# EFFECTS OF REARING ENVIRONMENT ON BEHAVIOR OF CAPTIVE-REARED WHOOPING CRANES (*GRUS AMERICANA*)

By Christy L. Sadowski

Whooping crane (*Grus americana*) numbers dropped dramatically with an all time low in the 1930s of 13 wild individuals due to settlement by the Europeans, overall habitat loss, and overhunting. The Whooping Crane Eastern Partnership (WCEP) was formed in 1999 with the main goal of establishing a migratory population of whooping cranes in eastern North America. Unfortunately, these reintroduction efforts have had little success due to poor reproduction in the wild after release. One proposed idea as to why their reproductive success is low is how they are reared in captivity: reared by humans in crane costumes versus reared by surrogate conspecific adults. From this idea, I hypothesized that rearing environment in captivity affects expressed behavior in chicks when presented novel environments. Ten-minute focal observations were conducted on chicks at Patuxent Wildlife Research Center in Laurel, Maryland when they were introduced to a novel environment. After data analysis, significant differences in expressed behaviors and movements were observed between rearing environments. Previous studies on newly released whooping crane chicks showed that differences between rearing environment groups while in captivity continued to be significantly different after release. This leads me to believe that there will be behavioral differences between the two groups when it comes to reproduction and parenting.

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INTRODUCTION

## Effects of Captive Breeding and Novel Environments

Due to increasing rates of habitat destruction and continuing species decline, the need for conservation and reintroduction efforts is increasing (Vickery & Mason, 2003). Captive-rearing programs were used to attempt to preserve only the most endangered species of animals. However, more recently they are being used to help maintain wild, declining populations (Araki et al., 2007). Bringing individuals of a threatened or endangered species into captivity aides in the attempt to preserve their species. For example, captive-rearing programs have been highly successful for many endangered and threatened species such as the California condor (*Gymnogyps californianus*), the Mauritius kestrel (*Falco punctatus*), the black-footed ferret (*Mustela nigripes*), and the Guam rail (*Rallus owstoni*) (Snyder et al., 1996, Jones et al., 1994).

Although there have been some successful captive-rearing programs, not all species may benefit from it and there are many difficulties that come with these programs. Captive rearing is expensive and time-consuming and results in less success than if individuals are reared by their wild conspecifics (Vickery & Mason, 2003). While in captivity, individuals are experiencing unnatural environments and a lack of natural environmental cues (Lee & Berejikian, 2008, Snyder et al., 1996) which leads to changes and deficiencies in behavior. While in captivity, individuals may develop poor foraging behaviors and lack of predator recognition behaviors (O'Regan & Kitchener, 2005).

Behavioral changes and deficiencies are important to be aware of because captive-rearing programs are often the first step in saving a threatened or endangered species. While captive-rearing programs help threatened and endangered species by protecting individuals from declining populations and increasing the number of offspring being reared (Araki et al., 2007, Kreger et al., 2005), in order for the animal's population numbers to increase in the wild, they must eventually be reintroduced into the wild. Wallace (1994) stated that the result of a successful reintroduction is a wild, self-sustaining population. In order for individuals to be reintroduced successfully after being reared in captivity, they must be able to behave adequately in the wild after release in order to survive and contribute to the expansion of their population (Brown & Day, 2002). They must be able to find food sources, interact socially with other members of their species, avoid predation, and successfully reproduce (McPhee, 2003). As stated above, these behaviors that are necessary to survive and eventually lead to a self-sustaining population might be lost or altered while being reared in captivity.

To better understand the effects of captivity on behavior, many studies have measured the effects of captive rearing on the behavior and success of released individuals. In a study by Combreau and Smith (1997), 85 houbara bustards (*Chlamydotis undulata*) were released after being reared in captivity. Fifty-four of those died post-release. Of those that died, 87% died due to predation. Another study compared wild to captive-reared coho salmon (*Oncorhynchus kisutch*) and showed wild males established dominance over captive-reared males in 11 out of 14 trials (Berejikian et al., 2001). One of the most well-known examples of behavioral deficiencies affecting the success of reintroduced animals is the golden lion tamarin (*Leontopithecus rosalia*). Once released into their natural habitats, the tamarins were unable to move and orient themselves (O'Regan & Kitchener, 2005).

There are steps that can be taken while rearing animals in captivity to minimize these inefficient behaviors. Some studies have introduced predators to captive animals with the hope that it would teach them to recognize those threats once they are released into the wild, thereby increasing their post-release survival rate (McLean et al., 1996 [rufous hare-wallaby (*Lagorchestes hirsutus*)], van Heezik et al., 1999 [houbara bustards (*Chlamydotis macqueenii*)], Shier & Owings, 2007 [black-tailed prairie dogs (*Cynomys ludovicianus*)]). For captive-rearing programs that involve the animals being reared by humans, such as that of the whooping crane, humans often assume the role of the animal's parent and teach them by example the correct responses to predators. While conducting daily walks with captive-reared whooping crane chicks, costumed humans would play recorded alarm cues of adult whooping cranes and elicit appropriate predator-avoidance behavior. This began after there was insufficient success from less-vigorous hand-rearing techniques, which led to tameness in released birds (Wallace, 1994).

Captive-rearing programs have incorporated many different rearing techniques, such as parent-rearing, cross-fostering, and isolation-rearing. The following descriptions of these rearing techniques are from Wallace (1994). Parent-rearing uses the animal's natural parents or foster parents of the same species to raise the animals. This is the most natural rearing technique and allows appropriate imprinting and socialization. For example, Bali mynahs (*Leucopsar rothschildi*) were reared by their natural parents in holding pens and then released into the wild. The 12 birds that were released were able to successfully assimilate into wild flocks, form pairs, and rear young within the first year after release (Wallace, 1994). Cross-fostering consists of animals being reared by animals of different but similar species. One potential problem of this rearing technique is that it can lead to behavioral problems in species recognition (Snyder et al., 1996), which was the result of cross-fostering attempts with whooping cranes. A total of 300 whooping crane eggs were placed with sandhill cranes (*Grus canadensis tabida*), with 209 of them hatching. A majority of the chicks that hatched were lost due to predation and collisions with powerlines. However, those that survived to adulthood expressed difficulty forming pair bonds with other whooping cranes (Wallace, 1994). Last, isolation-rearing is done when the use of the natural or foster parents is not practical, or they are unavailable. This rearing technique consists of rearing responsibilities being assumed by humans normally with the use of costumes and/or puppets. Isolation-rearing is extremely labor- and time-intensive. Although it is unnatural, there have been programs that used this rearing technique successfully, including those with peregrine falcons (*Falco peregrinus*), bald eagles (*Haliaeetus leucocephalus*), and Hawaiian crows (*Corvus tropicus*).

All three of these different rearing techniques have their own pros and cons and affect different species in different ways. A comparison was done by Ellis et al. (2000) on

Mississippi sandhill cranes (*Grus canadensis pulla*) that were reared in captivity using costume-rearing and parent-rearing techniques. The goal of their study was to observe the differences in survival rates between the two groups once they were released into the wild; they found that birds raised by humans had higher survival rates than those raised by other adult cranes over the duration of this study (Ellis et al., 2000). Powell and Cuthbert (1993) followed killdeer (*Charadrios vociferous*) that were being raised by one of three ways to determine if there were differences between the groups in behavior and survival. The killdeer in this study were either raised in the wild by their parents (parent-reared), raised by a similar species in the wild (cross-fostering), or they were raised in captivity by humans and released into the wild (captive rearing). Their results showed that captive-reared birds spent less time feeding and resting than parent-reared and cross-fostered birds (Powell & Cuthbert, 1993). These studies, among others, support the idea that different captive-rearing techniques have varying effects on the behaviors and survivorship of animals post-release.

Brown and Day (2002) state that the likelihood of individuals successfully surviving and contributing to wild populations depends greatly on their ability to adapt after release. Because of this, animals that are phenotypically plastic are predicted to be more successful post-release. Phenotypic plasticity is defined by Yeh and Price (2004) as the ability of an organism to express different phenotypes, such as behavior, depending on its environment. McPhee (2003) states that in the wild, appropriate behaviors necessary for acquiring resources and avoiding predation are shaped over evolutionary time to increase reproductive success. However, while in captivity, animals are not presented with the same pressures as they would be in the wild, thereby resulting in altered expressed behaviors that are different from their wild conspecifics (Price, 1999, McPhee, 2003). Studying the behaviors of captive-reared animals when presented with novel environments is important because the results will allow us to better understand how the individuals will respond to novelty of their post-release environments and the factors that are commensurate with it.

Many studies have been done to observe how animals in captivity respond to novel environments. One study on infant marmosets (*Callithrix jacchus*) observed their feeding behaviors when presented with novel food items while in captivity (Voelkl et al., 2006). They found that infant marmosets that expressed more hesitance toward the new food items either rejected the new food altogether or ate smaller proportions and investigated the food longer. These behaviors were more exaggerated with the absence of adults nearby (Voelkl et al., 2006). McPhee (2003) observed the behaviors of oldfield mice (*Peromyscus polionotus subgriseus*) to determine whether captivity affects the behaviors these mice expressed when presented with novel environments. She found that exploration, activity, and enclosure use did not vary between the wild-caught mice and the mice from the first captive-reared generation through generation 14. After generation 14, however, differences in behaviors were observed between captive and wild-caught individuals, suggesting that increased time and generations in captivity can result in differently expressed behaviors between captive-reared individuals and those from wild populations. Due to continuing species declines, captive-rearing programs are often the last resort in an attempt to save threatened and endangered species, with the end goal of releasing animals into the wild (Vickery & Mason, 2003). The success of captive-rearing programs is measured by whether they establish a self-sustaining population in the wild (Wallace, 1994). Captive rearing has been successful in some instances (Snyder et al., 1996, Jones et al., 1994) but also has failed due to behavioral deficiencies developed while in captivity (Combreau & Smith, 1997, Berejikian et al., 2001, O'Regan & Kitchener, 2005). Therefore, behavioral studies should be an important addition to the conservation of threatened and endangered animal programs (McDougall et al., 2006). Continued studies observing the effects of different rearing techniques and response to novel environments will provide additional information to lead us to develop more successful captive-rearing programs.

