Observations of behavioral development on common Porcupines (*Hystrix brachyura*) undergoing domestication

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**Abstract.** Common porcupine (*Hystrix brachyura*) is one of the protected mammals in Indonesia. The existence of this species is threatened due to habitat destruction and uncontrolled poaching. In order to maintain the sustainability of porcupine from extinction, the rescue is through captive breeding (ex situ conservation). The process of domestication of porcupine begins with observing the development of its behavior, making it easier to manage in captivity. The aim of the study was to determine the development of porcupine behavior related to the domestication process in captivity. The materials used were four porcupines (two males and two females) around 18 months old and a female porcupine and a young. Each pair of porcupines is placed inside an individual cage (3.9 m long, 2.1 m wide, and 2.6 m high), which has been equipped with a place to feed and drink. The parameters observed were eating and drinking activities, locomotion, resting, eliminative (urinating and defecating), grooming, and agonistic. Whereas the female porcupine and a young observed maternal porcupine care for the young. The observation method is based on one-zero sampling. Observations began at 6:00 a.m. - 6:00 p.m. with a time interval of 15 minutes. The results showed that daily activity of porcupines included 52.01% resting, 19.95% locomotion, 12.73% grooming, 10.05% feeding, 2.95% agonistic, 1.74% urinating, 0.39% drinking, and 0.18% defecating. Porcupine parental activity in the lactation period is breastfeeding (49.26%), cleansing the young’s body (36.16%), teaching grooming (5.71%), teaching opening the cage door (4.10%), teaching meal (2.89%), and agonistic (1.88%).

1. **Introduction**

Common porcupine (*Hystrix brachyura*) belonging to the Hystricidae family, the Rodensia order is one of the wild animals whose existence is threatened, due to uncontrolled poaching and habitat damage due to forest clearing for settlement, plantations, tourism or industry. Porcupines have a normal sense of sight but are strong for the sense of hearing and sense of smell [1]. This is very helpful for nocturnal porcupines in looking for food, and in a state of forced porcupines can also come out during the day to look for food. Reported that in Java Island [2], in South Sumatra and East Kalimantan [3], in their natural habitat porcupines like tubers, rhizomes, forest fruits, leaves, young stems, bulbs, shoots, the inside of the stem, roots, bark, and bamboo shoots.
These porcupines are monogamous rodents who only share setts with offspring until dispersal [4,5,6]. The pair cohabits at all times, and male parental care has been observed in previous studies [7,8,9]. In monogamous couples the mounting behavior may have at least two main goals: (a) to enable the male access to the female in those species and/or in those physiological states in which the female shows either an aggressive or reluctant attitude, (b) to contribute to the maintenance and the strengthening of the pair-bond. The mounting behavior may thus show differences indicative of the two cases [10].

In their habitat, female porcupine can breed twice a year and the pregnant period ranges from 100-110 days with the number of 1 – 4 young per birth [11]. Likewise on crested porcupine (Hystrix cristata) gives birth to one or two precocial offspring once or twice a year [12,13,14]. Among the hystricomorph Rodents, the genus Hystrix shows a social organization based on the formation of the pair, on small family groups or clans [7, 12, 5,16].

Although the status of porcupines is protected under Minister of Agriculture Decree No. 247 / Kpts / Um / 4/1979 and Government Regulation of the Republic of Indonesia No. 7 of 1999. International conservation status recorded on the IUCN The Red List of Least Concern but hunting for consumption purposes and trade continues, so feared that the porcupine population will continue decrease [17,18]. The use of porcupines in East Java (Pakis District, Malang Regency) and Central Java (Tawangmangu District, Karanganyar Regency; Kopeng, Getasan District, Semarang Regency; Delanggu District, Klaten Regency), marked by food stalls selling culinary extreme made from porcupine meat in the form of satay, krengsengan, rica-rica, and abon landak. To meet these needs, live porcupines are obtained from hunters who capture directly in nature. For this reason, proper supervision and control must be carried out so that the porcupine will not become extinct. One effort to save wildlife from extinction is through captivity [19].

Captive Breeding is one way to conserve wildlife outside its natural habitat (ex situ) that requires special knowledge, expertise, and courage. Basic knowledge that must be possessed in capturing wild animals such as porcupines, namely knowledge of biology and ecology, reproduction, habitat, behavior, feed, disease management, and other aspects / maintenance techniques. In captivity can be observed about various biological aspects of porcupines and their behavior in the domestication process, as well as cultivation efforts while maintaining their genetic purity. Porcupines and other wildlife that are kept in captivity need to be considered for their food and nutritional needs and good environmental conditions for their growth and development. Porcupines are adaptable and easy to learn something new [1]. In captivity porcupine can be kept in the floor cages and battery cages by showing normal growth [20]. Captive population is established for conservation education, exhibition of exotic species, scientific research, saving the threatened species from extinction and reintroduction of animals back into the wild areas [21].

