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Husbandry, behaviour and conservation breeding of Indian pangolin

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Abstract. Little is known about the biology of Indian pangolins (*Manis crassicaudata*) both in captivity and wild. Nandankanan Zoological Park, India (NKZP) is maintaining Indian pangolin in captivity since last 50 years (1962-2013). The housing, husbandry and behavioural observations that have contributed to successful upkeep and breeding of Indian pangolins at NKZP are described in the present paper. The successful maintenance and breeding of this elusive nocturnal species indicate that it can survive in captivity with application of established care techniques. The species can be maintained more successfully in captivity with provisions for their unique biological and behavioural needs.

Key words: *Manis crassicaudata*, diet, veterinary care, captive breeding, Nandankanan Zoological Park

Introduction

Indian pangolin (*Manis crassicaudata* Gray, 1827) is one of the eight living species of pangolins of the world belonging to the family Manidae of order Pholidota (Wilson & Reeder 2005). They are toothless mammals with 11-13 rows of large overlapping horny scales, long protrusible tongue and prehensile tail with a terminal scale on its ventral side (Pocock 1924, Heath 1995). They are distributed throughout peninsular India, Sri Lanka, Bangladesh and Pakistan (Prater 2005, Mishra & Panda 2012). Their populations are increasingly under threat throughout their range due to domestic and international demand for live pangolins, their skin, scales and meat. The biology of Indian pangolins particularly, low reproductive rate and a wide distribution make them vulnerable to over-exploitation (Mishra & Panda 2012). Considering the vulnerability, Indian pangolins are included in the Schedule I of the Wildlife (Protection) Act 1972 of India, listed as near threatened species by the International Union for Conservation of Nature (IUCN) and included under Appendix II of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). This warrants serious conservation measures to save this species from extinction. Therefore, for the *ex situ* conservation of the species, knowledge of captive management is of great importance. Research within zoos can contribute to conservation of the pangolin through an increased understanding of its behaviour, nutrition, reproduction and health care.

Nandankanan Zoological Park (NKZP) is one of the premier large zoos in India. The zoo is located near the Bhubaneswar city of Odisha in eastern India between 20°23′8″ to 20°24′10″ north latitude and 85°48′9″ to 85°48′13″ east longitude. This zoo comes under the geographical distribution range of Indian pangolins. Indian pangolins are being maintained since 1962 in NKZP. In 2008, a Pangolin Conservation Breeding Centre (PCBC) was established in an off exhibit area of NKZP with financial assistance from Central Zoo Authority (CZA), New Delhi with the objectives of developing proper methodology for housing, up-keeping, husbandry and captive breeding of Indian pangolins. The present paper reports husbandry, behavioural biology, veterinary care and conservation breeding of Indian pangolins at NKZP.

Husbandry

Management of Indian pangolin in captivity was first reported in 1892 (Sanyal 1892). But knowledge of how best to do so is still lacking. Pangolins are difficult to maintain in captivity, stress and malnutrition are the major cause of death of captive pangolins (Pattnaik 2008). Mortality rate of Indian pangolins is 67 % within one year in captivity (Lal-Mohan 1997).

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NKZP is maintaining and breeding Indian pangolins in captivity for last 50 years. Husbandry practices for Indian pangolins are further discussed briefly.

