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# A COMPARISON OF BEHAVIOR FOR TWO COHORTS OF CAPTIVE-REARED GREATER SANDHILL CRANES RELEASED IN NORTHERN ARIZONA

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*Abstract*: To determine how the behavior of greater sandhill cranes (*Grus canadensis tabida*) changes according to time of year, time of day, and number of days after release, we observed the activities of 2 groups of captive-reared greater sandhill cranes at Mormon Lake, northern Arizona. The behaviors we compared were alert, loafing, sleeping, foraging, preening, locomotion, and other. We found costume-reared subadult greater sandhill cranes that were established at the study site for a year spent more time foraging and being alert towards predators than parent-reared juvenile greater sandhill cranes that were recently released from captivity. We also found that with time juvenile sandhill cranes were increasingly alert and spent less time loafing. It appeared that captive-reared juvenile sandhill cranes learn behavior important for survival from previously released captive-reared cranes.

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**Key words:** Arizona, behavior, costume-rearing, *Grus canadensis*, parent-rearing, sandhill crane.

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To survive and reproduce, a crane must allocate a certain amount of time toward a variety of activities such as eating, sleeping, and being alert for predators. Orians (1961) argued that even subtle differences in time budgeting may affect an individual's reproductive success. Therefore, experiments designed to create or augment crane populations with captive-reared cranes need to consider how the behavior of birds that were recently released compares to either wild or to previously released conspecifics. Time budget comparisons may provide insight about differences in food gathering efficiency, predator awareness, and other survival skills. Additionally, discovering differences between released cranes that do and do not survive in the wild can provide lessons for future reintroductions.

We provide a time budget analysis for 2 groups of greater sandhill cranes that were captive-reared with different methods and released at different times in northern Arizona. The first group consisted of 4 costume-reared sandhill cranes (trucking cranes) from an original group of 12 sandhill cranes that were taught a migration route in October 1996 by following a truck approximately 620 km from Garland Prairie, northern Arizona, to the Buenos Aires National Wildlife Refuge, southern Arizona (Ellis et al. 2001*a*). The purpose of this trucking migration was to develop a technique, using the sandhill crane as a surrogate species, to create additional disjunct migratory populations of the whooping crane (*G. americana*).

The second group consisted of 8 parent-reared, juvenile greater sandhill cranes that were released into the group of 4 trucking cranes throughout the summer and fall of 1998 with the one-by-one release method described by Ellis et al. (2001*b*). In this release technique, the juveniles were released one at a time from an acclimated-release pen into the flock of the previously established trucking cranes. We released the juveniles to see if they would integrate into the social structure of the trucking cranes, survive, and eventually fly with the trucking cranes to the desired wintering grounds.

## STUDY AREA

The release site was located at Mormon Lake (34°52' N, 112°30' W) in northern Arizona. This shallow, bulrush (*Scirpus* sp.) marsh reaches a maximum area of ca 400 ha after the spring snowmelt and gradually decreases in size until completely dry in late fall. We chose this ephemeral lake because we hoped to restore a breeding population of sandhill cranes at this location where cranes last bred over 100 years earlier (Phillips et al. 1978). Also, because sandhill cranes have not recently summered at or near the release site, we considered the area appropriate to approximate the release situation of future reintroductions of the whooping crane. This is because future experiments attempting to create disjunct, migratory populations of the whooping crane will not have other whooping cranes available to lead releasees along a desired migration route. Mormon Lake also had several advantageous habitat characteristics for sandhill cranes (McMillen et al. 1992 and Faanes et al. 1992); (1) a fine substrate (i.e., clay or sand), (2) unobstructed visibility

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from bank to bank and unobstructed visibility of several hundred meters from bank across land, (3) width of lake >55 m for optimal predator avoidance at night, (4) open overhead visibility, (i.e., no tall trees, tall and dense shrubbery, or high banks near the roost site), (5) feeding sites close to roost sites, (6) little or no human disturbance, (7) large expanses of water <30 cm deep, (8) shallow slope at lake's border, and (9) little or no aerial hazards (i.e., powerlines).

Approximately 300 m from the eastern border of the lake was a 50-m tall cliff vegetated with one-seed juniper (*Juniperus monosperma*), Gambel oak (*Quercus gambelii*), Utah serviceberry (*Amelanchier utahensis*), and quaking aspen (*Populus tremuloides*). To the north and west was a mixed forest of ponderosa pine (*Pinus ponderosa*) and Gambel oak. Mormon Lake Village, a small town with a seasonally-dependent population was 2 km south of the lake. In the past, this village was a problem to a previous sandhill crane reintroduction experiment because the cranes learned to fly to town for food. Southeast of the lake was a field dominated by grasses and other nonwoody vegetation along with several cabins inhabited in the summer.

