1997

A REINTRODUCTION TECHNIQUE FOR MIGRATORY BIRDS: LEADING CANADA GEESE AND ISOLATION-REARED SANDHILL CRANES WITH ULTRALIGHT AIRCRAFT

William A. Lishman
Operation Migration

Tighe L. Teets
Operation Migration

Joseph W. Duff
Operation Migration

William J. L. Sladen
Environmental Studies, Airlie Center

Galvin G. Shire
Environmental Studies, Airlie Center

Authors
William A. Lishman, Tighe L. Teets, Joseph W. Duff, William J. L. Sladen, Galvin G. Shire, Kirk M. Goolsby, Wayne A. Bezner Kerr, and Richard Urbanek

A REINTRODUCTION TECHNIQUE FOR MIGRATORY BIRDS: LEADING CANADA GEESE AND ISOLATION-REARED SANDHILL CRANES WITH ULTRALIGHT AIRCRAFT

WILLIAM A. LISHMAN, Operation Migration, 2731 Durham Regional Road 19, Blackstock, ON L0B 1B0, Canada
TIGHE L. TEETS,[1] Operation Migration, 2731 Durham Regional Road 19, Blackstock, ON L0B 1B0, Canada
JOSEPH W. DUFF, Operation Migration, 2731 Durham Regional Road 19, Blackstock, ON L0B 1B0, Canada
WILLIAM J. L. SLADEN, Environmental Studies, Airlie Center, 6809 Airlie Road, Warrenton, VA 20187, USA
GAVIN G. SHIRE, Environmental Studies, Airlie Center, 6809 Airlie Road, Warrenton, VA 20187, USA
KIRK M. GOOLSBY, Environmental Studies, Airlie Center, 6809 Airlie Road, Warrenton, VA 20187, USA
WAYNE A. BEZNER KERR,[2] Operation Migration, 2731 Durham Regional Road 19, Blackstock, ON L0B 1B0, Canada
RICHARD P. URBANEK, U.S. Fish and Wildlife Service, Seney National Wildlife Refuge, Seney, MI 49883, USA

Abstract: No successful method for establishing self-sustaining populations of whooping cranes *(Grus americana)*, particularly in a migration situation, has been proven. This research initiated development of a reintroduction technique using ultralight aircraft to lead cranes from a natal area along a desired route to a predetermined wintering site. Canada geese *(Branta canadensis)* were used in initial migration efforts. Ultralight aircraft and pilots successfully led 86 juvenile geese on 3 southbound migrations from Ontario to winter sites 640–1,312 km from the natal area. Of 16 1993-hatched geese that survived their first winter in Virginia and 35 1994-hatched geese that were successfully led to South Carolina, 46 (90%) returned unassisted to their natal area in Ontario on their first spring migrations. Only 15 (50%) of 30 1995-hatched geese trucked to New York to begin aircraft-led migration returned to the Ontario rearing area the following spring. Of 16 geese trucked the entire route to Virginia but allowed to fly freely at predetermined stops, none returned to Ontario. In 1995, isolation-(costume-)reared sandhill cranes *(G. canadensis)* were trained to follow the aircraft in flights within 50 km of the Ontario rearing area. Planned future research will involve leading sandhill cranes, and then whooping cranes, on an actual migration.

PROC. NORTH AM. CRANE WORKSHOP 7:96-104

Key words: reintroduction, Canada goose, sandhill crane, whooping crane, migration, ultralight aircraft, isolation-rearing, costume-rearing, *Grus americana*, *Grus canadensis*, *Branta canadensis*.

The experiments of Lorenz (1978) with graylag geese (*Anser anser*) showed that in the first days after hatching, goslings become attached to large moving objects and that these young birds maintain this attachment to the surrogate parents through the juvenile period. Had Lorenz been able to fly, he could have carried his research further and led the birds in flight. In the 1970's Bartlett and Bartlett (1973) led imprinted snow geese (*A. caerulescens*) southbound during migration with a truck, and W. Carrick (Toronto, Ont., unpubl. data) trained Canada geese imprinted on a model aircraft to follow a boat. From 1986 to 1990, the senior author, in association with Carrick, trained Canada geese to fly with a motorcycle and a specially designed aircraft (Lishman 1989, 1991). In July 1988 these efforts resulted in the first flight of a flock of birds in formation behind an aircraft. This event supported the concept that techniques using aircraft-led birds could be developed to establish migration routes for specific threatened or endangered species.

Meanwhile, isolation-rearing techniques, using puppets and costumed humans as surrogate parents, were being developed to produce cranes suitable for release into the wild (Horwich 1989; Horwich et al. 1992; Urbanek and Bookhout 1992, 1994). The goal of this research was to develop a reintroduction technique for migratory populations of the endangered whooping crane. Unlike geese and swans (*Cygnus* spp.), successful reintroduction of cranes is dependent on birds that will avoid humans after release. Although isolation-reared sandhill cranes were successfully induced to migrate in the wild, their ultimate wintering areas were determined mainly by random association with wild sandhill flocks. In reintroduction of whooping cranes, particularly on a proposed migration route where sandhill cranes are not present, a specific, predetermined wintering area is desirable.

If the techniques of (1) isolation-(costume-)rearing to produce birds capable of surviving in the wild and (2) use of ultralight aircraft to teach birds an appropriate migration route and wintering area can be combined, an effective method for establishing migratory populations of the whooping crane may be created. This paper describes 3 major aircraft-led migrations with Canada geese and 1 flying experiment with isolation-reared sandhill cranes during 1993–95.