**Crane Population History and EMP**

There are currently 15 species of cranes worldwide, with one species listed as critically endangered (*Leucogeranus leucogeranus*), three listed as endangered (*Grus japonensis, G. americana,* and *Balearica regulorum*), and seven listed as vulnerable (*Anthropoides paradiseus, Antigone antigone, Antigone vipio, Balearica pavonina, Bugeranus carunculatus, G. monacha,* and *G. nigricollis*) (IUCN, 2016). Whooping cranes (WHCR) are one of the most endangered bird species in the United States (National Audubon Society, 2006) and barely avoided extinction (Urbanek et al., 2010).

These bright white birds are the tallest birds in North America, standing at a height of 1.5 meters (Johnsgard, 1983 as cited in Glenn et al., 1999). Their preferred breeding grounds include wetlands, while migratory populations prefer to winter in estuaries and salt flats (US Fish and Wildlife Service, 2016). One specific characteristic that is common in habitats occupied by whooping cranes is the presence of water. Marshes and wetlands provide adequate nest sites and abundant natural food sources such as frogs, crayfish, blue crabs, small fish, insects, and tadpoles (Armbruster, 1990). According to Allen (1952), the range of whooping cranes in North America prior to 1860 ranged from the Arctic Coast to Central Mexico and from Utah to New Jersey and South Carolina. Their numbers, although debated, were possibly between 1,300 and 1,400 individuals in 1860 (Allen, 1952). Due to the settlement of North America, whooping crane numbers dropped dramatically due to the settlement of land, development of agriculture, and hunting for food, sport, and market (Erickson & Derrickson, 1981, Glenn et al., 1999, Allen, 1952). Whooping cranes were thought to be extinct by some in the 1920s (Allen, 1952) but there was a small number of individuals that bred in Wood Buffalo National Park in Alberta, Canada and migrated to winter in Aransas National Wildlife Refuge in Texas. Population numbers were as low as 14 individuals in the fall of 1938 (Glenn et al., 1999). Because of their extremely low numbers, whooping cranes were listed as endangered in 1967.

Recovery efforts for the endangered whooping crane began in the 1960s. Captive-rearing efforts began in 1966 when eggs were removed from the Wood

Buffalo-Aransas population and brought to Patuxent Wildlife Research Center (PWRC) in Laurel, Maryland to be reared in captivity (Harrell & Bidwell, 2015). Reintroductions began in 1975, with the goal of establishing a migratory population of whooping cranes in Grays Lake National Wildlife Refuge in southeastern Idaho. These attempts included using the Rocky Mountain greater sandhill cranes as foster parents for the birds being reintroduced into the wild. These birds successfully migrated but were never observed nesting (Armbruster, 1990). A second non-migratory population was reintroduced in 1993 in central Florida (Urbanek et al., 2010). By 1997, due to reintroduction efforts and the additional protection of the Endangered Species Act, whooping crane numbers increased to 160 individuals in the Aransas-Wood Buffalo population, to 100 in captivity, and to 73 in reintroduced populations (Glenn et al., 1999). Numbers continued to increase, reaching 483 individuals in the wild in 2015 (Harrell & Bidwell, 2015).

Currently, the birds in the wild are part of one of four wild populations: the migratory Aransas-Wood Buffalo population (the only self-sustaining population, N = 330), the reintroduced non-migratory population in Louisiana (N = 36), the reintroduced non-migratory population in central Florida (N = 15), and the reintroduced eastern migratory population (EMP) that migrates from central Wisconsin to Florida (N = 102) (Harrell & Bidwell, 2015).

The EMP is managed by the Whooping Crane Eastern Partnership (WCEP). WCEP was established in 1999 and consists of a partnership between nine different federal and state agencies and non-profit organizations that are responsible for reintroducing a migratory population of whooping cranes in eastern North America (Urbanek et al., 2005). The main sites of reintroduction are the Necedah National Wildlife Refuge (NWR), White River Marsh, and Horicon Marsh, all of which are located in central Wisconsin. Reintroduction of captive-reared whooping cranes into Wisconsin began in 2001. Necedah NWR has large bodies of shallow, open water and upland prairies and oak forests. The White River Marsh Wildlife area consists of open marshes and wet meadows, swamp hardwoods, and upland prairie/oak savannahs in a 4800-ha area (Wisconsin Department of Natural Resources, 2016). Horicon Marsh is managed by the United States Fish and Wildlife Service and is the largest freshwater cattail (*Typha latifolia*) marsh in the United States (Wisconsin Department of Natural Resources, 2016). Birds released into the EMP were originally raised in captivity by humans in costumes and trained to follow ultralight aircrafts that led them on their first migration from Wisconsin to Chassahowitzka NWR in central Florida (Urbanek et al., 2010). Currently,released birds are raised in captivity by humans in costumes, or raised by a pair of adult WHCR.

Since 2001, the survival rates of these birds has been high and close to 100% (88% for unpaired birds and 99% for paired birds) (Harrell & Bidwell, 2015). Although the released birds are successfully surviving, migrating, and even laying eggs, their reproductive success is near 0% due to nest abandonment (Urbanek et al., 2010) and high chick mortality. There have been many proposed hypotheses as to what could be causing such low reproductive rates in these released whooping cranes. One hypothesis that has been prioritized by WCEP is that the captive-rearing environment of these birds is contributing to their low reproductive success in the wild.

**Rearing Techniques of Captive Whooping Cranes**

One technique biologists use to increase the WHCR populations is referred to as double-clutching where they remove a first-laid clutch of eggs from the wild which results in the adult pair laying a second clutch. Because whooping cranes normally lay one to two eggs with only one chick usually surviving to fledging, double-clutching results in more chicks than can be raised naturally in the wild. Therefore, the excess chicks need to reared in a different way other than by their parents (Kreger et al., 2005).

Whooping cranes are raised in one of two ways at PWRC: by humans in costume (costume-reared, CR) or by a pair of adult whooping cranes (parent-reared, PR). Eggs used in the captive-rearing program at PWRC are produced there or at other crane facilities such as the Calgary and the San Antonio zoos or the International Crane Foundation (ICF) located in Baraboo, Wisconsin. Eggs are also sent to PWRC from wild introduced whooping cranes (WHCR) who abandon their nests at Necedah National Wildlife Refuge. The following description of rearing methods is based on the USGS Patuxent Wildlife Research Center parent-rearing and hand-rearing protocols from 2012-2015 unless otherwise cited.

*Parent-Rearing*

The main goal of the parent-rearing (PR) program is to allow whooping crane chicks to be reared by a pair of adult whooping cranes, thereby minimizing the number of eggs artificially incubated and the number of chicks reared by humans. Prior to allowing a pair to raise a WHCR chick, WHCR pairs being considered for the PR program are evaluated based on previous history of the pair and observations made by technicians. Some criteria that are taken into account include attentiveness to chick, whether the pair shares incubating and rearing responsibilities, and whether they are able to adequately deal with routine disturbance from technicians. Pairs are also given a sandhill chick with which to practice rearing for one or two years. The pair is then rated using a scale from zero to five, with five being the strongest rating.

The adoption method consists of one of three different approaches. In the first, a pipped egg is brought into the pen and replaces an artificial egg or an egg that has been incubated for at least 21 days. The second approach is to place a chick under 350 grams in the pen on the nest in exchange for an egg. Last, some pairs are allowed to keep and incubate their own eggs. In this case, if the pair lays two eggs, one egg is removed.

Once the chicks hatch and their down is dry, a veterinarian and technicians temporarily remove the chick from the pen. The chick is weighed and checked for general physical abnormalities such as umbilical protrusions and anatomical abnormalities. Egg shell fragments and feces from the chick are collected. When the chick is returned to the pen, food dishes and water are brought in. The beak of the chick is dipped in the water to acquaint it with the water source. Food dishes and watering devices are removed, cleaned, and replaced daily by technicians during their early morning rounds. When the chick reaches approximately 50 days of age, food dishes are removed, and chicks eat from the same hanging cylindrical feeders as the adults. Watering devices are removed when the chick reaches a height where they are able to access the automatic watering cup in the pen.

The health of PR chicks is monitored daily. From age zero to three days, the chicks' health is monitored by a veterinarian. During these monitoring sessions, the chicks are handled, weighed using boxes on scales, and their body condition is checked. Technicians visually check the chicks twice daily from ages zero to seven days old. After age seven days, chicks are observed once a day unless a problem is noted.

Chicks remain with their foster parents in their large outdoor pens until around the age of fledging (~90 days), at which point they are moved to larger pens with the other PR chicks to form social groups of juveniles. They remain in these pens until they are transported to Wisconsin and released at the Necedah National Wildlife Refuge.

*Costume-Rearing*

Costume-reared (CR) chicks are raised such that they have audio-visual isolation from humans to avoid imprinting of the chicks on humans. They are exposed to adult conspecifics, conspecific crane chicks, mounted crane models, crane puppet heads, recorded conspecific crane vocalization, and humans disguised as cranes in full length white costumes and face-covering screens.

