Effect of incubating adult sex and clutch size on egg orientation in Sarus Cranes *Grus antigone*

K. S. GOPI SUNDAR and B. C. CHOUDHURY

Egg temperature in natural conditions in birds' nests is regulated by adjusting the timing of contact with the brood-patch (areas of highly vascularised bare skin on either side of the sternum) and by adjusting heat transfer during contact. In addition, field research and incubation experiments on several bird species have shown that egg position and orientation during incubation allows adult birds to effectively adjust egg temperature (Drent 1975, Massaro and Davis 2004). Given that eggs have varied shapes and that clutches can be arranged in various ways with respect to egg orientation and position, it is possible that birds use the most efficient combination to regulate required temperatures (Barta and Székely 1997, Massaro and Davis 2004). The orientation and position of eggs in the nest are relatively easy to measure, but have received little attention. This is in spite of the fact that these parameters have a direct bearing on hatching success (Drent 1975), and that incubation efficiency appears to have been an important selective pressure on the evolution of clutch size (Drent 1975, Barta and Székely 1997, Reid *et al.* 2000).

Sarus Cranes *Grus antigone*, like most other cranes, normally have one or two eggs per clutch (Meine and Archibald 1996). For most crane species, average breeding success at the dispersal stage is close to one (Johnson and Barnes 1992, Allan 1996, Meine and Archibald 1996, Coverdale 2004). It is suspected that the second egg is laid as insurance in case of the loss of the first one. Alternatively, two eggs may be more efficient to incubate. In this study, we determined the orientation of the eggs in the nest bowl, and how it varied with clutch size and sex of the incubating bird.

METHODS

KSGS located nests of Sarus Cranes during 2000–2001 in Etawah and Mainpuri districts, Uttar Pradesh, India. Descriptions of the study area and observations of other aspects of breeding ecology are presented elsewhere (Sundar 2003, 2004, Sundar and Choudhury 2003). Sarus Cranes have very large nests (up to 2 m in diameter), with a normal clutch size of one or two (Ali and Ripley 1968, Mukherjee 1999, Suwal 1999), and rarely three (Walkinshaw 1973) or four eggs (Sundar and Choudhury 2003). At the onset of incubation, both the male and female develop brood patches (G. W. Archibald *in litt.* 2004). Incubation duties are shared between the sexes; both adults actively change egg position before commencing an incubation bout and during incubation periods (KSGS, personal observation). If humans approach the nest, incubating adults typically stand and walk away from the nest taking care not to disturb the eggs. Sarus Cranes in the study area have been exposed to human presence for a very long time, and visiting nests during this study never prompted adults to abandon them. Most nests were constructed entirely of grasses and other wetland plants. Eggs usually lay in a concave depression on the nest when incubated and did not roll away when adults left the nest. Some nests had very little nesting material and in these the eggs were laid on nearly bare ground and tended to roll a little to the side when the adults rose to walk away. Observations on egg position from these nests were excluded from the analysis.

Nests were visited 1–5 times (modal frequency = 2) during incubation to collect information on egg position, orientation and hatching success. Information on egg orientation was collected more than once for the same nest only if it was at least a week between the visits, or if the sex of the incubating bird was different. The first observations were made within a week of laying in most cases (91%). Adult cranes were sexed by posture during unison calls, during which males droop their primaries and touch the secondaries over their backs. In addition, females in all the pairs observed were discernibly smaller when both birds were seen together. Incubating adults always positioned eggs with the long axis of the eggs parallel to the long axis of the adult's body, presumably to align the eggs with shape of the brood patches. Eggs in one- and two-egg clutches therefore had limited possible orientations during incubation (two and four possible combinations respectively: see Fig. 1). One four-egg clutch was also found, and this was reduced to a three-egg clutch when an addled and rotten egg was discovered prior to hatching and was removed by the investigator.

It was not possible to study other aspects of incubation such as egg shape, egg-turning (which reduces the incidence of premature adhesion of the extra-embryonic membranes in the first half of the incubation period) or how the orientation and position of eggs changed through the course of incubation. Fisher's exact tests and chi-squared tests were used to test the significance of differences in frequency of possible combinations of egg positions, and for differences between the sexes and for different clutch sizes.

RESULTS

Of 140 nests visited, egg orientation was observed 75 times in 64 different nests. In one-egg clutches, the pointed end of the egg was just as likely to point towards the posterior of the incubating bird (52.4%) as it was towards the anterior (47.6%, n=21 observations of both sexes at 20 nests). When males incubated, the pointed end of the egg appeared to be more likely to be placed towards the posterior of the bird (8/11 cases), whereas when females incubated, the pointed end more often pointed towards the anterior of the bird (7/10 cases), but this difference was not significant (Fisher's exact test, df=1, P=0.06).

In two-egg clutches, both sexes used all four egg-orientation combinations nearly equally (χ^2=4, df=3, P=0.26, n=22 males, 32 females, 43 nests; Fig. 2). Only one four-egg clutch was observed once, when incubated by a male: all four eggs had the pointed end aligned more-or-less with the posterior of the bird. When the same nest was observed when clutch size had been reduced to three (and when it was being incubated again by the male), the pointed end of two eggs pointed to the anterior of the bird, and the third pointed to the posterior.

The positions of eleven pipped eggs (i.e. those about to hatch) were also observed: all had the pointed end pointing towards the posterior of the incubating bird, with the pipped (chipped) part uppermost. In four nests, clods of earth were placed beside the eggs by incubating adults apparently to stabilise egg position, and in one nest dried roots were apparently used for the same purpose. When these materials were repeatedly removed by the observer, the adult cranes replaced them each time, indicating that their presence was not accidental.

