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RESULTS OF THE UTAH-ARIZONA STAGE-BY-STAGE MIGRATIONS

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Abstract: In an effort to find a safer means of teaching cranes new migration routes, each year (in 1998 and 1999) we transported a group of greater sandhill cranes (Grus canadensis tabida) stage-by-stage, in a horse trailer, with stops for brief flights at about 30-km intervals, along a 1300-1400-km fall migration route from Fish Springs National Wildlife Refuge (Fish Springs) in west-central Utah to the vicinity of Gila Bend, Arizona. Thereafter, we released them into a wild flock of sandhill cranes. All stage-by-stage birds were hand-reared with both a plastic crane decoy (to encourage them to roost in water) and a costume-draped humanoid form (called a scare-eagle and used for its namesake purpose). When these 2 teaching aids were made repeated migrations to or near our chosen northern terminus. However, after 1 winter in our chosen area, the birds have moved elsewhere to winter.

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The experiment described below is part of a general effort to develop 1 or more techniques to teach cranes new (or no longer used) migration routes. The other experiments include: (1) 2 truck-led migrations in Arizona (1995 [Ellis et al. 1997] and 1996 [Ellis et al. 2001a]), (2) 3 ultralight-led migrations from Idaho to New Mexico in 1995, 1996, and 1997 (Clegg et al. 1997, Clegg and Lewis 2001), (3) 2 ultralight-led migrations from Ontario to Virginia or South Carolina (Lishman et al. 1997; Duff et al. 2001a,b; Ellis et al. 2001b), and (4) an attempt to introduce juveniles into a flock of survivors from the 1996 trucking experiment (Mummert et al. 2001).

This experiment differed from the others in that trained cranes did not fly the route but rather were released at intervals (stages) along the route, encouraged to fly at these stops, then captured and placed in a trailer and transported along the next stage and released at the next stop.

This experiment was undertaken to obviate the hazards (to cranes and personnel) inherent in ultralight-led and truck-led migrations. In the West during both ultralight-led and truck-led migrations, golden eagle (Aquila chrysaetos) attacks on the cranes were common and sometimes fatal (Ellis et al. 1999). In the trucking migrations, crane-powerline collisions were frequent and 3 times fatal (Ellis et al. 1997, 2001a). During training and during the ultralight migrations, engine failure and rough terrain led to several non-fatal crashes, and cranes were sometimes entangled in the aircraft or struck by propellers. We pursued the stage-by-stage concept to avoid these hazards and to determine if, with a minimum of experience along a route, cranes could retrace the route or at least return to our chosen summering and wintering sites unassisted.

METHODS

Cranes involved in the experiments were greater sandhill cranes costume-reared (hand-reared by humans in amorphous gray costumes) at the Patuxent Wildlife Research Center (Patuxent) much as for hand-reared birds involved in releases in Mississippi (Ellis et al. 1992, 2000). Briefly, these birds were given imprinting cues including (1) a taxidermically prepared, whole body, brooder model, (2) a taxidermically prepared head and neck (puppet-head) feeding model, and (3) a live crane, imprinting model, penned adjacent to each chick during the first few days following hatching. In addition to these imprinting aids, the birds also received much experi-

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ence with costumed caretakers leading them afield, training them to enter and ride in the same horse trailer that would be used to transport them during training and during the migration.

Details of the timing of various imprinting and training cues and events for the 1999 cranes are presented in Fig. 1. The 1998 cranes were handled as in 1999 with the following exceptions: (1) in 1998, the birds spent more time in training groups and received more training sessions, (2) the plastic dummies were late arriving in 1998, so the colts had no experience with them until near fledging, and (3) in 1998, the chicks were trained until near fledging in a different trailer that, unlike the horse trailer, had solid walls.

The routes followed in 1998 and 1999 were very similar (Fig. 2), but stops were more frequent in 1999 (25 in 1998 as opposed to 36 in 1999). Our intention both years was to stop about every 25 km and release all birds at every stop.

