

Husbandry Standards for Keeping Porcupines in Captivity

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INTRODUCTION

The Order Rodentia includes the porcupines (families *Hystricidae* and *Erethizontidae*) whose unique characteristics are their quills. Porcupines are divided into two widely different types from the New World and Old World. New World porcupines (*Erethizontidae*) are largely arboreal, while Old World porcupines (*Hystricidae*) tend to be terrestrial. Neither group is thought to be closely related.

Porcupines not only vary in their lifestyles, but also in size and range from 4.4 lbs (2kg) up to 66 lbs (30kg). All porcupines are nocturnal and predominately herbivorous.

COMMON NAME	SCIENTIFIC NAME	ORIGIN
African brush-tailed porcupine	<i>Atherurus africanus</i>	Africa
Asiatic brush-tailed porcupine	<i>Atherurus macrourus</i>	S. E. Asia
Thin-spined porcupine	<i>Chaetomys subspinosus</i>	South America
Prehensile-tailed porcupine	<i>Coendou prehensilis</i>	South America
Upper Amazonian porcupine	<i>Echinoprocta rufescens</i>	South America
North American porcupine	<i>Erethizon dorsatum</i>	North America
Southern crested porcupine	<i>Hystrix africae australis</i>	Southern Africa
Malayan porcupine	<i>Hystrix brachyura</i>	S. E. Asia

Thick-spined porcupine	<i>Hystrix crassispinis</i>	S. E. Asia
Crested porcupine	<i>Hystrix cristata</i>	Northern Africa and Southern Europe
Indian Crested porcupine	<i>Hystrix indica</i>	India
Mexican porcupine	<i>Sphiggurus mexicanus</i>	Central America
Long-tailed porcupine	<i>Trichys fasciulate</i>	S. E. Asia

1. Abiotic Environmental Variables

1.1 Temperature: Temperature extremes should not exceed the porcupines' native habitats. With the exception of crested porcupines and North American porcupines, all species are from tropical or sub-tropical climates. The tropical species should be kept at temperatures ranging from 70 – 85 degrees F. In appropriate climates, these animals can be housed outdoors, but indoor housing allows a better control over the temperature range. Crested porcupines can adapt to a wide range of temperatures, provided that they have been properly acclimated. They should be housed within a temperature range of 55 – 80 degrees F. At room temperatures below 55, they need access to shelter that allows them to remain dry, warm and free of drafts. At temperatures above 80 degrees, shade should be available. North American porcupines can tolerate temperatures ranging from 90 degrees F to below freezing if shelter is available. At higher temperatures, these animals will seek ways to cool themselves. They do well in outdoor exhibits, and only need to be brought inside in severe weather.

1.2 Humidity: Enclosures should be well ventilated, with protection from the sun and wind. Humidity levels for Neotropical species should be at least 35%, and they do best at levels of 45 – 60% humidity (Xanten, 1997). The other species do not seem to be dependent on high humidity and can live comfortably with levels of 30 – 50% (Xanten, 1997). The recommended number of air changes per hour for indoor exhibits to maintain healthy animals will change depending on the number of animals and the size of the enclosure. As an example, to keep odors down to a satisfactory level, pet shops require a rate of exchange equal to 1.0 cubic foot of air/minute/square foot of floor space.

1.3 Illumination:

- 1.3.1** Natural, fluorescent or incandescent lighting is acceptable. Good quality lighting, either natural or artificial, needs to be provided and well distributed. Excessive illumination should be avoided.
- 1.3.2** All porcupines are nocturnal (Kingdon, 1984) and animals housed indoors may sometimes be more active if kept on a reverse light cycle of 13-14 hours of daylight and 10-11 hours of night. Although nocturnal, porcupines can be encouraged to be active during daylight hours by using enrichment, or hiding food items to encourage foraging. Even if not active, porcupines may often sun themselves in full view. Manipulation of the light cycle does not appear to be necessary for successful breeding.

1.4 Space:

- 1.4.1** Porcupines vary a great deal in size and behavior, and therefore there is a wide range of acceptable housing situations for them. Porcupines can be housed either indoors or outdoors, although they need protection from temperature extremes. New World porcupines are highly arboreal, and their enclosures should encompass vertical as well as horizontal space. Old World porcupines are largely terrestrial, and need a larger horizontal area.
 - 1.4.1.1** Brush-tailed porcupines are small and although they can climb, spend a great deal of time on the ground. Enclosures for a single animal should be at least 5'x5'x6' high (150 cu. ft.). For each additional animal, the enclosure should be increased by at least 20%.
 - 1.4.1.2** Prehensile-tailed and North American porcupines are arboreal and rarely move around on the ground. An enclosure for a single animal should be at least 5'x5'x8' high (200 cu. ft.). For each additional animal, the enclosure should be increased by at least 20%.
 - 1.4.1.3** Crested porcupines are large, ground dwelling animals that do not climb. Enclosures for a single crested porcupine should be at least 6'x8'x6' high (288 cu. ft.). For each additional animal, the enclosure should be increased by at least 25%.
- 1.4.2** Terrestrial porcupines are very powerful burrowers, requiring a substantial digging barrier under the exhibit substrate. The best choice is to have a concrete bottom beneath a natural substrate such as soil, grass, mulch or wood chips, which allows the animals to engage in their natural burrowing behaviors. A chain link or mesh bottom is not recommended, particularly with crested porcupines, since these animals are very strong and may pull the mesh up enough to dig underneath. They are poor climbers, however, and may be kept an open top exhibit provided the containment walls are at least 4' high and smooth enough so that the porcupines can't get enough of a grip to attempt to climb out. Cage furniture can consist of piles of branches,

