



Project frozen dumbo: elephant sperm banks

Zoos remain controversial amongst some conservationists. Some believe that they are cruel and should be closed and that the money saved should be used to protect species in their natural habitats. Others believe that this is impractical and argue that, via breeding programmes, zoos conserve animals that would otherwise be in danger of becoming extinct.

Typical Exam Question

Suggest three activities of zoos which can be used to justify keeping animals in captivity (3)

Markscheme
 Prevent extinction by maintaining breeding populations;
 Destruction of natural habitat;
 Breeding programme to increase populations;
 For reintroduction to wild;
 Scientific study / research;
 Education / raise awareness;

One challenge facing zoos is the need to maintain genetic diversity in their animal populations. In the US there are an estimated 213 African elephants in zoos, circuses and theme parks. Of these, only 39 are males (bulls). A single bull named Jackson (Fig.1) has sired many of the calves born in the last 10 years and zoo managers are concerned that the African elephant gene pool is now dangerously small. In simple terms, too many of the African elephants in the US are related to Jackson!

Fig.1 Jackson, he's the daddy!



Inbreeding

Inbreeding results from mating with close relatives. It reduces the size of the gene pool, increases the expression of disadvantageous/lethal recessive genes and reduces breeding success. By reducing genetic variation it increases the risk that, if the environment changes, the entire population may be wiped out.

In an effort to try to prevent inbreeding amongst Jackson's progeny, conservationists have collected 15 litres of semen from wild elephants in South Africa – enough to inseminate up to 324 elephants. The semen is frozen and is waiting to be flown to Pittsburgh zoo to establish the first elephant sperm bank in the US.

Hopefully, this will then be used to artificially inseminate elephants across the country, widening the gene pool and eliminating the need for elephants to be physically moved from zoo to zoo. Up until now, artificial insemination of elephants using previously frozen semen, as opposed to fresh semen has never succeeded. However, the technique has worked extremely well in other species so the zoo managers remain optimistic.

Typical Exam Question

Outline three advantages of using sperm banks to conserve species (3)

Answer
 Allows artificial insemination;
 Using sperm from best individuals;
 Even after their death;
 Means animals don't have to be transported between zoos;
 Allows genetic testing before insemination;
 May reduce/avoid inbreeding;

Typical Exam Question

- (a) African elephants are protected under CITES. Explain how this designation may have helped to reduce elephant poaching (2).
- (b) DNA analysis has led scientists to conclude that there are two separate species of African elephant: *Loxodonta africana*, the savannah elephant, and *Loxodonta cyclotis*, the forest elephant. Explain how this conclusion led to plans for elephant conservation being altered (2)

Markscheme
 (a) international trade of elephant products/ivory banned/
 restricted;
 less profit for ivory;
 demand for products declined;
 less poaching;
 (b) recognition of two gene pools;
 need to maintain genetic differences;
 separate sperm banks;
 separate breeding programmes;
 interbreeding prevented;
 different habitats require different conservation efforts;

Genetic variability of the semen

The semen used for artificial insemination itself needs to be genetically variable. One problem facing the scientists who collected it was that elephants have a highly developed social system.

Their society is described as a fission–fusion pattern where groups join together (fusion) into larger aggregations during the wet season when there is plenty of food and water, but then split up into the smallest social unit possible, the family or core group, during the dry season or drought. Groups are led by an old matriarch (>30yrs) and related females cooperatively forage and care for each other’s young. Such populations often have a high degree of relatedness and the scientists therefore were careful to take semen samples from geographically widely separated groups. DNA from dung samples of each group were compared to ensure genetic diversity before semen collection began.

