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EFFORTS TO RESTORE THE NORTHERN APLOMADO FALCON *Falco femoralis septentrionalis* BY CAPTIVE BREEDING AND REINTRODUCTION

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ABSTRACT: Since 1977 efforts have been underway in the United States to develop an effective programme for the captive breeding and reintroduction of *Falco femoralis septentrionalis*, an endangered subspecies that has disappeared from the northern half of its breeding range in Mexico and the south-western USA. Twenty-five young falcons were taken from the Mexican states of Chiapas, Tabasco and Veracruz between 1977 and 1988 to form a captive breeding colony. Through the 1991 breeding season, 10 females laid 279 eggs, of which 91 were fertile. Fifty-nine eggs hatched in incubators, and 48 young were reared to the fully fledged state. Twenty-four captive-bred young have been released by hacking at four locations in south Texas; 16 to 19 of these youngsters became fully independent birds and dispersed normally. Several have been seen in subsequent years, but no breeding in the wild has yet been recorded. Results indicate that once a large enough captive breeding group has been accumulated, captive breeding and reintroduction by hacking will be workable methods for restoring this species to portions of its vacated range.

KEY WORDS: aplomado falcon, *Falco femoralis septentrionalis*, captive breeding, reintroduction

Introduction

The aplomado falcon *Falco femoralis* is a New World species which breeds in arid to humid savannas, and some open montane habitats in the Andes, from Tierra del Fuego northward through Mesoamerica, formerly to the south-western United States (Bent, 1938; Keddy Hector, 1988). The large, northern subspecies *F. f. septentrionalis*, which bred from the southern Mexican states of Chiapas, Tabasco, Campeche and Yucatan, possibly Belize also, and from the Pacific coast of Guatemala north into Texas, New Mexico and Arizona, has disappeared as a breeding bird from most of its northern distribution and currently it is known to nest only south of the Tropic of Cancer, mainly south of 20°N lat. (Hector, 1987; Keddy Hector, 1990). It has also apparently disappeared from the Pacific coast of Guatemala (Fig. 1). Because of this range contraction and the loss of the species as a breeding bird in the United States, the US Department of the Interior officially listed the northern aplomado falcon as "endangered" in 1986 (Fed. Reg. 51 (37), Feb. 25, 1986, pp. 6686–6690).

This long-tailed, long-legged, accipiter-like falcon was formerly rather common in coastal and arid savannas of the south-west, where it hunted a variety of small to medium-sized birds and large insects and nested in the old stick nests of ravens and hawks located in widely spaced mesquite and yucca trees (Bent, 1938; Hector, 1988), possibly also in tall cacti. A colourful and dashing raptor, often hunting in pairs, and even pursuing prey on foot, the early Spanish explorers called it "halcon aplomado," the plumbeous or lead-coloured falcon, a reference to its bluish grey dorsum.

The aplomado falcon occurred widely throughout the humid coastal savannas of Texas and Tamaulipas and also in the more arid interior grasslands of the south-west and northern Mexico (Hector, 1987). As an indication of its abundance in south Texas, one collector obtained more than 125 sets of eggs between 1888 and 1915 (Hector, 1981). Pairs of falcons or nests continued to be reported nearly every year until 1930, but only

