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Abstract: Greater sandhlll crane chicks (*Grus canadensis tabida*) were hand-reared using moveable puppets and vocalizing crane models as substitute parents. Their parental attachment was transferred to a crane-costumed human who introduced them to a wild environment and to wild foods. Five chicks were gentle-released in Wisconsin when 3.5 months old, a period of high sociality, and all successfully joined wild cranes. Following their first few weeks in association with wild cranes, their behavior was normal and comparable to that of wild chicks and they achieved normal flight distance from humans. Four of the 5 were relocated in Wisconsin the following spring, having returned from their first winter migration.

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Production of cranes in captivity has the potential for bolstering populations of endangered species if reintroduction of captives can be carried out. Such releases of captive-reared cranes have often been unsuccessful in the past (Nesbitt 1979), with most successes involving parent-reared birds. Derrickson & Carpenter (1987) suggested that birds hand-reared using conventional methods are unsuitable for release in the wild and noted that subadult 1-2 year old parent-reared birds were best suited for release and integration into wild flocks. Parent-rearing in captivity, however, is riskier than hand-rearing and requires large numbers of surrogate parents (Derrickson & Carpenter 1987). Hand-rearing is more efficient for raising large numbers of young cranes in captivity (Archibald & Viess 1979).

Two problems associated with the release of captive hand-reared cranes are their attachment to humans and their inability to find enough food for survival (Nesbitt 1979). Using sandhill crane chicks as experimental animals, Horwich (1985, 1986, 1989; Erickson et al 1988) developed a method for hand-rearing cranes using models to imprint the chicks. Later, transferring the chicks' attachment to a costumed human, they were introduced to the correct stimuli at the correct developmental periods to prepare them for survival in their natural environment (Horwich 1985, 1986, 1989). This method has since been used in rearing endangered crane species (Nagendran and Horwich 1992; Price 1989). It has been repeated successfully in greater numbers (Urbanek 1990a & b, 1989) and has been used for a winter release (Nagendran 1990) of sandhill cranes.

The time of release was dependent on regressive or reattachment periods which have been determined to be common in a wide variety of mammals and birds (Horwich 1974). A cyclic nature of behavioral development was also noted in cranes (Voss 1976; Horwich 1987). The fluctuating nature of the mother-infant bond has species specific functions which involve maintaining or encouraging group cohesion (Horwich et al. 1977, 1982, 1983). Data on crane chick contact with models confirmed that social reattachment periods were important in cranes as well (Horwich 1989; Urbanek 1990a&b). Thus the chosen time for release of the chicks was coincident with a high reattachment level so that high chick sociality would facilitate the chicks joining wild crane flocks (Horwich 1989).

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METHODS

Two and 8 greater sandhill crane eggs were collected from Central Wisconsin and Grays Lake, Idaho, respectively, in the spring 1985 and transported to the ICF (Table 1). Two days prior to hatching, the 10 eggs were transferred from the incubator to the hatcher where white-naped crane (*Grus vipio*) brooding calls were played every 3-4 hours (sandhill crane brooding calls were unavailable). Upon hatching, the chicks were moved to individual indoor/outdoor enclosures measuring 1.8#m x 3.0#m x 2.4#m and 1.8#m x 6.0#m x 2.1 #m, respectively.

The chicks were restricted the first 3 days to a temporary l.O#m x l.O#m subenclosure containing either a mounted or fabricated crane model with an internal speaker, red food and water dishes, and a heat lamp suspended above the model (Fig. 1). After the third day, the subenclosures were removed, allowing the chicks to see each other. The chicks were observed through one-way mirrors. All crane-human interactions were conducted by humans disguised as cranes to prevent attachment to humans. The crane costume was a gray sack with viewing mesh and feathers sewn on the wings. The right arm was inserted into a puppet for interacting with the chicks and tape recorder with brooding calls was concealed in the costume (Fig. 2).

The chicks were reared according to ICF methods (Archibald & Viess 1979; La Rue 1981) except for being fed by a puppet resembling the head of a sandhill crane (Putnam 1982). The puppet was in the pens with the chicks at all times. The brooding calls were played through the speaker in the model during feedings every 2-3h, and during 2 daily 10 min. testing periods. Unison and guard calls were played to chicks on 2 occasions but were discontinued due to the chicks' alarmed responses. The chicks were subjected to slightly different rearing methods. Six Group B birds were raised with both the model and costume from hatching while 4 Group A birds were exposed to only the model for the first week, which was then replaced by a costumed human (Table 1). Group B birds had their models removed after 30 days.

