously been tested for the presence of gastrointestinal parasites, do not add to the substrate, as a smooth concrete floor is easier to thoroughly clean.

If an animal has finished its quarantine period, but is still being kept in a quarantine enclosure (e.g. because of space constraints), place soil and plant plants in the enclosure so that the animal has an opportunity to dig (Figure 3.3).

Figure 3.2: Quarantine enclosure modified with porthole (indicated by a red arrow) and a soil substrate for longer term care of pangolin

3.1.5 Quarantine Enclosure furnishings

Quarantine Bedboxes

Include at least one den/bedbox per animal. In the CPCP, two bedboxes are provided per enclosure to allow choice. Bedboxes should be large enough for one adult animal to turn around and curl up in comfortably. In the wild *M. javanica* prefer sleeping in tree hollows so bedboxes should be made from the wood and positioned in a dark place away from the heat and light.

One bedbox should be placed at ground level, to make it easier for weak animals to enter the box from the floor of the enclosure. Another box can be placed higher up. Bedboxes should be positioned so that they are easy to check and to capture animals for health assessments and treatment (Figure 3.3).

Figure 3.3: Interior of quarantine enclosure; tight fitting metal door, two bedbox entrances, branches for climbing into the top bedbox, concrete feeding

In the CPCP bedboxes are put inside a concrete shell that has openings on both sides – one has a small 30 x 30cm opening into the enclosure, the other side opens fully onto the corridor. The bedboxes are placed inside the shell via the corridor opening and can be accessed from the corridor. The top of the concrete shell has been made very smooth and can be used as a tabletop on which to place equipment or to place animals on during treatment (Figure 3.4).

Figure 3.4: Bedbox area in use in Quarantine; two bedboxes, top of sleeping area being used as a shelf for paperwork. Note the two slots (indicated by red arrows) for slide gates so that the animal can be shut in bedbox if needed.

Quarantine Bedding Material

Pangolins must be provided with bedding material year-round, particularly when the bedbox is made of hard wood or concrete. Straw, dry leaf litter, hay, sand, soil, paper, wood shavings and wood-chips have all been used.

Bedding in the CPCP consists of:

- Summer - dry leaf litter which the animal can nest in, or alternatively easily push away if they are hot
- Winter - straw which is easier for the animals to wrap around themselves to keep warm. Some other facilities have suggested that straw may cause irritation to pangolin's eyes; however this has not been seen in the CPCP.

Quarantine Climbing Material and Structure

M. javanica is a very good climber. The enclosure should therefore have enough space for furnishings that enable the animal to climb. Branches, logs and tree stumps are ideal.

However, since newly arrived animals may try to escape, and can easily hurt themselves by climbing and pulling on the wire mesh, enclosure furnishings should be placed far enough away so

that the animal cannot reach the wire ceiling. In the CPCP, relaxed animals have been found to be less likely to hurt themselves climbing on wire. Later in the quarantine period, when animals have relaxed in their new enclosure, furnishings can be placed closer to the wire ceiling. However animals will need to be carefully monitored for any signs of trauma (scratches around the face and limbs, lost nails). If a previously well animal becomes unwell or stressed it is recommended that the furnishings again be placed so that the wire mesh is out of reach of the pangolin .

Placement of furnishings within a quarantine enclosure should not interfere with the keeper's ability to adequately clean the enclosure.

Figure 3.5: Climbing structure inside quarantine showing pool, concrete feeding bowl and porthole between adjacent enclosures (Left), and an enlarged image of the hollow log being used by pangolin (indicated by arrow) in quarantine (Right)

Water Source and Drainage

Sufficient fresh water must be available for cleaning the quarantine block. Each enclosure must always have water available for the animal to drink and bathe, as pangolins like to spend time in water (Figure 3.6).

Many pangolins in captivity also defecate in water bowls. In the past, the CPCP provided one large bowl for bathing and one small bowl for drinking, however pangolins were found to defecate in both large and very small water bowls. It is therefore very important that strict hygiene be maintained in ponds in quarantine, particularly where animals are unwell, or prior to a test for gastrointestinal parasitism.

In the CPCP, each enclosure has a water pond with an area of 1.0 x 0.6m and a depth of up to 0.35m. Each pond has a drainage hole at the bottom, allowing water to drain via a plastic pipe to a water pit outside of the quarantine block.

All water used in cleaning each quarantine enclosure is also flushed away using this drain. It is therefore very important to provide a drain with sufficient diameter to enable water to drain away quickly.

In summer the pool is kept full to allow pangolins to bathe. In colder temperatures pangolins typically do not bath in the water, but the pool is still kept half full as many pangolins use the pond as a toilet for defecating.

Figure 3.6: Pool in quarantine enclosure, used for swimming and defecation.

Quarantine food bowl

Pangolins in quarantine at the CPCP are fed both live food (ants inside nests) and frozen ants (a mixture of ant eggs, larvae and adults) with some other supplementary feeds (including boiled soybean and silkworm pupae – see Chapter 7 for detailed information on pangolin diet). Live food is fed to provide wild pangolins with food they are familiar with, increasing the likelihood that they will eat on arrival in the centre. Special feeding bowls which prevent live ants from escaping are required. These not only prevent loss of food, but also reduce the risk of ants escaping and biting the staff working inside the enclosure.

In the CPCP, concrete bowls surrounded by a moat that is filled with water have been built directly onto the concrete floor (Figure 3.7). The bowl has a central width of 50cm, and is 15cm high. The moat surrounding it is approximately 7cm wide and 2cm high. This is filled with water, and in addition to keeping ants in the bowl, it also provides drinking water for the animals.

Figure 3.7: Concrete feeding bowl containing a nest of live ants, a moat of water to confine the ants.

Quarantine Lighting Requirements

Red light is recommended for use with nocturnal mammals such as *M. javanica* (Finley, 1959).

The light bulb should be set under the roof to protect it from weather but at minimum distance 20 cm above the ceiling wire to prevent the pangolins reaching it. Red lighting is also required in the service corridor to provide light during feeding time and for observing animals.

Washing Area

In the CPCP, each block of enclosures is treated as a discrete quarantine area. Each enclosure block has a foot bath and its own washing area, which comprises a sink, water supply, and racks for keeping soap and cleaning tools. This enables staff to wash hands on entry to and exit from each area, and for equipment to be kept within each enclosure block.

Suggestions for improvements of CPCP Quarantine Facility:

- Where enclosures neighbour each other, single quarantine enclosures can be more flexible if there are openings between adjacent enclosures. A small porthole (30 x 30cm) put in the wall between two enclosures can allow animals to move between enclosures if branches are provided to climb through. It is important that this porthole is a reasonable height from the floor (at least 1.2m from the floor) to reduce the risk of disease transfer along the floor between the enclosures (in the event of neighbouring enclosures being used by different individuals). Fitting the porthole with a metal slide door provides flexibility for it to be opened or closed as required..
- To give animals more space for climbing, the height of each enclosure should be increased. This is particularly important if ground area is limited.
- The CPCP has previously used solid tiles on enclosure roofing, because these reduce noise during heavy rain and keep enclosures cool in summer. However, tiled roofs are very heavy and require extremely strong roof framing. Insulated corrugated steel roofing (eg foam-backed Colorbond) over a metal frame is now recommended.
- Wooden bedboxes do not offer animals good thermal protection when placed inside a concrete shell because concrete is a very poor insulator. To combat this problem, the CPCP now places a large amount of straw bedding into bedboxes, allowing pangolins to dig down and burrow into the bedding material.
- An extra panel can be placed as a divider inside the bedbox to give protection from drafts that may enter through the animal access hole.

3.2 Long-Term Enclosure Requirements

There is limited information on the ecology and behaviour of *M. javanica* in the wild, therefore the design of long-term enclosures for this species in the CPCP was based on enclosures previously used for *M. pentadactyla* with some modifications. There are two striking differences between the two species that influence housing and husbandry. Firstly, *M. javanica* is highly arboreal and, as well as using burrows underground, nests in tree hollows. In contrast, *M. pentadactyla* is terrestrial and nests underground (Newton et al, 2008). Secondly, *M. javanica* prefers tree ants in its diet, whereas *M. pentadactyla* eats mostly ground ants and termites.

Figure 3.8: The CPCP 'Pangolarium' (constructed in 2007). Some refinements have been made to the design since this was constructed (see recommendations in this section)

3.2.1 Exhibit Design

M. javanica is an excellent climber, and use their powerful forelimbs for digging burrows. These behaviours must be taken into account when designing escape proof enclosures. Pangolins have been observed climbing from floor to ceiling via electrical wires and pulling apart poor quality fencing wire. Building a pangolin enclosure without a solid base risks pangolins escaping by digging their way out.

The long term enclosure in the CPCP, the Pangolarium (Figure 3.8), includes special design features to ensure that pangolins are kept safely. It is a 121.5m^2 building comprising four enclosures, each of which has a surface area of 27 m^2 (4.5m x 6m). Each enclosure includes:

- A surface area of 27m^2
- A solid concrete base (least 10cm depth to stop the animal escaping by digging) was placed 0.5m below ground level.
- 1m of soil was then placed on top of the concrete base to allow digging. Placing the soil lower than ground level keeps the humidity and temperature more natural.
- Concrete walls extended a further 1.5m from the top of the soil level. Walls need to be at least 20cm thick. The interior walls are mortared smoothly to prevent the animals climbing up the wall (particularly at the corners) and all walls were sealed to prevent water damage. Plastic pipes are set through the walls at ground level to allow water to drain out of the.
- The wall between adjacent enclosures is a solid concrete wall to stop animals from touching, smelling or hearing each other.

- From the top of the wall, wire mesh extends 1.8m to the wire mesh ceiling. At least 10cm overlap is placed where sheets of wire mesh meet, and sheets joined by placing wire ties at a minimum of 10cm along seams. It is critical that there are no loose and sharp ends from adjoining wire otherwise animals can injure themselves. All wire mesh is painted twice, first with galvanising primer and then with black paint to both prevent rust and to make it is easy to see through. Non-toxic paint is used.
- The ceiling was placed a minimum height of 3.3m from the top of the soil level.
- A service corridor 13.5 m^2 (1.5m x 9m) runs through the middle of the block, between the enclosures, and provides keeper access and maintains animal security while people are working inside (Figure 3.9).
- The interior wall, facing onto the service corridor, is made entirely of wire, to allow easy viewing of animals.
- The Pangolarium also has a solid tile roof which extends to cover 40% of the surface area of each enclosure. This provides some protection, while still allowing sunlight to dry the enclosure and rain to enter to water plants in the enclosures. Interviews with hunters by Newton *et al*., (2008) suggested that pangolins are more active just after rain.
- Enclosure furnishings include: Trees/branches for climbing on, rotting logs for the animal to dig into.

Schematic Drawings of the CPCP Pangolarium showing all dimensions are included in these guidelines as Appendix 1.

Figure 3.9: Service corridor in the Pangolarium showing keeper access to bedboxes (indicated by a red arrow), soil substrate with concrete pipe leading to bedbox, and branches.

Recommendations to improve future long term enclosures:

- To stop animals from climbing on the wire wall of the service corridor side, this wall should be solid and smooth for up to 1.2m. As the service corridor floor is sunken this would prevent viewing so glass windows in parts of the wall could be added to allow viewing.
- Presently 4cm wire mesh is used and animals can put their nose and head out and injure themselves. Additionally, mesh of this size allows juvenile pangolins to escape (Figure 3.10). In future, a smaller mesh size is recommended (2 x 2cm).
- Animals, especially males, get agitated when they are housed close to other males (this may be due to the sight, smell or sound of the adjacent male). Future designs will move towards a row of adjacent enclosures, rather than a square block of four enclosures.
- Currently pangolins housed in these enclosures cool off by climbing in big bowls of water. A permanent pond could be incorporated in the design to allow for bathing in the summer or as a defecating bowl.
- Any enclosures which house more than one pangolin require at least one bedbox per animal.

Figure 3.10: Baby pangolin escaping through wire (4 x 4cm) for a night-time foray.

3.2.2 Position of Enclosures

Enclosures need to be placed in a flat area, which is not prone to flooding. In our facility we have located the 'Pangolarium' in an old botanic garden which has trees for shade in summer and for wind protection.

3.2.3 Weather Protection

The CPCP's Pangolarium has a tiled roof that covers half of the building, including the entire service corridor and 40% (11 m^2) of each of the four enclosures. The roof has metal gutters to prevent rain from entering the enclosures.

The floor of each enclosure consists of 1-1.2m of soil over the concrete base, enabling pangolins to dig burrows that allow them to keep warm in winter and cool in summer. Use of soil provides a natural way for pangolins to regulate temperature and humidity.

Native plants grown inside each enclosure provide a naturalistic environment, and also contribute to protection from weather by providing shade and reducing heat from sunlight during summer.

3.2.4 Substrate

In general a substrate of natural materials such as leaf litter, wood bark, wood chips, grass, sand or soil is recommended. During construction of the Pangolarium in the CPCP, leaf litter, branches and logs were placed on the concrete floor to attract termites before we added 1-1.2 m of soil (Figure 3.11.

Plants, more leaf litter, logs, and tree stumps were then on top of the soil to attract termites, to increase the complexity of the foraging environment, to provide digging and nesting options and to give a naturalistic look. The soil and leaf litter is turned over monthly to expose fresh soil and leaves.

