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Historical Perspective

Lead Poisoning and the Reintroduction of the California Condor in Northern Arizona

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Abstract: Since 1996, The Peregrine Fund has released California condors (*Gymnogyps californianus*) in the Grand Canyon region of northern Arizona with the goal of establishing a self-sustaining population, disjunct from other released populations in California and Baja California. A free-ranging population of more than 60 individuals now ranges within northern Arizona and southern Utah and has produced 9 wild young. The most frequent cause of death is lead poisoning from the ingestion of lead bullet fragments and shotgun pellets in the remains of gun-killed animals. In response, the Arizona Game and Fish Department has effectively reduced lead occurrence within the foraging range of the condors through hunter education and the promotion of nonlead ammunition. Most hunters have participated in the program. Throughout the course of the reintroduction effort, veterinary science and application have played essential roles in diagnosing fatalities and treating lead-exposed condors, a species with such a low natural reproductive rate that every adult is significant to the population.

Key words: lead poisoning, The Peregrine Fund, avian, California condor, *Gymnogyps californianus*

There are few endangered species whose road to recovery is more intimately linked to veterinary science and to the skills of veterinarians than the California condor (*Gymnogyps californianus*). Condor restoration has come to include a variety of veterinary projects integrated within the fabric of adaptive wildlife management. The veterinary connection arose first from the need to identify the agents responsible for deaths among free-ranging condors, then to assist with condor propagation, and most recently from the necessity of saving condor lives in free-ranging populations that contain individuals of high demographic and genetic significance. The central importance of minimizing mortality derives from the naturally low reproductive potential of condors. Condors usually do not breed before 8 years of age, and successful pairs tend to lay a single egg every other year. Under the best conditions, population sustainability requires an annual adult survival rate of 90%–95%.[1,2]

Condors are obligate scavengers, and their early decline corresponded with the loss of the Pleistocene megafauna some 10 000 years ago. This event reduced the range of condors from what may have been the whole of temperate North America to its western coastal region.[3] Lewis and Clark found condors at the mouth of the Columbia River in 1805, but subsequent reductions in wild ungulates, marine mammals, and anadromous fish diminished condor food supplies. Although livestock production buffered those losses to some degree, by the early 1900s, condors were rarely reported outside southern California. Meanwhile, industrial society brought a variety of human-related mortality factors from which remaining condors had no natural defenses. Many condors were shot during the age when predators and predator look-alikes were considered undesirable; condors and their eggs were collected as specimens, and still others succumbed to predator poisons, wire strikes, and electrocutions.