## METHODS

### Releases

The 4 trucking cranes were survivors from a study described by Ellis et al. (2001*a*) wherein 5-month-old costume-reared sandhill cranes (reared in captivity by human caretakers wearing amorphous costumes disguising their human form) were taught a migration route by being led by a motorized vehicle from northern to southern Arizona in October 1996. The cranes subsequently wintered on the Gila River, southern Arizona, and summered at Mormon Lake, northern Arizona until spring 1999 when we placed some of them in captivity (Mummert et al. 2001).

The 8 parent-reared juveniles (reared in captivity by either the juveniles' natural parents or conspecific foster parents) were hatched and reared at the Patuxent Wildlife Research Center (Patuxent), Laurel, Maryland, in the spring of 1998. The cranes were transported to the release site in 2 groups in mid-July and mid-August 1998. Upon arrival at the release site, we placed the cranes in a netted pen. We fitted each crane with a VHF radio transmitter mounted on a plastic identification band and placed it above the tibio-tarsal (hock) joint. The entire package weighed about 60 g (approximately 1.25% of a subadult sandhill crane's total body weight).

We kept the juveniles penned 2–5 weeks, then transported 1 bird at a time to within 50 m of the trucking cranes, and using the one-by-one release method described by Ellis et al. (2001*b*), we released the bird into the trucking group. We spaced releases of individual juveniles 3 to 12 days apart. We released the first crane in early August and the eighth crane in mid-September. During the release, we placed a bucket containing pelletized food near the release site for 1–2 days to help initiate post-release socialization between the newly released and previously released cranes.

### Observations

We sampled behavior of the 4 trucking cranes from June to October 1998. The observations of the 8 juveniles began in early August when we released the first juvenile and concluded in mid-October when the trucking cranes and juveniles flew from the summering grounds. Because we released the first juvenile in early August and the eighth juvenile in late September, there was a disproportionate number of observation periods for the cranes released first.

We used the instantaneous sampling technique of Altmann (1974). We observed a focal bird for 30 consecutive minutes recording one of 7 behaviors at 20-second intervals onto a palmtop computer. After the allotted 30 minutes, we waited at least 15 minutes before beginning another 30-minute focal period on a different bird. We attempted to conduct continuous cycles of focal periods by consecutively observing all birds in a random order before returning to conduct an additional focal period on a previously observed bird. We discontinued this practice because birds were often separated by several kilometers making data collection inefficient. To avoid the problems associated with non-independence of observations from the same animal within a short time period and the observation of animals in the same group, we avoided conducting multiple focal periods of a given crane within 2 hours and did not conduct a sequential focal period on a crane within 50 m of the preceding crane if in that same group.

We classified the cranes' behavior into 7 categories: forage (head down), alert (head up with stretched neck), loaf (head up without stretched neck), sleep (bill lying on or tucked into the feathers of the dorsum), locomotion (walking with head up or flying), preen (from Ellis et al. 1992), and other (includes submissive and aggressive displays other than alert).

We stratified time of day for the beginnings of each focal period into 3 categories: 0500–1000 hr, 1000–1500 hr, and 1500–2000 hr. We stratified time of year into 3 categories: 1 June–15 July, 15 July–1 September, and 1 September–15 October. For juveniles, we classified the number of days since release into 4 categories: 1–10 days, 10–20 days, 20–30 days, and >30 days.

If a focal crane left our view, we stopped the timer, and if the bird returned to view within 5 minutes, we resumed collecting observations during the 30-minute focal period. If the bird did not return to view within 5 minutes, we discontinued making observations for the focal period. We conducted observations between 0.5 hr before sunrise and 0.5 hr after sunset. From June to October 1998, we collected 63,791 observational data representing 701, 30-minute focal periods. Of these focal periods, 155 (22.1%) were observations of juveniles and 546 (77.9%) were of the trucking cranes.

### Statistical Analysis

We tested the behavior for normality using the Kolmogorov-Smirnov test (SPSS 1997) and found that the observations we collected did not pass the normality assumptions of analysis of variance tests (ANOVA) even after we attempted numerous transformations ($y^3$, $y^2$, log y, $-1/y$, $-1/y^2$, $y^{1/2}$, $y^{1/3}$, $1 + y^3$, $1 + y^2$, 1 + log y, $1 + y^{1/2}$, $1 + y^{1/3}$) (Ott 1993). Because we did not meet the normality assumptions of parametric ANOVA testing procedures, we used nonparametric tests to analyze variance in the behavior of the cranes.

We used the Kruskal-Wallis test followed by a post-hoc nonparametric alternative to the Bonferroni test (Neter et al. 1996) to compare overall behavioral differences in the juvenile and trucking cranes. We also looked for behavioral differences in the 3 diurnal categories (0500–1000 hr, 1000–1500 hr, and 1500–2000 hr) and the 3 seasonal categories (1 June–15 July, 15 July–1 September, 1 September–15 October). To determine if behavior of the juveniles depended upon the amount of time post release, we also looked for behavioral differences between 10-day increments post release. We selected 10-day increments because these were the shortest periods that allowed for an adequate number of focal periods ($n > 9$) to be collected for statistical comparisons between periods.

