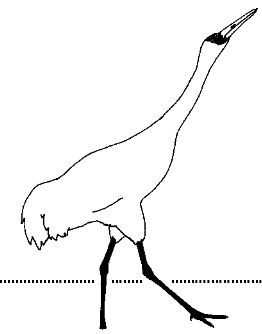
Egg and Semen Production



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This chapter reviews ways to induce egg and semen production in captive cranes and provides managers with guidelines for establishing and evaluating their programs.

Behavioral Factors

Pair Bond

Captive cranes need a **strong pair bond** to breed. In the wild, cranes freely choose mates, but in captivity, we choose mates based on availability and genetic concerns. During courtship, there are strong feedback mechanisms between **behavior and hormonal status** (Murton and Westwood 1977; see Chapter 7 for greater detail). Courtship synchronizes mates and promotes development of the reproductive system. This synchrony is critical because crane pairs must cooperate closely to copulate, incubate, and successfully raise chicks. Behavioral management is a critical component of successful captive propagation, and readers are encouraged to study Chapter 6.

Disturbance

In general, transferring pairs to different pens or breeding facilities disrupts reproductive activity (Mirande et al. 1989 unpubl.). However, cranes may benefit from **transfers**, such as removal from display or return to a pen where the pair previously bred. Annual rotation of pairs between adjacent pens (for disease management) does not seem to have an adverse affect. If moves are needed, they should be scheduled after the breeding season. Valuable breeding pairs should be kept "off-exhibit" because cranes maintained on **public display** produce significantly fewer eggs (Mirande et al. 1989 unpubl.).

Persistent **aggressiv e interactions** with cranes in neighboring pens can inhibit breeding and should be managed with visual barriers, buffer zones, or pen switches. Birds should be carefully monitored for behavioral **signs of stress** associated with disturbances, such as frequent pacing of pen boundaries, excessive preening, decreased or increased calling, egg breaking, etc. If you observe such behavior and cannot correct the problem, consider moving the birds (Derrickson and Carpenter 1987).

Egg and Chick Adoptions

Some pairs that have not laid eggs can be induced to incubate eggs and adopt chicks (see Chapter 5 for details of chick adoptions). The behavior associated with incubation and chick rearing strengthens the pair bond, may stimulate the pair to breed earlier, and may induce non-breeders to reproduce in subsequent years. We speculate that successful adoptions elevate the prolactin level in the pair.

Patuxent has introduced dummy eggs to eight pairs of Whooping Cranes that have never before laid eggs: two pairs accepted and incubated eggs. One of these pairs hatched a chick and the other adopted a chick. Both pairs laid eggs for the first time in the following year. ICF has attempted three egg adoptions with non-laying Whooping Cranes: none were successful.

To adopt an egg, watch pairs for **signs of laying**, such as increased Bill-down posturing (Fig. 3.1), nest building or attraction to one area of the pen, broodiness, aggressiveness, increased calling, or Copulation. Parents should be chosen based on their previous experience with chicks and eggs (see Chapter 5 section on Choosing Parents). To avoid disrupting natural reproduction, egg adoptions should not be attempted if a pair seems likely to lay. However, if the laying season is ending and the pair either shows no clear signs of laying or a decrease in nest attendance, it may work to give the pair a dummy egg to try to induce them to adopt. See Chapter 5, Choosing Parents section, for parameters to use in evaluating surrogate parent's adoption potential. Unrated or first time pairs

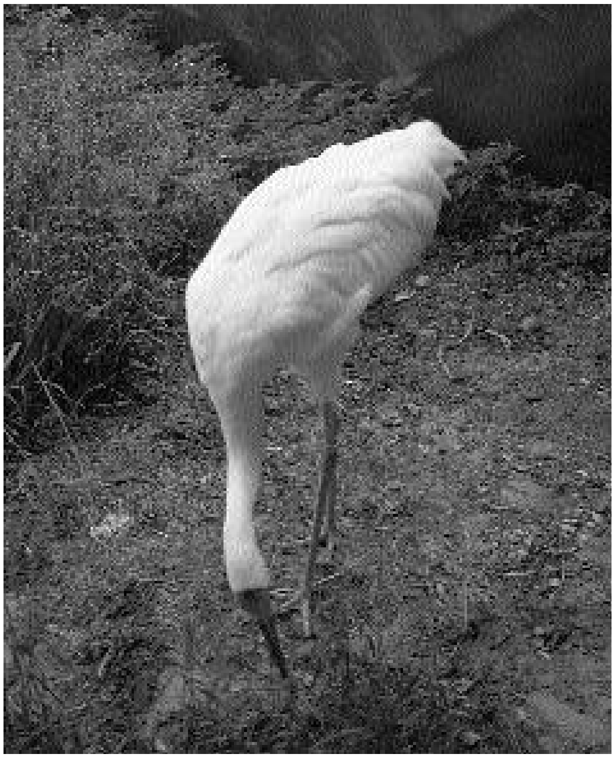


Fig. 3.1. *Nest searching or Bill-down posturing of a female Siberian Crane.* Photo Patty McCourt

should only be given non-endangered or non-valuable eggs for the first few years.

Quickly create a nest in an area of the pen where the pair seems most likely to lay. Then, without allowing the pair to see the egg in hand, **place a dummy egg** in the nest. If the pair initially ignores or attempts to break the egg, continue the adoption. It may take 2 to 7 days for the pair to accept the egg and begin incubating. After incubating for at least 14-21 days (25-30 is preferred by Patuxent), exchange the dummy egg for a pipped egg. If everything goes well, allow the pair to hatch or adopt and rear the chick.

To stimulate parental behavior in non-reproductive pairs, ICF also places 2-week- to 4-month-old chicks in the pen adjacent to pairs. Responses vary, but some adults stand in close proximity to the chicks and defend them. ICF was successful in adopting three 2-month-old Sandhill chicks to a lone female White-naped Crane and a 2-week-old Sandhill to each of two inexperienced pairs of Hooded Cranes.