CR eggs are artificially incubated at PWRC. On approximately day 27 of incubation, costume-reared eggs are played recorded crane brood calls for 5-15 minutes every three hours until hatched or when the eggs are routinely checked in the incubators, depending on which population into which they will be reintroduced. Once the eggs pip, they are moved to the hatcher and remain there until the chick is hatched and completely dry. Chicks are then weighed and given leg bands and assigned identification numbers. After hatching, they are transferred to the veterinary hospital's intensive care unit that consists of small solitary incubators where they are introduced to the crane puppet heads for the first time. The puppet is used as an imprint model and to introduce the chick to food and water. After 24 hours, the chicks are moved to their individual pens. These pens contain a mounted crane brood model, heat lamp, and water and food dishes with a puppet head that can be moved remotely to mimic feeding behavior of an adult.

Daily checks of CR chicks are conducted by individuals dressed in costume. Each chick is weighed regularly throughout its time in captivity to monitor weight gain and loss and to monitor hydration. From age 0-40 days, chicks are weighed daily early in the morning. For younger chicks (age 0-7 days), this is done when being handled for veterinary health examinations. After seven days of age, chicks are either handled for health examinations twice a week until 25 days of age, weekly until 50 days of age, then every other week, or only if necessary. When the chick reaches approximately 500g, it is weighed using a walk-on scale to reduce the risk of injury. Chicks are trained, using mealworm rewards, to walk onto the scale each morning. After 40 days, chicks are still weighed but on a much less regular schedule.

In addition to daily weighing, costume-reared chicks participate in exercise activities. They are trained daily, normally early in the morning, with the UL airplane or are given walks. All chicks are taken on daily walks with normally one or two other chicks. During the walks, the costumed humans stay in character by playing brood calls and purrs, showing chicks food items, and reacting adversely to predators. Chicks are also taken swimming for exercise for 12-15 minutes each day from day 10 to day 25 approximately. Some chicks swim longer or more frequently (two or three times daily) if they are experiencing excessive weight gain or are experiencing developmental leg problems.

Individual pens are cleaned daily. Chicks are locked in the outdoor portion of pens during cleaning. Drinking water is changed, and the bowls are cleaned. Food dishes are refilled daily. For chicks age 10-12 days and under, the pens' matting/carpets are vacuumed. If there are beta-chips in the pens, feces is scooped and removed. Later in the day, the chicks are locked indoors to remove, clean, and replace the water for the footbaths within the pens.

Chicks remain in these pens until approximately age 20-35 days of age, at which point they are introduced to larger outdoor pens (7.6m X 30.5m) that have food dishes, footbaths with water, and brood models. This is the first time they are housed in the same pen as other chicks of similar size and age. A costumed caretaker is present in these pens to monitor aggression between chicks. If aggression occurs, the puppet heads are used to deter aggression. At approximately age 30-105 days, the chicks are introduced to large open pens that have standing water. These pens include all chicks that will be released together and are raised the same. Chicks are able to stay in outdoor pens beginning at approximately age 25-35 days weather permitting. EMP chicks for the ultralight reintroductions are flown to Wisconsin (White River Marsh) and placed in a large pen with a dry portion as well as a marsh area at around age 40-50 days. Natural food and water are also available to them, together with food and water provided by technicians. They remain in this pen unless they are training with the UL plane. Once it is time to begin their first migration, they leave the pen as a cohort and follow the ultralight aircraft. Chicks that are not released in White River Marsh become part of the non-migratory population in Louisiana (LNMP).

Captive-rearing programs and techniques have been studied and the results often show differences in behaviors between the captive-reared animals and their wild conspecifics. Because whooping cranes are critically endangered, effective captive-rearing programs are needed in order to preserve their species. Unfortunately, these birds are showing low reproductive success once reintroduced into the wild which could be due to changes and deficiencies in behaviors from being reared in captivity. The two rearing techniques used for these birds differ greatly from one another which could lead us to believe there will be differences in behaviors between the two groups of chicks which has been observed from other studies as stated above. The addition of behavioral research on these chicks while in captivity is needed in order to improve their captive-rearing programs which could greatly assist in the preservation of their species.

# CHAPTER II

## EFFECTS OF REARING ENVIRONMENT ON BEHAVIOR OF CAPTIVE-REARED WHOOPING CRANES (*GRUS AMERICANA*)

### Introduction

Whooping cranes (WHCR) are one of the rarest and most endangered bird species in the United States (National Audubon Society, 2006) and barely avoided extinction (Urbanek et al., 2010). Due to settlement of the Europeans, development of agriculture, and hunting for food, sport, and market (Erickson & Derrickson, 1981, Glenn et al., 1999, Allen, 1952), their numbers reached an all-time low of approximately 13 or 14 individuals in the wild in fall of 1938 (Glenn et al., 1999). Today, whooping cranes occur in one of four wild populations: a wild, self-sustaining population that migrates from Wood Buffalo National Park, Canada to Aransas National Wildlife Refuge in Texas (the only self-sustaining population, N = 330), a reintroduced non-migratory population in Louisiana (N = 36), a reintroduced non-migratory population in central Florida (N = 15), or a reintroduced migratory population that migrates from central Wisconsin to southeast United States (eastern migratory population (EMP)) (N = 102) (Harrell & Bidwell, 2015).

Captive-rearing efforts began in 1966, when eggs were removed from the Wood Buffalo-Aransas population and brought to Patuxent Wildlife Research Center (PWRC) in Laurel, Maryland to be reared in captivity (Harrell & Bidwell, 2015). Beginning in 2001, a group called the Whooping Crane Eastern Partnership (WCEP) began reintroducing captive-reared WHCR from PWRC in central Wisconsin with the goal of establishing a self-sustaining migratory population of whooping cranes east of the Aransas-Wood Buffalo population. The main sites of reintroduction are the Necedah National Wildlife Refuge (NWR), White River Marsh, and Horicon Marsh, all located in central Wisconsin. Reintroduction of captive-reared whooping cranes into Wisconsin began in 2001. Necedah NWR has large bodies of shallow, open water and upland prairies and oak forests. The White River Marsh Wildlife area consists of open marshes and wet meadows, swamp hardwoods, and upland prairie/oak savannahs in a 4800-ha area (Wisconsin Department of Natural Resources, 2016). Horicon Marsh is managed by the United States Fish and Wildlife Service and is the largest freshwater cattail (*Typha latifolia*) marsh in the United States (Wisconsin Department of Natural Resources, 2016).

Although conservation efforts have been ongoing since 2001, WCEP has not yet established a self-sustaining EMP. The survival rates of the birds being raised in captivity and released into the wild have been high and close to 100% (0.88 for unpaired birds and 0.99 for paired birds) (Harrell & Bidwell, 2015). Although the released birds are successfully surviving, migrating, and even laying eggs, their reproductive success is near 0% due to nest abandonment (Urbanek et al., 2010) and high chick mortality. One hypothesis that has been prioritized by WCEP is that the captive-rearing environment of these birds is contributing to their low reproductive success in the wild.

Captive rearing is expensive and time-consuming (Vickery & Mason, 2003). Also, while in captivity, individuals experience unnatural environments and a lack of natural environmental cues (Lee & Berejikian, 2008), which lead to changes and deficiencies in behavior. Brown and Day (2002) stated that individuals must be able to behave adequately in the wild after release to survive and reproduce to allow population expansion. They must be able to find food sources, interact socially with conspecifics, avoid predation, and successfully reproduce (McPhee, 2003). Unfortunately, captive-rearing and reintroduction are often the only resort for populations that have experienced catastrophic declines, which is the case for whooping cranes. Many studies have examined the effects of captive-rearing and different rearing techniques. Combreau and Smith (1997) discussed how 85 houbara bustards (*Chlamydotis undulata*) were released after being reared in captivity, and 54 of those died post-release. Of those that died, 87% died due to predation. 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).

Because captive-rearing can have such profound effects on individual behavior, studies have been conducted to determine if there are differences between rearing techniques. A study done by Powell and Cuthbert (1997) followed killdeer (*Charadrios vociferous*) that were being raised in one of three ways to search for differences among the groups in behavior and survival. The killdeer in this study were either raised in the wild by their parents (parent-reared), raised by a similar species in the wild (cross-fostering), or raised in captivity by humans and released into to wild (captive-rearing). Their results showed that captive-reared birds spent less time feeding and resting than parent-reared and cross-fostered birds (Powell & Cuthbert, 1993).

While in captivity at PWRC, WHCR chicks are originally reared in one of two environments: (1) by humans in costume while initially housed solitarily in long, narrow pens (2.7m X 3.4m (Prop inside), 2.4m X 9.1m (Prop outside)/ 2.4m X 2.4m (CCB inside), 2.4m X 7.6m (CCB outside)) with both indoor and outdoor runs and later housed in different pens (described in Table 2) with other chicks or (2) by a pair of adult whooping cranes in large (13.7m X 19.8m (Blue), 10.7m X 30.5m (LFP)) outdoor pens and later housed in different pens (described in Table 2) without their foster parents and with other chicks (USGS Patuxent Wildlife Research Center Crane Program 2012-2015 Crane Hand-Rearing Protocol, 2012, USGS Patuxent Wildlife Research Center Crane Program 2012-2015 Crane Parent-Rearing Protocol, 2012). Costume-reared (CR) chicks are raised by humans in costumes in order to have the chicks be completely isolated visually to humans. They are introduced to food and water post-hatching with the help of a puppet head that is maneuvered by a caretaker. Costumed caretakers take the chicks on daily walks and take them swimming for exercise. A select number of the CR birds are trained to follow an ultralight plane that will assist them on their first migration post-release (the use of ultralight planes was discontinued after the summer of 2015). The group of chicks reared the second way, which is referred to as parent-rearing (PR), are raised by a pair of adult WHCR reducing the number of eggs being artificially incubated and reared by humans. There are three different adoption approaches for the PR chicks.

