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Abstract: Genetic studies during the 1980s concluded that the cheetah had suffered a population crash 10'000 years ago, where they lost more than 90% of their genetic variation. The now low genetic variability was thought to be responsible for the low breeding success, also in captivity. A recent study calls into question the validity of taking a strictly molecular approach to the sometimes murky science of species preservation, and it strongly suggests that scientists do not yet know enough about how certain genetic patterns detected in laboratory tests translate into the strengths and weaknesses of a wild animals. Scientists at the Center for the Reproduction of Endangered Species at the Zoological Society of San Diego say that those zoos that have trouble propagating cheetahs in captivity should not blame the animal's DNA, but rather their own inaptitude at animal husbandry and matchmaking.

Cheetahs Appear Vigorous Despite Inbreeding

By NATALIE ANGIER

SAN DIEGO

The cheetah may be a gorgeous Maserati among mammals, able to sprint at speeds approaching 70 miles an hour, yet it has not been able to run away from its many miseries.

Once the cat ranged throughout the African continent, the Near East and into southern India; now it is extinct almost everywhere but in scattered patches of the sub-Sahara. Farmers and ranchers in Namibia shoot them as vermin. On reserves, where cheetahs are often forced into unnatural proximity with other predators, they are at the bottom of the meat eaters' grim hierarchy; lions will go out of their way to

destroy cheetah cubs, while hyenas, leopards and even vultures can easily chase away a cheetah from its hard-caught prey.

And to make the magnificent cat's story more poignant still, many scientists have concluded that the species is severely inbred, the result of a disastrous population crash thousands of years ago from which the poor beast has hardly had a chance to recover.

Studies of cheetah chromosomes have shown a surprising lack of genetic diversity from one individual to the next, and as a result the cheetah has been widely portrayed as sitting under an evolutionary guillotine, the population so monochromatic that, in theory, a powerful epidemic could destroy many if not all of the 15,000 or so cheetahs that survive in the wilderness.

Some zoos have complained that their cheetahs are infertile, and they have attributed the problem to the cheetah's bleak genetic makeup, calling into question the long-term prognosis even for cats living in the pampered confines of a park.

Now scientists at the Center for the Reproduction of Endangered Species at the Zoological Society of San Diego argue that this widely held notion of the inbred cheetah may be way off the mark, if not outright wrong. They insist that, far from displaying the negative effects of inbreeding seen in other animals known to be genetically homogeneous, like some strains of laboratory mice or pedigreed dogs, cheetahs are in many ways robust, more like an ordinary house cat than the feeble product of what amounts to generations of incestuous couplings.

Some of the new results are scheduled to appear in an issue of the journal *Zoo Biology* that will be devoted solely to the cheetah. But the significance of the debate extends far beyond the spotted greyhound of a cat. Scientists are now seeking to calculate the

Species seems to be struggling to regain genetic diversity after a long-ago population crash.

odds that any number of endangered or threatened species are likely to survive into the 21st century, and among the many questions they are asking is how much genetic diversity a creature requires if it is to rebound from the brim of extinction.

Inbreeding is thought to be harmful to a species for two reasons: first, because it allows hazardous recessive traits that are normally in the genetic background to come to the fore, resulting in birth defects, stillbirths and in some cases infertility; and second, because it leads to a genetically uniform population without the diversity to resist epidemics and environmental changes. But the San Diego scientists said their cheetahs almost never bore defective cubs, were perfectly fertile and had great variation in their immune systems.

Of Cheetahs and Mice

"Cheetahs have been likened to inbred lab mice," said Dr. Donald G. Lindburg of the San Diego Zoo, who heads its cheetah breeding and research program. "This is the dogma that is so entrenched in the scientific literature right now. But when I think of inbred mice, I think of reduced litter size, retarded growth, retarded vitality and congenital defects. None of these problems apply to the cheetah as we know it."

Dr. Lindburg and a colleague, Dr. Michael B. Worley, a virologist and immunologist, argue that while the cheetah may look genetically tenuous when