Stops were conducted as follows. First, the trailer was driven a safe distance from the main road. Second, the tail gate was swung open and the birds were allowed to walk out. The group was typically offered water _ad libitum_. Food was rationed to facilitate recapture of hungry birds, but costumed caretakers typically cast handfuls of pelletized food when interacting with the birds. If the birds were not overheated, shortly after release, they typically went into pre-flight posture, called, and lifted off for flights which typically lasted about 5 min. and consisted of a series of low circles about 1 km in diameter.

After the flight, the cranes approached the caretakers and were given a limited amount of food. After about 30 min., the birds were herded toward and into the horse trailer. A metal feeder was normally placed in the trailer as an incentive. Birds reluctant to enter the trailer were either captured first or lured into the trailer with food. If conditions were good for flight but the cranes showed no interest in lifting off, we sometimes rushed the birds with a motor vehicle and forced them into flight. If the cranes flew far, the costumed caretakers flapped their arms, called loudly (brood call), moved the feeder into view, and sometimes shook the feeder to make the food rattle against the metal cylinder.

![Diagram of events in the training of cranes involved in 2 stage-by-stage migrations.](image-url)
We reared the birds in facilities like those described by Swengel and Besser (1996). The horse trailer, used both years, measured 3.7 x 1.7 x 1.7 m. When birds were first introduced in Utah and when birds were held overnight out of water on migration, they were confined under a nylon net (mesh size 5 cm) pegged or weighted to the ground and supported in part by wooden or plastic poles to a height of 1.5-3.0 m. For nearly all overnight stops, birds were not penned but allowed free access to a roosting pond. A costume-draped humanoid frame (the scare eagle) and 1 or more plastic crane decoys were positioned in the water at least 5 m from shore to designate for the cranes our chosen roost site. For dry roosts, the pen was ca 6 m or less in diameter. At Fish Springs and at the southern terminus, the pen was 6-8 m in diameter. Pens at both termini were protected by a solar-and/or battery-powered anti-predator fence consisting of one wire 10-30 cm from the ground.

The northern terminus (Fish Springs) was chosen because the area once harbored sandhill cranes (Walkinshaw 1949), so the habitat was believed suitable for the return and residence of our cranes. Only one pair of wild cranes was resident in 1998 and 1999, so our cranes on future migrations would have little chance of finding Fish Springs by following other cranes north.

The Gila River flood plain between Buckeye and Gila Bend, Arizona, was chosen for the southern terminus for 2 reasons. First, the wild flock on the Gila River is believed to migrate to Oregon and Nevada along a route very different than our stage-by-stage training route. We therefore expected that if our birds had learned the training route, they would separate from the wild flock and follow their own route north. Second, we planned to release the stage-by-stage birds into this wild flock as part of a release experiment (Ellis et al. 2001c).

While at Patuxent, 8-cm-tall, yellow, plastic leg bands were attached above the hock joint. At Fish Springs, battery-powered radio transmitters were attached on the opposite leg. These units with bands weighed ca 55 g, included a mortality sensor with a transmission rate for live cranes of 55 bpm and for immobile cranes of 110 bpm. All birds were placed in wooden crates and transported by air cargo from Maryland to Utah (17 hr in crate in 1998 and 13 hr in crate in 1999).

Training at Fish Springs consisted merely of releasing the birds, training them to enter the trailer for food, training them to roost near the scare eagle and plastic crane decoys, and transporting them in the trailer. All birds were tagged with conventional radio transmitters and could be readily located ground-to-ground from 2 to 8 km if in line-of-sight contact. A few birds (1 in 1998 and 3 in 1999) were tagged with satellite transmitters, thus enabling us to follow long-distance movements.

RESULTS

Not all cranes reared for the project were shipped to Utah. The primary basis for selection was gender (i.e., male cranes are more philopatric than females). Males were chosen over females as being more likely to demonstrate their ability to return to our chosen northern terminus. In the final analysis, we were limited in the number of males available, so the sex ratio of 28 birds flown west was 16:12 (8:6). Of these, 26 (12 in 1998 and 14 in 1999) commenced the migration south. Of the 2 remaining cranes, 1 died and 1 was removed from the experiment prior to migration because it was terrified of being confined with the other cranes in the horse trailer. As a result, it proved very difficult for us to capture. An alternate solution, untried by us, would have been to box unruly cranes during transport and thereby avoid the need to remove them from the experiment.