Housing

Ogilvie & Bridgwater (1967) stated that a pair of Indian pangolins (1M:1F) was housed together in a room measuring 2.4 m × 3.0 m and the floor covered with a litter of wheat straw or hay from which the female individual was transferred latter to a glass-fronted concrete enclosure of 2.0 m × 1.2 m × 0.9 m dimensions. Wilson (1994) reported that pangolins can be housed singly, in pairs or in smaller groups. At PCBC pangolins are individually housed except compatible breeding pairs and mother with its young. Each enclosure is 4.8 m × 4.2 m × 3.0 m in dimension and provided with 0.5 m deep red laterite soil as substrate. A six centimetre thick reinforced concrete base with 5 cm × 5 cm chain-link mesh netting is provided at the bottom of the soil layer to prevent escape of the animals. On all four sides above the concrete base up to height of 1.0 meter, reinforced concrete wall is erected. To facilitate proper ventilation and natural sunlight, chain-link mesh netting is provided on all four sides above the level of concrete base. An earthen mound of 2 m × 2 m × 1 m dimensions is provided to facilitate digging by pangolin to move into the deep burrows during day time to meet their circadian rhythm. A saucer shaped water pool (1 m diameter and 0.5 m depth) is provided inside the enclosure towards a corner to meet the water requirement of the animal. Hollow wooden logs and wooden poles are provided as enrichment materials. Besides, breeding enclosures were constructed with concrete as substrate to assist proper monitoring of mating event, post-mating separation. Netlon covering were provided towards outer side of the enclosure to keep the enclosures cool and to reduce the light intensity. The daily husbandry routine consisted of enclosure cleaning, water maintenance, feeding and health monitoring. Temperature ranges between 38 °C and 27 °C in summer (March to June), between 30 °C and 25 °C in rainy season (July to October) and between 28 °C and 19 °C in winter (November to February) inside the enclosure. The average recorded humidity inside the enclosure is 70 % which increase up to 90 % in rainy season and decrease to 30 % in summer months. There were instances of death of individuals at PCBC due to impaction as the pangolins rarely drink in winter months. Considering the low water temperature as a reason of refusal to water, warm water is added to the pool in the winter months. Besides, the supplied ant diet was moistened with water in winter months. In the summer month sprinkling of water in one part of the enclosure and exchange of pool water (with fresh and cool water) were carried out. Earlier studies at Taipei Zoo found that optimum ambient temperature range for the survival of Chinese pangolin was 18.1-26.9 °C. Increase in ambient temperature beyond 33 °C may induce heat stress whereas sharp decrease in temperature may cause pneumonia leading to death of the pangolin (reviewed by Bao et al. 2013). Therefore it is important to minimize the large fluctuation of ambient temperature and maintain a relatively constant burrow temperature in captivity to avoid the resulting sickness and death (Bao et al. 2013).

Kept animals need to continuously explore the environment to stay aware of food and water sources, shelters, hazards, territory intruders, and potential mates. Captive conditions, being more restrictive and less diversified than the wild, may offer the animal little opportunity for behavioural control and so are likely to exert some significant effects on their behaviour. Animals in captivity are typically maintained in static environments and have limited opportunities to explore. Enclosure enrichment which includes introduction of novel objects, scents, and exhibit changes are techniques used to stimulate exploratory behaviour. At PCBC, hollow wooden logs and dry tree trunks with intact branches were provided to increase the enclosure complexity. Pangolins were found climbing on the latter one to fulfil their behavioural need as they are agile climbers. The wooden logs were used as shelters. Pangolins were also found exploring, sanding and walking over it. Wet areas near the water pool were found preferable sites for digging by pangolins. Providing large water pool with ample of water fulfil their bathing need which is a necessity for thermoregulation during summer season. Mound provides shelter for hideout during the day time to meet their circadian rhythm. It also provides an elevated place for social interaction with other pangolin at neighbouring enclosures. The pangolins are housed in the same enclosure in both day and night time. They are occasionally shifted to other enclosure for breeding or treatment purposes. There is no direct visual contact between individual pangolins when they are on ground, but occasionally they do climb up the mound, water pool or chain linked wire mesh and interact with each other. This interaction is primary step of selection of mating pairs, because these pangolins are housed in such way that alternative enclosures have individuals of opposite sex and get a chance to show courtship behaviour.