We thank W. Carrick, G. Lishman, J. Dickens, K.

---

[1]Present address: Seney National Wildlife Refuge, Seney, MI 49883, USA.

[2]Present address: 249 Royal St., Waterloo, ON N2J 2J1, Canada.

Richards, M. Simpkinson, and J. Monohan for assistance with geese and crane rearing; R. Van Heuvelen for aircraft and pen construction and ground crew assistance; D. Woodhouse for piloting and aircraft maintenance; and G. Archibald and J. Langenberg, International Crane Foundation, for advice and encouragement. We are grateful to owners of the stopover sites used during migration, to R. Joyner for facilitating use of Tom Yawkey Wildlife Center as a wintering site, to Airlie Foundation, Yawkey Foundation, and to corporate sponsors Honda Canada, Ivoprop, and Bell Mobility. T. Bookhout, J. Clem, J. Kaplan, and G. Olsen provided useful comments on the manuscript.

STUDY AREA

Geese in 1993 and cranes in 1995 were reared in facilities maintained by the senior author at Purple Hill near Blackstock, Ontario. In 1994, geese were reared on a sod farm near Nestleton, about 11 km from Purple Hill. In 1995, 3 flocks of geese were reared: 2 at Nestleton and a third at Airlie Center, near Warrenton, Virginia. Geese were led along a predetermined migration route to Airlie in each autumn, 1993-95, and onward to the Tom Yawkey Wildlife Center (South Carolina Department of Natural Resources) near Georgetown, South Carolina, in 1994-95 (Fig. 1). Cranes were not led on a migration but were flown locally within 50 km of the rearing site in Ontario.

METHODS

Canada Geese

Canada geese were hatched in incubators from locally collected eggs. A taped recording of the particular aircraft that would be used after the birds fledged was played during the last week of incubation. Goslings were imprinted on caretakers who also carried and played the recording during walks (Lishman 1989). Normal human appearance of caretakers was not concealed, and the geese were not conditioned to fear humans.

When geese were 2 weeks of age, a wearable model of the aircraft, referred to as a "goose toddler," was used by the pilot/leader in conjunction with the tape-recorded sound of the engine, and the goslings were encouraged to follow. At 4-5 weeks the actual aircraft was introduced to the birds, and the engine was started and left to idle for short periods. Once geese could adequately avoid the tires, they were induced to follow the taxiing aircraft on a regular schedule at least twice daily. Other caretakers also ran with the birds alongside the aircraft.

During 1993-94, goslings were raised in groups of 6-12 birds of similar age. Colored bands were used to readily identify groups. Groups were penned and exercised separately but in close proximity. After fledging, the birds were integrated into larger groups and then combined into a single flock just prior to migration. Geese were tarsal-banded in Ontario and then neck-banded when they reached Airlie Center, Virginia. Neckbands were of gray tubular plastic design with black 4-digit codes (Sladen and Kistchinski 1977, Sladen and Limpert 1988).

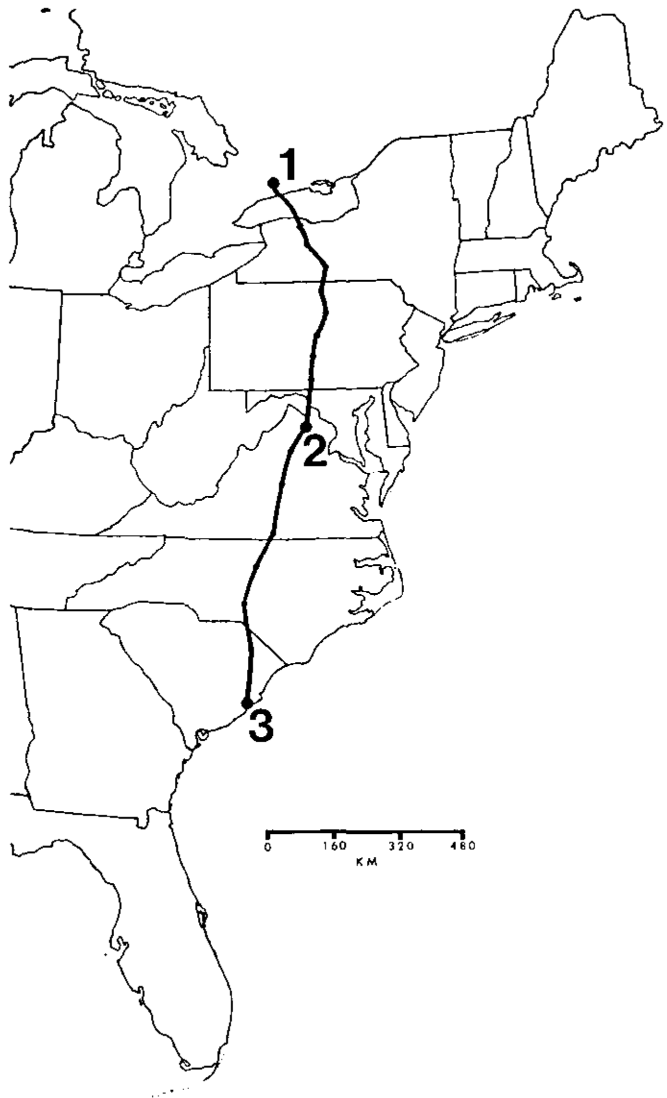

Fig. 1. Route on which captive-reared, juvenile Canada geese were led on autumn migration by ultralight aircraft, 1993-95: (1) Rearing area near Blackstock, Ont., (2) Airlie Center, Va., (3) Tom Yawkey Wildlife Center, S.C.