In the first, a pipped egg is brought into the pen and replaces an artificial egg or an egg that has been incubated for at least 21 days. The second approach is to place a chick under 350 grams in the pen on the nest in exchange of an egg. Last, some pairs are allowed to keep and incubate their own eggs. In this case, if the pair lays two eggs, one egg is be removed. All chicks are housed separately from one another and then later moved to larger pens and housed with more chicks.

To test the hypothesis that the captive-rearing environment of these birds is contributing to their low reproductive success in the wild, I conducted behavioral observations on all chicks at PWRC. I specifically looked for the movements of walking, standing, hock-sitting, laying, and running and the behaviors of vigilant, non-vigilant, preening, sleeping, eating, foraging, and drinking. I predicted that there would be clear differences between the two rearing techniques.

**Methods**

This work was conducted at Patuxent Wildlife Research Center in Laurel, Maryland. The center covers a 5136-ha area and is the largest captive-breeding facility in the country for whooping cranes.

Whooping crane eggs are provided to PWRC from populations in the wild and from pairs that lay in zoos. Captive pairs of WHCR at PWRC also provide eggs that are then raised in captivity. At PWRC, chicks become part of one of two groups. The first group of chicks is reared by humans in white costumes with puppet heads, while the second group of chicks is raised by a pair of WHCR adults. For more details, see Chapter I and the USGS Patuxent Wildlife Research Center 2012-2015 Crane Parent-Rearing and Hand-Rearing Protocol.

**Behavioral Observations.**

Beginning in mid-May 2015, I began conducting daily focal observations on each chick in captivity at PWRC (18 costume-reared, 4 parent-reared chicks). The order of the chick observations, location, and rearing method were randomized. Five-minute focal observations were conducted on each chick twice a day, with the first round of observations beginning at 8:00 and the second beginning at 14:00. For each observation, I noted the date, time, bird number, location, and weather. Once the 5-minute focal observations began, any changes in movement and behavior during the current observation period were recorded, together with the time of change. Specific movements that were observed and noted included standing, walking, hock-sitting, laying, and running (Table 1). Behaviors observed were eating, drinking, foraging, preening, sleeping, vigilance, and non-vigilance (Table 1). These data were collected for each chick twice daily when able.

Table 1. Ethogram describing behaviors and movements of chicks observed while in captivity.

| **Movement:** | **Description:** |
|---|---|
| Walking | Crane is upright, being supported by both legs, with legs moving one 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 one leg, and is either stationary or moving less than or equal to 5 continuous steps. |
| Running | Crane is moving in a forward, quick moving motion similar to walking in that legs alternate, but both feet leave the ground for a short instance. |
| Hock sitting | Crane is holding body weight on its hocks. |
| Laying | Crane has legs bent beneath it with its entire underbelly touching the ground. |
| | |
| **Behavior:** | **Description:** |
| 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 completely straight upward or out forward looking around and aware of surroundings. |
| Non-vigilant | Crane's neck slightly bent with bill parallel to ground. |
| Preening | Crane is moving its beak back and forth in or on top of feathers. |
| Drinking | Crane is dipping open beak in footbath or provided waterers and removing water. |
| Eating | Crane is using its beak to remove and break apart food pieces from provided food dishes and swallowing. |
| Sleeping | Crane's eyes are closed and beak is normally tucked behind wing. |

Any time a chick was moved to a novel environment, I conducted the same focal observations for 10 minutes using the same ethogram within one hour of it entering the novel environment (CR N = 18, PR N = 4). The only time novel environment observations were not conducted within the one hour time frame was when the PR chicks were first brought to their release sites. These observations were conducted within a two-hour time period. Costume-reared chicks experienced three novel environments while in captivity, and PR chicks experienced four. The different pens the chicks experienced are described in Table 2. Once the data sheets for the day were completed, mean percent time (in seconds) for each movement and behavior were calculated for each chick for each enclosure.

Table 2. Description of pens chicks experienced while in captivity.

| | **Approximate Dimensions (m)** | **Description** |
|---|---|---|
| **CR:** | | |
| Prop/CCB (Original Pen) | 2.7 X 3.4 (inside), 2.4 X 9.1 (outside)/ 2.4 X 2.4 (inside), 2.4 X 7.6 (outside) | Inside: matting or beta-chip bedding<br>Outside: grassy |
| White Series | 7.6 X 30.5 | Grassy, no standing water, food shed |
| Pond Pen | 24 X 30.5 | Grassy, standing water, food shed |
| White River Marsh (Release Pen) | 14.2 X 7.9 (dry pen)<br>15.3 X 22.8 (wet pen) | Dry portion with food shed and wet portion with standing water |
| | | |
| **PR:** | | |
| Blue Series (Original Pen) | 13.7 X 19.8 | Grassy, food shed |
| LFP (Original Pen) | 10.7 X 30.5 | Grassy, covered overhang, food shed |
| White Series | 7.6 X 30.5 | Grassy, no standing water, food shed |
| Pond Pen | 24 X 30.5 | Grassy, standing water, food shed |
| Necedah NWR (Site 4 Group Release Pen) | 14 X 7.9 | Oval shaped with dry and wet portions |

**Statistical Analyses.**

To measure differences between the rearing environments of the chicks while in captivity, I compared movement and behavior of CR and PR birds. Because I observed 12 movements and behaviors, there was a high chance of detecting significance. Thus, I used a Bonferroni correction to calculate an adjusted alpha of 0.008. To compare movement and behavior between rearing environments, I used a non-parametric Wilcoxon test because sample sizes were small and unequal. These comparisons were made for both the daily-observations data and the novel-environment data.

Because these chicks were being moved multiple times throughout their time in captivity, a statistical comparison was made to determine whether there was a difference between expressed movements and behaviors as function of rearing environment and which move it was, or a relationship of the two. A second comparison was made looking at whether or not there was a difference between expressed movements and behaviors as a function of rearing environment and pen location, or a relationship of the two. For this purpose, I used a repeated measures ANOVA because each bird was measured in multiple locations.

## Results

### Behavior and Movement in Original Pen.

Because there were variables besides rearing technique (i.e., use of costumes vs. use of conspecifics), such as pen environment and age, that could have affected chick behavior, I compared behavior and movement in the birds' original pens between rearing environments to measure any differences caused by either the rearing technique or original pen at the outset. I found a difference between the CR and PR chicks for mean percent time (in seconds) spent in the behaviors and movements of hock-sitting ($p = 0.005$, CR mean = 18.0%, PR mean = 6.1%, Figure 1a), non-vigilance ($p = 0.0003$, CR mean = 34.3%, PR mean = 36.3%, Figure 1b), preening ($p = 0.003$, CR mean = 20.7%, PR mean = 14.4%, Figure 1c), drinking ($p = 0.007$, CR mean = 4.1%, PR mean = 1.2%, Figure 1d), and eating ($p = 0.002$, CR mean = 6.9%, PR mean = 0.7%, Figure 1e). Costume-reared chicks spent more time hock-sitting, eating, drinking, and preening than PR chicks, while PR chicks spent more time non-vigilant than CR chicks while in their original pens. Using the standard alpha of 0.05, there was also a difference between the two groups of birds for walking ($p = 0.02$, CR mean = 16.5%, PR mean = 31.3%), where PR chicks spent more time walking than CR chicks and for laying ($p = 0.02$, CR mean = 11.3%, PR mean = 2.1%) and sleeping ($p = 0.02$, CR mean = 3.2%, PR mean = 0.07%), where CR chicks spent more time than PR chicks expressing these behaviors and movements. Because these differences were observed immediately post-hatch when not only the rearing technique varied but also their original pens, I cannot distinguish whether the differences were due to rearing technique, pen, or a combination of both. Accordingly, for the rest of the analysis, rearing technique and original pen together are referred to as rearing environment.

