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Christy L. Sadowski
University of Wisconsin-Oshkosh

Glenn H. Olsen
USGS Patuxent Wildlife Research Center

M. Elsbeth McPhee
University of Wisconsin - Oshkosh, mcpheem@uwosh.edu

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CHRISTY L. SADOWSKI, University of Wisconsin-Oshkosh, 800 Algoma Boulevard, Oshkosh, WI 54901, USA

GLENN H. OLSEN, U.S. Geological Survey, Patuxent Wildlife Research Center, 12100 Beech Forest Road, Laurel, MD 20708, USA

M. ELSBETH MCPHEE,[1] University of Wisconsin-Oshkosh, 800 Algoma Boulevard, Oshkosh, WI 54901, USA

Abstract: Whooping cranes (*Grus americana*) are 1 of the most endangered bird species in North America. In 1999 the Whooping Crane Eastern Partnership was formed to establish a migratory population of whooping cranes in eastern North America. These efforts have been extremely successful in terms of adult survival but reproductive success post-release has been low. One hypothesis developed to explain such low reproductive success is that captive-rearing techniques fail to prepare the birds to be effective parents. Captive-reared whooping cranes at the U.S. Geological Survey, Patuxent Wildlife Research Center, Laurel, Maryland, are either reared by humans in crane costumes or by surrogate conspecific adults. We hypothesized that the 2 captive-rearing techniques differentially shaped chick behavior. To test this, we measured chick behavior daily as well as when chicks were placed in novel environments. Twice per day, every day, 5-minute focal observations were conducted on each chick. When they were introduced to a novel environment, 10-minute focal observations were conducted within 1 hour of introduction. The 2 groups differed significantly: costume-reared chicks were, on average, more stationary than parent-reared birds. These data suggest that future research should be done to determine whether or not rearing technique could have long-term effects on post-release behavior and reproductive success.

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Key words: behavior, captive breeding, conservation, endangered species, *Grus americana*, novel environment, whooping crane.

Whooping cranes (*Grus americana*) are 1 of the most endangered bird species in North America and nearly became extinct in the mid-1900s (Allen 1952). Due to European settlement, development of agriculture, and hunting for food, sport, and market (Allen 1952, Glenn et al. 1999), their numbers reached a low of approximately 21 to 22 wild individuals in 1941 (Allen 1952). Whooping cranes can currently be found in 1 of 4 wild populations: 1) a self-sustaining population that breeds in the Wood Buffalo National Park, Canada, and winters at the Aransas National Wildlife Refuge, Texas (N = 431.9 ± 60.8 [95% CI], winter 2016-17; Butler and Harrell 2017), 2) a reintroduced non-migratory population in Louisiana (N = 67, Jun 2018; Szyszkoski 2018), 3) a reintroduced non-migratory population in central Florida (N = 14, Oct 2017; T. Dellinger, Florida Fish and Wildlife Conservation Commission, personal communication), and 4) a reintroduced population that migrates from central Wisconsin to the southeastern United States (Eastern Migratory Population [EMP]; N = 103, Thompson 2018). Of these 4 populations, 3 have relied on captive-reared birds for reintroductions.

In 2001 the Whooping Crane Eastern Partnership, comprised of state, federal, and private organizations, began reintroducing captive-reared whooping cranes from the U.S. Geological Survey, USGS Patuxent Wildlife Research Center (Patuxent), into central Wisconsin in an attempt to establish a self-sustaining migratory population of whooping cranes that is geographically separate from the Aransas-Wood Buffalo Population. The initial site of reintroduction was the Necedah National Wildlife Refuge (NWR). The White River Marsh State Wildlife Area and Horicon Marsh (Horicon NWR and Horicon Marsh State Wildlife Area) were added as additional release sites in 2011. The Necedah NWR is comprised of shallow, open water impoundments, upland prairies, and oak (*Quercus* spp.) forests (Cannon 1999). The White River Marsh State Wildlife Area consists of open marshes and wet meadows, swamp hardwoods, and upland prairie/oak savannahs (Wisconsin Department of Natural Resources 2017). The Horicon Marsh, consisting of both state and federal land, is the largest freshwater cattail (*Typha* spp.) marsh in the United States (Wisconsin Department of Natural Resources 2016).

Between 2015 and the first releases in 2001, 239 birds have been released into Wisconsin and 40%

[1] E-mail: mcpheem@uwosh.edu

survived (Harrell and Bidwell 2015). Although the released birds are surviving, migrating, and laying eggs, their reproductive success has been extremely low due to nest abandonment caused by black flies (Urbanek et al. 2010) and high chick mortality (Whooping Crane Eastern Partnership 2015). One hypothesis for the high chick mortality is that the cranes did not learn appropriate behavioral skills due to captive rearing and this is now contributing to low recruitment in the EMP.