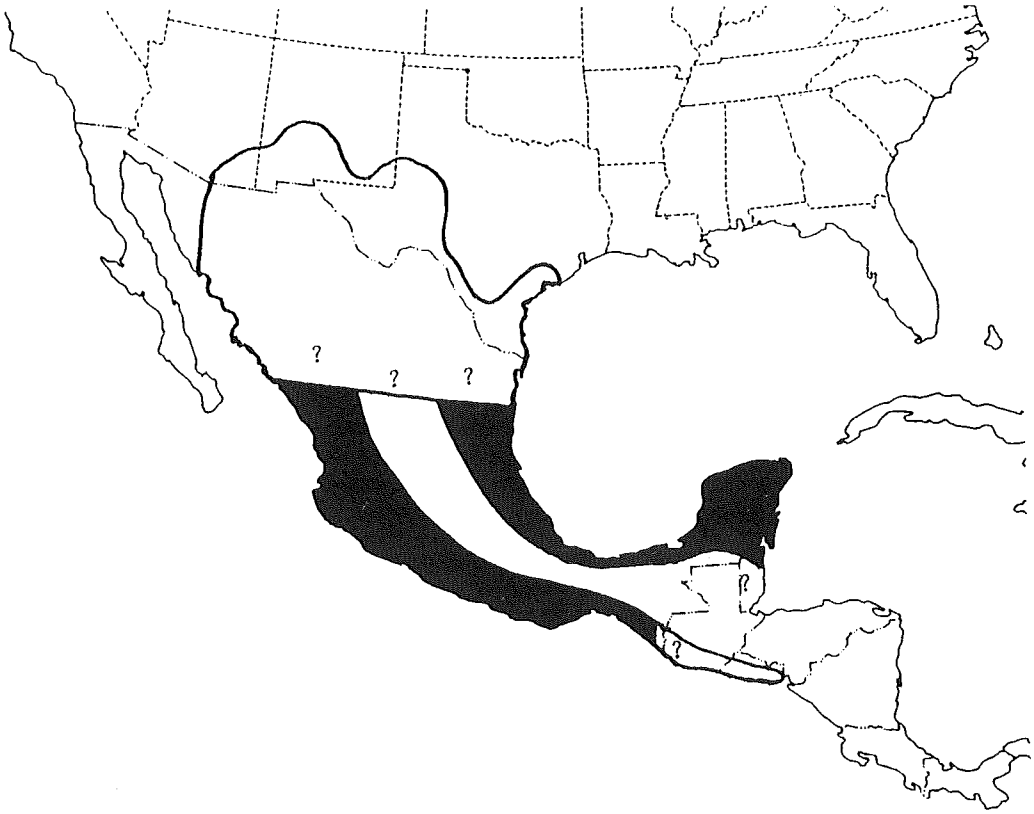

Fig. 1 Breeding distribution of the northern aplomado falcon *Falco femoralis septentrionalis*. The black area shows the approximate current range; heavy lines show the historical limits in the United States and Guatemala. Distribution maps typically show the range as covering most of mainland Mexico, but the species does not occur in dense tropical forest or in the higher elevations of central Mexico; it is essentially a bird of coastal lowlands and interior grasslands and was no doubt always absent from the mountainous parts of northern Mexico as well.

sporadically after that time (Hector, 1987). The last known nesting occurred in Texas (Brooks County) in 1941 (Oberholser, 1974) and near Deming, New Mexico in 1952 (Ligon, 1961). Likewise, no recent nestings have been reported from any of the northern Mexican states. Individual birds are, however, still infrequently sighted in the Brownsville region of Texas and along the US border with Mexico.

Considerable uncertainty remains as to exactly why the aplomado falcon disappeared from this northern portion of its range. Several factors may have been involved, but habitat modifications, pesticide use, and long-term climatic changes seem the most likely. Like another endangered species, the Attwater's prairie chicken *Tympanuchus cupido attwateri*, the aplomado falcon was closely associated with the savannas of the Texas gulf coast and began to disappear there in the second decade of this century. The humid gulf coastal prairies of Texas and Tamaulipas were maintained by naturally occurring range fires and grazing by bison *Bison bison* (Labuda, 1991). By the Second World War much of this prairie had been turned into cropland, and the remaining grassland — because of fire control — soon became overgrown with brushy species such as running mesquite *Prosopsis glandulosa*, blackbrush acacia *Acacia rigidula*, huisache *Acacia smallii*, live oak *Quercus virginiana*, and prickly pear cactus *Opuntia* spp., while many of the native grasses have been displaced by exotic species.

At the same time the arid savannas of west Texas, New Mexico, Arizona and adjacent Mexico were not only altered by the plough but by overgrazing as well. Overgrazing, combined with drought years in the 1930s and early 1940s, appears to have reduced the diversity of the native short grass prairie, enabling more aggressive, exotic species to invade and become dominant, resulting in severe desertification in extreme cases. In many areas the luxuriant tree yucca component of these grasslands had died out by 1950. In time these grasslands became less productive and less suited to the needs of the aplomado falcon. Retrospectively, the decline of the aplomado falcon beginning in the early 1900s foretold the end of the natural grassland ecosystems of this region, but ecologists at the time did not appreciate the significance of "indicator species."