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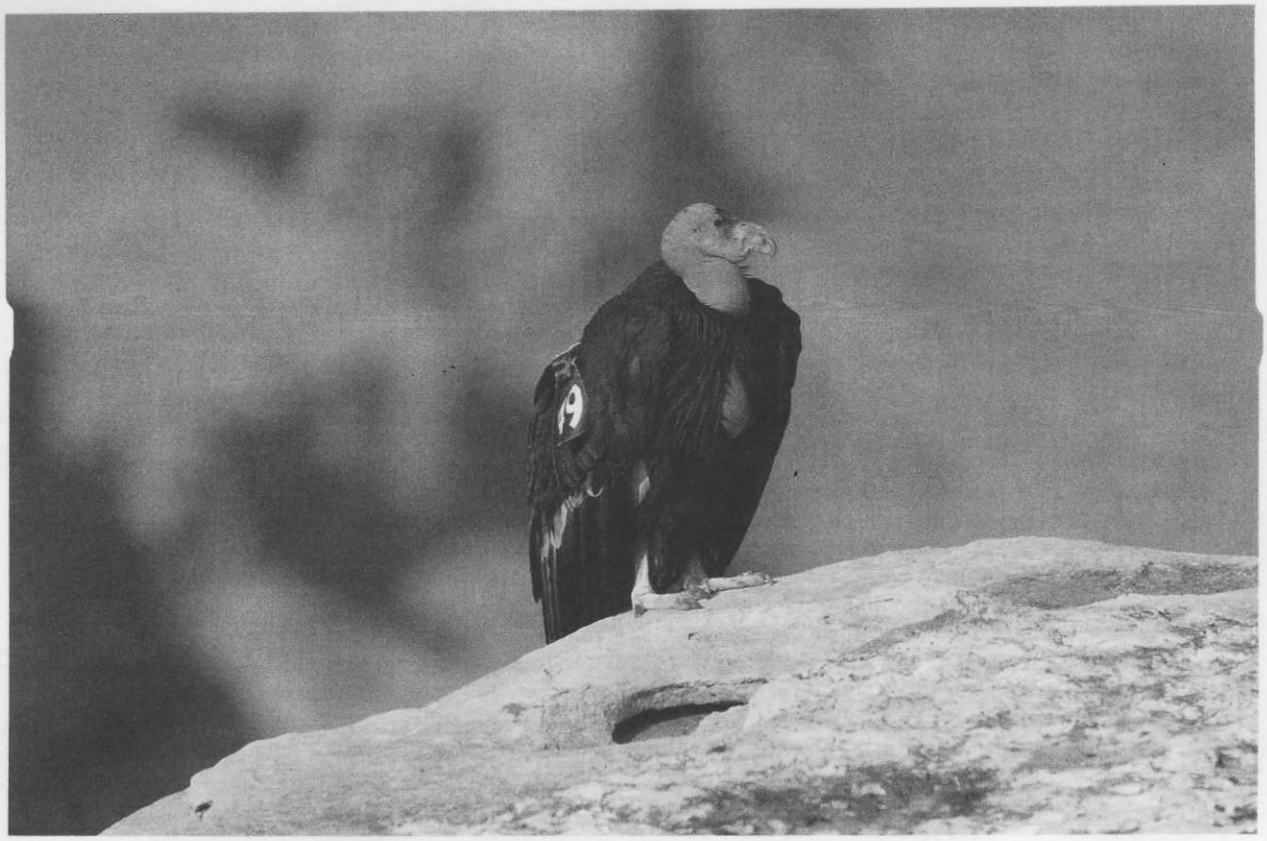

Figure 1. Adult California condor at the Grand Canyon in northern Arizona.

Some of the agents that impacted condor demography, however, were less obvious. Condors simply disappeared, their carcasses unavailable for necropsy. The solution was to radio tag and track free-ranging condors, a technique that increased the likelihood of recovering fatalities for diagnostic testing. In the mid-1980s, when condors had all but disappeared, lead poisoning was identified as the cause of death in 3 of 5 necropsies.[4] However, with no direct evidence about the pathway of lead contamination to condors, there was no achievable way of curtailing it. Soon thereafter, the US Fish and Wildlife Service removed the remaining population of 22 individuals to captive breeding centers.

Several hundred young condors produced at 4 facilities have since given rise to release projects in California, Baja California, and Arizona, with the ultimate goal of self-sustaining populations. The release project in Arizona emanated from a provision within the condor recovery plan that called for the establishment of a population disjunct from those in California. The Peregrine Fund initiated its project with the creation of a captive breeding facility at its headquarters in Boise, Idaho, and was soon producing young condors for release to the wild. In 1996, the Peregrine Fund began its experimental releases in the Grand Canyon country of northern Arizona. The region was chosen because of its remoteness, rugged terrain offering rising air currents favorable for soaring, numerous cliffs for nesting, and food supplies in the form of livestock and wild ungulates. There are now about 65 free-flying condors in Arizona and southern Utah, and the population is augmented each year with additional releases of captive-bred individuals (Fig 1). The first wild condor pair reproduced in Arizona in 2003, and 5 additional pairs have since increased the total to 9 young, of which 8 survive.