Individuals reared in captivity develop in unnatural environments with little exposure to natural environmental cues. Many studies have shown that, as a result, captive-reared animals released into the wild can exhibit diminished ability to find food, interact socially with other members of their species, avoid predation, and successfully reproduce (McPhee 2004). For example, since 1991, biologists have been releasing captive-reared houbara bustards (*Chlamydotis undulata*) into the Mahazat as-Sayd Protected Area in Saudi Arabia. In the initial release, all 4 birds expressed behaviors linked to stress and were deficient in anti-predator, foraging, and spatial orientation behaviors; all were killed by foxes (*Vulpes* sp.) within 3 days (Saint Jaime et al. 1996). Subsequently, multiple release techniques were tested but predator avoidance remained a significant problem for the population (Saint Jaime et al. 1996). A comparison between wild and captive-reared coho salmon (*Oncorhynchus kisutch*) showed that wild males established dominance over the captive-reared males in 11 out of 14 trials (Berejikian et al. 2001). Work with captive-bred swift fox (*Vulpes velox*) suggests that captivity can increase boldness; all radio-tracked individuals that died within the 6 months following release were those classified as bold in pre-release tests (Bremner-Harrison et al. 2004).

More detailed studies have shown that some rearing techniques are more effective than others at retaining natural behaviors. For example, Powell and Cuthbert (1993) followed killdeer (*Charadrius vociferus*) that were raised 1 of 3 ways to measure possible differences between the groups in behavior and survival. The killdeer in that study were raised a) in the wild by their parents (parent-reared), b) by a similar species in the wild (cross-fostered), or c) in captivity by humans and released into the wild (captive-reared). Their results showed that captive-reared birds spent significantly less time feeding and resting than parent-reared and cross-fostered birds (Powell and Cuthbert 1993). However, the impact of these behavioral differences on survivorship of captive-reared birds in the wild is still unknown. In Atlantic salmon (*Salmo salar*), Evans et al. (2014) observed a doubling of survivorship rates in offspring of parents in natural river systems compared to the offspring of captive parents that had been released when they reached the exogenous feeding stage. Survivorship of juvenile black-tailed prairie dogs (*Cynomys ludovicianus*) was positively influenced by behavior of the parents. Juveniles that underwent predator response training in the presence of adults were more likely to survive after reintroduction than those trained without experienced adults (Shier and Owings 2007). Unfortunately, reintroduction of captive-reared animals is often the only conservation option for populations that have experienced detrimental declines in abundance, which is the case for whooping cranes.

Whooping crane chicks at Patuxent were reared by 1 of 2 methods: 1) by humans in costume or 2) by a pair of captive adult whooping cranes (U.S. Geological Survey 2012*a*,*b*). To explore the hypothesis that the 2 captive-rearing environments and rearing techniques cause behavioral differences in the endangered whooping crane, we conducted behavioral observations on all chicks at Patuxent. Specifically, we predicted that the parent-reared birds would exhibit more foraging behavior and vigilance than the costume-reared birds.

STUDY AREA

This work was conducted at the USGS Patuxent Wildlife Research Center in Laurel, Maryland. The center covers a 5,199-ha area and was the largest captive-breeding facility for the endangered whooping cranes. Wild whooping crane eggs were provided to Patuxent from populations in the wild and from pairs that lay in zoos; captive pairs of whooping cranes at Patuxent also provided eggs. Chicks were raised in captivity for potential release into the wild following either costume-rearing or, beginning in 2013, parent-rearing.

METHODS

Rearing Techniques

Whooping crane chicks at Patuxent were reared by 1 of 2 methods: 1) by humans in costume or 2) by a pair of captive adult whooping cranes (U.S.

Geological Survey 2012*a*,*b*). Chicks raised by humans in costumes (referred to as costume-reared or CR) were raised without any exposure to human voices or faces. Immediately after hatch, they were housed individually in long, narrow pens with both indoor and outdoor sections (Table 1). For the first 5-7 days, chicks were confined to the indoor section, then allowed both outside and inside during the day, and after 25 days chicks were allowed outside even at night. They were introduced to food and water post-hatch with the help of a puppet head that was maneuvered by a costumed caretaker. At 25-35 days of age, they were transferred to larger enclosures and introduced to and eventually housed with other chicks. Costumed caretakers took the chicks for daily walks and swimming sessions and, from 2001 to 2015, CR individuals were also trained to follow an ultralight aircraft. The second rearing technique was parent-rearing (PR), where the chicks were raised by a pair of captive adult conspecifics. This technique was initiated in 2013. There were 3 adoption methods for the PR chicks. First, a pipped egg was brought into the pen and replaced an artificial egg or an egg that was incubated for at least 21 days. The second approach was to place a chick weighing less than 350 grams on the nest in exchange of an egg. Third, some pairs were allowed to keep and incubate their own eggs. In this case, if the pair laid 2 eggs, 1 egg was removed. Regardless of adoption method, all PR chicks were initially housed in outdoor pens with parents but no other chicks. At approximately 90 days of age, they were transferred to larger enclosures (Table 1) and housed with other chicks.