deadfall and hollow logs. In order to make these nocturnal animals more visible during the day, hollow logs can be placed so that the sleeping animals can be easily viewed. Live plants may be used, but they should be protected from gnawing by wrapping them with wire mesh. Crested porcupines in the wild do not tend to move in straight lines, and they tend to follow the edges of the vegetation (Pigozzi and Patterson, 1990). They will also tend to follow the perimeter of an exhibit, or stay near logs, brush or other items that offer security. When designing an exhibit, cage furniture can be placed in locations to provide the best view to the public while at the same time allowing the animals to engage in their natural tendencies. Porcupines like to gnaw on wood, so cage furniture should be replaced regularly as it becomes damaged and worn. Brush-tailed porcupines are good swimmers, and a water feature would be desirable.

1.4.2.1 The larger porcupines should have a shift area where the animals can be secured during exhibit cleaning and maintenance. These areas should be the same minimum size as the exhibits, and made of similar dig-proof construction. A concrete floor is the best choice, with concrete or block walls. The floor needs to have a drain for cleaning, and the drain cover should be made of metal, and needs to be secured to the floor to prevent the porcupines from chewing and/or removing it. Bedding such as straw or pine shavings should be used on the floor of the holding area.

1.4.2.2 Keepers may enter the enclosure with the porcupines, depending on the temperament of the animals involved. Due to their size and the length of their quills, it is advisable to carry a wooden shield into the exhibit while working around large porcupines. This will give the keeper a safe area to avoid coming in contact with the quills if an animal becomes aggressive. At the very least, a broom should be carried when entering an exhibit with a large porcupine.

1.4.3 Tree dwelling porcupines require an exhibit that is tall enough to allow the animal to climb. Branches, logs and other climbing structures are required in order to give the porcupine access to approximately 75% of the vertical space. Although Prehensile-tailed and North American porcupines do not spend much time on the ground, they can dig, and therefore require a solid or wire barrier beneath the exhibit to prevent escape. A 3' return buried 12 – 24" down under an outdoor enclosure is sufficient to prevent the animals from digging under the barrier. Substrate in an outdoor exhibit may be a natural material such as soil, wood chips or pine needles. Exhibits with solid floors can use straw, pine shavings, mulch, and pine needles as a substrate. Exhibits with solid floors should have a drain in order to allow for routine cleaning and disinfecting. Since these animals are excellent climbers, their exhibits should be completely enclosed by a solid (i.e. glass) or wire barrier. An open topped exhibit may be used provided the surrounding walls are at least 4' high and are smooth enough to discourage

climbing. A return of at least 12” along the top of the outdoor barrier is recommended to prevent escape. Branches and other cage furnishings need to be placed carefully so that they are not used to scale the exhibit walls. Cage furniture should consist of logs, branches, rock piles and concrete culverts. Shelters must be available for all animals in the exhibit. North American porcupines especially will seek out cooler areas in warm weather, so shaded, cool areas need to be provided.

1.4.3.1 Shift areas are useful, but not absolutely necessary. Arboreal porcupines will usually stay in the branches if at all possible, allowing keepers to service the exhibit while the animals are in it. Individual temperaments must be taken into account, and it is always advisable for the keeper to have a broom with them while servicing the exhibit.

1.4.4 Porcupine enclosures need to be cleaned daily. Natural substrates such as mulch, soil or pine needles can be spot cleaned daily. Artificial surfaces such as concrete should be hosed daily and scrubbed routinely with detergents or other disinfecting agents to reduce odors and eliminate parasites and bacteria. Food and water bowls should be disinfected daily.

1.4.5 Porcupines will gnaw on their cage furniture, and all branches and logs will need to be replaced regularly due to normal wear.

1.4.6 Porcupines, especially the large crested porcupines, are very powerful animals. Care must be taken to have all doorframes, backstops and other attachments securely fastened to the walls. Porcupines have been known to work at objects attached to the walls of their enclosure until they are able to pull them loose.

