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POST-RELEASE SURVIVAL OF HAND-REARED AND PARENT-REARED MISSISSIPPI SANDHILL CRANES[1]

DAVID H. ELLIS
USGS Patuxent Wildlife Research Center, 12302 Beech Forest Road, Laurel, MD 20708-4022, e-mail: david_h_ellis@usgs.gov

GEORGE F. GEE
USGS Patuxent Wildlife Research Center, 12100 Beech Forest Road, Laurel, MD 20708-4041

SCOTT G. HEREFORD
U.S. Fish and Wildlife Service, Mississippi Sandhill Crane National Wildlife Refuge, 7200 Crane Lane, Gautier, MS 39553

GLENN H. OLSEN
USGS Patuxent Wildlife Research Center, 12302 Beech Forest Road, Laurel, MD 20708-4022

T. DAVID CHISOLM
U.S. Fish and Wildlife Service, Southeast Louisiana Refuges, 1010 Gause Boulevard, Building 936, Slidell, LA 70458

JANE M. NICOLICH
USGS Patuxent Wildlife Research Center, 11510 American Holly Drive, Laurel, MD 20708-4019

KATHLEEN A. SULLIVAN
Florida Game and Fresh Water Fish Commission, 2303-A Simpson Ridge Circle, Kissimmee, FL 34744

NANCY J. THOMAS
USGS National Wildlife Health Center, 6006 Schroeder Road, Madison, WI 53711

MEENAKSHI NAGENDRAN
3452 Vinton Avenue, Los Angeles, CA 90034

JEFF S. HATFIELD
USGS Patuxent Wildlife Research Center, 11510 American Holly Drive, Laurel, MD 20708-4017

Abstract. The Mississippi Sandhill Crane (*Grus canadensis pulla*) reintroduction program is the largest crane reintroduction effort in the world. Here we report on a 4-year experiment in which we compared post-release survival rates of 56 hand-reared and 76 parent-reared Mississippi Sandhill Cranes. First-year survival was 80%. Surprisingly, hand-reared cranes survived better than parent-reared birds, and the highest survival rates were for hand-reared juveniles released in mixed cohorts with parent-reared birds. Mixing improved survival most for parent-reared birds released with hand-reared birds. These results demonstrate that hand-rearing can produce birds which survive at least as well as parent-reared birds and that improved survival results from mixing hand-reared and parent-reared birds.

Key words: Grus canadensis, *reintroduction techniques, Sandhill Crane.*

INTRODUCTION

Sandhill Cranes (*Grus canadensis*) were known to be resident along the Gulf of Mexico coastal plain from Alabama as far west as mid-Texas as late as the 1890s (Oberholser 1974). The breeding of Sandhill Cranes in Mississippi was first announced in a 1929 unpublished report by Aldo Leopold. Even prior to the description of the Mississippi Sandhill Crane as a separate subspecies (*G. c. pulla,* Aldrich 1972), this small, dark race was considered to be in danger of extirpation (McIlhenny 1938, USFWS 1991).

The causes for the decline of this population were unrestricted hunting and the conversion of its habitat to pine plantations (Leopold, unpubl.

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data, USFWS 1991). The installation of drainage ditches and road berms interrupted sheet flow of water across the landscape, left the area drier, and also made the remaining depressions more prone to flooding. Abnormally high levels of adenocarcinomas, probably caused by as yet unidentified air or water pollutants (Couvillion et al. 1991, White and Hardy 1994), have been found in this population (Langenberg et al. 1994).