Environmentdal Influences on Reproduction

Environmental factors, together with physiological conditions and endogenous rhythms, ensure proper reproductive timing (Marshall 1961; Sadlier 1969; Immelmann 1971, 1972; Welty 1975:147-153; Murton and Westwood 1977; Wingfield 1983; Wada 1984; Farner 1986). Physiologists define these environmental influences as either **ultimate** or **proximate** factors (see Chapter 7 for greater detail). By understanding how these factors affect reproduction, we can increase production by providing stimulatory cues and avoiding inhibitory factors.

Daylength (Photoperiod)

Farner (1986) says for birds "…in mid-to-high latitudes, the primary proximate factor is the annual cycle in daylength." Increasing the photoperiod stimulates breeding in many species of birds (Welty 1975:153-160; Murton and Westwood 1977; Farner 1986). Cranes that breed at **high latitudes** (Siberian, Lesser Sandhill, Hooded, and Whooping) often experience 20 or more hours of light each day. Although some individuals of these species have bred without an extended photoperiod, it is believed that extending the photoperiod artificially induced the first captive breeding of Hooded and Siberian Cranes. Most Hooded, Whooping, and all Siberian Cranes that have bred in captivity were provided with floodlights on automatic timers to artificially lengthen the photoperiod to 22-24 hours. Table 3.1 lists three **photoperiod control options** for breeding these species.

Mid-latitude cranescanalso respondtoanextended photoperiod.Whenartificially photostimulated, Greater Sandhill Craneslayeggsearlierthancontrols (Geeand Pendleton 1992). Fortropicalspecies,captive eggproductionis: (1) positivelycorrelatedwith day lengthin thosespecieswhich,inthewild,breedwhen days are longest(e.g., Sarus Cranes),and (2) negatively correlatedwith daylengthinspecies which breedin the winter(e.g., Wattled Cranes, p=0.01) when daysare shortest(Balzano 1989 unpubl.).

The high latitude species lay eggs in the cool and moist days of late May and June. Because these species breed in more southerly latitudes in captivity, it is important to stimulate breeding earlier in the season than would occur in the wild. Warm temperatures at

TABLE 3.1.

Three artificially lengthened photoperiod schedules used for breeding high latitude cranes in northern temperate zones.

A. General Schedule—ICF		B. Natural Siberian Crane Schedule—ICF		C. Whooping Crane Schedule—Patuxent	
Date	Daylength (h)	Date	Daylength (h)	Date	Daylength (h)
22-28 Feb	12:00	28 Feb-6 Mar	13:50	16-22 Feb	15:30
1-7 Mar	13:00	6-17 Mar	14:15	23 Feb-1 Mar	15:55
8-14 Mar	14:00	17-24 Mar	14:35	2-8 Mar	16:20
15-21 Mar	15:00	24 Mar-3 Apr	14:55	9-15 Mar	16:50
22-28 Mar	16:00	3-10 Apr	21:30	16-22 Mar	17:15
29 Mar-4 Apr	17:00	10 Apr-5 Jul	24:00[1]	23-29 Mar	17:50
5-11 Apr	18:00			30 Mar-5 Apr	18:25
12-18 Apr	19:00			6-12 Apr	18:55
19-25 Apr	20:00			13-19 Apr	19:30
26 Apr-2 May	21:00			20-26 Apr	20:05
3 May-5 Jul	22:00[1]			27 Apr-3 May	20:40
				4-10 May	21:20
				11-17 May	22:00
				18-24 May	22:30
				25-31 May	23:05
				1 Jun-	23:45[2]

[1] *To avoid possible harmful effects associated with a sudden decrease in daylength, ICF decreases photoperiod by one hour each week after production has ended (approximately 5 July). Artificial lighting is discontinued when natural daylength is reached. Patuxent completely discontinues the use of lights when the last egg hatches.*

[2] *ICF uses the same schedule for Whooping Cranes, but starts one week later.*

Patuxent in early May and at ICF in late May seem to inhibit reproduction. Extending photoperiod early in the spring stimulates these species to breed when **temperature and humidity** at the captive site resemble the native habitat.

Cranes will adjust their breeding schedule based on **latitude and climate** (primarily photoperiod and temperature). For example, Greater Sandhill Cranes not exposed to an altered photoperiod start nesting two weeks later at ICF than at Patuxent. To lengthen the laying season, site-by-site photoperiod adjustments are beneficial. For example, ICF advances the cycle by 5-7 weeks for Siberian Cranes to increase the photoperiod to 21.5 hours in early April when temperatures are similar to those in the native habitat in May. Also, after ICF received Whooping Cranes from Patuxent, the photoperiod schedule used at Patuxent was started one week later to compensate for the later spring at ICF.

Light intensity, and to a lesser extent **spectral** characteristics, are important when choosing an artificial light source. From the literature for other bird groups (Morris 1967), we recommend 16 or more foot-candles (ca 170 lux) throughout the pen and shelter. To meet this goal, check the most dimly lit corners in the pen with a standard photographic light meter (incident light measurement) after dark and adjust the light source to supply this minimum. Normal incandescent bulbs provide a good color spectrum, but burn out quickly and are energy inefficient. Some quartz or metal halide lamps provide a good light spectrum, are long lasting and efficient, and require fewer lamps to provide proper intensity throughout the pen. Lamps can be mounted on poles along pen perimeters or suspended overhead. If birds are rotated to fallow pens in alternate years, lamps on poles can be swiveled to accommodate the rotation (Fig. 3.2).

Fig. 3.2. *Photoperiod lights, if mounted on swivel heads, can be turned to illuminate the adjacent pen in alternate years. Thom Lewis adjusts the position of a light.* Photo David H. Ellis

Most facilities control photoperiod lights by a **timer clock** mounted near the pens. Timers should be adjusted weekly and checked regularly. Although a single night with altered photoperiod is normally insufficient to disrupt breeding, great care should be taken to prevent interruptions or other unprogrammed changes in the photoperiod regime.

