ISSN 1682-8356
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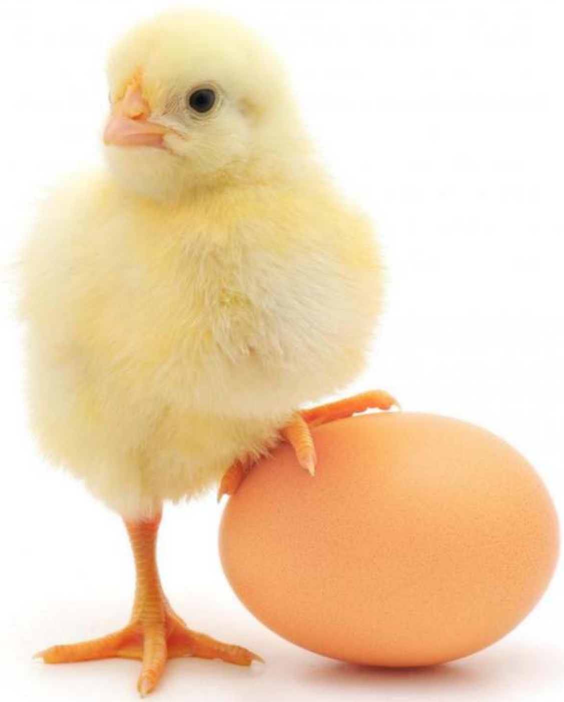

INTERNATIONAL JOURNAL OF POULTRY SCIENCE

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308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
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International Journal of Poultry Science 15 (2): 57-61, 2016
ISSN 1682-8356

Manual Egg Turning is Necessary for Optimal Hatching in Geese

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Abstract: Egg turning is a vital part of the incubation process in many bird species. However, the quality and quantity of turning can differ between species. Commercial incubators with domestic fowl automatically move the eggs that are set pointed end down, 45° either side from the vertical every hour. However, goose eggs are not set pointed end down vertically, but horizontally with the long axis parallel to the horizontal plain, i.e., laid flat on wire trays and turned as described above. With this method of incubation the down side of the goose egg will not find itself facing upwards during the incubation process if the eggs do not get additional hand turning. It was suggested (Bogenfurst, 2004) that goose eggs lying flat as above but at an angle of 45-60° on the trays, do not require manual turning. This study used eggs from one year old geese that were in addition hand turned (around the short or the long axis of the egg by 180°) once per day from d 10-26 of incubation. Turning was in the opposite manner on alternative days. Their hatchability was compared with eggs that had no hand turning. Fertility was >85.42% in all egg Groups. Overall, the hatchability of fertile goose eggs in Group C (no manual turning; 44.12%) was significantly lower than those of Groups A (manual turning around long axis; 63.77%; p = 0.002) and B (manual turning around short axis; 61.94%; p = 0.005). Manual turning did increased the hatchability of goose eggs with no significant difference between the short or long axis turning Groups.

Key words: Egg turning, goose, hatchability, incubation

INTRODUCTION

Many bird species turn their egg as part of the incubation process (Deeming, 2002), though for example the Megapodes do not turn their eggs, as the adult birds lose direct contact with their buried eggs (Jones *et al*., 1995; Booth and Jones, 2002; Deeming, 2002). Domestic fowl (*Gallus gallus domesticus*) probably move their eggs by rolling (Chattock, 1925), i.e., rotation around the long axis, approximately 1.33-2.88 times per hour (Chattock, 1925; reviewed in Deeming, 2002). Further, in domestic fowl the mean degree of individual egg turn was 52.7°, though the angles of turns ranged between 5-175° (Deeming, 2002), while the mean hourly angle of turn was 62.4° (Boone and Mesecar, 1989). In waterfowl the movement of the egg during turning is around the long axis (Kossack, 1947; Howey *et al*., 1984). Canada geese (*Branta canadensis*) turn their eggs 1.2 times in an hour (Kossack, 1947), while Greylag geese (*Anser anser*), Barnacle geese (*Branta leucopsis*) and Black swans (*Cygnus atratus*) turn their eggs approximately 0.75 times per hour (Howey *et al*., 1984; reviewed in Deeming, 2002). Further, using telemetric eggs Black swans turned their eggs 20-30 times a day up to day 15 of incubation, which then dropped to about 10-15 turns per day until day 40 of incubation and the frequency of egg turning increased during hatching (Howey *et al*., 1984; reviewed in Deeming, 2002).