1.4.7 **Shipping** International Air Transport Association (IATA) (2002) provides transportation regulations for the shipment of live animals. Container requirement #80 describes the regulations for shipping porcupines. Documents that are required to accompany the shipment should be attached to the outside of the carrier and easily obtainable.

1.4.7.1 The carrier may be made of wood and completely lined with mesh, sheet metal or welded wire. Because porcupines will gnaw easily through wood, the entire inside of the carrier must be protected against chewing.

1.4.7.2 Plastic pet carriers can be used as long as they are lined with sheet metal or wire mesh, as the porcupines can easily gnaw through plastic.

1.4.7.3 Carriers made completely of metal may also be used, although care must be taken to provide adequate ventilation.

1.4.7.4 The size of the carrier is dependant on the species being shipped. Normal habits and movement must be considered. Animals must be able to stand with their heads erect, turn and lie down comfortably. Arboreal porcupines do not like to be on the ground, and would be more comfortable with a platform or perch

in the carrier. Ventilation holes and mesh doors must be covered with a fine wire mesh. The door must be secured and not opened easily.

- 1.4.7.5** Food and water containers must be provided and fixed to the front of the carrier so that the animal cannot move them. Outside access for replenishment must be available. Soldered tin is not acceptable for food and water containers. Animals normally do not require additional feeding or watering during a 24-hour period following initial time of dispatch. If there is a delay, the animals must be provided with food such as fruit or vegetables. Instructions for the shipper must be included, and made obvious for the caretaker.
- 1.4.7.6** Absorbent bedding, such as wood shavings or straw, must be used in the transport container.
- 1.4.7.7** Only one animal should be shipped per compartment due to the possibility of injury from the quills.

1.4.8 **Water:** Fresh water must always be available. It should be provided in containers that are heavy enough to prevent spilling, and made of a material that resists chewing. Water bottles may be used provided they are protected from gnawing. All water containers must be cleaned daily and disinfected on a regular basis.

- 1.4.8.1** Water features may be included in the exhibit in the form of pools, streams, etc., but most species will not use them much. The exception would be brush-tailed porcupines, which are good swimmers and will readily make use of pools.

2. Biotic variables

2.1 Food and water:

- 2.1.1** Fresh, clean water should be available at all times. It may be presented using hanging water bottles that are adequately protected from chewing, in ceramic crocks, or in stainless steel bowls. All water containers must be impervious to chewing. Materials such as plastic or rubber do not last long with these aggressive gnawers. Water containers must be cleaned daily and disinfected regularly.
- 2.1.2** Food should be offered at least once a day. Food may be scattered throughout the exhibit for enrichment, or provided in containers. Food bowls should be either ceramic crocks or stainless steel bowls that resist gnawing. Food containers must be washed and disinfected daily. They must also be completely dry before using them for feeding in order to prevent the food from absorbing moisture and possibly getting moldy. All leftover food must be removed each day when the exhibit is cleaned. This is very important for food that is scattered for enrichment. Any food that has not been located or eaten must be collected and removed daily. Leftover food may be weighed and

recorded daily in order to monitor the animals' consumption. Mixed species exhibits which include porcupines, can make the routine collection of leftover food difficult. If this is the case, obtaining regular weights on the porcupines can help monitor food consumption. Medical problems, such as overgrown teeth, may be caught early by noting the length and condition of the incisors while had feeding part of the animals' diet.

- 2.1.3 All porcupines are largely herbivorous, but there is some dietary variation between species.
 - 2.1.3.1 Brush-tailed porcupines have a diet that consists mainly of green vegetation, bark, roots, tubers and fruit. They sometimes feed on cultivated crops, insects and carrion (Nowak, 1991).
 - 2.1.3.2 The prehensile-tailed porcupines feed largely on leaves, tender stems, fruits, blossoms and roots. The bark of certain trees may be peeled away to reach the cambium layer (Starrett 1967).
 - 2.1.3.3 North American Porcupines have a winter diet that consists mainly evergreen needles and the cambium layer and inner bark of trees. During the spring and summer the porcupines eat buds, tender twigs, roots, stems, leaves, flowers, seeds, berries, nuts and other vegetation. They are fond of salt and will gnaw on bones or antlers found on the ground because of the mineral content (Banfield 1974).
 - 2.1.3.4 The crested porcupines feed on bark, roots, tubers, rhizomes, bulbs, fallen fruits and cultivated crops, where they frequently become pests. Insects and small vertebrates are occasionally taken. Carrion feeding has been reported, but is not common. Bones are frequently gnawed to obtain calcium (Nowak, 1991).
- 2.1.4 In captivity, the nutritional needs of porcupines are fairly simple. Although the species are diverse, their dietary needs are similar. They should be fed a diet including a variety of the following: Rodent Chow, Monkey Chow, Leafeater biscuits, fruits, vegetables and browse (see Appendix A). The North American and Prehensile-tailed porcupines require more fresh browse than the other species, although all porcupines relish it. Sections of wood should be offered to help the porcupines wear down their teeth. Bones may be offered as an occasional treat. Some institutions require that all traces of meat be removed and the bones sterilized. Other institutions have offered raw knuckle bones with no ill effects. How best to offer bones would be the decision of the individual institution.