Figure 3.11: Pangolarium floor under construction; branches, leaves added over concrete floor before infilling with soil.

Figures 3.12 and 3.13: Pangolarium floor (above), and Pangolarium enclosure fully furnished and planted (Right)

3.2.5 Enclosure Furnishings

Dens

Each enclosure must have at least one bedbox suitable for one or two adult animals. In the CPCP, all enclosures contain a sunken concrete den which houses a bedbox that is accessible for staff from the service corridor (Figure 3.14). The bedbox den is square and measures 0.9m in length x 0.5m x 0.5m (Figure 3.15). The bedbox is reached by the animal via a concrete pipe (diameter 0.23m, 1m long) leading from ground level inside the enclosure (Figure 3.18).

Figure 3.14: Pangolin den without bedbox; circular entrance for pipe at the side of the den, ribbing on the floor to prevent the bedbox getting wet if flooding occurred.

Figures 3.15 and 3.16: Entrance to den and bedbox via concrete pipe during construction (above) and pipe in use by pangolin (right).

Basic bedbox design is as discussed in Section 3.1.5 and each bedbox has a round opening the same size as the concrete pipe (0.23m in diameter) for the animal to enter. Each bedbox also has a hinged panel that can be opened by staff from the service corridor. A second door (mesh) provides security and prevents the animal from pushing the bedbox backwards out into the corridor.

Figure 3.17: Pangolin sleeping in a bedbox den with a wooden bedbox *in-situ* (left). On the right Pangolins are shown in a concrete bedbox den where the wooden bedbox has been removed, and replaced with soil.

As the bedbox area is partially underground, drainage is important in case of flooding. The bedbox den has a concrete shell which is 10cm thick, with many drainage holes at the bottom. Underneath the concrete base is a seepage pit in case of flooding.

In the past, all pangolins were provided with a wooden bedbox, which fit snugly into the bedbox den (see figure 3.17, left). However, observation studies suggested that many pangolins preferred to sleep in the concrete tunnel rather than in the wooden bedbox. As a result, wooden bedboxes were removed, and replaced with a soil substrate (see figure 3.17, right).

Bedding materials

Bedding used in the Pangolarium is the same as for quarantine enclosures (Section 3.1.6) and includes soil, straw or leaf litter.

Climbing material and structure

All enclosures contain furniture consisting of branches of native plant species. These are selected to be of varying diameters and heights and could be moved around to provide an enriching environment e.g. to reduce pacing behaviour. The branches are tied together. Ideally, the animals should be prevented from climbing the wire fencing so the branches/logs should be set up at least 0.8m from the wire. However, if the animals are climbing the wire, place the branches next to it so they can at least use these to get off the wire and will hopefully prefer clambering on branches rather than wire. In addition to the branches, 2cm thick ropes are also hung from high branches to provide extra climbing opportunities.

Lighting requirements

All enclosures are illuminated by two 75W red lights located at least 20 cm above the ceiling to prevent the animals reaching them. There are two fluorescent lights (painted red) in the service corridor.

Heat mats

Supplementary heating is provided during winter months, this is described in more detail in Section 5.2

Feeding bowl

Pangolins require both live (e.g. ants) and non-live food and require a special feeding bowl that prevents live food from escaping and also from biting the staff working inside the enclosure. To achieve this we designed a special metal bowl (95cm diameter) that has a central bowl surrounded by 10cm width water filled moat. In areas of high humidity rust is a problem so ideally the feeding bowl should be made using stainless steel (Figure 3.18). Alternatively, these can be made of concrete as in the quarantine enclosures (section 3.1.6).

Figure 3.18: Metal bowl with live ants and water moat

Other Furnishing

Bamboo matting has been trialled as an addition to the wire mesh in an effort to reduce visibility between enclosures and decrease the incidence of stress related behaviour caused when animals can see each other. However, the animals can hurt themselves by clawing the matting (as it is very sharp when shredded) and this is not recommended.

Sheets of mica (Perspex) have also been added to the wire mesh to prevent animals climbing. While the animals cannot climb the mica, they do climb anywhere where this joins hence it was only partially successful in preventing the animals from climbing on the walls.

Schematic Drawings of the Pangolarium showing all dimensions are included in these guidelines as Appendix 1

3.2.6 Interspecific Compatability

In the CPCP pangolins are not maintained with other species. However, in Taipei Zoo *M. pentadactyla* has been kept successfully with an owl species (Chin, J., *pers. comm*.).

3.2.7 Cleaning Requirements for Enclosure

The following procedures are carried out in the CPCP:

Daily

- The bedboxes are checked daily for signs of defecation or urine. Bedding material is changed if dirty or wet. To change the bedding material we work around the pangolin (or move it slightly to remove bedding underneath). If the bedbox is wet or dirty we move the pangolin into a spare bedbox, the dirty bedbox is removed and cleaned with water and detergent and dried in the sun.
- Enclosures are spot cleaned daily. It is very important to look for and remove any faeces or urine that is on the floor.
- The large water bowls which the pangolins use for defecating and bathing are emptied and washed with detergent. These are returned to the enclosures, and filled with clean water.

- The drinking bowls are scrubbed in mild detergent to prevent algal build up. Drinking water is available at all times.
- Small food bowls used for frozen food are emptied of all remaining food, washed with detergent and dried.
- Wire mesh must be checked daily for rust, holes where animals may be able to escape, or any wires which may have become loose.
- The floor of the service corridor is swept and cleaned every day.

Weekly

- Furniture (for example, branches) is checked to make sure none are rotten or can fall off.
- More leaves are added to the floor of the enclosure, to help attract insects and to provide a substrate for the pangolins to forage and hunt insects in.
- The outer security fence is checked to ensure it is intact

General

- A supply of dry leaves or other bedding is always available to replace the bedding when it gets dirty or wet.
- A constant rat/mice live-trapping regime occurs in our centre to minimise contact between captive animals and free-ranging rodents. This reduces the risk of disease from the rodents to our animals, between our animals and also reduces the theft of food.
- Biodegradable rubbish (faeces, ants, food) is disposed of in a 6m deep pit that is kept covered with mesh.

Chapter 4 - Handling and Transport

4.1 Timing of Capture and Handling

Pangolins are easily stressed, and should only be captured or handled when absolutely necessary.

Pangolins are nocturnal therefore the easiest time at which to catch and handle is during the daytime. Doing this will help to:

- Reduce stress during capture and handling.
- Aid rapid recovery from handling because the animals can be returned to the bedbox and will go back to sleep rather than move around in the cage.

Some animals will sleep outside the bedbox – in tree hollows or burrows they have dug into the ground. In these cases, they will need to be caught while active at night. If this is the case, ensure that the pangolin has defecated and eaten prior to capture, because they will often retreat immediately to their favoured sleeping spot after capture and handling.

4.2 Catching Bags

Pangolins move quite slowly, which makes it easy to catch them without catching bags or any tools. If you want to catch a pangolin when it is awake and active outside in its enclosure at night, its burrow/bedbox entrance will need to be blocked beforehand to prevent it retreating back inside.

4.3 Capture and Restraint Techniques

Active pangolins can be caught by firmly grasping the tail (Figure 4.2). Make sure the animal is lifted away from anything it can grasp with it forefeet

To catch a sleeping or curled up animal, reach in and hold it with two hands like you would a ball (Figure 4.1). If it wakes up transfer to the tail hold

Note:

- Dont put your hands under the pangolin's tail or belly because your hands can be cut or wounded by the animal's sharp claws, very strong tail and sharp scales.
- Dont try to catch a pangolin if it is already holding onto something such as the edge of a burrow, bedbox or branch. Pangolins have very powerful forefeet – you are unlikely to succeed and will cause stress to animal. It is much easier to wait until the animal decides to move.

Figure 4.1 and 4.2: Holding a curled up pangolin (Far left), holding a pangolin by the tail (left)

4.4 Weighing

There are several ways to weigh pangolins:

1. Weigh the pangolin within their bedbox and later weigh the empty bedbox to calculate the weight of the pangolin. As a pangolin's bedbox is quite heavy (10-15kg) you will need to have a suitable scale.
2. If the animal is curled up or is inactive, put the animal into a plastic bucket/bowl or bag and weigh using a hanging scale (Figure 4.3).
3. If the animal is really active put it in a bag then use a hanging scale (Figure 4.4).

Figure 4.3 and 4.4: Weighing a pangolin using a large plastic bowl (Far left) and using a hanging scale to weigh a pangolin in a bag (left).

4.5 Initial introduction of a pangolin into an enclosure

Animals can be moved to their new enclosure during the day and placed into their enclosure bedbox. They will self-release at night when ready.

If moved during the night, animals are still placed in a bedbox first and allowed to let themselves out – this is so they are familiar with the bedbox and know where to return to sleep. For a newly arrived or unhealthy animal ensure the entrance to the bedbox is easy to access (eg. at ground level or with a branch leading into it).

4.6 Transport Requirements

The Sunda pangolin (*M. javanica*) is listed in Appendix II of the Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES). This provides a zero annual export quota for this species. Transferring any animal across international borders requires a CITES permit. More information is available from http://www.cites.org/eng/resources/transport/mm1.shtml

Contact the CITES office in each country for information on transportation within national borders.

4.6.1 Transport Box Design

A transport box should be big enough for a large adult animal to turn around in and curl up, and to provide space for a water bowl and a food bowl. Ideally transport one animal per box (excluding mother/infants who must stay together).

Wooden boxes should be constructed from timber at least 1cm thick. Ensure there are no gaps between joins in the wood because pangolins could put their claws in and break the box. Do not use wire or sharp metal for the box because the animals can cause injury to the animal.

The box should have two doors, one small one (10 x 10cm) for checking the animals during transportation and one large one for letting the animal in/out and for providing water and food. Each door must be very secure and must include padlocks.

The box must be drilled with a few small (pencil sized) holes for ventilation during transporting.

Figure 4.5: Confiscated pangolins being removed out of a net bag (commonly used for transporting live pangolins in the illegal wildlife trade) and placed into a transport box.

4.6.2 Furnishings

Leaf litter or shredded paper is recommended to use as substrate for the transport box. Alternatively use any type of matting such as hessian sacks, towels or any soft fabric. The CPCP have never had any problems with the animals getting fabric threads caught in claws or with them ingesting bedding material.

Food and water bowls must have a large base and be heavy enough to prevent them being toppled over during transport.

4.6.3 Water and Food

Depending on the length of the journey, animals may require access to food and water. This is particularly important in hot weather. If the journey will be conducted at night, the normal feeding time for pangolins, a bowl of frozen ants can be offered.

4.6.4 Animals per Box

Ideally, only one animal should be transported per box to reduce stress. However, if animals have been kept together during transportation within the wildlife trade then they can be kept together for short transportation to a rescue centre. Two females can be transported in the one box if required, however, adult males must always be transported by themselves (Figure 4.6).

Do not separate a mother and her baby when transporting them. A juvenile can be kept together with a female adult, because it can be comforting for the juvenile. However, if the adult animals shows stress with the presence of the juvenile, then keep the juvenile by itself with something to hold (such as a stuffed teddy bear).

Figure 4.6: One male pangolin has been separated from one female and juvenile in transport box.

4.6.5 Timing of transportation

Pangolins should be transported to a rescue centre as soon as possible after confiscation. However, during times of non-urgent transportation, such as transporting from one rescue centre to another, the best time to transport pangolins is during the daytime when animals are asleep.

If they must be transported at night time, it is recommended that the transport box be extremely secure as the animals are very active at night.

Chapter 5 - Health Requirements

5.1 Routine Treatments

NB: A formulary of drugs which have previously been used successfully in pangolins is included in this manual as Appendix IV.

5.1.1 General Health Monitoring

Keepers should monitor an animal's health daily, as pangolins have been known to deteriorate quickly after showing initial signs of ill health.

In the CPCP, keepers check animal bedboxes each morning, monitor the amount of food left over by each animal, observe animal behaviour during feeding and remain observant for any general signs of ill health (such as wounds, abnormal movement, or noticeable weight loss).

Faeces are also monitored daily, and keepers describe any abnormalities they see (Figure 5.1).

Figure 5.1: Faeces from a healthy pangolin fed a mainly natural diet (ant adults, eggs and larvae)

5.1.2 Physical Examination

A thorough physical examination of all pangolins should be conducted during the quarantine period, and at any sign of ill health. Two people are required for a physical examination – one person as the pangolin handler, leaving the second person free to perform the visual health assessment.

It is impossible to uncurl an adult pangolin which is curled into a ball. Patience and gentle handling are required so that the pangolin will uncurl of its own accord. Once the pangolin is uncurled, grasp it gently by the tail, lifting so that its forelimbs are just touching the ground. Ensure that you have plenty of room, and that the area is free of objects – pangolins will naturally grasp onto anything within reach.

If the pangolin does not relax, anaesthesia may be required (see Section 5.6.2 Anaesthesia).

In particular, the following physical attributes are noted during health assessment in the CPCP:

- **Sex** (see information on sexing pangolins in section 5.6.1 of this chapter)
- **Morphometrics** (see description in Chapter 2 of these guidelines)
- **Body temperature** – Normal body temperature for pangolins is 33-35^{0}C.