Until now, information about the behavior of porcupines in captivity is still very limited, for that it is necessary to study the porcupine behavior. Observation of porcupine behavior in captivity, including (1) daily behavior, such as how to eat, drink, grooming, locomotion, rest, urination, and defecation, (2) mating behavior, and (3) maternal behavior during breastfeeding. This information is expected to support better management, guarantee its growth, and improve its breeding in captivity, so that the process of domestication of these animals can be achieved optimally. Domestication is a condition in which the breeding, care and feeding of animals are more or less controlled by humans [22, 23, 24].

2. Materials and Methods

2.1. Daily behavior

Research has been carried out in Small Mammals Captive Breeding facility, Zoology Division, Research Center for Biology – Indonesian Institute of sciences (LIPI), Cibinong. The material used was two porcupines (one male and one female) aged approximately 18 months. During the study, each porcupine was placed inside an individual cage measuring 3.9 m x 2.1 m x 2.6 m (length x width x height) which was equipped with a feed and drinking place. Feed given during the study consisted of
sweet corn \((Ze\text{a} m\text{ay}s))\), sweet potato \((I\text{pom}o\text{e}a b\text{a}t\text{a}t\text{a}s))\), guava \((Ps\text{i}d\text{i}um g\text{ua}j\text{a}v\text{a}))\), Jicama \((P\text{a}c\text{h}y\text{r}h\text{i}z\text{i}us e\text{r}o\text{u}\text{su}s))\), and water spinach \((I\text{pom}o\text{e}a a\text{q}u\text{a}t\text{i}c\text{a}))\). Drinking water available is \textit{ad libitum}. Feed was delivered twice a day, at 08.00 a.m. and 04.30 p.m. Preliminary research is carried out for ten days and the data collection period is carried out for 42 days (6 weeks) from 06.00 a.m. to 06.00 p.m. Observation time is divided into three periods, namely morning (06.00 - 10.00 a.m.), daytime (10.00 a.m. - 02.00 p.m.) and latenoon (02.00 - 06.00 p.m.). Each period is divided into 15 minutes intervals. The observation method is based on one-zero sampling [25]. If there is an activity given a value of 1 and if no activity is given a value of 0.

The parameters observed in this study were eating and drinking activities, locomotion, resting, eliminative (urination and defecation), grooming, and agonistic. During the study, the temperature and humidity in the enclosure and its surroundings were recorded in the morning, afternoon and evening. Observation on the selection of feed by porcupines is done by order of the type of feed consumed by porcupines and also noted the porcupine preference for the feed given. The data obtained were analyzed descriptively.

2.2. Mating behavior

Observation of mating behavior has been carried out between 06.00 a.m. and 06.00 p.m. for 40 days. This study used four common porcupines (two males and two females). Each porcupine pair is placed in an individual cage, each measuring 2.13 m x 1.86 m x 2.25 m (length x width x height). Visual observation is carried out on mating activities and photo shoots and calculated how long it takes for the porcupine to perform the mating process, from the process of making out to copulation (intromission). The data obtained are objectively tabulated and analyzed descriptively.

2.3. Maternal behavior during lactating period

Observation of lactating behavior on the porcupine is carried out for 5 months, from the time the young is born until it reaches the age of 5 months and is weaned from its mother. Mother and the newborn are placed in individual cages measuring 2.0 m x 2.0 m x 2.25 m (length x width x height). Observations were carried out from 06.00 a.m. to 06.00 p.m. Observation time is divided into three periods, namely morning (06.00 - 10.00 a.m.), daytime (10.00 a.m. - 02.00 p.m.), and latenoon (02.00 - 06.00 p.m.). Each observation period is divided into 2 hourly intervals. Data recording is based on one zero sampling method [25]. A value of 1 is given if there is an activity and 0 if there is no activity. The variables observed were (1) lactating activity, (2) licking activity the newborn, (3) maternal activity to teach young to eat, (4) activity to teach young to clean themselves (grooming), (5) activity to open the door of the cage with mouth, and (6) agonistic activity (self-defense). The data obtained were tabulated and analyzed descriptively.

