DOLING OUT DNA

Biologists make their debut as molecular matchmakers for endangered species

By RICK WEISS

What do you get when you cross two captured African elephants? If you're not careful, says conservation biologist John Patton, you may get nothing more than "a hybridized mess."

Patton is one of a handful of scientists who are trying to avoid that genetic Waterloo by applying state-of-the-art DNA "fingerprint" tests to endangered species in captive breeding programs.

In cooperation with the St. Louis Zoo and Wildlife Conservation International — a conservation arm of the New York Zoological Society in New York City — Patton is preparing a sort of dating-service database for the endangered elephant, whose numbers have been declining in recent years as it is increasingly poached for its tusks (SN: 5/21/88, p.333). His little black book of genetic information should help biologists decide which individual African elephants now held in captivity should be mated to preserve the ideal degree of genetic variability within the species.

"I've been trying to understand what is this thing we call an African elephant," says Patton, a researcher at Washington University in St. Louis. But unlike the legendary blind men who had a similar quest and who came to disparate conclusions by getting a feel for an elephant's ears, trunk and tail, Patton is using microscopic samples of the animal's DNA to settle the issue once and for all.

DNA testing, which other researchers are applying to a growing number of species, is becoming increasingly important as zoos in the United States and other countries take on new roles as breeders of rare and endangered animals.

"Zoos are increasingly involved in trying to do something more than simply putting animals on display," says Susan Haig of the Department of Zoological Research at the National Zoo in Washington, D.C. "Zoos are starting to switch their whole way of thinking away from the Noah's ark phenomenon, where they want two kingfishers, two Guam rails, two of this and two of that. In general they are moving more in the direction of managing populations, and especially those of endangered species."

Caroline Emerich

The Guam rail nearly went extinct after tree snakes were inadvertently introduced onto the Pacific island in the 1940s. U.S. biologists hope to nurse a captive population back to health.

But when only a few of these exotic individuals have been captured and made available for breeding, problems can arise. In some cases, several adults may be close kin and thus likely to produce weakened offspring because of inbreeding. In other cases, breeders have mistakenly mated pairs of individuals that look like they belong to the same species but that in fact would never have mated in nature. That can lead to what biologists call "outbreeding depression" — a weakening of the species due to a hypervariability of the genetic code.

"The problem with zoo biology is that too often, when you have relatively few animals brought in, you don't know where the hell they came from," Patton says. "Somebody may *say* it came from here or there or somewhere else, but mostly managers don't have the reference samples to double check and make sure things are even the same species."

And yet, Patton says, "zoos have freely been breeding these animals one to another until there's no real species that's left anymore. Instead, what they've got is a big hybridized mess that quite often gives reproductive problems down the road."

Until recently, population biologists relied mostly on morphology — or physical appearance — to lump animals into taxonomic groupings such as genus, species and subspecies. But appearances can be deceiving. So these naturalists are joining forces with molecular biologists to get a more precise handle on just how similar — and just how different — are the various individuals of a given species.

They use DNA fingerprinting to measure these differences. Developed only three years ago, it has already triggered a

Bruce Read, St. Louis Zoo

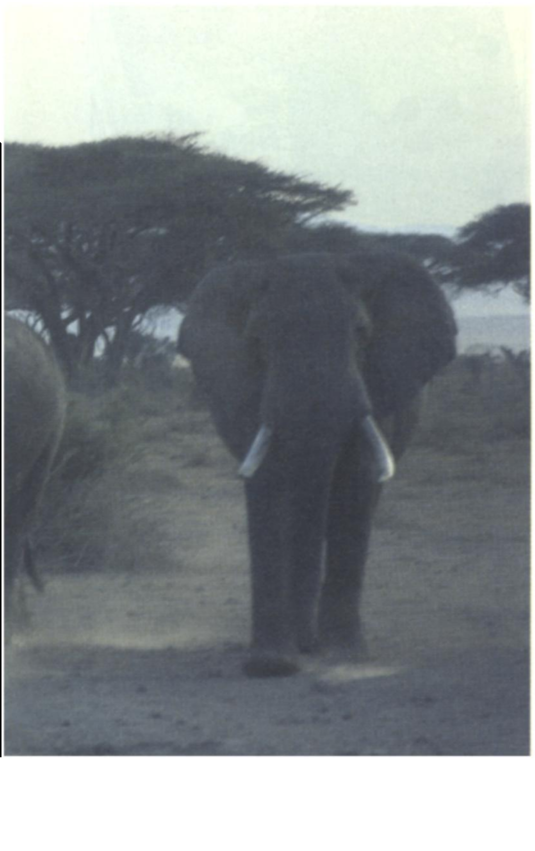
revolution in molecular genetics (SN: 4/23/88, p.262) and has begun to find its way into U.S. courtrooms because of its ability to link tiny bits of evidence such as hair or semen to accused murderers or rapists.