For the CR chicks, there were initially 2 locations used, the Propagation Building and the Crane Chick Building (CCB). Dimensions differed for the 2 facilities, with the Propagation Building having inside pen dimensions of 2.7 × 3.4 m and outside dimensions of 2.4 × 9.1 m, while the CCB had inside dimensions of 2.4 × 2.4 and outside dimensions of 2.4 × 7.6 (Table 1). The PR chicks were initially housed in 2 sets of pens used to house the adult birds which were their parents or surrogate parents. These were the Blue Series Pens, dimensions 13.7 × 19.8 m or the Lower Flight Pens, dimensions 10.7 × 30.5 m (Table 1). After the initial pens, both the CR and PR birds were housed in the same facilities, namely the White Series Pens and the Pond Pens (Table 1), although the 2 groups were never together in the same pen. The Propagation Building and CCB had food delivered inside, but all other areas (Blue Series Pens, Lower Flight Pens, White Series Pens, and Pond Pens) had food delivered in a cylindrical gravity feeder measuring 35.5 cm round at the base, with a 25.5-cm diameter cylinder 40.6 cm above the base. The gravity feeders were made of galvanized metal. All gravity feeders used in the outdoor pens were kept in feed sheds to protect them from the weather. The same gravity feeders were used in the release pens at Necedah NWR.

Table 1. Description of pens that chicks experienced while in captivity at the USGS Patuxent Wildlife Research Center, Laurel, Maryland, 2015.

Facility	~Dimensions (m)	Description	Move no.	~ Age (days) when birds were moved
Costume-rearing				
Propagation building[a]	2.7 × 3.4 (inside), 2.4 × 9.1 (outside)	Inside: matting or bedding Outside: grass	0	NA
Crane chick building[a]	2.4 × 2.4 (inside), 2.4 × 7.6 (outside)			
White series	7.6 × 30.5	Grass, no standing water, feed shed	1	25
Pond pen	24 × 30. 5	Grass, standing water, feed shed	2	35-50
White River Marsh (release pen)	14.2 × 7.9 (dry pen) 15.3 × 22.8 (wet pen)	Dry portion with feed shed and wet portion with standing water	3	45-55
Parent-rearing				
Blue series[a]	13.7 × 198	Grass, feed shed	0	NA
Lower flight pen[a]	10.7 × 30.5	Grass, covered overhang, feed shed	0	NA
Pond pen	24 × 30.5	Grass, standing water, feed shed	1	70-75
Necedah NWR (Site 4 group release pen)	14 × 7.9	Oval shaped with dry and wet portions	2	80

[a] Original pen.

The feed sheds were of wood construction, with doors that opened on 1 side to allow entrance of the birds. Generally, the door openings were to the south or east sides, as prevailing winds and weather at Patuxent generally come from the west or north. The feed sheds in the Blue Series Pens, Lower Flight Pens, and Pond Pens were all of similar dimensions and measured 1.8 × 1.9 m with a peaked roof, height ranging from 2.0 m at the sides to 2.3-2.4 m at the peak. As stated, 1 side was open to the pen; another side was built into the pen fencing and had a door 7.1 × 1.8 m. All feed sheds had sand floors. The feed sheds in the White Series pens were 1.9 × 4.5 m, with a height of 2.3 m at the low sides to 3.0 m at the peak. They also had a flat roofed porch 2.3 × 4.5 m in size. However, the shed was separated into 2 equal sections by a plexiglass wall, and the outside porch was divided in 2 by the chain link fence separating the 2 pens that shared the feed shed. This design allowed the gradual introduction of chicks to each other to avoid possible aggression.

Behavioral Observations

Between May and September 2015, C. Sadowski conducted daily focal observations on each chick in captivity at Patuxent (18 costume-reared, 4 parent-reared). Five-minute focal observations were conducted on each chick twice daily with the first round of observations beginning at 0800 hr and the second beginning at 1400 hr in order to observe any possible differences in behaviors affected by time of day. The times for observation were chosen to avoid conflict with scheduled animal care activities. The order of chick observations, location, and rearing method were randomized. During each observation, any changes in behavior were recorded as well as the time of change. Behaviors fell into 1 of the following categories: standing, walking, hock-sitting, laying, foraging, preening, sleeping, and vigilance (Table 2).

Chicks were first observed anywhere from 4 to 20 days of age, depending on when C. Sadowski was allowed access to the enclosures. Any time a chick was moved to a novel environment, C. Sadowski conducted focal observations for 10 minutes within 1 hour of the chick entering the novel environment (n_{CR} = 18, n_{PR} = 4). The only time novel environment observations were not conducted within the 1-hour time frame was when the PR chicks were first brought to their release sites in Wisconsin. These observations were done within a 2-hour time period to allow for any extra time needed for logistics associated with the move. Costume-reared chicks experienced 3 novel environments while in captivity and some PR chicks experienced 4. The different pens experienced by the chicks are described in Table 1.

Observations of CR chicks prior to their first move were conducted from inside the building. Observations of all chicks that were in outdoor pens were conducted from a viewing shed such that the observer was not visible to the cranes. We avoided making observations of the CR birds during walks, swims, and ultralight training sessions because behaviors exhibited at those times where highly contingent on an environment that the PR birds did not experience.

