

## Starlings star in X-ray movies

To trace the intricate motions of bird flight, researchers have made what they say are the first X-ray movies of flying birds. In doing so, they have identified two skeletal movements that may help birds meet the increased metabolic needs of flight. Previous knowledge of bird flight has come from conventional photography, which does not directly reveal the mechanics of muscular-skeletal interaction.

European starlings flew in a small, room-sized wind tunnel at speeds of 20 to 45 miles per hour while being radiographed from the side and above, at 200 frames per second. Analysis revealed that on the downstroke of the wings, the wishbone, which joins the shoulders, bends and widens; on the upstroke, it recoils. The sternum also moves, rising upward on downstroke and descending on upstroke, the researchers found.

Because the wishbone shafts lie close to an air sac — an apparent reservoir for extra air — in the starling's upper body, the researchers envisioned a functional relationship between the two structures. When they artificially inflated the sac, the wishbone spread, supporting that hypothesis. Based on their observations of wishbone spread (presumably inflating the shoulder air sac) and simultaneous upward movement of the sternum (apparently compressing posterior air sacs) — all in synchrony with wingbeat — the researchers further suggest that most small and medium-sized birds, including starlings, may have a secondary method of moving air between air sacs and lungs, beyond normal inhalation and exhalation.

The research, conducted by Farish A. Jenkins of Harvard University, Kenneth P. Dial of the University of Montana in Missoula and George E. Goslow of Northern Arizona University in Flagstaff, is described in the Sept. 16 *SCIENCE*.

The new work grew out of a comparative study of mammalian and reptilian patterns of locomotion and neuromuscular control. "We wanted to describe the basic relationship of form and function and how various structures of the shoulder and wing worked for birds," Dial says. "Previous studies relied on traditional methods of dissection and interpretation. We were interested in making actual measurements of how these structures perform." Future investigations by the group will include study of the relationship of shoulder design to wing type and flight mode.

The process of studying a dynamic, movable skeleton, Dial says, is "a thrill. But it takes a lot of work to get the birds to fly. Only 1 in 5 really cared to fly in the tunnel."

— C. Eron

## Mausoleum brings Moche culture to life

Nearly a year of intensive excavation at an archaeological site in northern Peru known as Sipan has uncovered one of the richest and most significant pre-Columbian tombs ever found in the Americas, according to scientists at a press conference held at the National Geographic Society in Washington, D.C., last week.

The 1,500-year-old burial place, untouched by looters who ravaged another nearby tomb, contains a wooden coffin with the remains of a warrior-priest of the little-known Moche culture. The Moche people farmed a series of river valleys along a 220-mile stretch of northern Peru from roughly A.D. 100 to 700. The Inca civilization appeared around A.D. 1400.

According to Walter Alva, head of the excavation and director of the Bruñey Archaeological Museum in Lambayeque, Peru, several similar burials surround the tomb, forming a royal mausoleum. Excavation of a second unlooted tomb at Sipan is nearly complete, and work on a third unlooted tomb is underway. The burials lie in an adobe platform in front of a flat-topped mud pyramid raised by the Moche around A.D. 200.

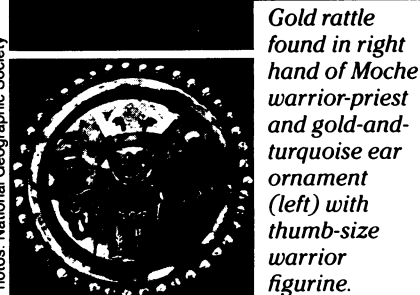
"This is the richest tomb ever excavated archaeologically in the Western Hemisphere," says anthropologist Christopher B. Donnan of the University of California, Los Angeles, who analyzed photographs of objects from the tomb and compared them to a photographic archive of Moche art at UCLA. "The quality of the gold work is stunning. It puts our understanding of New World metallurgy on a different plane."

Among the Moche treasures recovered are a 2-foot-wide, solid-gold crown, a gold face mask with pupils of lapis lazuli, a gold knife, two strands of gold and silver beads fashioned into large peanuts, a ceremonial rattle made of hammered sheet gold, a gold warrior's shield weighing nearly 2 pounds and gold-and-turquoise ear ornaments with minute decorations.

These remains reveal an extensive Moche trade network, Alva says. Gold was brought from the eastern Andes Mountains, turquoise from southern Peru or northern Argentina, and lapis lazuli stones from Chile.

Alva and his co-workers also found more than 1,000 small pots, bowls, beakers and jars. "It's the greatest cache of pre-Columbian ceramics ever found," he says.

The artifacts in the Sipan tomb clearly identify the main occupant as a Moche warrior-priest, Donnan says. Analysis of the warrior-priest's skeleton indicates he was about 5 feet, 6 inches



Photos: National Geographic Society

Gold rattle found in right hand of Moche warrior-priest and gold-and-turquoise ear ornament (left) with thumb-size warrior figurine.

tall and in his early 30s when he died of unknown causes.

Entombed with the "Lord of Sipan," as Alva calls him, are eight more people, including several servants and two young women who may have been his concubines or wives. Flanking the main coffin are the skeletons of two men. A copper shield, headdress and war club indicate one was a warrior; the other is buried with a dog that may have been a prized hound of the warrior-priest.

Since the Moche people had no written language, most of what is known about them comes from paintings on the walls of looted tombs and decorated pottery depicting a wide range of activities. The Moche apparently fought frequently to capture prisoners for sacrifice. Drawings show a ceremony in which prisoners had their throats cut and their blood presented in goblets to a warrior-priest figure.

The second unlooted tomb further confirms the Sipan platform as a principal burial place for a succession of Moche leaders, Alva adds. It is somewhat smaller and less rich than the first tomb, but contains a Moche elite with a warrior buried next to him. Warriors in both tombs are missing feet, he notes, probably as part of a ritual amputation so they would not abandon their guardposts in the afterlife.

Alva traced artifacts seized by police from a looter's house in February 1987 to a tomb at the Sipan site. There he discovered several similar burials surrounding the looted tomb. — B. Bower