- **Body condition score -** A body condition score out of 5 is given to each animal.
- **Body weight** – Rapid weight loss has been found to precede death, so getting a good impression of body condition and body weight are very important.
- **Respiratory rate** – It is difficult to get an accurate impression of the respiratory rate of an alert pangolin, because the respiratory rate is masked by the repetitive sniffing. Attempts to measure respiratory rate in the CPCP have suggested this rate is rapid (60-100 breaths per minute). Respiration of healthy pangolins measured while sleeping is deeper and much slower (12-16 breaths per minute).
- **Heart rate** – It is very difficult to obtain an accurate heart rate in an alert pangolin, because the heart sounds are muffled by the sounds produced during sniffing, and the pangolin will try to curl around and grasp the stethoscope. Awake HR ranging from 80-200 beats per minute have been recorded in the CPCP.
- **Demeanour** – Healthy pangolins are alert and responsive, and will very frequently sniff the environment and people handling them. When stressed they rapidly curl into a strong, tight ball. Pangolins in poor health are slow to respond to human touch and show less interest in sniffing the environment. They often sleep in a slightly uncurled position and offer little resistance to attempts to uncurl them.
- **External lesions** – Check for any external trauma, including snare trap wounds and dog bite wounds in newly arrived animals. Many trade confiscated pangolins transferred to the CPCP have moist dermatitis beneath some scales, a condition which is likely to be secondary to the poor hygiene and husbandry practiced within the wildlife trade system.
- **Eyes** – Check for discharge and signs of inflammation. Corneal ulceration has been seen in trade confiscated animals, possibly with a traumatic aetiology. **Note** – pangolins often have moist tear staining around their eyes, as they tend to produce a large volume of tears. This is normal.
- **Nose** – Check for discharge. While this has been reported in other captive centres (Chin *et al,* Unpublished data), it has not been reported in the CPCP.

5.1.3 Gastrointestinal Parasitism

Faecal examination, for the presence of parasite eggs, larvae or adult worms, should occur at least annually for resident pangolins.

Faecal samples are examined as soon as possible after collection, using a 33% Zinc Sulphate solution as a faecal float solution and Fecalyzer® containers (EVSCO Pharmaceuticals, Buena, NJ). Both sample processing and parasite identification follows the technique described by (Zajac and Conboy, 2006).

If there is any evidence of gastrointestinal worms, animals are injected with subcutaneous Ivermectin 10mg/ml (Ivomec® 1% Injection for Cattle and Swine, Merial) at a dose of 200-400µg/kg bodyweight. A follow up faecal is performed one week later, and animals are re-treated if required.

Where there is evidence of coccidian oocysts in faeces, animals are treated orally with Toltrazuril (Baycox 2.5%, Bayer Healthcare AG) at a dose rate of 5mg/kg, once a day for three days. Faecal float is then repeated, and treatment is continued until faecal floatation tests are negative.

In the case of a group faecal exam, all animals in the group are treated if a positive faecal float is found.

5.2 Heating Requirements

Both *M. pentadactyla* and *M. javanica* have been kept at the CPCP. While the CPCP is within the natural geographic range of *M. pentadactyla*, *M. javanica* are not naturally found this far north, and are likely to be adapted to a more tropical climate.

Anecdotal evidence suggests pangolins require supplemental heat during times of low temperature. In Taipei Zoo, the risk of respiratory disease has been found to increase when environmental temperature drops below ~21^0C (Chin *et al.*, 2003). Respiratory disease has not been seen in pangolins in the CPCP, and pangolins within the centre seem to be able to comfortably withstand much lower temperatures than 21^0C. However, the winter pangolin mortality rate is higher than the mortality rate seen in summer. As a result, the CPCP uses heat mats to warm pangolin bedboxes once ambient temperature drops below 10^0C. Heat mats are always provided for pangolins in quarantine and for any animals showing signs of ill health.

Care must be taken when using heat mats with pangolins. They should never be placed on the floor of the bedbox, as animals must be able to move away from the heat source. Pangolins have been known to bury themselves behind side mounted mats, causing thermal burns to the skin. In the CPCP, heat mats are controlled by a thermostat which maintains the temperature within the bedbox at around 23^0C. Heat mats are securely mounted to the side wall of the box, using a wooden frame specifically designed to place a barrier between the animal and the mat, and so that it is impossible for animals to move between the heat mat and the wall of the box. It is important that the bed box is large enough so that there is a thermal gradient, allowing animals can move around inside the box, towards or away from heat as required.

Extra bedding, in the form of straw, dry leaves or hessian sacks are also provided to pangolins in winter. Some females have moved to self dug burrows in winter, and this may indicate that they prefer the subterranean temperature within these burrows, however further environmental monitoring is required to investigate the relationship between temperature and burrow use.

Figure 5.2: Photo shows two female pangolins asleep in a bedbox heated by a thermostat controlled heat mat. The heat mat is side mounted, however, after one animal managed to burrow between the heat mat and the side wall of the bedbox, resulting in severe thermal burns, the frame used to hold the heat mat in place as depicted in this photo is no longer used. Frames are now made sturdier to prevent access behind the heat mat, and to place a physical barrier between the pangolins and the heat mat.

5.3 Known Health Problems

5.3.1 Oral, Oesophageal and Gastric ulceration

Ulceration of the oral, oesophageal and gastric mucosa is the most common sign visible on necropsy of pangolins examined at the CPCP. This has also previously been reported in other captive centres (Chin *et al.*, 2003).

The underlying cause of these ulcerative lesions is unknown; however, stress is believed to play an important role. Histopathology has failed to identify any infectious cause.

Treatment

Prophylactic treatment, including oral gastric medications and prophylactic antibiosis, is begun as soon as a pangolin begins to show signs of ill health.

- Oral gastric medications. In the CPCP, where animals are still eating these medications are added to a small bowl of frozen ant mix. Where animals have ceased eating, medications are administered directly into the mouth using a syringe.
    - Ranitidine HCL (Zantac Syrup, GlaxoSmithKline UK) 3.5mg/kg twice a day, administered orally (can be given for as long as required).
    - Sucralfate (Antepsin* Suspension, Chugai Pharma Uk Ltd.), 0.5ml twice a day, administered orally
- Prophylactic antibiosis: Amoxycillin/clavulanic acid, 8.75 mg/kg administered subcutaneously once a day for 7 days.

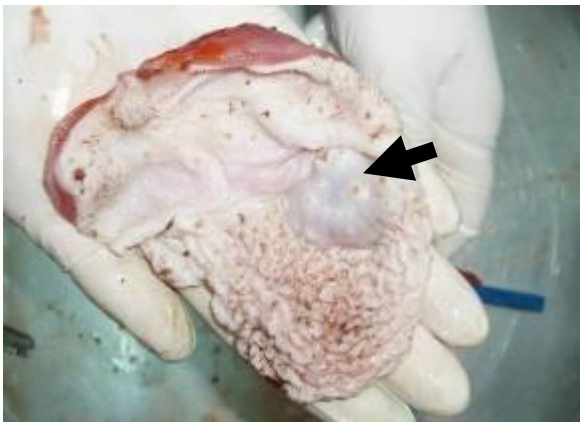

Figure 5.3: Photo shows the ulcerated gastric mucosa of a young, male pangolin which was born in captivity, and died soon after being weaned from its mother. The animal showed signs believed to be associated with stress in the days preceding death. The large, bulbous structure indicated with an arrow is the gastric gland, a normal anatomical feature in pangolins (Nisa *et al.*, 2005). This feature is visible as a defined area of opacity on abdominal radiographs, and can be mistaken for a mass or other abnormality.

5.3.2 Moist Dermatitis beneath Scales

The majority of newly arrived pangolins in the CPCP have presented with infected, moist, ulcerative dermatitis beneath their scales. This is probably due to being transported curled up inside tight net bags while in the wildlife trade. They are unable to move inside these net bags, so they are normally covered in faeces, dirt and urine on arrival.

Treatment

- Topical treatment: Affected areas are cleansed daily using dilute chlorhexidine in water (use a syringe to flush the area, and cotton tips to remove dirt and necrotic material). Dilute Iodine solution is then syringed under the scales. Advanced hydrocolloid products, such as

DuoDERM® Hydroactive Paste (Convatec Inc.), applied topically have been found to speed up the healing process in the CPCP

- Antibiosis: Amoxycillin/clavulanic acid, 8.75 mg/kg administered subcutaneously once a day for 7 days.

Most animals improve steadily and wounds beneath scales generally heal within 7 to 10 days.

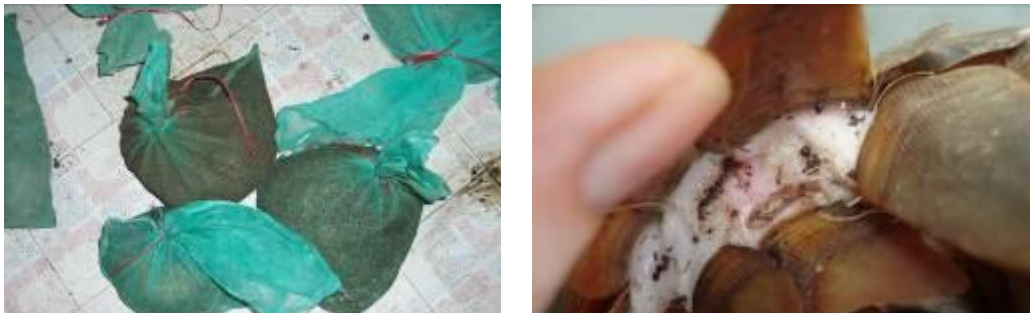

Figure 5.4 and 5.5: Three pangolins in bags just after confiscation from illegal wildlife traders in Phy Ly Town, Ha Nam Province (Left). Dermatitis beneath the scales of a newly transferred pangolin. This photograph was taken after two days of treatment (Right).

5.3.3 Corneal Ulceration

The depth of corneal ulceration is assessed using flouroscene dye and a UV lamp.

Treatment

- Topical treatment - Superficial corneal ulceration has been successfully treated in the CPCP conservatively, using topical application (five times per day) of a non-steroidal antibacterial eye cream. Each case must be assessed on an individual basis and surgical intervention may be required. Pangolins do possess a third-eyelid, so performing a third-eyelid flap or other surgical intervention is possible if an experienced veterinarian is present.

Figure 5.6: Corneal ulceration in a juvenile pangolin following confiscation. This ulcer was assessed using flouroscene stain, and successfully treated using topical, non-steroidal, antibacterial eye ointment (three times a day for ten days)

5.3.4 Traumatic Wounds Associated with Hunting and Trade

Both dog-bite wounds and snare trap wounds have been seen in newly arrived pangolins in the CPCP. Normal considerations regarding the treatment of traumatic wounds apply.

Treatment

- Topical treatment: Affected areas are cleansed daily using dilute chlorhexidine in water (use a syringe to flush the area, and cotton tips to remove dirt and necrotic material). Advanced hydrocolloid products, such as DuoDERM® Hydroactive Paste (Convatec Inc.) and SoloSite* Gel (Smith and Nephew), applied topically have been found to speed up the healing process of these wounds. In the case of snare trap wounds on limbs, bandaging the affected area daily, during the morning treatment period, provides a clean, moist healing environment at least until the animal becomes active in the evening. Bandaging materials are adapted to suit as the wound heals.
- Antibiosis: Amoxycillin/clavulanic acid, 8.75 mg/kg administered subcutaneously once a day for 7 - 10 days.

Figure 5.7 and 5.8: Snare trap wound on presentation (left) and one month later (right). Treatment consisted of Amoxycillin/clavulanic acid administered subcutaneously for 14 days and intensive topical treatment. Initially wound was cleaned, duoderm paste was applied and the wound was bandaged daily (in the early morning). The bandage remained in place throughout the day, and came off at night as the pangolin moved about the quarantine enclosure. As wound healing progressed the frequency of topical treatments was gradually reduced.

5.4 Routine Vaccinations

There are currently no known diseases for which routine vaccinations are required.

5.5 Routine Quarantine Treatments

5.5.1 Length of Quarantine Period

The quarantine period generally lasts for 30 days, but this is extended if there is any sign of disease or if the animal is still receiving treatment for a medical condition.

5.5.2 Quarantine Visual Health Assessment

A rapid assessment of the animal's condition and weight is made on arrival in the centre. Any wounds requiring treatment are dealt with immediately. Emergency care of critical pangolins is dealt with in Section 5.5.3. A more thorough examination is performed as soon as possible after arrival, once the animal has stabilised, following the protocol for physical examination described in Section 5.1.2 of this chapter.

On arrival, wild pangolins are likely to be stressed by human contact, and will rapidly curl into a ball when touched or picked up. Patience and gentle handling are required; however, anaesthesia may be required for some pangolins.