All methods were approved by the University of Wisconsin-Oshkosh Institutional Animal Care and Use Committee (protocol #0026-000290-03-15-16) and the USGS Patuxent Wildlife Research Center Animal Care and Use Committee, 2010-06 as revised 2015.

Table 2. Ethogram of behaviors and movements of chicks observed while in captivity at the USGS Patuxent Wildlife Research Center, Laurel, Maryland, 2015.

Behavior	Description
Walking	Crane is upright, being supported by both legs, with legs moving 1 in front of the other in either a forward or backwards motion for more than 5 steps.
Standing	Crane is upright, being supported by both or 1 leg, and is either stationary or moving less than or equal to 5 continuous steps.
Hock sitting	Crane is holding body weight on its hocks.
Laying	Crane has legs bent beneath it with its entire underbelly touching the ground.
Foraging	Crane's neck is slightly bent with bill oriented toward the ground and eyes looking down. Pecking at ground or vegetation.
Vigilant	Crane's neck is completely straight upward or out forward looking around and aware of surroundings.
Preening	Crane is moving its beak back and forth in or on top of feathers.
Sleeping	Crane's eyes are closed and beak is normally tucked behind wing.

Statistical Analyses

We compared differences in the behaviors of CR and PR birds using a non-parametric Wilcoxon test because sample sizes were small and unequal. Because we observed 8 separate behaviors, we used a Bonferroni correction to calculate an adjusted alpha of 0.006. To compare behavior between rearing environments, we used a non-parametric Wilcoxon test because sample sizes were small and unequal.

Chicks were moved multiple times throughout their time in captivity. Therefore, when comparing behavior as a function of location and to measure the interaction between rearing environment and location, we used a ranked repeated measures ANOVA. We used a ranked test because we did not have data for all birds at all moves as some moves occurred at the same time as other moves or conflicted with other activities of the research staff. Again, our alpha was 0.006 for the main test with an alpha of 0.02 for the pairwise Wilcoxon tests. All analyses were conducted and box plots created by using R (R Core Team 2017).

RESULTS

Daily Observations in the Original Pen Only

To start, we used daily observations to compare chick behavior between rearing methods in their initial enclosure. This provided a baseline of differences observed as newly hatched chicks. Costume-reared chicks spent significantly more time hock-sitting (W = 67, P = 0.005) and preening (W = 68, P = 0.003) than PR chicks while in their original pens (Fig. 1). Because these differences were observed within the first few days after hatch when not only the rearing technique (costume or parent) varied but also their original pens varied, we were unable to distinguish whether or not subsequent differences were due to rearing technique, pen, or a combination of both. As a result, for the rest of the analysis *rearing technique* will refer to the combination of costume rearing + indoor enclosure versus parent rearing + outdoor enclosure.

Daily Observations

The 2 rearing techniques were compared using daily observations taken throughout the chicks' time in captivity in all enclosures. None of the recorded behaviors differed as a function of rearing technique (P > 0.05). We also compared daily behaviors as a function of the interaction between costume- versus parent-rearing and pen in which the chick was housed. Comparable data between these variables were only available for the original pen and the Pond Pens. For these 2 locations, no significant interactions between

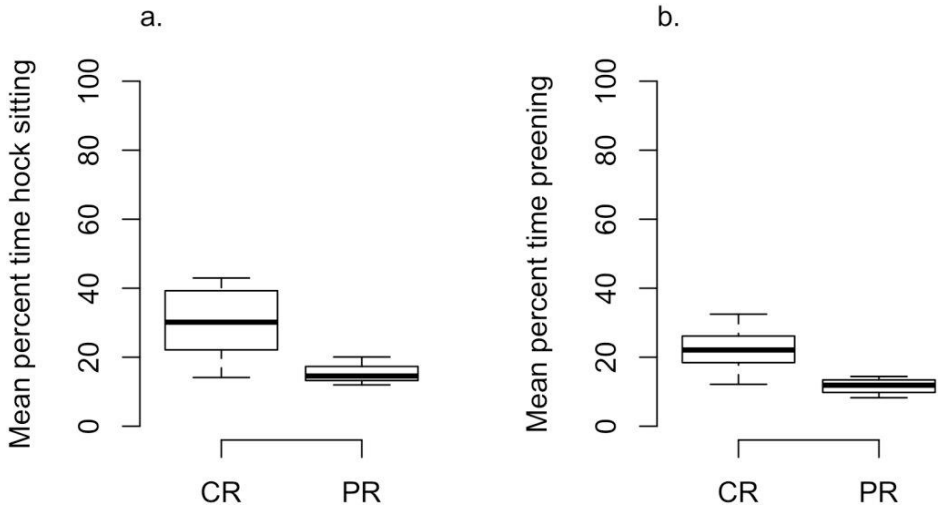

Figure 1. Mean percent time that whooping crane chicks were observed a) hock sitting and b) preening in their original enclosure as a function of rearing technique; *x*-axis is rearing technique (CR = costume-reared, PR = parent-reared). Dark horizontal bars represent the median. Fifty percent of the data are within the box, and the other 50% are within the whiskers. Data were collected at the USGS Patuxent Wildlife Research Center, Laurel, Maryland, 2015.