At 2-3 weeks of age, the chicks were socialized into their respective groups. Aggression was so intense the first few weeks they could not be left together safely without the costumed parent present. When inter-chick aggression decreased at 4-6 weeks, the chicks were led in groups by the costumed parent to fields and marshes on ICF grounds and shown insects. One of the chicks (F) developed severe leg problems at this time and was euthanized (Table 1). At 4 weeks, the chicks were led by costumed parents to a field where they were chased and touched roughly by humans to instill fear, then led back to their enclosures. At 5 weeks, each was banded with individual combinations of 2.54#cm color bands, U.S. Fish and Wildlife Service aluminum bands and solar/Ni-cad powered transmitters (Telemetry Systems Inc., Mequon, WI) attached to 7.62#cm plastic bands (Melvin et al 1983). At this time they were also examined for evidence of disease; blood, buccal and cloacal swabs were taken, and each was weighed.

At 8 weeks, the 9 remaining chicks (Table 1) were moved to Necedah National Wildlife Refuge, Wisconsin for gentle release from 2 pens of 2.5 mesh chicken wire, approximately 30#m in diameter and containing individual 1.2#m x 1.2#m x 1.5#m sheds in which the chicks were locked each night to protect them from predators (Horwich 1989). The release area was part of an open peninsula extending into a marsh area a kilometer from a known crane roosting area. An observation tent was situated within viewing distance of both pens. Two chicks (T & S) were lost from myopathy in transit from ICF, and a third (Dd) died in a cyclone. The 6 surviving birds (Table 1) were placed in the remaining pen. A second health test was conducted at 10 weeks of age while at the release site.

The chicks were led around the marsh area daily by the surrogate parent, and taught to eat corn (*Zea mays*), arrowhead roots (*Sagittaria latifolia*) and buckwheat (*Fagopyrum esculentum*). At 10 weeks, all became heavily reattached to the costumed parent as indicated by a reduction in following distances (Horwich 1989). This regressive period is typical in mammals (Horwich 1974) and cranes (Yoss 1976; Horwich 1987, 1989). In such periods the young display high levels ot infantile behaviors, including remaining a high percentage of the time in close contact with parents (Horwich 1989). Throughout this period supplementary food was

reduced to encourage natural foraging and to easily lock them inside each night. We removed the provisioned food during the day and measured the amount individually eaten at night (about 1/3-2/3 their normal consumption). At this time, the chicks were spending more time with the surrogate parent and frequently stayed around the observation tent waiting for the costumed parent. Since they more frequently were seeing humans, they were always chased by uncostumed humans to prevent secondary imprinting (Vidal 1976).

Since their reattachment to the parent seemed to reduce their foraging, we decided to "release" them. On 16 September, at 3.5 months of age, we removed all vestiges of captivity, including the costumed parent and all supplementary feeding. The birds were then monitored with AVM, Telonics, and Cedar Creek receivers, and observations were made with 7 x 35 binoculars, a 15 x 60 powered scope, and a 50/80 Questar telescope.

RESULTS

One chick (M) showed some interest in wild cranes before release, returning their calls as they flew overhead. The others showed only mild interest and only occasionally called to or looked up at wild cranes. Between 15-24 August, all 6 chicks could fly 90 m circles around the area and exhibited more ritualized aggressive behavior and the hierarchy became less defined. Chick CL showed the first real interest in wild cranes, flying toward 3 calling adults and then circling back.

All the chicks foraged on arrowhead roots, animal matter, seedheads and other plant materials. Due to their more frequent viewing of humans near the tent as they waited for the costumed parent, their wariness decreased and we could approach them without the costume within 3-6 m. One chick (Dk) had seen the costumed parent with hood off during treatment for a bill injury and began approaching humans.

By 16 September, when we decided to release the chicks, all were capable of sustained flight, which they usually did in a flock. They were eating wild foods as well as corn, but were remaining near the tent most of the time and had lost much of their fear of humans.

On 17 September, a wild adult approached the chicks giving a crouched aggressive threat, chicks seemed wary and uneasy. They were later joined by a wild chick, and the most aggressive chicks (N, Dk) dominated the wild one, who in turn dominated CL, a less aggressive chick. The wild chick, following the hand-reared chicks would walk past a human observer at a distance of less than 6 m, although displaying some wariness. The group's lack of fear probably influenced the wild chick. The released chicks could be approached to within 3 m.

Although the chicks were capable of extended flight at this time, they usually look a few flights per day, especially once in early morning. They walked to areas where it would have been easier to fly, and once M and R swam a 6 m wide canal rather than fly.