All individuals wear standard, patagial-mounted or tail-mounted VHF (very high frequency) tracking radios and are intensively monitored by a team of biologists throughout the year.[5] Beginning in 2003, a moderate proportion of the population has also carried satellite-reporting GPS (global positioning system)-equipped transmitters, which offer precise hourly location fixes

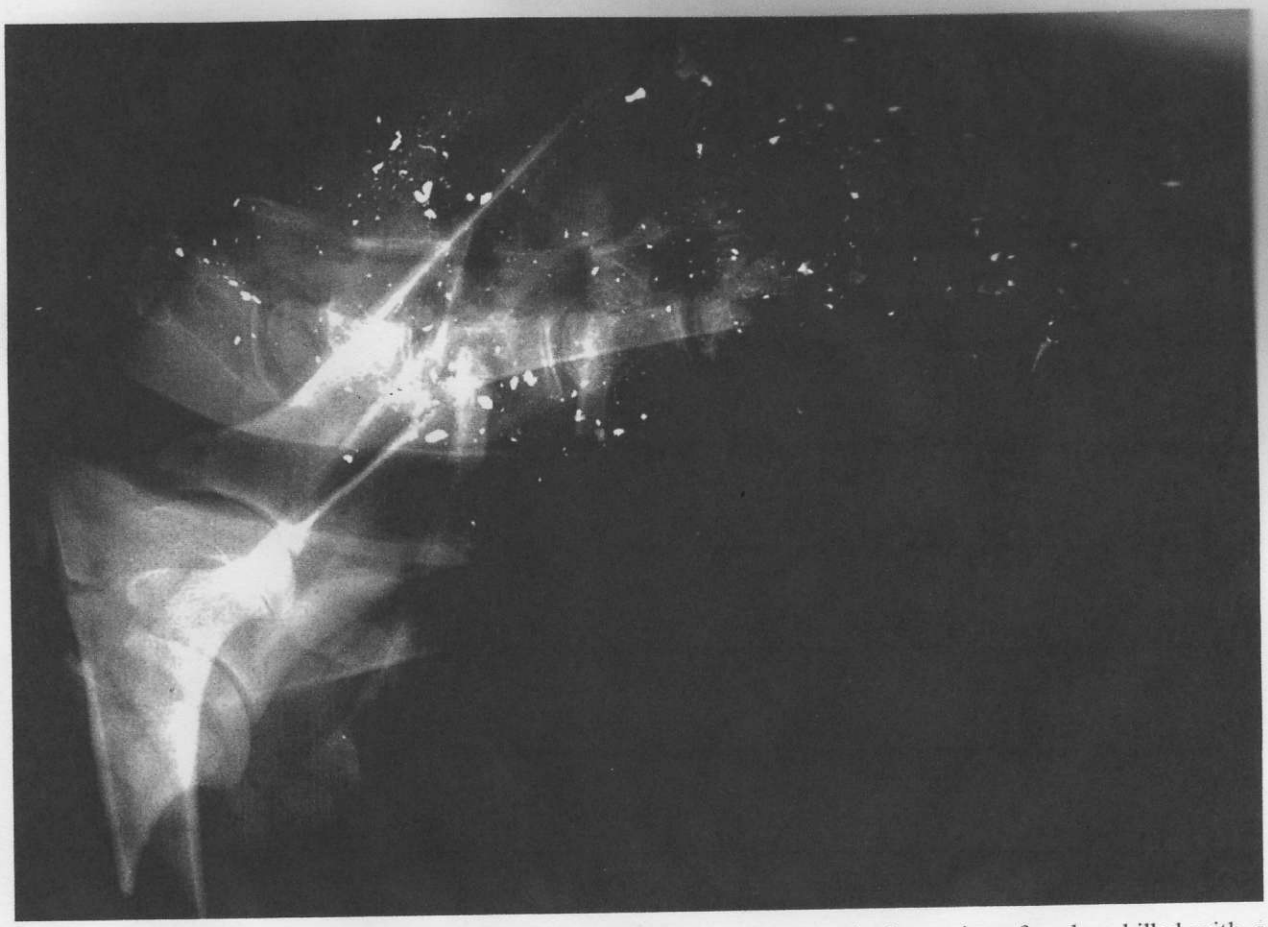

Figure 2. Radiograph, showing numerous rifle-bullet fragments in the spinal remains of a deer killed with a standard lead-based rifle bullet in caliber .270 Winchester.