In 1993, 2 identical aircraft were used to train the birds. These were Cosmos Echo trikes with Ghost 16-m^2 wings (10-m wingspan). This aircraft consisted of a hang glider type

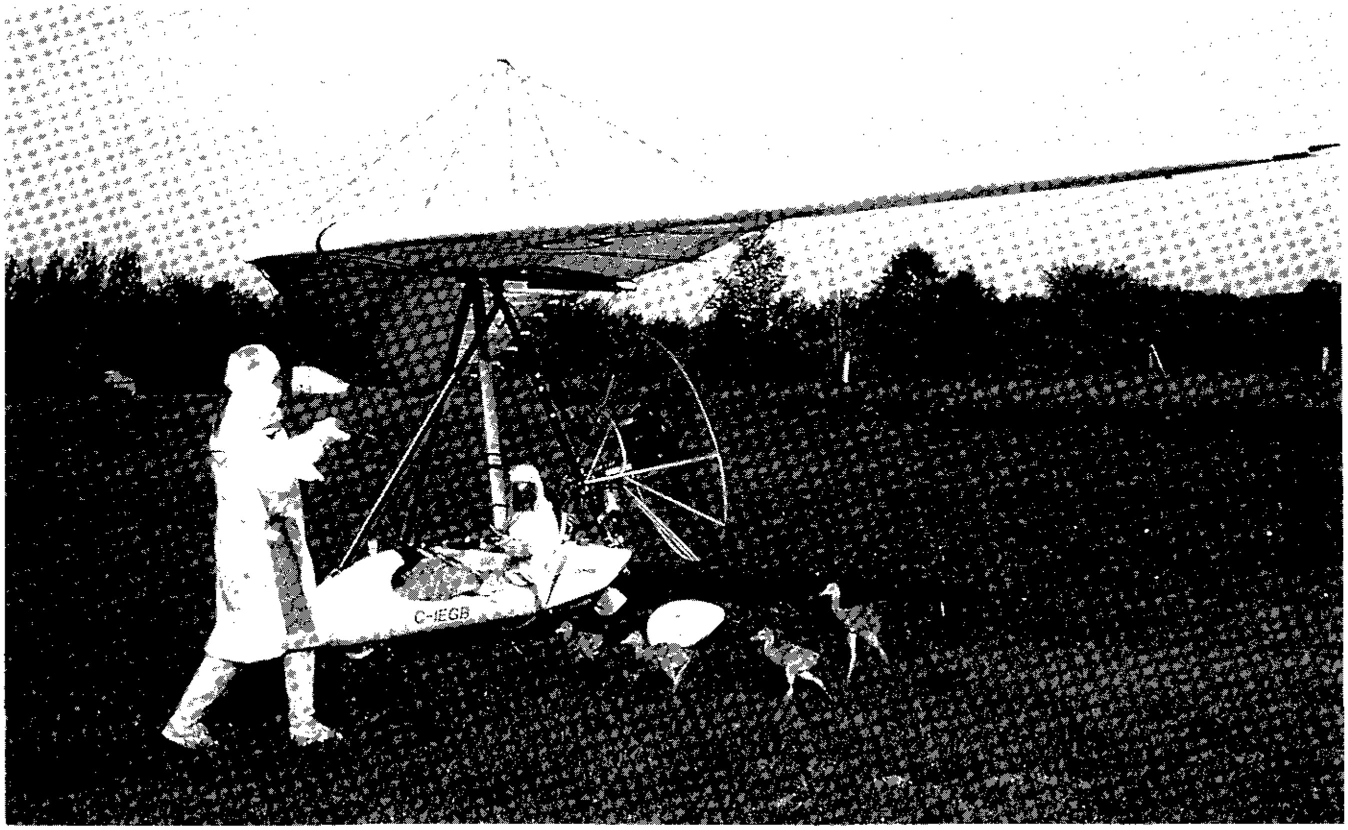

Fig. 2. The attraction of chicks to the costumed parent was used in initial training of sandhill cranes to follow the ultralight aircraft (photo by R. P. Urbanek).

wing with a tricycle cockpit and gear assembly suspended below. Both aircraft were powered by Konig 2-stroke, 4-cylinder, 28-horsepower radial engines and 4-blade propellers. In 1995, 4 identical Cosmos Phase II aircraft with Zoom 19-m^2 wings were used due to the requirements of filming for the motion picture *Fly Away Home* by Columbia Pictures. These were powered by Rotax 503, 2-stroke, 50-horsepower engines with reduction gears and 6-blade props. All of the trike aircraft used a pusher propeller fitted with an aluminum ring or "goose guard" around the perimeter to minimize danger to the birds. The geese were also habituated to, but not imprinted on, 2 other aircraft for the purpose of filming. These were a modified Easy Riser powered by a Konig 3-cylinder, 2-stroke engine with a 2-blade propeller and a Max Air Drifter powered by a Rotax 503 engine and a 3-blade propeller. The aircraft used were capable of sustained flight between 45 and 72 km/h. No ground vehicles were used in the imprinting process.

Sandhill Cranes

Sandhill cranes were isolation-reared (Horwich 1989, Urbanek and Bookhout 1992) from eggs collected by helicopter along the north shore of the North Channel of Lake Huron. Eggs were incubated in a separate building, and then hatchlings were transferred to the rearing facility. The facility consisted of 9 adjacent 0.8- × 1.2-m indoor compartments, each connected by a sliding door to a 0.8- × 2.4-m outdoor run. Each compartment could be accessed by a door opening into a common workroom. Outdoor runs were positioned along a 275- × 15-m grass runway on which chicks could be trained with the Cosmos Echo ultralight aircraft. The immediate area also contained grassy fields and a small pond where chicks were given additional exercise.