With the creation of the Mississippi Sandhill Crane National Wildlife Refuge (hereafter, Refuge) in 1975, efforts focused on bolstering the wild population and restoring habitat. From the 1940s through the 1980s, the wild population was estimated at 25–60 birds. Releases of captive-reared juveniles began in 1981 with birds reared in 1980. Birds involved in the early releases were reared by pairs of Sandhill Cranes in pens at the Patuxent Wildlife Research Center (hereafter, Patuxent), then released during their first winter. One-year survival rates for these early releases varied greatly (Zwank and Wilson 1987, Zwank et al. 1988) but averaged 62% (41 of 66 cranes: Ellis et al. 1992b). Since 1988, over half of the wild flock has consisted of birds of Patuxent origin, and by then, a few release birds had successfully paired and reproduced (McMillen et al. 1987, Valentine and Hereford 1997). Even with infusions of 2 to 13 birds annually (total from 1981–1989, 66 or 67 birds), the population is believed to have never exceeded 65 birds until the present study began.

With the release of nearly 300 birds, the Mississippi Sandhill Crane program is the largest crane reintroduction effort in the world. In the amount of "potential birds" released, the only comparably large release is the, now terminated, Grays Lake experiment which involved placing 289 Whooping Crane eggs in Sandhill Crane nests in Idaho (Drewien et al. 1982, Ellis et al. 1992a).

During the past two decades, many attempts have been made to release small numbers of captive-reared cranes of several species around the world. Hand-reared birds at first proved unsuitable for reintroduction because they were reluctant to associate with wild conspecifics (Nesbitt 1979). As a result, most recent releases have involved rearing birds in pens with their natural or surrogate parents (Nagendran et al. 1996). These parent-reared birds proved to be much wilder than birds hand-reared by uncostumed humans, and consequently were better able to adapt to the wild (Drewien et al. 1982, Zwank and Derrickson 1982). Parent-reared cranes learn some foraging skills from their parents. Unfortunately, parent-rearing requires maintaining a captive flock of foster parents. Care of crane chicks also is much more difficult in field pens, and parent-rearing increases the risk of disease, parasite infestation, exposure to weather extremes, predation, and accidents (Ellis et al. 1996).

In 1989, Patuxent began a concerted effort to produce and release about 30 chicks annually. This was accomplished not only by an increase in the number of parent-reared chicks, but also by the addition of chicks hand-reared by humans disguised in amorphous gray costumes. We reasoned that if we could adapt a hand-rearing technique to produce birds suitable for reintroduction, the aforementioned problems associated with parent-rearing could be avoided, and a larger number of cranes could be released.

Herein, we compare survival rates of 56 hand-reared and 76 parent-reared chicks reared from 1989 through 1992 and released during their first winter. We also report the survival effects of the composition of the release group, release pen, and year. Although cause of death is very often not known, we report the importance of general mortality categories where known.

METHODS

Except for three chicks hatched from eggs collected from wild nests in Mississippi, birds used in the study were from eggs produced by the captive flock at Patuxent. Eggs were either naturally incubated under Sandhill Crane parents or machine incubated. Chick fledging rates at Patuxent averaged 76% (163 of 215 Mississippi Sandhill Crane chicks) from 1989–1992.

REARING TECHNIQUES

The hand-rearing technique used for this study is based on costume-rearing (humans wearing costumes) first begun in the 1960s at Patuxent, developed for release birds by Horwich (1986, 1989), refined for use with larger numbers of cranes by Urbanek and Bookhout (1992, 1994), and made more elaborate specifically for this study (Ellis et al. 1992b).

Our rearing techniques are described in detail elsewhere (Ellis et al. 1992b). In general, parent-reared chicks were hatched under their own or

FIGURE 1. Parent-reared chicks were introduced as eggs or hatchlings to their Sandhill Crane foster parents. Thereafter, the foster parents reared the chicks much as would wild cranes.

foster parents and remained in their parents' pen for 95–156 days (Fig. 1). Thereafter, they were combined into small cohorts of up to a dozen birds in large, netted, flight pens (15- to 30-m long) at Patuxent. The general process in hand-rearing (Ellis et al. 1992a) involved costumed humans (Fig. 2) using taxidermy mounts of crane heads to teach the chicks to feed, mounts of adults lying in brood posture with a heat lamp overhead, and Sandhill Crane brood calls played by tape recorder during hatching and either played when interacting with chicks as in 1989 or imitated by humans as in 1990–1992. A live adult Sandhill Crane "imprinting model" was housed adjacent to neonatal chicks, and a group of Sandhill Crane "socialization models" were housed outdoors adjacent to the end of each chick pen (see pen diagram in Fig. 12.3, Swengel and Besser 1996). Each chick was reared in a separate pen, with each pen having an indoor and an outdoor run. At 3–5 months of age, colts were pooled into release cohorts at Patuxent just as for parent-reared chicks.