during daylight hours. There has been no indication that either type of transmitter has had any detrimental effect on the condors; each transmitter is approximately 0.7% of body weight.

There was little evidence of lead exposure in the early years of the release program in Arizona (1996–1999), when condors mainly relied on an artificial supply of dairy-calf carcasses continually maintained at the release site. With increasing dependence on wild foods, however, condors began encountering lead. An episode of lead shotgun pellet ingestion by at least 13 condors in 2000 produced 2–4 fatalities; 9 individuals required chelation therapy.[2] This event, although regarded as anomalous, gave rise to a regular program of blood lead monitoring of the entire condor flock at least twice per year, as made possible by the frequent return of condors to the release site.[6]

As condor behavior developed in ways more typical of a wild population and flock movements became more expansive, the increasing role of lead as a mortality factor was apparent. A high incidence of lead exposure in the fall of 2002 corresponded with increased condor visitation to deer hunting areas on the Kaibab Plateau, a relationship that continued in subsequent years.[7] To further test the hypothesis that gun-killed deer remains were the source of lead exposure during the hunting season, The Peregrine Fund conducted a radiographic study that confirmed that most deer killed with standard lead-based rifle bullets, as well as deer offal, contained numerous (often several hundred) small bullet fragments that radiated widely from the wound channel (Fig 2).[8] These separate lines of evidence, together with that of isotopic consistency of lead used in the production of ammunition with that retrieved from sick or dead condors,[9] strengthened the hypothesis that the ingestion of ammunition fragments in gun-killed animals had been a principle factor in the condor decline.

Lead poisoning remains the leading cause of death of condors in Arizona, and regular testing

