Captive Elephant Infertility: Consequences for Conservation

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Figure 1. Puspita - born September 1999, Sumatra.

Elephants are a much studied species provoking affectionate interest from an enormous TV audience exposed to both wild and captive populations. Controversy arises over aspects such as ivory trading, and the consequent suffering of individual animals. Both wild and captive species are under threat from different pressures and the current overpopulation in some wild habitats, particularly Africa, is thought likely to be short term. Free ranging Asian elephants are already on the brink of extinction (Thitaram et al, 2008). Currently, the approximate number of elephants across the African continent is 637,600. Asian counterparts have wild populations of around 50,250 (Hermes et al, 2007).

Captive herds are a potential conservation resource available to bolster any decline in wild populations but infertility in these captive animals may lead to their loss within a few decades (Wiese, 2000; Hutchins and Keele, 2006).

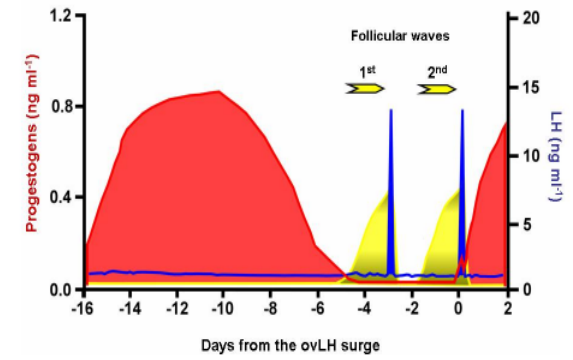
Captive females suffer from acyclicity (absence of oestrous cycle) and abnormalities of the reproductive tract. The reasons behind these problems are not fully understood but may be linked to endocrine function, nutritional status and stress within captive herds due to husbandry (Brown et al, 2004). As a consequence, breeding programmes in captivity rely upon artificial insemination (AI). This technique was introduced successfully in 1998 following advances in endocrine monitoring techniques and a better understanding of the reproductive tract (Brown et al, 2004), see below. However, AI is not always possible due to a lack of viable sperm donors and compliant females. It would be preferable for fertilization to occur naturally.

The Oestrous Cycle of the Elephant

The female elephant has a unique oestrous cycle and an unusually shaped reproductive tract. Elephants demonstrate the longest oestrous cycle which occurs over 13-17 weeks. It comprises two phases, a follicular phase of 4-7 weeks and a luteal phase of 8-10 weeks. During the follicular phase, follicles mature in the ovary which results in ovulation. Thereafter, the formation of a corpus luteum occurs in the luteal phase, ending in either pregnancy or luteolysis (corpus luteum degradation) (Hess et al, 1983; Plotka et al, 1988). There are two further characteristics that make this cycle highly distinctive. The presence of steroids called progestins in the circulation and two surges of luteinising hormone within the follicular phase of the cycle. In comparison, other

species experience a single LH surge (Brown et al, 1999a, Kapustin et al, 1996).

Progestins are relatively high in concentration during the luteal phase. Conversely, concentrations fall to baseline levels in the non-luteal phase. Progestogins tend to increase in relation to continual accessory luteal and corpus luteal maturation during this phase, explaining the fluctuating hormone patterns (Hodges, 1998; Hildebrandt et al, 2006).



Elevated progestin hormones during the luteal phase

Indicate the waves of follicular development

Indicates the double LH surge during the follicular phase and how LH falls during the luteal phase

Figure 1. The ovarian cycle of the cow elephant. A progestogin rise stops follicular development in the luteal phase. However, removing progestogins means follicular activity is reinitiated shown by the two waves of follicular development. These waves finish with the well timed LH surges (Hildebrandt et al, 2006).

The first of the two LH surges is described as the anovulatory (anLH) surge, with no inducement of ovulation occurring. The second is described as the ovulatory (ovLH) surge, where ovulation is induced (Brown et al, 1999a; Hermes et al, 2000; Hildebrandt et al, 2000). The first surge is timed within 2-3 weeks, or 12-21 days, after the end of the luteal phase, when the levels of progestin drop to baseline. The second follows around 3 weeks, or 19-22 days later (Hermes et al, 2000; Kaputsin et la, 1996; Brown et al, 1999a; Brown et al, 1999b).