5.5.3 Emergency Care of Pangolins

Pangolins deteriorate and die very quickly. Pre-mortem clinical signs can appear to be mild, and are generally fairly non-specific. Concerning signs include:

- Poor appetite or anorexia
- Lethargy – sick pangolins will generally remain inside the bedbox overnight. While this may be normal behaviour for one or two nights in a stressed pangolin which has just arrived, a healthy pangolin should be curious, and should get up to forage for food.
- Weakness – pangolin lies in a slightly 'uncurled' position, and offers little to no resistance to being uncurled.
- Temperature – while normal temperature for pangolins is low (33-35^{0}C), healthy pangolins are still warm and dry to touch. Sick pangolins may feel damp (clammy or moist) and cool to touch
- Pale – sick pangolins appear pale, and slightly grey in colour. The skin of healthy pangolins is a pale pink colour.
- Superficial skin ulceration on the footpads pads and around their face. These non-healing superficial ulcerative lesions are commonly seen in very sick pangolins. Their cause is unknown but may be traumatic (abrasions from fencing or cement floor) or infectious. They respond poorly to topical and parenteral wound treatment.

In case of any of the above clinical signs, begin the following treatment immediately:

1. Provide warmth (see Section 5.2 of this chapter)
2. Address any external traumatic lesions as required. In the CPCP, prophylactic antibiotics and treatment for gastric ulceration is initiated immediately in all newly arrived pangolins showing signs of ill health (see Section 5.3.1 of this chapter)
3. Rehydrate the animal using Lactated Ringers, administered subcutaneously, if required. Intravenous rehydration has not previously been attempted in the CPCP, as vascular access for catheter placement is difficult in conscious pangolins.

4. Provide a small amount of frozen ants within reach of the animal
5. Reduce stress (noise, people, other animals)

5.5.4 Weighing Frequency

Pangolins in quarantine should be weighed regularly, as rapid weight loss has been found to precede mortality. In the CPCP, pangolins in quarantine are weighed on a weekly basis

5.5.5 Gastrointestinal Parasites

Faecal tests carried out during the quarantine period of newly arrived pangolins in the CPCP commonly reveal nematode worm eggs and coccidian oocysts.

Preparation of faecal samples, faecal floatation and examination are carried out as described in Section 5.1.3 of this chapter.

If there is any evidence of gastrointestinal parasites, animals are treated as described in Section 5.1.3 of this chapter.

Animals must remain in quarantine until they have returned two negative faecal floatation tests, one week apart. This is particularly important if animals are to be transferred to a soil bottomed enclosure after quarantine.

5.5.6 External Parasites

Many newly arrived pangolins at the CPCP carry a heavy burden of ticks. While likely to be an incidental finding on clinical examination of healthy animals, ticks are routinely removed during quarantine in the CPCP since animals confiscated from the wildlife trade are generally in poor condition.

Removal of Ticks

It is important to remove all of the ticks. Do not to leave the 'head' embedded in the skin of the animal, as this will cause irritation. Gently remove tick by:

1. Grasp as close to the skin as possible with forceps
2. Gently twist and pull at the same time
3. Check the tick afterwards – you should see a round body (abdomen), with a smaller head and legs.
4. Store ticks in a small vial with a screw top lid, filled with 70% Ethanol. Label the vial with as much information as possible, including date, species of pangolin, animal origin, and health status upon arrival in the centre

Identification of Ticks

Ticks removed from pangolins in the CPCP have all been identified as *Ambylomma javanensis*. Ticks can be posted to Dr Richard Robbins for identification:

Richard G. Robbins, Ph.D.

AFPMB

WRAMC, Forest Glen Annex

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5.6 Vet Procedures

5.6.1 Sexing Pangolins

It is virtually impossible to sex a fully curled pangolin. Male pangolins have internal testicles, and their penis can be difficult to see when the pangolin is in the curled position.

Once a pangolin is uncurled, examine the external genitals. Male pangolins have a small penis located just cranial to the anus. Female pangolins have an obvious vulva, similarly located at the cranial border of the anus.

Both male and female pangolins have one cranial pair of nipples. Small, but noticeable, mammary development occurs in lactating female pangolins.

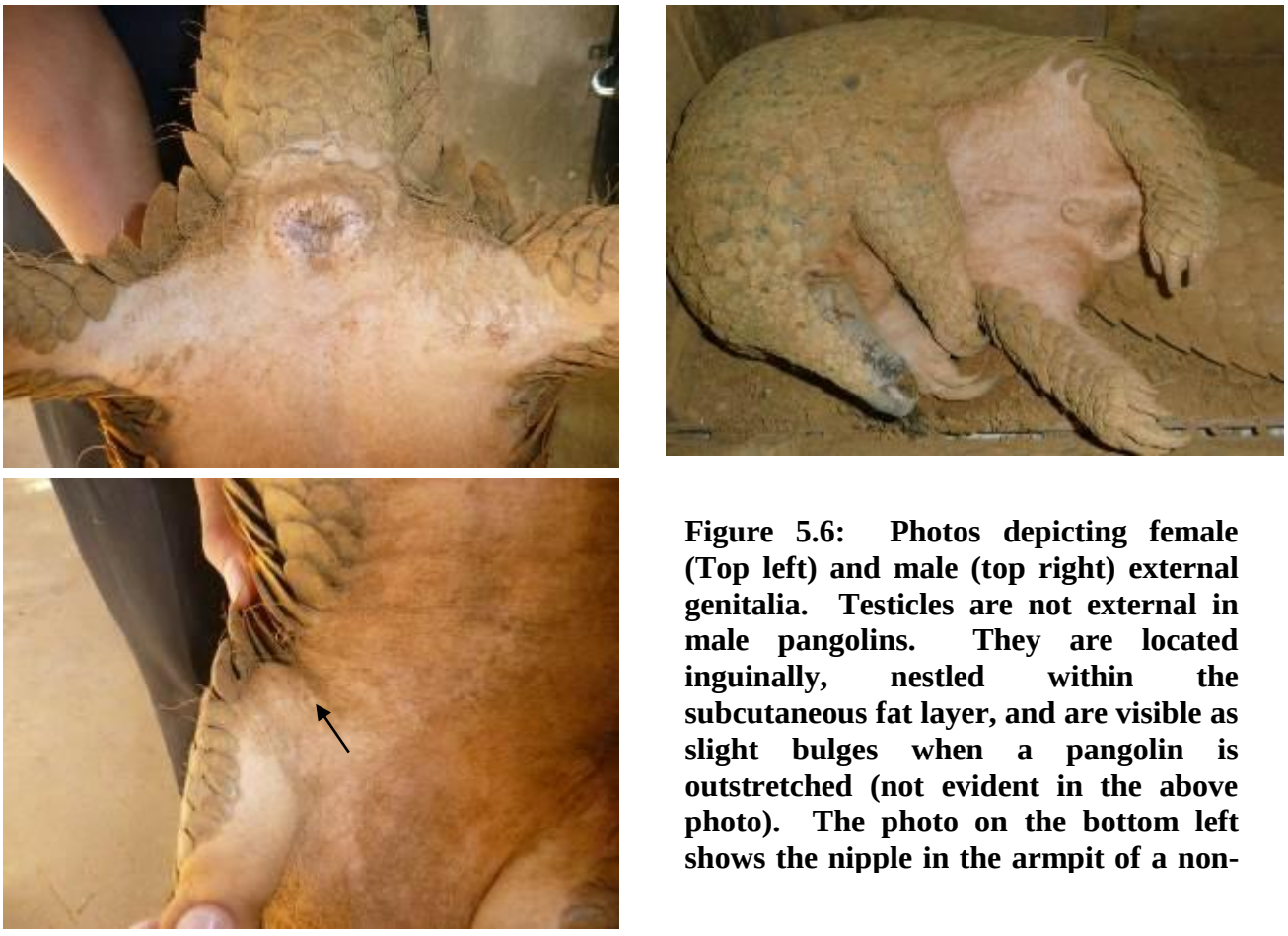

Figure 5.6: Photos depicting female (Top left) and male (top right) external genitalia. Testicles are not external in male pangolins. They are located inguinally, nestled within the subcutaneous fat layer, and are visible as slight bulges when a pangolin is outstretched (not evident in the above photo). The photo on the bottom left shows the nipple in the armpit of a non-

5.6.2 Anaesthesia

Inhalational anaesthesia has been found to be safe and effective in pangolins. Animals can be easily placed into an induction box, allowing induction of anaesthesia using 5% Isoflurane, mixed with oxygen at a flow rate of 100ml/kg. Animals can be safely maintained using Isoflurane (~2%, however concentration of isoflurane depends on clinical judgement) delivered via face mask for short procedures.

Another captive centre has reported the use of Ketamine (10-20mg/kg) and a commercially prepared mixture of Zolazepam and Tiletamine (Zoletil) (3-5mg/kg), both delivered intramuscularly. Premedication with Atropine (0.04mg/kg) is recommended (Chin *et al.*, Unpublished Data). These drug combinations have not previously been used in the CPCP.

5.6.3 Blood Collection

Blood can be collected from a ventral medial tail vein. Advance a 22 gauge needle at an angle of ~45 degrees, in a dorsocranial direction, at the point where two ventral tail scales meet at the midline.

Figure 5.7: Blood collection from a conscious pangolin. A butterfly catheter is useful in conscious pangolins, because it allows flexibility if the pangolin moves during blood collection.

5.6.4 Post Mortem Examination

Since very little is currently known about the pathophysiology of pangolins, it is strongly recommended that post mortem examination is standard practice within any captive facility holding pangolins.

The post mortem protocol used in the CPCP is included in these guidelines (Appendix II)

Chapter 6 - Captive Behaviour

6.1 Habits

Pangolins are strictly nocturnal. Their behaviour and activity levels appear to be seasonal, and may be associated with changing ambient temperatures and daylight length.

During winter (sunset 5 pm), pangolins in the CPCP generally wake up and begin foraging from 6-7 pm. In summer (sunset 7 pm), their average wake-up time appears to be later (around 8-9 pm). This is most likely associated with longer daylight hours.

The number of hours spent actively foraging, climbing on branches and moving about the enclosure is highly variable. It is related to a number of individual and environmental factors including levels of stress (new arrivals seem to sleep for longer periods), ambient temperature and the presence of rain. During cold weather pangolins forage for shorter periods, and sleep longer. Activity appears to increase during light rain or following rain.

On waking, pangolins may spend up to 45 minutes at their burrow entrance sniffing and investigating. Presumably, this behaviour is to make sure it is safe to exit, because the length of time spent sniffing is greater if anyone is close to their burrow entrance.

Once awake, pangolins often defecate first, then eat, drink and bathe (in large water bowls). Most pangolins defecate in water (in either the large water bowl or small pond where provided) (Figure 6.1). Ideally, pangolins should be provided with a water bowl which is big enough for them to stand inside. It is also common for some individuals to dig small holes in the ground and then defecate in these holes. Some pangolins will bathe, drink and defecate in the same water bowl.

Defecation or urination inside bedboxes can be an indication that the pangolin is unwell.

Figure 6.1: Sunda pangolin defecates in a heavy water bowl.

Based on a study of seven of our pangolins, on average they spend about 14.5 % of their active time climbing on branches or standing on their hind limbs sniffing the air and about 13.0% of their active time walking or foraging on the floor (Challender et al., in press). There is considerable variation between individuals.

Pangolins dig both to reach food and to build burrows. The time spent digging is very small about 1% of active time and they prefer to dig sleeping burrows under logs or tree stumps.

6.2 Feeding Behaviour

Detailed information on nutritional and feeding requirments of pangolins can be found in Chapter 7 of this manual.

By feeding pangolins both live ants and frozen food, a range of feeding behaviours can be observed.

With live Weaver ants (*Oecophylla smaragdina*), an entire leafy nest is placed in a big bowl, surrounded by a water moat. The pangolin uses it forelimbs to move the leaf matter, puts its head directly into the ant nest and uses its tongue to lick up the ants. The pangolins will also consume ants wandering in the food bowl, but no observations have been made at CPCP of pangolins feeding on ants caught in the water moat.

The nests of the Heart-shaped ants (*Crematogaster spp*.) are very hard and fibrous. In the CPCP, these nests are either buried in soil or hung from a branch within the pangolin's enclosure, and therefore provide an element of behavioural enrichment. The pangolins break into the centre of the nest with their forelimbs to get to the eggs and larvae, and consume ants as they go.

Frozen food is fed in a small bowl and the pangolin uses its tongue to lick up all the food. If the proportion of ant eggs and larvae is low compared to the proportion of adult ants within this food, the pangolins use their forelimbs to dig into the food. A possible interpretation of this behaviour is that the pangolins show a preference for the eggs and larvae due to their higher fat content, and will actively search for these food items but this needs further study, both in captive and wild populations.

Pangolins use their long sticky tongue to drink water from the water bowls or from the water in the moat which surrounds the live food bowls (Figure 6.2).

Figure 6.2: *Manis javanica* drinking water from the live-food moat.

6.3 Sleeping

Most pangolins sleep in bed boxes, although in the summer some pangolins sleep in the concrete pipe leading to the bedbox. This is presumably because the pipe is cooler than the bedbox. One pangolin at the CPCP sleeps in a burrow that she dug for herself, however she moves to the bedbox when it rains or if the bed box is provided with a heat mat during cool weather. Some pangolins in quarantine enclosures sleep in the corner near the water pond. This area is cooler than inside the bedboxes, and this might explain this preference, particularly during the summer months. The CPCP has also observed pangolins sleeping in hollow logs and in the open on branches exposed to full sunshine. These arboreal behaviours may be more conducive to thermoregulation, particularly in warmer months. Sleeping location may also simply be a matter of individual preference.