A known and accepted function of egg turning is to prevent the embryo from adhering to the egg shell (Eycleshymer, 1907; Chattock, 1925; New, 1957; Freeman and Vince, 1974; Deeming, 2002). Several other benefits have been identified, including the reduction of embryo malpositioning (Robertson, 1961; Tullett and Deeming, 1987; Elibol and Brake, 2004) and the proper and timely closure of the chorioallantoic membrane (Tullett and Deeming, 1987; Deeming, 1989a, b). Turning is required for the normal rate of growth of the *area vasculosa* of the yolk sac membrane (reviewed in Baggott *et al*., 2002), for embryonic growth (Tullett and Deeming, 1987; Deeming, 1989a, b, 1991) and the proper utilization of albumen by the developing embryo (Tullett and Deeming, 1987; Deeming, 1989a, 1991). Embryos in unturned eggs have reduced levels of sub-embryonic fluid and reduced volume of allantois and amnion also (Deeming, 1989a, 1991; Baggott *et al*., 2002). The interval between days 3 to 7 are important for turning with positive effects on hatchability and embryo growth in domestic fowl (New, 1957; Deeming, 1989a). Elibol and Brake (2004) using domestic fowl found that days 0 to 2 were very important for turning, as no turning treatments during this period resulted in high early mortality.

Egg turning studies were mainly conducted with domestic fowl eggs (Eycleshymer, 1907; Chattock, 1925; Olsen and Byerly, 1936; New, 1957; reviewed in

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Deeming, 1991) and it is generally accepted that turning more than 24 times a day is unnecessary (Freeman and Vince, 1974). Commercial incubators use automatic turning systems that move the eggs through 90° (45° either side from the vertical) every hour (Deeming, 1991). This turning rate and pattern may not be appropriate for other species (Deeming, 2002) and Deeming (1991) suggested that eggs with differing amounts of albumen would require different rates of turning. Thus eggs producing altricial young that have high albumen content (relative to egg size), would require more turning than eggs from precocial species where relative albumen content is lower (Deeming, 1991, 2002).

In domestic fowl the best hatching results are achieved by incubating eggs pointed end down. However domestic goose (*Anser anser domesticus*) eggs for pragmatic reasons related egg shape and weight are incubated horizontally, ie. lying on their side (Bogenfurst, 2004). When eggs are set horizontally and their long axis is parallel with the setting tray (see setting method A in Fig. 1), then additional manual turning of 180° is required (once per day from day 5 to 10 of incubation, twice per day from day 11 to 20 of incubation) apart from the hourly automatic 90° turning (Bogenfurst, 2004). However, it was suggested that when the goose eggs are set horizontally, but set with a 45-60° angle relative to the long axis of the setting tray (see setting method B in Fig. 1), then manual turning should not be necessary (Bogenfurst, 2004).

Here the above hypothesis was tested to examine the hatchability of goose eggs with or without manual turning (ie. turning by hand) by 180° when set in an angle relative to the long axis of the setting tray (Fig. 1). Two manual turning methods were used: turning the eggs around the long axis or through the short axis of the egg by 180° (Fig. 2).

MATERIALS AND METHODS

Eggs from a flock of one year old Legarth geese were collected in April 2015 at Ballyrichard (Arklow, Ireland; 52°50'5" N, 6°7'49" W). Housing and management were as described by Kent and Murphy (2003) and Salamon and Kent (2013). Briefly, the geese were housed at night and released at 9:30 am to adjacent grass fields with water supply. The birds had access to their houses during the day where meal was provided. They were maintained on a natural daylight schedule.

The eggs were collected on goose release in the mornings at 9:30 am and continuously during the day, washed and stored until setting at weekly intervals. The eggs were weighed on a digital scale (± 0.1 g), then set on goose trays (according to setting method B in Fig. 1) and placed in a Bristol S-60 incubator (Bristol, UK)-with temperature and relative humidity set in accord with the manufacturer's instructions and prior experience-with automatically turning through 90° (45° either side from the vertical) at hourly intervals. Here, eggs from one year old geese were used, as they were small enough to be set at the angle described in setting method B (Fig. 1) and by Bogenfurst (2004).

