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## PHOTOPERIOD AND NESTING PHENOLOGY OF WHOOPING CRANES AT TWO CAPTIVE SITES

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Increasing day length is considered to be a stimulus to breeding in many avian species in northern latitudes (Welty 1975). Crane species that breed in high latitudes include Siberian crane (*Leucogeranus leucogeranus*), lesser sandhill crane (*Grus canadensis canadensis*), hooded crane (*G. monacha*), and whooping crane (*G. americana*). The first captive breeding records for hooded and Siberian cranes were induced with the use of artificially extended photoperiods (Mirande et al. 1996). Most likely, cranes that breed in mid-latitudes also respond to increasing daylight. In 1 study, captive greater sandhill cranes (*G. c. tabida*) were stimulated to lay earlier than controls by using artificial lights to alter the photoperiod (Gee and Pendleton 1992).

The physiological response to light may be combined with an environmental or climate effect. Observations of breeding captive whooping cranes in Wisconsin and Maryland indicate that when temperature and humidity rise, breeding activity ceases, despite the continued use of artificial light to increase the photoperiod (Mirande et al. 1996). For Siberian cranes a temperature  $>21^{\circ}\text{C}$  stops semen production (Einsweiler 1988).

Light intensity and the spectrum of the light are important. Morris (1967), studying poultry, found that  $>16$  foot-candles (170 lux) was required in the cage area to detect a photoperiod effect on breeding. Quartz or metal halide lamps are recommended as providing a good light spectrum, and these lights are longer lasting and more energy efficient than traditional lamps. I examined the past light cycles and breeding season results from whooping crane pairs at U.S. Geological Survey (USGS) Patuxent Wildlife Research Center (Patuxent), Laurel, Maryland, and the International Crane Foundation (ICF), Baraboo, Wisconsin.

Patuxent staff used 3 different photoperiod regimens during 2002-2009: 1) in 2002-2007 there were 2 lights used to produce light of 170 lux in the crane pens, 2) in 2008-2009, only 1 photoperiod light was used for each pen, reducing the light by 50%, and 3) in some years during the period 2002-2009, some whooping cranes had no photoperiod lights. Photoperiod lights were first turned on between days 42 and 55 (11 and 24 February) (2002-2009, mean = day 48, 17 February), with the exception of 2006 when photoperiod lights were not

turned on until day 75 (16 March) due to extensive pen damage from a late winter snowfall. For the years with 2 photoperiod lights per pen (2002-2005, 2007), the mean first lay date was day  $93.6 \pm 12.1$  (3 April) with a range of mean first lay dates of days 81 to 121 (22 March to 1 May). When 1 light per pen was used (2008-2009), the mean first lay date increased to day 103 (13 April), with a range of days 94 to 116 (4 April to 26 April). When no photoperiod lights were used on some pens, the mean first lay date was day  $109.3 \pm 13.8$  (19 April) with a range of days 94 to 129 (4 April to 9 May).

In the 1 year (2006) when the lights were turned on approximately 1 month late (16 March), the mean first lay date was day 108 (18 April) with a range of days 100 to 123 (10 April to 3 May), very similar to the effect seen with no lights. Starting the photoperiod 1 month late was essentially equivalent to having no photoperiod lights. However, the delayed first lay date was not persistent, as the next year (2007) 3 females that laid in both years had earlier first lay dates in 2007 of 3, 6, and 25 days. Photoperiod lights were first turned on in 2007 on day 53 (22 February). There were 4 pairs that did not lay eggs during 2002-2009 despite the photoperiod lights. Twelve pairs that did lay during this period are included in the results above.

Results from ICF were similar to the results from Patuxent. With photoperiod lights, the mean day of first lay was day  $108.66 \pm 2.39$  (1 SE) (18 April), and without photoperiod lights the mean day of first lay was day  $116.26 \pm 2.34$  (26 April), almost a week later. This difference was statistically significant ( $P = 0.026$ ,  $F = 5.16$ , 1-way ANOVA). Neither the number of eggs laid ( $P = 0.510$ ,  $F = 0.44$ ) nor the length of the egg-laying season ( $P = 0.243$ ,  $F = 1.38$ ) was significantly different between years when photoperiod lights were used and when they were not used. There were highly significant differences for first egg lay dates and number of eggs laid by individual females (first egg lay date by female,  $P < 0.001$ ,  $F = 9.19$ ; number of eggs laid per year by female,  $P = 0.011$ ,  $F = 2.75$ ). The length of the egg-laying season did not vary significantly among the various female whooping cranes ( $P = 0.171$ ,  $F = 1.51$ ). The strength of the photoperiod lights in the ICF whooping crane pens was not known. First lay dates

shifted from year to year but there was no significant pattern (Figure 1).