Figure 6.3: One *Manis javanica* sleeping inside a log hollow.

Figure 6.4: *Manis javanica* sleeping at one corner on the floor when it is very hot

6.4 Social Behaviour

6.4.1 Adults and Infants

The CPCP has only observed two mother-infant pairs in captivity (and this is discussed in Chapter 8). During the first week after birth the mother leaves the baby in the bedbox when she goes to feed. She will often go back to check on the baby. After this initial week, young pangolins are frequently carried around on their mother's back/tail until weaned.

Five orphaned juveniles have been transferred to the CPCP. Juveniles kept in enclosures with other pangolins have often been observed attempting to climb on the back of other animals, even others of the same bodyweight. For this reason, young rescued pangolins should be kept with other adult pangolins, but monitored closely. Based on observations of two orphans, one captive born pangolin and the behaviour of four adult females, some female adults appear very maternal. The adults curl up around the young pangolins when sleeping and the young pangolins will ride on the tails of the adults. However, since not all adult females have responded favourably to the presence of juveniles, all adults should be carefully monitored for signs of stress when placed together with juvenile pangolins.

In one case, two infant females were kept in the same enclosure as an older adult male. The three pangolins were initially observed curled up together to sleep, and the infants regularly rode on the male's back. However, as the infants grew bigger, this behaviour appeared to cause stress to the older male, particularly when both females climbed onto his back simultaneously, and a decision was made to separate the male from the females (Figure 6.5).

The two females continue to live together as fully grown adults, and are still often observed sleeping curled up together.

Figure 6.5: Two juvenile Sunda pangolins trying to climb on the back of one male pangolin whilst he is eating dead ants. Since this behaviour appeared to cause stress to the older male, a decision was made to separate the male from the females.

6.4.2 Adult Groups

In the CPCP, pangolins are typically kept by themselves, but we have experimented with keeping groups. Groupings have included: all females (n = 3), male and female pairs (n = 2) and one mixed group which consisted of two females and three males.

This experience has shown that adult females can be kept together successfully without any aggression. However, further research is required on the effects of keeping a mixed sex pair of one male and one female together. Two mixed sex pairs have been kept together in the CPCP successfully for 1 and 1.5 years respectively, but both males eventually died. One of the deaths is likely to be have been stress-related and due to the presence of another male nearby, but the cause of death in the second case is unclear, and may be related to temperature as this occurred during a particularly cold winter when the mortality rate in the CPCP in general was high. This aspect of husbandry is an important question to address in future studies.

Males have not been kept together in the CPCP, as two males which lived in adjacent enclosures with clear visual access to each other, were previously observed displaying behaviours which were suggestive of severe stress.

These behaviours included: climbing on the wire of the cage, scratching at and through the wire and putting their head repeatedly through the wire mesh. Significant weight loss was observed in both males and a long-term resident died three weeks after the new male was placed in close proximity to him. For this reason, without further study, males are no longer kept together or within visual contact.

In quarantine and the long term enclosure (the Pangolarium), males in the CPCP are kept in adjacent enclosures, however only when these enclosures are separated by a solid concrete wall, and visual barriers are used so that the males cannot see each other. No social problems have been observed since these steps were implemented.

6.4.3 Introducing New Adults

The CPCP has little experience in introducing a new adult to an enclosure already occupied by a resident pangolin. This is an important aspect of husbandry needing study as grouping animals, rather than keeping them singularly, could clearly solve space problems within a rescue facility.

6.5 Courtship

Unknown.

6.6 Bathing

When the temperature is $>30^0$C pangolins often bath in the large water bowls/water pond. Animals either walk through the water bowl/pond, or slowly slide down from a branch hanging above the water bowl/pond. One individual has been regularly observed to ‘drop’ from 2m into her pond, and deliberately climb back up to repeat the activity.

Bathing is rare in winter. Increased bathing activity has been observed after feeding on live ants. This may be to cool down, to reduce itchiness caused by ant bites, or to remove ants from underneath pangolin scales.

Figure 6.6: Sunda pangolin slides down into the water pond from branch.

6.7 Behavioural problems observed in captive pangolins

A number of behavioural problems have been identified in the CPCP. One group of problems are defined as 'stressed behaviours', the others include stereotypic behaviours.

6.7.1 Stressed behaviour

When pangolins are agitated they show a group of behaviours which the CPCP regards as stress behaviours. These include: rapidly climbing on the enclosure wire and along the wire ceiling, running very quickly on the ground or branches, repeatedly putting their head through the wire mesh while clawing at the mesh, and scratching at the door of the enclosure. Pangolins displaying these behaviours often injure themselves on their face and claws. These animals may still be eating and drinking but in our experience, all animals showing these behaviours lose weight. Almost all pangolins that have exhibited these behaviours during the quarantine period have died.

While there may be many causes of stress a number of factors are believed to play an important role. These include: environmental temperatures, the quality of food available and the nature of enclosures. Given a lack of space in the CPCP, some animals remain in the quarantine facility for well beyond their quarantine period. Higher mortality rates are seen in animals residing long term in the quarantine compared to those residing in the Pangolarium, even when animals were eating the same food and were subject to the same weather conditions.

The highest mortality rate in the CPCP was seen in January and February of 2008, a year in which the coldest winter in 100 years was recorded for Vietnam. Thermoregulation may play a role in the lower mortality rate seen in stressed animals residing in the Pangolarium compared to the quarantine facility. Pangolins spend the highest proportion of the daily time budget asleep in their bedbox. The options for sleeping quarters in the Pangolarium are more varied. Some of these may be warmer in winter.

Dietary work carried out by the CPCP suggests that low quantities and poorer quality of live food available during winter months has contributed to a higher mortality rate. Since 2008, a more energy rich diet has been provided during winter months, and both the incidence of stressed behaviours and mortality rate have reduced significantly since then. Since changing to this more energy rich diet, one animal has been kept successfully in the quarantine facility for 2 ½ years, and two others for 1 ½ years, with no stressed behaviours observed during the winter period.

Enclosures within the Pangolarium are also much larger, and contain naturalistic furnishings. This may be a less stressful environment for these pangolins.

To reduce the occurrence of stressed behaviours it is recommended that pangolins are kept in large naturalistic enclosures, providing sufficient quantities of good quality food, and the provision of supplementary heating during times of low environmental temperature (this is discussed in greater detail in Chapter 5 of this manual).

6.7.2 Stereotypic Behaviour

Pacing has been observed in a small number of pangolins captive within the CPCP (Challender *et al*., *In Press*). During this study, one animal was observed repeatedly walking a circuit, mostly on branches. This behaviour ceased when the enclosure branches were rearranged. Another pangolin was observed walking a tight circuit around a log. Again, the problem ceased when the enclosures furniture was rearranged. These two cases suggest that regularly re-arranging enclosure furnishings may help to reduce the incidence of stereotypic behaviours in captive pangolins.

6.8 Environmental Enrichment

Like all captive mammals, the aims of environmental enrichment are to:

- Provide animals with the opportunity to exhibit natural behaviours;
- Provide animals with choice;
- Provide an ability to exercise some control over their environment;
- Increase the time spent foraging and
- Increase time spent actively moving around.

6.8.1 Food Enrichment

Enrichment activities related to feeding have included:

1. Feeding a wild diet of live ants within a nest. This provides an opportunity to express natural foraging behaviours.
2. Placing ant nests on the branches within the enclosure to make access more challenging.
3. Hiding ant nests underground, requiring animals to locate and dig up the nest.
4. Collecting wood/debris containing termites, and placing them in enclosure for the animals to find.

5. Placing frozen food inside a plastic box, into which small holes (15mm) have been drilled. Pangolins use their tongue to extract the food from these boxes.
6. Provision of leaf litter on the floor of the enclosure to attract insects and provide hiding places for insects for the pangolins to find.

6.8.2 Enclosure Enrichment

Other forms of environmental enrichment used within the CPCP have included:

1. Provision of soil for digging
2. Provision of tree hollows for sleeping
3. Provision of climbing branches
4. Provision of ropes and unstable climbing objects to improve balance and physical fitness
5. Provision of a pool for swimming
6. Provision of a deep soil floor in the enclosure and turning over this soil every month or more to provide novelty.
7. Provision of mutliple denning options (e.g. bedbox, hollows and burrows) so the animals can exercise choice hence decrease stress.
8. Changing furniture (branches) every second month, to provide novelty and alternative physical pathways so the animal exercises slightly differently

Chapter 7 - Feeding Requirements

7.1 Captive Diet

Pangolins in the CPCP are fed a diet which includes both natural and artificial components. Unfortunately due to lack of study, no one knows exactly what pangolins eat in the wild. During hunter interviews, many reported that both the Chinese pangolin (*M. pentadactyla*) and Sunda pangolin *(M. javanica*) eat ants and termites, and that they have also been known to feed on bee larvae and eggs (Newton *et al*., 2007).

Ants and termites are difficult to farm or collect in sufficient quantities to feed a 100% natural diet to pangolins. Also, Sunda pangolins appear to prefer tree ant species, and those within the CPCP have not shown any interest in termites, and only one has shown interest in ground ant species.

Early in our project we determined that we needed to develop an artificial diet to replace natural food for confiscated pangolins. We contacted, and visited, a large number of international zoos with experience in keeping ant-eating species, to learn how to develop artificial diet.

Artificial diets are used to feed pangolins in Taipei Zoo (*M. pentadactyla pentadactyla*) and Night Safari, Singapore Wildlife Reserves (*M. javanica*). These diets are reproduced here (Table 7.1):

Table 7.1: Pangolin diet provided by Taipei zoo and Night Safari (Yang *pers. comm.*, Vijayan *et al.*, 2008).

Ingredient	Amount/animal/day (Taipei Zoo)	Amount/animal/day (Night Safari)
Bee pupa	100 g	-
Yellow mealworm	22.5 g	-
Calcium carbonate	0.5 g	-
Coconut powder	1.5 g	-
Yeast powder	3 g	-
Egg yolk	0.5 g	-
Apple	65 g	-
water	60 g	-
Chitin	10 g	-
Commercial mixture	1.5 g	-
Vitamin K	0.05 g	-
Hard boiled egg	-	2 whole egg
Mazuri® Insectivore pellets	-	80g
Horse meat	-	120 g
Mealworms	-	150 g
Water	-	350ml
Salmon oil	-	1 pump
Powdered Termite mound	-	4 tablespoons
Nutroplex® multi-vitamin liquid	-	2 tablespoons

An exact replication of these artificial zoo diets in the CPCP was not possible due to the lack of availability or high expense of many of the ingredients (e.g. chitin, Mazuri® Insectivore pellets) in Viet Nam. The CPCP is currently working with SeaWorld & Busch Gardens (SWBG), United

States, to develop an artificial diet for pangolins. In October 2008, adult ants, eggs and larvae of three different species *Oecophyla smaragdina*, *Crematogaster* sp and *Polyrhachis* sp were sent to the Zoo Nutrition Centre of Busch Gardens, US for nutritional analysis and this work is underway.

7.1.1 Natural Diet (Live Ants)

Since 2006, the CPCP has collected a range of different ant species and presented these to captive pangolins. Four species are eaten readily: Weaver ant (*Oecophyla smaragdina*), Heart shaped ant (*Crematogaster* sp.), Genus *Polyrhachis* (*Polyrhachis* sp.), and Crazy ant (*Anoplolepis gracilipes*). In order to continue to feed live ants, the CPCP has needed to develop both ant collecting and ant farming skills. This process is ongoing.

After collection, wild tree ant nests are stored in a large canvas sack. They are then fed to pangolins in a large round bowl which is surrounded by a moat to stop the ants from escaping (these bowls are described in greater detail in Chapter 3, Section 3.2.6).

In the early stages of the program, pangolins within the CPCP were fed solely live ants. All animals did very well on this diet. However, in order to ensure a stable supply of ants, and to assist in the introduction of an artificial diet in the future, frozen ants were introduced to the pangolin diets. Over the following $1^1/_2$ years the number of live ant nests fed per week to each pangolin was reduced and frozen silkworm pupae was added to the frozen component of the diet (see below, Table 7.2)

Note: In the CPCP, newly arrived confiscated pangolins are still fed live ant nests for the first three days after arrival, in order to provide them with a familiar diet to reduce nutritional stress. Newly arrived pangolins in the centre seem to know exactly how to eat live ants – they have been observed immediately ripping open nests, and putting their heads inside to eat the live ants, eggs and larvae. Over the next two weeks they are gradually transitioned to a diet which consists mainly of frozen food. In contrast, not all pangolins immediately eat frozen ants – it can sometimes take a few days of continuing to offer frozen ants before they will eat this food. However, the CPCP has never had a pangolin that continued to refuse to eat frozen ants over a long period.

7.1.2 Artificial Diet (Frozen diet)

Frozen food initially consisted of frozen, thawed ants only. Over time we have developed this diet, and it now consists of a blend of ants and silkworm pupae.

We have also experimented with feeding pangolins on a variety of different foods. Each of these diets was trialled for a minimum of three nights. Most diets were not accepted by the pangolins. No diet with ground ants was accepted (no food was eaten by pangolins). In contrast, all diets with whole ants were accepted, but to varying degrees. Table 7.2 outlines all diets, and the degree to which they were accepted.

