ephants there are confined to small, isolated populations that are vulnerable to inbreeding and to natural disasters such as drought and disease. According to Richard Barnes, these small populations would also be at risk should countries fall prey to civil unrest.

Logging not only destroys forest habitat, however; it opens up once-remote areas to farmers and miners. And when this occurs, elephants can run into trouble with their neighbors. Throughout Africa, "crop raiding" has turned elephants into feared and hated pests. Last July, for example, 13 village chiefs from around Ghana's Kakum National Park marched on the nation's capital to protest park-dwelling, forest elephants that foraged in nearby fields.

Efforts to find solutions are bringing together unusual allies. At a meeting last fall in Washington, D.C., at Conservation International, an environmental group, Ben Asamoah-Boateng, director of Kakum, met with Richard Barnes and Jack Birochak of the Pennsylvania-based Counter Assault Tactical Systems, a company specializing in personal safety devices. Birochak has designed a special capsicum pepper spray—a larger version of what city dwellers carry to deter muggers—that will be tested on the park's crop-raiding elephants.

Some researchers contend that, in certain areas, crop-raiding claims may be exaggerated. In Gabon, cane rats and porcupines cause far more damage, White says, but are not nearly so hated by farmers. The difference, he says, is psychological. "An elephant may have raided your farm [only] once 10 years ago, but you never forget an elephant."

–Laura Tangley

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PALEONTOLOGY

How Reptiles Took Wing

In 1910, a copper miner in central Germany picked up a nearly flawless fossil: an unusual reptile with a winglike fan of bones spreading from each shoulder. When he sold the specimen to Otto Jaekel, the premier German paleontologist, the miner labeled it "Flying Reptile." But Jaekel thought the animal too improbable and removed the bones of the wings, believing they were the fin rays of a fish superimposed on the reptile. In later years, it turned out that the miner was right and the expert wrong. Now, a report in this issue of *Science* (p. 1450) makes clear just how bizarre a beast *Coelurosauravus jaekeli*—the earliest known flying vertebrate—really was.

By examining several new, exquisitely preserved specimens collected by amateur fossil hunters, Eberhard Frey and Wolfgang Munk of the State Museum of Natural History in Karlsruhe, Germany, and Hans-Dieter Sues of the Royal Ontario Museum in Toronto, show that this 250-million-year-old animal glided on a unique set of wings, unlike any others known in living or extinct animals. The long, hollow bones that strengthened these wings formed directly in the skin itself. "*Coelurosauravus* is totally bizarre because in every other animal that flies, wing support draws on the normal skeleton," says Sues. For example, the wing bones of birds and bats are converted forelimbs.

Strange as *Coelurosauravus*'s wings are, they teach an important evolutionary lesson, says vertebrate paleontologist Robert Carroll of McGill University in Montreal: "We typically think of evolution as taking an existing structure and making some new function of it, but this animal has taken the capacity to produce bone and elaborated it in a completely unique way."

Carroll was the first paleontologist to identify *C. jaekeli* as a flying reptile, back in 1978. Based on the partial fossils then available, he interpreted the reptile's wing rods to be extensions of its ribs, like the wing struts of the modern gliding lizard *Draco*. Later, researchers suggested that the animal had hinged, two-part ribs. But in the early 1990s, Sues and Frey began to question this assumption. They reasoned that such a reconstruction required *C. jaekeli* to have a rib and a vertebra for each of its 24 to 28 wing rods, creating an animal with an implausibly long, flat trunk, stretched into a kind of "reptilian pancake."

Looking for a more plausible picture, they examined several beautifully preserved specimens, most of them owned or discovered by private collectors. Two partial skeletons showed that "the [wing] rods had nothing to do with the ribs," Sues says. A nearly complete skeleton sold by an amateur collector to the museum in Karlsruhe offered the final proof. This fossil had only 13 vertebrae, but 22 rods on each side, which splayed out in bundles and were unattached to any other skeletal elements.

Winging it. *Coelurosauravus*'s wings were supported by new bones that formed in the skin, rather than by modifications of existing bones.

Thus, the wings of this precocious flyer opened like an old Japanese fan, explains Sues. The bundles of bony rods formed directly in the skin and radiated from the shoulder area. When spread, the bundles extended to form two curved wings that could carry *Coelurosauravus* tens of meters. The long tail, which made up half of the 30-centimeter body length, may have added stability in flight.

Carroll himself is now persuaded of this unusual wing structure. "The new German material is good enough that it should settle most of the arguments," he says. "This demonstrates how early flight, even if not active, flapping flight, was achieved by vertebrates." And the new understanding of *C. jaekeli* could also spur new insights into the mechanics and evolution of flight in other animals, adds Kevin Padian, a paleontologist and pterosaur expert at the University of California, Berkeley: "It may now prove interesting to take another look at later flying vertebrates that evolved independently."

Frey and his colleagues owe their close look at *C. jaekeli* to the work of several amateur fossil hunters, including a German house painter and a baker. They are among the hundreds who pore over the spoils of abandoned copper mines in central Germany's Kupfershiefer formation every weekend, splitting open blocks of copper-shale and noting their finds in detail. Because most of the fossils from this region are already well described, no professional paleontologists work these mines, says Sues, and amateurs have gathered almost all the known *Coelurosauravus* specimens. "Paleontology, unlike particle physics, is something an amateur can make important contributions to," says Sues.

Of course, relations between amateurs and professionals are not always so cordial. For example, given the surprising results on *C. jaekeli*, paleontologists would like to see what else may be learned from little-known groups such as the kuehneosaurs, rare, 225-million-year-old reptiles whose wings are thought to be adaptations of ribs. But researchers say that the best specimen, once held by the American Museum of Natural History, is now back in private hands—and unavailable for scientific study.

–Bernice Wuethrich

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