OPINION

Vasectomy of older bulls to manage elephant overpopulation in Africa: a proposal

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Abstract

The paper proposes a new, humane and safe approach for managing the problem of overpopulation of the African elephant (*Loxodonta africana*) without disrupting social behaviour. It is based on using vasectomy on a part of the dominant bull population to lower the birth rate in a population. Advantages and disadvantages of male versus female sterilization are described, as well as general, technical, sex-related and financial aspects of vasectomy of elephant bulls. After dominant bulls are selected, treatment of less than 2% of the elephants would stabilize a population in parks with a natural population growth rate. For parks with 100 to 300 elephants, occasional vasectomy of a dominant bull would provide an effective elephant family planning tool.

Résumé

Cet article propose une nouvelle approche, humaine et sûre, pour gérer le problème de la surpopulation de l'éléphant africain (*Loxodonta africana*) sans perturber le comportement social. Il se base sur la vasectomie d'une partie de la population de mâles dominants pour réduire le taux de natalité dans une population. Les avantages et les inconvénients de la stérilisation des mâles par rapport à celle des femelles sont décrits, ainsi que les aspects général, technique, lié au sexe et financier de la vasectomie des éléphants mâles. Après la sélection des mâles dominants, le traitement de moins de 2% des éléphants stabiliserait une population dans des parcs où le taux de croissance est naturel. Pour les parcs qui abritent de 100 à 300 éléphants, la vasectomie occasionnelle d'un mâle dominant pourrait être un outil efficace de planning familial.

Introduction

In some countries unrestricted growth of the African elephant (*Loxodonta africana*) population causes serious problems. In Botswana and Kenya, where elephants roam free, they come into conflict with the human population by causing damage to human life and property (Poole 1993). In Zimbabwe and South

This proposal, although based on scientific literature, does not present evidence that the vasectomy concept will work, as vasectomy had never been performed on elephants before this concept was first presented at an Elephant Symposium of the Elephant Management and Owners' Association (Bokhout et al. 2004). Since then, the operation has been carried out a number of times in South Africa (Mark Stetter, pers. comm. 2005). This paper is intended, rather, to stimulate discussion and experiments to find an alternative solution for the problem of elephant overpopulation.

Africa all elephants are fenced in. Here elephant overpopulation ultimately leads to destruction of their habitat and that of other animals as well, ultimately leading to loss in biodiversity (Whyte et al. 1999).

Several population control methods have been tried—culling, translocation and contraception for female elephants.

Culling as a management tool was practised as early as 1967. Population increases in Kruger National Park (KNP) in South Africa led to culling about 14,500 elephants between 1967 and 1994 (Whyte 2001). Although a controversial control strategy from the start, culling is by far the fastest method for reducing population size. Because of public debate and other factors, culling at KNP was put on hold in 1994 (Whyte et al. 1999).

Up to 1994 young elephants were translocated to other parks after the adults of a herd were culled (Garaï et al. 2004). But moving juveniles without adults led to problems, one of which was that the juveniles became aggressive to other species such as rhino (Slotow et al. 2000). Thus since 1994, only entire cow-and-calf groups have been translocated to nearly 60 reserves (Garaï et al. 2004). Translocation is a humane method, providing new, mostly small areas for elephants to live in.

During the last decades several techniques of contraception for female elephants have been discussed and tried. These include terminating pregnancy, practising hormonal control using oestradiol-17b (oestrogen) implants, and immunocontraception (Poole 1993; Fayrer-Hosken et al. 1997; Whyte and Grobler 1998; Whyte et al. 1999; Fayrer-Hosken et al. 2000; Fayrer-Hosken et al. 2001; Pimm and Van Aarde 2001). Oestrogen implants were reported to induce behavioural aberrance, resulting in substantially increased stress levels on the treated cows and their calves (Whyte and Grobler 1998). The use was suspended as it was considered unacceptable on both humanitarian and ethical grounds. Recently Delsink et al. (2004) reported results of using porcine zona pellucida glycoproteins (pZP) (Fayrer-Hosken et al. 1997). This approach significantly reduced population growth in a small population of elephants.