2.4. Data analysis

The data collected during subsequent studies were analyzed quantitatively and descriptively. Quantitative analysis is used to determine the percentage of porcupine activity and descriptive analysis by means of quantitative calculation data made in the form of tables or graphs/diagrams, then the results are described to conclude the results of the study.

3. Results and discussion

3.1. Daily behavior

The average temperature around captivity in the morning, noon and late noon during the study was 24.9 ± 1.15°C; 31.2 ± 1.65°C; and 30.1 ± 1.47°C, while the average air humidity was 82.8% ± 3.52%; 63.9% ± 4.04%; and 70.2% ± 3.13% respectively. The room temperature for the ideal tropical porcupine is around 21-29.4°C. Porcupine conditions and activities will be affected by low temperature conditions and high humidity in the morning and high temperatures and low humidity during the day [11].
Feeding behavior is influenced by genetic factors, environmental temperature, types of available food and habitat [26]. Porcupine eating behavior begins with the choice of the type of feed given, smelt the feed, then take the feed with his mouth. The feed taken is then held with both front legs, chewed, and swallowed, but before that the porcupine makes a sound like tasting.

The general activity of porcupines observed consists of activities that are directly related to eating activities (eating, drinking, urination, and defecation) and activities that affect eating activities (locomotion, grooming, and resting). Wild animals have various behavioral patterns that can be tried for a situation. In this case, the porcupine will learn to apply one pattern that produces the best adjustment [27]. From Figure 1 it can be seen that porcupine feeding activity is 10.05%, indicating that eating activities during the day are lower than locomotion, rest, and grooming activities. This is as reported that porcupines are nocturnal animals [11]. However, for the maintenance management of porcupines in captivity feeding can be given during the day to facilitate maintenance. Porcupine drinking activity is only 0.39%, this indicates that porcupine is very rarely drinking. Allegedly the porcupine has enough to get water from the feed given, among others in the form of fruits such as cucumber, papaya, and tomatoes. Conditions like this will facilitate the management of captive porcupines that do not need much water, especially in dry and highland areas. The percentage of elimination activity included 1.74% urination and 0.18% defecation. It appears that defecation activity is lower than urination activity. Porcupines usually do defecation at night, seen when the observation begins at 6:00 a.m., porcupine droppings have been piled on the cage floor. Porcupines do activity in one corner of the cage and never move their position. Porcupines always throw/place the feces in one corner of the cage and always in the same place, this indicates that these animals like cleanliness, so that porcupines can be used as pet animals.

Locomotion of 19.95% is a moving activity carried out from one point to a certain point. This activity has the second highest value of total activity after a break and is usually carried out by porcupines while eating. This shows that the porcupine requires a large amount of space to move so that the porcupine cultivation requires sufficient cage area.

Grooming has a percentage value of 12.73%, is an activity of self-cleaning or self-caring, such as licking, rubbing, scratching, rubbing against the wall of the cage, and sharpening teeth by biting hard objects such as walls or door cages made of metal. This activity is usually carried out when the porcupine is resting, like silence and lying down. Grooming activity is dominated by gear sharpening activities such as destroying corn cobs or biting walls and metal doors. This activity is usually carried
out when the hedgehog is resting, like silence and lying down. Thus, in the management of porcupine maintenance, it is better to have bones, stones, or whole coconut in the cage which has a shell so that the porcupine can sharpen its teeth.

Resting of 52.01% shows the highest percentage of total activity. This is because the high temperature around the cage during the day (31.2°C) results in the porcupine being lazy to move, and this is thought to reduce body heat. The high resting activity during the day, this is because these animals are nocturnal or active at night [11].

Agonistic is the activity of the porcupine alert and ready to attack the enemy. This activity is characterized by the tinkling of the tail which is caused by the quill tail hair colliding with each other so that it makes a jingling sound. Besides that, it is marked by body hair / quills that are upright and raised and porcupines turn around. Porcupines will develop their hard hair so that the whole body looks full of sharp quills, and at that time the porcupine will act aggressively by rewind the body, then when in its habitat the porcupine is ready to attack by releasing its sharp quill like releasing arrows from its bow in order to stick to the body of his enemy [28]. The percentage of agonistic activity in this study was 2.95% of total activity. The low level of activity indicates that porcupines are animals that are not aggressive so it is very possible to be cultivated as pets.