In isolation-rearing of cranes, caretakers were dressed in costumes that concealed the human form, particularly the face and hands (Horwich 1989, Urbanek and Bookhout 1992). The costume included a puppet head that resembled an adult crane and that was used to interact with the chicks. Chicks were walked approximately 2 hours each day to reinforce following response and reduce the possibility of developmental leg deformities that could result from inadequate exercise (Wellington et al. 1996). During these exercise periods, taped sound recordings of the ultralight

Table 1. Summary of flights in ultralight aircraft-led migration of Canada geese, 1993–95. False starts and local flights are not included.

Group	Year	Dates	Route segment[a]	Distance (km)	No. of flight days	No. of flights	Flight duration (min) Range	Mean	Total flight time (hr)
UG1	1993	19–25 Oct	Ont.-Va.	640	4	6	60–180	122	12.2
UG2	1994	11–16 Oct	Ont.-Va.	640	5	9	48–125	84	12.6
		1–10 Dec	Va.-S.C.	672	7	12	27–100	66	13.2
UG3b	1995	30 Oct–10 Nov	N.Y.[b]-Va.	640	6	9	51–120	88	14.7
UG3a,b		16–20 Nov	Va.-S.C.	672	4	8[c]	70–160	117	15.6

[a] Refer to Fig. 1.
[b] Trucked from rearing site in Ontario around Lake Ontario to Gaines, New York, on 28 October.
[c] On 16 November, 2 groups of geese were flown separately for 70 and 105 min., respectively, during the same flight. Mean for these 2 groups was used in calculation of mean flight duration and total flight time.

engine were continuously played to accustom chicks to the sound of the aircraft. Then, at 2–3 weeks of age, the smaller "goose toddler" model craft was introduced to help the chicks overcome fear of the overhead wing. This model could be easily carried during exercise periods and recordings of the engine were played from it to help the chicks associate movement with sound of the aircraft. This process continued until the birds could be grouped together and introduced to the actual aircraft at about 5 weeks of age.

The aircraft was introduced from a distance. The costumed parent sat next to it so that chicks would acclimate to the larger aircraft and wing. Eventually the engine was started for short periods, and later, with the engine running, a parent sat in the cockpit to propel the craft. This continued during the pre-fledging period. Once the chicks were comfortable and acclimated to the aircraft, the aircraft was taxied on the runway. During taxiing, 1 costumed parent operated the aircraft while another walked or ran directly under mid-wing. This technique accustomed the chicks to close proximity and association with the taxiing aircraft by use of the more desirable walking parent to evoke the following response (Fig. 2). Because the young chicks could be controlled more easily by the walking parent, the same method was used later as the birds reached fledging age and the aircraft left the runway. Flights were generally attempted in early morning or evening during optimal conditions for flying aircraft. The pilot was costumed during all flights.

RESULTS

1993 Goose Cohort

In 1993, 23 geese in 2 groups were taken southbound on a predetermined, 640-km route from southern Ontario to winter at Airlie Center, Virginia. In the first experiment, 18 geese (UG1's) were led by 2 ultralight aircraft 19–25 October with 4 stops en route; in the second, 5 geese (TG1's) were trucked in a closed vehicle on 10 December (Tables 1 and 2). At Airlie, the 2 flocks were penned separately alongside different lakes in good habitat frequented by resident and migratory Canada geese. Each flock was released daily under supervision but stayed in the vicinity of its pen. On 1 January, the close of migratory goose hunting season, both flocks were no longer penned. The UG1's were flown with the aircraft about once per month. Both flocks remained in the general vicinity of their release sites and were given supplementary feed of corn.

Two UG1's died during the winter. The remaining 16 UG1's were last observed at Airlie on 1 April 1994. In mid-April, at least 13 (81%) of the UG1's returned to or near the natal area in Ontario; 12 were observed at Purple Hill and another 80 km away. Detailed accounts were provided by Sladen and Lishman (1994), Sladen et al. (1994), and Sladen and Lishman (1995). The geese soon dispersed to presumably better habitat, and none were subsequently seen in their natal area, although reports of 2 being shot were received. The 5 trucked geese (TG1's) remained at their winter area at Airlie, and all survived to molt, when 1 was killed by a fox. The remainder disappeared, presumably shot, on the first day of the resident goose hunting season on 6 September 1994.

1994 Goose Cohort

On 11 October 1994, a flock of 38 geese (UG2's) was led south by 2 ultralight aircraft to Airlie along the same migration route used by the UG1's. Three dropped out en route, 1 of which was recaptured and added to the flock at Airlie. After 6 weeks at Airlie, 36 UG2's were led by the same aircraft on a 672-km predetermined route to the Tom Yawkey Wildlife Center, near Georgetown, South Carolina.

Table 2. Number of captive-reared Canada geese led by ultralight aircraft or transported by truck on autumn migration to winter in Virginia or South Carolina and number returning to the rearing area in Ontario, 1993-95.