Already greatly reduced in number and increasingly isolated from the more substantial southern breeding populations, the remaining aplomado falcons were probably eliminated by the widespread agricultural use of chlorinated hydrocarbon pesticides (DDT and dieldrin) beginning in the late 1940s and early 1950s. This factor seems likely because aplomado falcons feed heavily on birds which accumulate pesticide residues and because falcons nesting in eastern Mexico have laid eggs heavily contaminated with DDE residues and with much thinner (−25%) than normal eggshells (Kiff *et al.*, 1980).

Today, the future appears brighter for the northern aplomado falcon because of current rangeland practices which employ controlled burning to eliminate brush, a reduction in the use of organochlorine pesticides in the United States, and preservation of some of the remaining stands of tree yuccas in New Mexico. Also, successes by The Peregrine Fund with other species of falcons have encouraged the development of a propagation and reintroduction programme for the northern aplomado falcon in the south-western United States and northern Mexico (Hunt, 1983). The US FWS "Northern Aplomado Falcon Recovery Plan" recommends the use of these techniques to re-establish a viable population in the northern vacated range and has set a goal to establish a minimum of 60 breeding pairs within the next two to four decades (Keddy Hector, 1990). Based on our experience with restoration of the peregrine falcon *Falco peregrinus* in the eastern USA (Barclay, 1988), The Peregrine Fund estimates that it will require the release of 30 to 50 young birds each year over the next 15 to 20 years to achieve that goal, at which time the species might be considered for downlisting to "threatened." To produce this number of young each year will probably require a minimum of 15 to 20 productive pairs or fertilizable females.

Early Research and Conservation Efforts

In 1977 the Chihuahuan Desert Research Institute (CDRI) in Alpine, Texas initiated a programme of research on the effects of DDT on bird-eating raptors in Mexico under the direction of W. Grainger Hunt. This work led to a report on pesticide-related eggshell thinning in aplomado falcons and bat falcons *Falco rufigularis* (Kiff *et al.*, 1980), and to the first detailed ecological studies of the northern aplomado falcon, carried out by Dean Hector (Keddy Hector, 1988). His research has covered diet composition (Hector, 1985), hunting behaviour, including co-operation between male and female (Hector, 1986a), and habitat requirements (Keddy Hector, 1988). In addition, he has extensively discussed the decline of the aplomado falcon in the United States (Hector, 1985, 1986b, 1987, 1988; Keddy Hector, 1988, 1990). As a part of this programme, in 1977 Grainger Hunt, John Langford and Dean Hector were able to obtain four nestling northern aplomado falcons to start a captive breeding project in Alpine, Texas. The following year they obtained four more falcons from Mexico. Langford was put in charge of the captive birds, and he eventually raised the first captive-bred aplomado falcon in 1982. In 1983, the CDRI turned over the eight remaining aplomado falcons from their facility in Alpine to The Peregrine Fund, Inc., and they were subsequently sent to breeding quarters at the Santa

Cruz Predatory Bird Research Group, University of California, Santa Cruz, where they remained until 1989–90. Gary Beeman, a California falconer, added one more falcon to the collection at Santa Cruz.

Involvement of the Peregrine Fund, Inc.

Since the captive breeding of northern aplomado falcons became the responsibility of The Peregrine Fund in 1983, one of our priorities has been to obtain additional breeding stock from Mexico, because the total number of captives available from CDRI is too small to constitute a viable population and because their advanced age (some birds are now 13 to 14 years old) severely limits the amount of future productivity to be expected from them. In September 1986 we began to develop a cooperative arrangement with the Mexican government to collect this additional breeding stock. The Secretaria de Desarrollo Urbano y Ecologia (SEDUE), through the help of Dr. Edgardo Hicks and Douglas Shaffer of the US Embassy in Mexico City, approved our proposal to collect 20 nestling aplomado falcons (10 potential pairs) from nests in the southern part of the breeding range of *F. f. septentrionalis*. This project has become a truly cooperative undertaking, because aplomado falcons released by The Peregrine Fund in south Texas may well disperse southward and help to repopulate northern Mexico. To facilitate this process further, The Peregrine Fund also plans to provide SEDUE with captive-bred falcons, technological assistance, and trained personnel to conduct releases in northern Mexico in areas of suitable looking habitat.