location and rearing technique were found. Using only those 2 locations, however, we found that CR chicks spent more time hock sitting ($F_1 = 8.6$, $P = 0.006$) and sleeping ($F_1 = 9.0$, $P = 0.005$) than PR chicks regardless of location (Fig. 2). We also found that, regardless of rearing, chicks were more likely to hock sit ($F_1 = 38.0$, $P < 0.001$), sleep ($F_1 = 14.1$, $P < 0.001$), and display vigilance ($F_1 = 50.5$, $P < 0.001$) and were less likely to forage ($F_1 = 22.0$, $P < 0.001$) and stand ($F_1 = 14.0$, $P = 0.006$) in their original pen as compared to the Pond Pen (Fig. 2).

Novel Environment

During their time in captivity, chicks were moved multiple times to new pens; CR and PR chicks experienced 3-4 moves (CR: propagation/CCB pens to white series to Pond Pens to release site pen to wild; PR: Blue Series/Lower Flight pens to Pond Pen to release site pen to wild). Observations were made after each move to see whether there were differences in behaviors when presented with a novel environment. When all responses were averaged per bird (i.e., moves were pooled), CR chicks were observed walking more ($W = 11$, $P < 0.001$) and standing less ($W = 179$, $P = 0.002$) than PR chicks when introduced into a new environment (Fig. 3).

When responses were broken down by move and all birds pooled regardless of rearing technique, hock sitting ($F_2 = 6.9$, $P = 0.003$), preening ($F_2 = 6.3$, $P = 0.005$), and vigilance ($F_2 = 7.2$, $P = 0.002$) differed significantly as a function of move (Fig. 4). Preening was observed more after move 3 than move 1 ($W = 22$, $P = 0.010$; Fig. 4), although none of the pairwise relationships were