Diet

Indian pangolins are primarily myrmecophagus (Prater 2005), feeds on termites and ant by frequent in and out movement of their tongue. Diet has long been presumed to be the primary cause of pangolins inability to thrive in captivity (Yang et al. 2007, Pattnaik 2008). There are reports of attempts about maintaining Indian pangolin on artificial diets. Despite the variety of diets prescribed by various workers (Chevenix-Trench 1922, Crandall 1965, Ogilve & Bridegwater 1967, Yadav 1973, Ramakantha 1992, Lal-Mohan 1997) Indian pangolins can be difficult to adapt to captive diets.

Red weaver ants (*Oecophylla smaragdina*) with their eggs are best accepted by the Indian pangolins in captivity. The pangolins at PCBC are provided with freshly dead red weaver ant as feed at afternoon hours. These ants are collected from nearby forest. The ant-collector climb up the tree and collect the entire leaf nest containing red weaver ants and their eggs, in polythene bags. The ants and their eggs are shocked and cleaned with water discarding leafs and other debris and brought to PCBC. About six hundred grams of freshly dead red weaver ant are given as feed to each adult individual (5 % of their body weight). Young pangolins were provided with red weaver ants of 10 % of their body weight. In case of short supply of red weaver ant, boiled poultry eggs mixed with milk powder (Amul-spray; Gujarat Cooperative Milk Marketing Federation Ltd., Gujarat, India) is provided as alternate feed.

Feed is given both in feeding marble feeding platforms (60 cm × 60 cm dimension and 15 kg weight) on the ground and over round shaped feeding stations (25 cm diameter, 7 cm depth and 200 g weight) made up of stainless steel fixed on the dry tree branches. It has been observed that the pangolin of the particular enclosure is habituated with the place of the feeding tray and directly approach the tray without any exploration. To enhance the exploratory behaviour of the pangolins, feed is given both in feeding platform and feeding station. Besides, the position of feeding platform was changed periodically. Drinking water was provided in the enclosures to cater the water need of the pangolins. Food given in different places of enclosure instead of one (feeding platform) also increase the time spent in feeding activity of pangolins. During earlier study reported by Pattnaik (2008) when entire nest of red weaver ant hanged in the dry tree trunk inside the enclosure stimulated exploration and climbing in pangolins. But it was difficult to get the nests all the time and the intake was less in comparison to directly providing the diet over feeding platform.

Veterinary care

Data are meagre on the captive husbandry and veterinary care of Indian pangolins. Upon arrival at NKZP, general health checkups are performed by the veterinary wing for all the Indian pangolins. Some of the rescued pangolins received at NKZP are found to carry ticks, which are manually removed with local application of antiseptic ointment. Tick infestation of Indian pangolin with *Amblyomma javanense* Supino, 1897 from NKZP (Sanyal et al. 1987) and *Aponimma gerviasi* Lucas, 1847 from Thrissur zoo (Pillai & George 1997) have been reported. Healthy individuals are then assessed for suitability of introduction in to the PCBC. Daily observation through video recordings, intermittent direct observation and monthly physical examinations are used to evaluate health status of the pangolins so as to provide early diagnosis of any sickness. Monthly physical examination includes measurement of length and weight of the individual pangolin, examination for any injury, examination for presence of ectoparasites and for secretion from their natural orifices like nose, mouth and genitalia etc., if any. They were found to carry gastrointestinal parasites e.g. strongyls as revealed by microscopic examination of faecal samples. Routine deworming of the pangolins has been carried out with administration of broad spectrum deworming drug e.g. Albendazole, 20 mg/kg body weight (Zentel™, GlaxoSmithKline Pharmaceuticals Ltd., Bangalore, India) in feed at three months interval. Besides, faecal samples are examined at weekly interval to find out parasitic infestation, followed by appropriate treatment. Previous study by Narayana et al. (1997) reported several species of bacteria *Escherichia coli*, *Klebsiella aerogenes*, *Proteus vulgaris*, *Pseudomonas aeruginosa*, *Streptococcus faecalis* and coliforms from stool, *E. coli* from urine and *E. coli*, *Streptococcus faecalis* and *Staphylococcus* sp. from blood of diseased Indian pangolins. To improve appetite, digestion and assimilation process in pangolins showing partial anorexia, liver stimulant drugs e.g. Liv-52™, (The Himalaya Drug Company, Himachal Pradesh, India) syrup are administered with feed for 15 consecutive days. Multivitamins like Becosule-C™ (Pfizer Limited, Bangalore, India) syrup are provided as feed supplement periodically. During pregnancy and lactation the mother is provided with an additional 10 % diet along with supplementation of calcium (Ostocalcium™, GlaxoSmithKline Pharmaceuticals Limited, Nashik, India) vitamin B12 (Becosule-C) syrup in the feed.