- 2.2 **Social Considerations:** The Old World porcupines tend to be more social than New World porcupines. Crested porcupines are usually found in small family clans, consisting of an adult pair and their various offspring (Kingdon, 1984) which share the same burrows, paths and feeding sites. Although the young travel with their mother for about a year, they may remain in the family burrow for longer. Brush-tailed porcupines also live in small

colonies of 6-8 individuals that share a burrow and a feeding territory (Nowak, 1991). These territories are regularly marked with dung deposits. North American porcupines tend to have individual territories. Females have exclusive territories, but males often have territories that overlap and may vary widely in size. Although there has not been a lot of research on the natural history of prehensile-tailed porcupines, it is thought that they are similar to the North American porcupines.

2.2.1 Group composition

- 2.2.1.1** Most porcupines can be maintained in pairs or small groups that include one adult male, one or more adult females, and possibly several juvenile offspring.
- 2.2.1.2** If not related, same sex animals tend to fight when they reach adulthood. For exhibit purposes, related single sex groups may be maintained indefinitely.
- 2.2.1.3** Females do not need to be removed for parturition. Male porcupines are not normally aggressive towards their offspring, and in the Old World porcupine species, they play an active role in raising and protecting the offspring. Care must be taken when entering the enclosure of a pair of porcupines with offspring. They can be very protective and will attempt to drive off intruders.
- 2.2.1.4** Porcupines do not need to be removed for seasonal reasons. Compatible pairs can remain together at all times.
- 2.2.1.5** Young porcupines should typically stay with their mothers for between 6 months and one year. Typically, the main reason for separating the young at one year is to prevent inbreeding. North American porcupine male will start showing aggression towards their male offspring by this age, but the crested porcupines could live in extended groups for longer if necessary.
- 2.2.1.6** If any aggression is seen towards the offspring, they must be removed from the group in order to prevent injury.

2.2.2 Group size

- 2.2.2.1** All porcupine species may be kept either singly, in pairs or in small groups containing one adult male. Once established as a stable pair or group, porcupines can stay together permanently and do not need to be separated overnight (Husbandry Survey, 2003). Porcupines are popular outreach animals, and these animals are best housed individually in order to maintain their relationship with their handlers.
 - 2.2.2.1.1** New World porcupines are largely solitary throughout their lives (Roze, 1989). They may be maintained in pairs, but there must be sufficient space for the animals to avoid each other when necessary. There also must be sufficient climbing, hiding and feeding opportunities

for all individuals. Same sex animals may show some aggression towards each other.

2.2.2.1.2 Old World porcupines are social and are often found in family groups. A few species, including *Hystrix africaeaustralis*, are reported to be monogamous. These porcupines appear to require a great deal of bodily contact, and are often found in close proximity to each other (Roze, 1989). Although they may do well housed alone, especially if they receive a lot of contact with their handlers, these animals are best housed in pairs, with or without their previous offspring.

2.2.2.1.3 There is no need for conspecific groups to be housed next to each other. There also appear to be no deleterious effects if there are animals housed within visual range of each other.

2.2.2.2 Mixed species groups

2.2.2.2.1 Porcupines, despite the obvious concerns about their formidable defensive mechanisms, have been successfully housed with flying foxes, vultures and other various birds, prairie dogs, meerkats, marmosets, two-toed sloth, acouchi, gibbons and mandrills. Care must be taken during the initial introduction period, and a period where the species can view each other through a howdy cage or door is recommended. The various species of porcupines are very specialized for living in trees (New World) or on the ground (Old World), so it is recommended that compatible species be chosen that will utilize the parts of the exhibit that the porcupines do not. Feeding areas must be well separated and care must be taken to ensure that each species has the proper access to its food and water. Sometimes there are individual concerns that have to be addressed, but overall, porcupines are so confident in their defenses that they ignore other species in their exhibits. Mixed groups should be monitored more closely if breeding is occurring in one or more of the species. Breeding may increase aggression between the species, and offspring may be injured or killed as a result.

2.2.2.2.2 Single sexed groups of porcupines can be very successful, especially if it is desirable to control breeding. There may be aggression between adult male North American and Prehensile-tailed porcupines, so these groups must be monitored closely. Related single-sex groups are the most successful, but unrelated

individuals may be introduced in order to form stable groups, especially with Old World porcupines.

