



Investigating temporary acyclicity in a captive group of Asian elephants (*Elephas maximus*): Relationship between management, adrenal activity and social factors



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ARTICLE INFO

Article history:

Received 8 May 2015

Revised 4 September 2015

Accepted 17 September 2015

Available online 21 September 2015

Keywords:

Temporary acyclicity

Animal welfare

Asian elephant

Glucocorticoids

Management

Oestrous synchrony

Reproduction

ABSTRACT

Routine faecal steroid monitoring has been used to aid the management of five captive Asian elephant (*Elephas maximus*) females at Chester Zoo, UK, since 2007. Progestagen analysis initially revealed synchronised oestrous cycles among all females. However, a 14- to 20-week period of temporary acyclicity subsequently occurred in three females, following several management changes (increased training, foot-care and intermittent matriarch removal for health reasons) and the initiation of pregnancy in another female. The aim of this study was to retrospectively investigate whether these management changes were related to increased adrenal activity and disruption of ovarian activity, or whether social factors may have been involved in the temporary cessation of cyclicity. Faecal samples collected every other day were analysed to investigate whether glucocorticoid metabolites were related to reproductive status (pregnant, cycling, acyclic) or management (training, foot-care, matriarch presence). Routine training and foot-care were not associated with adrenal activity; however, intensive foot-care to treat an abscess in one female was associated with increased glucocorticoid concentration. Matriarch presence influenced adrenal activity in three females, being lower when the matriarch was separated from the group at night compared to being always present. However, in the females that exhibited temporary acyclicity, there was no consistent relationship between glucocorticoids and cyclicity state. Although the results of this study do not fully explain this occurrence, the highly synchronised nature of oestrous cycles within this group, and the concurrent acyclicity in three females, raises the question of whether social factors could have been involved in the temporary disruption of ovarian activity.

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1. Introduction

Asian (*Elephas maximus*; (Choudhury et al., 2008)) and African (*Loxodonta africana*; (Blanc, 2008)) elephants are threatened with extinction in the wild, due primarily to habitat loss, human-wildlife conflict and poaching (Riddle et al., 2009). Captive populations of endangered species serve as important reservoirs to support declining *in situ* populations, allow the generation of

knowledge and act as conservation ambassadors to raise awareness for the plight of their wild counterparts. To fulfil these roles, populations must be self-sustaining and high levels of welfare maintained. There are currently around 700 Asian and 400 African elephants in zoological institutions around the world (AZA, 2011). However, historically these populations have not been self-sustaining (Clubb et al., 2009; Faust and Marti, 2011; Hutchins and Keele, 2006; Wiese and Willis, 2006), with irregular reproductive cyclicity, asymmetric reproductive ageing, reduced survivorship, high infant mortality and insufficient breeding males amongst the issues being reported (Brown et al., 2004b; Clubb and Mason, 2002; Clubb et al., 2008, 2009; Hermes et al., 2004; Hutchins and Keele, 2006). Additionally, the welfare of captive elephants has been questioned in recent years, with issues such as poor enclosure design, inappropriate social groupings, lack of

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sufficient exercise, poor foot health, abnormal gait, and unsuitable nutrition being identified as significant problems (Clubb and Mason, 2002; Harris et al., 2008). To address some of these concerns, research is underway to better understand the welfare requirements of zoo-maintained elephants for optimal health and reproduction (Carlstead et al., 2013; Posta et al., 2013).

In North America, comprehensive reproductive surveys and longitudinal hormone analyses have been conducted to assess cyclicity (Brown et al., 2004a,b; Dow et al., 2011; Proctor et al., 2010b) and found that irregular ovarian activity is a key factor in limiting fecundity; with as many as 25% of Asian and 46% of African elephants in North American zoos exhibiting either irregular cycles or complete acyclicity (Dow et al., 2011). Although a similar comprehensive survey has yet to be conducted in Europe; irregular ovarian activity has been observed (Hermes et al., 2004; S. Walker, personal communication). This acyclicity may be temporary, lasting a few weeks or months and often referred to as irregular cyclicity, or more long-term lasting several years (Brown et al., 2004a). Due to the prevalence of these issues, previous research has investigated a number of factors relating to acyclicity in African elephants, including social status, body condition and life histories (Freeman et al., 2009). However, exactly which aspects of the captive environment are involved in ovarian cycle problems have yet to be fully understood (Brown et al., 2004a; Proctor et al., 2010a).