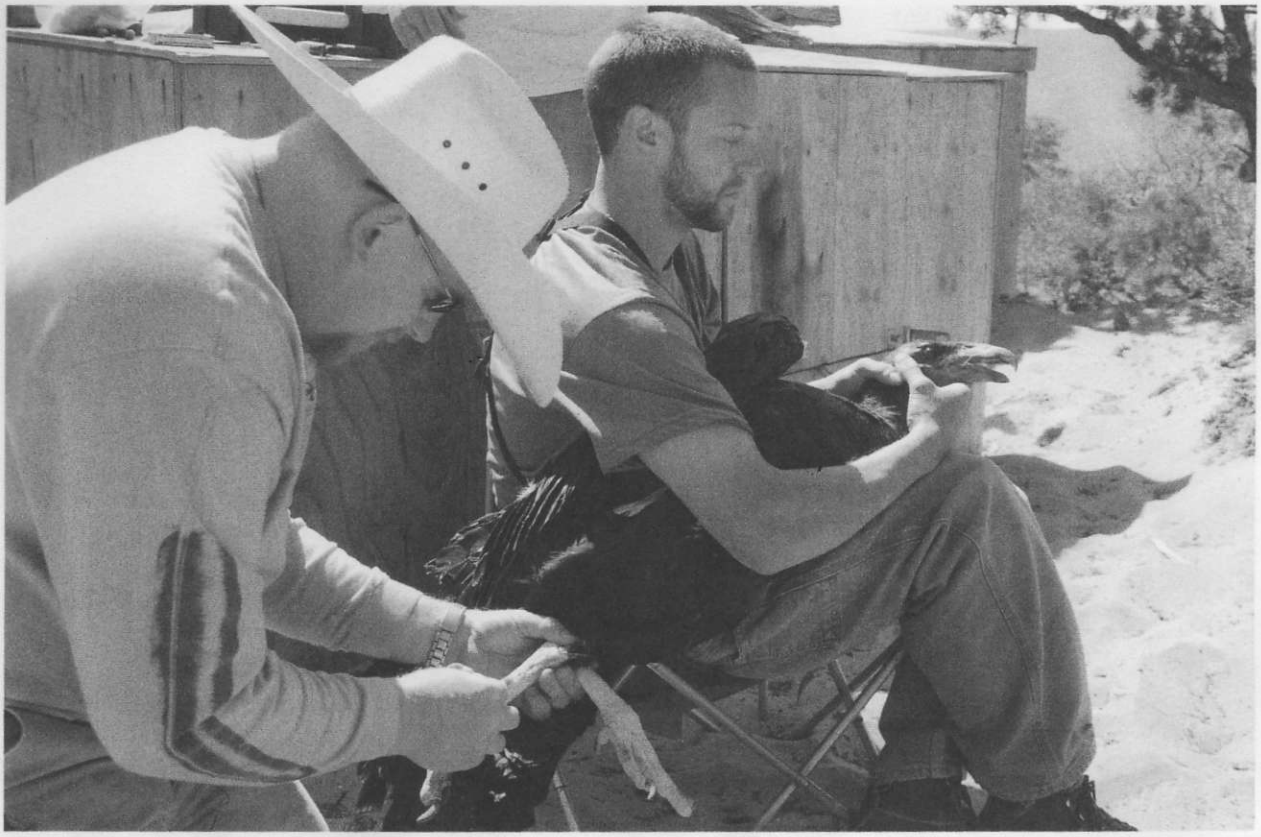

Figure 3. Peregrine Fund biologists taking a blood sample for lead analysis from a young free-ranging condor at the Vermilion Cliffs release site in northern Arizona.

continues to show exposure each fall and winter. Fortunately, the birds still regularly return to the cliff-top release site, where they are routinely captured and tested (Fig 3). Those showing high lead levels undergo chelation therapy that consists of intramuscular injections of Ca EDTA (calcium edetate) twice daily for 5 days, a procedure that usually produces a rapid decrease in blood lead levels.[10] Lethargic and dehydrated condors are given oral or subcutaneous fluid (lactated Ringer's solution). Condors that show these and other obvious physical signs of poisoning in conjunction with rising blood lead levels are radiographed to search for metal presence (lead and copper) in the digestive system (Fig 4).[6] Condors so diagnosed are placed in the care of veterinarians at the Phoenix Zoo who retain them until they pass the lead bodies, a process sometimes facilitated by purging with psyllium fiber or by surgery in extreme cases. Phoenix Zoo veterinarians also care for condors sick or injured from other causes. Dead condors obtained from the field are quickly transported to the Wildlife Diseases Laboratory at the San Diego Wild Animal Park (San Diego, CA, USA) for necropsy.

Despite these efforts, however, lead exposure continues. In 2006, for example, 54 of 57 condors (95%) tested in Arizona showed blood-lead levels indicative of lead exposure, 40 (70%) required treatment, and at least 3 died of lead poisoning. If the condor population in Arizona is to become self-sustaining, and with veterinarians no longer needed, then it will be necessary to reduce the prevalence of lead in gun-killed animals. In 2005, the Arizona Game and Fish Department began an innovative program, now in its fourth year, to reduce condor lead exposure through hunter education and by offering free nonlead ammunition to hunters drawing deer permits in the condor range.[11,12] Most hunters have accepted the offer each year, with the result of demonstrably less lead in the environment and fewer fatalities.[13] A recent detailed analysis of the incidence and severity of lead exposure, together with data on condor movements, suggests that the condor population might become self-sustaining