2.2.3 Introductions When introducing porcupines to conspecifics, it is important that staff be prepared and well trained in case there is a problem. Although most porcupine introductions are uneventful, these animals are capable of inflicting severe wounds on each other, and fights sometimes occur. Keepers need to be standing by to break up fights if necessary. They need to have the proper equipment available so that they can intervene without receiving injuries themselves. Heavy leather gloves should always be available, as well as brooms that can be used to separate fighting animals. During introductions with crested porcupines, a wooden shield or push board should be available so that the keeper can enter the exhibit safely if a fight should break out. When introducing porcupines, the animals should have visual and olfactory access to each other through a howdy door or cage for a few days prior to putting them together (Husbandry Survey, 2003). If at all possible, introductions should take place in an exhibit that neither animal is familiar with. If this is not possible, then the introduction should occur in the largest space that is available. When the animals are put together, they should be watched closely for signs of aggression, such as chasing and biting. They should be separated overnight for the first few days until the observers are confident that the animals are showing no signs of aggression.

2.2.3.1 New World porcupines tend to be less social than Old World porcupines. Once a group is established, it is almost impossible to introduce a new animal to the group. This will often result in much fighting and bloodshed (Husbandry Survey, 2003). Introducing male/female pairs offers the best chance for success. Unrelated animals of the same sex tend to fight. Offspring of the original pair can remain with the group but as they mature, the males often become aggressive towards each other. Hand-raised porcupines are often highly aggressive to conspecifics and may be nearly impossible to safely introduce to other porcupines.

2.2.3.2 Although aggression is always a possibility, Old World porcupines are social animals and introductions are usually uneventful (Husbandry Survey, 2003). Introducing male/female pairs is usually successful, and the animals seem to enjoy the interaction. Introducing same sex animals has the potential for aggression although it is often accomplished successfully if the animals are given several days with access to a howdy door so that they can become familiar with each other. Sometimes two adults of the same sex will fight while a juvenile can be introduced without any problem (Husbandry Survey, 2003). Once established, these groups can remain together at all times.

2.2.4 Human/Animal interactions Porcupines are usually calm animals and do not react to keepers entering their exhibit with extreme flight response or aggression. This is undoubtedly due to their quills, which form an efficient defense against predators. Although they do not normally flee or attack, care must be taken when working in an exhibit with porcupines due to the risk of being injured. It is always advisable to have a shift area where the animals can be restricted while the keepers service the exhibit. Although quills are the porcupine's best means of protection, they can bite and will not hesitate to do so if they feel threatened. This is an increased risk when dealing with a family and their offspring, as the parents become very protective.

2.2.4.1 Many porcupine species are used successfully as education or outreach animals. Hand-raised individuals become quite tame, and are easily handled. Gloves should be worn when handling porcupines as an added measure of safety.

2.2.4.2 When entering an enclosure with crested porcupines, it is advisable to carry a broom or a wooden shield to keep the animals at a safe distance. These porcupines are quick and powerful, and their quills can be driven backwards with a great deal of force.

2.2.4.3 All porcupine species respond very well to positive reinforcement, and they can be trained for veterinary and management behaviors. Although they may become quite tame, all porcupines should be handled with caution to avoid injury from the quills.

3. Health and Nutrition

3.1 Diet The AZA Nutrition Advisory Group has written Feeding Program Guidelines for AZA Institutions. These guidelines are available on their web site (www.NAGonline.net) . Some of the important points are:

- a. Aim to provide a nutritionally balanced diet.
- b. Provide a diet that reasonably stimulates natural feeding behavior
- c. Provide a nutritionally balanced diet that the animal consumes consistently.
- d. Provide a diet that meets all of the above criteria, and is practical and economical to feed.

When formulating diets, consultation with an exotic animal nutritionist can help identify the necessary components of a balanced diet. The four steps to formulating a diet are:

- a. Background research
- b. Diet Evaluation
- a. Diet implementation
- a. Diet update

Detailed records should be kept and are an integral part of a feeding program. Food items used for behavioral enrichment must be calculated into an animal's diet as well.

3.2 Medical Management The keeping of thorough and accurate medical records is essential for the maintenance of a species in captivity. A computerized medical system such as Med ARKS is extremely beneficial. Some of the medical problems seen in porcupines include overgrown teeth and other dental diseases, ectoparasites, intestinal parasites, ingrown quills, and dry skin.

3.2.1 Quarantine and Hospitalization. The standard quarantine period for all porcupine species is 30 days. Prior to shipping, CBC panel, blood work and three negative fecals are recommended. A complete physical should be performed on each animal shortly after arriving in quarantine. The quarantine area should be isolated from other animals in the collection to reduce the chance of parasite or disease transfer. The lifestyles of the species involved should be taken into account when setting up quarantine space. New World porcupines should have the ability to climb on sturdy perches, while Old World porcupines will utilize mostly floor space. There should be ample space for the staff caring for the porcupines to work around them safely. Porcupines tend to adjust quickly to new circumstances, but unfamiliar animals should remain separated during quarantine to reduce stress and prevent injury.