Behavioural biology

Few accounts have been published about the behaviour of Indian pangolins in wild (Blandford 1916, Israel et al. 1987, Prater 2005) and on their behaviour and maintenance in captivity (Acharjyo 2000, Pattnaik 2008, Mishra & Panda 2010). They are shy, solitary and nocturnal in habit (Israel et al. 1987, Prater 2005) and remain in burrows during the day time. They excavate their own burrow and digs into termite nests for prey (Prater 2005). Indian pangolins are agile climbers and probably climb trees in pursuit of ants (Heath 1995). They have very poor sense of vision and hearing but an excellent sense of smell (Israel et al. 1987). They use their sticky slender tongue to catch the prey in to its mouth. *Manis crassicaudata* walks quadrupedally, with back arched and both trunk and tail parallel to the above the ground (Israel et al. 1987, Prater 2005). It often stands on its hind limb with head elevated to survey the surroundings and emits a hissing sound when disturbed (Israel et al. 1987, Acharjyo 2000).

Comprehensive knowledge of pangolin behaviour will be central to assessing welfare and management of pangolins for potential captive breeding programme (Challender 2009). Introduction of infra-red enabled close circuit television (CCTV) cameras at PCBC greatly improved behavioural observation of the captive Indian pangolins that provide valuable information about their biology and behavioural needs in captivity. Information about the animals' daily activity pattern was thought to be of particular relevance in determining the suitability of the species for display in zoological

Table 1. Details of birth of Indian pangolins (*Manis crassicaudata*) at NKZP (data collected from zoo records).

Date of birth	Date of death	Longevity (in days)	Gender	Dam's date of acquisition	Period of captivity of dam during delivery	Cause of death (remark)
17-11-1971	21-11-1971	4	Male	26-10-1971	22	Rejection by mother
07-04-1977	08-04-1977	1	Male	16-07-1973	1361	Rejection by mother
26-09-1982	29-08-1983	337	Male	17-08-1982	40	Pneumonia
07-01-1985	09-01-1985	2	Male	21-10-1984	78	Lack of nourishment by mother
26-04-1995	05-05-2002	2566	Female	*	*	Heat stroke associated with pneumonia
03-01-1998	03-01-1998	0	Unsexed	27-03-1996	647	Still birth
19-01-1999	19-01-1999	0	Male	27-03-1996	1028	Killed by predator
07-01-2001	22-06-2001	166	Male	27-03-1996	1747	Pneumonia
24-10-2003	04-12-2003	41	Female	17-03-2003	221	Asphyxia resulting from strangulation by negligent mother
22-09-2005	25-07-2010	1767	Male	*	*	26-03-2007 (escaped), 30-03-2009 (recaptured) died in infighting
08-12-2005	09-12-2005	1	Male	*	*	Traumatic injury and shock resultant to trampling
02-02-2006	07-02-2006	5	Unsexed	*	*	Starvation due to rejection by mother
11-12-2006	22-12-2006	11	Male	*	*	Trampling
14-01-2007	14-01-2007	0	Female	05-08-2001	1988	Still birth
16-11-2007	24-03-2010	859	Female	25-03-2001	2427	Carcass putrefied, cause of death could not be ascertained
04-03-2008	08-03-2008	4	Unsexed	05-08-2001	2403	Rejection by mother
22-04-2008	22-04-2008	0	Unsexed	02-01-2008	111	Still birth
17-07-2009	01-03-2013	1323 days as on 01-03-2013	Male	05-08-2001	2903	Alive
28-08-2009	01-03-2013	1281 days as on 01-03-2013	Male	02-01-2008	604	Alive
03-08-2011	01-05-2012	272	Female	17-09-2008	1050	Glossitis with strangulation of tongue