Twilight is a time of great activity for cranes, and its simulation may increase the rates of courtship, copulation, etc. Twilight is much longer at high latitudes (sometimes exceeding three hours) and is likely to be most important for boreal and austral cranes. Future **research** on the importance of twilight and the effects of an artificial photoperiod on reproduction in cranes is needed, although controlled experimentation with adequate sample sizes is difficult.

Rainfall

Tropical species, including the Sarus, Brolga, and Crowned Cranes, breed during the rainy season (Archibald and Swengel 1987; Konrad 1987). Rainfall may be the proximate or ultimate factor stimulating breeding in these species. The laying season of captive Sarus Cranes was positively correlated with rainfall in two of three captive centers ($p<0.05$) and in the wild ($p<0.001$, Balzano 1989 unpubl.). Wild Wattled Cranes usually nest at the end of the rainy season. Egg laying in Wattled Cranes was negatively correlated with rainfall in the wild population ($p<0.05$) and in one of three captive centers studied ($p<0.01$, Balzano 1989 unpubl.).

Although tropical cranes have bred without **artificial rain**, sprinklers at ICF simulating the rainy season (Fig. 3.3) are believed to have stimulated the first captive breeding of Brolga Cranes. Other zoos have also used sprinklers to increase laying in Crowned Cranes.

We recommend that a **sprinkler system** provide a fine mist covering the entire pen. The system should operate two to five times each day, and the length of each shower should be adjusted to prevent the development of puddles of stagnant water in the pens. Shield nests to prevent nesting materials from becoming moldy.

Latitude

The onset of egg laying varies with latitude. For north temperate zone breeding birds (disregarding the effects of altitude), the laying season begins an average of three to four days later for each degree of increasing latitude (Welty 1975:148). Data on wild Sandhill Cranes clearly demonstrate later initiation dates and peak production periods as latitude increases (Walkinshaw 1973); the Mississippi Sandhill Crane is an exception (see Fig. 3.4). A similar pattern is observed in captive Greater Sandhill Cranes when laying dates for different breeding centers are examined (Table 3.2). Because of these temporal trends, we recommend that boreal and temperate species be maintained at higher latitudes. Tropical species do best in areas with less climatic variation.

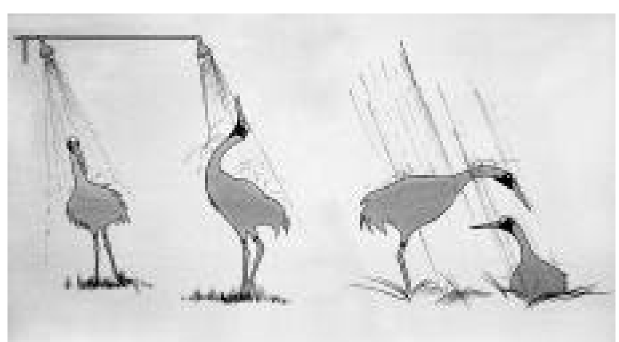


Fig. 3.3. *Sprinklers can be used to simulate rainfall to promote breeding in tropical cranes, here Brolgas.*

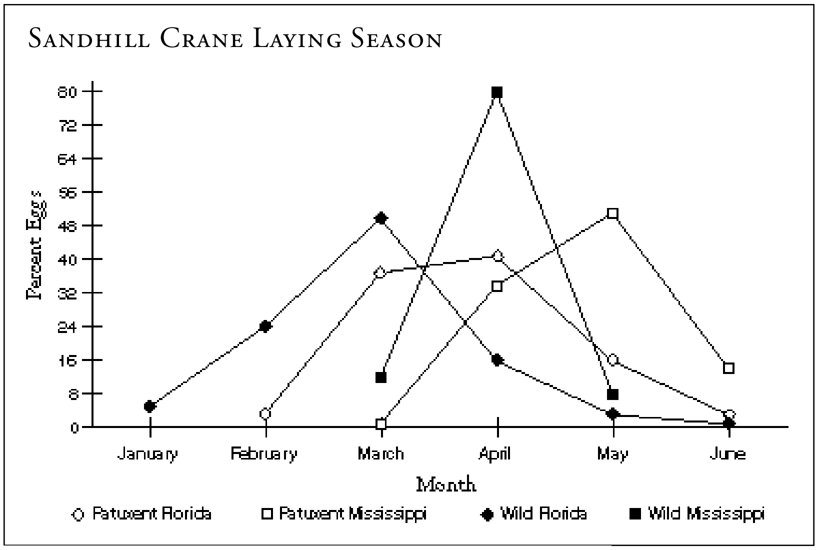


Fig. 3.4. *Laying season for two nonmigratory, warm-climate races of the Sandhill Crane. The Patuxent colonies are ca 8-11° further north than the wild populations.*

Temperature

Temperature affects both the onset and termination of the breeding season. Balzano (1989 unpubl.) found that temperature and egg laying rates were positively correlated in Sarus Cranes ($p<0.05$ in 2 of 3 captive populations), negatively correlated in Wattled Cranes ($p=0.002$ in the wild population; $p<0.001$ in 1 of 3 captive populations), and uncorrelated in White-naped Cranes. Male Sandhill Cranes have produced semen in winter when kept indoors at moderate temperatures (21° C; 70° F) and on a lengthened photoperiod (ca 24 hours) (Gee and Pendleton 1992).

The onset of hot weather seems to terminate semen production. For Siberian Cranes, semen production ceases above 21° C (70° F) daytime peak (Einsweiler 1988 unpubl.). This can result in insufficient semen to fertilize late eggs. For other species, the males may stop producing based on female behavior, not temperature.

Open Water

Opinions differ on the importance of standing water to promote breeding in cranes. Water conditions around nest sites variously stimulate or inhibit egg laying in birds (Lack 1933; Welty 1975:152). At the Wildlife Survival Center in Georgia operated by the Wildlife Conservation Society, cranes were successfully bred in large marshy enclosures. During a study of Wattled Cranes in which some pens were artificially flooded (half of each pen) and controls were not, higher productivity was observed in the flooded pens (C. Sheppard, Wildlife Conservation Society, Bronx, New York, personal communication).