When we tested for behavioral differences between the juveniles and trucking cranes, we analyzed data from the 4 trucking cranes and the first 6 juveniles we released. We did not analyze data we collected from the last 2 juveniles released, because we collected fewer than 10 focal periods for these juveniles before they left the area. When we compared the behavior of the trucking cranes and juveniles, we analyzed only those focal periods for the trucking cranes collected after the first juvenile was released. When we tested for behavioral response differences between the 10-day increments after release categories, seasonal categories, and diurnal categories for the juveniles, we only analyzed the behavior of the first 3 juveniles we released. We did not analyze focal periods collected from the last 5 release juveniles, because we collected less than 10 focal periods for these birds for at least 1 of the categories for which we tested.

Because we sampled a focal crane's behavior at 20-second intervals, dependence of behavior between subsequent observations presented a statistical problem. Hejl et al. (1990) found that dependence between sequential observations leads to artificially lowered variance levels in behavioral data. These lowered variance levels using dependent observations lead to erroneous rejections of null hypotheses. To determine if dependence between subsequent observations occurred, we analyzed the focal period in 2 ways. First, we analyzed the data with only the initial observation of each 30-minute focal period (1 observation per focal period). Second, we analyzed the data with all the sequential observations collected at 20-second intervals for each 30-minute focal period (91 observations per focal period). For both levels, we considered the combined focal periods for each crane an independent sample and analyzed the combined focal periods with the Kruskal-Wallis test (SPSS 1997) followed by a post-hoc nonparametric alternative to the Bonferroni test for multiple comparisons (Neter et al. 1996).

## RESULTS

### Behavioral Differences Between Trucking Cranes and Juveniles

*Initial observations*: Analyzing the data with the initial observations from each 30-minute focal period, we found that over the entire study period (15 July–15 October 1998) the juveniles ($n = 3$) spent more time loafing and in locomotion than the trucking cranes ($n = 4$). The trucking cranes spent more time sleeping and foraging than the juveniles (Table 1).

*20-second intervals*: Analyzing all the data for all behavior points (i.e., up to 91 points) collected during each 30-minute focal period, we found that over the entire study period the juveniles ($n = 6$) spent more time loafing and in locomotion than the trucking cranes ($n = 4$). The trucking cranes spent more time performing alert, sleep, and forage than the juveniles (Table 1).

### Juvenile Behavior Differences Corresponding to Number of Days after Release

*Initial observations:* Analyzing the data for the initial observations only, we found that the behavior of juveniles ($n = 8$) did not change significantly ($P < 0.1$) in 10-day increments after release (Table 2).

*20-second intervals*: Analyzing all data for up to 91 behavior points for each 30-minute focal period, we found that after 30 days post-release the juveniles spent more time in the alert behavior than in the first two periods (0–10 days, 10–20 days). The amount of time the juveniles spent loafing was greater from 0–10 days post-release than 10–20 days post-release. The amount of time the juveniles spent foraging was significantly lower ($P < 0.1$) after 30 days post-release than either 10–20 days or 0–10 days post-release.

**Table 1. Means and standard deviations for percentages of time that all (juveniles and trucking) cranes ($n = 7$), trucking cranes only ($n = 4$), and juveniles only ($n = 6$) spent in behaviors with $P < 0.1$ representing the probability of incorrectly rejecting the null hypothesis that there is no difference in the amount of time trucking cranes and juveniles spent in behaviors analyzed using only initial observations of each 30-minute focal period (initial observations) and using all observations recorded at 20-second intervals for each 30-minute focal period (20-second intervals), Mormon Lake, northern Arizona, 15 July–15 October 1998.**