A total of 432 goose eggs in 3 batches were used. The eggs were randomly allocated to three Groups of 48 eggs in each Batch. Group A was turned manually (i.e., turned by hand) once a day 180° around the long axis of the egg from d10 to d26 (see turning method A in Fig. 2). Group B was turned manually once a day 180° from end to end (around the short axis of the egg) from d10 to d26 (see turning method B in Fig. 2). Group C did not receive hand turning. The eggs were turned over and back, not over and over, as turning in one direction could cause the rupture of the blood vessels or the yolk sac resulting in embryo death (Bogenfurst, 2004). All eggs in all three Batches were cooled once a day before manual turning (Groups A and B) or no manual turning (Group C). Eggs were candled and transferred to the hatcher on d28 of incubation.

Fertility was recorded on candling at Day (d) 10 of incubation. A yolk was termed infertile when no evidence of early embryonic mortality was found at post-mortem examination. The yolk was termed fertile, but dead when there was evidence of early embryonic mortality at d10.

Proportion tests were employed to compare the hatchability of the different Groups (A, B, C) within Batches (1, 2, 3) using the statistical software R (version 3.2.2, R Development Core Team, 2015). The Groups were also compared when all Batches were combined. Independent T-tests were used to compare the mean egg weights of Groups within each Batch.

RESULTS

Egg weight did not differ between Groups in each Batch (all $p>0.05$; Table 1). Further, the combined mean egg weight (±SD) of all eggs in each Group (A, B, C) did not differ from each other (Batch 1: 156.51±6.51 g; Batch 2: 157.02±7.27 g; Batch 3: 155.5±7.62; all $p>0.05$).

Fertility of goose eggs was high (>85.42%) in all Batches and Groups (Table 1). There were eight dead eggs removed at candling on d10 (n = 2 in Groups A and C, n = 4 in Group B), all Batches combined. These were all early dead, approximately d 3-4, containing blood rings. Between d 11 and 26 there were 13 dead embryos in Group B, approximately half of what were in Groups A (n = 24) and C (n = 27). This shows that additional manual turning around the short axis of the egg (see turning method B in Fig. 2) is beneficial during this period of incubation. After the eggs were transferred to the hatcher (d28) Group A had the least dead embryos (n = 24), Group B (n = 34) and Group C (n = 46). A few of these eggs were pipped (n = 2 in Groups A and B, n = 3 in Group C) and the embryos were in normal hatching position.

Table 1: Egg weight, fertility, mortality and hatchability of different groups and batches of goose eggs

Groups	No. of eggs	Mean egg weight (g) (±SD)	No. of fertile	Fertility	Died during incubation	Died during hatching	Hatched	Hatchability
Batch 1								
A	48	157.81 (±6.15)	46	95.83%	6 (0)	9 (1)	30	65.22%[a]
B	48	155.8 (±5.66)	46	95.83%	7 (0)	9 (0)	30	65.22%[a]
C	48	155.91 (±7.5)	45	93.75%	8 (0)	12 (1)	24	53.33%[a]
Batch 2								
A	48	157.49 (±7.41)	47	97.92%	10 (0)	7 (0)	30	63.83%[a]
B	48	157.8 (±7.49)	41	85.42%	3 (1)	10 (0)	27	65.85%[a]
C	48	155.78 (±6.88)	46	95.83%	8 (1)	15 (0)	22	47.83%[a]
Batch 3								
A	48	156.23 (±8.57)	45	93.75%	8 (2)	6 (1)	28	62.22%[a]
B	48	155.17 (±6.89)	47	97.92%	3 (3)	13 (2)	26	55.32%[a]
C	48	155.11 (±7.41)	45	93.75%	11 (1)	16 (2)	14	31.11%[b]

Number of eggs; mean egg weight (g) (±SD); number of fertile eggs; fertility (%); number of eggs removed during incubation between d11 to d28 (number in brackets show eggs removed at candling on d 10); died during hatching (entered airspace and pipped [number in brackets]; d 29-32); number of hatched eggs and hatchability (%) for each Group (A: turned manually by 180° around long axis once a day between d 10 and 26 of incubation; B: turned manually by 180° around short axis once a day between d 10 and 26 of incubation; C: eggs were not turned manually) in each Batch. In each Batch the eggs were laid within a week prior to setting. In each Batch, hatchability values with differing superscript letters differed significantly ($p<0.05$)