* Data not available in zoo records.

Table 2. Details of alive Indian pangolins (*Manis crassicaudata*) presently housed at NKZP.

Date of acquisition	Gender	Sire	Dam	Age/captive longevity as on 01/03/2013	Remarks
16-07-2000	Female	Wild	Wild	4611	Rescued
09-11-2007	Male	Wild	Wild	1939	Rescued
02-01-2008	Female	Wild	Wild	1885	Rescued
17-09-2008	Female	Wild	Wild	1626	Rescued
20-09-2008	Male	Wild	Wild	1623	Rescued
17-07-2009	Male	0006A29238	0006A2ACA3	1323	Zoo born
28-08-2009	Male	0006A29238	0006A2A395	1281	Zoo born
03-07-2012	Female	Wild	Wild	241	Rescued (hand reared)

parks and as a possible aid in assessing the housing and husbandry practices being employed.

Mishra & Panda (2010) during the study on behaviour of six captive Indian pangolins at PCBC, NKZP reported that, Indian pangolins are strictly nocturnal and sun set and light intensity play a major role in initiating their activity. The maximum time was spent in walking (155.99 minutes in average, n = 6) followed by feeding (45.05 minutes in average, n = 6), digging (19.37 minutes in average, n = 6), and drinking (17.9 minutes in average, n = 6) and the less time has been reported for climbing behaviour (9.96 minutes in average, n = 6). They also reported the observed activity pattern as individual specific.

Some preliminary observations at PCBC revealed that captive Indian pangolins display the natural pattern

Table 3. Causes of death of Indian pangolin (*Manis crassicaudata*) at NKZP.

Causes of death	Between 16-01-1962 and 30-06-1997 (Acharjyo, 2000) (N = 46)	Between 30-06-1997 and 01-03-2013 (Zoo records) (N = 24)	Total (Between 16-01-1962 and 01-03-2013)
Maternal rejection	3	2	5
Still birth	-	3	3
Trampling	-	2	2
Septicaemia	2	-	2
Gastroenteritis	5	-	5
Intususception of small intestine	1	-	1
Pneumoenteritis	1	-	1
Pneumonia	9	7	16
Heat stroke associated with pneumonia	-	1	1
Heat stroke	2	-	2
Pulmonary hydatidosis	1	-	1
Hepatitis	1	1	2
Nephritis	-	1	1
Pericarditis/cardiac failure	3	-	3
Starvation debility	17	1	18
Traumatic injuries	1	-	1
Asphyxia resulting from strangulation by negligent mother	-	1	1
Infighting	-	1	1
Predatory bite	-	1	1
Impaction	-	1	2
Glossitis with strangulation of tongue	-	1	1
Cause of death could be ascertained as the carcass was putrefied	-	1	1

of nocturnal activity with a peak in activity between 20:00-21:00 h. They spend a large proportion of their time walking in the enclosure. Though they are intermittently active between 17:00-05:00 h., activity terminates earlier (at about 23:00 h.) in winter months. Some of the pangolins exhibit pacing behaviour in the shape of "8" or "O". Wet soil substrates were preferred for digging activity. Beside the burrows made in the mound or substrate soil, they also use hollow wooden logs as shelter. Pangolins were commonly seen exhibiting short head movements in vertical or horizontal plane to the longitudinal axis of the body, directed towards its proximate environment. Such behaviours may be displayed to detect odours in the air, locating feed, locating intruder/animal keeper and locating conspecific as a part of social interaction between the opposite sex individuals or between a mother and her baby.

