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The Management of Large Mammals in Relation to Male Strategies and Conflict with People

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ABSTRACT

Many large mammals such as elephant, rhino and tiger often come into conflict with people by destroying agricultural crops and even killing people, thus providing a deterrent to conservation efforts. The males of these polygynous species have a greater variance in reproductive success than females, leading to selection pressures favouring a 'high risk–high gain' strategy for promoting reproductive success. This brings them into greater conflict with people. For instance, adult male elephants are far more prone than a member of a female-led family herd to raid agricultural crops and to kill people. In polygynous species, the removal of a certain proportion of 'surplus' adult males is not likely to affect the fertility and growth rate of the population. Hence, this could be a management tool which would effectively reduce animal–human conflict, and at the same time maintain the viability of the population. Selective removal of males would result in a skewed sex ratio. This would reduce the 'effective population size' (as opposed to the total population or census number), increase the rate of genetic drift and, in small populations, lead to inbreeding depression. Plans for managing destructive mammals through the culling of males will have to ensure that the appropriate minimum size in the populations is being maintained.

INTRODUCTION

Many large mammals such as the Asian elephant *Elephas maximus*, the African elephant *Loxodonta africana*, the Great Indian rhinoceros

Rhinoceros unicornis and the tiger *Panthera tigris* come into conflict with people by destroying agricultural crops, domestic livestock and even killing people. This creates considerable antipathy among people living on the periphery of nature reserves and is a deterrent to conservation efforts.

The Asian elephant, for instance, is estimated to damage crops worth US$0·5 million and kill 30–50 people annually in southern India (Sukumar, 1985, 1989). In the Indian state of West Bengal a small population of about 150 elephants was responsible for killing nearly 50 people during 1988 alone and causing considerable damage to crops (D. K. Lahiri Choudhury, pers. comm.). In peninsular Malaysia the economic loss to a single agency (Federal Land Development Authority) from destruction of oil palm and rubber plantations by elephants is estimated to be US$20 million per year (Blair *et al.*, 1979). The African elephant similarly comes into conflict with agriculture (Allaway, 1979). The Indian rhino may damage the entire crop in some villages in the vicinity of Royal Chitwan National Park, Nepal (Mishra, 1982). In the Sundarbans mangrove region of India and Bangladesh, an average of 57 people were killed each year by tigers during 1975–84 (Khan, 1987; Sanyal, 1987).

Although it may be impossible to eliminate conflict totally, except by exterminating the offending animals, there is no doubt that this problem must be minimized if conservation efforts are to succeed in developing countries facing harsh socio-economic realities. Large, potentially destructive mammals need to be conserved by a combination of various management strategies. For instance, electrified human dummies have been used successfully in reducing the incidence of man-eating by tigers in recent years (Sanyal, 1987; Rishi, 1988) and high-voltage electric fences have reduced depredation of crops by elephants in peninsular Malaysia (Blair *et al.*, 1979). In this paper, I outline another approach to reducing conflict, taking into consideration social organization, behavioural differences between the sexes and demographic processes of the species.

SOCIAL ORGANIZATION, BEHAVIOUR AND CONFLICT WITH PEOPLE

Many large mammals, including those mentioned above, are polygynous species with marked sexual dimorphism. The males attain a larger adult body size than the females and may have secondary sexual characters such as horns (Clutton-Brock *et al.*, 1982). There is strong selection for these characters in the male since they enhance its ability to succeed in male–male competition for females. In polygynous species the males have a greater variance in reproductive success than females. It follows from this that selection would favour a 'high risk–high gain' strategy which promotes reproductive success (Trivers, 1985). Differences in risk-taking behaviour between the sexes may become manifest at an early age, as in the elephant seal *Mirounga angustirostris* (Reiter *et al.*, 1978).

This inherent risk-taking behaviour may also bring the male of the species into greater conflict with people. A study of the Asian elephant's interaction with people in the Chamarajanagar and Satyamangalam forests of southern India illustrates this point (Sukumar, 1985, 1989, 1990; Sukumar & Gadgil, 1988). Although both male and female elephants raid crops and the risk of death during a raid is the same for both sexes, an adult male elephant entered cultivation about six times more frequently (49 nights in a year on the average) than did a member of the female-led family herds (8 nights per year), obtaining a higher proportion (9·3%) of its total diet from crops compared to the latter (1·7%). Raiding itself is related to the higher palatability and nutritive value of cultivated crops compared to wild plants (Sukumar, 1989, 1990). Clearly the male elephant is more willing to take risks in obtaining the extra nutrition which could be translated into better growth, adult body size and a successful expression of musth (or rut), all of which may mean an enhanced reproductive success (Sukumar & Gadgil, 1988).