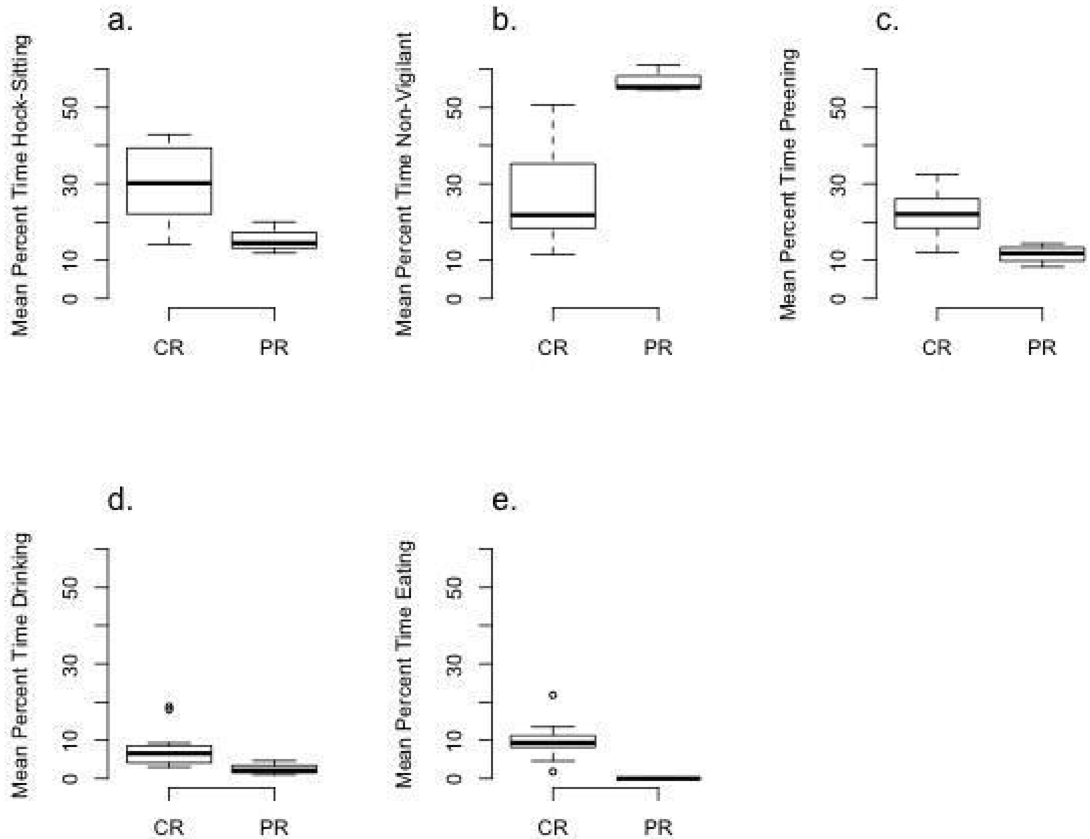


Figure 1. Boxplots comparing mean percent time in seconds while in original pen a. hock-sitting (p = 0.005, CR mean = 18.0, PR mean = 6.1), b. non-vigilant (p = 0.0003, CR mean = 34.3, PR mean = 36.3), c. preening (p = 0.003, CR mean = 20.7, PR mean = 14.4), d. drinking (p = 0.007, CR mean = 4.1, PR mean = 1.2), and e. eating (p = 0.002, CR mean = 6.9, PR mean = 0.7) for daily observations in original pens only.

**Daily Observations.**

The two rearing environments were compared using daily observation data taken throughout the duration of the chicks' time in captivity. Differences were observed for foraging ($p = 0.007$, CR mean = 65.0%, PR mean = 16.1%, Figure 2a), preening ($p = 0.0003$, CR mean = 64.9%, PR mean = 21.5%, Figure 2c), and eating ($p = 0.003$, CR mean = 20.8%, PR mean = 0.5%, Figure 2b), with CR chicks expressing these behaviors and movements more often than PR chicks. Using the standard alpha of 0.05, I also found differences for walking ($p = 0.04$, CR mean = 43.8%, PR mean = 75.3%), laying ($p = 0.04$, CR mean = 41.6%, PR mean = 16.1%), vigilance ($p = 0.05$, CR mean = 19.8%, PR mean = 43.5%), and drinking ($p = 0.03$, CR mean = 13.6%, PR mean = 5.8%), suggesting that if there was a larger, less different sample size, more differences may have been observed.

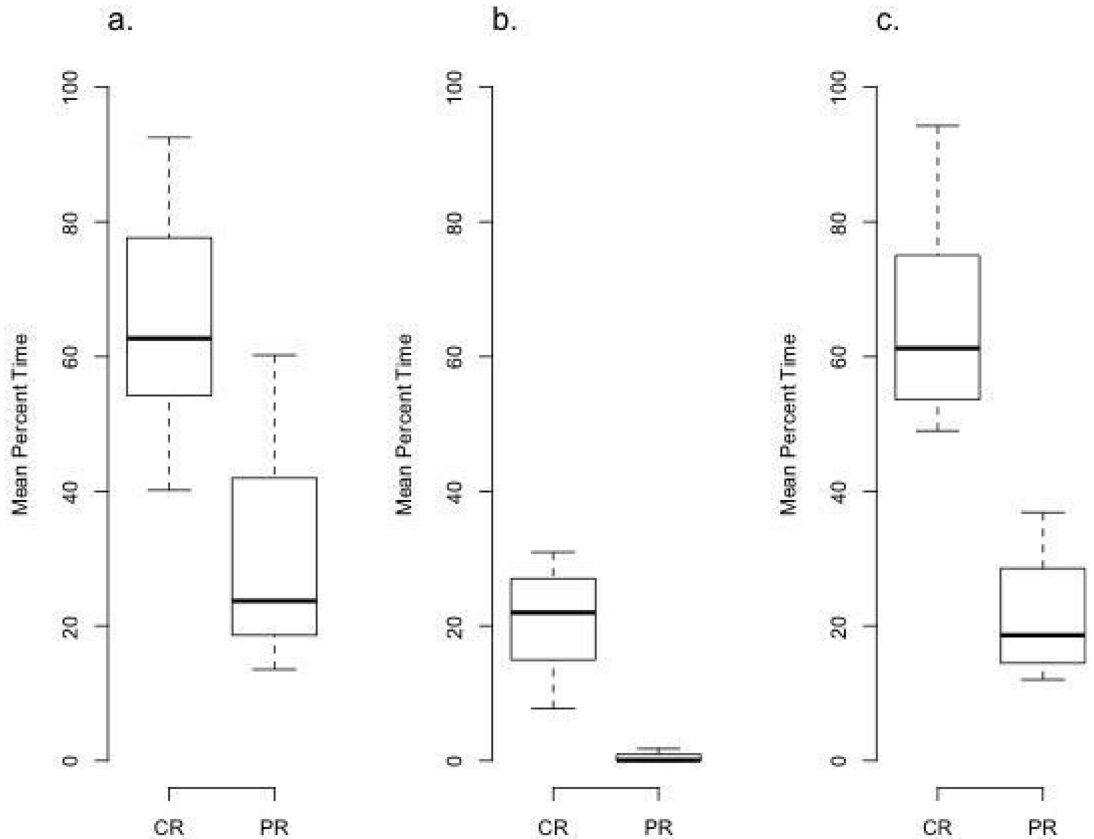


Figure 2. Boxplots comparing mean percent time in seconds a. foraging (p = 0.007, CR mean = 65.0, PR mean = 16.1), b. eating (p = 0.003, CR mean = 20.8, PR mean = 0.5), and c. preening (p = 0.0003, CR mean = 64.9, PR mean = 21.5) between rearing environment for daily observations.

**Daily Observations as a Function of Rearing Environment and Location**

I also compared daily behaviors and movements as a function of both rearing and pen. Comparable data between these variables were only available for the original pen in which the chicks were housed and the Pond Pens. The reason for this being that when the PR chicks were moved to the White Series pens, I was in Wisconsin conducting behavioral observations on the CR chicks. Although results were already reported above on a comparison between rearing environments using the daily observation data, the following results differ because the analysis only used data from the original pens and the pond pens. Differences between the rearing environments were observed for laying (p = 0.008, CR mean = 12.1%, PR mean = 3.0%, Figure 3c), hock-sitting (p = 0.002, CR mean = 20.6%, PR mean = 8.7%, Figure 3b), and sleeping (p = 0.003, CR mean = 4.4%, PR mean = 0.1%, Figure 4c), with CR chicks spending more time expressing these behaviors and movements than PR birds. Changes were observed when looking at the changing behaviors and movements as a function of location. Standing (p <0.0001, original pen mean = 40.1%, Pond Pen = 58.6%, Figure 3a) and foraging (p <0.0001, original pen mean = 16.5%, Pond Pen mean = 31.4%, Figure 5a) were both different, with the chicks (regardless of rearing) spending more time expressing these behaviors and movements in the Pond Pen than their original pens. Laying (p = 0.0009, original pen mean = 14.8%, Pond Pen mean = 5.8%, Figure 3c), hock-sitting (p <0.0001, original pen mean = 26.8%, Pond Pen mean = 9.5%, Figure 3b), sleeping (p = 0.002, original pen mean = 5.5%, Pond Pen mean = 1.6%, Figure 4c), vigilance (p <0.0001, original pen mean = 9.5%, Pond Pen mean = 0.1%, Figure 4a), and drinking ($p < 0.0001$, original pen mean = 6.5%, Pond Pen mean = 1.0%, Figure 5b) were all different, with the chicks, regardless of rearing, expressing these behaviors and movements more often in their original pens than the Pond Pens. When considering the interaction of rearing and pen, non-vigilance ($p = 0.006$, Figure 4b) was also the only change when looking at changing movement and behavior movement as a function of both rearing environment and location.