RELEASING CRANES

Release cohorts were formed each year by randomly assigning 9–12 chicks to one of three experimental groups. One group was composed entirely of costume-reared chicks, another of parent-reared chicks, and a third group contained a combination of costume-reared and parent-reared chicks (hereafter, mixed cohort). Chicks were held in release cohorts for 4–5 weeks, then boxed and shipped by air to the Refuge in mid-November.

At the Refuge, the cohorts were placed in one of three release pens chosen as follows. During the pilot (1989) and following (1990) years, pen assignments were random. To be sure that each cohort type was present in each pen in some year, in 1991 pen assignment was restricted-random and, for the same reason, in 1992 the as-

FIGURE 2. Hand-reared crane chicks were occasionally led afield by a costumed caretaker and given opportunities to forage for insects and to use natural marsh habitat.

signments were fixed. Release pens were at least 1 ha and unnetted, so the cranes had to be wing brailed (i.e., one wing is bound by a plastic strap to prevent flight: Ellis and Dein 1996) during the month-long acclimation period.

Each release experiment began when the wing brails were removed, sometime between 11 and 22 December. After the brails were removed, the cranes entered and left the pen until they were assimilated into the wild flock. Interaction with wild cranes actually began prior to debrailing because wild birds often entered the release pen for pelletized food. Juvenile movements were visually monitored daily from distant blinds and via radio telemetry.

BANDING AND RADIO TAGGING

VHF radio transmitters were attached when the chicks were introduced into their release pens at the Refuge in mid-November. These were mounted on 7.7-cm-tall plastic leg bands and attached just above the hock joint as recommended by Melvin and Temple (1987) and Nesbitt (pers. comm.). Transmitters weighed 50–60 g (about 2% of the chick's body mass), including band, and were equipped with mortality switches which changed pulse rates from 45–70 bpm to 80–130 bpm when the transmitter laid inactive for 6 hr (i.e., following death). About half of the transmitters were solar powered (SolarR), and half were lithium battery-powered (LiR). LiR transmitters had a projected life expectancy of 730 days. Reception varied, but nearly all could be received 2–3 km ground-to-ground or 10–12 km air-to-ground.

Each crane also was fitted with a U.S. Fish and Wildlife Service metal band attached just above the toes and a 7.7-cm-tall, colored, plastic band attached above the other hock joint. Plastic bands, including those used with radio transmitters, were of bilaminate plastic and were inscribed with 2-cm-tall black or white letters. Bands could be read at approximately 250 m with a 25–60× telescope.

CONVENTIONS IN DATA HANDLING

The following conventions were followed in data acquisition and analysis. First, in measuring

TABLE 1. Number of birds released for each combination of year, rearing method, and cohort (mixed or not mixed). The proportion of censored observations, birds either alive at the end of the study or that disappeared during the study (all birds other than those found dead), are shown in parentheses.