Not only does an adult male elephant raid six times more frequently, but each time it enters a cultivated area it consumes more than twice as much crop *per capita* than does a member of a family herd because of its larger body size and requirements. An adult bull weighs about 4000 kg compared to 1750 kg of an average herd member (Sukumar *et al.*, 1988), and consumes on average 1848 kg (dry weight) of crop plants per year compared to only 139 kg by a herd member—or a level of damage 13·3 times higher (Fig. 1). Further, an adult male is more prone to damage crops such as coconut (they can push down large coconut trees more easily), which are economically more valuable than cereals or millet. The net result is that an adult male elephant damages crops worth about US$600–700 compared to only US$30–35 per year by a family herd member, a 20-fold difference in economic terms (Sukumar, 1989).

The relative proportion of total loss of crops due to adult males and herds would, of course, depend on the population structure or proportion of these categories. In the southern Indian study area, in which adult males (> 15 years) constituted about 7% of the elephant population, the adult males caused 62% and herds 38% of the total economic loss during 1981 (Sukumar, 1989). Figure 2 depicts the relative loss due to adult males and herds for differing population structures with 20-, 10- and 5-fold differences in *per capita* damage.

A variety of mammals including primates, rhino, deer and wild pig are known to damage crops. Mohnot *et al.* (1981) observed that all-male bands

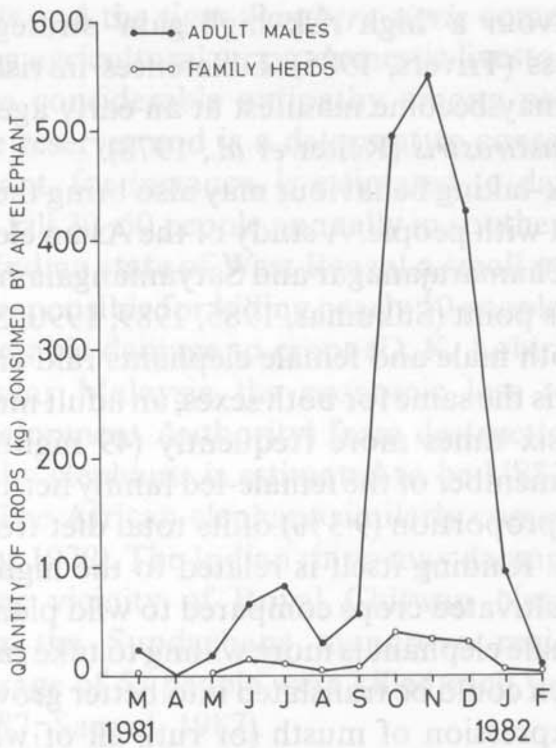

Fig. 1. Quantity of crops in kg (dry weight) consumed by an average adult male elephant or an average individual in a family herd during different months.

of Hanuman langur *Presbytis entellus* may raid orchards and gardens more readily compared to the bisexual troops. I do not know of comparable observations of differences between the sexes of other species in raiding crops, but would predict a similar pattern of greater risk-taking by the male in polygynous species.

There may also be sex-biased patterns in manslaughter by animals. Records of manslaughter by elephants in southern India show that over 80% of the killings were by male elephants above 10 years in spite of the fact that they constitute less than 10% of the total population (Sukumar, 1989). Nearly half the incidents occurred inside cultivated areas when male elephants came to raid crops.

There may be some exceptions to this pattern. For instance, a few herds of elephants comprising some 40 individuals dispersed from their original habitat to a new area in southern India during the mid-1980s (Sivaganesan & Bhushan, 1986). These have been responsible for considerable damage to crops and over 30 human deaths, many of them due to the ignorance of local people unaccustomed to wild elephants. A similar situation has arisen in central India where about 60 dispersed elephants have been causing similar havoc to crop and human life (unpublished and newspaper reports).