On 18 September, N, CL, and Cy made a short flight after some wild birds, but circled back. On 20 September, the chicks showed wariness of 5 adults who landed near them. The following day they made their first extended flight (5 km) foraging near a lumber yard. On 22 September, Cy, N and R disappeared from the area and were located a few days later near Tomah, nearly 48 km from the release site. On 23 September, Dk, whose bill had been injured earlier showed weakness and was caught. She died 2 days later. Flight distances of the other birds at this time were about 25 m. The 3 chicks which left the release site remained in the Tomah area for 3 days and made flights from dogs of 100 m, but humans could still approach to within 2 m of them.

On 26 September, M and CL flushed with a group of wild cranes but broke away and flew back to the release site, and were seen foraging with a family of 3 the following day.

On 2 October, 19 days after release, the 2 chicks at the release site were consistantly wary of humans, with average flight distances of 12-21 m.

A week later, CL made an extended non-stop flight alone, lasting 46 min, landing alone in an alfalfa fleld 2.6 km south of the release site. The next day N, one of the chicks sighted near Tomah, was observed alone 153 km southwest of the release site, near Bloomington, Wisconsin, where a farmer had been feeding him grain. He was wary, and when approached, would run into a shed (both he and Dk, before release, would run into their shelters from humans). On the farm, N had shown interest in a flock of turkeys. We again introduced N to the costumed parent and he showed intense greeting behaviors, submissively bowing and pecking the puppet bill. He immediately followed the parent and was easily loaded into a van and taken back to the release site.

Upon leading him to the release site by the costumed parent, 2 groups of wild cranes were

flushed in succession. N called to the first group, then called and flew after the second group for a short flight before returning to the costumed parent. The next day N was located foraging in a cut cornfield 12#km southwest of the release site wlth a large flock of about 200 cranes which were flushed by hunters. N returned wlth the flock to the refuge.

The 29th day after release was the first day that N, CL and M were found foraging in a cornfield together with 13 wild birds including a family with 2 chicks for a total of 9 chicks. The 3 chicks remained with this flock for more than a week. The flock seemed to remain fairly constant ln compositlon, and often grouped with another similar-sized flock. We often saw 23-24 members in the flock, which returned to forage in the same cornfield for 10 days (about 24 km east of the release site). They returned each night to the roost area 1#km from the release site. The chicks generally foraged together as a subgroup, much like famlly groups forage. They were displaced or dominated by adults much as wild chicks were. About this tlme, N who had always been dominant, became subordinant to M.

The flock soon began fluctuating in size, attaining as many as 55 individuals, but the hand-reared chicks seemed to always be in a subflock of 12. This subflock began roosting on the Petenwell Flowage 16#km east of the release site, probably due to its proximity to the foraging area since they continued to forage in the same general area.

On the 42nd day after release, N and CL were observed alone in an alfalfa field in the previously noted foraging area. When approached, they flushed at 100#m spiralling high out of sight and were not subsequently relocated in the area that fall. M remained with what appeared to be the same flock, feeding in the same area and roosting at the Petenwell Flowage roost. He disappeared from the area on 3 November and was not located again. He was last seen with a flock of 40 birds spiralling upward, presumably beginning migration.

About that time, N and CL were located on the Jasper-Pulaski Wildlife Area by A. Wenner, a biologist with the Florida Game and Fresh Water Fish Commission. Initially together, they separated soon after and CL left Jasper-Pulaski without N, 53 days after release. N remained at Jasper-Pulaski until 3 December.

The major movements of the chicks during the introduction period are summarized in Fig. 3, and Table 1 provides basic data and the fates of the individual chicks.

Post-migration Observations

A search in Florida in the winter of 1985-86 failed to locate any of the chicks (Wood & Anderson, This Proceedings). In early April, a report was made to ICF of 2 cranes wearing green bands in association with an unmarked crane near Farmington, lowa near the Mississippi River. Although not confirmed, those birds were probably Cy and R who had strayed with N down the Mississippi flyway.

In early May, Cy and R were found together ln a cranberry bog 2#km northeast of Tomah, Wisconsin. They separated in mid-June when Cy returned to the refuge. By mid-May, 4 of the 5 released birds were located and positively identified in Wisconsin. Three had returned to near the release site, and N was 129#km to the southeast at White River Marsh, Greenlake County, Wisconsin. Only M, the most socially tenacious bird, was never relocated. By this time, whenever the birds were approached by humans, all flew at distances of about 100m, similar to wild cranes in the area. The released birds were consistently with unmarked members of a wild non-breeding flock.