Prior to each LH surge, a follicular wave is seen. This first wave consists of several follicles. Follicles comprise oocytes in development. Eventually a single oocyte will ovulate. However, follicles in this wave will never ovulate or become a full sized oocyte surrounded by follicular cells. After the anLH surge the follicles regress. Over the next few weeks a second wave becomes apparent and one large dominant follicle begins to form. This follicle is ovulated 24 hours after the ovulatory surge (Hildebrandt et al, 2006).

Anatomy of the Reproductive Tract

Along with the unique oestrous cycle comes the distinctive anatomical structure of the reproductive tract. The female reproductive organs have been hard to evaluate due to their size and locations within the tract. The vaginal opening is situated between the hind legs on the underside of the body. Due to this difficult positioning and the occasionally uncooperative female, the chances of successful mating are very low. Artificial insemination is also made more difficult.

The tract is very large and has particular features not common in other species. A large portion of the tract from the outside to the vagina is called the vestibule. The distance between the vestibular opening and ovary is 2.5m (Balke et al, 1988). The vestibule follows a curved path occurring vertically for 1.0-1.4m to the tail, then horizontally towards the pelvic bone, leading to the vagina.

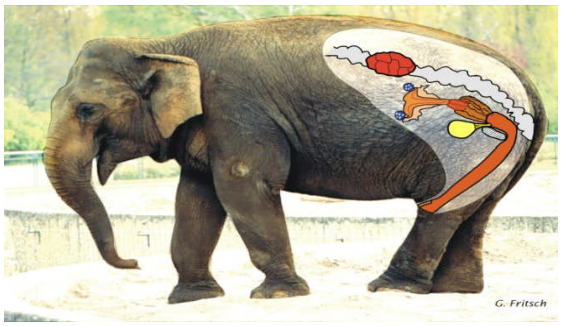


Figure 2. The diagram shows the urogenital tract of a female Asian elephant. The labels and arrows indicate the various anatomical features of the tract and their positioning within the elephant . Adapted from http://www.elephanttag.org/General/general_elephant_reproduction.html, accessed 22/04/09) Thomas Hildebrandt permission.

Additionally, the vaginal opening/hymen is very small in the elephant; with a diameter of less than 1 cm, particularly in those females who have never birthed a calf. Natural intercourse sees ejaculate deposited in the vestibule. Successful fertilization is sometimes hindered due to the sheer size of the urogenital tract. Captive animals are inseminated artificially. Thus, during artificial insemination semen must be inserted to the depth of the vagina or cervix for successful conception (Brown et al, 2004).

The Major Problem

Nearly all of the captive female elephant population do not experience a regular oestrous cycle. As a consequence the tract becomes susceptible to ovarian or uterine disease affecting conception and successful pregnancy (Brown et al, 1999a; Hildebrandt et al, 2000). One example would be chronic cystic ovarian disease, a condition that is also found in dairy cows (Brown et al, 2004; Jainudeen and Hafez, 2000). If the number of acyclic females continues to rise, then it is inevitable that populations will soon decline (Hildebrandt et al, 2000). Aging populations mean most females are exceeding their prime age of reproduction. Females reach sexual maturity at the age of 4-7 years in captivity. Elephants of 30 years or more are exhibiting no oestrous cycles (Brown et al, 2004; Hermes et al, 2004).

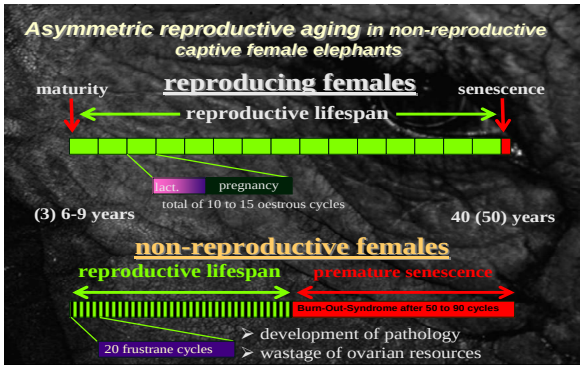


Figure 3. This schematic diagram represents the process of reproductive aging in captive female elephants for those reproducing and non-reproducing (Hermes et al, 2004)