Field Collections and Natural History

Between 27 April and 4 June 1987 a field team consisting of John Langford, Alfonso de Anda Tenorio, Dean Huisman, Ken Sterner and Rafael del Valle Reyna searched

PLATE 1 *TOM CADE*
R. del Valle Reyna with young aplomado falcons *Falco femoralis septentrionalis* in his mews, prior to their shipment to the United States.

approximately 500km of roadside in the states of Tamaulipas, Veracruz, Tabasco and Chiapas for nesting aplomado falcons. They observed a total of 19 aplomado falcons, three individuals and eight pairs, seven with active nests. The nests were in either old raptor stick nests, among epiphytic bromeliads, or in the tops of palm trees. Perhaps the most interesting nest was one located approximately 30m up in a huge, isolated ceiba or silk cotton tree *Ceiba aesculifolia* standing in a cow pasture. The difficult climb to reach this nest took more than six hours and involved the use of an elaborate system of rope ladders.

Five young females and two young males were collected and transported to a US Department of Agriculture quarantine station. Upon release from quarantine the young falcons were sent to The Peregrine Fund's World Center for Birds of Prey in Boise, Idaho, and to SCPBRG in Santa Cruz, California.

Again, between 01 April and 30 May 1988, a team including Ken Sterner, Alfonso de Anda Tenorio, Brian Mutch, Rafael del Valle Reyna and Peter Jenny surveyed suitable habitat in the Mexican states of Veracruz, Tabasco, Chiapas and Campeche for nests of aplomado falcons. These investigators found 25 territories in 43 days of search covering 8,000km of travel. They located 15 active nests in Veracruz, Tabasco and Chiapas, and they believe that many more nests could have been found given more time. The mean brood size for these nests was 2.3 young per nest (N=10) with a range from one to four.

These nests were located in epiphytic growths or in small, abandoned nests of the grey hawk *Buteo nitidus*, roadside hawk *Buteo maginostris*, and brown jay *Psilorhinus*

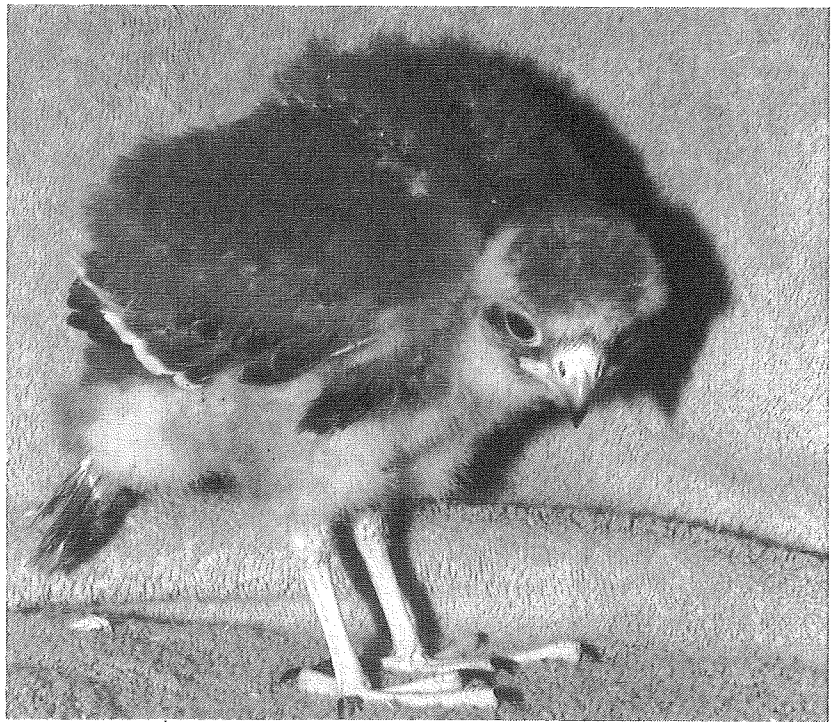

PLATE 2 *TOM CADE*
Downy young aplomado falcon *Falco femoralis septentrionalis* 21 days old. Note the unusual bi-coloured, second down, which is deep smoky grey on the dorsum and greyish white on the ventrum. Specks of pure white down appear on the tips of some contour feathers. In contrast, the first, natal down is a yellowish, sandy white and also emerges at the tips of contour feathers. Note the relatively long, accipiter-like legs.

morio at the very tops or at the extreme edges of large, isolated trees. Climbing to the nests was difficult and often dangerous, as the size of the limbs supporting the nests were quite small and the branches themselves very brittle.

It is worth noting that all observed aplomado falcon territories were in close association with cattle ranching operations. Possibly the vegetative morphology resulting from cattle grazing may be important in maintaining optimum nesting habitat for aplomado falcons.