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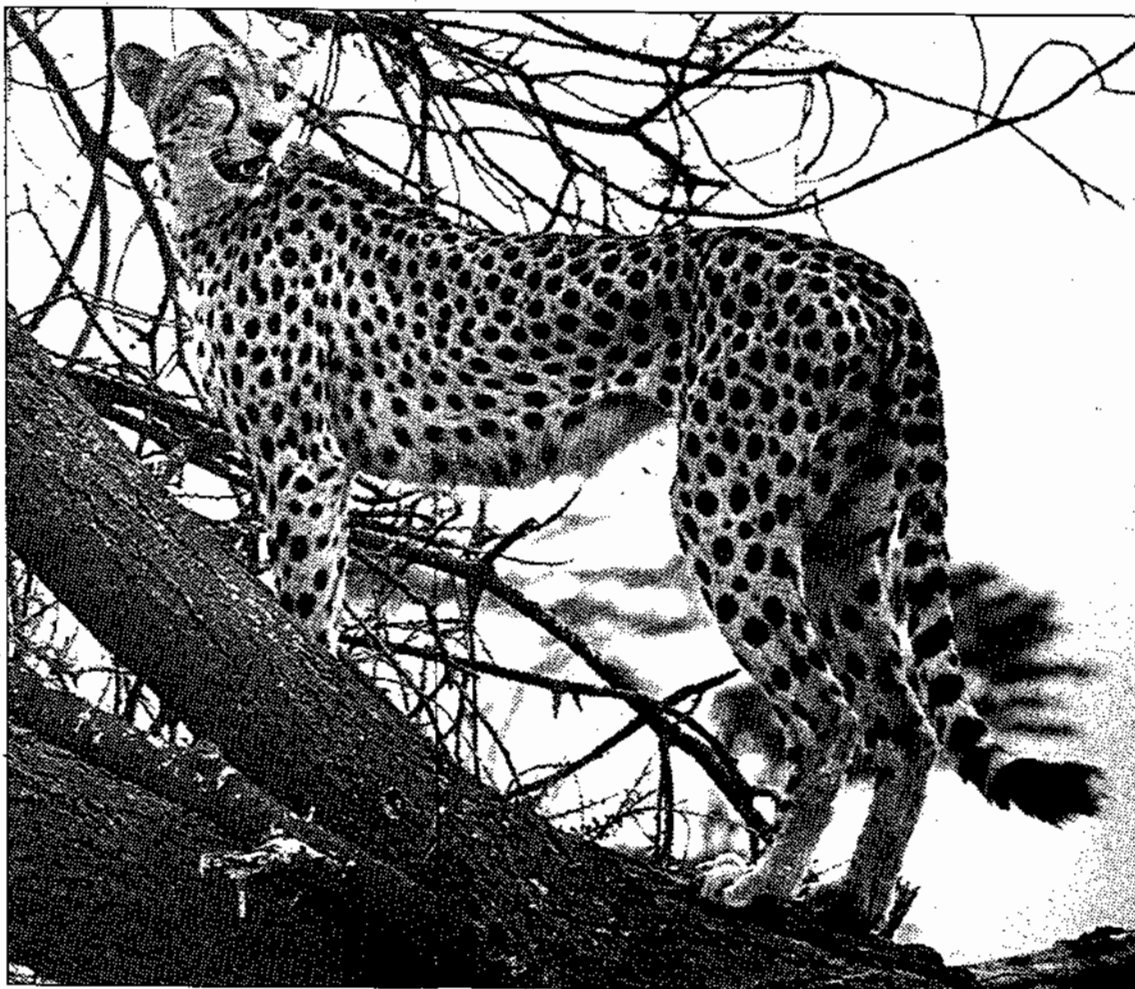


Photo Researchers

Once wide-ranging, cheetahs are now found in pockets in Africa. This one is in a reserve in Kenya.

Cheetahs Are Vigorous Despite Much Inbreeding

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its DNA is appraised, by such real-life measurements as fecundity, litter size, cub health and immune response, the cat is perfectly fit for the next millennium.

The work calls into question the validity of taking a strictly molecular approach to the sometimes murky science of species preservation, and it strongly suggests that scientists do not yet know enough about how certain genetic patterns detected in laboratory tests translate into the genuine strengths and weaknesses of a wild animal.

Those zoos that have trouble propagating cheetahs in captivity, said Dr. Lindburg, should not blame the animal's DNA, but rather their own ineptitude at animal husbandry and matchmaking. At the San Diego Zoo, the cheetahs breed so readily that the keepers sometimes call a moratorium on reproduction, just to keep down the resident cub population.

Proposal Is Disputed

Others sharply dispute the conclusions of the San Diego scientists, maintaining that cheetahs are indeed abnormally inbred and that their genetic monotony does compromise their long-term prospects. They said cheetahs clearly suffered from chronic health problems that might be linked to a defective immune system and overall genetic frailty.

The San Diego scientists "are trying to attack what has become a commonly accepted series of experiments," said Dr. Stephen J. O'Brien of the National Cancer Institute in Frederick, Md. "I've written 10 papers on the genetic structure of cheetahs, and in every case we've been able to support the thesis that the genetic structure is remarkably depleted compared to other big cats."

Dr. O'Brien, who is considered the world's authority on molecular studies of exotic cats and other endangered animals, was the principal author on the first and most spectacular report alerting the world to the cheetah's genetic plight, a paper that appeared in the journal *Science* almost 10 years ago.

He performed experiments demonstrating, for example, that when skin

from one cheetah is grafted onto another, it takes an extraordinarily long time for the immune system of the transplant recipient to reject the added flesh — strong evidence that cheetahs are practically clones of one another.

Through extensive DNA analysis, Dr. O'Brien has concluded that the cheetahs suffered a population crash 10,000 years, at the end of the last ice age. He postulates that humans, advancing rapidly in the wake of the retreating glaciers, in short order wiped out the creatures everywhere but in pockets of Africa.

In that mass extermination, he said, cheetahs lost more than 90 percent of their genetic variation, and they have since managed, through gradual mutations in DNA, to recover only a fraction of the diversity.