Unless the flooded area is large or there is good water flow, **disease risks** heighten. Factors such as surface area, flow rate, temperature, water depth, soil type, and amount of crane use need to be considered. Access to open water also increases the danger of frozen feet in cold climates. Artificial pools are expensive, labor intensive, and costly to maintain.

Patuxent formerly provided flowing water in **concrete pools** (about four feet in diameter sloping to one foot in depth). The cranes spent much time standing, bathing, and drinking in the pools. However, preliminary data indicated that pairs with flowing water (provided in elevated cups, Fig. 12.13) produced more eggs than pairs in pens with pools and did so without the maintenance and disease problems associated with pools. Nevertheless, the pairs with pools may have ultimately done better with improved husbandry.

ICF is currently examining the effects of **seasonal pen flooding** (Fig. 3.5) to stimulate breeding in nonproductive, but sexually mature, Siberian and Whooping Cranes. Preliminary observations show an increase in foraging and pair interactions and a decrease in territorial defense. Rate of flow is adjusted so water continually drains into the soil reducing disease risks. Seasonal flooding reduces disease risks by allowing soil to dry for 9-10 months each year. Sandy soils at ICF also insure good drainage.

Because many cranes breed without open water, we do not recommend pools for most breeding centers. However, when open water can be managed efficiently, it should promote breeding. One compromise is to provide open water to the most genetically valuable or most difficult to breed pairs, especially if AI is not feasible.

Nest Sites

Cranes need undisturbed nesting sites. Wild cranes generally nest in isolated places where the risk of predation is minimal. Some captive cranes (especially wild caught or nervous birds) also seek seclusion for

TABLE 3.2.

Monthly distribution of eggs (%) laid by captive and wild cranes.

Percent of Eggs Laid by Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
International Crane Foundation (Latitude 43° 35′)—Captive												
Northern cranes												
Florida Sandhill	–	–	17	30	32	15	4	2	–	–	–	–
Greater Sandhill	–	–	–	12	68	20	–	–	–	–	–	–
Red-crowned	–	–	7	26	54	13	–	–	–	–	–	–
Demoiselle	–	–	–	46	54	–	–	–	–	–	–	–
Common	–	–	–	19	65	16	–	–	–	–	–	–
White-naped	–	–	–	23	52	23	2	–	–	–	–	–
Hooded[1]	–	–	–	–	100	–	–	–	–	–	–	–
Siberian[1]	–	–	8	43	48	1	–	–	–	–	–	–
Whooping[1]	–	–	–	50	50	–	–	–	–	–	–	–
Tropical and southern cranes												
Eastern Sarus	–	–	–	–	3	32	49	16	–	–	–	–
Indian Sarus	–	–	–	–	16	44	24	16	–	–	–	–
Blue	–	–	–	–	14	64	21	–	–	–	–	–
Wattled	16	28	16	16	16	–	–	–	–	–	3	6
Brolga	–	–	–	–	17	42	25	17	–	–	–	–
Patuxent Wildlife Research Center (Latitude 39° 02′)—Captive												
Whooping[1]	–	–	11	56	33	–	–	–	–	–	–	–
Florida Sandhill	–	3	37	41	16	3	–	–	–	–	–	–
Greater Sandhill[1]	–	–	3	48	48	1	–	–	–	–	–	–
Mississippi Sandhill	–	–	1	34	51	14	–	–	–	–	–	–
Audubon Park and Zoological Gardens (New Orleans, Louisiana) and San Antonio (Texas) Zoo (Latitudes 30° 00′ and 29° 25′)—Captive												
Whooping	–	12	29	22	29	8	–	–	–	–	–	–
Wild Cranes[2]												
Northern cranes												
Florida Sandhill	5	24	50	16	3	1	–	–	–	–	–	2
Greater Sandhill[3]	–	–	–	62	36	1	1	–	–	–	–	–
Red-crowned	–	–	5	63	32	–	–	–	–	–	–	–
Demoiselle	–	–	–	9	78	9	3	–	–	–	–	–
Common	–	–	–	29	54	17	–	–	–	–	–	–
Tropical and southern cranes												
Blue	11	7	2	–	–	–	–	–	–	15	26	39
Wattled	4	3	2	4	18	19	13	14	3	9	3	7
Brolga	14	25	31	5	3	–	–	8	5	3	5	–

[1] *Captive birds managed under photoperiod lights.*

[2] *From Walkinshaw (1973).*

[3] *Cranes breeding in Michigan.*

Fig. 3.5. *A small pool in a Whooping Crane pen.*
Photo Ann Burke

nesting. Other cranes sometimes build their nests in the most disturbed area of their pen or inside shelters. The rate of egg breakage at ICF is higher when eggs are laid indoors than when laid in the open pens. To minimize disturbance, place food and water near the pen entrance. At Patuxent and ICF, we enter food sheds from a separate outside door to minimize disturbance. For birds on display, caretaker activity and public viewing should leave sections of the pen undisturbed. Reproduction in ICF's crane exhibit building greatly increased when caretakers changed to providing food and water from the exterior, public-viewing area. The pairs selected nest sites in the undisturbed areas of the pens (Mirande et al. 1989 unpubl.).

Nest size varies greatly by species. The largest nests may be 3 m in diameter and 1 m tall in wet areas, or a mere scrape or a few arranged twigs in dry enclosures. Even within a single species, great variation occurs. Greater Sandhill Crane nests at Gray's Lake, Idaho vary from thick (0.6 m) mats 2-3 m wide on water to scrapes on the dry hillside. Some Demoiselle Cranes lay on the open steppe without any evidence of a nest. For all species, provide a suitable supply of twigs and coarse grasses to stimulate nesting behavior. Avoid materials that readily mold to reduce the risk of fungal infection. Patuxent primarily provides wheat straw (*Triticum aestivum*). In an experiment, ICF provided Siberian Cranes with four species of prairie grass including big bluestem (*Andropogon gerardi*), little bluestem (*A. scoparius*), Indian grass (*Sorgastrum nutans*), and Canada wild rye (*Elymus canadensis*). All except little bluestem, the finest grass, were used with stems 0.6 m and shorter preferred.

