General and Comparative Endocrinology 201 (2014) 37–44

Contents lists available at ScienceDirect

General and Comparative Endocrinology

journal homepage: www.elsevier.com/locate/ygcen

Non-invasive assessment of reproductive status and stress in captive Asian elephants in three south Indian zoos

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ARTICLE INFO

Article history:
Received 30 September 2013
Revised 7 March 2014
Accepted 13 March 2014
Available online 1 April 2014

Keywords:
Asian elephant
Progestogen
Androgen
Glucocorticoids
Stress
Musth

ABSTRACT

Asian elephants in captivity need immediate attention to be bred so as to meet the increasing demand for captive elephants and to overcome the dependence on supplementing the captive stock with wild animals. Unfortunately, captive breeding programs across the globe have met with limited success and therefore more effort is needed to improve breeding in captivity. Endocrine profiling of reproductive hormones (progestagens and androgens) and the stress hormone (glucocorticoids) could facilitate better management and breeding strategies. In the present study, we investigated reproductive and stress physiology of 12 captive Asian elephants for 10–27 months using a non-invasive method based on steroid analysis of 1700 elephant dung samples. Most of the elephants were cycling regularly. Males during musth showed increased fecal androgen metabolite concentrations and exhibited a slight increase in fecal glucocorticoid metabolite levels. Elephants used in public festivals and processions showed significantly increased in faecal glucocorticoid metabolite levels. The results indicate that captive elephants require periodic health care, better husbandry practices and scientific management for sustainable captive population.

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1. Introduction

Asian Elephant (*Elephas maximus*) is an endangered species (IUCN, 2012) with both *ex situ* and *in situ* populations decreasing at an alarming rate. Its survival is under threat because of continuous poaching and loss of habitat and corridors due to rapid habitat fragmentation. The captive Asian elephants constitute 22–30% of the total Asian elephant population (Lair, 1997; Sukumar, 2003) and are an indispensable workforce for forest departments. Elephants are a big tourist attraction and frequently used in religious processions. In India, captive elephants are normally managed by traditional knowledge and skills of mahouts. But, over the years, the quality of mahouts available has declined due to low monetary and improper welfare measures (MoEF 2004; Vanitha et al., 2009) thus impinging on the management of captive elephants (Vanitha et al., 2009). The problem is further compounded by the fact that captive breeding in elephants is not very successful (Rees, 2003), as e.g. less than 20% of Asian and 10% of African elephants of reproductive age have given birth in captivity in North American zoos (North American Regional Studbook, 2010; Brown et al., 2004). As a result, captive populations are regularly supplemented with elephants caught in the wild, adding further pressure on the struggling wild population (Sukumar, 1989). The limited success in captive breeding of elephants seems amongst others attributed to ovarian inactivity and acyclicity due to reproductive pathologies, neoplasias, etc. (Millspaugh and Washburn, 2004; Keay et al., 2006).

Studies on the reproductive physiology of female African (Wasser et al., 1996; and Asian elephants (Brown et al., 2004, 2009; Brown, 2000; Slade-Cain et al., 2008; Thitaram et al., 2008; Ghosal et al., 2011) have indicated that female captive elephants exhibit a long oestrous cycle of 14–17 weeks, with a 4–8 week follicular phase and an 8–10 week luteal phase (Brown, 2000; Slade-Cain et al., 2008; Hodges, 1998; Brown et al., 1999). Thus, routine endocrine monitoring can be viewed as a valuable tool to make decisions about the reproductive management of elephants.

Male elephants mature at the age of 15–20 years and periodically enter into a sexually active mode known as "musth". During musth they spend most of their time searching for females and less time in feeding resulting in significant weight loss (Poole and Moss, 1981). In African elephants, the association between glucocorticoids and musth is not clearly understood (Ganswindt et al.,

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http://dx.doi.org/10.1016/j.ygcen.2014.03.024
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2003), while other studies in Asian elephants have shown significant relationship between testosterone and cortisol levels in blood during musth (Brown et al., 2007; Rasmussen et al., 1984). Thus, understanding the changes involved during musth could immensely help in management and breeding of elephants in captivity.

With the advent of non-invasive hormone analysis using dung samples, it is indeed possible to monitor faecal progestogen, glucocorticoid and androgen metabolites levels to assess the reproductive cycle and stress of captive male and female elephants both on a short and long-term basis without collecting blood samples. In the present study, we examine the reproductive (progesterone, testosterone) and stress (cortisol) status of 12 captive Asian elephants with reference to different husbandry practices and body conditions in three south Indian zoos. More specifically, we investigate (i) whether reproductive cycle in females, (ii) stress levels in both the males and females, and (iii) musth in males are affected by different husbandry practices in three south Indian zoos.