If Dr. Lindburg and Dr. Worley have such great evidence to contradict the premise of cheetah inbreeding, Dr. O'Brien said, they have yet to persuade him.

Stamp of Approval

"I have a less than enthusiastic reaction" to their latest arguments, he said. "I like Don and Mike, but if their work was really any good, they would be dying to get my approval. They don't seem to be doing it."

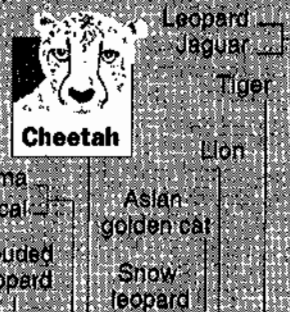
Dr. Linda Munson of the College of Veterinary Medicine at the University of Tennessee in Knoxville, who studies cheetah diseases, suggested another explanation for the cheetah's depleted DNA. She proposed that the cat lacks genetic diversity not because it once suffered through a catastrophic population bottleneck, but because it is the most specialized cat of all, with a body designed from snout to spine for the sole purpose of running at supermammalian speeds.

By this argument, the evolutionary process that focused on enhancing the cat's capacity to sprint ended up throwing out a lot of other genes along the way. In other words, the business of being a cheetah could require genetic homogeneity, and a modest life span could be part of the package deal.

And the cheetah is a spectacular example of streamlined design. It is relatively petite and light-boned, weighing only about 70 pounds, has an aerodynamically small head, unusu-

Generations of Cheetah Cousins

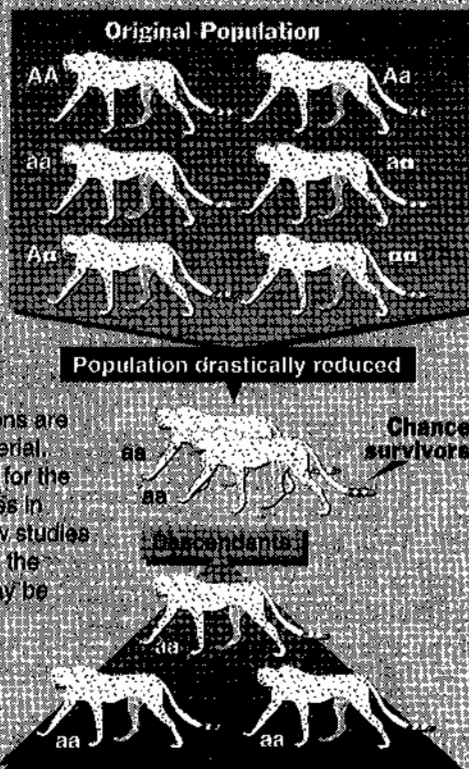
Acinonyx jubatus, the African cheetah, appeared millions of years ago. The only remaining cheetah species of five that once existed, its survival is in doubt. The extraordinary genetic similarity among cheetahs suggests that a disaster, perhaps overhunting, drastically reduced the population 10,000 years ago.



The population bottleneck

The tiny group of survivors retained only a fraction of the original population's genetic variations. Their descendants are severely inbred and depleted of genetic variability. In humans, about 10 percent of the approximately 100,000 genes come with second copies so that two variations are carried in the genetic material. Cheetahs have variations for the equivalent of only 67 genes in 100,000. Despite this, new studies say, the genetic variability the cheetah does possess may be sufficient for its survival.

Sources: Dr. Michael B. Worley, "The Nature of Life" (McGraw-Hill); "Carnivore Behavior Ecology" (Gomstock Publishing Association)



ally long legs, a flexible spinal column and a sliding shoulder to lengthen the stride.

Its canine teeth are very small to leave plenty of room for its nasal passages, which are extremely wide so the animal can take in a lot of oxygen. The cheetah hunts not by stalking prey, but by bolting at its quarry in an explosion of energy so exhausting the cat has to wait 15 to 20 minutes, panting, before it can eat.

A Defense Problem

Because the cheetah is slighter than most other African carnivores, and it lacks large canines to defend itself, it cannot ward off competing meat eaters that want its dinner, and when confronted it will usually give up and skulk away. Indeed, the cat is so unaggressive by nature that when a visitor went into a large pen at the San Diego Zoo to see a mother and her five young cubs, the cats allowed her to approach to almost within stroking distance, the mother looking

on with a mixture of boredom and irritation, the cubs cutely raising up their fur and hissing ever so slightly.

Some ecologists see the cheetah's long-term future resting not on genetic research, but on old-fashioned remedies like preserving its remaining habitat and collaborating with Africans. In Namibia, for example, where the cheetah does not have to compete with many other carnivores, as it does in other parts of Africa, the feline is faring reasonably well, and its biggest problem is ranchers who shoot it in misguided defense of their livestock. Biologists working there are seeking to persuade the cattle owners that cheetahs kill very few livestock animals.

"Namibia is one of the last countries with a big free-ranging population of cheetahs," Dr. Munson said. "If the ranchers can be convinced to take pride in the cheetah as a unique Namibian species and to work for their survival, this may be the cheetah's best hope."

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