3.2.2 No vaccinations are currently recommended for rodents, although several institutions do use limited vaccinations. The most common vaccinations are rabies and tetanus.

3.2.3 Capture and restraint of porcupines for medical procedures should be undertaken with caution due to the impressive defense capabilities of these animals.

3.2.4 Crested porcupines have large, smooth quills, which are held erect when the animal is excited or threatened. The quills make hand restraint difficult, if not impossible. For extended medical procedures, anesthesia is recommended, but the quills can make delivering the drugs very difficult. Blow darts and pole syringes may be used successfully although care must be taken not to injure the animal. Brooms and boards can be used to move the porcupine into an enclosed area, which allows for easier injection. A 55-gallon trash can will function well for containing or moving a crested porcupine. Using brooms and push boards, the animal should be steered into the can which can then be turned upright to prevent escape. Another method involves the use of a commercially available squeeze cage. The cage can be easily modified to handle porcupines without damaging their quills. As a temporary measure, cardboard can be cut to fit along the inside of the side bars and fastened with cable ties, leaving 4 – 5" along the bottom of one side open to allow for injection. The animal is run into the modified squeeze using brooms. Once confined, the

animal can be squeezed and hand-injected with anesthesia. Once the anesthesia takes effect, porcupines can easily be pulled out of one of the open ends of the squeeze. If desired, more permanent bar covers can be fabricated from sheet metal and fastened to the inside of the bars with cable ties. As long as sufficient space is provided along the bottom edge so that the animal can be hand injected, this method works extremely well and protects both the porcupine and the handlers from injury.

- 3.2.4.1 A variety of chemical agents have been successfully used on crested porcupines, including:
- a. Telazol
 - b. Telazol & Butorphanol
 - c. Ketamine & Metatomadine (reversed with Atipamezole)

Careful monitoring of the anesthetic depth and vital signs is important for porcupine immobilization. Isoflourine gas is frequently used to maintain a good level of anesthesia. Care must be taken when handling porcupines so as to avoid tearing their skin. If an attempt is made to move an immobilized porcupine by grabbing handfuls of quills, the result may be a large wound where the skin has torn away from the body. Although easily sutured, it is best to avoid this situation altogether by using a blanket or towel as a sling and supporting the animal when moving it.

- 3.2.5 North American, prehensile-tailed and brush-tailed porcupines are commonly hand restrained for simple medical procedures. Although the potential for injury exists, it is possible to handle these animals using leather gloves. Care must be taken when handling brush-tailed porcupines since their tails easily break off during handling. North American porcupines do not have quills on the undersides of the tail and body and skilled handlers can capture one by holding the tip of the tail and then sliding a hand under the body to lift the animal (Fowler, 1995). Prehensile-tailed porcupines have quills that are less sharp than the others, and can be readily handled using leather gloves. Once restrained any of these porcupines can be immobilized with isoflourine gas or ketamine. For quick visual exams, a crate or barrel can be used to restrain the animal.

4. Reproduction

4.1 Cycles and gestation

- 4.1.1 Crested porcupines have an estrous cycle of 30 – 35 days and a mean gestation period ranging from 93 – 110 days. Litter size ranges from one to four, with two being average. The young are well developed, but small – weighing only about 3% of the mother's body weight. The adult pair invests a great deal of time in raising their offspring. They typically reproduce yearly, although twice per year is possible. The young porcupines nurse for 3 – 4 months but can feed on solid food at

2 – 3 weeks and can survive if separated prematurely. The young grow quickly for 4 – 5 months, then slow down, reaching adult weight at 1 – 2 years. Females attain sexual maturity at 9 – 16 months and males at 8 – 18 months. (Nowak, 1991).

- 4.1.2 Brush-tailed porcupines may produce up to three litters per year. The gestation period is 100 – 110 days. Litter size is from one to four young, although a single offspring seems to be the norm. The young are well developed and weigh 150g each. The young typically nurse for 8 weeks but can eat solid food after 2 – 3 weeks (Nowak, 1991).
- 4.1.3 North American porcupines breed in fall or early winter. Heat lasts for 8 – 12 hours and the female will recycle in 25 – 30 days if fertilization does not occur. Gestation lasts 205 – 217 days and the young are born from April to June. Litters contain a single offspring, although twins have been documented on rare occasions. The young are well developed and weigh from 340 – 640g. Although lactation lasts for an average of 127 days, the young are capable of eating solid food after 2 weeks. Sexual maturity is typically reached at 2.5 years, although some males are capable of reproducing at 16 months (Nowak, 1991).
- 4.1.4 Prehensile-tailed porcupines have a mean gestation period of 203 days and give birth to a single offspring. Young of this species weigh 415g and are able to climb shortly after birth. The female will mate again immediately after giving birth. The young will nurse for 10 weeks, and reach adult size at 48 weeks. Sexual maturity is reached after 19 months (Nowak, 1991).