Migration progression	1993 Aircraft (UG1)	1993 Truck[a] (TG1)	1994 Aircraft (UG2)	1995 Aircraft (UG3b)	1995 Truck[b] (TG2)
Departed from Ontario	18	5	38	30[d]	16
Arrived at Airlie	18	5	35[c]	29	16
Departed from Airlie			36	29	
Arrived at Tom Yawkey			35	29	
Survived winter	16	5	≥33		
Returned to Ontario	13	0	33	15	0

[a] Enclosed truck; birds were not allowed to fly during transport.
[b] Birds trucked from Ontario to Virginia were periodically released and allowed to fly freely at predetermined stops en route.
[c] An additional goose dropped out en route, was retrieved, and then trucked to Airlie for a total of 36 birds at that site.
[d] Trucked first leg of migration around Lake Ontario.

One goose dropped out on the first leg and returned to Airlie. This bird returned to its natal area alone the next spring. The remaining 35 birds arrived at the South Carolina destination on 10 December 1994. Total distance of the UG2 migration was 1,312 km (Fig. 1). Six days after release in South Carolina, the UG2's disappeared and were not observed again until they started appearing at their natal area in Ontario the following spring. In all, 33 of 35 (95%) geese that arrived at Tom Yawkey Wildlife Center returned to their natal area on 19-20 April. The UG2's left the sod farm on 12 June, prior to molting. Three returned when barely able to fly before the molt was completed, and by 9 September, 19 geese had returned to Nestleton. These birds came and went from the Nestleton location during the autumn of 1995. On 27 September, 3 of the UG2's were shot 2 km east of Nestleton, and on 16 November the remaining birds departed from Nestleton. A detailed account was provided by Sladen and Lishman (1995).

1995 Goose Cohort

Three separate flocks of geese were reared in 1995, partially to provide imprinted geese for the fictional feature film *Fly Away Home*. Two groups were raised at the sod farm in Ontario, and the third group was reared at Airlie, Virginia. One group of 30 was imprinted to fly with aircraft (UG3b's) and was led to Airlie in late October after having been trucked around Lake Ontario (Tables 1 and 2). Transport by truck was necessary to avoid crossing the lake by aircraft during persistent poor weather. Two geese dropped out in New York. One was retrieved to rejoin the flock. Thus 29 geese arrived at Airlie on 10 November.

The other group of 16 birds raised in Ontario (TG2's) was not taught to fly with aircraft but was likewise imprinted on humans and was trucked at the same time, stopping at several locations en route to overnight, like the UG3b, in pens open to the sky, but, unlike the UG3b, allowed to fly freely at each stop. When at Airlie they were penned at night for 2 weeks and then released to fend for themselves, being provided with only a minimum of supplementary feed in cold weather. As of September 1996, all but 3 which disappeared in March and 1 that died remained at Airlie.

The third group of 31 geese (UG3a's) was hatched and trained to fly with an identical aircraft at Airlie. These geese joined with UG3b's for a total flock of 60 birds, which, on 16 November, was led by 4 ultralight aircraft from Airlie to the Tom Yawkey Wildlife Center along the same route used by the UG2's the previous year. A total of 59 geese arrived at their winter destination on 20 November. The migration and daily study of these birds and the TG2's were described by Sladen (1996).

Only 15 of the UG3b's returned to the Ontario natal area the following spring. None of the 16 TG2's has been sighted in Ontario (Table 2).

1995 Sandhill Crane Cohort

Rearing and Initial Flights at the Rearing Facility.—Eight chicks hatched during 20-31 May, 2 of which died when less than 1 week old. The remaining chicks were trained with the aircraft. All responded well to the aircraft during daily sessions. However, 2 of these chicks developed severe leg deformities and were subsequently euthanized at 4-5 weeks of age. Another chick, learning to fly at age 10 weeks but not yet fledged, fractured its leg while following the taxiing aircraft and had to be removed from the experi-

Table 3. Flight summary for isolation-reared juvenile sandhill cranes trained to follow an ultralight aircraft, Blackstock, Ontario, 27 July–14 September (n = 3) and 17–28 September (n = 2), 1995.

Period or date	Number of flights	Flight departure runway[a]	Flight duration (min)	Distance (km)	Distance from start (km)	Maximum altitude (m)
27 Jul–14 Sep	18	PH	0–18	0– 3	0– 2	0– 60
17 Sep	3	FCF	31–34	5– 8	1– 3	90–350
18 Sep	2	FCF	16–65	15–27	8–13	140–350
21–24 Sep	3	PH	24–70	13–35	1–11	150–390
25 Sep	1	PH	84	64	48	560
25 Sep	1	Omemee	86	56	40	450
27–28 Sep	3	PH	30–80	32	10–13	490
28 Sep	1	SF	100	15	6	1,300

[a] PH = Purple Hill, FCF = Frew's cornfield, SF = Nestleton sod farm.

ment. Because the accident was not witnessed, whether the fracture was due to collision with the aircraft or merely ambulatory (Olsen 1994) was not determined. The remaining chicks fledged and successfully followed the aircraft in flight, but were reluctant to leave the vicinity of the rearing facility and would only remain airborne a short time (Table 3). On 16 September, as caretakers prepared to move the birds to a temporary pen erected at a different runway, 1 of the birds was startled when costumed parents carrying cardboard transport boxes approached the facility. Birds appeared excited because conditions were windy and they had not been released for exercise that day. The crane jumped in its run, struck some part of the interior pen structure, and broke its neck.

Flight Performance After Birds Were Moved to an Unfamiliar Runway.—On 17 September the 2 remaining cranes were moved to an unfamiliar runway in Frew's cornfield, 12 km from the runway at the Purple Hill rearing facility. Much improved performance was immediately achieved at the new runway. Flight times increased from 15–18 minutes to 30 and 65 minutes within 4 days. Altitudes increased from less than 60 m prior to 17 September to more than 300 m. Regular flights were made at 300 m and later to more than 1,200 m for increasing periods of time (Table 3).