In addition to the above activities carried out by porcupines in their daily behavior, apparently there are other activities such as trying to climb the wall and trying to dig a hole by scavenging walls and floors. This activity is a porcupine habit in its habitat, so sometimes it is still done in captivity. As reported that porcupines that live in the wild make nests in their own ground [29]. While African crested porcupines are excellent diggers and live in an extensive burrow systems, caves, rock crevices or aardvark holes [30].

The types of feed given in this study are sweet corn, sweet potato, guava, jicama, and water spinach. The selection activity of porcupine feed in captivity shows selective properties of the feed given. Animals have a relatively high selection of available feed, so that porcupines will eat more of their most preferred feed. The order of feed rankings ranging from 1 to 5 are sweet corn, sweet potato, guava, jicama, and water spinach. The level of palatability of feed is influenced by several factors, namely flavor, texture, temperature, taste, and nutritional content [31]. Sweet corn that is still attached to the cob is the most preferred type of feed, this may be due to the fact that this feed is easy to hold, hard, and tastes sweet. The next sequence is feed ingredients derived from tubers (roots), this is very in accordance with the nature of the porcupine in its habitat that likes roots. Porcupines consume food that is mostly in the form of forage, plants, roots, tubers, and fruit. In addition, these animals often also consume cultivated plants, insects, and animal corpse to gnaw their bones to get calcium [11].

3.2. Mating behavior

The success of captivity is characterized by the development of a population of wild animals that are bred. In captivity, wildlife experiences changes in habitat / environment from the wild to be limited, including changes in the adaptation process and mating behavior. Until now, information about the behavior of porcupines in captivity is still limited, even though this is needed in the process of supervision/management and handling of reproduction. This observation aims to study the mating behavior patterns of porcupines in captivity as a reference in their cultivation efforts. This scientific information is expected to help in the management of porcupine cultivation in captivity. Observations show that at the time of mating, the male porcupine will always walk closer to the female. Sexual behavior is here defined as all behavioral activities of the female or male toward the male and female, respectively, and includes approach, contact, presenting, and mounting. Copulatory behavior included all of these except that mounting was followed by copulation [5]. The process of mating behavior begins with the process of mounting, but this is not absolutely the case. Sometimes the making process is not carried out and immediately conducts copulation (intromission). The rate of maturation of sexual behaviors may be accelerated in domestic animals since reproductive success under many mating systems employed in captivity may not be contingent on attainment of high social status [32].
The method of mounting on common porcupine begins with males who try to approach the female gradually and slowly. Initially, the female porcupine will expel the male by straightening its quills and wagging its tail. But the male just dodges for a moment and then approaches again. This process occurs repeatedly until the female shows signs of willing to accept male. Furthermore, the process of seduction activities will repeat itself starting from walking together, flirting to mating. Furthermore, if the female is lustful and accepts the male, the female will raise her tail so that the male is more free to mating. Male porcupine will immediately approach the female slowly while sniffing the back of the female body, as if adjusting the position of the female. If the female position is felt to be good enough, the male will crawl forward slowly while lifting the front leg that has been bent forward with the body upright until the male reproductive organs are attached to the female reproductive organs and there is copulation which lasts approximately 30-45 seconds. After the copulation process is complete, both males and females wag their tails with clattering and female as if leaving and immediately drive away or chase the male. But male only evade briefly and are not far from females. Sometimes male tend to chase females. This shows that male are more aggressive in mating behavior. The length of time since mounting until copulation takes about 5 minutes. This relationship was partially confirmed by the observations of on the copulation of *H. afercaeeaustralis*, which has a duration of copulation ranging 1 from 2-3 minutes with an average of 38 thrustings [5]. Reported that when mating a female porcupine is not aggressive, a male performs activities such as approaching a female and then slightly backs off while making a sound, and when ready to mating, the female will flatten its quills and raise its tail position [33]. The Cape porcupine (*Hystrix africaceaaustralis*) shows a nightly rhythm of mounting with copulation occurring only in the oestrus period [5], while the Indian crested porcupine (*Hystrix indica*) performs mounting and copulation independently of the oestrus state [6,7,8].