4.2 Breeding

- 4.2.1 Crested porcupines are very difficult to sex as males and females appear very similar. A true scrotum is not present but the penis can be palpated in its sheath and everted by pressure from behind (Roze, 1989). There is very little difference in terms of size and weight, although the females tend to be slightly heavier than the males. Female porcupines are not aggressive with males that they are familiar with but may be very aggressive towards strangers. Males initiate mating with a ritual display where they will approach and retreat from the female while making squeaking sounds. When ready to mate, the female will flatten her quills and raise her tail. After mating, a copulatory plug is formed by the male, as fresh semen sets to form a gel (Roze, 1989).
 - 4.2.1.1 Species identification can be difficult when dealing with the two African crested porcupines – *Hystrix cristata* and *Hystrix africaeaustralis*. When dealing with imported animals, the country of origin can give a clue as to species identification. *H. cristata* is found throughout much of Africa north of the Congo, and in southern Europe. *H. africaeaustralis* is found mainly in southern Africa. There is some overlap of the two species in east Africa. The most

reliable characteristic by which to tell the two species apart is the color of the short rump spines and the underside of the tail, which are white in *H. africae australis* and black or mottled in *H. cristata* (Kingdon, 1984). More work needs to be done in regards to accurately identifying these two species.

4.2.2 North American porcupines are normally solitary, so finding a receptive member of the opposite sex is always a challenge. As the female approaches estrous, the membrane that covered her vaginal opening begins to dissolve and she begins to secrete a thick mucous which serves as an olfactory signal for the male (Roze, 1989). Male porcupines engage in a peculiar sort of courtship that consists of standing on his hind legs, grunting and showering the female with urine. If the female is ready to mate, she does not object to being soaked from head to tail. She will then elevate her hindquarters and curl her tail up over her back. The male can now mount her by standing on his rear legs and either resting his front paws on the underside of her tail, or letting them hang loosely. Copulations typically last 1 to 5 minutes, but may be repeated over several hours. Within hours of mating, the semen forms a vaginal plug, reducing the chance that the female will mate with another male. The testes of male porcupines are found in the abdomen throughout most of the year, but descend into the scrotum during the breeding season.

4.3 All porcupine species give birth to well-developed precocial young.

4.3.1 Sample growth rates for brush-tailed porcupines:

Birth weight	150g
1 month	500g
3 months	1000g
5 months	1500g

(Storch, 1990)

Sample growth rates for *Hystrix africae australis*

Birth weight	350g
3 months	4kg
5 months	6kg
11 months	10kg

(Storch, 1990)

Sample growth rates for North American porcupines

Birth weight	0.45kg
15 days	0.85kg
3 months	1.85kg
4 months	2.15kg

(Roze, 1989)

4.3.4 There is no documentation that a nest box is necessary for successful parturition (Husbandry survey, 2003). It is possible that the ideal design hasn't been discovered that best meets the

animals' needs. It is recommended that the female be offered the choice of several hollow logs, bedding to use as nest material, and possibly access to an off exhibit area for privacy when birth is imminent.

4.4 Hand rearing

- 4.4.1 Successful hand-rearing of mammals requires the selection of a formula that will support adequate growth and not cause GI upset, offering it at the proper intervals and amounts, and keeping all feeding utensils clean and disinfected (Frasier, 1991). Most precocial species, which includes all of the porcupine species, have been hand-reared successfully.
- 4.4.2 Whenever possible, data on milk composition and hand-rearing case histories should be consulted before attempting to bottle raise a porcupine for the first time. Fortunately, several institutions have successfully hand-reared porcupines, and the data is available. Commercial dog milk replacer is frequently used.
- 4.4.3 Many neonates must be stimulated to defecate and urinate by gently rubbing the ano-genital area.
- 4.4.4 Frequency of feeding and amount fed depends on natural nursing behavior, formula composition, desired rate of gain and practical man-hour restrictions. As a general guide, most newborns should be fed every 2 to 4 hours (Frasier, 1991). Appetite and general health should be monitored closely, and body weights recorded at frequent intervals.

4.5 Contraception MGA implants and Depo-provera are recommended by the AZA Contraception Advisory Group for rodents. Little data exists on the success of these methods or any deleterious effects. Neutering male porcupines by a vasectomy or castration is also successful.