Conservation breeding

Little is known about Indian pangolin reproduction. Although several zoos have maintained this species and its breeding in captivity have been reported from few zoos, e.g. Calcutta zoo, (Jarvis 1965), Oklahoma zoo (Ogilvie & Bridgwater 1967), Nandankanan Zoological Park (Acharjyo & Misra 1972, Acharjyo & Mohapatra 1978, Pattnaik 2008).

At PCBC compatible mating pairs were selected on the basis on their courtship interactions observed between opposite sex adult individuals housed in neighbouring enclosure. This compatible mating pair was allowed for mating under keen observation. Initially the mating pair of pangolins approaches each other cautiously and inspects each other with noso-genital or noso-nasal contact, followed by mounting attempts by the male. When mutual confidence is established, the female remained in a particular place and the male approached the female from back and clasp the her from top. Thereafter, the male shift its body towards lateral side of the female and position its tail under the tail of the female pangolin. This was followed by insertion of genitalia for two to seven minutes. The female then gets out of clasp of the male pangolin. Then they are isolated to release in to different enclosure after checking the overall health status of the individual pangolin. Proper monitoring of the mating event is carried out by both from CCVT and direct observation. Pairing of individuals was allowed in the night time only. Pangolins have been micro-chipped with Passive Integrated Transponder (PIT) for their individual identity and to facilitate captive management, breeding and research.

At PCBC, pangolins are housed in such a way that they can find a chance to interact with the opposite sex individual in the neighbouring enclosure. They can climb up the mound, water pool or chain-link mesh to interact and may squirt urine. At times, male individual lie near the chain-link mesh on his back exposing the ventral surface of the body outward. Such behaviour is interpreted as a sexual display to attract female pangolin. Basing on above courtship interactions mating pair is selected and housed together in breeding enclosure under close observation. Preliminary interaction between the mating pair includes approaching the opposite sex individual, which is followed by a long period of noso-nasal or noso-genital inspection. A quadrupedal or bipedal chasing movement may be observed as the male pangolin try to mount the female pangolin. During mounting, male pangolin climbs up the female's back from rear or side with his claws grasping her scale and adjust his angle and relative position with the female to attain an ideal copulation state. After obtaining a copulation state with his neck fully extended to point at the female's head, the male grasps the female's tail with his tail and inserts his penis into the female's genitalia. Copulation may occur during dorso-lateral mounting position. Event terminated when individuals breaks bodily contact. Upon termination of copulation, the pair move away separately and at times become retreat.

Pangolins did not show any significant morphological changes for pregnancy. Thus, it was difficult to assess the pregnancy of these individuals. Births have been reported throughout the year except May and June (Asdell 1964, Ogilvie & Bridgwater 1967, Acharjyo & Misra 1972, Acharjyo & Mohapatra 1978, Acharjyo 2000, Prater 2005, Pattanaik 2008). At birth a baby pangolin weighed 235 g and measured 30 cm in total length including 12.5 cm long tail (Acharjyo & Misra 1972). Three day old Indian pangolin born at Oklahoma Zoo measured 310 mm from tip to tip and with a 125 mm tail (Ogelvie & Bridgwater 1967). Usually a single young is produced (Israel et al. 1987), but occasionally two are born (Prater 2005). In 20 births of Indian pangolins recorded at NKZP including 3 births at PCBC, the litter size was always one young. Panda et al. (2010) reported that, the gestation period of Indian pangolins is about 165 days. The pangolin baby used to stay inside the burrows made by the mother for about 3 months. By observing the difference in the behaviour (i.e. mother remaining off fed inside the burrow for a couple of days) the gestation period was suspected. Eventually,