Food

During egg laying, birds draw on fat and calcium reserves and increase food consumption to provide essential energy, protein, and other nutrients for egg formation (Murton and Westwood 1977:147-214). Cranes may breed in response to factors associated with future food supply (e.g., rainfall, amount of open water, etc.) as well as the direct availability of food. Whooping Cranes feed more heavily on aquatic life during the breeding season, thereby increasing the amount of animal matter in the diet (Serafin and Archibald 1977 unpubl.). In captive females, Halibey (1976 unpubl.) documented increased consumption of feed and oyster shell (a calcium supplement) during egg production.

In a management regime, provide a **constant supply** of **fresh**, **nutritionally balanced food** to cue thecranes thatconditionsare optimalfor reproduction (see Chapter 2 for diets). Patuxent provides a breeder diet with 22.0% (by weight) protein, 3.0% calcium, and 0.8% phosphorus. Similar values for ICF are 20.5%, 2.45%, and 0.89% respectively. Oyster shell is provided *ad libitum* one to two months prior to egg laying to all species and both sexes. Additional research is needed on the nutritional requirements for reproduction in cranes.

Sexual Maturity and Reproductive Lifespan

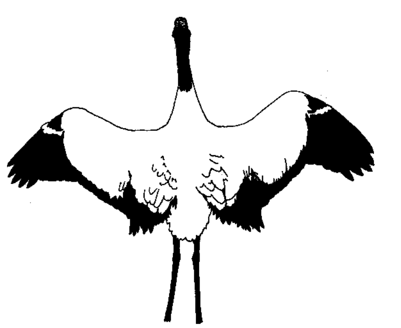
The age of **sexual maturity** and the initial appearance of reproductive behavior varies between species and individuals, and is strongly influenced by rearing history and management within species. In general, cranes form mating pairs when two to three years old and begin to reproduce when three to five years old. With rare exceptions, females lay eggs only when paired. Pair bonds persist and egg production continues (although sometimes at a lesser rate) even when members of a pair are separated into adjacent pens (Gee and Sexton 1979). **Egg production** usually begins one to two years after formation of a pair bond. Laying as early as two years of age has been occasionally reported in captive Wattled, Red-crowned, Eastern Sarus, and Sandhill Cranes, and is common in Mississippi Sandhill Cranes (25% of two-year-old females; Nicolich 1993).

For most species, captive cranes achieve reproductive success earlier than wild cranes. For some species, however, captivity appears to **delay egg production**. Captive Whooping Cranes generally start laying at 5-7 years of age, even though wild birds lay as early as three years of age (Kuyt and Gossen 1987). The mean age of first breeding is decreasing as management improves (Mirande 1994 unpubl.). Until a few years ago, most captive Siberian Cranes bred at seven years of age or older. However, with improved rearing and pairing techniques, Siberian Cranes are now breeding as early as four to six years of age (Panchenko 1993 unpubl.).

Sperm production generally begins at 2-3 years of age with regular production of quality semen usually occurring the following year. Unlike females that lay eggs only when mated, even unmated males produce sperm.

Captive cranes can live long and have an extended **reproductive lifespan**. A male Siberian crane at ICF lived to be at least 78 years of age and produced sperm until at least age 75. A pair of White-naped Cranes and a pair of Demoiselle Cranes produced young when both adults in each pair were at least 60 years of age. Great longevity has important management implications (see Chapter 9).

Age and experience increase reproductive success in cranes (Kuyt 1981; Nesbitt and Wenner 1987) and some other families of birds, especially those with delayed sexual maturity (Richdale 1951; Minton 1968; Gauthier 1989). At ICF, several trends are evident which appear to apply to all cranes. During the first three years of egg laying, (1) the first egg of the season appears progressively earlier (independent t-test, $p=0.038$), (2) the number of eggs produced increases ($p<0.001$), and (3) breeding season lengthens ($p<0.001$). The same trends were noted at Patuxent, but statistical tests were not applied because of confounding variables. First time breeders at both ICF and Patuxent are also more likely to break their eggs than experienced breeders.



Management of Egg Production

Characteristics of Egg Production

In all species, egg production is strongly **seasonal** (Table 3.2). External stimuli such as increasing daylength awakens the reproductive endocrine system. These hormones stimulate the development of the gonadal and accessory reproductive tissues. Eventually, ovulation occurs and an egg is laid about two days thereafter (see Chapter 7).

Timing and length of breeding season vary by species. Table 3.2 shows the egg production season for both captive and wild cranes. Initiation of laying dates for individual females is predictable, and females within a given species generally start laying in the same order each year. However, unusual events like sickness, pen moves, or other disturbance can alter the breeding schedule.

Cranes are indeterminate egg layers capable of renesting and multiple clutching. **Renesting** occurs after eggs are removed, destroyed, or abandoned. In the wild, renesting usually involves starting a new nest at a new location. In captivity, where sites are limited, pairs frequently reuse the same nest.

The **clutch size** for most species is two eggs. Wattled Cranes often lay a single egg, while Crowned Cranes may lay up to five eggs in a clutch.

The time period between successive eggs (whether from the same clutch or a new clutch) is known as the **egg laying interval**. If successive eggs are laid within 2-4 days of the previous egg, we consider them part of the same clutch.

From long-term data kept for each female (see Table 3.3), laying patterns begin to emerge. These patterns allow managers to better predict when a female will lay her first egg of the season, the timing of successive eggs, and the AI schedule. Two general patterns have emerged: some females maintain a clutching pattern (i.e., alternating long and short intervals) while other females exhibit gradually increasing intervals between eggs.