| Behavior | Cranes | Initial observations | | | 20-second intervals | | |
|---|---|---|---|---|---|---|---|
| | | Mean | SD | *P* | Mean | SD | *P* |
| Alert | All | 13.5 | 8.5 | | 16.8 | 2.1 | |
| | Juveniles | 8.8 | 9.5 | 1.00 | 15.1 | 0.1 | 0.03 |
| | Trucking cranes | 17.0 | 5.9 | | 18.0 | 2.0 | |
| Loaf | All | 5.5 | 5.9 | | 6.3 | 3.6 | |
| | Juveniles | 6.9 | 8.4 | 0.03 | 10.0 | 0.2 | 0.03 |
| | Trucking cranes | 4.4 | 3.2 | | 3.4 | 0.6 | |
| Sleep | All | 1.1 | 2.3 | | 1.2 | 1.0 | |
| | Juveniles | 0.0 | 0.0 | 0.03 | 0.5 | 0.5 | 0.08 |
| | Trucking cranes | 1.9 | 2.8 | | 1.7 | 1.0 | |
| Forage | All | 51.6 | 10.2 | | 51.0 | 5.7 | |
| | Juveniles | 48.2 | 14.9 | 0.03 | 45.7 | 1.7 | 0.03 |
| | Trucking cranes | 54.1 | 3.3 | | 55.0 | 3.8 | |
| Preen | All | 12.8 | 7.7 | | 9.9 | 1.7 | |
| | Juveniles | 15.0 | 10.3 | 0.29 | 9.3 | 2.1 | 0.37 |
| | Trucking cranes | 11.1 | 5.0 | | 10.4 | 1.6 | |
| Locomotion | All | 15.1 | 9.9 | | 13.6 | 4.0 | |
| | Juveniles | 20.4 | 12.9 | 0.03 | 17.8 | 1.0 | 0.03 |
| | Trucking cranes | 11.1 | 4.1 | | 10.4 | 0.5 | |
| Other | All | 0.5 | 1.5 | | 1.3 | 0.3 | |
| | Juveniles | 0.7 | 2.2 | 0.16 | 1.5 | 0.3 | 0.16 |
| | Trucking cranes | 0.3 | 0.7 | | 1.1 | 0.3 | |

### Trucking Crane and Juvenile Behavioral Differences Corresponding to Period of Year

*Trucking cranes, Initial observations:* Analyzing the data using only the initial observations for each 30-minute focal period, we found that the trucking cranes ($n = 4$) spent more time sleeping during the first period of year (15 July–1 September) than the second period of year (1 September–15 October) (Table 3).

*Trucking cranes, 20-second intervals*: Analyzing the data with all the behavior points from each 30-minute focal period, we found that the trucking cranes spent more time foraging during the first period than the second period of year. The trucking cranes spent less time in the alert, loaf, locomotion, and other categories during the first than the second periods of year (Table 3).

*Juveniles, Initial observations:* Analyzing the data using only the initial observations from each 30-minute focal period, we found no significant temporal differences in juveniles for any behavior category.

*Juveniles, 20-second intervals*: Analyzing the data with all the behavior points from each 30-minute focal period, we found that the juveniles increased the amount of time alert and in locomotion from the first to the second seasonal period. The amount of time the juveniles spent foraging decreased from the first to the second seasonal period.

### Trucking Crane and Juvenile Behavioral Differences Corresponding to Time of Day

Trucking cranes, Initial observations: Analyzing the data using only the initial observations for each 30-minute focal

**Table 2. Means and standard deviations for percentages of time juvenile cranes ($n$ = 6) spent in behaviors during 4 periods (0–10 days, 10–20 days, 20–30 days, >30 days) after release with $P < 0.1$ representing the probability of incorrectly rejecting the null hypothesis that there is no difference in the amount of time juveniles spent in behaviors between the 3 diurnal periods analyzed with initial observations of each 30-minute focal period (initial observations) and with observations recorded at 20-second intervals for each 30-minute focal period (20-second intervals), Mormon Lake, northern Arizona, 15 July–15 October 1998.**

| Behavior | Days after release | Initial observations | | | 20-second intervals | | |
|---|---|---|---|---|---|---|---|
| | | Mean | SD | *P* | Mean | SD | *P* |
| Alert | 0 to 10 | 8.5 | 12.7 | 0.37 | 12.3 | 1.7 | 0.01 |
| | 10 to 20 | 1.0 | 2.7 | | 14.3 | 4.0 | |
| | 20 to 30 | 5.8 | 8.1 | | 16.4 | 3.4 | |
| | >30 | 11.7 | 12.6 | | 20.6 | 2.4 | |
| Loaf | 0 to 10 | 13.8 | 12.0 | 0.78 | 13.2 | 4.2 | 0.09 |
| | 10 to 20 | 6.8 | 8.5 | | 8.8 | 3.0 | |
| | 20 to 30 | 14.0 | 21.9 | | 12.0 | 2.8 | |
| | >30 | 10.0 | 10.0 | | 13.7 | 2.1 | |
| Sleep | 0 to 10 | 0.0 | 0.0 | 1.00 | 0.4 | 1.1 | 0.78 |
| | 10 to 20 | 0.0 | 0.0 | | 0.8 | 1.5 | |
| | 20 to 30 | 0.0 | 0.0 | | 1.0 | 1.5 | |
| | >30 | 0.0 | 0.0 | | 0.6 | 1.0 | |
| Forage | 0 to 10 | 42.6 | 12.9 | 0.93 | 42.4 | 12.0 | 0.06 |
| | 10 to 20 | 49.6 | 29.7 | | 46.7 | 12.7 | |
| | 20 to 30 | 45.5 | 6.2 | | 34.4 | 4.0 | |
| | >30 | 50.0 | 30.0 | | 30.2 | 0.8 | |
| Preen | 0 to 10 | 10.4 | 13.6 | 0.79 | 9.0 | 6.3 | 0.84 |
| | 10 to 20 | 9.3 | 12.0 | | 9.3 | 2.5 | |
| | 20 to 30 | 9.8 | 9.4 | | 9.5 | 3.8 | |
| | >30 | 18.3 | 16.1 | | 8.0 | 2.2 | |
| Locomotion | 0 to 10 | 22.6 | 12.9 | 0.69 | 17.8 | 9.3 | 0.34 |
| | 10 to 20 | 33.2 | 35.7 | | 19.2 | 6.9 | |
| | 20 to 30 | 24.8 | 19.4 | | 25.5 | 5.9 | |
| | >30 | 10.0 | 17.3 | | 24.5 | 2.3 | |
| Other | 0 to 10 | 2.1 | 5.9 | 0.60 | 1.2 | 0.8 | 0.20 |
| | 10 to 20 | 0.0 | 0.0 | | 1.4 | 0.6 | |
| | 20 to 30 | 0.0 | 0.0 | | 1.2 | 1.1 | |
| | >30 | 0.0 | 0.0 | | 2.4 | 0.8 | |