With 2 lights per pen at Patuxent, whooping cranes laid their first egg on average 10 days earlier than when 1 light was used and 16 days earlier than when no lights were used. At ICF the difference between lights on a pen and no lights was only 8 days in the first lay dates, but still this was statistically significant.

The conclusion from these data is that artificially increasing the day length at the captive centers helps to lengthen the breeding season by up to 2 weeks, which potentially results in more eggs from the captive pairs. However, raising cranes 1 year on a photoperiod date that is later than the norm (such as day 75, 16 March, in 2006) has no permanent effect on subsequent years when the photoperiod increase starts at the earlier February date. Therefore, there should also be no effect of the artificial photoperiod lights on the young birds produced from these pairs. Rather, when the offspring mature and begin breeding, they will respond to the light cycle encountered in their breeding area. There is also no effect of starting the breeding period earlier or later 1 year by using or not using photoperiod lights on the first lay date in subsequent years. That is, altering the lay date 1 year does not alter subsequent lay dates if the factor causing the alternative lay dates, such as artificial lighting, is removed.

What triggers the breeding season in non-migratory whooping cranes in Florida and in Louisiana, where the change in photoperiod is much smaller than that on

the northern breeding grounds in Canada or at the more northerly captive breeding facilities? One might suspect rising temperature and/or humidity may play a role in triggering the onset of breeding activity. The whooping cranes in Florida, when they breed, are known to breed earlier than the whooping cranes in captivity in Wisconsin or Maryland.

### Effects of Multiple Clutching

In the wild, whooping cranes lay 1 clutch of 2 eggs. The first lay date of whooping crane females in captivity is somewhat predictable. Each female starts laying on or about a certain date dependent on some external variables such as photoperiod as already discussed above, but also the health of the female, unusual disturbances (e.g., weather events such as a snow storm in late winter 2006), movement to a different pen, or a new mate. The 2 eggs in a clutch are normally laid about 2-4 days apart. One-egg clutches are possible.

Whooping cranes are indeterminate egg layers, as are all cranes (Mirande et al. 1996). If something happens to the first nest resulting in abandonment or loss of the eggs, whooping cranes are capable of renesting. In captivity, we remove eggs from a nest to stimulate cranes to lay additional eggs, which is called multiple clutching. Two techniques are used to increase reproduction. In the first the eggs are removed as laid. The second technique is to allow the female to complete the clutch of 2 eggs before removing both eggs. Kepler