It calls for a cocktail of highly specific enzymes and molecular "probes" that can cut and label pieces of DNA bearing particular molecular sequences. Scientists apply these labeled DNA fragments to a gelatin strip that sorts the pieces by size. The result is an easy-to-read, black-and-white representation of an animal's genetic code that resembles the "bar codes" found today on the packaging of most grocery items. The scientists can then compare this bar code, or DNA fingerprint, with those of other animals to measure their degrees of genetic similarity. And with that information in hand, they can choose pairs of prospective parents that are not too alike and not too different.

"The single most important tool we have for management of gene-pool resources in zoos is our ability to know individuals as individuals and to establish and manipulate pedigrees," explains Oliver Ryder of the San Diego Zoo. "DNA fingerprinting is a very powerful technique that allows us the potential to very efficiently manage gene-pool resources."

Ryder has DNA fingerprinted all 28 California condors now held by scientists who hope to breed them in captivity. His fingerprinting efforts are part of a larger effort to save the severely endangered birds, none of which remains in the wild.

As ivory prices go up, the African elephant population goes down. Geneticists say DNA tests on tusks should help them pair ideal mates for captive breeding programs, and may be useful for tracing the flow of illegally obtained ivory.



"For almost half these condors we know who their parents are, but there are still a number for whom the genetic relationships are completely unknown," Ryder says. "Surely some of them are related in some way. So we're trying to get some assessment of the degree of relatedness of these wild-caught condors in order to help the pairing decisions."

Ryder was just starting those fingerprinting studies last year as zoo officials celebrated the first birth of a baby condor to captive parents (SN: 5/7/88, p.295). Happily, Ryder reports, although genetic testing was not used in the selection of Molloko's parents, subsequent DNA tests on the chick revealed that its parents were not especially closely related. Future matches of adult condors will take into account DNA data, Ryder says.

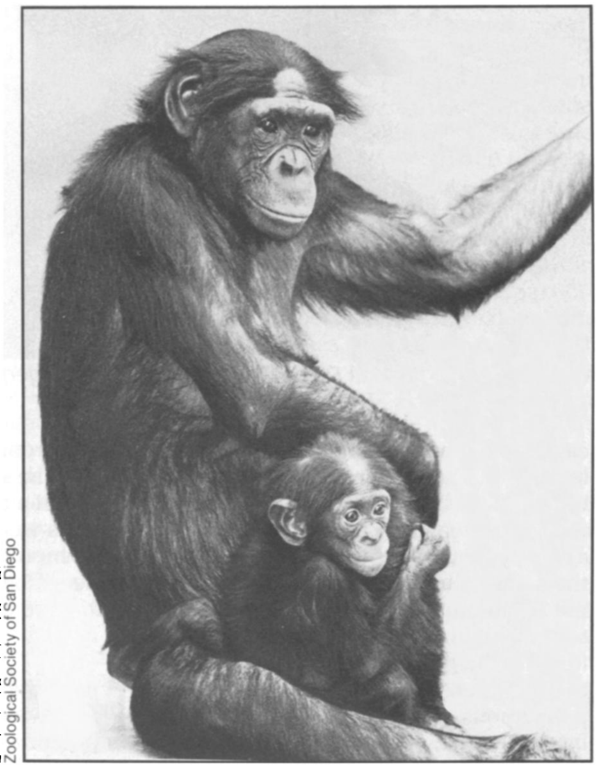
Ryder is also using DNA fingerprinting to determine the relatedness of the zoo's Galápagos tortoises. "We know they all came from the Galápagos but we don't know which island each one came from," he says. Since tortoises on different islands remain largely isolated from each other in nature, "we'd like to use some of these genetic approaches to determine [their relatedness] retrospectively." That way, he says, "the tortoises we breed in captivity can reflect the gene pools of the isolated tortoise populations in the wild."

At the National Zoo, Haig and her coworkers are applying DNA fingerprinting methods to save two species of forest birds that are on the brink of extinction on the Pacific island of Guam. During World War II, Haig says, military transports from the Philippines introduced to Guam a new predator: the brown tree snake. Over the years, the voracious reptile ate its way through almost every species of forest bird on the island. By 1984, for example, the Guam rail population had dropped from about 40,000 in 1960 to just 18 individuals.

"Guam rails breed like rats, and to have a species like that go extinct is a major thing," Haig says. "This is not like some rare species that wasn't having great success in the first place. They were doing very well."

In January 1984, biologists from the National Zoo captured all but two of the last remaining rails and initiated a captive breeding program. In cooperation with 10 other zoos, they got the population back up to 120 in captivity, and have temporarily halted all further breeding pending completion of DNA fingerprint analyses of the surviving birds.

Who's the father? Zoo biologists have used DNA fingerprinting techniques to do paternity testing on animals like this mother and child pygmy chimpanzee.



