bleaching may ultimately help reef corals to survive the recurrent and increasingly severe warming events projected by current climate models of the next half-century[3]. Bleaching is an ecological gamble in that it sacrifices short-term benefits for long-term advantage. This counters conventional wisdom that bleaching is detrimental from all perspectives, and supports the role of symbionts as adaptive agents[10,11].

Andrew C. Baker
Wildlife Conservation Society, Osborn Laboratories of Marine Science, New York Aquarium, Surf Avenue at West 8th Street, Brooklyn, New York 11224, USA
e-mail: abaker@wcs.org

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Population control

African elephants and contraception

Protected from hunting and provided with access to water-holes during droughts, elephant numbers can double in a decade, severely damaging natural vegetation and the many species dependent upon it. Culling is an effective but controversial control strategy, so Fayrer-Hosken *et al.*[1] have assessed the efficacy of using immunocontraception through vaccination, concluding that this could be a practical way of controlling elephant numbers. However, an intervention feasible in reproductive physiology may not be a practical way to control a population. Fayrer-Hosken *et al.* have not considered calculations[2,3] that undermine the practicality of their method, nor alternative management strategies.

Controlling elephants in Kruger National Park, South Africa, by immunocontraception would necessitate treatment of 2,250 cows each year over an initial period of 11 years (ref. 3). Even if individual treatments were 100% effective, the costs would be likely to exceed the total management budget of the South African national parks. The best results of Fayrer-Hosken *et al.* involved two of ten elephants becoming pregnant, and that was after receiving two booster vaccinations.

The effectiveness of this method may be less than claimed. Of the control group, 89% became pregnant within a year. This seems high, exaggerating the difference between treated and control groups. Data from 813 adult cows culled in Kruger National Park between 1979 and 1994 showed that 51% (range, 36–77%) were pregnant. This is to be expected: gestation lasts 22 months and the calving interval is 44 months (ref. 2), so about 50% of a sample of cows should be pregnant. Thus, on average, females go for 22 months without becoming pregnant. In a random sample of females monitored for 12 months, only 55% (not 89%) should therefore become pregnant.

Between 16 and 1,846 elephants of all age classes and both sexes were culled annually in Kruger National Park from 1967 to 1994. We share the desire to reduce culling and have sought methods to do so. Removing or sterilizing 250 subadult females each year should reduce population growth to zero[2,3]. Moreover, densities of greater than 0.37 elephants per square kilometre result in reduced population growth rates — probably due to reduced reproductive output by newly sexually matured females or to increased calving intervals[2]. Culling, as conducted, maintained densities at which population growth was near its maximum. Culls should be delayed for one year after counts exceed 0.37 elephants per square kilometre to allow density dependence to reduce numbers naturally[2]. Culls may still be necessary, but they would then be much less frequent and involve far fewer animals.

Stuart L. Pimm*, Rudi J. van Aarde†
**Center for Environmental Research and Conservation, Columbia University, 1200 Amsterdam Avenue, New York, New York 10027, USA*
e-mail: stuartpimm@aol.com
†Conservation Ecology Research Unit, University of Pretoria, Pretoria 0002, South Africa

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Fayrer-Hosken et al. *reply* — Pimm and van Aarde question the feasibility of controlling elephant numbers by immunocontraception, arguing that the sterilization or removal of 250 subadult cows each year is the answer to population growth. However, there are no known safe methods of sterilizing free-roaming African elephants. Moving 250 subadult females to another park is impractical as there are very few areas able to receive elephants from Kruger National Park without becoming confronted with an elephant overpopulation problem of their own.

This number of subadult cows cannot be moved without disrupting the social order within their herds. Keeping them in their herds would mean that (assuming a mean herd size of 12.4, as shown in our study, and an average of 3 subadult females per herd) Kruger National Park would have to move 1,033 elephants — an unrealistic and expensive proposition. Hence the only practical way to remove 250 subadult females would be to cull them, which Pimm and van Aarde agree is an unacceptable solution.

We have shown that immunocontraception using porcine zona pellucida (pZP) works in the African elephant, although its long-term effectiveness in controlling populations is still being evaluated in South Africa. The cost and speed of field delivery have not been assessed for vaccinating large groups of elephants. However, contrary to the calculations of population modellers[1,2], immunocontraception has worked in herds of wild horses and white-tailed deer[3].

Preserving these magnificent creatures and their genetic contribution for the future is a common goal. On the basis of a single administration of a multiple-release pZP vaccine that is being developed for use in horses (I. K. M. Liu, personal communication), it should be possible to reduce the first three vaccinations used in our original study to a single dose and so minimize the stress, cost and labour of elephant immunocontraception.

We therefore question Pimm and van Aarde's criticism regarding the practicality of field immunocontraception for Kruger Park's elephant herds. It is our judgement that preserving these animals through immunocontraception is a realistic strategy that would save elephants without having to kill them.

R. A. Fayrer-Hosken*, D. Grobler, J. J. van Altena, H. J. Bertschinger, J. F. Kirkpatrick
**College of Veterinary Medicine, University of Georgia, Athens, Georgia 30602-7385, USA*
e-mail: rfh@calc.vet.uga.edu

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