On the initial flights from Frew's runway, the cranes, particularly the dominant No. 5, broke from the aircraft in the short-distance flights and returned to the runway area from several kilometers away, demonstrating the ability to home on a previous, though relatively unfamiliar, point of flight origin. Cranes were also led to land and then take off again within a short period of time from new runways; for example, on 18 September the birds were led airborne for 16 minutes from Frew's runway, landed, and then were led airborne again without difficulty.

Examples of Imprinting Response to the Aircraft.—On 21 September the pilot made an unscheduled landing at the Nestleton sod farm because of high winds. While he waited for the ground crew to arrive with transport boxes for trucking the cranes back to Purple Hill, an unfamiliar caretaker stayed with the birds as the aircraft was put in the hangar, out of sight. The birds then took flight and flew above the hangar, while repeatedly calling, and would not land on the runway. Only when the aircraft was removed from the hangar and moved into view more than 100 m away did the birds land near the caretakers and plane. The aircraft could not be put away until the ground crew arrived and the birds were boxed for transport to the rearing area.

During an otherwise routine morning flight on 22 September, both birds left the Purple Hill runway, but crane No. 5, apparently disturbed by high winds, was reluctant to follow the aircraft away from the rearing facility. As winds increased, No. 5 landed in front of the facility, where he began to call loudly. Crane No. 2 responded by flying farther behind the plane. After approximately 15 minutes of attempting to entice No. 5 back into the air, the pilot flew low over the rearing facility, at which time No. 2 landed beside No. 5. After confirming that both birds were on the ground, the pilot returned to the Nestleton sod farm, remaining airborne approximately 20 minutes at 400–500 m while the birds called loudly and flew in tight circles 100 m over the aircraft hangar. The pilot returned to an area of the runway free from uncostumed humans, and No. 2 responded by immediately landing and approaching the pilot/aircraft. Apparently No. 2 had left No. 5 to pursue the aircraft soon after the pilot departed from the rearing area at Purple Hill. Because the pilot rapidly climbed to a high altitude and was not watching for the birds, he did not know that No. 2 had followed until the bird was observed shortly after landing at the sod farm.

Cross-country Flight.—On 25 September, a round-trip flight to Omemee gliderport, 64 km from Purple Hill, was made to evaluate long-distance flight performance and thermal flying behavior. The initial 48-km leg was initiated at 0930 hours during a period of relatively intense low level thermal convection. As the pilot attempted to leave Purple Hill, both birds left their customary flying position astern and beside the aircraft. They were found circling in a narrow but strong thermal at approximately 250 m. When the aircraft joined them and began circling aggressively in the thermal core, the birds resumed their normal positions off the wingtip. A slow ($\bar{x}$ = 0.3 m/sec) climb was continued to 600 m, where a level of smooth air remained above the convective layer. The remainder of the flight proceeded in normal flying formation in smooth air. Upon approach at Omemee, aircraft and birds began descent from 600 m and all glided downward for approximately 15 minutes. Upon landing, the birds and pilot rested for approximately 1 hour with the costumed principal caretaker. Total flight time was 84 minutes at a mean ground speed of 45 km/h (Table 3).

During initiation of the return flight, the birds demonstrated a desire to follow the principal caretaker, who remained on the ground, but once the plane was in the air the birds were eager to follow and left this new runway without reluctance. On this flight, to permit examination of thermal flying behavior of the cranes, the pilot reduced engine RPM to a level below that required to maintain level flight. After an initial climb in a thermal to approximately 500 m, an average sink rate of 0.5 m/sec was established, analagous to gliding flight. To avoid having to add power (analagous to flapping flight), the pilot used thermals for climb to regain altitude lost during forward progress. Rather than navigate in straight lines back to the natal area, a course was selected based on estimations of where thermals were most likely to be encountered. The cranes quickly showed their superiority in thermal flying, easily outclimbing the aircraft by circling tightly in the thermal core. Although the cranes were able to climb more quickly than the aircraft, they rarely climbed more than 50 m above it, and they left thermals to continue following the aircraft on course. As the flight proceeded, thermal strength increased such that the pilot was unwilling to climb above 500 m because of control concerns. Vertical gusts as strong as ±5 m/sec were outside the control range of the aircraft but seemed to attract the birds. Because of strong headwinds, a precautionary landing was made at the Nestleton sod farm after a flight of 56 km and 86 minutes at a mean ground speed of 39 km/h. The birds had readily followed the aircraft to land at new runways, but their behavior after landing at these runways differed from that observed at Purple Hill. They appeared hungry immediately after flight and did not wander more than 10 m from the caretaker or plane while on the ground.

Terminus.—The sandhill crane project ended on 1 October when the birds were returned to captivity in accordance with Canadian Wildlife Service permit requirements.

DISCUSSION

Spring Migration and Return of the Geese

Of 16 1993-hatched geese that survived their first winter in Virginia and 35 1994-hatched geese that were successfully led to the Yawkey Center in South Carolina, 46 (90%) returned unassisted from their first spring migration to the natal area in Ontario. This high return rate bodes well for use of ultralight aircraft to teach birds a migration route in reintroductions. The geese returned despite flying in a migration route occupied by many migratory and resident Canada geese. They found their way back despite diversions from other geese, much as had isolation-reared sandhill cranes previously released into wild sandhill flocks at Seney National Wildlife Refuge (NWR) (Urbanek and Bookhout 1992, 1994).