Male elephant contraception is hardly mentioned or at most is mentioned indirectly (Poole 1993), arguing that even the removal of a large number of males would not reduce existing populations. This paper shows that contraception for elephant bulls may have advantages, on condition that the males are not removed. It focuses on comparing the pros and cons of an apparently promising immunocontraception with pZP in female elephants with those of what is for the present a hypothetical method of selective contraception by vasectomy in older dominant males.

Male versus female contraception

General aspects

In an elephant's life, males need to be sterilized once, whereas females have to be treated at least four times, not counting 'boosters', to prevent births (table 1).

The treatment of older solitary males can be done

Table 1. Technical aspects of female versus male contraception relevant for contraception choice

Aspect	Female sterilization	Male vasectomy	Literature if relevant
Number of treatments per animal	4 to 6[a]	1	Moss 2001
Herd disturbance	Yes	No	—
Tracking down and capturing (1st time)	Easy (herd)	Less easy (solitary)	—
Tracking down and capturing (2nd time)	Difficult	Irrelevant	—
Selection of elephants to be treated	Easy	Fieldwork essential	—
Experience with treatment in elephants	Yes	No	—
Evaluation of treatment	After 2 years	Immediately[b]	—
Influenced behaviour due to hormonal change	Yes / probably	Not to be expected	Whyte and Grobler 1998; WHO 2004
Risks	'New' diseases[c]	Infection	—

[a] based on average number of births during life of a female elephant (Moss 2001) to prevent any births (each sterilization requires at least two treatments separated in time)
[b] fast adjustments of techniques possible (if necessary)
[c] risk that porcine viruses or parts of (viral) nucleic acids within the injected porcine derived product, may induce 'new' diseases in elephants.

far from any herd. Although females can be injected from a distance using projectile syringes, the procedure agitates all members of their family and probably their entire family group (Moss 1983). After a first immunization females have to be tracked down again—a difficult job that requires radio collaring (Whyte 2003) of the immunized females.

Single males are more difficult to trace than a herd with females. However, during the last decades of their life older males prefer to return to the same restricted 'bull area' after each mating period, thereby making it easier to track them down.

Selecting males to be treated depends on their age, ranking and musth period. Determining the first criterion is fairly easy. However, to draw up an inventory of males to be treated requires extensive fieldwork (see Discussion). Selection of females to be treated is based solely on estimating age. Most females conceive their first calf when they are between 11 and 13 years of age (Moss 2001). A number of the selected females will likely already be pregnant before contraception is practised. This means some of the immunized females will calve. Delsink et al. (2004) reported that ca. 60% of the cows were already pregnant before they were immunized during the first year. Up till now hardly any information is available on possible effects of immunocontraception in females (Whyte and Grobler 1998).

Two methods are possible for sterilizing male elephants: castration and vasectomy. As elephants have intra-abdominal testes both methods require surgery within the peritoneal cavity. As castration alters the hormone balance, inducing un-bull-like behaviour (Olson and Byron 1993), it would only lead to more mating by other males. Moreover, vasectomy is much more humane, routinely done on human males all over the world, and ejaculation is normal, albeit without semen. In men, vasectomy produces no change in the function or amount of male hormones produced (WHO 2004), and there is no reason to suppose that in vasectomized elephant males, hormone production would be changed (Cees Wensing, pers. comm.).

Vasectomy calls for surgical experience not yet available for elephants. However, development of vasectomy techniques has one big advantage compared with sterilizing female elephants: techniques can be rapidly refined, for the vasectomy result is immediately visible endoscopically. Before being able to evaluate and improve female sterilization techniques, one has to wait about two years, the average length of the gestation period.

