Introduction

In Sri Lanka and in other Asian countries, mature male captive Asian elephants (*Elephas maximus*) are an integral part of celebrations related to cultural, religious and state occasions. However, the annually occurring musth period of adult males (Fig. 1) may hinder sourcing of elephants for these events (Lincoln & Rathnasooriya 1996; Jainudeen et al. 1972).

Musth in mature males is a testosterone dependent (Rasmussen et al. 2008), highly predictable event, which lasts between 3–6 months. When in musth, privately owned captive males are kept tethered in stables (Ananth 2000; Rajapaksha et al. 2004). During this period male elephants can be difficult to handle and often are aggressive to the point that they may injure handlers and in some instances, even kill them (Pool 1989; Rasmussen & Perrin 1999).

Endocrinologically, the mean normal serum testosterone concentrations in captive Asian male elephants vary from 1–10 ng/ml while in pre-musth and musth, the levels are 10–20 ng/ml and 20–50 ng/ml, respectively (Yon et al. 2008). During musth, bull elephants show marked increase in testosterone secretion and studies have shown high sensitivity of the testes to GnRH during the non-musth period (Somgird et al. 2016).

Controlling and monitoring the aggressive behaviour of captive male elephants during musth is of paramount importance not only from a public safety perspective but also from an animal welfare standpoint. De Nys et al. (2010) were able to reduce musth-related aggression by surgical castration. However, as elephants have intra-abdominal testes, this procedure is difficult, costly and irreversible. The use of anti-androgens, oestrogens (Hettiarachchi et al. 2005), GnRH agonists, and GnRH antagonists also has limited value due to unpredictable results and practical difficulties in administration.

De Nys et al. (2010) and Talwar et al. (1995) suggested the use of GnRH vaccine to down-regulate the hypothalamic-pituitary-gonadal axis, as noted in several other species of animals (Miller et al. 2000), which could be a useful, reversible (Miller et al. 2000) and a relatively inexpensive procedure to suppress musth in elephants. No detrimental effects of this vaccine on elephants have been reported.
The objective of this study was to investigate the effects of GnRH vaccine in the postponement of musth in captive male elephants.

Methods

Four privately owned males and two males from Pinnawela Elephant Orphanage were selected for the study. For musth suppression, three doses of GnRH vaccine (800 µg per dose; BOPRIVA® bovine immune castration vaccine, Zoetis GMS Australia) was injected IM at monthly intervals so that the last injection was approximately one month prior to the anticipated date of musth.

At the time of each vaccination, blood samples were collected from the ear vein, the serum separated and stored at -20ºC until analysis. Testosterone levels were assessed using an Enzyme-Linked Immuno Sorbent Assay.

Elephant owners and handlers were educated on musth, its undesirable effects and potential threat to public safety and the effect of musth postponement by GnRH vaccine was explained (Fig. 2). The elephant keepers were asked to keep a note on the behaviour i.e. obedience, of the elephants in their care.

Results

Of the four privately owned elephants, all three doses were given to one elephant, two doses to each of two elephants and a single dose to one elephant (Table 1). The full course could not be

![Figure 2. Explaining the procedure to the mahout before vaccination.](image-url)
given to all as the owners and keepers did not comply with the injections and advice. Blood samples could not be collected from Tharaka, one of the privately owned males because he was aggressive and a new keeper had been employed.

The elephant receiving all three doses demonstrated a three-month delay in the onset of musth (Table 1), together with a marked reduction in aggressiveness. The two elephants that received two doses showed signs of musth around the expected time, however, there was a reduction in aggression. The animal that received a single dose came into musth two months prior to the expected date with higher aggression and had a prolonged period of musth.

Of the two Pinnawala elephants, one had been in continuous musth for almost two years when the first dose was administered and he came out of musth immediately after the first injection and had lowered aggression. However, musth reappeared approximately 13 months after the third dose (Table 1). The other had a history of irregular musth twice a year and responded by delayed commencement of musth by approximately 10 months after the third dose (Table 1), with lowered aggression.

Testosterone levels were reduced in two of the four privately owned elephants in which all tests were done and one of the Pinnawala elephants while the other Pinnawala elephant showed an increase in testosterone levels (Table 1).

Discussion

This is the first time that the vaccine was used on privately owned captive elephants in Sri Lanka. One elephant with a typical history of musth, given three doses of GnRH vaccine, responded with decrease in serum testosterone levels, postponement of musth, and decrease in aggressiveness.

A high serum testosterone level at the time of the first vaccination may be associated with eliciting a good response to the course of injection, as seen by the delay in musth and reduced aggression, by elephants Saliya and Suranimala. In three of four animals tested, the serum testosterone level declined after the vaccinations. Privately owned male elephants have an assigned keeper for several years, while in the Pinnawela Orphanage, this is not the case. Although musth is essentially testosterone dependent, the elephant-keeper relationship could possibly influence the behaviour during musth (Hettiarachchi et al. 2005), which may have had an effect on levels of aggression observed in this study.

In Thailand five bulls vaccinated with 600 µg GnRH two months before expected musth and boosted three times with 600 µg at four week intervals, showed decreased serum testosterone levels with musth postponement in three and skipping of musth for that year in the other two (Somgird et al. 2016). In Sri Lanka, three of six bulls given 600 µg GnRH, in three injections one month apart, showed reduced serum testosterone levels while others did not show anticipated response (Rajapaksa et al. 2010).

Unpredictable behaviour in male elephants can be seen even naturally when serum testosterone decreases after the peak in musth (Lincoln & Ratnasooriya 1996). Therefore elephant keepers must be made aware that, though GnRH is likely to postpone musth, the length of post-musth period could vary. Some elephant owners in Sri Lanka believe that disruption of musth in healthy males leads to intractable handling difficulties (Rajaram 2006). In this study, an attempt was made to address this belief by education to the contrary. However, this may have been the reason for non-compliance by two of the privately held

![Figure 3. Vaccination of a captive bull.](image)
elephant owners in completing the three doses of vaccine. Incentives such as service priorities and
discounts in professional costs may help increase compliance.

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