DISCUSSION

Sarus Cranes frequently adjusted the orientation of eggs in their nests. Eggs were aligned parallel with the axis of the body of the incubating adult, but there was no significant preference for eggs to point towards the anterior or posterior, nor were there significant differences between males in females, in either one- or two-egg clutches. The dimensions of brood patches often differ on each side of incubating adults, and may differ between the sexes (Riley 1982). Optimal egg orientation and position may therefore vary between individuals. On average, however, there may be no systematic bias, and this may have generated the non-significant results we found. Repeated observations on the same individuals would have revealed whether individuals have particular preferences for certain egg orientations and positions.

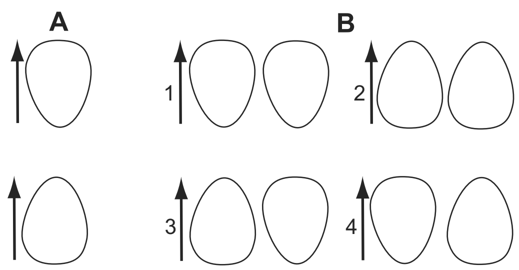

Figure 1. Possible combinations of egg orientation in (A) one-egg and (B) two-egg clutches. Eggs are drawn as seen from above the nest and arrowheads indicate the anterior of the incubating bird. Combinations in the upper row of two-egg clutches show symmetric orientation; combinations in the lower row show asymmetric orientation.

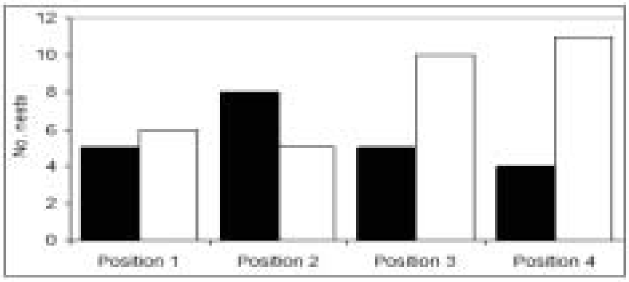

Figure 2. Frequency of different combinations of egg orientation in two-egg clutches incubated by male (solid bars; n=22) and female (open bars; n=32) Sarus Cranes *Grus antigone*. Positions refer to those illustrated for two-egg clutches in Fig. 1

Observations of egg orientation in the wild in other crane species are only available for Sandhill Crane *G. canadensis* (Walkinshaw 1982). In 49 two-egg clutches, egg orientation was symmetric in 27 clutches and asymmetric in 22 clutches, which is consistent with our results for Sarus Crane. The effect of sex or clutch size on egg orientation was not recorded by Walkinshaw (1982).

In some cases, adult Sarus Cranes used clods of earth and roots to maintain the position of eggs, a behaviour that had not previously been described in cranes (Walkinshaw 1973, Johnsgard 1983, Allan 1996, Meine and Archibald 1996). The positioning of pipped eggs with their pointed ends towards the posterior of the incubating bird matches the normal hatching position in captive cranes (Gabel and Mahan 1996), and is not surprising given that chicks are positioned with their heads towards the broad end of the egg.

Theory using space-optimising models predicts that eggs in one-egg clutches should be spherical and that eggs in larger clutches should have biconical to ellipsoid shapes in order to obtain the maximum benefit of the brood patch of incubating adults (Barta and Székely 1997). All cranes have ellipsoid eggs, perhaps indicating a selective advantage (at least in the past) for multiple-egg clutches. However, in the four-egg clutch we observed, the nest bowl was too small to retain all eggs adequately, and eggs were visible from the side of the incubating bird. This suggests that incubation efficiency was being compromised and eggs were being heated inconsistently. When this clutch was reduced to three eggs, the orientation was such that the central egg probably received more heat than the outer eggs. Hence one- or two-egg clutches appear to be optimal.

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K. S. Gopi Sundar and B. C. Choudhury, Wildlife Institute of India, Post Bag 18, Chandrabani, Dehradun 248 001, India. *Correspondence and present address: Indian Cranes and Wetlands Working Group, c/o International Crane Foundation, E – 11376, Shady Lane Road, Baraboo, Wisconsin 53913-0447, U.S.A. Email:* gopi@savingcranes.org.

First record of Long-billed Plover *Charadrius placidus* in Singapore

VOLKER KONRAD

On the morning of 24 February 1990, I visited the coast south of Changi airport, Singapore, and walked north-east along the beach at the far end of the East Coast Parkway and the beginning of the Changi Coast Road. The weather conditions were good. Just before 12h00, I found a solitary *Charadrius* sp. plover on the sandy beach close to the water's edge. I observed it for 10 minutes at a distance of 25 m as it stood resting. When I approached closer it ran a few metres in a typical *Charadrius* manner, to keep a minimum distance of several metres away from me. I observed the bird for a total of c.25 minutes, taking notes and photographs from a distance of c.12 m.

My first impression had been that of a fairly large, relatively strong, almost massive *Charadrius* sp. plover. I assumed it was either Lesser Sand Plover *C. mongolus* or Greater Sand Plover *C. leschenaultii*, but soon came to the conclusion that it was something different. In size, it was obviously stronger and heavier than Little Ringed Plover *C. dubius*, probably larger than Common Ringed Plover *C. hiaticula*, close in size to Lesser Sand Plover, but probably too small for a Greater Sand Plover. It was rather large-headed and long-tailed, with the tail very clearly projecting beyond the wing-tip. The legs were thin and long, providing a high stance. They were pale greenish, perhaps even yellowish, but