	Parent-reared		Hand-reared	
Year	Mixed cohort	Not mixed cohort	Mixed cohort	Not mixed cohort
1989	8 (0.88)	8 (0.50)	2 (1.00)	9 (1.00)
1990	7 (1.00)	12 (0.67)	4 (0.50)	10 (0.90)
1991	9 (0.89)	11 (0.27)	4 (1.00)	8 (0.63)
1992	7 (0.86)	14 (0.79)	7 (1.00)	12 (0.67)
Totals	31	45	17	39

survival, day 0 was the date of debrailing. Consistent with this rule, one bird that died in the release pen prior to debrailing was eliminated from the study. Other cranes deleted include a bird that was debrailed but died due to an accident prior to flying from the release pen and a bird judged to be too tame for release while still at Patuxent. Another six hand-reared and five parent-reared cranes were eliminated from the study when they were determined to be physically unfit for release. An additional eight birds had significant heart mummers still present when shipped to Mississippi. Because a high proportion of such birds die within two years even if retained in captivity (Olsen and Gee 1997), these eight were released but not included in the data set. The remaining 132 birds were included in the analyses (Table 1). Because survival estimates are only through 31 January 1996, we present six years of survival data for birds reared in 1989 but only three years for birds reared in 1992.

PREDATOR CONTROL AND CONVENTIONS IN HANDLING WEAKENED OR DEAD CRANES

After 5 of 10 juvenile cranes released on the Refuge in 1984 were killed by predators, the Refuge commenced a program of intermittent, seasonal trapping for predators. During the years of our experiment, an annual average of 33 (range = 28–42) predators of the size likely to take grown cranes were removed.

Cranes recovered (mostly by telemetry) after death were preserved by refrigeration or freezing, then sent to the National Wildlife Health Center, Madison, Wisconsin for necropsy. Necropsies were performed for 17 study cranes. At necropsy, samples of the major organs from most cranes were fixed in 10% buffered formalin. Tissue sections were paraffin embedded, hematoxylin- and eosin-stained, and then examined by light microscopy. Selection of other diagnostic laboratory tests was based on the history and gross lesions and included various microbiologic, virologic, parasitologic, and toxicologic procedures. Liver lead concentration (Boyer 1984), brain cholinesterase activity (Smith et al. 1995), and gastrointestinal parasitism were assessed in most of these same cranes.

Five other cranes were recovered emaciated or otherwise judged incapable of survival in the wild and removed from the study. Because these birds were captured by uncostumed humans and were therefore judged to be highly vulnerable to predation, we used the date of capture as the death date.

STATISTICAL ANALYSES

We used survival analysis (Lawless 1982, Blackwood 1991) in testing for differences among years, pens, release cohorts, and treatments. This little-used technique has proven useful in other recent studies (Fox 1993, Fuller et al. 1995, Erwin et al. 1996). One of its advantages is that it allows for use of censored data (Table 1), whereas chi-squared and contingency table analyses do not. Data are censored after a bird disappears from the study area but its fate is unknown. Data also are censored at the end of the study for all survivors. We used the Kaplan-Meier product-limit nonparametric method for the computation of functions among variables (Proc LIFETEST, SAS 1996) and the log-rank statistic to test for differences. Differences were considered significant when $P < 0.05$.

RESULTS

DISPERSAL AND LONG-TERM IDENTIFICATION

Data collection for this study was complicated by the dispersal of a few release cranes. Three were relocated 4, 4.5, and 5 km from the Refuge. Lost (and sometimes presumed dead) cranes have reappeared on the Refuge. The extremes for study birds were 25 and 26 month absences for three birds. Band loss also complicated our efforts to determine survival. For example, one crane was last located by radio in September 1992, then lost its radio and plastic band. We did not know its fate until October