3.3. *Maternal behavior in lactating period*
Some activities of the common porcupine are when the mother lactates the young, cleanses/licks the body of the young, teaches the young to eat, teaches to cleanse the body, teaches to open the cage door, and agonistic (Table 1).

| No. | Activity and description |
|-----|--------------------------|
| 1.  | **Lactating**            |
|     | - Mother suckles the newborn while laying down, the newborn sucks the nipple from the side of the mother |
|     | - Mother while walking slowly and the newborn sucks on the mother's nipple for a few minutes |
|     | - As long as the mother is lying down, the newborn continues to suckle on the mother |
| 2.  | **Licking / cleaning the newborn** |
|     | While lactating, the mother licks the neck, head, abdomen and rectum of newborn. This behavior is often performed by a mother, when the newborn is in a sitting or lying position |
| 3.  | **Teach the young to eat** |
|     | - Mother deliberately eats in front of the young, the young mimics the behavior of the mother |
|     | - While eating the mother makes a sound and the young comes in and makes a sound and joins the meal |
| 4.  | **Teach the young to clean the body (grooming)** |
|     | In front of or beside the young, the mother licks her body, and the young mimics the mother's movements |
Lactating activity of mother porcupine is the highest activity among other activities, this shows the existence of a relationship of closeness and the nature of longing. Previous study showed that the dominant behavior in first month observation was resting and followed by suckling [34]. In addition, the young who are 2.5 months old are in a stage of growth that requires the intake of nutrients derived from mother's milk, because the young are only at the level of learning to eat. In addition, digestion of young is not yet perfect digesting solid food, so that lactating activities are still ongoing. The young is in intensive care by the mothers until they are 8 weeks old, but young can already consume solid foods at 2–3 weeks [35].

The activity of cleaning/licking young is the second highest activity. This activity is carried out by the mother to provide a sense of comfort and indirectly maintain the health of young. In addition, the mother is very protective in keeping young with an agonistic level of 1.88% (Figure 2). Lactating activities are often carried out simultaneously by cleansing the body of the young.

The young who will suckle at the mother begins the movement by always following the mother’s motion. Next the mother will approach young and prepare an ideal position to start lactating. At the time of lactating the mother is more often in a position to lay down and be still. The young sucked while their mothers were in a crouching position and twins always sucked from opposite nipples. Nearly continuous teat contact during the first 2 weeks post parturn was followed by intermittent contact for up to 20 weeks of age [36]. This will make it easier for the young to suck the nipple in the chest area near the front foot of the mother [5].

| No. | Activity and description |
|-----|--------------------------|
| 5.  | **Teach the young to open the cage door**  
Mother with her mouth tries to push or scratch the cage door as it will open, especially when the animal keeper comes to bring the feed to the cage. Also seen the young mimic mother behavior |
| 6.  | **Agonistic**  
- Occurs when the animal keeper feeds, looks alert mother  
- At the time of eating, the mother seemed to attack the young who tried to approach the feed, the young mimicked the mother back to attack |

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Figure 3. Percentage of mother porcupine activity in the morning, noon, and late noon.

Based on the time period, the most activity of porcupine mother, both in the morning, noon and late noon, is lactating and cleaning licking the young (Figure 3). This indicates that the mother continues to lactating the young in three time periods, even though the activity decreases in the afternoon.

The mother activity looks like it will open the door. This is because in the morning after the cage is cleaned, the keeper will provide feed, so that the activity becomes a routine for the mother in waiting for food to arrive. In addition, in the morning period, the mother also taught grooming to young, namely the mother doing the activity of cleaning the body and the young following the mother movement. Allelomimetic behavior, which is the behavior of imitating one group member to perform the same movement with several reciprocal stimulation and coordination stages [37]. Whereas behavior is influenced by the status of animal physiology, environment, and local events [38].

4. Conclusion
The percentage of porcupines activity during the day was 52.01% resting, 19.95% locomotion, 12.73% grooming, 10.05% eating, 2.95% agonistic, 1.74% urination, 0.39% drinking, and 0.18% defecation. The low agonistic activity indicates that porcupines are easily tamed animals, besides that porcupines are animals that like cleanliness because they throw feces in one corner of the cage without moving, so that it is possible to cultivate as pets. The selection of feed based on the type of feed taken is sweet corn, sweet potato, guava, jicama, and water spinach. The choice of feed is expected to be useful in the management of feeding in captivity so that feed can be used efficiently.

During the mating period, male porcupines exhibit their aggressive nature and are followed by several male rituals approaching female and then retreat while making a sound, for some time later copulation occurs. To fulfill the ritual activities of the male during mating, it is recommended that a pair of porcupines be given sufficient cage area. The length of time since mounting until copulation takes about 5 minutes. Lactating activity is the highest activity of mother porcupine compared to other daily activities. The activity of cleaning/licking the young is more often done together with lactating. The young still needs a lot of mother’s milk, so the mother activity teaches the young to eat less than the activity of teaching to open the door and teaching the young to cleanse the body/grooming.

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