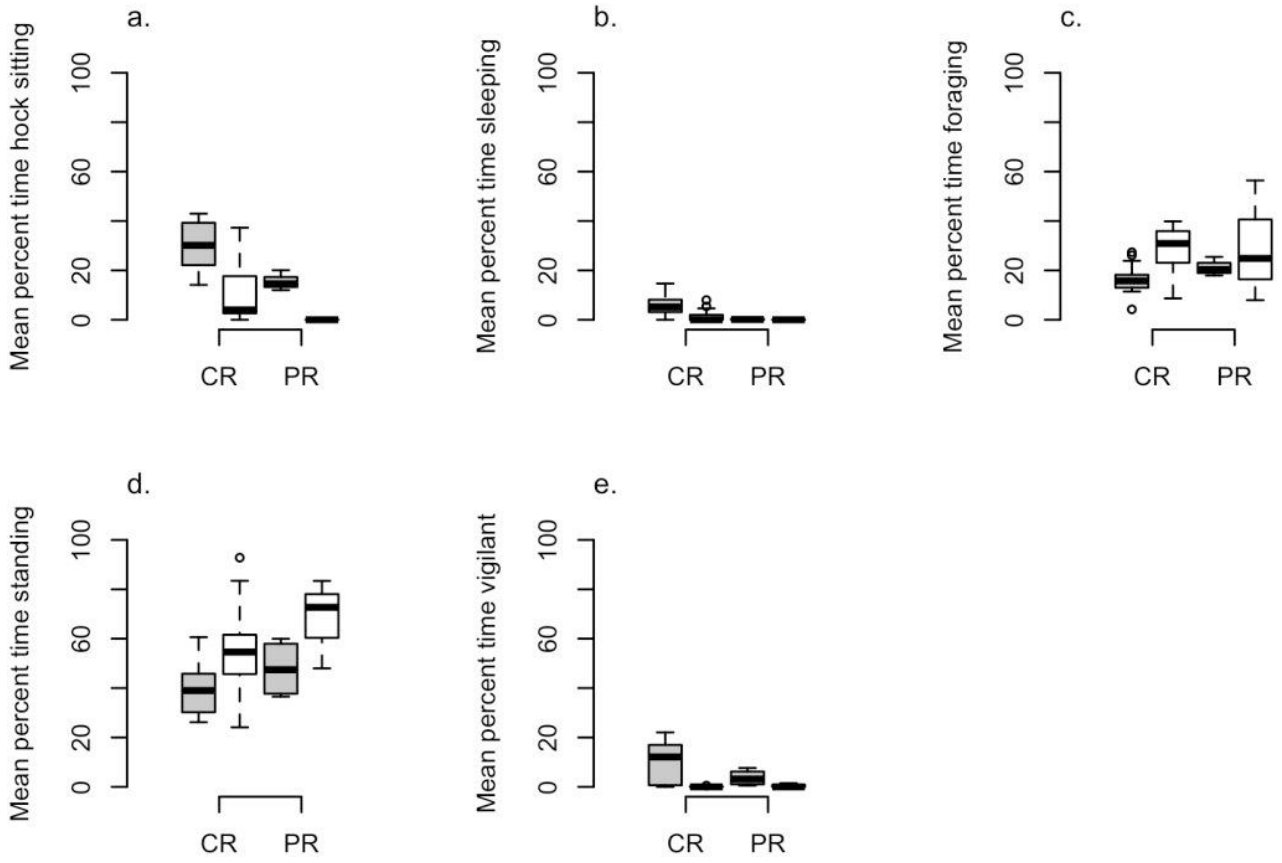

Figure 2. Mean percent time that whooping crane chicks at Patuxent were observed a) hock sitting, b) sleeping, c) foraging, d) standing, and e) vigilant across all enclosures and all days as a function of rearing technique; *x*-axis is rearing technique (CR = costume-reared, PR = parent-reared). Gray boxes represent the original pen; white boxes represent the Pond Pens. Dark horizontal bars represent the median. Fifty percent of the data are within the box, and the other 50% are within the whiskers; open circles represent outliers. Data were collected at the USGS Patuxent Wildlife Research Center, Laurel, Maryland, 2015.

significant for hock sitting or vigilance. No behaviors differed as a function of the interaction between rearing technique and move for moves 2 and 3. Considering rearing technique and move separately, CR birds were observed foraging ($F_1 = 8.4$, $P = 0.007$) and standing ($F_1 = 14.4$, $P < 0.001$) more often than PR birds, but there were no differences as a function of move (Fig. 5).

DISCUSSION

To determine whether or not rearing technique affects behavior in captive whooping cranes, we measured behavior in PR and CR birds at Patuxent. From hatch to release, we observed chicks daily as well as for extended periods when they were introduced into a novel environment. When differences were detected, CR chicks were, on average, more stationary than PR birds. This was the case when the chicks were just hatched and in their original pen as well as when daily behaviors were compared between the original pen and the Pond Pens. The more sedentary nature of CR chicks could be a result of enclosure size—the CR chicks had 29% less square area than PR chicks (Table 1). This explanation makes intuitive sense and has been shown to decrease activity in other species. For example, in a study of activity in domestic fowl as a function of enclosure size, Leone and Estevez (2008) found that larger enclosures encouraged more exploratory movement. Available space not only affects activity but can affect other behaviors as evidenced by the fact that male domestic turkeys were more aggressive in smaller pens than larger ones (Buchwalder and Huber-Eicher 2004).

Costume-reared chicks could have been less active during the observation period because, outside of our observations, they experienced daily exercise such as ultralight training, walks with costumed caretakers, and swimming. Increased activity during other times of day could have decreased their activity levels during observations. Another possible reason that PR chicks were more active than CR chicks could be due to the influence of their foster parents. Although the adults were not systematically observed for this study, they were rarely observed expressing sedentary behaviors such as laying and hock-sitting during observation sessions (C. L. Sadowski, personal observation).

Separating the effects of rearing technique from effects of the physical environment was difficult given that the birds in the 2 groups were never housed in the same enclosures. Thus, when direct comparisons were possible (between the original pen and the Pond Pen) we analyzed behavior as a function of enclosure type. Regardless of rearing technique, birds were less vigilant and more active (more foraging and standing) in the Pond Pen as compared to their original pen.

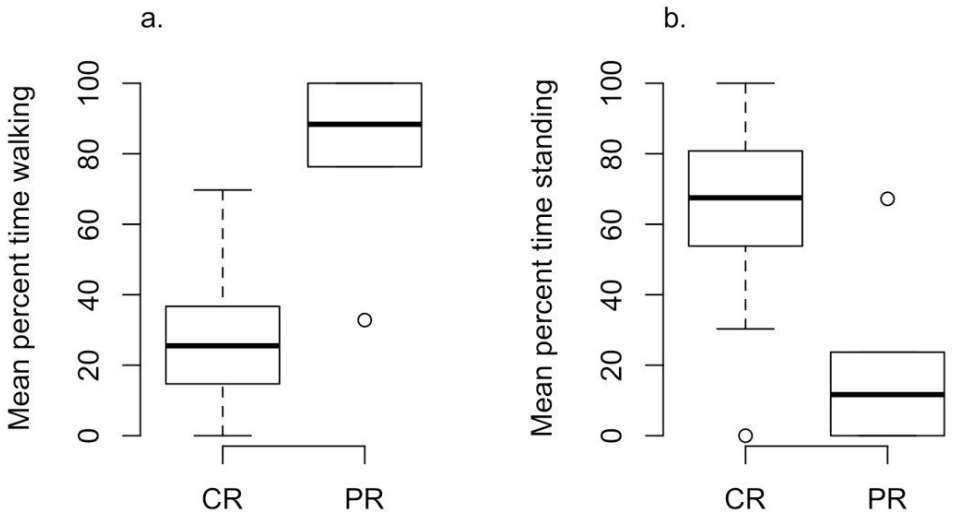

Figure 3. Mean percent time that whooping crane chicks at Patuxent were observed a) walking and b) standing when introduced into a novel environment as a function of rearing technique; *x*-axis is rearing technique (CR = costume-reared, PR = parent-reared). Dark horizontal bars represent the median. Fifty percent of the data are within the box, and the other 50% are within the whiskers; open circles represent outliers. Data were collected at the USGS Patuxent Wildlife Research Center, Laurel, Maryland, 2015.