Some observations on human killing by tigers also suggest that the male may be the worse offender, although the evidence is not that conclusive. Ten

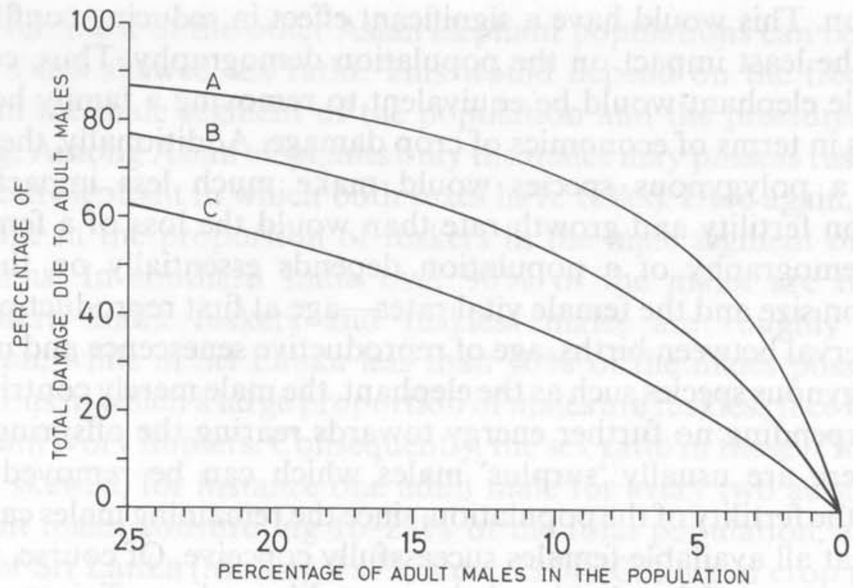

Fig. 2. Percentage of total economic loss to crops caused by adult male elephants as a function of differing percentages of males in the total population assuming (A) 20-, (B) 10- and (C) 5-fold difference in *per capita* damage by an adult male compared to an individual in a family herd.

out of 13 man-eaters recorded by Hendrichs (1975) in the Sundarbans of Bangladesh were males and these accounted for 86% of the victims. Similarly, most of the human kills in the Royal Chitwan National Park, Nepal, since 1980 could be attributed to three male tigers (McDougal, 1987). Apparently these male tigers were displaced from their former territories by rival males and hence moved to the periphery of the park where they claimed their human victims. During an eight-year period (1980–87), however, four male and three female tigers were involved in man-eating or life-threatening situations in the region (Mishra *et al.*, 1987). Corbett (1944, 1954) describes six male and five female man-eating tigers. When we consider the fact that in wild populations the adult sex ratio of male to female tigers is likely to be 1:3–4 (Sunquist, 1981), the above observations also seem to support the hypothesis that the male tiger is more likely to come into conflict with people. The Champawat man-eater (Corbett, 1944)—which is reputed to have killed 436 people—was, however, a female.

CULLING OF MALES, SKEWED SEX RATIOS AND DEMOGRAPHY

If the male of a polygynous species is involved in a more serious conflict with people than the female, one way of managing such potentially destructive species would be to selectively remove the offending males from the population. This would have a significant effect in reducing conflict, while making the least impact on the population demography. Thus, culling an adult male elephant would be equivalent to removing a family herd of 20 elephants in terms of economics of crop damage. Additionally, the loss of a male in a polygynous species would make much less impact on the population fertility and growth rate than would the loss of a female.

The demography of a population depends essentially on the female population size and the female vital rates—age at first reproduction, size of litter, interval between births, age of reproductive senescence and mortality. In a polygynous species such as the elephant, the male merely contributes the sperm, expending no further energy towards rearing the offspring. In that sense, there are usually 'surplus' males which can be removed without affecting the fertility of the population, since the remaining males can usually ensure that all available females successfully conceive. Of course, if the sex ratio becomes too female-biased there would not be sufficient males for mating with available females, resulting in a decline in fertility.

At this time we do not have sufficient information on what the 'critical' adult sex ratio is for a polygynous species; this would vary from one species to another and among different populations of a species depending on spatial distribution, density, seasonality in breeding, duration and periodicity of oestrus in females, reproductive behaviour and so on. It may be possible, however, to give an upper limit to the sex ratio that should be maintained to ensure 'normal' fertility in a population. The elephant populations of southern India have the most skewed sex ratios in Asia, because of high male mortality from ivory poaching (Sukumar, 1986, 1989). In the southern Indian population studied in detail, the adult male-to-female ratio of 1:5 still ensured an inter-calving interval of 4·7 years (birth rate of 0·21/adult female/year) which compares favourably with the most fertile African elephant populations having a positive growth rate (Douglas-Hamilton, 1972; Laws *et al.*, 1975; Sukumar, 1989). The operational sex ratio in this population at a given time would have been less skewed, in the range of 1:2 to 1:3, since a certain proportion of female elephants would be pregnant or in lactational anoestrus.

Because poaching of male tuskers continued, their proportion in the population declined further, resulting in an adult male-to-female ratio of about 1:8 by 1987 (Sukumar, 1989). The consequences of this skewness on the demography will be known only during the coming years. Culling of male elephants as a management policy to reduce conflicts may not be justified in southern India, except in rare cases, because poaching has already taken a heavy toll on the males. In fact, this has already significantly reduced crop damage. Many of the villages in the Chamarajanagar and Satyamangalam region which suffered heavy damage to crops during 1981 reported a sharp decline in depredation by 1988 (personal observation).