period, we found that the trucking cranes spent more time alert during the morning (0500–1000 hr) than during midday (1000–1500 hr). Trucking cranes spent more time loafing during morning and midday than the afternoon (1500–2000 hr). The amount of time the trucking cranes spent sleeping was higher in the afternoon than the morning period. The amount of time the trucking cranes spent preening was higher in the midday and afternoon periods than the morning period (Table 4).

*Trucking cranes, 20-second intervals*: Analyzing the data using all the behavior points collected during each 30-minute focal period, we found that the trucking cranes spent more time sleeping and preening during the midday and afternoon periods than the morning period. The trucking cranes spent

**Table 3. Means and standard deviations for percentages of time trucking crane ($n = 4$), and juvenile cranes ($n = 3$) spent in behaviors during 2 periods of year (15 Jul–1 Sep, 1 Sep–15 Oct) with $P < 0.1$ representing the probability of incorrectly rejecting the null hypothesis that there is no difference in the amount of time trucking cranes or juveniles spent in behaviors between the 2 periods of year analyzed using only initial observations of each 30-minute focal period (initial observations) and using all observations recorded at 20-second intervals for each 30-minute focal period (20-second intervals), Mormon Lake, northern Arizona, 1998.**

| | | Trucking cranes ($n$ = 4) | | | | | | Juveniles ($n$ = 3) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Behavior | Period of Year | Initial observation | | | 20-second interval | | | Initial observation | | | 20-second interval | | |
| | | Mean | SD | $P^a$ | Mean | SD | $P$ | Mean | SD | $P$ | Mean | SD | $P$ |
| Alert | | | | 0.41 | | | 0.02 | | | 0.37 | | | 0.07 |
| | 15 Jul–1 Sep | 17.7 | 4.7 | 0.29 | 17.5 | 2.3 | 0.03 | 9.3 | 8.5 | | 14.2 | 0.4 | |
| | 1 Sep–15 Oct | 9.4 | 12.0 | 1.00 | 22.0 | 1.0 | 0.03 | 7.9 | 8.4 | | 17.0 | 1.4 | |
| Loaf | | | | 0.36 | | | 0.02 | | | 0.53 | | | 0.75 |
| | 15 Jul–1 Sep | 5.6 | 3.4 | 0.74 | 3.0 | 0.4 | 0.03 | 6.1 | 2.0 | | 8.6 | 1.1 | |
| | 1 Sep–15 Oct | 3.1 | 6.3 | 0.33 | 7.4 | 3.4 | 0.08 | 9.0 | 10.1 | | 12.7 | 2.1 | |
| Sleep | | | | 0.06 | | | 0.77 | | | 1.00 | | | 0.50 |
| | 15 Jul–1 Sep | 0.4 | 0.8 | 0.39 | 1.8 | 1.1 | 0.08 | 0.0 | 0.0 | | 0.3 | 0.4 | |
| | 1 Sep–15 Oct | 0.0 | 0.0 | 1.00 | 1.4 | 1.3 | 0.28 | 0.0 | 0.0 | | 0.4 | 0.4 | |
| Forage | | | | 0.39 | | | 0.02 | | | 0.92 | | | 0.08 |
| | 15 Jul–1 Sep | 55.1 | 5.6 | 0.16 | 57.8 | 4.4 | 0.16 | 47.4 | 5.9 | | 52.7 | 2.5 | |
| | 1 Sep–15 Oct | 42.6 | 29.5 | 1.00 | 31.5 | 6.6 | 0.48 | 43.8 | 20.0 | | 33.0 | 3.0 | |
| Preen | | | | 0.55 | | | 0.39 | | | 0.12 | | | 0.75 |
| | 15 Jul–1 Sep | 10.2 | 4.6 | 0.29 | 10.7 | 1.6 | 0.48 | 13.2 | 6.6 | | 8.9 | 3.2 | |
| | 1 Sep–15 Oct | 15.4 | 11.2 | 1.00 | 8.1 | 3.5 | 0.48 | 17.7 | 22.3 | | 9.6 | 0.9 | |
| Locomotion | | | | 0.29 | | | 0.02 | | | 0.83 | | | 0.83 |
| | 15 Jul–1 Sep | 11.0 | 3.0 | 0.48 | 8.4 | 1.1 | 0.03 | 22.7 | 19.7 | | 14.1 | 1.5 | |
| | 1 Sep–15 Oct | 29.5 | 23.4 | 0.72 | 27.2 | 2.3 | 0.29 | 20.4 | 19.5 | | 24.7 | 3.7 | |
| Other | | | | 0.11 | | | 0.02 | | | 0.32 | | | 0.29 |
| | 15 Jul–1 Sep | 0.0 | 0.0 | 0.25 | 1.0 | 0.3 | 0.47 | 1.4 | 2.4 | | 1.2 | 0.3 | |
| | 1 Sep–15 Oct | 0.0 | 0.0 | 1.00 | 2.2 | 0.5 | 1.00 | 0.0 | 0.0 | | 2.1 | 0.4 | |