Ten young ranging in age from 14 to 28 days were taken from 10 different nests. Rafael del Valle Reyna constructed a temporary holding facility at his home and gave expert care to the young until they could be exported. Prior to export he raised the young falcons together in a group while at the same time exposing them to normal human activities in an effort to produce semi-tame but normally socialized falcons. The young were quarantined on 31 May in New York and then sent to The World Center for Birds of Prey, where they were joined in 1989 and 1990 by all of the aplomado falcons previously held by SCPBRG.

Captive Breeding

Methods: Generally the methods adopted for housing, feeding and managing the reproductive output of captive aplomado falcons have followed those worked out earlier for the peregrine and other species (see Weaver and Cade, 1985). Housing and husbandry have varied somewhat among the three facilities where aplomado falcons have been bred in the United States. (Parenthetically it should be noted that Johan Geladé (pers. comm.) has also bred aplomado falcons in captivity in Belgium.) For instance, in the mild climate of California at SCPBRG the paired falcons were kept in enclosures with opaque walls and with open roofing to allow for maximum natural light and fresh air, whereas in Idaho where the winters are much colder at the WCBP, the birds are in enclosures with partially open exposure to the outside at one end only. Inside illumination can also be supplemented with artificial light, and some chambers have controlled temperature. Otherwise, the furnishings are much the same at the two facilities and consist of one or more specially designed nest boxes, one-way glass viewing or video monitoring of the chambers, and a variety of perches arranged to allow the falcons to get plenty of exercise in an area of approximately 3 by 6m and height of 4 to 6m. Food is introduced covertly through inclined chutes onto a shelf perch, and water for drinking and bathing can be provided remotely.

The falcons are fed a variety of whole animal carcasses, including coturnix quail, other smaller birds and lab. mice, with occasional supplements of crickets or meal worms. During the mating season, domesticated zebra finches *Poephila guttata* are introduced into the chambers, and the male falcons feed these to their mates. This procedure appears to strengthen the pair bond by stimulating courtship feeding and to promote sexual activity.

The usual clutch in the wild is three eggs. As with the peregrine and other species, reproduction has been manipulated in captivity by extending the laying cycle by sequential removal of eggs or by multiple clutching, by artificial insemination in some cases, and by incubating and hatching eggs in laboratory incubators (Weaver and Cade, 1985). Typically the chicks are hand-reared in the laboratory until they are 10 to 14 days old and then, when possible, given to a parentally motivated pair to raise to the fledgling stage; otherwise, they are reared in groups of two or more to promote normal socialization.

At SCPBRG the birds were tended by Karen Burnson, Janet Linthicum and Nancy Clum. Willard Heck and Peter Harrity manage the breeding colony at the WCBP.

Results and Discussion: At CDRI a female laid three infertile eggs in 1980. Since then ten females have laid a total of 279 eggs, of which 91 (33%) were fertile. Fifty-nine eggs hatched, and 48 young have been raised. These data are summarized in Table I. Only about one third of all eggs laid have been fertile, and only 65% of the fertile eggs hatched. It should be noted, however, that many of the infertile eggs were laid by single females, females with immature males, females with a human-imprinted male, or females accidentally paired with another female. Clearly there is a need to increase the rate of fertility and hatchability. These are the same two hindrances that have impeded the productivity of all captive breeding programmes for raptors, but they are especially serious in the case of the aplomado falcon. On the other hand, survival of hatchlings to maturity has been good, with only 11 losses out of 59 hatched.

The aplomado falcon has proved to be a more difficult species to breed in captivity than the peregrine and shows more similarity to the merlin *Falco columbarius*, another difficult species. Although in the wild aplomado falcons are rather tame in the presence of human observers and easily approached, they tend to be excitable and nervous in confinement, easily startled by strange sights or sounds. The mates often exhibit high levels of aggression toward each other during certain phases of the breeding cycle, especially the female toward the male during laying and incubation. Part of the hatching failure may stem from this aggression during early incubation before the eggs are removed to the laboratory. Supplementing the food with live prey at this time may help to reduce aggression. Chris Olwagen (pers. comm.) in South Africa has found that giving live prey to captive red-headed falcons *Falco chicquera*, a species behaviourally similar to the aplomado falcon, greatly facilitates mating and the production of fertile eggs.