In North America, 71% of non-cycling female African elephants have elevated serum prolactin concentrations (Dow and Brown, 2012), a condition that has been linked to stress in women (Sobrinho, 2003), and which can lead to the suppression of gonadotropins and oestrous cyclicity (Das and Khan, 2010). Although a previous study by Proctor et al. (2010a) did not find any relationship between social status, long-term acyclicity and chronic adrenal activity in female African elephants, potential relationships with temporary acyclicity, or indeed among Asian elephants have yet to be explored. There has been some suggestion that temporary cessation of ovarian cyclicity in captive elephants could be a distinct phenomenon from long-term acyclicity, and may be a stress response to social or environmental conditions (Hermes et al., 2004; Schulte et al., 2000). One of the biological responses to real or perceived stressors is the activation of the hypothalamic–pituitary–adrenal (HPA) axis (Moberg, 2000). This results in the production of glucocorticoids from the adrenal gland, which facilitates the mobilisation of energy stores and allows the individual to respond accordingly. Although this stress response is primarily adaptive, and can result from exposure to both positive and negative stimuli (Buwalda et al., 2012), prolonged activation can be detrimental and lead to suppression of immune (Khansari et al., 1990) and reproductive (Dobson and Smith, 2000) function. Captive elephants are faced with a myriad of challenges in their environment, which can include abnormal social groupings and inadequate enclosure design, as well as un-naturalistic substrates, lighting regimens and sounds, and husbandry routines (Clubb and Mason, 2002; Harris et al., 2008). These factors could potentially lead to increased adrenal activity (Morgan and Tromborg, 2007), and if individuals are unable to cope appropriately, could disrupt normal ovarian function leading to irregular oestrous cycles or acyclicity (Kalantaridou et al., 2004; Matteri et al., 2000).

Chester Zoo, UK has a breeding herd of Asian elephants, and has been using faecal progesterone monitoring since 2007 to aid reproductive management. Five of the females were considered to be potential breeders, and were included in this programme. Apart from during pregnancy and lactation, all five females have exhibited regular oestrous cycles from the initiation of this monitoring programme to the present, and in fact have shown a high degree of synchrony among females during this time. However, one exception to this was in 2008, when three females experienced a temporary cessation in cyclicity lasting between 14- and 20-weeks. In more than

7 years since routine reproductive monitoring began on this group, this was the only period of acyclicity observed, so in an attempt to understand why this unique period of temporary acyclicity occurred, the following study was established to retrospectively explore some of the potential factors that could have been involved.

The elephants at Chester Zoo underwent the transition from a free-contact to a protected-contact management programme just prior to the observed period of acyclicity. This transition resulted in a number of husbandry changes taking place during this study period, including both the type and amount of training required to enable day to day husbandry practices and to perform a routine foot-care regime. In captive elephants, non-resolvable foot infections and arthritis are major causes of euthanasia (Fowler and Mikota, 2006); thus, regular preventative foot-care is a vital component of captive elephant management. During this same period, a decline in the health of the matriarch also required her separation from the rest of the herd to allow medical treatment and supplementary feeding. Due to their highly complex social structure and the importance of sociality for welfare and reproductive success in elephants (Schulte et al., 2000), even temporary physical separation could be perceived as a stressor by individual elephants. Therefore, removing the matriarch of this herd, even temporarily, could have consequences for the remaining individuals. One hypothesis for the observed temporary period of acyclicity was that the accumulation of multiple husbandry changes, namely matriarch presence and the type and frequency of training and foot-care, over a relatively short period could have been perceived as a stressor, and increased adrenal activity may have led to the disruption of ovarian activity.

Alternatively, there may have been a social basis for this disruption. In early July 2008, one of the females in the group was mated and successfully conceived. As these females' oestrous cycles were highly synchronised, an alternative hypothesis for the temporary cessation in cyclicity is that it was in some way related to this pregnancy. The aim of the current study was therefore to determine the impact of changes in social management and routine husbandry on adrenal glucocorticoid activity of five potential breeding females within a captive herd of Asian elephants, using non-invasive faecal hormone analyses that were temporally-matched with husbandry data (Edwards et al., 2013). In addition, the degree of oestrous synchrony within this group was examined and analysed as a potential alternative explanation for the temporary cessation of ovarian cyclicity.

2. Materials and methods

2.1. Study subjects

This study was conducted on a captive herd of Asian elephants (*E. maximus*) at Chester Zoo, UK. At the time of the study, the herd was composed of three males (one breeding bull and two juveniles) and seven females (Table 1). The nucleus of this herd consisted of three generations of related females (CZF5, CZF6 and CZF7), along with four unrelated females. The oldest and most dominant female (CZF1) had been at the zoo since 1965, and although she was considered to be the herd matriarch, the dynamics within the group were not strictly linear at this time, with female CZF3 frequently challenging the matriarch, CZF1. Five females were included in the current study, all of which have been part of a non-invasive reproductive monitoring programme since February 2007. The other two older females (CZF1 and CZF2) were considered to be non-reproductive, and were not included in routine faecal monitoring or this study.

All seven female elephants were housed together as a single herd, including the two juvenile males (CZM2 and CZM3). The herd

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