Both male and female contraception run the risk of inducing diseases. As males have to be vasectomized in the bush there is the chance that they may be infected with bacterial or viral agents. The risk that simply darting will infect female elephants is far smaller. However, injection with a pZP glycoprotein product, if it is isolated from pigs and not produced synthetically, is not without danger. We are not able to calculate the risk that porcine viruses or parts of (viral) nucleic acids within the injected product will induce diseases new to elephants, comparable with the induction of bovine spongiform encephalopathy (Race et al. 2002; Smits, pers. comm. 2005).

Sexual- and behaviour-related aspects

The combination of sexual- and behaviour-related aspects of the African elephant forms an important element of the vasectomy concept. Many fewer males than females are involved in producing offspring. Male–female and male–male interaction behaviour also favours the role of small numbers of males.

Unique behaviour studies in Amboseli National Park provide wide knowledge of elephant reproductive patterns in a savanna ecosystem (Moss 2001). These studies provide evidence that based on sex ratio, considerably fewer males than females have to be sterilized to lower the birth rate identically. First, males have not begun sexual cycles, not experiencing their first musth period until they are 25 or 30 years of age (Poole 1989a,b, 1999) whereas females may conceive their first calf when they are between 11 and 13 years (Moss 2001). Further, in any given year a sexually active bull will mate with a number of cows (Poole 1989b). Third, fewer bulls reach the age at which they get the opportunity to mate. Moss (2001) reported that only 39% of males survived to the age when they regularly enter musth and were likely to mate a significant number of times, whereas 82% of females survived to the age of first reproduction. When bulls reach the age when bull dominance peaks (Poole 1989b) at 40 to 50 years, there normally are far fewer bulls than cows (Moss 2001).

Apart from these sex-related aspects the preference for sterilization of older males is based on the following behaviour-related bull characteristics and male–female and male–male interactions.

Bull characteristics

The duration and intensity of a male's musth period is correlated closely with his age (Poole 1989a). Differences in the duration of musth are a strong argument in favour of the vasectomy of older bulls. Sessions of musth among individuals 25–35 years old are short (several days to perhaps a week) while older males experience longer periods (2–5 months) of musth (Poole 1989b, 1999**)**. Male elephants during periods of musth have very high testosterone levels (Poole 1989a, 1999). In a number of species such as red deer (*Cervus elephas*), this has been shown to correspond with increased spermatogenesis. Older bulls may therefore be more likely to impregnate a female (Moss 1983).

Male–female and male–male interactions

During oestrus (4–6 days) females show preference for males of older age classes (Moss 1983) and actively stay close to a preferred male (Poole 1989b). They facilitate mating with large males by standing still, while they attempt to outrun younger males (Poole 1989b).

At the beginning of oestrus females become wary of males and elude their pursuers nearly 70% of the time (Moss 1983). During that period and also during late oestrus, the large, older males show little interest in the females, while males 25 to 35 years old sometimes manage to mate (Poole 1989b).

Mid-oestrus is a relatively quiet 3- or 4-day period during which the female and the large musth male guarding her, 35 years of age or older (Poole 1989b), stay close and other males do not chase the female (Moss 1983). The ability of male elephants to guard oestrus females and copulate during mid-oestrus increases dramatically late in life (Poole 1989b). During those days the guarding male mates infrequently (Poole 1989b). Behavioural data suggest that the overall number of times of mating with a female is less important than who guards and mates with her during mid-oestrus (Poole 1989b)—which is the older, dominant bull. It is suggested that guarding serves primarily to avoid harassment. The older bull achieves this situation by chasing off younger bulls, thereby preventing them from mating (Moss 1983). There is behavioural evidence that lower-ranking bulls when chased drop out of musth (Poole 1989a)—again minimizing chances that younger bulls mate.

Thus the behaviour of oestrus females, as part of male–female and the outcome of male–male interactions, results in their mating with males who are old, vigorous and healthy (Poole 1989b), making them the prime target for vasectomy.