However, most of the other Asian elephant populations can be expected to have a less skewed sex ratio. This would depend on the frequency of tuskers in the male segment of the population and the pressures of ivory poaching. Among Asian elephants only the males may possess tusks (unlike the African elephant in which both sexes have tusks). Here again, there is a wide range in the proportion of tuskers in the male segment of different populations. In southern India over 90% of the males are tuskers, in northeastern India tuskers and tuskless males are roughly in equal proportion, while in Sri Lanka less than 10% of the males possess tusks. Populations in which a large proportion of males are tuskless face little or no threat from ivory hunters. Consequently, the sex ratio in these is likely to be the least skewed, for instance one adult male for every two adult females, with adult males constituting 16–23% of the total population, as in some regions of Sri Lanka (McKay, 1973; Kurt, 1974). Culling of crop raiding or 'rogue' males from such populations can be an effective management measure to reduce conflict. The culling need not necessarily be killing of the males, at least in Asia, although this may have to be done in the case of extremely troublesome animals. Traditions of domesticating elephants are ancient in Asia. Some of the culling can simply be by capturing them, using chemical immobilization techniques, for domestication.

SEX RATIOS, EFFECTIVE POPULATION SIZE AND MANAGEMENT

There is one more aspect to be considered, that of the genetic consequences of a skewed sex ratio. If too few males do all the breeding, there could be problems of inbreeding depression, especially in small populations. The effective population size N_e (as opposed to the total population or census number N) is equal to $4N_mN_f/(N_m + N_f)$, where N_m and N_f are the number of breeding males and females respectively (Franklin, 1980; Frankel & Soulé, 1981). The more skewed the sex ratio the lower would be the effective population size. It has been suggested that inbreeding should be kept below 1% per generation, which means that an effective population size of at least 50 individuals should be maintained, for short-term viability of a population. For long-term viability, in terms of maintaining evolutionary potential, an effective population size of 500 has been suggested (Franklin, 1980; Frankel & Soulé, 1981).

Although these figures of 50 and 500 are still theoretical and may not apply to wild populations (Soulé, 1987), these are the best available estimates for maintaining genetic viability of a population. Management of destructive mammals through selective culling of males should ensure that an appropriate effective size is maintained in the population. This would necessitate a knowledge of size and structure of the population to be managed. There are few Asian elephant populations which have effective population sizes of over 500 breeding individuals. Most of those in fragmented habitats may have to be managed only from a short-term perspective, or as metapopulations through exchange of individuals in order to maintain genetic variation (Santiapillai, 1987; Sukumar, 1989). Many African elephant populations, however, are still relatively large enough to allow a certain reduction of the male segment without any genetic problems arising (see Douglas-Hamilton, 1987, for population sizes) although the recent spate in ivory poaching may have considerably skewed the sex ratios (Poole & Thomsen, 1989).

In the case of endangered species such as the tiger, an effective population size of even 50 is doubtful in most populations. This would severely limit the manager's options in dealing with man-eaters, especially if these cannot be reliably identified. Rhino populations, both in Africa and in Asia, are even more endangered. Only two populations of the great Indian rhino, one of about 1000 at Kaziranga National Park in Assam and the other of about 300 at Royal Chitwan National Park in Nepal, are of viable size. Decisions of culling the males would be even more difficult to make for rhino populations, although capture for translocation to another area may be acceptable.

CONCLUSIONS

Management practice has not always been based on sound ecological principles. For example, the northeast Indian states of Assam and Meghalaya were permitted to capture 200 elephants, mostly as family herds, during the mid-1980s as a crop protection measure. The same results could have been achieved by capturing 10–15 male elephants, while at the same time ensuring a near-normal demographic growth of the population. The exception to selectively culling only males would obviously apply to stray, dispersed herds which may have to be removed.

Lest it be misunderstood that I am advocating the culling of mammals as a routine management policy, let me emphasize that culling should be the last resort of a manager. Often the choice may be between losing an entire population of a species in deference to the wishes of people who have suffered its depredation or reducing conflict through culling. Anti-conservation feelings run high among people in the periphery of many protected areas. Whether one likes it or not many elephants are being electrocuted or shot in defence of crops, and tigers poisoned. This is a reality that conservationists and managers have to keep in mind when dealing with problem areas. If a decision to cull has been taken, it is usually better to selectively cull the male of the species.

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