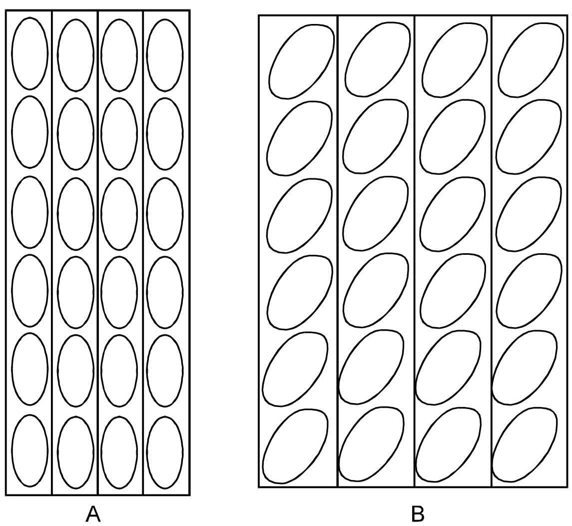

Fig. 1: Setting methods described by Bogenfürst, 2004, Goose eggs set horizontally with their long axis parallel to the long axis of the setting tray (A). Eggs set horizontally and their long axis is in a 45-60° angle relative to the long axis of the setting tray (B)

In Batch 1 in Group A more embryos died during hatching than during incubation, while in Batches 2 and 3 the trend was the opposite in Group A, i.e., more embryos died during incubation than during hatching. In Groups B and C, more embryos died during hatching than during incubation in all Batches.

With all Batches combined, hatchability in Group C (44.12%, 60/136) was significantly lower than in Groups A and B (63.77%, 88/138 and 61.94%, 83/134, respectively; $p = 0.002$ and $p = 0.005$, respectively; see Fig. 3). The hatchability in Groups A and B did not differ ($p = 0.852$).

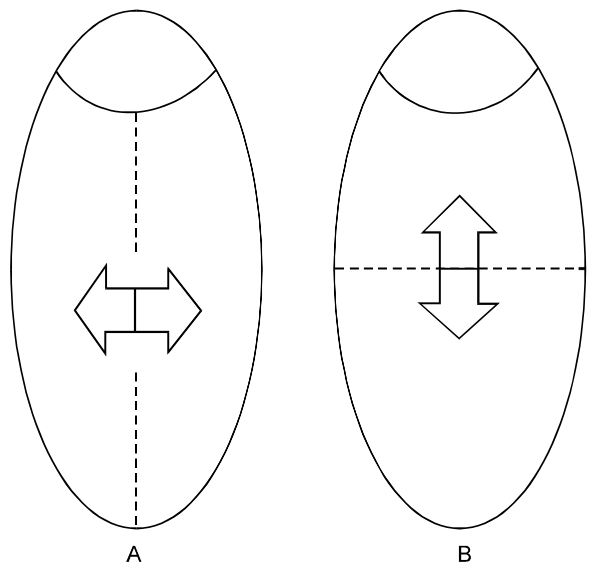

Fig. 2: Manual egg turning methods in this study: around the long (A) and short axis (B). Goose eggs were turned over and back on alternative days

In all Batches, embryos in Group C eggs were more likely to die during hatching than in Groups A and B. Hatchability within Batches in Groups A and B ranged from 55.32 to 65.85%, while the same in Group C ranged from 31.11 to 53.33% showing a declining trend from Batch 1 to 3 (Table 1). However, only Batch 3 showed statistical difference, where the hatchability in Group C (31.11%, 14/45) was significantly lower than in Group A and B (62.22%, 28/45 and 55.32%, 26/47, respectively; $p = 0.006$ and $p = 0.033$, respectively; Table 1). These results show that manual turning in addition to the incubator turning increased the hatchability of goose eggs.

DISCUSSION

Egg weight between the Groups within Batches did not differ and the mean egg weight between the three Batches did not differ. Previous studies with one year old domestic geese showed a steady increase in egg weight over the laying season (Brun *et al.*, 2003; Dodu, 2010; Salamon and Kent, 2013). This study over a 3-week study period is too short to study seasonal factors. The study took place in mid season when young geese are producing eggs of optimal weight (Salamon and Kent, 2013).

Fertility was high (>90%) in all Groups within the three Batches and higher than in previous studies using one year old domestic geese (53.8-71.7%; Gillette, 1977; Mazanowski *et al.*, 2005). Group B of Batch 2 had the lowest fertility (85.42%).