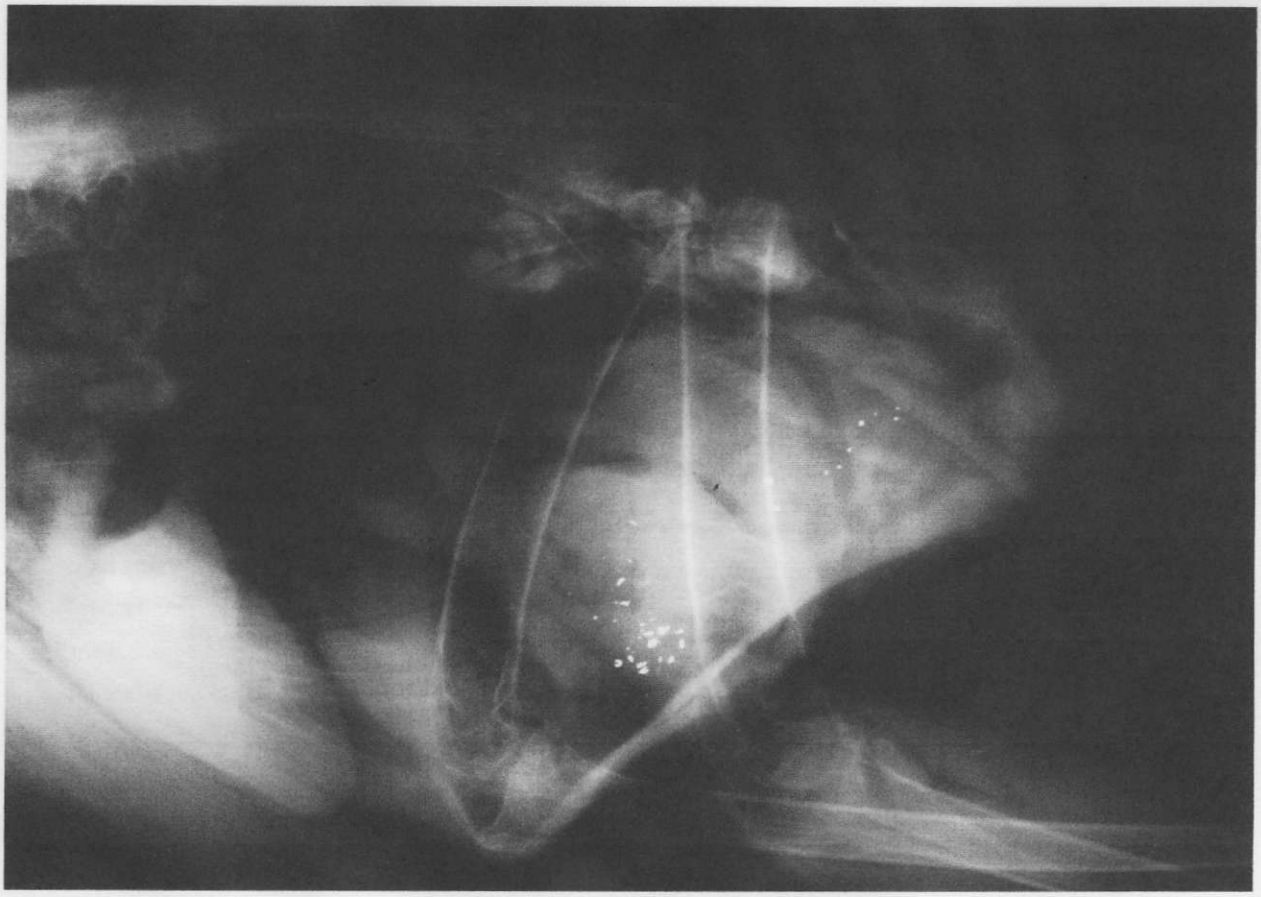

Figure 4. Radiograph of California condor with lead bullet fragments visible in the digestive system.

if the State of Utah were to institute a lead-reduction program like that in Arizona and obtain similar rates of hunter participation.[14,15]

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