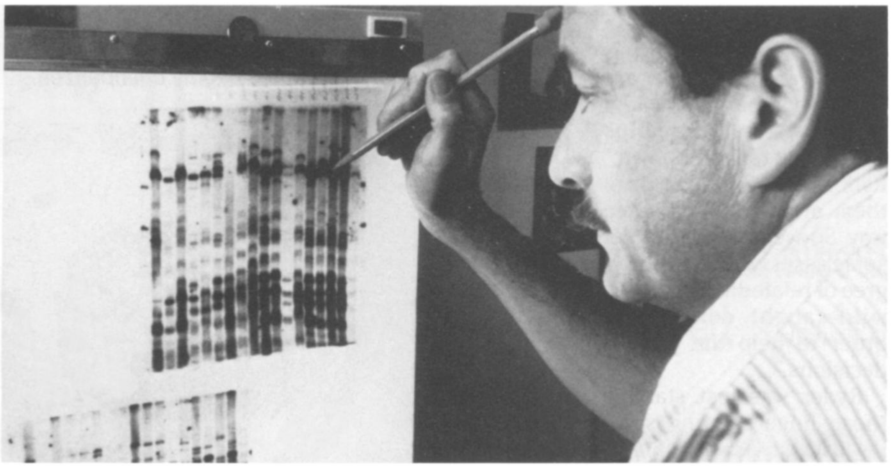
Zoological Society of San Diego

"The big problem is that of those 16 birds brought from Guam, we don't know how they are related," she says. "And there's a very good chance that among those 16 we've got a bunch of siblings and parents and offspring."

Using the results of her genetic studies, biologists will place together under suitably romantic conditions appropriately diverse adult birds, probably within the next three months. She hopes about 100 offspring from these hand-picked parents will be introduced to the island of Rota, about 40 kilometers from Guam, sometime this summer. Rota resembles Guam ecologically in most respects — but extensive searches suggest it harbors no brown tree snakes.

Haig is also involved in similar efforts to preserve the Guam kingfisher — another of the brown tree snake's victims. Zoo conservationists brought the last 32 Guam kingfishers to the United States in 1984, and have since boosted the birds' numbers to 48. But the endangered avians don't breed well in captivity, and Haig is not optimistic about the Guam kingfisher's chances for survival — even with the best of genetic counseling.

Meanwhile, in St. Louis, Patton is preparing his database of genetic information for use by breeders of



Ron Garrison/Zoological Society of San Diego

Oliver Ryder of the San Diego Zoo examines DNA fingerprints taken from captive California condors.

captive African elephants. But his problem is somewhat different from that faced by Haig.

African elephants, it turns out, come in a variety of subtypes that look essentially the same to most humans but that tend not to mix much in nature. Beyond the two major forms – the savannah and forest forms, distinguishable by ear size and tusk density – various intermediate populations appear to have diverged during the course of evolution, Patton says. His database should prevent scientists from inadvertently matching such genetically diverse elephants, saving the difficult-to-arrange sessions of behind-bars *amour* for elephants of the same or similar ecological subtype.

Patton's goal is to be able to get enough DNA from a small sample of tusk to tell the difference between various subtypes of the African behemoth. If the tusk technique proves feasible, he suggests, DNA fingerprinting may prove valuable to the species' survival not only by improving mate selection but also by identifying illegally transported ivory from poached elephants.

Despite the imposition of export quotas by African countries, sloppy paperwork and corrupt officials have hampered efforts to slow the export of ivory, Patton and others say. Part of the problem, they note, is that some countries with no remaining elephants nevertheless retain generous export quotas. Thus they continue to serve as a conduit for ivory taken from poached elephants in other countries.

"If they don't have any elephants but some official signs off and says this is a legal consignment for export, how do you prove this elephant *didn't* come from there?" Patton asks. "Right now you can say I don't believe the tusk came from there. But if the paper trail is appropriately covered there's no way you can find out for sure."

DNA fingerprinting may change all that, he says.

"Let's say we can genetically define an animal from Kenya and we can differentiate it from one from Tanzania or Zimbabwe," he says. "At the very least we can point out a discrepancy about where the animals were really poached from. And there's no way they can destroy the evidence because if they do they've got nothing to export."

In addition to tracking down telltale tusks, biologists foresee many other potential applications of DNA fingerprinting in conservation biology.

Researchers in Florida hope DNA analyses may help them gain a better understanding of the mysterious mating habits of the endangered manatee. Others, including Ryder at the San Diego Zoo, have used the technique to help determine paternity when they come upon a pregnant pygmy chimpanzee or Siberian crane.

Ryder also has used fingerprinting studies to learn more about the relationship between genetics and behavior in animals. "One thing that's come out of all these genetic analyses and behavioral studies," he says with some surprise, "is that the [behaviorally] dominant males don't always father the offspring." Findings like these seem to fly in the face of classical evolutionary theories, which generally assume dominant males have an increased chance of passing on their genes.

Still, for the increasing number of species whose only remaining habitat is a captive breeding center in a park or zoo, DNA fingerprinting's greatest value is its skill as a molecular matchmaker.

"The idea is that we should attempt to breed animals with gene pools similar to the gene pools that exist in the wild," says Ryder.

It's not difficult to get orangutans from Borneo and orangutans from Sumatra to mate and give birth to viable offspring, he says. "But there's a lot of water between Borneo and Sumatra," he adds, and biologists have no reason to move those islands – or their inhabitants – closer together. □