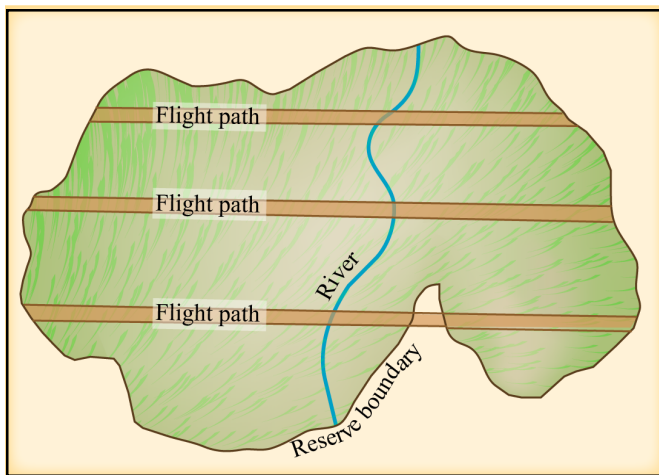
Estimating elephant populations accurately

Accuracy: how close your estimate is to the real value

Conservationists need to estimate populations of wild elephants because:

- A population may be becoming too small and in danger of inbreeding
- A population may be becoming too large and causing habitat damage or spreading out of a reserve into cropland

But getting accurate estimates is difficult. It is usually impractical or impossible or impossibly expensive to actually count every elephant. In South Africa reserve managers use aerial transects i.e. they fly over a known percentage area of the reserve, count the elephants they see and then multiply up to get a final estimate



Total area of reserve: 8200 km²
 Area of aerial transect: 656 km²
 No. of elephants counted: 18

Population estimate: 8200/656 x 18 = 225

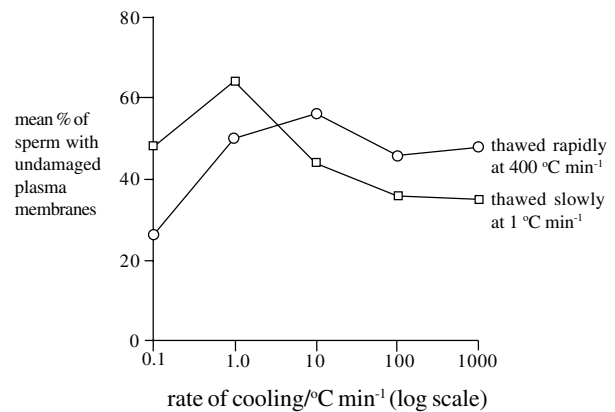
Q. How could this estimate be made more accurate?

Answer: Accuracy can be improved by taking more samples i.e. flying over a larger area or repeating the transect at different times of the year. It may also be improved by using video over the flightpath, enabling more careful counting and checking later.

Practice Questions

1. Zoos usually have a small number of animals of each species. This makes it difficult to maintain populations of healthy captive animals over several generations. Describe and explain how zoos try to overcome such problems (3).
2. (a) Explain the role of a sperm bank (3).
 (b) Describe how a sperm bank is maintained (3).
 (c) The viability of sperm that are intended for artificial insemination is influenced by how they are frozen. If they are frozen too quickly ice particles form and the sperm are damaged. If they are frozen too slowly they dehydrate and are again damaged.

Scientists cooled samples of elephant sperm to -190 °C at five different rates and then thawed half of them slowly (1°C min⁻¹) and the other half rapidly (300°C min⁻¹). They then measured the percentage of damaged sperm in each sample. The graph shows the results.



How should the elephant sperm be cooled and thawed to minimize damage? (2)

1. Introduce new / unrelated animals;
 artificial insemination;
 reference to sperm bank / prevention of inbreeding;
 stud books / pedigree records;
 collaboration between zoos;
 reference to embryo technology;
2. (a) act as a gene bank/genetic resource;
 of traits for future selective breeding;
 in changed/climate/in case of new pathogen;
 prevent/counteract inbreeding;
- (b) sperm are checked for abnormalities/mortality/genetic disease;
 X and Y sperm are separated;
 diluted, with extender medium/albumin/citrate buffer;
 frozen in liquid nitrogen / at -196 °C; in 'straws';
 cooled at 1°C min⁻¹;
 thawed, slowly / at 1°C min⁻¹;
- (c) cooled at 1°C min⁻¹;

Mark schemes