Assisted Reproduction in Captive elephants

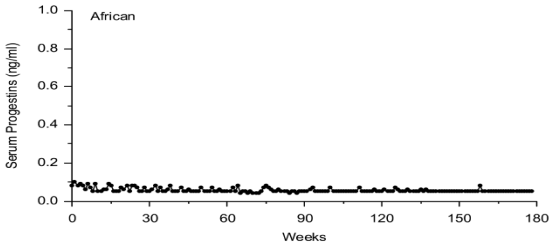
To overcome the two main problems considered above and assist captive elephants to mate requires intervention. Administering steroid and gonadotrophic hormones to "fake" an oestrous cycle might help but may have side effects. Even so, the essential problem of acyclicity still has to be explained.

A Possible Explanation for Acyclicity

In captive environments, elephants are fed a continual supply of food with no fluctuations in feeding patterns. This has led to many animals displaying obesity.

Obesity is related to poor reproduction and infertility in humans and an excess of body weight disrupts ovulation (Wittemer et al, 2000; Clark et al, 1998).

Graph 2



Graph 3

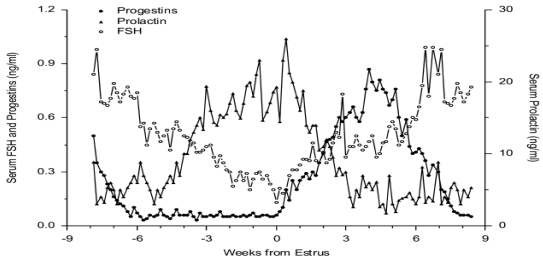


Figure 4. This represents a profile of serum progestin concentration measured in an African female that is not cycling. From the graph (2), the progestin monitoring test produced a 'flatliner' result. Conversely, graph 3 demonstrates serum progestins, FSH and prolactin during the oestrous cycle of an African elephant that is experiencing a normal reproductive cycle. The progestin concentrations particularly are different (Brown et al, 2004)

In elephants, it has been shown that the acyclicity percentage increases with the BMI (Body Mass Index) (Hamilton et al, 1995). A study of 77 elephants was undertaken in UK zoos and 6 individuals were found to score a normal bodyweight. However, 75% were classed as 'overweight' or 'severely overweight.' The majority of UK elephants are generally scored as overweight in captivity (Harris et al, 2008).

A possible approach is to target the hormones involved in body composition, food intake and reproduction.

Leptin is a protein hormone that plays a vital role in signaling nutritional status of the body to the forebrain and gonads (Zieba et al, 2005). Leptin plays a role in linking the brain and fat in the body, decreasing food intake and increasing energy expenditure. A lack of leptin in some animals results in the development of profound obesity and subsequently infertility. If treated with leptin, normal fertility is restored and food intake lowered (Messinis and Milingos, 1999). In man, obesity is thought to be due to acquired leptin resistance (Montague et al, 1997) due to leptin receptor mutations.

With continual feeding patterns, nutritional hormones that have a link with reproductive functions are always active. Nutritional hormones,

like leptin, may constantly be binding to receptors, such as LH (Luteinising hormone) receptors in the reproductive tract. LH is a gonadotrophic hormone, secreted by the anterior pituitary and is required for the maturation of follicles in the ovary (Bray et al, 2005). Thus, its reproductive receptor could become less sensitive or hormone resistant through constant binding of a nutritional hormone leading to acyclicity.

Future Studies

Any investigation of the role of leptin in acyclicity might involve the following:-

1) Establishing the effect of leptin on the reproductive system of the elephant.

2) Devising wild type feeding patterns whilst monitoring leptin and acyclicity.

In conclusion, the complex reproductive biology of the elephant and the link between nutrition and endocrine function has to be understood further. This is essential to overcome reproductive tract pathologies and acyclicity in captive breeding populations which are important as stock animals to supplement those in the wild.

Further Reading

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