[a] Upper $P$ signify differences in amount of time trucking cranes or juveniles spent in behaviors between the 2 periods of year; middle $P$ signify differences between trucking cranes and juveniles for the amount of time spent in behaviors during the first period of year (15 Jul–1 Sep); lower $P$ signify differences between trucking cranes and juveniles for the amount of time spent in behaviors during the second period of year (1 Sep–15 Oct).

more time in locomotion during the morning than during either the midday or afternoon periods.

*Juveniles, Initial observations:* Analyzing the data using only the initial observations for each 30-minute focal period, we found no significant differences in juvenile behavior according to time of day.

*Juveniles, 20-second intervals*: Analyzing the data using all points collected for each 30-minute focal period, we found that the juveniles foraged and slept more during the morning than afternoon.

## DISCUSSION

### Social Interactions Between Groups

We experienced problems with social interactions between the trucking cranes and juveniles. The first 3 juveniles, upon release, integrated with the 4 trucking cranes. Juveniles released subsequently did not socialize with the trucking cranes. The birds formed 2 flocks at the release site. One group contained the 4 trucking cranes and the first 3

**Table 4. Means and standard deviations for percentages of time trucking crane ($n = 4$), and juvenile cranes ($n = 3$) spent in behaviors during 3 diurnal periods (0500–1000 hr, 1000–1500 hr, 1500–2000 hr) with $P < 0.1$ representing the probability of incorrectly rejecting the null hypothesis that there is no difference in the amount of time trucking cranes or juveniles spent in behaviors between the 3 diurnal periods analyzed using only initial observations fromeach 30-minute focal period (initial observations) and using all observations recorded at 20-second intervals for each 30-minute focal period (20-second intervals), Mormon Lake, northern Arizona, 15 July–15 October 1998.**