The lower return rate (50%) of geese that were trucked around Lake Ontario to begin aircraft-led migration from New York and the failure of any of the geese trucked the entire route from Ontario to Virginia to return are consistent with results of sandhill crane studies at Seney NWR. In a release of 16 isolation-reared cranes in 1988 (Urbanek 1990), 8 began migration correctly from Seney by following wild cranes. The other 8 birds formed a self-guiding flock, did not depart with the wild cranes, and were subsequently transported in boxes for release on staging areas in Wisconsin, 370 km away. Of the 8 cranes that began migration correctly, all returned to Upper Michigan the following spring. Of the 8 cranes released in Wisconsin, only 3 (38%) were observed at Seney the following spring, although transmitter failures in this group reduced probability of finding all of these birds. These studies indicate the important relationship between captive-reared birds beginning migration from the natal area on their own power and subsequent successful migration.

The UG1's and UG2's did not have transmitters attached for following their migration north, so we have no data on the route they used. We only know that 90% successfully returned to their natal area.

Sandhill Cranes

Like geese, sandhill cranes were readily trained to follow the aircraft. We believe that long-distance flight behind the aircraft could have been accomplished sooner, but aircraft and pilot availability was limited by conflicts with the concurrent goose work. Cranes were initially reluctant to leave their rearing area but did so without hesitation after some long-distance flying experience. Moving the birds to a different runway was useful to overcome this initial reluctance. As the study continued, the cranes grew physically stronger and more eager to fly with the plane. They flew in an energy-efficient formation slightly behind the plane, just off the wing tips, as they would in a flock of wild cranes. Birds followed at all distances and altitudes tested. Flights were limited by capabilities of the aircraft rather than of the birds. Like wild cranes, and unlike geese, the cranes found thermal lift, and when the plane remained in the thermal, the birds also stayed and gained additional altitude. Cranes could be led to land and then take off again without difficulty from new runways. The innate ability of cranes to remain aware of their geographic location was demonstrated by cranes returning unassisted to runways used only 1 or few times.

The small number of cranes available for flights resulted from mortality during rearing. Most, perhaps all, of the crane deaths were avoidable. Captive-rearing of cranes is labor-intensive and requires special facilities, but the procedures have been thoroughly developed (Horwich 1989, Urbanek and Bookhout 1992, Nagendran et al. 1996, Wellington et al. 1996) and need only be followed to ensure high survival. However, this project represented the first effort at rearing cranes at this site, where previously only geese had been raised. Delay in completion of the facility, inadequate design safeguards, and insufficient manpower were all problems which can be corrected in future rearing attempts. Only 1 death was related to the aircraft, and this occurred because of inadequate assistance. In that incident a single caretaker attempted to release the chicks, which were just learning to fly, and then taxi the aircraft with the birds following and not in view. The apparent collision of the bird with the plane was not witnessed by the pilot and probably could have been avoided by use of another costumed parent to maneuver the birds, which was the usual protocol.

Differences Between Flight of Geese and Cranes with Aircraft

Differences in flight of geese and cranes were related primarily to wing loading, i.e., the total weight of the bird divided by the area of the wing. Wing loading in geese is relatively high, which requires the bird to work harder to maintain flight. Both species took advantage of the vortices created by the aircraft wing. However, cranes, because of their larger wing area, could more easily sail behind the wing. They were able to ride this air current in a greater range of conditions and at a greater distance from the wing. Cranes therefore displayed greater flight endurance shortly after fledging than did geese.

Cranes also demonstrated more efficient climbing and descent ability than geese. Flying with well rested geese under the best conditions yielded the greatest rate of climb recorded, 30 m/min. Under the same conditions, climb rates of 100-130 m/min were achieved with sandhills. Descent rates were also greater with cranes. On several occasions, descent from high altitude by aircraft with geese proved to be a slow process. Geese commonly wiffled, or flipped while dropping; however, altitude lost was minimal. For geese, wiffling was effective at positioning but was not a method the birds would use to descend from more than 1,000 m. Sandhills, because of their light wing loading, descended rapidly. We estimated that cranes descended at a rate of 160-180 m/min, although precise data were not recorded. Final approach of cranes could be nearly vertical, unlike the more horizontal, aircraft-style, running landing of geese. In general, the ultralight aircraft that was used could more easily fly with cranes than with geese.

Development of the Technique for Reintroducing Cranes: Current Progress and Future Needs

In 1995 use of ultralight aircraft to lead sandhill cranes on a southbound migration route was tested in the Rocky Mountains when Clegg et al. (1997) successfully trained 15 sandhill cranes to follow an aircraft and led 7 birds from Idaho to New Mexico. It has now been conclusively demonstrated that geese and cranes can be successfully taught to follow an ultralight aircraft for long distances. A successful autumn migration was also achieved when Ellis et al. (1997) trained 10 sandhill cranes to follow a truck and then led 9 of them successfully from northern to southern Arizona. As of September 1996, no studies have confirmed that cranes or geese will return of their own volition to a previously taught wintering area. Work with cranes has not yet progressed sufficiently to address this objective, and none of the experimental geese led by aircraft to predetermined wintering areas has been reported in those areas during subsequent winters. The small number of geese, the resident goose hunt in Virginia, and our inability to determine the winter location of the UG2's after they left the Yawkey Center have confounded assessment of return to wintering area. Successful development of this technique will require return of the birds to the wintering area that they were taught on their first migration. In future work it is imperative that birds are monitored, e.g., by radiotelemetry, on subsequent migrations so that their wintering sites are documented and, if not the desired site, can be studied to determine why the birds are wintering there.