Multiple Clutching

Inducing captive cranes to lay higher numbers of eggs in one season by removing eggs from the nest is known as **multiple clutching**. Eggs can be removed

TABLE 3.3.

Sample egg laying interval record for one Florida Sandhill Crane at the International Crane Foundation.

Year	Total Number of Eggs	Season Length	First Date	Last Date	Egg Number[1]							
					2	3	4	5	6	7	8	9
1981	2	3	19 Apr	22 Apr	3							
1982	4	61	9 Apr	9 Jun	3	56	2					
1983	6	58	6 Apr	3 Jun	3	20	3	29	3			
1984	6	43	6 Apr	19 May	3	21	5	13	3			
1985	6	65	21 Mar	25 May	2	15	3	43	2			
1986	6	24	30 Mar	23 Apr	2	8	5	3	6			
1987	9	47	28 Mar	13 Jun	3	6	7	26	3	6	5	9
1988	8	38	5 May	12 Jun	2	4	8	4	6	8	6	
1989	6	35	10 May	14 Jun	3	5	14	5	8			
1990	2	2	18 Apr	19 Apr	1							

[1] *Number of days between successive eggs (i.e., in 1982, the second egg came three days after the first, the third followed the second by 56 days, and the fourth was laid two days after the third*

(Fig. 3.6) as laid or by clutch. Determine **egg removal procedures** before each laying season based on differences in behavior, incubation skills, laying patterns, genetic objectives (see Chapter 9), and space available for raising chicks and housing new adults.

Single-Egg Removal. When eggs were removed as laid, one captive Florida Sandhill Crane at ICF laid 19 eggs and one Greater Sandhill Crane at Patuxent laid 18 eggs in one season. Eggs were removed as laid from nine pairs of Greater Sandhill Cranes at Patuxent in a three-year study of clutch size and laying intervals. The study birds averaged 3.0 +0.8 days between eggs (75 eggs) in the same clutch and 10.1 +4.1 days between clutches (48 clutches) (Gee 1983). The number of eggs laid varied from one to four eggs per clutch with 30% being 1-egg clutches, 45% 2-egg clutches, 20% 3-egg clutches, and 5% 4-egg clutches. The study cranes showed neither a decline in egg production nor an increase in health problems that could be attributed to maximizing egg production during the three year study.

Kepler (1978) found that single-egg removal resulted in greater egg production in Sandhill Cranes than complete-clutch removal (6.4 eggs per bird verses 5.3). ICF uses single-egg removal to maximize the egg production of experienced breeders or with females designated to be surrogate incubators. Patuxent seldom uses single-egg removal.

Complete-Clutch Removal. For first time layers and to correct problems with egg breakage (see Egg Breakage section), ICF and Patuxent leave eggs until the bird completes the clutch. Disadvantages of removing complete clutches include extended intervals between clutches, reduced egg production, and a shorter reproductive season. Disadvantages to removing eggs as laid include over production by highly fecund females and reduced completion of first clutch by first time layers. Choose the method that fits your situation, bird by bird.

Fig. 3.6. *Removing eggs can stimulate cranes to lay additional eggs. Here Jane Nicolich defends as Yula Kapetanakos removes eggs from Sandhill Cranes.* Photo David H. Ellis

Possible Consequences of Multiple Clutching. Multiple clutching may effect reproductive parameters. In a preliminary study, Putnam and Russman (1987 unpubl.) reported a seasonal decline in weight from first egg to last egg in 6 of 29 cranes. Patuxent and ICF have used multiple clutching with some pairs for decades with no apparent negative effects. From our records, we believe that a minor decline in egg weight over the season is common, but does not limit productivity.

Hunt (1994) noted a slight negative effect of multiple clutching in that the last eggs of the season were slightly less likely to produce fledged chicks than earlier eggs. Stated more precisely, as egg order (number of egg in laying sequence) increased, the fledging rate decreased ($P=0.023$). This minor reduction in fledging rate, however, is more than outweighed by the added productivity coming from the additional eggs. Number in laying sequence had no effect on hatching rate.

Other effects of "extended production" in cranes may include calcium depletion, post-laying "collapse," laying of uncalcified eggs, decreased growth rate and survivability for chicks, and reduced probability of fertility or hatchability (Koga 1976; Putnam and Russman 1987 unpubl.).

In cranes, little is known about the complex relationships between multiple clutching and stress, age, experience (several differences often occur between a dam's first and her subsequent seasons), rearing history, and physical and behavioral abnormalities (Sturkie and Mueller 1976; Putnam and Russman 1987 unpubl.; Mirande and Archibald 1990). Early studies with other species (e.g., Koga 1955, 1961, 1976) concluded that multiple clutching increased fertility.

When multiple clutching, **monitor** dams and their eggs for abnormalities; watch for changes in behavior. Record laying date for each egg, interval length, fertility, hatchability, and measurements (fresh weight, length, and width). Minimizing disturbance is especially important around these females.

Stopping Egg Production. To stop production, merely allow pairs to incubate the last clutch (eggs or dummy eggs) for a week or more. We do not recommended this method during extremely hot or cold weather when incubation may be more stressful than egg production. During extreme environmental conditions, birds stop laying naturally although incubation behavior may persist.

Egg Breakage

Egg breaking behavior is common in many species of captive birds. It has been documented in both experienced and inexperienced crane pairs. Breaking generally occurs shortly after laying but has been observed any time during incubation. **Factors** which may predispose cranes to break eggs include disturbance around the nest site, nutritional deficiencies, laying of abnormal eggs (soft shelled or undersized), inability to incubate properly, and incompatibility with mate.

Limit human activity around pairs with a history of egg breaking. **Behavioral monitoring** helps if facilities allow unobtrusive observation: video cameras can help. Observations may reveal sources of disturbance and help guide management decisions. If the male is responsible, move him to an adjacent pen 1-2 days before the female lays. Other responses may include reducing human activity, adding visual screening, moving the pair to a different pen, or removing an adjacent pair.