This obstacle (i.e., our inability to capture subordinate cranes) proved to be the major difficulty in the stage-by-stage migration. During our travels south in 1998, we lost 1 bird as uncatchable. In 1999, 2 birds became uncatchable and were left behind. An interesting observation from the stage-by-stage migrations and the trucking migrations of 1995 and
1996 is that as soon as the most subordinate crane in a group was eliminated, another crane (or 2) would immediately become very subordinate. Such birds would quickly become terrified of being confined with the group in the horse trailer. They would then become very difficult for the caretakers to control. We managed this difficulty by trying always to catch the subordinate crane first.

This difficulty to recapture subordinate cranes was the primary factor controlling the frequency of stops in both years. Simply put, each day we would continue stages and stops as long as our cranes were still controllable. Once a bird or 2 was beyond control, we either did not release that bird(s) for one or more stops, or we moved immediately to an appropriate overnight stop.

In 1998, our expedition consisted of 25 stages: in 1999 it consisted of 36. This resulted in an average direct line distance per stage in 1998 of 34.5 km and in 1999 of 25.6 km (Table 1).

Although survival rates during rearing and training were very high, from Table 2, it is evident that we lost more than half of our birds during the migration in 1998. One of these was a subordinate bird that would not allow recapture during the first day of the migration. The remaining 5 birds died from an unknown toxin at the ninth stop. A sixth bird was weakened by the toxin and nearly died, but was eventually released and survived the winter. Carcasses of some birds were rushed to the National Wildlife Health Laboratory in Madison, Wisconsin, but on repeated tests, cause-of-death was never determined. In 1999, we avoided this stop. Even with these losses, we experienced good success in leading our birds south on migration.

The ability to translocate birds stage-by-stage is of little or no value unless the birds demonstrate that they can home on taught summering and wintering areas unassisted. Our 1998 birds had an opportunity to go north in the spring of 1999. From weekly visits to the cranes, we know that they remained behind in March when the wild flock along the Gila River went north. From satellite data, we know that they started north and were traveling widely in northern Arizona between 4–6 April. Then by 8 April, they returned south to near their wintering area but continued south, then southeast and were reported for a 13 day period on the border with Mexico, about 200 km south-southeast of their wintering area. On 23 April, the last satellite location was received. Although we searched the border region in May and listened for radio signals at the wintering area during winter 1999–2000, the birds were never detected again.

More information about navigational skills comes from 3 of our 12 cranes from the 1999 migration. Immediately after their stage-by-stage migration, we released them one-by-one into the wild flock along the Gila River. After spending 2–4 days afield with wild cranes, in early November 1999, we donned costumes and captured the 3 (2 females and 1 male) and transported them to the Clear Lake Waterfowl Management Area (Clear Lake) (Fig. 2), an important stopover area and only 111 km from the northern terminus of our experiments. Although the ultimate test of our experiment will come from seeing if our cranes follow our route north and south in the coming spring and fall, we decided upon this 3-bird subexperiment to immediately determine if our birds had learned the route. In the night of 3 November, we released the birds into the marsh, then camped nearby to deter mammalian predators. On the morning of 4 November, we saw all 3 of our cranes. The birds remained near Clear Lake until 6 November, but by 14 November, the satellite telemetry bird was detected ca 90 km northeast. This bird (presumably with its 2 companions) was last detected at this northern location on 7 December. On 15 December, 2 of our 3 cranes were reported at the same latitude as the Gila Bend wintering site.

Table 1. Details of the stage-by-stage migrations (distances in km) for sandhill cranes transported south in 2 stage-by-stage migrations from west-central Utah to southwestern Arizona, 1998 and 1999.