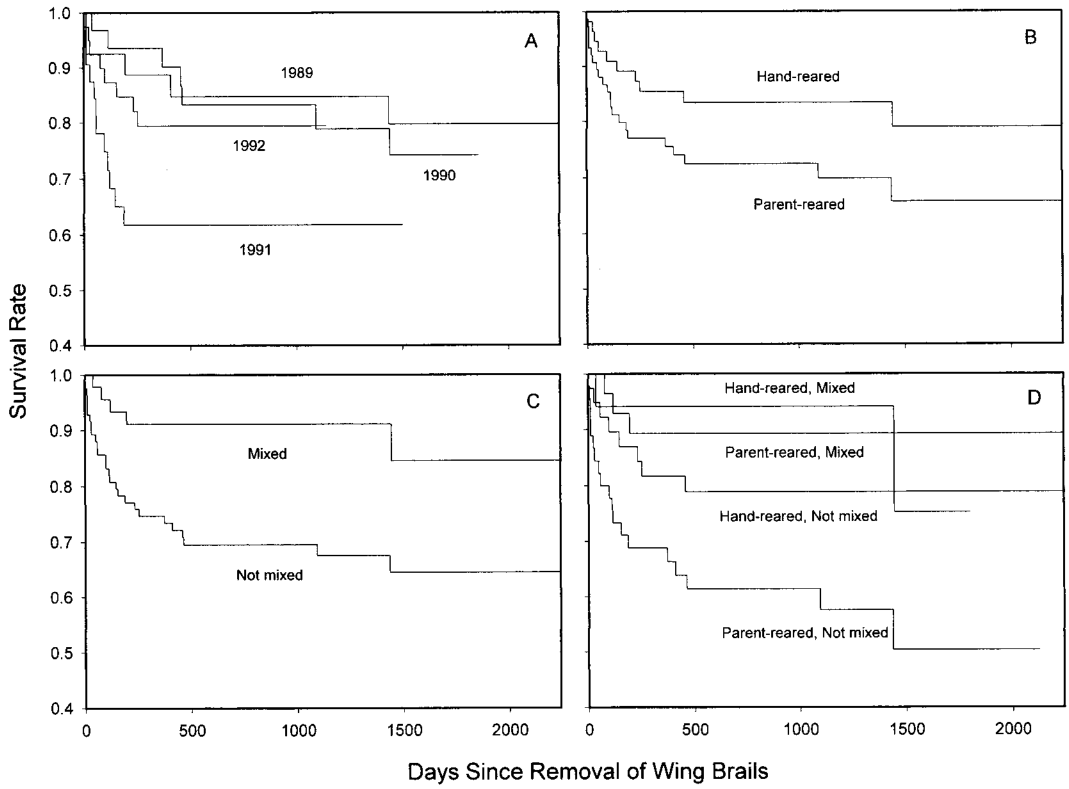

FIGURE 3. Nonparametric survival functions showing survival rates of (A) cranes reared in the years 1989–1992, (B) the two rearing methods, (C) the mixed and not mixed cohorts, and (D) the four treatment combinations of rearing method and release cohort.

1995 (37 months later) when the crane was trapped and its metal band read.

The long duration of the study led to logistical problems with the VHF radios. The major problem was band breakage. Because we tried to locate cranes three times/week, we normally could visually detect birds with failed or fallen radios by first finding flock mates with functional radios. However, the difficulty of reading bands on birds without radios led us to expend great energy trapping birds to replace radios. Although the average longevity of radios was comparable for LiR (383 ± 238 days, n = 66) and SolarR (366 ± 316 days, n = 68), variability was lower for LiR.

SURVIVAL RATES AND MORTALITY FACTORS

Because there were no statistically significant differences in survival among years (χ^2_3 = 6.6, P = 0.09, Fig. 3A), we did not consider year effects in the remainder of our analyses. Differences between survival rates for the three release pens were not significant (χ^2_2 = 4.0, P = 0.14). There was considerable difference in survival between rearing methods, especially for the first four years (Fig. 3B). Although it was counterintuitive, hand-reared birds showed better survival; however, when we compared survival for the duration of the study, there was no detectable statistical difference (parent-reared versus hand-reared, χ^2_1 = 2.5, P = 0.11). There was significantly higher survival for mixed versus not-mixed cohorts of either parent-reared or hand-reared cranes (χ^2_1 = 6.9, P = 0.01, Fig. 3C).

