

## VETERINARY MEDICINE

# Camel Scientists Ask: What's Sinking the Ships of the Desert?

A wave of deaths among Saudi Arabian camels is the latest reason for a surge in research into these rugged, unusual, and highly valuable animals

When more than 2000 camels perished in Saudi Arabia this year, the mysterious die-offs caused a nationwide furor. Investigations were launched and camel “beauty contests” suspended. And when evidence mounted that the killer was not an infectious disease but rather a toxic substance in the animals’ feed, a government council demanded punishments and reforms.

Camels are serious business in the Middle East and North Africa. And, increasingly, camel research has become a hot topic. “Camels are amazing animals,” says Ulrich Wernery, scientific director of Dubai’s Central Veterinary Research Laboratory, which has a staff of 15 camel experts and a herd of 50 dromedaries. (The camelid group includes one-humped dromedaries, Asia’s two-humped species, and South America’s llamas and alpacas.) Educated in Germany, Wernery first treated camels during a veterinary stint in Somalia in the 1970s, and he has been hooked ever since. “They have fantastic qualities, able to survive without water for 2 weeks in temperatures of 50° centigrade in the shade. They can drink water that is 3% salt.” The animals also make unusual antibodies that may have applications including human diagnostics and snake antivenins (see sidebar, p. 1373).

But just as scientists in North Africa and the Middle East are expanding research into these seemingly impregnable desert juggernauts, the animals appear to be increasingly vulnerable to disease and toxins. Although epidemiological data are scarce—especially in the camel-rich but politically troubled

nations of Somalia and Sudan—some scientists argue that the illnesses striking camels are changing. “We are seeing new diseases in camels, and we often don’t have a good explanation,” says Bernard Faye, chair of the newly formed International Society of Camelids Research and Development (ISOCARD).

## Dromedary die-offs

In North Africa, there have been several unexplained dromedary die-offs during the past decade, but the incidents have not shown a consistent pattern so far. In the late 1990s, hundreds of camels perished in Ethiopia, followed by isolated incidents of dying animals showing similar symptoms—pneumonia and fevers, for example—in Kenya and Sudan over the past 7 years. Faye, who is working with Kenyan scientists to investigate the deaths there, says a small ruminant virus that normally infects cattle and sheep was the likely cause, but other pathogens were also found in the dead animals. “The biggest problem is getting blood and organ samples,” says Faye, a veterinary scientist with the French Agricultural Research Centre for International Development in Montpellier.

Another scourge of dromedaries, camelpox, is also a perennial suspect. The disease has been controlled with a vaccine in some regions, but Saudi scientists say it does not protect all camel populations. Other persistent or emerging camel diseases being scrutinized by North African investigators include tuberculosis, sleeping sickness, brucellosis, and rotavirus infections. There are

no vaccines for such camel diseases, complains biochemist Mohamed Bengoumi of the Hassan II Institute of Agronomy and Veterinary Medicine in Rabat, Morocco.

In both North Africa and the Middle East, scientists have also noted an increase in the number of “food intoxications,” camel deaths or sickness caused by harmful substances in plants or in the livestock fodder the animals eat. Bengoumi says camels are highly susceptible to high-nitrogen plants as well as fungal mycotoxins, neither of which are typically found in dry regions.

Faye collaborates with camelid scientists from Mongolia to Morocco, and he suspects that climate change in the Sahel region—the transition between the Sahara desert and wetter areas of central Africa—may be altering disease patterns among camels there. “There are two major factors affecting camels in North Africa: desertification and changes in the rainy seasons that tend to increase insect disease vectors,” he says.

Other scientists suggest that changes in how people use camels—these days, more for their milk and meat and less for long-range desert transport—could make the animals susceptible to new illnesses. Yet another reason may be the expanding geographical range of dromedaries, now found as far south on the African continent as Nigeria and Tanzania.

Although he shares the perception that camel pathologies are slowly changing, Ghaleb Alhadrami, dean of the agriculture college at United Arab Emirates University in Al Ain, which hosted ISOCARD’s first conference last year, says there is not enough evidence to link any shifts to climate change. He speculates that increased stress from keeping ever-larger herds in confined spaces and from camel racing—a multimillion-dollar industry in the Middle East—weakens the immune systems of many camels. But Alhadrami, like other researchers, says more data are needed, especially from North

**Desert mystery.** The recent deaths of more than 2000 camels in Saudi Arabia, such as this one near the capital city of Riyadh, belies their image as rugged desert juggernauts.



## 'Camelized' Antibodies Make Waves

When biologists at the Vrije University in Brussels by chance substituted leftover camel serum for mouse serum in a laboratory experiment, they made a startling discovery: The camel antibodies were fundamentally different from their murine counterparts.

"We were amazed," recalls Belgian biochemist Serge Muyldermans. Instead of being composed of two "heavy-chain" subunits and two "light-chain" subunits, the camel antibodies have only two heavy chains, making them smaller and more durable than typical antibodies.

Since this discovery—first reported in 1993—more than 130 papers have been published on the properties of camel antibodies and their uses, which include diagnostic tests and biodefense assays. At least two companies are trying to develop clinical products using antibodies from camels or related species, such as llamas and alpacas.