the mother introduces the young to the different parts of the enclosure. Young is carried on the dorsal base of the mother's tail (Phillips 1928, Israel et al. 1987). The mother was noticed very protective towards its young when anticipated any fear. When disturbed, the female with young will coil in to a sphere around its offspring. The offspring is protected at the centre of the sphere next to the ventral surface of the female (Phillips 1928, Acharjyo 2000). The young of the pangolin become independent at 5-8 months of age. The mating and breeding behaviour of Indian pangolins are monitored and the exact gestation period, age of sexual maturity and inter birth interval can be ascertained after few more observations in captivity. Though available knowledge is inadequate about reproductive biology of pangolins, there were studies estimating gestation period, weight of pangolin baby and period of maternal care on other asian pangolin species. Chin et al. (2012) found out the gestation period of Formosan pangolin *Manis pentadactyla pentadactyla* is as short as 318 days or longer than 372 days basing on progesterone radioimmunoassay. The study also stated the weight of the pangolin baby was 80 g at birth (Chin et al. 2012). Heath & Vanderlip (1988) reported birth weight of two Chinese pangolins as 92 g and 93 g respectively. The periods of maternal care was estimated to be three to four months in *Manis javanica* (Lim & Ng 2008) and about six months in *M. pentadactyla* (reviewed by Challender 2009*)*.

Longevity and cause of death

On January 16, 1962, NKZP received its first female Indian pangolin specimen. Until 1997, 65 specimens (30 males and 35 females) were received in the park (Acharjyo 2000). Out of 65 specimens received in the park, 2 specimens escaped out, 60 specimens died and 3 specimens were under exhibition on 30-06-1997. During this period, 32 specimens had been introduced in to NKZP including 15 zoo born individuals (Table 1) and 17 rescued specimens (4 males and 13 females). From these 35 specimens, 3 had escaped, 24 died and 8 are still alive including 2 zoo born adults and a young Indian pangolin which was hand reared at PCBC (Table 2). The causes of death of the pangolins determined by post-mortem examination are given in Table 3 which includes the causes of death as reported by Acharjyo (2000) and the information collected from the zoo records.

Before 1997, 42 pangolins (70 %) died within one year of their arrival in NKZP, 16 pangolins (26.7 %) died within 1-5 years whereas only two pangolins (3.3 %) died after remaining in captivity over 5 years in the park (Acharjyo 2000). Between 1997 and 2013 out of 24 deaths, 16 pangolins died (66.7 %) within one year of their arrival to the park, 4 pangolins (16.7 %) died within 1-5 years, 2 pangolins (8.33 %) died after 7 years and 2 pangolins (8.33 %) died after 8 years of survival in captivity. Heath (1995) reported 13.5 years longevity in Indian pangolin in captivity. The longest longevity recorded in this park is with a living female Indian pangolin of more than 12.6 years (Table 2). The age of other living specimens is given in Table 2.

Conclusion

The ultimate aim of captive management is to have a long-term viable population for captivity as well as a reserve for the wild population. Our experience indicates that pangolins can be maintained in captivity in good health if proper attention is paid towards appropriate housing, diet and veterinary care. The red weaver ants supplied for the Indian pangolins might be a cause for the better survival of the species in captivity. Proper housing facility with sufficient environmental enrichment considering the need of the pangolins is essential for a successful captive breeding programme. Behavioural observation is crucial not only to understand their activity pattern but also to discriminate their different biological events like courtship behaviour, mating behaviour, mother-young interaction, sickness and other behavioural needs in captivity. The captive breeding of healthy population of Indian pangolins is one of the measures to contribute towards its conservation. The captive population serves the purpose of public education and awareness as well as a model for the wild population within the framework of research for conservation and management. Further detailed study on reproductive biology and veterinary aspects is necessary to act upon current priorities for *ex situ* conservation of Indian pangolins.

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