DISCUSSION

Two main developmental ideas were used in this release program which helped the newly fledged chicks become successful release candidates. The first was based on imprinting studies done mainly on domestic fowl ln the 1960's (Hess 1972; Hess & Petrovlch 1977), which demonstrated that there is a "critical" period after hatching when precocial birds imprint on a parental model. Important species-specific stimuli were used in the process. The second was that social development proceeds in a cyclic fashion; the initial high level of the mother-infant bond fluctuates rather than showing a linear reduction in contact (Horwich 1974, 1987, 1989) and is the foundation for later social grouping behavior. With age, these mother-infant attachment fluctuations serve to maintain group bonds during specific seasons (Horwich et al. 1977, 1982). Although mainly researched in mammals, previous studies on red-crowned and sandhill cranes indicated that crane behaviors exhibit cyclic development as well (Voss 1976 ; Horwich 1987, 1989).

Thus, when the hand-reared chicks began exhibiting intense regression by attempting to be close to their surrogate parent, it became necessary to

release them (Horwich 1989). The vital questions were whether they could feed themselves well enough and whether they would associate with their own species when the costumed parent was removed. The latter was answered when all chicks exhtbited increased interest in wild cranes once the surrogate parent was removed. One chick (N) demonstrated how intense the post fledging fall social bonding drive is when he visited a farm and showed interest in turkeys, the only large birds available. However, when reconfronted with wild cranes at Necedah, he showed immediate interest, even vacillating between the wild cranes and his surrogate parent. Once the parent was removed, he immediately joined a large flock of wild cranes. Wild chicks probably go through similar accidental "releases" when they lose their parents during migration. However, the flocking drive at this time probably provides a safety measure for lost chicks to survive without parents by joining wild flocks.

Imprinting is considered to influence eventual mate selection, and indeed there are examples of hand-reared cranes that as adults attempted to mate with humans. It seems, however, that there are one or more secondary imprinting periods which seem to correlate with the regressive periods, in which young cranes can reimprint on or resocialize to another species, as with dogs (Scott 1962). Domestic young chickens exposed to parental models for 3 developmental periods indicated a sexual imprinting period at 31-45 days and may be associated with the development of adult plumage (Vidal 1976). The regressive period of the sandhill crane chicks in this study began at 10-12 weeks, with the mature plumage. If so, captive cranes for future release should be grouped with or near their own species prior to this secondary imprinting period to maximize proper species identity at this critical period. Improper species identification at this critical period in whooping cranes cross-fostered with sandhill crane parents at Grays Lake, Idaho, may be a major factor in the poor formation of pair bonds even though they have been associating with other whooping cranes (Lewis 1986 pers. comm.; U.S. Fish & Wildlife Service 1980). In contrast, sandhill cranes reared by this surrogate method in 1984 and 1986 have formed palr bonds in captivity with their own species, laid eggs and incubated them (Mirande, pers. comm.). In the field as well, five 2-year old cranes similarly reared by Urbanek (1990b) have also formed pair bonds with wild sandhill cranes (Urbanek 1990a) indicating that the surrogate technique develops socially normal birds.

In past reintroductions, hand-rearing has resulted in attraction of the birds to humans as well as their lack of fear of humans. Thus, instilling fear of humans was a secondary goal of this study. We tried to develop fear by keeping the chicks totally removed from the sight and sound of humans but some sights and a good deal of sounds reached the chlcks. In addition, their wariness was reduced as they acclimated to humans entering the tent as the costumed parent. The use of negative stimuli (chasing the chicks) helped to keep some of the chicks wary of humans, and other negative handling during health checks contributed to the development of early fear. But it was not until the chicks had been associating continually with wild cranes that their fear of humans became well established. Behaviorally, the juvenile birds were very maleable and followed the example of wild birds.

This surrogate parent reintroduction technique was successful for 3 main reasons: 1) it was gradual, 2) it eliminated identification with humans, and 3) it utilized fluctuating social periods, especially a probable peak of species or sexual indentity, at the time of reintroduction.

The technique shows promise for future releases of endangered cranes and other avian species in which experienced adults are available as role models to teach them foraging areas, migratory routes, and fear of humans and other predators. It could be used to supplement the cross-fostering method, especially if cross-fostering is shown to retard pairing.

Finally, with the results of Urbanek (1990a&b) the method should be tried as an alternative for reintroducing a species into areas where there is no wild population. In that situation, better methods should be developed to instill fear of predators, and longer supplementary feeding might need to be maintained. Most importantly the sociality should be monitored continuously and selected social stimuli should be used during the highly social periods to secondarily imprint the chicks. The technique has already been used in rearing endangered Siberian cranes (Nagendran & Horwich, 1992) and Mississippi sandhill cranes (Price 1989) and has been duplicated with even better success than this study(15 of 16 birds completed a round trip migration) (Urbanek 1990a & b) and has been used ln reintroducing chicks at the wintering grounds (Nagendran 1990) as an experiment which could be tried on Siberian cranes in India.

