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Immunocontraception of African elephants

Concerted efforts to nurture elephant populations have resulted in elephant overpopulation in several areas, which in turn has led to damaging levels of browsing. As an alternative to culling entire family groups in order to control this damage, we have developed an immunocontraceptive vaccine from pig zona pellucida which safely and successfully controls free-roaming African elephants.

Immunocontraceptive vaccines cause the immune system to produce antibodies that prevent fertilization, without the side effects of hormonal contraceptives. The vaccine antigens are the proteins of the zona pellucida, the clear protein coat surrounding mammalian eggs. The surface structures of the elephant zona pellucida are very similar to those of the pig zona pellucida (pZP)[1–3].

Female zoo elephants vaccinated with pZP and an adjuvant all developed antibodies that persisted for 12–14 months[1,2], at a level equivalent to those found in horses given immunocontraception[4,5]. Based on this, we planned field trials in Kruger National Park, in conjunction with the South African National Parks.

Initial trials using 41 adult female elephants tested the efficacy of pZP as an immunocontraceptive. Elephants were located from a helicopter, and females to be anaesthetized (by aerial darting) were identified as non-pregnant by the presence of a calf smaller than 1 metre high. We then used ultrasound scans to confirm that females were not pregnant, and all non-pregnant animals were bled to obtain pre-vaccination serum samples. Twenty-one elephants were given an initial vaccination of pZP with adjuvant; 20 controls received a placebo.

All treated elephants were fitted with radiocollars. The control females were fitted with numbered collars and paired in a family unit with a vaccinated elephant. The vaccinated elephants were located 6 weeks later and received a first booster, followed by another 6 months later. Both boosters were administered remotely with drop-out darts from a helicopter.

Twelve months after the initial vaccination, the elephants were recaptured and scanned for pregnancy. Of those treated with pZP, 19 were recaptured (two were not found because their radiocollars failed). Nine of the 19 were pregnant, ten were not. One of the pregnant elephants was in the last trimester of gestation (22 months) and gave birth to a healthy calf, showing that the vaccination of a pregnant elephant with pZP has no effect on gestation, the fetus or parturition. Eighteen of the 20 control elephants were located, 16 of which were pregnant. Therefore, significantly (χ^2, $P=0.005$) fewer vaccinated elephants (44%, 8/18) were pregnant than the control females (89%, 16/18).

Subsequently, we vaccinated ten elephants using a revised schedule. Females received an initial vaccination, followed by identical boosters delivered from a helicopter two and four weeks later. All elephants were fitted with radiocollars; five had global positioning satellite (GPS) collars (Lotek, Newmarket, Canada) which recorded their location hourly.

Of the ten elephants, two (20%) were pregnant after 10 months. This was significantly (χ^2, $P=0.001$) lower than the conception rate of the control elephants (89%, 16/18) and initial immunocontraception rates (44%, 8/18).

Female elephants with oestradiol implants have shown aberrant behaviour by separating off within the family unit (D.G., personal observation). GPS-collar location data indicated that there was no abnormal separation of the vaccinated females within a family unit over 8 months. This, combined with field observations of vaccinated females, suggests that the immunocontraceptive vaccine causes no behavioural abnormalities.

Finally, we tested the reversibility of immunocontraception, and its application for a second consecutive year. Of seven elephants from the group that had initially received immunocontraception, four were vaccinated with pZP and adjuvant, and three were not. Twelve months later, the seven elephants were captured and re-evaluated. Ultrasound scans showed that all three untreated females had conceived again, compared with none of the vaccinated elephants, although all were cycling. This indicates that the vaccine is reversible, and that it has no deleterious effect on the ovary and its cyclicity.

Elephants are intelligent and empathetic mammals, and culling is a last resort in controlling their numbers. Our immunocontraceptive study shows that free-roaming African elephants vaccinated with pZP are protected against conception. This pZP immunocontraception is safe and reversible and is thus a practical tool for controlling elephant populations.

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Sexual conflict and speciation

Sexual conflict occurs because males are selected to produce as many offspring as possible, even if this means lowering the overall reproductive output of individual females. A new model proposed by Gavrilets[1] suggests that strong asymmetries between males and females in the costs and benefits of mating will create runaway coevolution between the sexes, promoting rapid divergence between populations and hence speciation. This is an intriguing possibility, not least because it runs counter to existing models[1] which suggest that greater sexual conflict will result in males mating more indiscriminately, breaking down reproductive barriers between divergent populations. One reason for this difference is that the new model is based on the idea that females can avoid costs of mating if they are incompatible with some males, whereas we suggest that in reality this may rarely be the case.

Gavrilets' model[1] assumes a quadratic relation between female fitness and the proportion of the male population with which she is compatible (morphologically, physiologically or genetically). The shape of this relationship is not theoretically derived (as it might be), but is the simplest function under which there is an intermediate optimum proportion of compatible males. This relationship is based on observations suggesting that females experiencing unusually