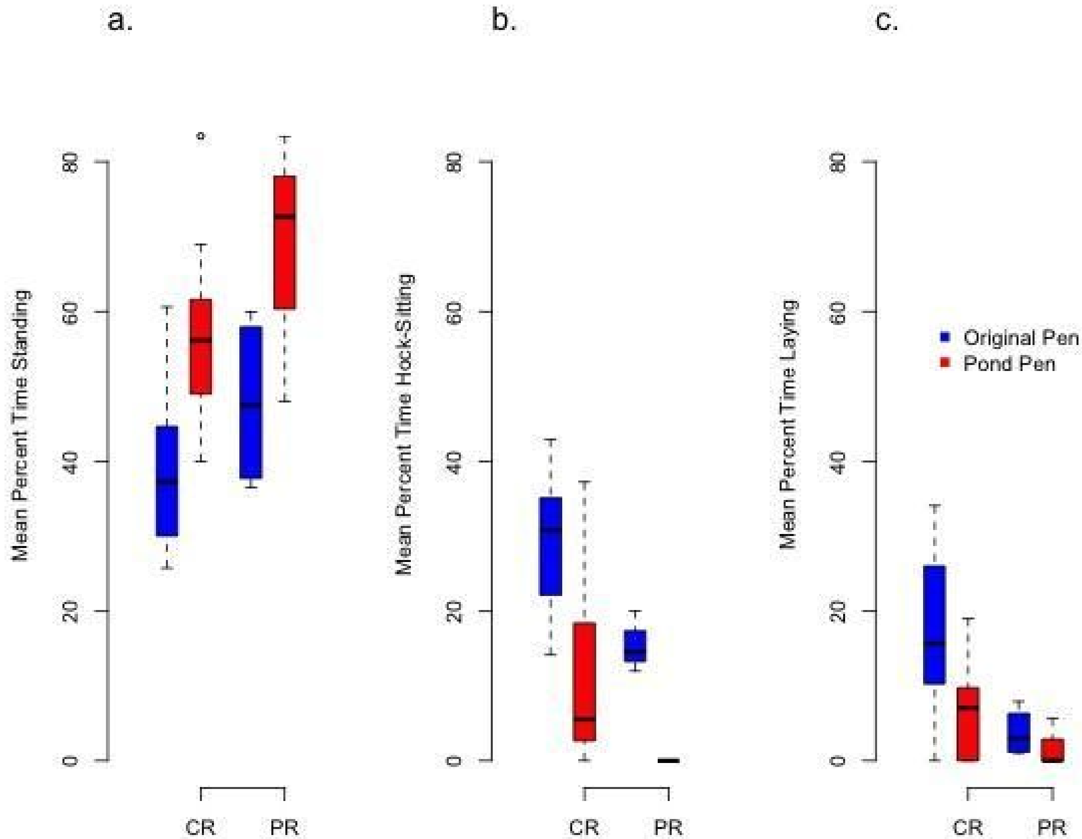


Figure 3. Boxplots comparing mean percent time in seconds a. standing (location p <0.0001, original pen mean = 40.1, Pond Pen mean = 58.6), b. hock-sitting (rearing environment p = 0.002, CR mean = 20.6, PR mean = 8.7; location p <0.0001, original pen mean = 26.8, Pond Pen mean = 9.5), and c. laying (rearing environment p = 0.008, CR mean = 12.1, PR mean = 3.0; location p = 0.0009, original pen mean = 14.8, Pond Pen mean = 5.8) as a function of rearing environment and location.

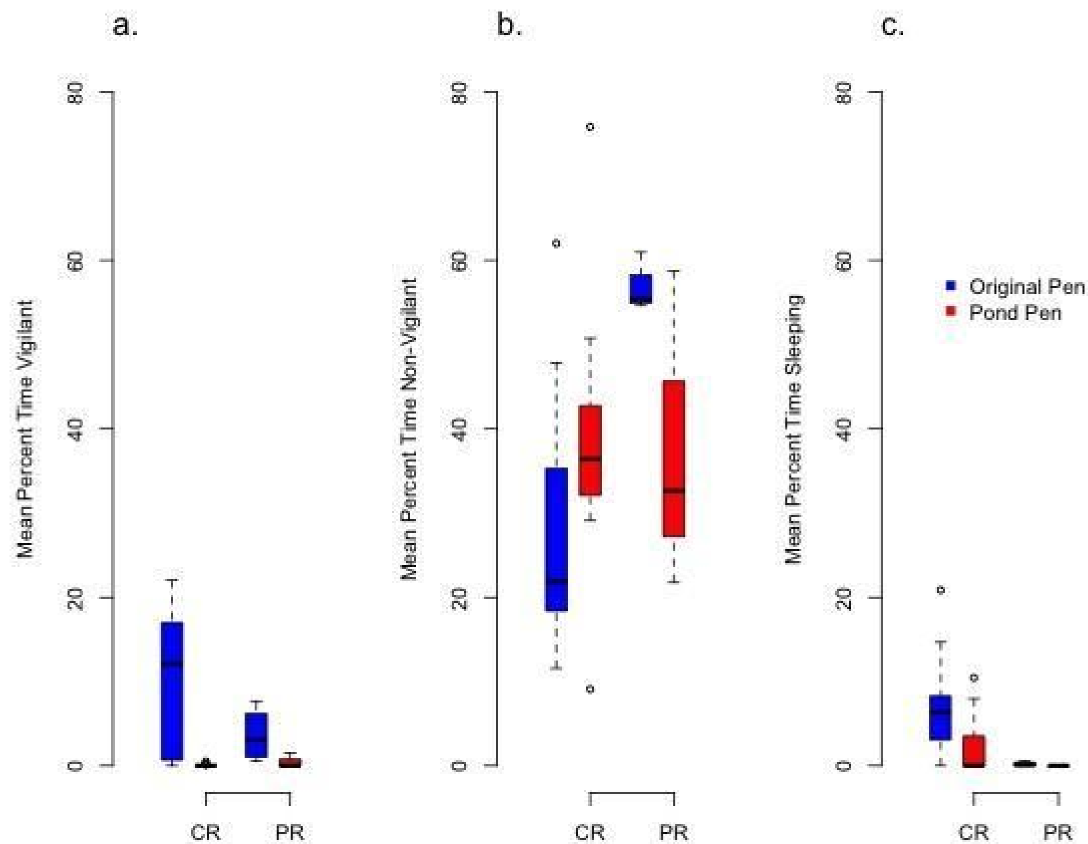


Figure 4. Boxplots comparing mean percent time in seconds a. vigilant (location p <0.0001, original pen mean = 9.5, Pond Pen mean = 0.1), b. non-vigilant (rearing:location p = 0.006), and c. sleeping (rearing environment p = 0.003, CR mean = 4.4, PR mean = 0.1; location p = 0.002, original pen mean = 5.5, Pond Pen mean = 1.6) as a function of rearing environment and location.

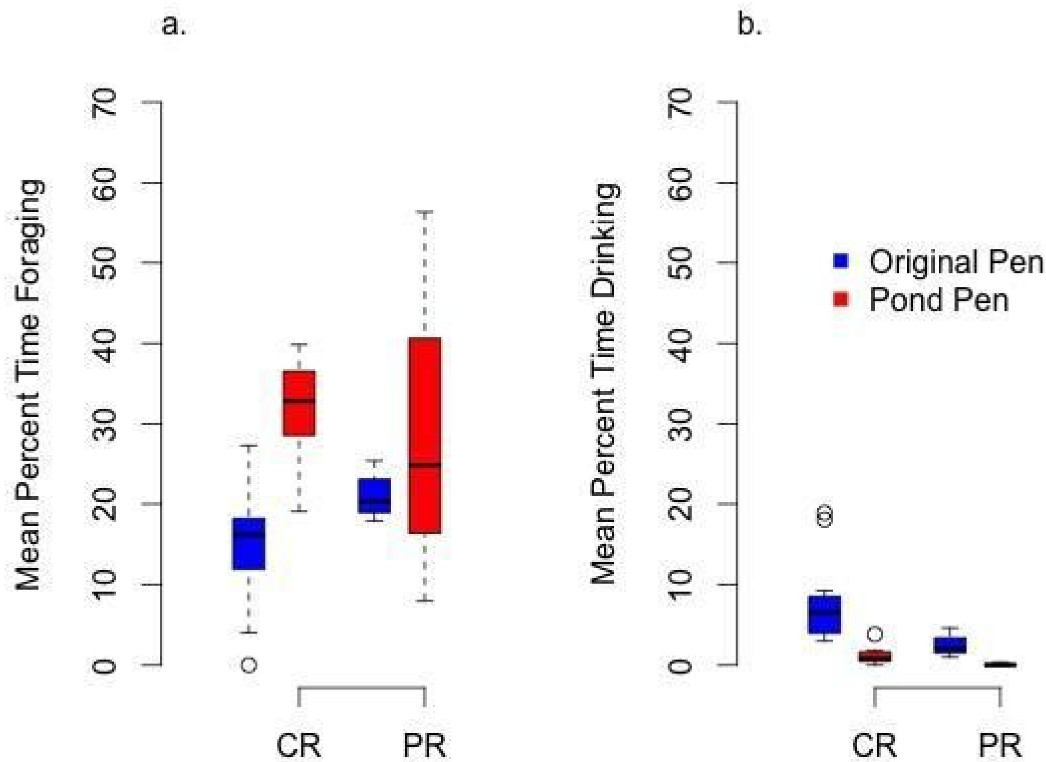


Figure 5. Boxplots comparing mean percent time in seconds a. foraging (location p <0.0001, original pen mean = 16.5, Pond Pen mean = 31.4) and b. drinking (location p <0.0001, original pen mean = 6.5, Pond Pen = 1.0)as a function of rearing environment and location.

**Novel Environment.**

During their time in captivity, chicks were moved multiple times to different pens. Observations were made within one hour of each move to determine whether there was a difference in behaviors and movements when presented with a novel environment. Using the adjusted alpha of 0.008, there was no difference between expressed movements and behaviors between rearing environments. However, when using an alpha of 0.05, differences were seen for walking ($p = 0.04$, CR mean = 26.2%, PR mean = 58.6%), standing ($p = 0.03$, CR mean = 58.0%, PR mean = 32.1%), and foraging ($p = 0.05$, CR mean = 26.8%, PR mean = 9.5%) where CR birds spent more time standing and foraging immediately after being presented with a novel environment than PR birds. Parent-reared birds spent more time walking than CR birds after being presented with a novel environment.