Muyldermans says these camelid antibodies pose lower risks to humans than antibodies from other animals, and they can survive elevated temperatures, are highly soluble, and can penetrate more quickly than normal antibodies through cell layers in tissue to reach their targets. Because of those and other qualities, drug companies are already using camel antibodies to speed identification of leads for therapeutics. And at the University of Munich in Germany, Heinrich Leonhardt's group is fusing fluorescent markers to camelid antibody fragments and using

them to target and trace molecules in living cells.

The heat resistance of camelid antibodies has attracted the interest of the U.S. Naval Laboratory and the Southwest Foundation for Biomedical Research. They are testing the antibodies in biosensors designed to detect bioterrorism agents in hot environments. Another group, at Washington University School of Medicine in St. Louis, Missouri, has used the antibodies to develop a simple test to measure the caffeine content of hot beverages.

Ulrich Wernery of Dubai's Central Veterinary Research Laboratory, speculates that dromedaries developed heat-resistant antibodies to survive in harsh desert conditions. But Muyldermans says scientists don't truly know why the animals have such odd antibodies, which probably resulted from mutations about 50 million years ago, after camelids split from ruminants and pigs.

One unusual application of camelid antibodies comes from Wernery's lab, where camels are used to produce antibodies to the venom of poisonous animals. The researchers obtain the antivenin by exposing a group of 15 dromedaries to venom from cobras, spitting vipers, and other poisonous snakes. Some people have severe reactions to traditional antivenins produced in horses, but Wernery says, "there is no problem with camel antivenins." The first clinical trial is scheduled for next year in Nigeria.

—R.K.

Africa. "There are few reliable statistics on camel disease trends," Bengoumi notes.

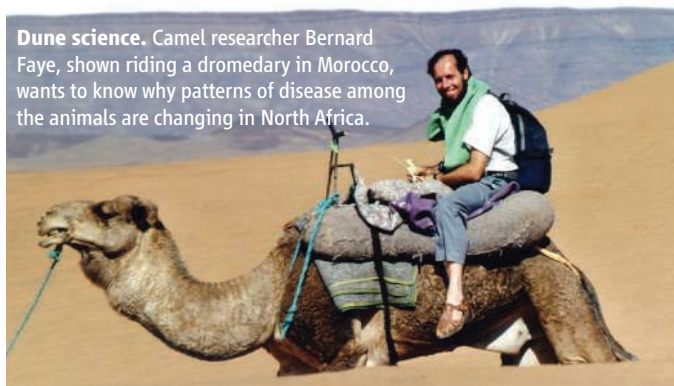
### Furor in Arabia

Although mysterious camel deaths have occurred elsewhere in the Middle East and North Africa, no recent event matches the extent of this year's Saudi die-off, during which at least 2000 dromedaries perished in a region mainly south of Riyadh, Saudi Arabia. One unofficial estimate placed the death toll at 5000.

Initial reports focused on the possibility of an infectious disease or intentional poisonings. But after an investigation by the nation's agriculture ministry—which sent camel blood and fodder samples to both Saudi and outside labs—government officials asserted that the camels succumbed to contaminants found in their bran fodder: the antibiotic salinomycin, a supplement in chicken feed that is toxic to camels, and a fungal species whose mycotoxins can damage some animals' nervous systems.

The Saudi government has shared few details of its investigation with outside experts, which has puzzled camel scientists who felt they could have contributed. "Many questions remain open," says Faye. He suggests that the deaths may involve several factors, possibly including viral infections that suppress camels' immune systems. But Saudi

**Dune science.** Camel researcher Bernard Faye, shown riding a dromedary in Morocco, wants to know why patterns of disease among the animals are changing in North Africa.



Arabia's deputy agriculture minister for research, Abdullah Al-Obeid, says the lab tests showed no evidence of infectious disease. Steps are now being taken to improve the transport and storage of fodder for the nation's half-million camels, he says.

Although Wernery's lab hasn't yet studied tissue samples from the recent deaths, he says, "neither mycotoxins nor any known disease could have killed 5000 camels in that short span of time." He favors the antibiotic explanation, noting that the Saudi die-off appeared similar in symptoms to the deaths of about 120 racing camels in Dubai a few years ago. The cause was also later determined to be salinomycin in the fodder.

Whatever its origins, the Saudi debacle may help energize camel studies in the region. ISOCARD has been attracting new members, and Sudan has opened a camel research lab in Khartoum. In Saudi Arabia, Al-Obeid says his

ministry plans to strengthen camel research, which is under way at several centers, including King Faisal University, where infectious-disease expert Abdulsalam Abdulan Bakhsh is investigating camel maladies.

Also, in January, the newest phase of the Camel Breeding, Protection, and Improvement Center—built with help from the U.N.'s Food and Agriculture Organization—will open in northern Saudi Arabia. Its technical

director, veterinary scientist Mukhtar Taha Abu-Samra, says the facility will boast a camel hospital with seven diagnostic labs, a radiology and ultrasound room, and a surgery theater. By training camel specialists and upgrading research programs, he says the center aims to "bridge major gaps" in our knowledge of dromedaries.

Certainly, many gaps remain. Camels' desert survival skills include kidneys that release very little urine in order to preserve water, an intestinal system that recycles water, and a nasal "air-conditioning system" that cools the blood vessels heading to their brains. And scientists suspect they will find more quirks of dromedary physiology, some that might even eventually benefit human medicine.

"Camels are wonderful research subjects," says Wernery, "and we can learn a great deal from them."

—ROBERT KOENIG