<table>
<thead>
<tr>
<th></th>
<th>1998</th>
<th>1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>Route length (road distance)</td>
<td>1282</td>
<td>1372</td>
</tr>
<tr>
<td>Route length (sum of stages: dot-to-dot)</td>
<td>862</td>
<td>923</td>
</tr>
<tr>
<td>Shortest distance between termini</td>
<td>758</td>
<td>758</td>
</tr>
<tr>
<td>Number of stops (stages)</td>
<td>25</td>
<td>36</td>
</tr>
<tr>
<td>Average length of stage</td>
<td>34.5</td>
<td>25.6</td>
</tr>
</tbody>
</table>

Table 2. Results of rearing, training, and migration of sandhill cranes transported on stage-by-stage migrations, Utah-Arizona, 1998 and 1999.

<table>
<thead>
<tr>
<th></th>
<th>1998</th>
<th>1999</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hatchlings reared for project</td>
<td>24</td>
<td>23</td>
<td>47</td>
</tr>
<tr>
<td>Number surviving rearing</td>
<td>21</td>
<td>22</td>
<td>43</td>
</tr>
<tr>
<td>Number transported West</td>
<td>14</td>
<td>14</td>
<td>28</td>
</tr>
<tr>
<td>Number surviving training in West</td>
<td>13</td>
<td>14</td>
<td>27</td>
</tr>
<tr>
<td>Number commencing migration</td>
<td>12</td>
<td>14</td>
<td>26</td>
</tr>
<tr>
<td>Number completing migration</td>
<td>6</td>
<td>12</td>
<td>16</td>
</tr>
</tbody>
</table>
One was 64 km east of Gila Bend. The second (and presumably the third) was detected by satellite 120 km east of Gila Bend. The second and third were still at this location when captured and translocated to the Gila River on 21 January 2000.

Now concerning the most important data, the spring movements of the 1999 cranes during their first flight north. By late February 2000, most of the wild cranes had left the wintering grounds. Our cranes (11 of 12 still detectable by conventional radiotelemetry) remained behind on the Gila River. Between 2 and 9 March (based on radiotelemetry data), our birds flew north. Unlike the 1998 birds, our 1999 cranes apparently did not separate from the wild flock but followed the route of the wild birds north. The first satellite locations after departure put them well west of our route, but directly on the route known to be used by the wild flock. On 9 March, all 3 satellite transmitters were detected about 80 km south-southwest of Ely, Nevada, and in a wetland frequently used by migrating cranes. At this point, they were about 220 km southwest of Fish Springs, our intended summering area. The birds were likely confused by the unfamiliarity of the terrain, and by 13 March, they moved south to the vicinity of Lake Meade and therefore very close to our route. On 14 March, we rushed north to see which cranes were still with the 3 satellite transmitter birds. We found 9 of our cranes, including all of the males, in agricultural fields (much like their wintering habitat on the Gila River) near Glendale, Nevada. So 9 of our birds had separated from the wild flock and traveled far south to our migration route. Among them were 2 of the 3 cranes translocated and released in November. Three 3 cranes, we searched north toward Ely and found 1 female only and with her plumage matted with mud. We captured her, then rushed south and released her near the 9 at Glendale.

Now only 2 cranes were missing, and 1 of these was the bird with the silent radio. We left the cranes in hopes they would resume their migration north. The satellite data showed that 1 male (but how many others were with him?) wandered far north and east between 22 and 30 March. The other 2 satellite telemetry males remained at Glendale.

The next round of satellite telemetry data revealed that our cranes, although seemingly lost, could readily retrace the route they had flown. On 8 April, our group was well on their way, not north to Fish Springs, but south to the Gila River. Between 8 and 10 April, they settled in on the Gila River, ca 8 km south of their wintering area. On 15 April, we confirmed that not only the 3 satellite telemetry males, but all 9 cranes from Glendale (the mud-caked crane retrieved near Ely was never seen again) were on the Gila River.

We immediately began baiting the area (i.e., we placed 2 plastic decoys and a feeder in an appropriate roost) in hopes of capturing and transporting most of the birds to Fish Springs. On 17 April, we captured 1 crane. On 20 April, we captured 6 more. Leaving 2 behind loose near Gila Bend, on 24 April we transported the 7 to Fish Springs and released them.