Further research and consequent modifications of husbandry will continue, and we feel confident that the productivity of our captive falcons will improve. It should be possible to obtain a fertility rate of at least 50%, and a hatch rate of 80–85%, as indicated by our 1991 results (Table 1). The loss of hatchlings has resulted mainly from an unidentified pathogen currently under investigation.

TABLE I. REPRODUCTION BY CAPTIVE APLOMADO FALCONS IN THE UNITED STATES.

Year	No. of adult females	No. of laying females	No. of fertile females	Total eggs	Eggs fertile	Eggs hatched	Young fledged
1980*	3	1	0	3	0	0	0
1981*	3	0	0	0	0	0	0
1982*	3	3	1	21	3	1	1
1983	3	2	0	5	0	0	0
1984	4	4	2	15	6	2	2
1985	5	5	3	32	15**	4	4
1986	5	5	2	31	9	6	5
1987	5	5	2	29	9	6	6
1988	5	5	2	30	12	9	8
1989	8	8	4	30	9	7	6
1990	11	10	4	40	6	6	4
1991	13	8	4	43	22	18	12
Totals	—	—	—	279	91	59	48

* Data provided by John Langford.

** Some of these eggs which "died" early under the female may have been infertile.

Reintroduction

Methods: Ten groups of two to four young were experimentally released at four sites in south Texas to see whether the modified hacking procedure developed for the reintroduction of the peregrine falcon (Sherrod *et al.*, 1981) would also work for aplomado falcons. Hack boxes were placed on 4 m high supports with mammalian predator guards and located in suitable looking savanna habitat in south Texas. The boxes were specially insulated and painted white as protection against the intense solar heat of the region. In addition, the tops of the boxes were covered with mesquite brush to break up the silhouette of the perched falcons and provide a natural camouflage as partial protection against great horned owls *Bubo virginianus* and other predators. More recently 26 artificial stick nests have been placed in tops of existing plants in the vicinity of hack sites as potential perching, roosting, feeding and nesting locations for the released falcons.

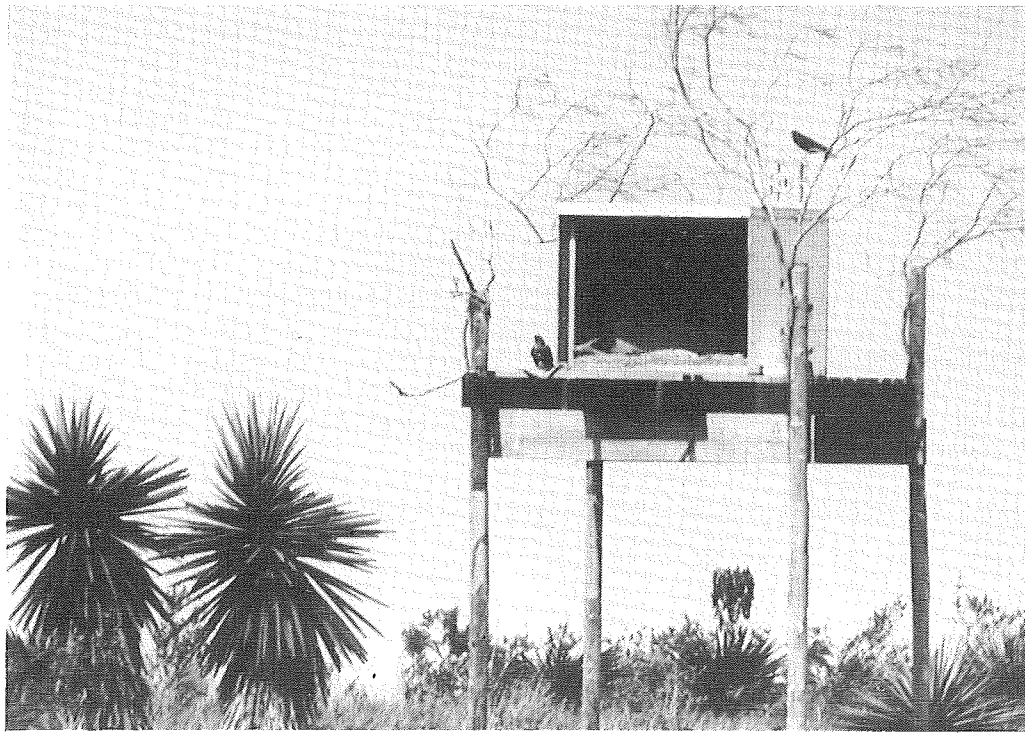

PLATE 3 *TOM CADE*
Hack tower in the Laguna Atascosa National Wildlife Refuge, Texas.