According to data taken in Amboseli National Park in Kenya, males 35 years of age or older accounted for 54% of successful mating (Poole 1989b). Based on the Amboseli figures, we have calculated that in parks with 100 to 300 elephants with a natural population growth rate, occasional vasectomy of a dominant bull would provide an effective elephant family planning tool. We further calculated, based on an estimated 3.8% growth rate of the KNP elephant population (Whyte 2001; Blanc et al. 2003), that vasectomy of fewer than 150 to 200 dominant bulls (less than 2% of the elephant population) would lead to a more or less stable population. To obtain the same result by immunocontraception Whyte (2003) calculated that 75% (ca. 3000) of all breeding females (> 30% of the total KNP population) must be constantly under treatment. So, about 15 times more elephants would have to be treated year after year using immunocontraception instead of once-only vasectomy.

An elephant cow will return to oestrus in 15 weeks if she does not conceive. If she mates with a vasectomized bull, she will continue to come into oestrus until eventually she conceives by mating with a younger, lower-ranking bull that has been vasectomized. We are of the opinion that careful selection of dominant bulls will minimize the influence of bulls lower in rank even after a number of years. At present, nobody knows or can accurately predict the outcome of vasectomy; only a scientific pilot study can verify if our supposition is correct.

Surgery

Elephants have been castrated (Olson and Byron 1993; Foerner et al. 1994; Bengis 2004), indicating that vasectomy by laparoscopic surgery is theoretically possible. In 2004 ovarectomy was successfully performed on female elephants **(**Mark Stetter, pers. comm.). This operation, performed in a reserve in South Africa, showed that it is feasible to operate on elephants in the bush.

Based on the anatomy of the male reproductive organ (Short et al. 1967) and castration experience, technical problems that may be encountered are 1) cutting through the peritoneum, as it is very strong, elastic and covered by a thick layer of fibroelastic tissue (Foerner et al. 1994) and 2) endoscopically locating the vas deferens, as it may be obscured by intraperitoneal fat layers. Attributed to increased activity and metabolic rate and decreased feeding, a male during musth loses a lot of weight, positively correlated with the duration of his musth period (Poole 1989a, 1999). Also for this reason it is logical to perform vasectomy on old males during the month(s) after musth, as the problem of locating the vas deferens will be minimized.

Financial aspects

Vasectomy of elephant bulls involves 1) capture and anaesthesia, and 2) surgery using endoscopic instruments.

Capture and anaesthesia of one elephant costs about USD 1000 (Hofmeyr 2003). Endoscopic instruments are calculated at USD 30,000 to 60,000. If we assume complete depreciation of the instruments after 200 bull operations, the cost per elephant would be USD 150 to 300. The vasectomy team's pay is estimated at USD 1000 per elephant, meaning that all together the prime costs would be less than USD 2500 per vasectomy. Additional costs would come from the fieldwork necessary to register ranking, timing and duration of musth periods of dominant bulls in the population, and to locate bull areas.

Discussion

This paper focuses on comparing the pros and cons of immunocontraception in female elephants (Fayrer-Hosken et al. 1997) with a hypothetical method of contraception in older, dominant males by vasectomy. Based on Amboseli figures (Poole 1989b) we calculated for stabilization of the KNP elephant population with a ratio of 15 to 1, where 15 is the number of frequently treated females and 1 is the once-only vasectomy of older dominant males. Based on the assumption that the average female will produce four calves in her lifetime (Moss 2001) theoretically about 60 times more treatments are necessary using immunocontraception than vasectomy.

The number of treatments can be calculated easily. However, the outcome of the vasectomy concept is not as easy to predict. Let us look at a worst-case, a best-case, and a most-realistic scenario imaginable.

A worst-case scenario will show a birth rate that is the same as or only a bit lower than the average birth rate over the past years. This may be caused by vasectomy of bulls that are lower in rank than the bulls that mate most successfully. Vasectomy will never result in preventing all calves from being born.