5. Behavioral Management

5.1 Porcupines are excellent candidates for husbandry training programs. Since they are not typically aggressive, yet difficult to handle, training them to participate in routine husbandry procedures is beneficial for both the animals and their keepers. Porcupines are commonly used in educational programs as well, and may be trained to perform behaviors that demonstrate some of their physical abilities, as well as making them easier to transport and handle. Standard training techniques are successfully used with porcupines of all species. Some of the behaviors that have been trained at various institutions include:

- Shifting on and off exhibit
- Target
- Paws up (step up on a specified object)
- Crate (enter a crate on command)
- Follow

Foot (holds foot up for nail trims)
Come
Climb a perch and sit on top
Go to a “mark” or station
Stand on a scale
Sit up for visual inspection
Mouth open (to check teeth)

5.2 As with all animals, consistency is critical to training success. Keepers involved in porcupine training should understand the concepts of animal training and be able to use a variety of techniques. Managers should also understand training techniques, and help guide the keeper staff in regards to consistency and the prioritization of training goals.

5.3 Enrichment ideas should be integrated into the routine daily care of all porcupine species. Natural history, exhibit constraints, and individual history all must be taken into account when designing an enrichment program. Browse of an approved type is always relished by porcupines, which often prefer bark and sticks to leaves. Flowers can also be used as browse and offered to the animals. Porcupines have been known to gnaw on bones or dropped antlers in the wild, and these items are excellent enrichment items, as is rawhide. Toys of various types, such as Kongs, plastic balls and plastic spindles can be used as long as they are regularly checked for safety as the porcupines will inevitably gnaw on them. Toys with holes in them can have food placed inside, and the porcupines will manipulate the items to get the food out. Cardboard boxes, shredded newspaper, cardboard tubes and paper bags are also useful for hiding food. Paper mache can also be used to hide food items, and although it is easily opened by a determined porcupine, it can be made into many unusual shapes and forms and provides interest to the animal in that way. Sand or mulch can be used as a substrate in a part of the exhibit, and food items buried in it, which encourages digging behavior. Food items can be used as enrichment as well, such as cereal, raisins, popcorn, oyster crackers, and bread. In warm weather, ice treats with frozen produce inside are often used with porcupines. Sections of logs can have holes drilled in them and food items stuffed in the holes, encouraging the porcupines to gnaw on the wood to get to the treats. Spices and perfume can be placed throughout the enclosure as scent enrichment for the animals to investigate. Porcupines that are used for educational programs can be taken out of their enclosure for walks or allowed to explore a new area.

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Appendix A
Sample Porcupine Diets

Brush-tailed porcupine (*Atherurus africanus*)

Folsom Children's Zoo

Diet for 1.1 animals

1/2 potato

1/2 apple

1/2 orange

1 1/2 banana

on occasion: cucumber, celery, peaches, pears, grapes, berries, rodent blocks,
gorilla biscuits

Virginia Zoo

Diet for 0.2 animals

AM: 1/3 cup Rodent Chow

M/W/F 1/6 cup mixed seeds

PM: 1/4 cup apple

1/4 cup carrot

1/4 cup sweet potato

1/4 cup greens

Prehensile-tailed porcupines (*Countou prehensilis/Sphiggurus mexicanus*)

Baltimore Zoo

Diet for 1.0 animal

45g Zu-Preem canned primate diet

75g apple

35g carrot

55g yams

2 peanuts

1 block low protein Monkey Chow

10g kale

corn on the cob

special produce on occasion

sunflower seeds and squash as treats

Memphis Zoo

Diet for 1.1 animals

15 spinach leaves

2 sweet potatoes

1 apple

1/2 cup Rodent Chow

Crested Porcupines (*Hystrix cristata/H.africaeausstralis/H. indica*)

San Diego Zoo

Diet for 1.2 animals

2 cups ½” high fiber herbivore pellets

10 pieces large (gorilla size) dry folivore biscuits

1/2 ear corn on the cob

One of the following daily: ½ head cabbage, 12 leaves kale, 8 leaves collard greens, 8 bunches spinach, 8 leaves dandelion greens.

One of the following daily: 2 carrots, 1 yam, 200g root vegetable

Glen Oak Zoo

Diet for 1.1.1 animals

2 apples

1/2 orange

1 banana

2 carrots

2 sweet potatoes

12 pieces Monkey Chow

4 cups Rodent Chow

2 cups Dry dog food

Utah’s Hogle Zoo

Diet for 1 animal

258g yam

230g potato

75g carrot

209g apple

148g primate browser chow

32g kale

260g spinach or arugula

North American Porcupine (*Erethizon dorsatum*)

Wildlife Conservation Society/Bronx Zoo

Diet for 1 animal

1/2 cup Rodent Chow

large slice of yam, carrot and banana

1 or 2 peanuts

2 leafeater biscuits

assorted greens

timothy/alfalfa mix

Sedgewick County Zoo

Diet for one animal

1 cup Rodent Chow
one 2" square of lettuce
1/2 carrot
1 apple
5 drops Poly-Vi-Sol
pinch of mineral salt