Urbanek's (1990a&b,1989) work deserves note in that it has been able to securely reinforce some

aspects of the technique to a point where there is an excellent probability to use the technique for successfully reintroducing a second whooping crane migratory flock in Michigan. Besides the incredible survival of his sandhill crane young through the first winter of 94% (Urbanek 1990c), the work has shown that the imprinting costume can be used in controlling the young for over one year in some cases and that it can be used to induce yearlings to be a successful surrogate parent in leading younger cohorts along the migratory route (Urbanek, 1990a). It has also shown how important rearing at the site was for site attachment (Urbanek 1990a).

SUGGESTIONS FOR FUTURE CRANE RELEASES

1. Perform all release phases and processes gradually, with transitional stages to allow birds adequate time in a secure situation to adjust to the change.

2. Allow birds adequate socialization time prior to placement on a release site to allow them to explore a new environment as a flock. Do not allow too much time together prior to the release to prevent permanent bonding (Drewien et al. 1982). One to 3 months seems to be a good period.

3. Use small groups of 3-6 to prevent the released birds from flocking exclusively with other released birds, which might inhibit their joining wild cranes (Mitchell & Zwank 1987).

4. Introduce cranes to known wild foods, including crop grains they may encounter in the wild, in advance of their transference to a release site.

5. Release cranes during highly social periods, i.e in the fall, especially migratory cranes, with winter a second choice. Weekly behavioral measures of sociality will help determine this time.

6. Release cranes that are under 2 years of age (Drewien et al. 1982); well prepared post fledging birds which have been introduced to stable wild food sources or are provisioned seem to be the best candidates (Horwich 1989; Urbanek 1990 a&b, 1989).

7. In captive, hand-reared or cross-fostered chicks, regroup chicks with others of their own species as early as possible after their aggressive period ends. Two months should be a good age. Maintain them in cages adjacent to other adult birds of their species. Do not keep other species within their sight.

8. Maintain release birds at a release site for at least 2-4 weeks so they can become acquainted with and acclimated to the area. This will enable them to respond to the area as a home base and preclude premature dispersal. Rapid wandering from release sites has proved disasterous in some releases (Mitchell & Zwank 1987). For maximum site attachment, rear them at the release site (Urbanek 1990a).

9. Continue supplementary feeding in the same areas for at least a few weeks while released cranes are exploring. In a non-migratory situation, supplementary feeding can be maintained as long as desired. Close monitoring of the feeding station will allow some idea of when to terminate the feeding.

10. Minimize human contact, especially during the first few days and at fledging time. Do not give cranes opportunity to associate humans with feeding or following. Discourage approaches to humans by mildly scaring or chasing those which approach humans.

11. Allow fledging to occur by flying in and out of wire mesh enclosures. This may give chicks experience in avoiding wires.

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Table 1. Sandhill crane chicks hand-reared and released

Chick Identity	Hatch Date	Source	Social & Research Grouping	Last Weight and Date (kg.)	Sex Known or Supposed	Fate
F Foxy)	May 7	Wis.	B		?	Euthanized at 7 weeks
Cy (Cyclops)	May 30	Idaho	B	3.5 Aug 6	♂ (?)	Located spring 1986 in Wisconsin
CL Chicken Lips)	May 30	Wis	B	3.0 Aug 6	♀ (?)	Located spring 1986 in Wisconsin
N (Noah)	May 30	Idaho	B	3.4 Aug 6	♂ (?)	Located spring 1986 in Wisconsin and winter 1987 in Florida
T (Titan)	June 1	Idaho	A	3.9 Aug 6	♀	Died at 9 weeks from myopathy during transport
S (Siren)	June 1	Idaho	A	4.0 Aug 6	♂	Died at 9 weeks from myopathy during transport
M (Medusa)	June 1	Idaho	A	3.6 Aug 6	♂ (?)	Last seen in a flock presumably migrating south at 5 months
R (Ratibida)	June 2	Idaho	A	1.4 Aug 6	♀ (?)	Located spring 1986 in Wisconsin
Dk (Doink)	June 5	Idaho	B	2.0 Aug 6	♀ (?)	Died from predator bites and lack of food at 13 weeks
Dd (Dude)	June 5	Idaho	B	2.6 Aug 6	♂ (?)	Eaten by predator after tornado at 2 months