**Novel Environment Observations as a Function of Rearing Environment and Move.**

Because observations were made each time the chicks moved to novel environments, we were able to determine if there were differences in expressed behaviors and movements between the two groups as a function of both rearing technique and move number. Comparable data are only available for all birds on move number 2, which is the move from the White Series to the Pond Pens, and move number 3, which is the move from the Pond Pens to their release sites in Wisconsin (White River Marsh for CR birds and Necedah NWR for PR birds). As stated above, differences were not observed between the rearing environments using the novel environment data. However, when using the same data and looking at expressed movement and behavior as a function of both rearing environment and which move the chick was experiencing, there were differences between the rearing environments for walking ($p < 0.0001$, CR mean = 27.5%, PR mean = 81.0%, Figure 6a), standing ($p = 0.003$, CR mean = 63.1%, PR mean = 19.0%, Figure 6b), and vigilance ($p < 0.0001$, CR mean = 0.9%, PR mean = 37.5%, Figure 17b). Parent-reared chicks spent more time walking and being vigilant than CR chicks, while CR chicks spent more time standing than PR chicks. When looking at differences in behaviors and movements between the two groups solely based on which move they were experiencing, hock-sitting ($p = 0.005$, Move 2 mean = 0.08%, Move 3 mean = 19.0%, Figure 6c), vigilance ($p < 0.0001$, Move 2 mean = 1.1%, Move 3 = 25.0%, Figure 7b), and preening ($p = 0.0009$, Move 2 mean = 9.1%, Move 3 mean = 38.3%, Figure 7d) increased from the Pond Pens to the release site pens while foraging ($p = 0.002$, Move 2 = 30.0%, Move 3 mean = 5.1%, Figure 7a) and non-vigilance ($p < 0.0001$, Move 2 mean = 56.5%, Move 3 mean = 18.8%, Figure 7c) decreased after the move from the Pond Pens to the release site pens. Considering the interaction between move and rearing environment, only vigilance was affected ($p < 0.0001$, Figure 7b).

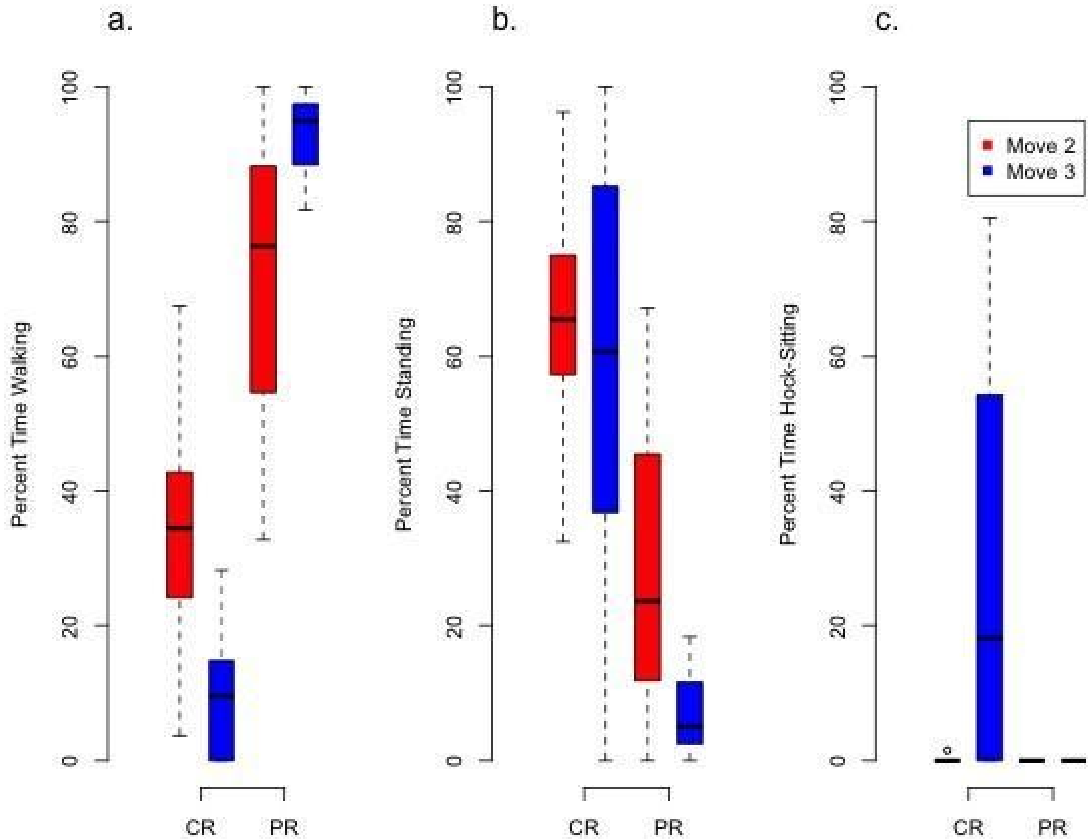


Figure 6. Boxplots comparing percent time a. walking (rearing environment p <0.0001, CR mean = 27.5, PR mean = 81.0), b. standing (rearing environment p = 0.003, CR mean = 63.1, PR mean 19.0), and c. hock-sitting (move number p = 0.005, move 2 mean = 0.1. Move 3 mean = 19.0) as a function of rearing environment and move number.

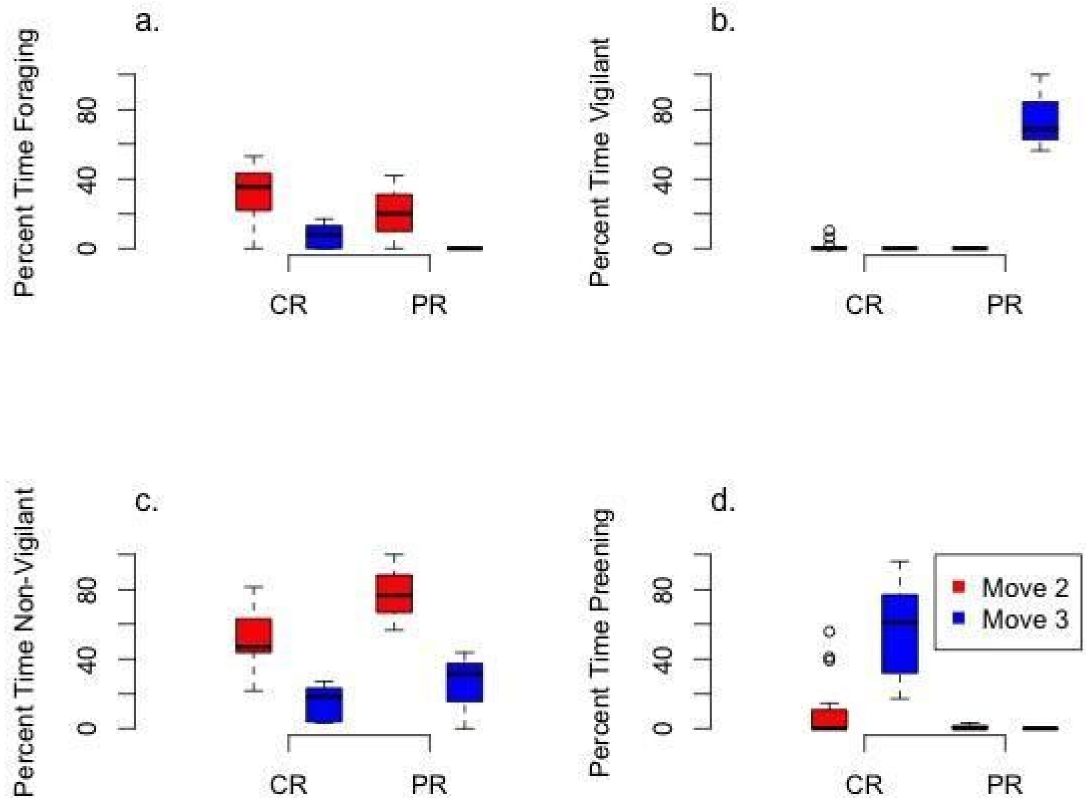


Figure 7. Boxplots comparing percent time a. foraging (move number p = 0.002, move 2 mean = 30.0, move 3 mean = 5.1), b. vigilant (rearing environment p <0.0001, CR mean = 0.9, PR mean = 10.4; move number p <0.0001, move 2 mean = 1.1, move 3 mean = 25.0, rearing environment:move number p <0.0001), c. non-vigilant (move number p <0.0001, move 2 mean = 56.5, move 3 mean = 18.8), and d. preening (move number p = 0.0003, move 2 mean = 9.1, move 3 mean = 38.3) as a function of rearing environment and move number.

## Discussion

The use of captive rearing as a conservation and management tool has become increasingly popular due to increasing decline in suitable habitat for many species. Unfortunately, research has shown that rearing animals in captivity leads to less desirable behavior once the animals are released into the wild, as in the case of houbara bustards (*Chlamydotis undulata*) (Combreau & Smith, 1997), coho salmon (*Oncorhynchus kisutch*) (Berejikian et al., 2001), and golden lion tamarin (*Leontopithecus rosalia*) (O'Regan & Kitchener, 2005).

For the whooping cranes, their numbers reached such critically low levels that captive rearing was the only hope to save the species from extinction. After being released into the wild, they are able to survive, migrate, and even reproduce. Unfortunately, they are unable to successfully rear their chicks in the wild, resulting in the need to continue to intervene and release additional birds. The purpose of my study was to observe the whooping crane chicks in captivity to determine whether there were differences in expressed behaviors between the chicks being reared by humans in costumes or by a pair of adult whooping cranes.