During the incubation period eggs receiving manual turning (d 11-26) had the least mortality (Group B, n = 13). In Group A 24 and in Group C 27 embryos died in the same period. This shows that somehow turning around the short axis of the egg (Fig. 2) is beneficial in terms of embryo survival. However, when the mortality after hatching was examined there was almost no difference between Group A (n = 48) and Group B (n = 47) when eggs in the same Groups from all Batches were combined. Thus this raised the question whether turning around the short axis of the egg was really beneficial in terms of embryo survival or it was delaying the inevitable death of unfit embryos. However, it was clear that Group C had the highest mortality (n = 46) thus showing that additional hand turning is necessary for goose eggs during incubation. The hatchability results show similar pattern with significantly better values for Groups A (63.77%) and B (61.94%) compared to Group C (44.12%) with no hand turning (Fig. 3). Even when goose eggs are set with a 45-60° angle relative to the long axis of the setting tray additional manual turning is needed to achieve better hatchability contrary to the suggestion of Bogenfurst (2004). There is no difference between the two manual turning methods. It should be noted that from a practical point of view based on our experience turning around the long axis (method A in Fig. 2) is faster, but may not achieve a full 180° turn, while turning around the short axis (method B in Fig. 2) may be slower, but ensures a 180° turn.

These results should be applied to the incubation of adult goose eggs (2 years or older). Adult geese lay heavier/larger eggs (Brun *et al.*, 2003; Salamon and Kent, 2013) and cannot be set in a 45-60° angle relative to the long axis of the commercial goose egg setting trays (see method B in Fig 1.). In our experience goose eggs weighing 175-190 g may be set up to 20° angle relative to the long axis of the setting tray, but goose eggs over 200 g can only be set according to method A (Fig. 1) Thus hand turning additional to incubator turning of such large goose eggs is necessary.

It is important to note that wild geese turn their eggs approximately 0.75-1.2 times per hour (Kossack, 1947; Howey *et al.*, 1984; reviewed in Deeming, 2002) and based on work carried out on domestic fowl (Eycleshymer, 1907; Chattock, 1925; Olsen and Byerly, 1936; New, 1957; reviewed in Deeming, 1991) it is generally accepted that turning more than 24 times a day is unnecessary (Freeman and Vince, 1974). For this reason commercial incubators use automatic turning systems that move the eggs through 90° (45° either side from the vertical) every hour (Deeming, 1991). However, based on the above and on the findings of this study there can be a difference in the quality of the turning of goose eggs in natural and in artificial conditions. It is possible that in natural conditions wild geese will turn their eggs more than 90° on some occasion. They can be expected to turn their eggs more than 180°, if not on one occasion then communlatively over a few turns.

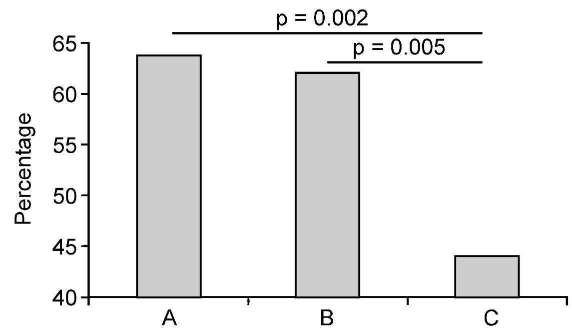

Fig. 3: Hatchability (% of fertile eggs that hatched); Group A: manual turning, once a day, around long axis by 180°, Group B: manual turning, once a day, around short axis by 180°, Group C: no manual turning. In each Group eggs from all Batches are combined

Further, it was suggested that eggs with relatively higher amount of albumen would require more turning, particularly the eggs of altricial species (Deeming, 1991; 2002), though the eggs of domestic fowl and domestic goose require similar turning frequency (Kossack, 1947; Howey *et al.*, 1984; Deeming, 2002). A domestic fowl egg contains approximately 57-65% albumen (Carey *et al.*, 1980; Deeming, 2002; Bogenfurst, 2004), while there is about 51.5-58% of albumen in a goose egg (Carey *et al.*, 1980; Bogenfurst, 2004; Mazanowski *et al.*, 2005). It has to be noted that goose eggs are three times larger than domestic fowl eggs and the hand turning additional to the incubator turning may enable the better access and utilization of the albumen by the developing embryo.

Conclusion: It is concluded that goose eggs receiving manual turning in addition to conventional incubator turning achieved higher hatchability rates, but it did not matter if the eggs are turned around the short or the long axis.

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