Continuous monitoring often makes it possible to collect eggs before they are broken and to replace them with either unbreakable (i.e., wooden or plaster-filled; Fig. 3.7) **dummy eggs** or blown crane eggs filled with a **foul-tasting** liquid (i.e., mustard, hot [tabasco or jalapiño] sauce, or methyl anthranilate). Foul-tasting dummies have been used with only limited success in an attempt to create an aversion to egg breaking/eating. Further experimentation with distasteful but non-toxic substances may prove useful. Replacement with wooden or **unbreakable** dummies has proven successful in several cases where pairs have accepted and incubated these "eggs." Four pairs of

Fig. 3.7. *Unbreakable dummy eggs are used to replace real eggs for pairs that break eggs.* Photo Patty McCourt

TABLE 3.4.

Timing and length of breeding season in male cranes at ICF from 1978-1990.[1]

Species	Sample Size	Earliest Semen	Latest Semen	Mean Season Length (days)	Peak Production	Mean Semen Volume (cc)
Blue	1	1 Apr	8 Jul	71	17 May-20 Jun	0.04
Siberian	11	8 Mar	18 May	69	10 Apr-22 Apr	0.03
Florida Sandhill	9	20 Mar	27 May	79	3 Apr-1 May	0.03
Greater Sandhill	5	24 Mar	19 May	70	16 Apr-2 May	0.05
Eastern Sarus	8	29 May	29 Jul	62	25 Jun-24 Jul	0.04
Indian Sarus	4	1 May	29 Jul	60	30 May-6 Jul	0.04
Brolga	6	27 Apr	18 Jul	81	16 Jun-17 Jul	0.08
White-naped	8	6 Mar	7 Jun	110	12 Apr-20 May	0.10
Common	4	22 Mar	22 May	66	18 Mar-14 May	0.05
Hooded	1	24 Mar	24 Mar	0	24 Mar-24 Mar	0.03
Red-crowned	11	5 Mar	24 May	82	27 Mar-8 May	0.03
Whooping[2]	7	16 Mar	14 May	59	30 Mar-26 Apr	0.03
Demoiselle	3	11 Apr	20 May	39	26 Apr-24 May	—
Wattled	2	8 Mar	10 May	76	16 Mar-18 May	—

[1] *Crowned Cranes are not included because they lay throughout the year.*

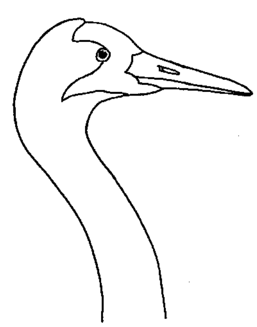
[2] *Data from Patuxent.*

Whooping Cranes at Patuxent broke every egg which was not immediately removed from their pens. All were subsequently given wooden dummy eggs. All pairs initially pecked, then ignored the eggs, and eventually adopted and incubated the wooden eggs. Three of the four pairs thereafter laid their own eggs and incubated without further breakage. ICF has had similar success with Wattled and Whooping Cranes. Incubation and parenting behavior is reinforced by allowing these pairs to incubate full term, and then hatch and rear a chick.

Although no research has been conducted on the relationship of diet to egg breaking, this behavior may also be linked to **nutritional deficiencies**. At ICF, we provide high protein treats (newborn mice or smelt) in food bowls or we toss them to the birds. Treats also help calm or tame the birds. Tame birds, we believe, are less prone to break eggs.

Characteristics of Semen Production

Table 3.4 summarizes crane semen production. These data provide guidelines for collecting semen. Crane semen samples are very small; the average is 0.03 to 0.10 cc for different species. Semen volume in one ejaculate can vary dramatically between males of the same species, from a smear to 0.78 cc. Measurements of semen quality and quantity are described in Chapter 11A.



Literature Cited

Archibald, G., and S. Swengel. 1987. Comparative ecology and behavior of Eastern Sarus Cranes and Brolgas in Australia. Pages 107-116 *in* J. C. Lewis, editor. Proceedings 1985 Crane Workshop. Platte River Whooping Crane Habitat and Maintenance Trust and U.S. Fish and Wildlife Service, Grand Island, Nebr.

Balzano, S. A. 1989 unpubl. Climatic influences on crane production. Paper presented at the 1989 North American Crane Workshop.

Derrickson, S. R., and J. W. Carpenter. 1987. Behavioral management of captive cranes—factors influencing propagation and reintroduction. Pages 493-511 *in* G. W. Archibald and R. F. Pasquier, editors. Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wis.

Einsweiler, S. 1988 unpubl. Factors affecting reproduction of the Siberian Crane at the International Crane Foundation. International Crane Foundation, Baraboo, Wis. 20 pp.

Farner, D. S. 1986. Generation and regulation of annual cycle in migratory passerine birds. American Zoologist 26:493-501.

Gauthier, G. 1989. The effect of experience and timing on reproductive performance in Buffleheads. Auk 106:568-76.

Gee, G. F. 1983. Crane reproductive physiology and conservation. Zoo Biology 2:199-213.

Gee, G. F., and G. W. Pendleton. 1992. Effects of extended photoperiod on Sandhill Crane reproduction. Pages 149-159 *in* D. A. Wood, editor. Proceedings 1988 North American Crane Workshop. Florida Nongame Wildlife Program Technical Report #12.

Gee, G. F., and T. Sexton. 1979. Artificial insemination of cranes with frozen semen. Pages 89-94 *in* J. C. Lewis, editor. Proceedings 1978 Crane Workshop. National Audubon Society and Colorado State University Printing Service, Ft. Collins, Colo.

Halibey, T. 1976 unpubl. Feed and feeding habits of captive cranes. ICF report. 19 pp.

Hunt, M. C. 1994. Analysis of the relationship between egg order (1-15) and egg quality as determined by hatching and fledging rates in Siberian, Florida Sandhill, White-naped and Red-crowned Cranes. Aviculture Magazine 100(1):29-34).