Activity could have been greater in the Pond Pen due to the presence of other birds. In their original pens, both CR and PR chicks were housed separately from other chicks, but while in the Pond Pen they were housed with up to 5 other chicks. At this point, the PR birds, separated from their parents, were moved into Pond Pens to give them experience roosting in ponds. The increase in foraging behavior in the Pond Pens may have been due to the availability of more natural foods such as aquatic insects, frogs, and snails.

Behavioral differences between pens could also be due to age of the chicks at the time they were in each pen. For example, sleeping was observed more in the original pens than in the Pond Pen. This could be because the chicks were older when in the Pond Pen than in their original pen (Table 1) and were thus roosting more at night when observations were not being conducted as opposed to during the day. In addition, the higher vigilance in the original pens as compared to the Pond Pen could have been due to decreased aggression toward other chicks as a function of age or familiarity. Also, as the chicks become older, they experience less disruption from technicians. All of these variables could have influenced chick behavior.

Our main question, however, was whether or not rearing technique affected how captive-reared whooping cranes respond to novel environments. Comparing behavior across all moves to new enclosures revealed differences in hock sitting, preening, and vigilance. Considering only moves 2 (to the Pond Pen) and 3 (to the release site), the same pattern held—in general, CR chicks were less active than PR chicks.

Comparison of behaviors at the move to the Pond Pen versus the move to the release site showed no significant differences regardless of rearing technique. This was surprising because, prior to release, the chicks were handled, placed in crates, flown to Wisconsin, and released into new pens with other chicks. The lack of behavioral differences could be due to the fact that the 2 locations were not that different from each other: both were large outdoor enclosures with a water feature and included other birds. We predicted that, at a minimum,

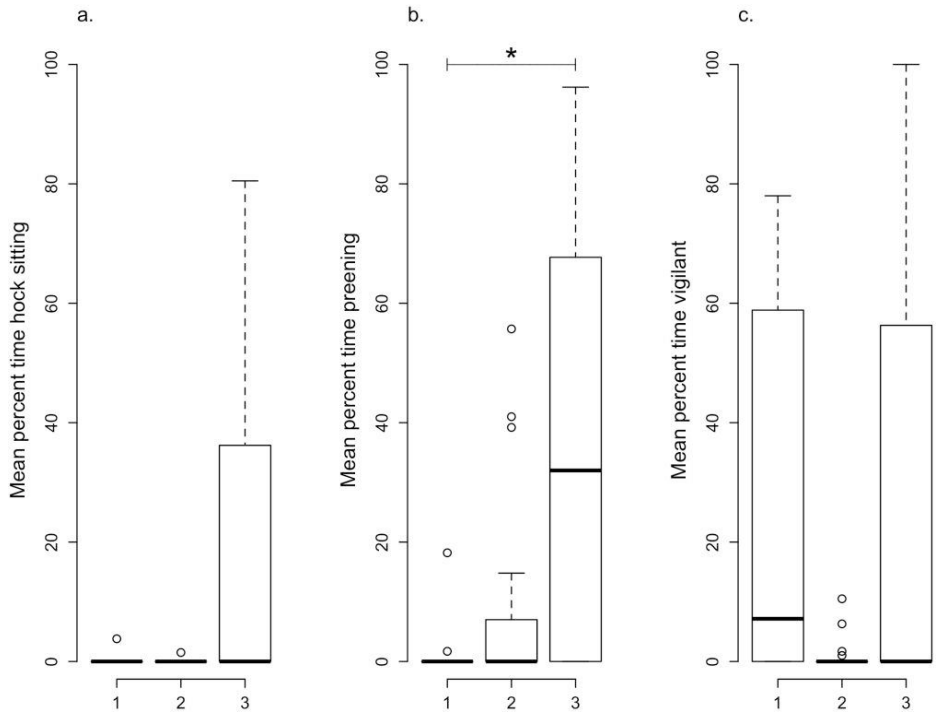

Figure 4. Mean percent time that whooping crane chicks at Patuxent were observed a) hock sitting, b) preening, and c) vigilant in the first hour as a function of a move to a new pen; *x*-axis is move number (i.e., first move, second move, and third move). Dark horizontal bars represent the median. Fifty percent of the data are within the box, and the other 50% are within the whiskers; open circles represent outliers. Asterisk indicates significant difference. Data were collected at the USGS Patuxent Wildlife Research Center, Laurel, Maryland, 2015.