Through May, the satellite data reported the birds at Fish Springs. A late May check at Gila Bend failed to locate the 2 left behind. All satellite locations from 5 June onward were not from Fish Springs, but from Utah Lake (ca 150 km east northeast). Biologists at Fish Springs reported confirming observations: the cranes all left in early June. When we traveled north in late August to make our pre-migration search, we located at least 7 of our cranes at Utah Lake. Most surprising was the discovery that 2 of the 7 were birds we had left at Gila Bend in April. Neither of these birds had ever been to Utah Lake before. We suspected that these 2 rejoined their flockmates at Fish Springs, then traveled to Utah Lake with the flock, 2 members of which were part of the group of 3 that had traveled to Utah Lake in November 1999.

So the spring and summer 2000 movements were complicated, confusing, yet somewhat encouraging. By autumn 2000, all 3 satellite transmitters had expired. When none of these birds reappeared on the Gila River, we searched known crane wintering areas near Eden and Wilcox, Arizona, and all along the Gila River from Phoenix to Yuma. We searched along the Colorado River from Parker, Arizona, to Cibola National Wildlife Refuge, then searched the Salton Sea area of southern California. None of our birds were found. Most likely these birds wintered along the Rio Grande in New Mexico. The only crane found in the winter of 2000/2001 was the bird suspected of having continued north in Nevada with the wild flock in March 2001.

In April 2001, we visited the previous year’s summering areas and located 1 of our birds at Fish Springs and 2 at Utah Lake. As conventional radio transmitters expire, it becomes increasingly difficult to locate the birds, but visual observations by employees at Fish Springs reveal that 2, and as many as 5, were at Fish Springs during spring 2001. Crane habitat at Utah Lake is vast, so finding birds without active radios becomes impractical. Only 1 of the 2 we detected had a functional radio.

CONCLUSIONS

We experienced high survival and no accidental injuries during the rearing, training, and migration phases of our study. Our only major loss was of 5 birds to an unknown toxin. Also we were unable to recapture the 3 birds (3 of 26) lost along the routes. All 3 of these birds eventually approached humans and were transported to appropriate crane wintering sites and released. On the negative side, we should also mention that another 3–5 birds became so difficult to
capture that they were not released at some stops. Neverthe­less, our 2 experiments proved that it was practical to release, recapture, and transport our birds stage-by-stage over long distances.

From the spring movements of the 1998 birds, we suspect that the cranes did not retain enough information about their training route to successfully complete a migration. From the December movements of the 3 cranes involved in the November experiment to rerelease birds in central Utah, we have good evidence that the 1999 cranes had enough experience to at least grossly retrace their route. That all 3 cranes came south as far as Gila Bend but no further, leads us to suspect that these birds had learned (from sun inclination?) the proper latitude of their wintering area but were confused about longitude.

From the halting northward, then southward, movements of our 1999 birds in March and April 2000, we know that the birds (except 3) separated from the wild flock. They also proved they could return south from Lake Meade unassisted (albeit at the wrong time of year). From the 3 birds left untrapped at Gila Bend in April 2000 (2 of which were found at Utah Lake in late summer), we know that some birds could perform the whole northward journey. That they traveled so late suggests they did so unassisted by any wild cranes. That none of the Utah cranes returned to even the vicinity of our chosen wintering grounds in winter 2000–01 suggests that even after 1 winter at our chosen location, the birds were willing to follow wild flockmates to a far removed wintering site. We are left to wonder if the cranes, given a bit more experience, would have performed better. We failed to develop the stage-by-stage technique into an operational reintroduction tool. Yet, results are positive enough to encourage further experimentation.

ACKNOWLEDGMENTS

We express our deep appreciation to those at Patuxent who helped us rear our cranes and to Jay Banta and his staff at Fish Springs for hosting our lengthy stay. We also appreciate our short-term hosts Lyn Zubeck of the Utah Division of Wildlife Resources for hosting our visits to Clear Lake and to Keith Brose of the Nevada Division of Wildlife for arranging our stays at Overton Bay on Lake Meade. We are indebted to Bill Campbell, Patrick Coronado, and Jon Robinson at NASA-Goddard Space Flight Center for satellite telemetry support. Norm and Sylvia Young attended our 1999 migration and contributed greatly to our social welfare and caloric intake.

LITERATURE CITED


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