The first hack site in 1985 was located in the Conejo Pasture of the King Ranch, Kleberg County, Texas, the locality where the last aplomado falcon was collected in Texas in 1949. The habitat there is a brush/grassland mosaic dominated by mesquite *Prosopsis juliflora* and sweet acacia (huisache). The topography is generally flat, and the climate is hot and humid. Thunder showers were frequent, often heavy, and somtimes lasted all day during the period of release. Hacking was also conducted in 1986 through 1989 at three different locations in or near the Laguna Atascosa National Wildlife Refuge, Cameron County, Texas. This refuge is a rich coastal area of interdigitating waterways, marshes, and at higher, inland elevations, extensive open grasslands with scattered hummocks of tree yuccas and mesquite. Small birdlife abounds, and there are fewer great horned owls than in the bushier areas of south Texas. The releases were carried out under the field supervision of Craig Himmelwright and Matt Nixon.

TABLE II. RESULTS OF RELEASING CAPTIVE-BRED APLOMADO FALCONS IN SOUTH TEXAS.

Year	Location	Number Released		Number Independent***	
		Males	Females	Males	Females
1985*	King Ranch	2	2	1?	1?
1986	Laguna Atascosa no. 1	2	2	2(1?)	2
1987	Laguna Atascosa no. 2	1	1	1	1
1987	Buena Vista Ranch	1	1	1	1
1988*	Laguna Atascosa no. 2	5	2	3	1
1989**	Laguna Atascosa no. 2	5	2	3	2
	Totals	14	10	9–11	7–8

* Two staggered releases from one box.
** Three staggered releases from two boxes.
*** Birds capable of hunting on their own and fully independent of human care.

Results and Discussion: Table II summarizes the results of these experimental releases. Difficulties were quickly encountered at the site on the King Ranch from unexpectedly persistent harassment of the newly fledged young falcons by scissor-tailed flycatchers *Tyrannus forficatus* and predation by great horned owls. Following their rescue from the flycatchers and a second release from the hack box, two birds dispersed prematurely, probably because of their advanced age, and were never seen again, even though they were carrying radio transmitters. Great horned owls killed two other birds released later at the same site.

The releases at Laguna Atascosa refuge have been more successful and lead to confidence that a slightly modified hacking procedure provides an effective way to reintroduce aplomado falcons into vacant range. Of the 20 falcons released there, only three were killed by predators during hacking, while one male disappeared early. Since aplomado falcons become self-sufficient and independent hunters at an earlier age than peregrines do, an "early dispersal" does not necessarily mean that the bird will not survive.

Reports of subadult and adult aplomado falcons in and around the Laguna Atascosa NWR have increased in the last few years. From the beginning there have been late autumn and winter sightings in the refuge, indication that some of the released falcons were surviving. Then, in the summer of 1989 a banded (ringed) subadult male appeared at the hack site on 7 June and became a daily visitor. He fed on food provided to the young, but he also initiated hunts on birds, in which the released falcons participated. Nightly he joined the released young at their evening roost. This is the first record of an aplomado falcon returning at least one year after release. Falcons were again wintering in the refuge and around the Port of Brownsville in 1990–91; and two adults were seen perched side by side in April of 1991 near Deer Island on Laguna Madre, not far from the refuge (S. Francis, pers. comm.).

Conclusions

Twenty-four captive-bred aplomado falcons have been released in south Texas from 1985 to 1989 and the results have led to some modifications of the standard hacking procedure first developed for the peregrine falcon to suit the needs of this species. Suitable habitat for the release and re-establishment of the aplomado falcon appears to occur along the southern gulf coast of Texas and northern Mexico and may even

be increasing under recent land management practices. Potential habitat for the reintroduction of aplomado falcons may also exist in southern New Mexico and Arizona. To implement the US FWS recovery plan for this endangered species will require the release of 30 to 50 young falcons per year for 10 to 15 years. The current level of captive propagation will need to be increased four-fold to accomplish this goal, but we believe that the 35 subadult and adult falcons now assembled at the World Center for Birds of Prey have the potential to reach this level of production in two more years.

Acknowledgements

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