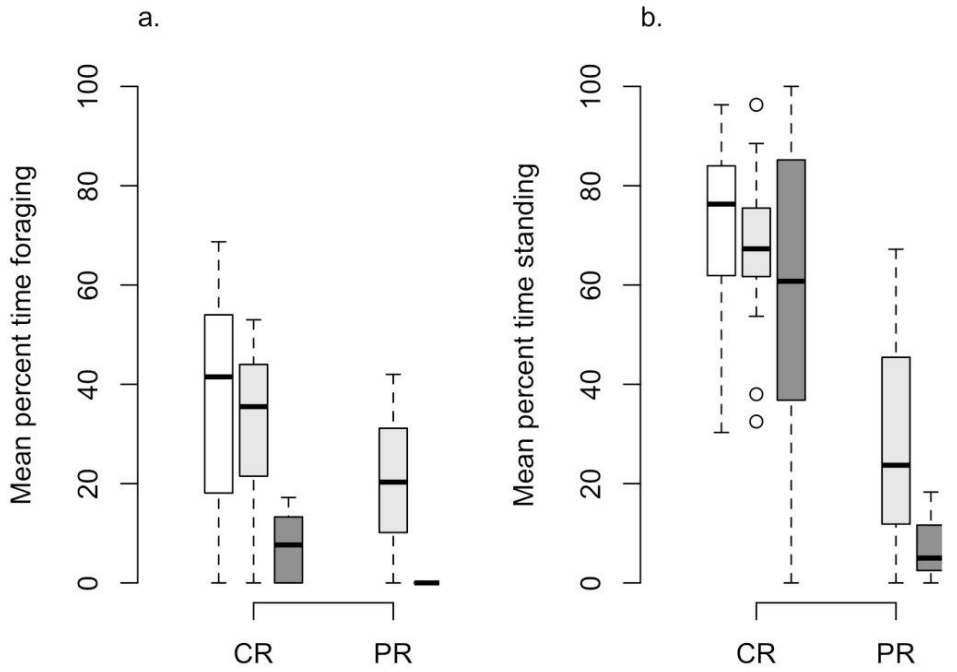

Figure 5. Mean percent time that whooping crane chicks at Patuxent were observed a) foraging and b) standing as a function of move and rearing technique; *x*-axis is rearing technique (CR = costume-reared, PR = parent-reared). White boxes represent move 1, light gray boxes represent move 2, and dark gray boxes represent move 3. Dark horizontal bars represent the median. Fifty percent of the data are within the box, and the other 50% are within the whiskers; open circles represent outliers. Data were collected at the USGS Patuxent Wildlife Research Center, Laurel, Maryland, 2015.

activity levels and vigilance would increase in the release pen as compared to the Pond Pen because, in all pens before the release, the chicks were more active and were even observed pacing (C. L. Sadowski, personal observation) in potentially stressful situations. Pacing is a common response of captive animals to stressful situations (Morgan and Tromborg 2007) and has been seen in species as diverse as American mink (*Neovison vison*) (Meagher and Mason 2012) and the greater rhea (*Rhea americana*) (de Azevedo et al. 2013).

After being released into central Wisconsin, captive-reared cranes are able to survive, migrate, and even reproduce. Unfortunately, reproductive success is very low, resulting in the need for additional releases of captive-reared cranes into the Eastern Migratory Population. While high pre-fledging mortality should be expected in habitat with high predator populations and interspersion of woody vegetation and upland such as occurs at Necedah NWR, the levels observed were of concern. One hypothesized cause of their low fledge rate is behavioral deficiencies caused by captive-rearing. Behavioral deficiencies have been observed in other reintroduced bird species; for example, reintroduced captive-reared rheas were deficient in predator response behaviors after release (de Azevedo and Young 2006). Captive-reared thick-billed parrots (*Rhynchopsitta pachyrhyncha*) experienced poor survival rates due to the inability to forage and socialize appropriately as well as inability to avoid predators (Snyder et al. 1994). Informal observations suggest that parental behaviors have been on par with wild-reared birds, but often behavioral changes can be subtle and difficult to detect without systematic study. Currently, there are not a sufficient number of parent-reared whooping cranes that have persisted on the landscape in Wisconsin long enough to test the hypothesis that parent-reared whooping cranes become better (e.g., more vigilant, more aggressive) parents when mature.

MANAGEMENT IMPLICATIONS

Our results show clear differences in behavior of chicks while still in a captive setting as a result of the 2 different rearing techniques (costumed humans vs. adult whooping crane pair). These differences might, over

the long term, affect chick behavior in the wild. In a previous study, Kreger et al. (2005) compared behaviors of whooping cranes that were either costume-reared or parent-reared at Patuxent and released in central Florida. Their results showed that PR birds spent less time foraging than CR birds in the 6 weeks post-release, which is consistent with our results. Kreger et al. (2004, 2005) found that behaviors expressed by a certain group of chicks while in captivity continued to be expressed more than the other group once released. Our results combined with the work of Kreger et al. (2004, 2005) suggest that long-term research is warranted to determine whether the behavioral differences observed in captivity translate into differences in the wild.

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