Inducing cranes to winter on a predetermined site will depend on building and reinforcing their affinity for that site during their first winter. Because of the benefits of control by and interaction with the costumed parent, these required techniques can best be developed with isolation-reared birds. Procedures could be largely site dependent and will most effectively be developed at an actual whooping crane reintroduction site.

The use of ultralight aircraft as a reintroduction tool, with possible support from ground vehicles, should next be tested with whooping cranes isolation-reared at a northern reintroduction site and then led to a predetermined wintering area. In accordance with recovery plans for the whooping crane (Edwards et al. 1994, U.S. Fish and Wildlife Service 1994), this trial could represent the initial step in establishing a population of whooping cranes that breed in a prairie province of Canada and winter in the southeastern United States.

LITERATURE CITED

BARTLETT, D., and J. BARTLETT. 1973. Beyond the north wind with the snow goose. Natl. Geogr. 144:822-847.

CLEGG, K. R., J. C. LEWIS, and D. H. ELLIS. 1997. Use of ultralight aircraft for introducing migratory crane populations. Proc. North Am. Crane Workshop 7:105-113.

EDWARDS, R., S. BRECHTEL, R. BROMLEY, D. HJERTAAS, B. JOHNS. E. KUYT, J. LEWIS, N. MANNERS, R. STARDOM, and G. TARRY. 1994. National recovery plan for the whooping crane. Rep. 6. Recovery Nat. Endangered Wildl. Comm., Ottawa, Ont. 39pp.

ELLIS, D. H., B. CLAUSS, T. WATANABE, R. C. MYKUT, and M. KINLOCH. 1997. Results of an experiment to lead cranes on migration behind motorized ground vehicles. Proc. North Am. Crane Workshop 7:114-122.

HORWICH, R. H. 1989. Use of surrogate parental models and age periods in a successful release of hand-reared sandhill cranes. Zoo Biol. 8:379-390.

______, J. WOOD, and R. ANDERSON. 1992. Release of sandhill crane chicks hand-reared with artificial stimuli. Pages 255-262 *in* D. A. Wood, ed. Proc. 1988 crane workshop. Florida Game Fresh Water Fish Comm. Nongame Wildl. Prog. Tech. Rep. 12.

LISHMAN, W. A. 1989. C'mon geese. Cooper-Lishman Prod., Blackstock, Ont. Video. 30min.

______. 1991. Conditioning migratory birds to fly with ultralight aircraft. Unpubl. Rep., Blackstock, Ont. 20pp.

LORENZ, K. Z. 1978. The year of the greylag goose. Harcourt, Brace, and Jovanovch, New York, N.Y. 199pp.

NAGENDRAN, M., R. P. URBANEK, and D. H. ELLIS. 1996. Reintroduction techniques. Pages 231-240 *in* D. H. Ellis, G. F. Gee, and C. M. Mirande, eds. Cranes: their biology, husbandry, and conservation. Nat. Biol. Serv., Washington, D.C., and Int. Crane Found., Baraboo, Wis.

OLSEN, G. H. 1994. Crane orthopedics: pediatrics and adults. Semin. Avian and Exotic Pet Med. 3:73-80.

SLADEN, W. J. L. 1996. Ultralight/Canada goose migration experiment. Unpubl. Prog. Rep. 4, Airlie Cent., Warrenton, Va. 2pp.

______, and A. A. KISTCHINSKI. 1977. Some results from circumpolar marking programs on northern swans and geese. Pages 498-507 *in* T. J. Peterle, ed. Proc. XIII Int. Congr. Game Biol., Wildl. Manage. Inst. and The Wildl. Soc., Washington, D.C.

______, and R. LIMPERT. 1988. Methods of marking penguins and waterfowl in captivity. Proc. Annu. Conf. Am. Assoc. Zool. Parks and Aquariums 1988:672-674.

______, and W. A. LISHMAN. 1994. Progress report on ultralight/Canada goose migration experiment. Trumpeter Swan Soc. Newsl. 23:22-23.

______, and ______. 1995. Ultrageese #2 (UG2). Unpubl. Prog. Rep. 4, Airlie Cent., Warrenton, Va. 2pp.

______, ______, and G. G. SHIRE. 1994. Ultralight/Canada goose migration experiment. Unpubl. Prog. Rep. 3, Airlie Cent., Warrenton, Va. 10pp.

U.S. FISH AND WILDLIFE SERVICE. 1994. Whooping crane recovery plan. U.S. Fish Wildl. Serv., Albuquerque, N.M. 92pp.

URBANEK, R. P. 1990. Behavior and survival of captive-reared juvenile sandhill cranes introduced by gentle release into a migratory flock of sandhill cranes. Unpubl. Rep., Ohio Coop. Fish Wildl. Res. Unit, Columbus. 98pp.

______, and T. A. BOOKHOUT. 1992. Development of an isolation-rearing/gentle release procedure for reintroducing migratory cranes. Proc. North Am. Crane Workshop 6:120-130.

______, and ______. 1994. Performance of captive-reared cranes released into a migration route in eastern North America. Pages 121-129 *in* H. Higuchi and J. Minton, eds. The future of cranes and wetlands. Wild Bird Soc. Japan, Tokyo.

WELLINGTON, M., A. BURKE, J. M. NICOLICH, and K. O'MALLEY. 1996. Chick rearing. Pages 77-95 *in* D. H. Ellis, G. F. Gee, and C. M. Mirande, eds. Cranes: their biology, husbandry, and conservation. Nat. Biol. Serv., Washington, D.C., and Int. Crane Found., Baraboo, Wis.