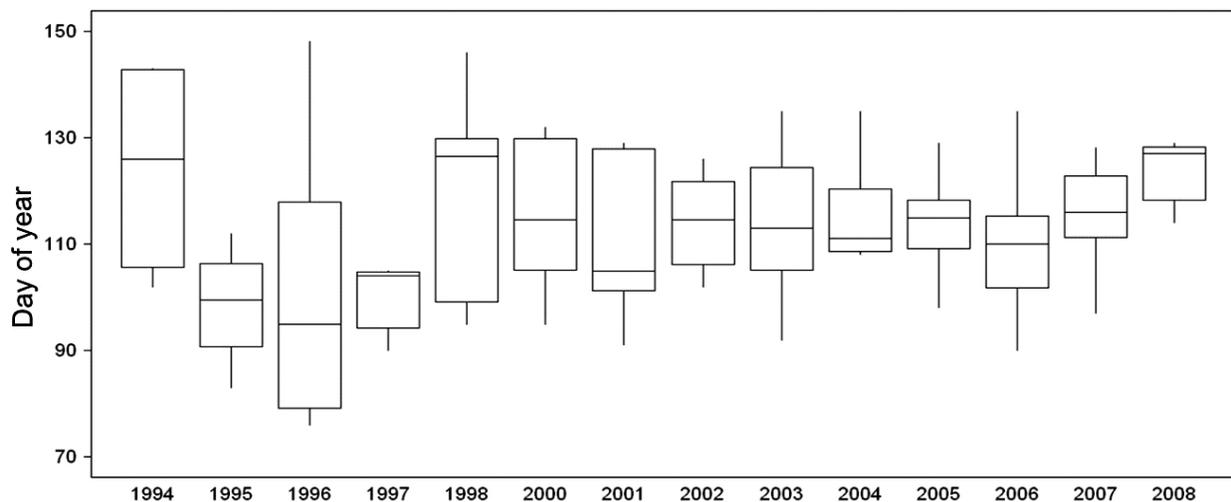


Figure 1. Mean first egg lay dates (median, quartiles, range) for whooping crane eggs ( $n = 82$ ) laid at the International Crane Foundation, Baraboo, Wisconsin, 1994-2008.

(1978) found that for nesting whooping cranes, when each egg is removed shortly after being laid, there was an increased production (6.4 eggs per female) as compared to the technique of waiting for the clutch to be complete before removing the eggs (5.3 eggs per female).

Multiple clutching has a significant negative effect ( $P = 0.023$ , Hunt 1994) on the fledging rate. Eggs laid late in the breeding season in late clutches have a decreased probability of fledging. Hunt (1994) did not directly look at whooping crane data, but examined information from Siberian, Florida sandhill (*Grus canadensis pratensis*), white-naped (*G. vipio*), and red-crowned (*G. japonensis*) cranes. At Patuxent we have noted a decrease in egg size with later eggs when multiple clutching. There may also be an increase in medical problems in late-clutch chicks. We will be studying these effects of multiple clutching further.

There are also problems for the female that are associated with multiple clutching. Calcium depletion leading to uncalcified eggs or even to the collapse of

the laying female is possible. Decreased hatchability, decreased growth rate, decreased survival, and decreased fertility have been reported for later eggs when multiple clutching (Koga 1976). Despite all the potential problems, the gain in production of live, healthy chicks far outweighs the problems encountered when multiple clutching. On the positive side, some studies (Koga 1955, 1961, 1976) have shown that multiple clutching may actually improve fertility.

One question that has been asked by members of the Whooping Crane Eastern Partnership is whether multiple clutching has any effect on shifting the date when the first egg is laid. Patuxent has been multiple clutching for many years. During this time there has been great variation in first lay dates (Figure 2). However, most of this variation is explained by the variation in photoperiod light intensity (see above section on photoperiod lights) and by weather factors, especially several recent years with heavy late winter snowfalls. If the years 2002-2005 and 2007 are examined when the photoperiod lights