| | | Trucking cranes ($n$ = 4) | | | | | | Juveniles ($n$ = 3) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Initial observation | | | 20-second interval | | | Initial observation | | | 20-second interval | | |
| Behavior | Time of Day | Mean | SD | *P* | Mean | SD | *P* | Mean | SD | *P* | Mean | SD | *P* |
| Alert | | | | 0.04 | | | 0.50 | | | 0.56 | | | 0.74 |
| | 0500–1000 | 21.9 | 6.3 | | 16.2 | 2.1 | | 6.7 | 11.5 | | 15.7 | 2..6 | |
| | 1000–1500 | 12.9 | 3.7 | | 15.1 | 1.3 | | 9.9 | 11.9 | | 14.7 | 2.4 | |
| | 1500–2000 | 16.2 | 4.3 | | 14.6 | 2.1 | | 9.7 | 8.9 | | 15.0 | 1.7 | |
| Loaf | | | | 0.03 | | | 0.79 | | | 0.12 | | | 0.18 |
| | 0500–1000 | 5.6 | 1.5 | | 3.4 | 0.9 | | 8.0 | 1.2 | | 11.0 | 4.2 | |
| | 1000–1500 | 6.5 | 3.2 | | 4.5 | 1.6 | | 4.4 | 7.7 | | 10.0 | 3.9 | |
| | 1500–2000 | 1.2 | 1.4 | | 4.4 | 2.4 | | 8.3 | 14.4 | | 9.3 | | |
| Sleep | | | | 0.07 | | | 0.04 | | | 1.00 | | | 0.08 |
| | 0500–1000 | 0.0 | 0.0 | | 0.5 | 0.7 | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | 1000–1500 | 1.3 | 1.6 | | 3.2 | 0.8 | | 0.0 | 0.0 | | 1.1 | 1.2 | |
| | 1500–2000 | 4.5 | 3.3 | | 4.1 | 2.6 | | 0.0 | 0.0 | | 0.0 | 0.2 | |
| Forage | | | | 0.15 | | | 0.17 | | | 0.70 | | | 0.07 |
| | 0500–1000 | 51.9 | 1.8 | | 59.1 | 4.6 | | 46.4 | 17.2 | | 40.5 | 10.8 | |
| | 1000–1500 | 55.4 | 1.4 | | 54.0 | 3.2 | | 38.4 | 13.1 | | 47.9 | 7.0 | |
| | 1500–2000 | 55.1 | 5.0 | | 53.8 | 4.4 | | 59.7 | 8.9 | | 50.4 | 5.5 | |
| Preen | | | | 0.09 | | | 0.08 | | | 0.46 | | | 0.45 |
| | 0500–1000 | 8.9 | 7.6 | | 8.4 | 2.5 | | 10.5 | 9.4 | | 9.8 | 5.3 | |
| | 1000–1500 | 14.5 | 2.7 | | 12.8 | 1.2 | | 22.1 | 7.9 | | 9.5 | 1.5 | |
| | 1500–2000 | 10.1 | 1.1 | | 12.4 | 3.1 | | 12.5 | 12.5 | | 8.2 | 2.3 | |
| Locomotion | | | | 0.30 | | | 0.08 | | | 0.61 | | | 0.26 |
| | 0500–1000 | 11.7 | 6.1 | | 11.5 | 1.4 | | 26.1 | 7.6 | | 21.5 | 1.4 | |
| | 1000–1500 | 9.1 | 1.9 | | 9.3 | 0.6 | | 25.3 | 16.6 | | 15.9 | 2.2 | |
| | 1500–2000 | 12.5 | 3.4 | | 9.5 | 2.0 | | 9.7 | 8.7 | | 14.8 | 1.8 | |
| Other | | | | 0.57 | | | 0.52 | | | 0.37 | | | 0.86 |
| | 0500–1000 | 0.0 | 0.0 | | 0.9 | 0.5 | | 2.2 | 3.9 | | 1.5 | 0.5 | |
| | 1000–1500 | 0.4 | 0.9 | | 1.2 | 0.4 | | 0.0 | 0.0 | | 1.3 | 0.3 | |
| | 1500–2000 | 0.5 | 1.0 | | 1.2 | 0.2 | | 0.0 | 0.0 | | 2.1 | 0.7 | |

juveniles released. The second group contained the 5 juveniles we released later. This observation may indicate that a threshold ratio may be present for the number of juvenile sandhill cranes that can be socially integrated into an already established flock.

We also found that when the 4 trucking cranes flew from the northern summering grounds in mid-October 1998, the first 3 juveniles that we released initiated migration with the trucking cranes. We later located the 4 trucking cranes on the target wintering grounds but could not locate any of the juveniles. These results are similar to those in another experiment wherein Drewien et al. (1997) found that recently released, captive-reared cranes did not follow established conspecific "guide birds" on migration.

In that experiment, adult whooping cranes from the Grays Lake cross-fostering experiment were captured and placed in pens near Grays Lake National Wildlife Refuge (GLNWR), Idaho (Drewien and Bizeau 1978, Drewien et al. 1997). The biologists placed 5 whooping crane chicks in enclosures with the adult whooping cranes for approximately 2 months before the adult and juvenile whooping cranes were released from the pens. The objective of the experiment was to have the adults adopt and lead the juveniles on migration from GLNWR. Although the adults and juveniles were thought to have established bonds while in the pens, after their release into the wild the adults did not maintain the social bonds with the juveniles and migrated without the young cranes (Drewien et al. 1997). Even though using guide birds to teach survival skills and a migration route to juveniles has been to date unsuccessful, it appeared to the authors of this paper that this technique deserved further attention.

**Comparing sequential and initial observations**

We compared both initial observations for each 30-minute focal period and all the sequential behavior points we collected at 20-second intervals during each 30-minute focal period. We compared the cranes' behavior using the sequential observations even though autocorrelation may have resulted in some erroneous conclusions, because analyzing the data using only the initial observations poorly represented the amount of time the sandhill cranes spent in various behaviors, especially rarely observed behaviors such as sleeping. We found that more of the tests analyzed with the sequential data resulted in rejecting the null hypotheses (Tables 1, 2, 3, and 4). This higher detection rate for sequential data was due to the higher variances associated with using only the initial observations (1 observation per focal period) compared to the variance levels of the sequential data (typically 91 observations per focal period).