A best-case scenario will lead to a birth rate that is about 60% lower than the former average birth rate. That percentage is based on elephant studies in Amboseli combined with observations of musth periods in South Africa. In Amboseli 54% of the successful mating was achieved by a small number of older, dominant bulls (Poole 1989b). In Amboseli the year can be divided into a wet season and a dry season; older males preferably have their musth period and mate in the wet season (Poole 1989a). In the fenced parks in southern Africa elephants have permanent access to water. This may be the origin of frequent fathering by a small number of dominant males (Whitehouse 2002) due to longer musth periods (Bradley Schrôder, pers. comm.). These longer musth periods may lead to vasectomized bulls mating more successfully and thus result in lower birth rates. In a best-case scenario birth rates will be further lowered when some medium-ranking males are also treated, as they will mate with any female they find that is not already guarded by a high-ranking male (Poole 1989a).

The most-realistic scenario leads to an estimate of ca. 50% lower birth rate. For even when all relevant bulls are vasectomized the female that mates with a treated bull (a chance of about 60%) will again come into oestrus about 4 months later. At that time, a slightly larger than normal number of females will be in oestrus during the same period. The percentage of mating with younger males will probably grow slightly, because a dominant bull will be less able to guard his female in oestrus or he will want to mate with another oestrus female in the herd, thereby leaving his first female unguarded.

To get a valid indication of the real value of the vasectomy concept, a pilot experiment is necessary. Further theorizing is not useful as there are too many unpredictable variables:

- percentage of successful mating in general is unknown.
- park area in combination with the density of the elephant population influences the possibilities of male–female and male–male communication by sound and other signals (Poole 1989a, 1999).
- herd size: a dominant bull will more easily be able

to guard oestrus female(s) and chase away bulls lower in rank in small herds than in large.

- sex ratio: the larger the number of oestrus females in relation to dominant males the smaller will be the chance of a dominant male mating successfully, as lower-ranking males will get more opportunity.
- percentage of lower-ranking males in relation to dominant males on an annual basis: the larger the first category the greater the chance that its members will 'steal' females and mate successfully.
- percentage of older, experienced females in the population who show a preference for large (that is, old) males (Moss 1983).

Pilot experiment

A pilot will best be executed in a small park with a well-known history. Data of the elephants in the park that should be available are: the number of elephants and their sex ratio, the average population growth rate during past years, and the dominant bulls and their musth periods over the year. The last data set is relevant because the musth periods of older males are asynchronous and each male comes into musth at a specific time every year. As the timing of a dominant male's musth period is relatively consistent from one year to the next (Poole 1989a), this information is necessary to cover a calendar year with vasectomized dominant bulls.

After a park has been chosen, a vasectomy pilot could follow the steps as suggested in table 2. First a surgical team would practise vasectomy on 10 to 20 elephants, not necessarily in the same park, to train the team and to fine tune the surgery, adjust surgical instruments if necessary, and optimize anaesthesia of the bull during surgery. In the meantime inventories and photographic identification (Moss 2001) would be drawn up from the bull's ranking and musth periods.

As soon as enough expertise is available vasectomy would start on the first selected bulls that come out of musth. Surgery would continue until all selected bulls have been treated. When the bulls come into musth again for the first time after treatment a variety of observations would be registered such as the timing and duration of the musth period, guarding and mating behaviour, and the behaviour of oestrus females towards the treated males.

Two years after the last bull has been vasectomized a census would be necessary to learn the actual annual growth rate of the population, including the number of newborn calves. Thereafter the vasectomy pilot project would be evaluated.

As vasectomy uses the natural behaviour of elephant populations, using it to reduce the population will be slow. Reducing population dimensions also depends in large part on the natural death rate. But vasectomy will substantially lower the birth rate.

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Table 2. Suggested activities, in sequence, of a vasectomy pilot programme in a small park

Steps to be taken
Form a chirurgical team
Conduct trial surgery to gain experience and refine laparoscopy, endoscopy, vasectomy and anaesthesia of bulls
Inventory bull population (for use in phase 2)
Inventory and select accessible areas for bull treatment
Perform vasectomy of selected bulls after their individual musth period
Study behaviour of vasectomized bulls
Monitor programme two years after completion of the vasectomy surgeries
Perform vasectomy of other bulls based on census

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