There were highly significant differences among treatments (χ^2_3 = 13.5, P < 0.01, Fig. 3D). Most of these differences were due to the parent-reared, mixed birds having much better survival than parent-reared, not-mixed birds (χ^2_1 = 8.3, P < 0.01), but there also was significantly better survival for hand-reared, not mixed birds compared to parent-reared, not mixed (χ^2_1 = 4.6, P = 0.03). We also found significantly lower survival for parent-reared, not mixed when compared with hand-reared, mixed (χ^2_1 = 4.7, P = 0.03). No other pairwise comparisons revealed significant differences. When a Bonferroni adjustment was made for these multiple comparisons, only the first pairwise comparison (parent-reared, mixed versus parent-reared, not mixed) above showed significant differences ($P < 0.01$).

Of 17 study cranes that did not survive and were necropsied, 5 were confirmed as having been killed by predators. Another two died from traumatic injuries of unknown sources and were suspected predator kills. Disease and contaminants accounted for one crane each (Seal and Hereford 1994, unpubl. data).

DISCUSSION

This paper provides our best estimates of survival of captive-reared Sandhill Cranes. However, a companion paper (available from the first author) provides the actual counts of the individuals known to be alive at various intervals after release. Presentation of our data now, six years after the release of the last birds, allowed time for survival data to accumulate and for those birds that were temporarily lost because of transmitter failure, band loss, or emigration to be reidentified. The number of birds dispersing or losing plastic bands was small enough (ca. six birds) that our statistical treatment of the data should be little affected. Lost birds were censored in the Kaplan-Meier estimator.

Overall, survival of study birds was excellent: our estimation of 1-year survival for all cranes was about 80% (Fig. 1B). If we consider only those birds known to be alive (unpubl. data), 1-year survival was 72% (77% for 56 hand-reared cranes, 68% for 76 parent-reared cranes), little different from our estimate.

Many studies have provided estimates of crane survival for various stages of crane life-history. Most of these are hampered by small sample size, involve periods of time that are not comparable to our survival estimates, and/or involve migratory populations that are extremely difficult to monitor long term. The only study of a wild population that provides comparable data is Nesbitt's (1992) estimate of survival from fledging to independence, day 80 through 290, for Florida Sandhill Cranes (*G. c. pratensis*). Of 25 Florida Sandhill Cranes that fledged, 82% by one estimate and 87% by another estimate, survived to independence 210 days later. Our estimates of survival from removal of brails to 1-year thereafter was 80%.

The most important finding of this study was that hand-reared cranes survived at least as well as parent-reared birds. From Fig. 3B, hand-rearing provided some survival benefit not only to the hand-reared cranes, but also to those parent-reared cranes released with hand-reared birds (Fig. 3D). One likely explanation is that our parent-reared chicks had acclimated to the approach of motor vehicles and uncostumed humans while being reared at Patuxent. They were, as a result, less wary of the approach of humans and predators after release. In our study, these less-wary birds benefited by associating with more wary, hand-reared flock mates, hence the improved survival of parent-reared chicks released in mixed cohorts with hand-reared chicks (Fig. 3D). The minor improvement in survival of hand-reared chicks released with some parent-reared chicks is perhaps associated with the former learning foraging skills from parent-reared chicks which had been raised afield with ample opportunity to learn from their parents. How well our birds would have survived without predator control is unknown. It is certain, however, that the predators were common on the refuge even with predator control.

During our study, the crane population on the Refuge increased stepwise and dramatically to 133 birds in October 1993. For seven years prior to the study, the wild population (October counts) ranged between 32 and 54 birds even with the release of 2 to 13 parent-reared birds annually. Since 1993, fall counts have ranged between 96 and 133. Although parent-reared cranes from previous releases at the Refuge have bred with wild cranes and successfully raised chicks (Zwank and Wilson 1987, Ellis et al. 1992b), we have just recently seen hand-reared birds from this study pair and attempt to breed. Our high survival rates for hand-reared birds are encouraging and allow for the release of larger numbers of cranes without the expense of maintaining a captive colony of adult pairs to support a parent-rearing program. Highest survival, however, was achieved from a mix of hand-reared and parent-reared birds.

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