Table 7.2: All diet trials and their level of acceptability by pangolins

Ant component	Other ingredient	Acceptability
Ground ants	uncooked raw chicken eggs	None eaten
Ground ants	ground silkworm pupae	None eaten
Ground ants	ground mealworms	None eaten
Ground ants	ground dried shrimp	None eaten
Whole ants	powered frozen silkworm pupae and ground fresh soybean pre-boiled for one hour	Soybeans initially comprised 5% of diet, but acceptability was poor. This was increased to 20% and the diet was accepted well for a 1 month trial. The pangolins ate all their food.
Whole ants	powered frozen silkworm pupae and dried ground soybeans pre-boiled for one hour	The soybean initially comprised 5% of diet, but the pangolins ate less consuming only 30% of diet. The trail was stopped due to reduced food intake.
Whole ants	bee larvae (5-10% of diet was bee larvae)	Fed to 7 animals for 10 feeds, and was readily accepted except where the bee larvae were large
Whole ants	diced frozen silkworm pupae	This diet was accepted by all pangolins. Modifications to this diet gave rise to the pangolins current diet.
Whole ants	dried powdered silkworm pupae	Silkworm pupae initially comprised 5% of the diet but it was not well accepted (only about 50% the food was eaten). The trail was extended to two weeks, with no change to acceptability.

7.1.3 Current Diet

All pangolins in the CPCP are currently maintained on a diet of whole frozen ants and frozen powdered silkworm pupae. While pangolins accepted the diet with whole ants and diced silkworm pupae, many pupae remained after the pangolins had fed. This may have been because pangolins did not like the size and form of silkworm pieces, so pupae were subsequently frozen and blended to create a powder. This powder was then mixed with the frozen ants. The pangolins readily eat this, and indeed do not always finish eating the frozen ants if the power has not been mixed in.

Initially, only a small amount of the powdered silkworm was used but this amount has increased over time. The CPCP fed a diet of 75% powdered silkworm pupae and 25% frozen ants for one year. However, the current pangolin diet includes 20% frozen ants, 50% frozen powdered silkworm pupae and 30% cooked soy bean. This diet has been tried for 3 months with closely monitoring weight of the animals and behaviours. It showed that the pangolins maintained their weight well without any stress sign. The high proportion of pupae fed and soy bean have become necessary due to the poor availability of ants and to provide protein and fat source, but the pangolins continue to do very well on this diet.

The development of an artificial diet continues. While the nutritional content of silkworm pupae is available (Nguyen, 1990) the nutritional content of ants and ant larvae is not yet complete. Once this information is known, it will provide a solid basis for further diet development.

The link between quantity (in grams) of frozen diet provided and the bodyweight of pangolins is illustrated below, Figure 7.1.

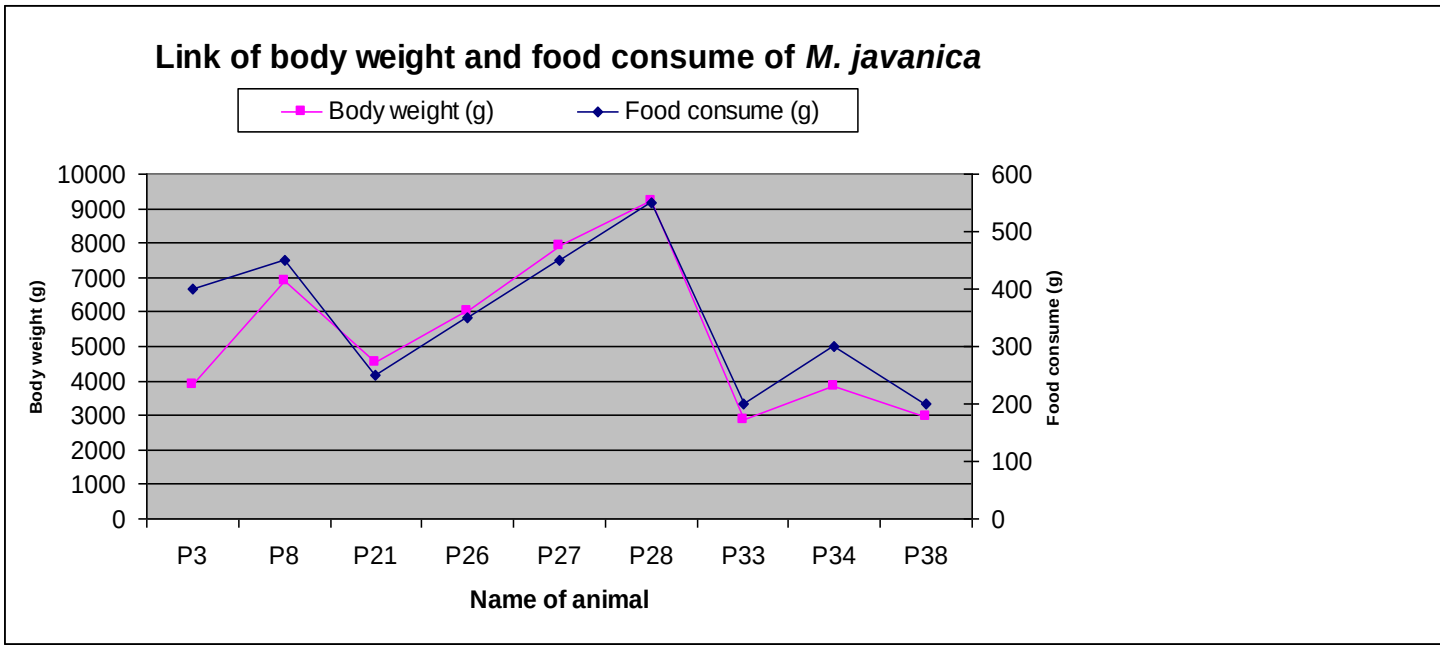

Figure 7.1 The graph above provides a snapshot view of the quantity of food consumed on a single day and weight of the pangolin. Further research investigating the quantity of food consumed according to weight over time is planned.

7.2 Nutritional Supplements.

No nutritional supplements are provided in the CPCP

7.3 Presentation of Food

Pangolins in the CPCP are fed once a day in the early evening (normally 5.30- 6.00pm). Those in quarantine requiring both live ants and frozen food need a special feeding bowl that prevents live ants from escaping (see Chapter 3, Section 3.1.6). Frozen food is placed in a ceramic bowl and is thawed by the time the animal is awake (see Figure 3.8).

For animals that have finished quarantine, and have moved to the Pangolarium, food is presented in a number of different ways. Weaver Ant nests are placed a specially designed metal bowl (95cm diameter) that has a central bowl surrounded by a 10cm water filled moat to prevent ants escaping. Heart Shaped Ants nests are used for behavioural enrichment. This harder structured nest is buried underground or hung on a branch for the pangolins to find. Frozen food is placed in a ceramic bowl.

Figure 7.3: Metal live ant feeding bowl for Weaver Ants nests, with water moat

Chapter 8 - Breeding Requirement

There is little known about pangolin reproduction, and they have rarely bred in captivity.

8.1 Breeding System

There are no published reports describing pangolins mating in the wild, although Heath and Coulson reported finding a male and female Cape Pangolin (*M. temminkii*) sharing a burrow, and this behaviour was interpreted as being related to mating activity (Heath & Coulson, 1997).

A small number of pangolins have been observed mating in captivity. Sunda pangolins have been observed mating in an artificial burrow at the Night Safari, Singapore Wildlife Reserves (M. Vijayan, *pers. comm.*), while *Manis pentadactyla pentadactyla* has been reported to mate on the branches inside their enclosure in Leipzig Zoo, Germany (F. Wicker, *pers. comm.*). In both instances, male pangolins have climbed on the back of the female to mate.

8.2 Age at First Breeding and Last Breeding.

Unknown

8.3 Ability to Breed Every Year

This is unknown, but given a potential gestation period of less than 6 months, and a dependency of less than 6 months, it seems possible for the females to breed every year.

8.4 Timing of Breeding

Sunda pangolin (*M. javanica*) does not appear to have a defined breeding season. Reports of pangolins giving birth in captivity, and the presence of juvenile pangolins in the wild all year round suggest that breeding may occur at any time of year (Lim & Ng, 2008; Nowak, 1991). Breeding reports in the literature, for both wild and captive pangolins, are summarized below, Table 8.1.

8.5 Nesting/Hollow and Other Requirements

Pangolins use hollows and burrows extensively, but it is not known how their requirements change during breeding. Interviews with hunters (Newton *et al.,* 2008) suggest that mothers tend to use one burrow regularly.

Lim & Ng (2008) followed one female with a juvenile for 65 days and she was observed to use three dens. Most commonly, the animal spent 5-10 days sequentially using the same den before changing to one of the others, but in one case she used one den for 24 days. Two dens were located in the trunks of trees and one in a log, and these ranged from 54 – 104 cm in diameter. The entrances to the dens were 14 – 24cm diameter. This information may assist in devising dens suitable for breeding pangolins, and in offering alternative bedboxes/dens.

Table 8.1 Detail breeding record of both Chinese pangolin (*M. pentadactyla*) and Sunda pangolin (*M. javanica*) in captivity and in the wild

Species	Date of birth	Length and mass	Location	Reference
Manis javanica	4 October	420g after half month	Cuc Phuong, Vietnam	CPCP Records
	22 November	143g after 2 days old	Cuc Phuong, Vietnam	CPCP Records
	24 February	0.27m, 113g	Cuc Phuong, Vietnam	CPCP Records
	31 December		Cuc Phuong, Vietnam	CPCP Records
	16 January	0.27m and 116g (unborn foetus)	Cuc Phuong, Vietnam	CPCP Records
	September		Singapore (wild)	(Lim and Ng, 2008)
	April		Night Safari, Singapore Wildlife Reserves	(M. Vijayan, *pers. comm.*)
	September		Cu Chi, Vietnam	(M. Wills, *pers. comm.)*
Manis pentadactyla	5 February	0.2 m, 92 g	University of California, San Diego, US	(Heath and Vanderlip, 1988)
	August	–	Oklahoma Zoo, US	(Ogilvie and Bridgewater, 1967)
	14 November	0.21 m, 93 g	University of California, San Diego, US	(Heath and Vanderlip, 1988)
	25 December	200 g at 16 days	Uenno Zoo, Tokyo, Japan	(Masui, 1967)
	November to February	–	China (wild)	(Fang & Wang, 1980), (Fang, 1981)

8.6 Breeding Diet

Unknown

8.7 Gestation, Parturition and Maternal Care

8.7.1 Gestation

For most species of pangolins, including *M. javanica* no published records of gestation period exist (Payne & Francis, 1998). The gestation period of *M. pentadactyla* has been estimated to be greater than 169 days (Yang et al, 2007).

The following information was obtained from pangolins giving birth in the CPCP:

- Two confiscated pregnant females gave birth 129 and 178 days after arrival. This suggests gestation of > 178 days.

- One pangolin has been conceived in captivity. Based on the presence/absence of males in her enclosure her gestation period was either more than 361 days (~ 1 year) or less than 168 days.

8.7.2 Parturition

Two of the five pangolins which have given birth in the CPCP exhibited behaviour which was considered to be atypical during this period:

- One pangolin was active during the day, running, climbing, and scratching on the wire mesh enough to hurt her feet. She returned to the bedbox at midday and gave birth in her bedbox that night.
- The second pangolin dug out of her enclosure 2 days before giving birth (and was recaptured just prior to giving birth).
- There were no changes in behaviour observed in the remaining three pangolins, but this due to a lack of observations during the night time.

Collectively, these observations suggest that providing pregnant pangolins with alternative denning opportunities may help meet their denning requirements during parturition.

8.7.3 Maternal Care

During 2008, one of the mother/young pairs was observed for 38 nights as part of a formal study on captive pangolin behaviour (Challender, *et al*, In Press). When sleeping, the mother was observed curling herself around the baby (Figure 8.1). The mother tends to uncurl slightly to allow the baby to suckle. In the CPCP, babies have emerged from the bed box at about 1 week old. They are carried on the tail or back (Figure 8.2). In the presence of people, the mother will generally return to the bedbox/den. No grooming (of the baby by mother) has been observed.

Figure 8.1: Mothers in the CPCP have been observed sleeping curled around their baby.

Figure 8.2: The mother caries about one week old baby on the back of her tail.

8.8 Litter Size

Five pangolins in the CPCP have given birth to a single young, three pangolins have been observed to be pregnant at necropsy, and all of these were single pregnancies. Elsewhere, only single young have been recorded (Lin & Ng, 2008).

8.9 Age and weight at Weaning

This is unknown, however, one wild female *M. javanica* was observed to nurse her infant for 3 to 4 months (Lim & Ng, 2008). Nursing for 6 months has been observed at Taipei Zoo for *M. pentadactyla pentadactyla* (Yang *et. al* 2007). In the CPCP, one baby was still being milk fed when it died aged 4 months. Prior to the death of the infant, 'wrestling' behaviour had regularly been observed between the infant and its mother. Wrestling comprised a mother and its four month old offspring rolling on the floor clawing at each other. On one occasion this behaviour lasted for 12 min. Claws making contact with scales were heard suggesting some level of aggression although the underlying cause and function of this behaviour remains unknown. It was presumably a maternal interaction but such behaviour warrants future investigation. Another young male born in the centre died aged 9.5 months, however it is unknown if this animal was still being fed milk at the time of death.