**Behavior**

*Trucking cranes versus juveniles:* When we analyzed the data collected at 20-second intervals, 2 of the juveniles' behavior became more similar to that of the trucking cranes as the juveniles spent more time at the release site. Differences in the amount of time apportioned to sleep and locomotion differed ($P < 0.1$) for the juveniles and trucking cranes between 15 July–1 September and were similar ($P < 0.1$) from 1 September–15 October. The only behaviors that remained significantly different ($P < 0.1$) between the trucking cranes and the juveniles for both seasonal periods were the alert and loafing behaviors. We feel that the juveniles spent more time loafing and less time in the alert behavior than the trucking cranes because of age and because the juveniles had recently been released from captivity. In a previously conducted study, Alonso and Alonso (1993) observed that juvenile common cranes (*Grus grus*) spend less time being alert toward predators than did adults. Drewien et al. (1982) noted that sandhill cranes recently released from captivity were less vigilant compared to nearby wild sandhill cranes. This may have been due to their previous life in captivity where avoidance of predators was not necessary, or it may be merely a reflection of the less vigilant attitude of young cranes.

*Juvenile behavior differences corresponding to number of days after release:* Our data collected at 20-second intervals showed that the juveniles increased time being alert. This trend may be partially due to season of year, because we noted that both the juveniles and the trucking cranes increased the amount of time alert from the first seasonal period 14.2% and 17.5% respectively (15 July–1 September) to the second seasonal period 17.0% and 22.0% respectively (1 September–15 October). These changes represent 19.7% and 25.7% increases between periods respectively. We feel that the amount of time after release is probably the primary factor that influenced juveniles to increase their time in the alert behavior. Between the first period (0–10 days post release) and the fourth period (>30 days post release), the juveniles increased the average percentage of time alert from 12.3% to 20.6% (a 67.5% increase).

In 10-day increments post-release, the juveniles also decreased the amount of time spent foraging. Because the juveniles had pelletized food while in captivity but no pelletized food after release, they had to learn to identify, locate, and consume new foods at the release site.

*Trucking crane and juvenile behavioral differences corresponding to period of year:* We found that both the trucking cranes and juveniles increased the percentage of time spent alert, loafing, and in locomotion and decreased the percentage of time foraging from the first period (15 July–1 September) to the second period (1 September–15 October).

*Trucking crane and juvenile behavioral differences corresponding to period of day:* The trucking cranes spent much of their time foraging throughout the day with higher periods of alert during the morning. Loafing and preening dominated at midday, and sleeping was more important during the afternoon. The juveniles concentrated their foraging efforts during midday and afternoon, while most of their diurnal sleeping occurred at midday. These results for both the trucking cranes and juveniles were similar to those of Bizeau et al. (1987) wherein sandhill cranes rested and preened more during the midday hours than other periods of day.

### Limitations

We found several obstacles that made data analysis and subsequent interpretations difficult. First, we did not have the resources to experimentally test multiple experimental and control populations of sandhill cranes to help determine if the juveniles in this study would have made similar changes in behavior over time without having the trucking cranes in close proximity. Second, our data were highly skewed as a negative binomial distribution created by the high proportion of zeroes. Although researchers have found that ANOVAs are robust toward negative binomial distributions (White and Bennetts 1996), we felt the data were too skewed to accommodate the normal distribution assumptions of parametric ANOVA tests. Therefore, we opted to use the Kruskal-Wallis test. One disadvantage of this test, being nonparametric, is the reduced power compared to an ANOVA testing procedure. Another disadvantage of the Kruskal-Wallis test is that we could simultaneously test for the effects of only 1 independent variable instead of interaction effects of multiple variables as is possible with 2- and 3-way ANOVA tests.

Also complicating our interpretations was the brief time frame in which we were able to conduct this study. We were able to observe all 4 adults for 4.5 consecutive months. In contrast, we observed the juveniles for varying periods depending upon the date we released them. We were able to observe the first release juveniles for 2 months until all the birds migrated in mid-October. Due to complications, however, we could not release the later juveniles until early fall, less than 1 month before migration.

## CONCLUSIONS

Due to our inability to integrate more than 3 juveniles into the group with the 4 trucking cranes and because sandhill and whooping crane parents most often rear 1 juvenile at a time, we suggest that future experiments with either sandhill or whooping cranes not exceed a 2:1 ratio between previously established cranes and recently released juvenile conspecifics. Future experiments using guide cranes may require longer integration periods before migration.

We suggest that recently released cranes decreased time spent foraging because of their increased proficiency at locating and consuming wild foods. However, the birds in this experiment probably also decreased the amount of time spent foraging because of changing food resources. Most likely due to increased food availability, the cranes spent less time foraging shortly before their autumn migration. High amounts of loafing and sleeping at middays were most likely due to the higher temperatures at this time.

Although our juveniles failed to arrive on the wintering grounds with the trucking cranes, we believe that in future reintroduction experiments, young, recently released, captive-reared cranes can be integrated into a wild flock or even learn survival skills from previously established captive-reared cranes. In so doing, we forecast that disjunct populations may be created using costume-reared cranes taught a migration route. Thereafter, parent-reared cranes that inherently have greater fear of humans can be used to augment the new disjunct population.

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