2. Materials and methods

2.1. Sample collection

About 1700 samples were collected from 12 elephants (four males and eight females) from three south Indian zoological parks over a period of 280–800 days (Table 1). Elephant dung samples were collected twice a week from Nehru zoological park, Hyderabad (3 females and 1 male), Sri Chamarajendra zoological garden, Mysore (3 females and 1 male) and Sri Venkateshwara zoological park, Tirupati (2 females and 2 males), in the morning hours between 7 and 8 am in 50 ml plastic tubes (Table 1). Dung samples were also collected daily (for 10 days before and after public procession) from one female, used for festivals (Vanaja) was housed at Hyderabad zoo. The duration of sample collection was 27 months (July 2010–September 2012) for Hyderabad zoo, 14 months (July 2011–August 2012) for Mysore zoo and 10 months (May 2012–February 2013) for Tirupati zoo.

2.2. Sample storage

Samples collected in Hyderabad zoo were immediately frozen after collection and stored at −30 °C whereas Mysore and Tirupati zoo samples were stored in 80% methanol and brought to the lab within a week for further analysis. Methanol stored samples were further extracted within a week after collection to avoid variation in hormone concentrations due to long-term storage of samples (>3 months) as reported by Hunt and Wasser (2003). To examine different storage conditions, the dung samples were pooled from different animals and mixed thoroughly to ensure the hormone distributed properly before making subset of samples ($n = 7$, each of 5 samples) for different day storage and extraction analysis (Hunt and Wasser, 2003). Faecal hormone metabolite concentration did not vary significantly for 30 days of storage in methanol (K–W $X^2 = 9.13$, $P = 0.17$, $n = 35$, for faecal progestogen and K–W $X^2 = 9.48$, $P = 0.15$, $n = 35$. for faecal glucocorticoids, respectively). Furthermore we did not find significant difference in faecal steroid metabolites concentrations between samples directly stored in −30° C and those preserved in methanol in 30 days (faecal progestogen M–W Test, $U = 97$ $P = 0.10$, $n = 10$; faecal glucocorticoid M–W Test, $U = 6.5$, $P = 0.22$, $n = 10$; Fig. 1a and b).

2.3. Study animals and husbandry

The age of the elephants ranged from 9 to 58 years (Table 1). In Mysore zoo, both male and females were kept together in a large enclosure from 8 am to 5 pm unchained and rest of the time they were individually chained in a shed. In Hyderabad zoo, two females (Asha and Jamuna) were allowed to roam freely in a large open enclosure from 10 am to 4 pm and subsequently chained for the rest of the time in a shed, which also housed two other elephants, Vanaja, a female and Vijay, a male. Vanaja was taken for rounds inside the zoo a few days prior to use in public processions or festivals by *mahouts*. The male in Hyderabad zoo was always chained due to its aggressive nature and was not allowed to interact with other individuals. In Tirupati zoo, the elephants were individually released between 10 am and 4 pm, on alternative days, into the adjacent reserve forest with long chains to forage and for the rest of the day they were kept chained in a shed with only visual contact with males.

2.4. Musth and behavioural observations

Musth conditions in bulls were identified when temporal gland secretion, urine dribbling and increased aggressive behaviour were all observed for two consecutive observations in three days time (Ganswindt et al., 2005a; Poole, 1987). The above information, participation in public procession, injury and other activities were

Table 1
Details of age/sex, body condition, duration of sample collection, cyclicity status and faecal glucocorticoid metabolite concentrations in captive Asian elephants from three south Indian zoos.

S No	Zoo	Name of elephant	Sex	Age as on July 2013 (years)	Body condition grade*	Duration of sample collection (days)	Female cyclicity status	Mean faecal glucocorticoid metabolite concentration# (ng/g dry weight)	Faecal glucocorticoid metabolite concentration range (ng/g dry weight)
1	Hyderabad	Vijay	Male	29	4	800	–	3.86	0.20–16.80
2	Hyderabad	Jamuna	Female	39	8	800	Yes	4.10	1.00–12.00
3	Hyderabad	Asha	Female	40	6	800	Yes/ irregular	5.00	1.00–79.00
4	Hyderabad	Vanaja	Female	42	6	800	Yes/ irregular	5.24	1.21–49.25
5	Mysore	Rama	Male	18	7	385	–	3.19	0.32–8.62
6	Mysore	Airavathi	Female	9	8	385	Yes	3.84	0.75–15.00
7	Mysore	Gajalakshmi	Female	33	9	385	Yes	2.98	0.20–7.82
8	Mysore	Padmavathi	Female	58	8	385	No	2.54	0.27–7.10
9	Tirupati	Venkanna	Male	32	8	284	–	3.40	2.10–7.90
10	Tirupati	Vinayaka	Male	40	8	280	–	9.31	3.40–20.40
11	Tirupati	Rani	Female	57	7	280	Yes	8.31	3.60–21.70
12	Tirupati	Padmavati	Female	12	8	280	Yes	9.41	4.80–75.00

* Body condition rating was done using criteria described in Wemmer et al. (2006).
\# Excluding values during musth, injury and public procession.

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