In the absence of other information, it is recommended that mother and young are provided with an enclosure where they can separate themselves *by choice*. For example, an extra bedbox, whose entrance or access tunnel was of a diameter more suited to the size of a juvenile than an adult, would provide an element of choice for a young pangolin wishing to separate itself from its mother.

Table 8.2: Records of one baby Sunda pangolin in the CPCP

Time after birth	Weight (kg)	Length – Nose to tail (cm)	Activities
0.5 months	0.42	-	Come out of bedbox on the back of mother
1.0 months	0.62	46.5	Got off the mother's back and independently ate food
1.5 months	0.94	53.5	-
2.0 months	1.163	62.5	-
2.5 months	1.3	65	-
3.0 months	1.5	-	-
3.5 months	1.6	-	Baby scratches on the face of his mother

8.10 Young Weights.

Baby pangolins born in the CPCP have weighed between 110-130 grams at birth.

8.11 Age and weight of Removal from Parents.

Unknown (See Section 8.9)

Chapter 9 - Artificial Rearing of Pangolins

9.1 Animal health

Orphan pangolins require the same health assessment and quarantine precautions as newly arriving adult pangolins. Refer to Chapter 5 of this manual for further information on pangolin health and quarantine requirements.

9.2 Housing

Orphaned mammals should be provided with a clean, dry bed box, which is kept in an area which is free of drafts.

In the CPCP, an orphaned pangolin was confiscated amongst a group of five other juvenile pangolins. In this case, the baby pangolin was not kept in a separate bed box, but was returned to the group quarantine enclosure to sleep between feeds.

This resulted in a number of advantages – the baby curled up next to other juveniles to maintain normal body temperature while sleeping, it was given social contact with others of its own species, and it followed the older pangolins when they went out of the bed box at night to eat solid food.

The pangolin slowly began to accept more and more live ants of its own accord, and we were able to wean off accordingly (See more Section 9.9).

If there are no potential foster 'parents' available, the baby pangolin should be given something to cling onto – a teddy bear or something similar will suffice.

Decisions on whether to foster an orphaned animal or to separate it and hand rear it individually need to be made on a case by case basis, taking into account the orphan's health, age, and the availability of potentially suitable foster pangolins.

Figure 9.1: Juvenile pangolin group in the CPCP. This photo was taken a few weeks after their arrival in the centre. The red arrow points towards the individual being hand raised. This social grouping removed the need for separate housing for the hand raised infant.

9.3 Temperature Requirements

A pangolin's normal body temperature is low, 33-35^{0}C. However, infants in general have a poor ability to regulate their own body temperature, relying on their mother's body heat to keep warm. It is highly possible that an infant may be very cold on arrival in the centre. Use a thermometer to measure the infant's temperature.

To warm up a baby that is very cold you can hold it gently in your hand and put it into a warm bath of water – make sure its head (mouth, nose and eyes) stay out of the water. You can also use a heat mat, placed into a box and wrap the baby in a warm towel or blanket. As a last resort, if you have no warm water or electricity, gently hold the baby under your shirt against your skin.

Even once the infant's temperature has returned to normal, it will require an external heat source to keep warm. The best way to provide heat for an orphaned infant is to use a thermostat controlled heat mat, covered in a towel, placed into a bed box so that the animal feels secure and is safe.

The thermostat should be set at around 30-34^{0}C. Make sure that the infant's bed box is kept in a dry, warm room, and that it is protected from cold wind.

The pangolin hand raised in the CPCP did not require a heat mat because it slept with curled around one of the other juveniles within its group, therefore helping to maintain normal body temperature.

9.4 Monitoring weight

Infants should be weighed daily, and a daily record should be kept. This information helps to determine the correct volume of milk to feed, and provides an indication that the baby is developing well. Infant's weight should increase steadily over time.

Babies should be weighed at the same time everyday, so choose a time which suits the running of the centre and the infant's feeding schedule and stick to it. The CPCP hand raising daily record sheet is included as Appendix 3.

Figure 9.2 and 9.3: Weighing baby pangolins in the CPCP. Something for the baby to cling onto gives a more accurate weight (the animal stays still allowing the scales to register weight), and provides a degree of comfort for the baby.

9.5 Diet

Do not feed milk immediately – feeding can only begin once the baby's body temperature is normal.

9.5.1 Formula type

The pangolin hand raised in the CPCP was fed kitten formula. The infant was started on formula made from KMR® Powder (PetAg Pty. Ltd., Hampshire, IL, www.petag.com). This was tolerated well, and the infant gained weight steadily. Ideally, we would have continued to feed the pangolin on the same formula until weaned, however, the small supply we had on-hand in the centre ran out.

Since good quality infant animal formulas are not available in Vietnam, we were reliant on a visitor coming from Australia to replenish this supply. As a result, the animal was switched to Wombaroo Cat Replacer Milk (Wombaroo Food Products, Adelaide, Australia, www.wombaroo.com.au). The infant accepted this formula change very well, with no ill effects, and continued to develop well on this milk until weaned.

9.5.2 Volume to feed

Starting an orphaned animal directly onto full strength milk formula can lead to gastric problems (diarrhoea, constipation or bloat). If the baby is severely dehydrated, you can simply give oral or subcutaneous fluids for the first 24 hours, introducing milk formula on the second day. Regardless, it is suggested that the concentration of milk formula is gradually increased to 100% over the first 24-72 hours.

As an example, the following dilution procedure can be implemented:

- Day 1: total volume fed = 25% full strength milk formula: 75% water or electrolyte solution
- Day 2: total volume fed = 50% full strength milk formula: 50% water or electrolyte solution
- Day 3: total volume fed = 75% full strength milk formula: 25% water or electrolyte solution
- If there is no constipation, diarrhoea or bloating (gassy stomach), then from the fourth day you can feed 100% full strength milk formula. Alternatively, if the animal is very strong, and seems hungry, the rate of introduction to 100% milk formula can be increased. Decisions regarding how quickly to feed 100% milk formula must be made on a case by case basis.

Most commercially available milk formulas will provide an indication of the volume of milk to feed per day, based on the infant's body weight. In general, the infant will require 20% of total body weight over 24 hours.

The number of meals to feed per day depends on the age and bodyweight of the infant on arrival. The infant hand raised in the CPCP weighed 700gm on arrival. This baby was initially fed four times per day (total volume of 20% bodyweight, divided into four equal meals), however this was quickly reduced to three meals per day, and the animal continued to maintain bodyweight.

Further research will be required to give more detailed information on the number and volume of feeds per day for orphaned pangolins. In the meantime, monitoring bodyweight, activity levels, and behaviour before during and after feeding must be used as a guide.

9.5.3 How to feed

In the CPCP a syringe (10ml or 20ml, depending on the volume of milk fed per feed) with a long, thin silicon cat teat on the end was used to feed. This has the advantage of being calibrated, so that the exact volume fed per meal can be easily recorded. Syringes are also cheap and easily available locally. However, using syringes can become time consuming as the animal grows, and the volume of milk fed per feed increases. Also, care must be taken not to depress the plunger too quickly. A slow and steady pressure should be applied to the plunger, while watching that the infant is swallowing comfortably.

Milk should never be seen coming out of the nostrils or bubbling around the corner of the lips – both of these events suggest that milk is being fed too rapidly, and the animal is unable to swallow the volume being fed, and aspiration pneumonia may result.

Test the temperature of the milk BEFORE FEEDING. Dribble a small volume on the inside of your wrist – you shouldn't be able to feel it. If it's too hot you will feel a burning sensation. If it's too cold you can feel the cold dribble on your skin. If its body temperature (perfect!) you can barely feel the milk on your skin.

Figure 9.4: Using a 10ml syringe and a long, thin rubber teat (Catac Products UK Ltd, www.catac.co.uk) to feed an orphaned pangolin in the CPCP.

9.6 Hygiene and Special Precautions

It is very important to maintain very strict hygiene when hand rearing. Orphaned animals are far more susceptible to infectious diseases than animals being reared naturally by their mothers.

Some particular points to note include:

- Always wash your hands prior to, and after, feeding the infant pangolin.
- Only make up enough formula to last for 24 hours, and keep the milk in the refrigerator. Any milk remaining after 24 hours should be thrown away, not kept for the next day.
- Never reheat milk – throw away any remaining milk at the end of each feed.

9.7 Weaning

There is currently scant concerning the reproductive biology and behaviour of pangolins. Considerable further research (of reproduction in both wild and captive pangolins) is required to determine optimum age and weight for weaning pangolins, as this is currently unknown.

The pangolin hand raised in the CPCP self-introduced itself to solid food and live ants. This may be because it continued to live with a group of older pangolins, or it may simply be an instinctive behaviour.

In order to determine the volume and frequency of milk feeds required during this weaning process, the infant's weight was monitored carefully. Milk feeds were initially ceased too soon, and the animal was unable to maintain bodyweight on a solid food diet. At this stage, a single milk feed was re-introduced until the animal had regained weight, and continued to grow. At this stage the volume of milk fed in the single daily feed was gradually reduced. This individual was completely weaned from milk by 2kg bodyweight.

Chapter 10 - References

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Chapter 11 - Glossary

CPCP Carnivore and Pangolin Conservation Program

APCP Asian Pangolin Conservation Program

Pangolarium Long-term Enclosure for pangolins of CPCP

CITES Convention on International Trade in Endangered Species of Wild Fauna and Flora