Immelmann, K. 1971. Ecological aspects of periodic reproduction. Pages 342-389 *in* D. S. Farner, J. R. King, and K. C. Park, editors. Avian biology. Academic Press, New York.

Immelmann, K. 1972. Role of the environment in reproduction as source of "predictive information." Pages 121-147 *in* D. S. Farner, editor. Breeding biology of birds. National Academy of Sciences, Washington, D.C.

Kepler, C.B. 1978. Captive propagation of Whooping Cranes: a behavioral approach. Pages 231-241 *in* S. A. Temple, editor. Endangered birds: management techniques for preserving threatened species. University of Wisconsin Press, Madison.

Koga, T. 1955. On the artificial incubation of cranes (*Grus vipio* and *Grusjaponensis*). Journal of the Ueno Zoo 1:1-12.

Koga, T. 1961. Studies on the reproduction of cranes, especially on their artificial incubation and breeding. Journal of Japanese Association of Zoological Gardens and Aquariums 3:51-65.

Koga, T. 1976. Increasing captive production of Japanese and White-naped Cranes. Pages 351-355 *in* J. C. Lewis, editor. Proceedings of the International Crane Workshop 1975. Oklahoma State University Publishing and Printing.

Konrad, P. M. 1987. Rainy season ecology of South African Grey Crowned Cranes in the Luangwa Valley, Zambia. Pages 337-344 *in* G. W. Archibald and R. F. Pasqier, editors. Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wis.

Kuyt, E. 1981. Population status, nest site fidelity, and breeding habits of Whooping Cranes. Pages 119-125 *in* J. C. Lewis and H. Masatomi, editors. Crane research around the world. International Crane Foundation, Baraboo, Wis.

Kuyt, E., and J. P. Gossen. 1987. Survival, age composition, sex ratio, and age of first breeding of Whooping Cranes in Wood Buffalo National Park, Canada. Pages 230-244 *in* J. C. Lewis, editor. Proceedings 1985 Crane Workshop. Platte River Whooping Crane Habitat and Maintenance Trust and U.S. Fish and Wildlife Service, Grand Island, Nebr.

Lack, D. 1933. Nesting conditions as a factor controlling breeding time in birds. Pages 231-237 *in* Proceedings of the Zoological Society of London.

Marshall, A. J. 1961. Breeding seasons and migration. Pages 307-339 *in* A. J. Marshall, editor. Biology and comparative physiology of birds. Vol. II. Academic Press, New York.

Minton, C. D. T. 1968. Pairing and breeding in swans. Wildfowl 19:41-60.

Mirande, C. 1994 unpubl. Genealogy of the Whooping Crane. International Crane Foundation, Baraboo, Wis. 19 pp.

Mirande, C. M., and G. W. Archibald. 1990. Sexual maturity and pair formation in captive cranes at ICF. Pages 216-225 *in* American Association of Zoological Parks and Aquariums 1990 Annual Conference Proceedings, Indianapolis, Ind.

Mirande, C. M., J. W. Carpenter, and A. Burke. 1989 unpubl. The effect of disturbance on the reproduction and management of captive cranes. Paper presented at the 1989 North American Crane Workshop. 18 pp.

Morris, T. R. 1967. Light requirements of the fowl. Pages 15-39 *in* T. C. Carter, editor. Environmental control in poultry production. Oliver and Boyd, Edenburgh and London.

Murton, R. K., and N. J. Westwood. 1977. Avian breeding cycles. Oxford University Press, Oxford, England. 594 pp.

Nesbitt, S. A., and A. S. Wenner. 1987. Pair formation and mate fidelity in Sandhill Cranes. Pages 117-122 *in* J. C. Lewis, editor. Proceedings 1985 Crane Workshop. Platte River Whooping Crane Habitat Maintenance Trust and U. S. Fish and Wildlife Service, Grand Island, Nebr.

Nicolich, J. 1993. Appendix 1. Patuxent captive population data. Page 97 *in* U. S. Seal, editor. Mississippi Sandhill Crane (*Grus canadensispulla*) Population and Habitat Viability Assessment Workshop. Conducted by IUCN/SSC Captive Breeding Specialist Group.

Panchenko, V. 1993 unpubl. International Siberian Crane studbook. Oka State Nature Reserve, Ryazan, Russia. 12 pp.
Putnam, M., and S. Russman. 1987 unpubl. Changes in egg characteristics and laying intervals in captive cranes laying multiple clutches. 42 pp.
Richdale, L. E. 1951. Sexual behavior in penguins. University of Kansas Press, Lawrence. 316 pp.
Sadlier, R. M. F. S. 1969. The ecology of reproduction in wild and domestic mammals. Methuen and Ltd., London. 321 pp.
Serafin, J. A., and G. W. Archibald. 1977 unpubl. Natural and synthetic diets for cranes and other Gruiformes. 7 pp.
Sturkie, P. D., and W. J. Mueller. 1976. Reproduction in the female and egg production. Pages 306-311 *in* P. D. Sturkie, editor. Avian physiology. 3rd ed. Springer-Verlag, New York.
Wada, M. 1984. Photoperiodism in avian reproduction. Pages 101-113 *in* K. Ochiai, Y. Arai, T. Shioda, and M. Takahashi, editors. Endocrine correlates of reproduction. Japan Scientific Society Press, Tokyo, Japan.
Walkinshaw, L. H. 1973. Mississippi and Florida Sandhill Crane egg records. The Cranes: a Journal Dealing with World Cranes 1:6.
Welty, J. C. 1975. The life of birds. 2nd ed. W. B. Saunders Co., Philadelphia, Pa. 623 pp.
Wingfield, J. C. 1983. Environmental and endocrine control of avian reproduction: an ecological approach. Pages 265-288 *in* S. Mikanu et al., editors. Avian endocrinology and ecological perspectives. Japan Scientific Society Press, Tokyo.