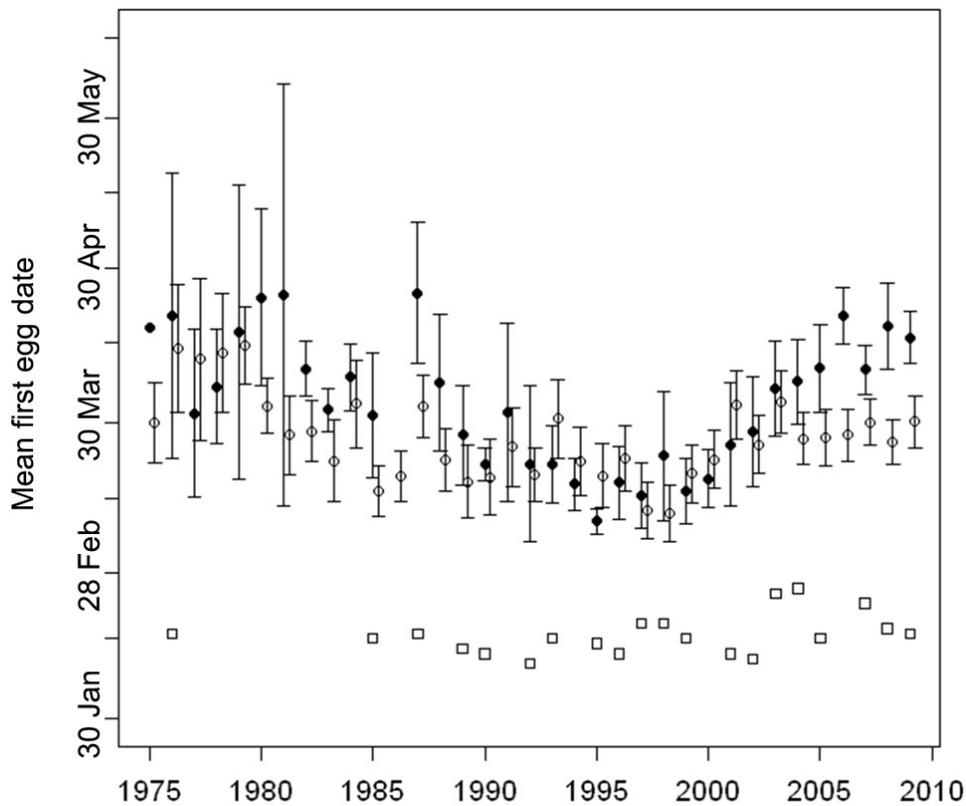


Figure 2. Mean first egg lay dates for whooping cranes and sandhill cranes at USGS Patuxent Wildlife Research Center, Laurel, Maryland. Filled circles are whooping cranes, open circles are greater sandhill cranes, and open squares are Florida sandhill cranes.

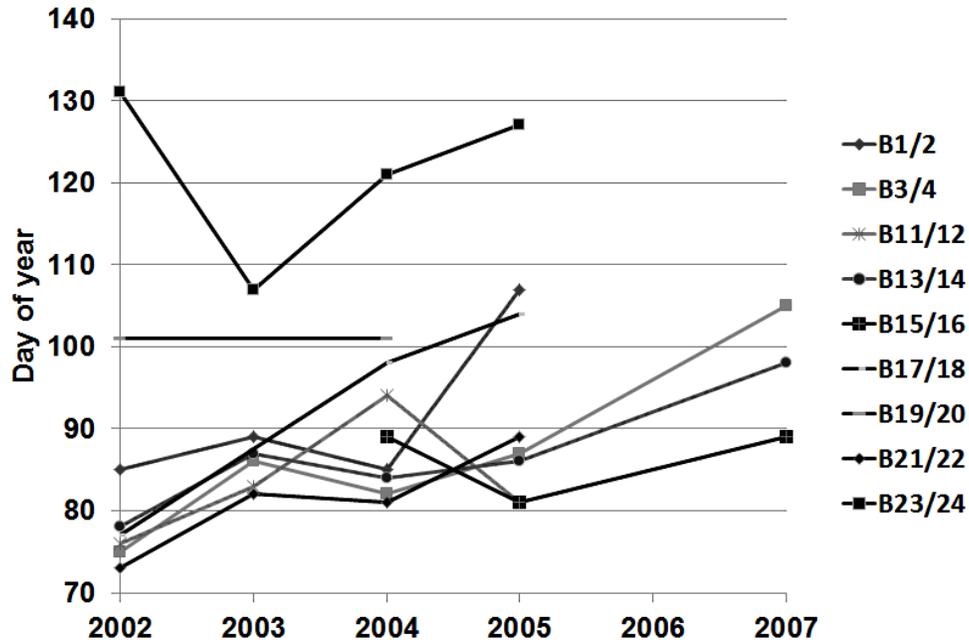


Figure 3. First egg lay dates for 9 whooping cranes at USGS Patuxent Wildlife Research Center, Laurel, Maryland, 2002-2007. All whooping cranes were multiple clutched and received photoperiod lights starting in mid-February and of the same intensity of 170 lux.

were kept at maximum brightness and there were no late winter snow storms, there still appears to be great variation in first lay dates (Figure 3). The mean change in the 7 whooping cranes showing later first lay dates was 14 days; the range was 1 to 27 days later. For the 2 cranes that had earlier lay dates, 1 was 1 day earlier and only laid twice in the 5-year period. The other crane showed no constant pattern, as 2003 was 24 days earlier than 2002, but 2007 was only 4 days earlier than the date in 2002. None of these shifts was statistically significant. When comparing recent first lay days with those over the entire history of captive breeding at Patuxent (Figure 2), we see that there is great variation from year to year and that current first lay dates are only now approaching those seen in the early years of the program, thus no conclusions regarding the effect of multiple clutching on first lay date can be formulated. More study of factors affecting first lay dates is warranted, especially the effects of weather, including temperature.

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