IUCN International Union for Conservation of Nature

WCS Wildlife Conservation Society

WWF World Wildlife Fund

Chapter 12 - APPENDICES

Appendix 1 - Schematic Drawings of Pangolarium with dimensions in the CPCP

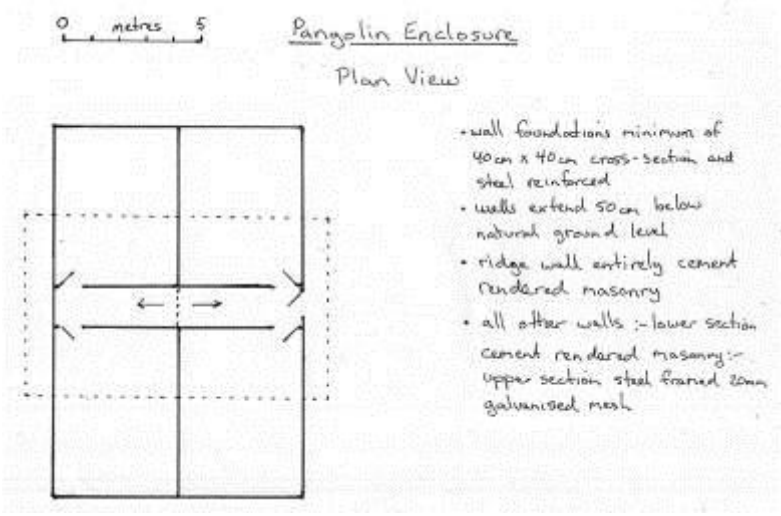

Figure 12.1: Plan View

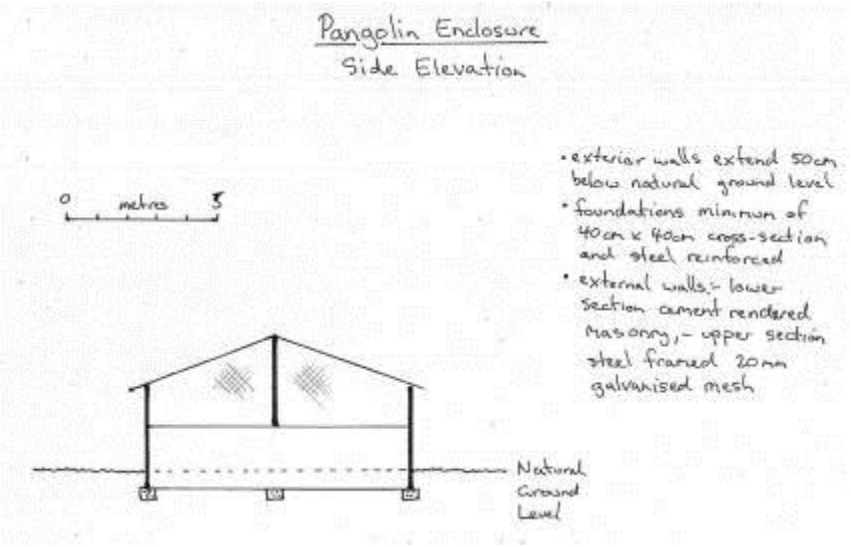

Figure 12.2: Side View

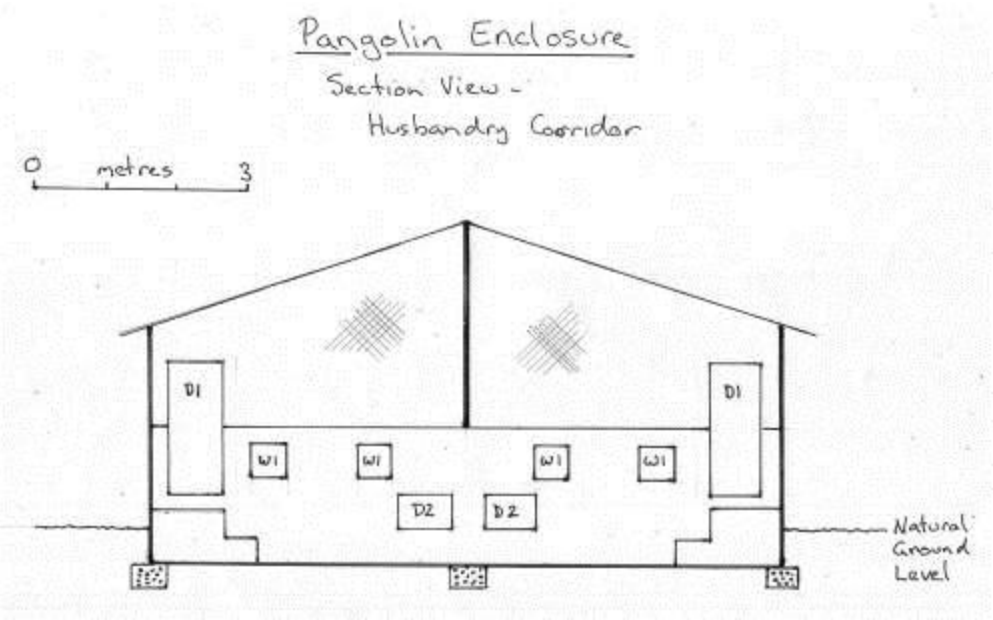

Figure 12.3: Section View

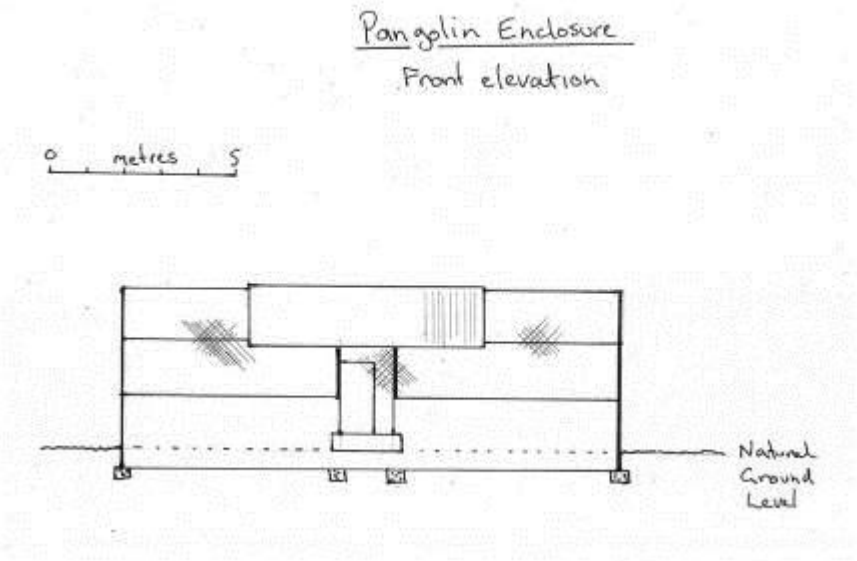

Figure 12.4: Front Elevation

Appendix 2: CPCP Post Mortem Reporting Form

Date of PM:
PM performed by:

SIGNALMENT

Species (common and scientific name):
Name/ID number:
Age/date of birth:
Sex:

POST MORTEM HISTORY:

(Provide detailed information on the date and time of death and the storage of the body prior to PM)
Date of death:
Time of death:
Animal found dead by:
Body storage prior to PM (fridge, freezer, none):
Other comments:

CLINICAL HISTORY PRIOR TO DEATH

(Concise notes on the animals condition, treatment and response to treatment prior to death. Medical history can be attached to this report if required)

Describing abnormalities found during gross PM

If you see anything you think might be abnormal, describe it according to the following criteria:

Location
Number and distribution
Colour
Size
Shape
Consistency and texture

For example: "the liver contains multiple cream coloured, firm nodules. They range from 1-3cm in diameter, and they are distributed throughout all liver lobes." (Adapted from Munson, L *Necropsy of Wild Animals* downloaded from www.wcs.org/science/wildlifehealthsci/fieldvet/fvp-techpages.html, accessed 17th November 2007)

Take photographs of every stage of your PM, and particularly of anything you think is abnormal

1) Examination of external body and body condition (Provide detailed description of the body condition – score out of 5, where 1/5 is emaciated and 5/5 is overweight. Note if you can feel the bony prominences easily. Make a comment on the muscle mass of the animal. Carefully examine the body for any external lesions, such as trauma, bruising to the skin, limbs/digits missing. Look both inside and outside the ears and comment if you see anything you think is abnormal)

Body Weight (kg):

External body condition score (out of 5):

Other comments:

2) Oral Cavity

(Look inside the mouth and note the presence of oral ulceration of other lesions. Comment on the condition of the animal's teeth and gums and note any teeth missing. Make sure to check the oropharyngeal region right at the back of the oral cavity). Take samples of any lesions. Take a sample of the tongue.

3) Cut through skin

(Look at the subcutaneous tissues and comment on their colour and consistency. Take a sample of any tissue you think is abnormal. Examine the superficial lymph nodes and take samples of each. Place superficial lymph nodes into separate tissue cassettes, labeled with pencil according to the original location of the lymph nodes. Examine the skeletal muscles and comment on their colour and consistency. Take a sample of skeletal muscle).

Comments

4) Abdominal cavity

Take a photograph of the abdominal cavity as soon as you open the cavity.

Is there any free fluid in the abdominal cavity? Comment on colour (yellow, blood tinged) and consistency (clear, turbid). Collect samples of fluid in plain blood tube.

Gastrointestinal tract You should remove the entire gastrointestinal tract from the body, being careful not to spill GIT contents into the abdomen. Collect the stomach contents and the contents of the intestines. Collect representative samples from each section of GIT and comment.

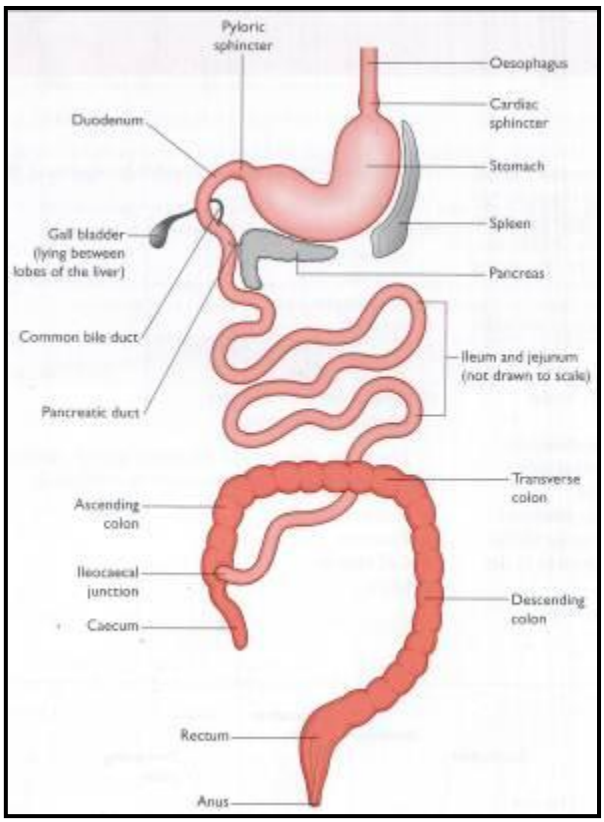

Diagram 1: Diagram 1 shows the organs of the digestive system once removed from the body. From Aspinall and O'Reilly (2004) *Introduction to veterinary anatomy and physiology* Butterworth-Heinemann (Elsevier Science) UK.

Mesenteric Lymph Nodes These are the small, round, firm nodes which are found in the mesentery (the clear, tissue which is attached to the small intestines). Remove some and store in a separate, small jar of formalin (important to label this 'Mesenteric Lymph Node'). Describe what you see – are they uniform in colour? Do they have a mottled dark/light appearance?

Gastrointestinal parasites Open along the entire length of the intestine. Are there any worms present? If so, remove these and place them in a separate, small, labeled jar of formalin.

Liver Remove the liver from the abdominal cavity. Take samples and comment.

Comments

Pancreas

Comments

Spleen

Comments

Kidney

Comments

Adrenal glands

Comments

Bladder

Comments

Reproductive organs

Comments

5) Thoracic cavity Take a photograph of the abdominal cavity as soon as you open the cavity.

Is there any free fluid in the abdominal cavity? Comment on colour (yellow, blood tinged) and consistency (clear, turbid). Collect samples of fluid in plain blood tube.

Remove heart and lungs from thoracic cavity.

Heart

Comments

Lungs

Comments

6) Brain and spinal cord

Spinal cord

Remove sections of spinal cord from cervical, thoracic and lumbar region.

Comments

Brain

Comments

Tissue storage

Store all samples in 10% Formalin. Store only those with blank spaces Frozen (plain) and in Viral Transport Medium.

Tissue	10% Buffered formalin	Frozen Plain (-20^0C)	Viral transport medium (-20^0C)
Tongue			
Oral mucosa plus any areas with erosions, ulcerations of other lesions			
Superficial Lymph Nodes – ensure that lymph nodes are stored separately and their location is written on the label – it is impossible to tell where they come once you've removed them from the body. Information on location can help in understanding local inflammation/infection			
Trachea			
Oesophagus			
Lung			
Heart			
Liver			
Spleen			
Kidney – both			
Stomach			
GI Tract – collect 3cm long sections from all sections of intestines. Flush formalin through the lumen of the GIT sample to ensure that fixation occurs properly			
Mesenteric Lymph Nodes – be sure to store these in a separate, labeled, small jar of formalin.			
Any Parasites found during PM			
Omentum			
Pancreas			
Adrenal gland			
Urinary bladder, ureters and urethra			
Reproductive tract			
Eye			
Brain			
Spinal cord – cervical, thoracic and lumbar. Ensure samples are labeled with location.			
Skeletal muscle (from thigh)			
Skin (full thickness)			

Appendix 3 - CPCP Hand rearing Recording Form

Animal Name:_____ **Page no._____**

Date					**Date**					**Date**					**Date**				
Weight					Weight					Weight					Weight				
Head/body length					Head/body length					Head/body length					Head/body length				
Tail length					Tail length					Tail length					Tail length				
Time	Milk	Solids	Urine	Faeces	**Time**	Milk	Solids	Urine	Faeces	**Time**	Milk	Solids	Urine	Faeces	**Time**	Milk	Solids	Urine	Faeces
Total					**Total**					**Total**					**Total**				

Appendix 4 - Pangolin Drug Formulary

Drug type	Drug name	Used to treat	Dose (mg/kg) & Route	Dosing frequency	Reference for dosing regimen	Comments
Anti-parasitic agent	Ivermectin (Ivomec)	Common gastrointestinal roundworms, and external parasites	400µg/kg under the skin	One off (check faecal float for evidence of GIT parasites)	Chin, S., Guo, J.C., Yang, C.Q, Chao, J *Veterinary practices of the pangolins*, Taipei Zoo, Taiwan (unpublished)	Pangolins have very thick skin
	Toltrazuril (Baycox)	Coccidiosis	5mg/kg orally	ONCE a day for 3 days, then recheck faeces for presence of oocysts – treat again as required	*Pers comm.* To Leanne Clark from Dr Geoff Pye, San Diego Zoological Gardens, USA, 2007	At the APCP we find it easier and less stressful to put drug onto frozen ants than to tube feed (only if animal is still eating)
Antibiotics	Amoxycillin/clavulanic acid (many trade names, including Noroclav, Clavulox)	Most commonly used antibiotic in the CPCP. Used for all skin wounds, and whenever blood is seen in faeces.	8.75 mg/kg (combined) under the skin	ONCE a day for 7 days (continue treatment for at least 2 days after signs have resolved, monitor)	BSAVA Small Animal Formulary, 4th Edition (2003) Ed: B Tennant, BSAVA, Gloucester England.	
	Enrofloxacin	Respiratory conditions, deep skin wounds	5mg/kg under the skin	TWICE a day for 5-7 days (continue treatment for at least 2 days after signs have resolved, monitor)	BSAVA Small Animal Formulary, 4th Edition (2003) Ed: B Tennant, BSAVA, Gloucester England.	

Anti-ulcer medication	Sucralfate (Antepsin Suspension)	To treat ulceration and inflammation of the stomach lining	50mg/kg orally (0.25ml/kg)	TWICE a day.	Extrapolated from cat dose in BSAVA Small Animal Formulary, 4th Edition (2003) Ed: B Tennant, BSAVA, Gloucester England.	▪ This drug is preferably given on an empty stomach, however due to the stress of stomach tubing we normally give the daily doses on a small amount of frozen ants
H_2Antagonist	Ranitidine (Zantac syrup)	To help treat and prevent stomach ulcers	3.5 mg/kg orally	TWICE a day (can drip medication onto food – give small bowl of frozen ants in the morning to enable twice a day dosing)	BSAVA Small Animal Formulary, 4th Edition (2003) Ed: B Tennant, BSAVA, Gloucester England.	▪ We currently do not know if this drug has any effect on stomach ulcers in pangolins ▪ we find it easier and less stressful to put drug onto frozen ants than to tube feed (only if animal is still eating)