Immediate differences in movements and behaviors were observed between the CR and PR chicks when they were in their original pens post-hatch. While in their original pens only, CR chicks expressed more sedentary behaviors and movements, such as laying, hock-sitting, and sleeping more often than PR birds, suggesting that CR birds are less active than PR chicks from the outset. This could possibly be due to the fact that the CR chicks had smaller pens than PR chicks, giving them less area in which to walk. Costume-reared chicks also experienced daily exercise while in their original pens, such as ultra-light training, walks, and swimming, which could have exhausted them, leading to the expression of more sedentary behaviors and movements. Another possibility as to why PR chicks spent less time expressing sedentary behaviors and movements could be because they had the influence of their foster-parents who, although did not have their behavior measured directly, were rarely observed expressing sedentary behaviors (personal observation) such as laying and hock-sitting during observation sessions. Although eating and drinking were different between the CR and PR birds while in their original pens, this could be due to inconsistencies in my data. CR chicks were observed eating and drinking more often than PR chicks. CR chicks had more water available in their pens (foot baths and watering devices) than the PR chicks (only watering devices). During observation sessions for the PR chicks, they were observed being directly fed by their parents. This behavior was not considered eating or foraging according to my ethogram, so when it was observed, it was recorded as ‘other.’ Also, the food provided to the PR chicks by technicians was located in a foodshed that was out of my view during observation sessions. Because of this, every time a chick entered the food shed to presumably eat, I had to mark them as out of view instead of assuming they were eating while out of view. Interpreting the results that show that CR chicks preen more often than PR chicks is difficult. Preening was often seen after the CR chicks had been taken on walks or had just been taken swimming. As suggested by Kreger et al. (2004), who also conducted behavioral observations on captive-reared WHCR, these walks and having wet plumage after swimming could result in the chicks preening more often.

Similar differences, as described above, were observed throughout the time that chicks were in captivity. CR chicks were foraged and ate more than PR chicks. From a biological standpoint these results are difficult to interpret because they probably occurred due to the inconsistencies and restrictions with my observations for the PR chicks that I stated earlier. Preening continued to be different, with CR birds preening more often than PR birds. Although not always significant when compared to the adjusted alpha, differences in behaviors and movements were observed between the two rearing environments throughout their time in captivity and when presented with novel environments. These differences were consistent with each other, where the same group of chicks was observed expressing certain behaviors and movements more than the other, regardless of the data being used for analysis (first pen only, daily observations, novel environment observations, rear~move). PR birds spent more time walking, while CR spent more time standing and laying, which suggests that PR chicks are more active than CR chicks.

The comparison between behaviors and movement as a function of rearing environment and location using the daily observation data revealed many differences between moves. Using these data, sleeping, laying and hock-sitting were observed more in the chicks' originals pens than in the Pond Pen, while standing was observed more in the Pond Pen. This suggests that activity increased from when the chicks were in their original pens to when they were in the Pond Pens. This could be because when they were in their original pens, they were housed separately from other chicks, and while in the Pond Pen, they were housed with up to five additional chicks. The extra chicks may have caused individuals in the Pond Pens to be more mobile. Foraging increased from the original pens to the Pond Pen; this may have been because the Pond Pen had more natural food sources, such as aquatic insects, frogs, and snails, than their original pens. Although I compared pen locations, differences in expressed behaviors could also be because of the variation in age of the chicks at the time they were in each pen. An example of how age could possibly affect expressed behaviors is that sleeping was observed more in the original pens than in the Pond Pen. This could be because the chicks were older in the Pond Pen than in their original pen and were roosting at night when observations were not being conducted. Another example of how age may affect expressed behavior is that vigilance was higher in the original pens than in the Pond Pen. Although the chicks were in a larger pen with other birds, as they mature, their aggressiveness towards other chicks decreases. Also, while in the Pond Pens, there was less disruption from technicians than when the chicks were younger in their original pens.

Differences in expressed behaviors were observed between move numbers when using the novel environment data. Due to lack of comparable data, data from only Move 2 (move into the Pond Pen) and Move 3 (move to release site: Necedah NWR for PR chicks and White River Marsh for CR chicks) were used. Vigilance and preening were both observed more when the birds were moved to the release site than in the Pond Pen.

Observations on the chicks when presented with their release sites were conducted after the chicks had been handled, placed in crates, flown to WI, and released from the crates into new pens. Preening may have been observed more upon release as a comfort behavior or because they were in the crates for a long duration. Vigilance may have been high due to the handling and transportation of the chicks. Increased vigilance in the release site pens compared to the Pond Pen could have been due to increased visual stimulus of other birds and wildlife found at the release sites. Although vigilance was higher at the release sites, hock-sitting was also observed more frequently. I did not predict this; rather, I predicted more walking and standing would have been observed due to the stress of transportation. Neither of these behaviors (walking or standing) showed a difference even with the more standard alpha of 0.05. Interpreting the increase in hock-sitting in the release site pens is difficult because, from personal observations, normally when stressed, the chicks were more active and even paced.

Non-vigilance was observed more after Move 2 into the pond, which could have been because the move was from a nearby pen and less stressful. Foraging was also observed more after Move 2. The Pond Pens and the Release Site pens were very similar in size and composition (dry land and standing water), suggesting that the differences were due to previous differences in rearing environment and technique.

In addition to rearing environment, this study incorporated many confounding variables, which could be causing changes in behavior, such as age and the pen type. Rearing of the chicks by this method at PWRC has been ongoing since 1966, and there was unfortunately no way to alter these methods and rear both groups of chicks in similar pens, allowing a comparison to be made solely between rearing techniques. Ideally, future studies of this type would have larger and more equal sample sizes, identical original pens for the two rearing techniques, and a similar timeline of pen use for the chicks. This would allow us to determine if there are specific differences from rearing technique alone.

My results clearly show differences in expressed behavior between two very different rearing environments. Because these differences were observed in captivity, they suggest that there are behavioral differences between the two groups in the wild, which can be supported by Kreger et al (2005). Kreger et al. (2005) conducted behavioral observations on released WHCR chicks that were either costume-reared or parent-reared at PWRC and released in central Florida. Their observation period lasted six weeks post-release because this is when the newly-released birds are most susceptible to predation. Also, after a 6-week period, the birds tend to disperse from the release site area, making tracking and observations more difficult. Their results show that PR birds spent less time foraging than CR birds, which is consistent with my results from observations while the chicks are in captivity. Parent-reared birds were also observed to be closer to other birds and in larger flocks than CR birds. Because the newly-released birds are unfamiliar with their release environments, excess foraging may lead them into unsafe and undesirable territories. However, when food is abundant and predation pressure is high, if birds are in larger groups, it could result in more safety. Because the

PR birds are spending less time foraging and occur in larger flocks, Kreger et al. (2005) suggest that PR birds have better anti-predatory strategies. Kreger et al. also found that between the two studies (2004, 2005), behaviors and movements expressed more by a certain group of chicks while in captivity continued to be expressed more than the other group once released. My data and those of Kreger et al. (2004, 2005) suggest that, because there are differences between expressed behaviors and movements while in captivity, these are likely to continue once released and thus cause differences in reproductive and parenting behaviors between the two rearing environment groups in the wild.

Behavioral observations on the chicks after their first migration and when they are sexually mature should be conducted to further determine if there are differences between the two groups. If we were able to keep all conditions consistent for the chicks while in captivity except for rearing technique and differences were observed as well as differences in reproductive success in the wild between the two groups, we could better assess which rearing technique is more fit for the whooping cranes.

While in captivity, animals are not experiencing the same pressures they would in the wild. Because of this, the behaviors expressed in captivity may not be those needed for the animals to survive in the wild post-release. Not only does captive rearing alone affect behavior, but the rearing technique being used could affect behavior. Different rearing-techniques have different levels of success on different species. Bali mynahs (*Leucopsar rothschildi*) were able to be successfully parent-reared in captivity and released into the wild (Wallace, 1994). Peregrine falcons were reared in captivity by humans and a portion of them were fed simply by being provided food dishes while the others were introduced to food sources by the use of a puppet (Wallace, 1994). After the chicks were placed in nests with adult falcons, those that were taught by puppets were able to recognize adult falcons as a source of food. Another study used three of the main rearing techniques (captive rearing, cross fostering, and parent rearing) to see how behavior in killdeer would vary. They found that birds being raised in captivity spent significantly less time feeding than the parent-reared and cross-fostered birds (Powell & Cuthbert, 1993). Although behavioral ecology is not highly represented in the field of conservation, it is extremely important to take into account the behaviors of the captive-reared animals.

# CHAPTER III
## CONCLUSIONS

To study the low reproductive success of reintroduced captive-reared whooping cranes (WHCR), I explored the hypothesis that rearing environment while in captivity affects expressed behavior. After conducting behavioral observations on all whooping crane chicks being reared in captivity at Patuxent Wildlife Research Center in the summer of 2015, I compared the two rearing environments: chicks being raised by humans in costume with their original pens in captivity being long and narrow (2.7m X 3.4m (inside), 2.4m X 9.1m (outside) or 2.4m X 2.4m (inside), 2.4m X 7.6m (outside)) with both indoor and outdoor runs and are housed solitary or chicks being raised by a pair of adult WHCR in large (13.7m X 19.8m or 10.7m X 30.5) outdoor pens. Observations and comparisons were also made on the chicks when presented with a novel environment while in captivity. After analysis, differences were seen between the two rearing environments, which supports my prediction that there would be differences in expressed behaviors and movements between rearing environments. My findings are consistent with a similar study done by Kreger et al. (2004), who observed WHCR chicks in captivity at PWRC. Unfortunately, due to many different variables, I was unable to determine what is causing these differences. Although this is true, the fact that I saw differences between the two groups of chicks while in captivity could lead us to believe that there are behavioral differences between the two groups while in the wild post-release. This idea is supported by another study done by Kreger et al. (2005) that showed that differences between chicks from different rearing environments while in captivity continued to be different between the two groups after they were released into the wild. Because differences are seen in captivity and post-release, this strongly suggests that there will be behavioral difference between the two groups during reproduction and parenting in the wild. This could be an extremely important factor leading to low reproductive success for WHCR. Research needs to continue on these highly-endangered birds to develop management and conservation tools to prevent extinction.

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