Int. Agrophysics, 1994, 8, 629-633

EFFECTS OF EGG ROLLING AND DAMAGE IN LAYER HEN CAGE

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A b s t r a c t. The angle of the cage bottom, wire mesh spacing and diameter were studied in their effect on the roll characteristics and breakage of the egg.

K e y w o r d s: egg cracking, layer hen cage

INTRODUCTION

Several investigators refered to the high losses which can reach 12 % in egg production due to shell crackage after the egg is laid and before it reaches the market [1-3,5] and this drew the attention of researches to study physical properties of the egg shell [1-3,7].

Egg cracking in layer hen cage may make a considerable part of the mentioned losses. Insufficient literature was found on the effect of design parameters on egg damage. In general it is indicated that the area per hen has to be at least 450 cm^2, the cage bottom has a tilt angle between 6^o and 14^o, the wire diameter is 2-2.5 mm, and the wire spacing is not less than 20 mm [5,8]. The cross wires are welded underneath the longitudinal wires.

Table 1 shows the dimensions drawn in Fig. 1 of the layer cage bottom of different makes used in Egypt.

In this work the tilt angle of the cage bottom, wire mesh spacing and diameter were studied in their effect on the roll characteristics and breakage of the egg.

MATERIALS AND METHOD

A tilting apparatus discribed in reference [4] was used. It is equipped with a tilting frame on which a cage bottom of 50 cm length is fixed and its inclination can be measured. The hen lays the egg directly on the cage bottom without any drop. Simulating this action, the egg can be placed on the cage bottom, when it is horizontal, close to its supposed upper end. The bottom is then inclined slowly and the egg would roll and drop in a separate collecting channel from a

Table 1. Dimensions of the tested layer cage bottom

Make	Wire diameter	Spacing		Inclination	Length
	a (mm)	b (mm)	c (mm)	Θ (^{o})	$\bar{L}$ (cm)
Bigdutchman	2.5	25	50	7	50
Salmet	2.1	25	40	11	48
Facco	2.4	22	50	7	52
Daneau	2.4	25	48	10	47

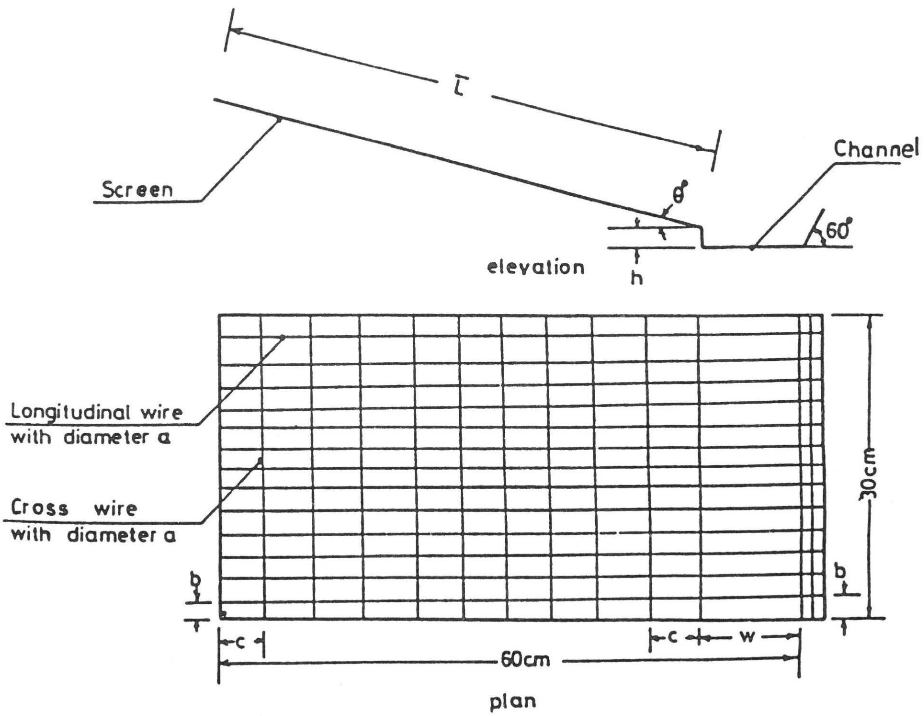

Fig. 1. Dimensions of the tested layer cage bottom.

height h which ranges 15-25 mm according to the tilt angle. The tilt angle, at which the egg begins to roll (rolling angle Θ) was measured at different combination of wire dimensions namely wire diameter a (1.5, 2, 2.5, or 3 mm); spacing b (20 or 25 mm), and spacing c (40 or 50 mm) of the longintudinal and cross wires, respectively (Fig. 1).

The egg channel was kept horizontal and was of 10 cm width and has no cross wires. The egg can roll only when its length axis is perpendicular to the roll direction and paralell to the cross wires. In this respect we have to distinguish between two possible initial positions of the egg. When the egg is initially placed midway between two consequtive cross wires the measured rolling angle will be denoted by ∅. When it is initially placed directly close to a lower wire, the measured rolling angle will be denoted by $\bar{\varnothing}$. In this case the egg may get in contact with the cross wire and be retarded in rolling.

For determination of the breakage angle α, several trials were conducted with the same egg by inclination of the bottom slowly and recording the least inclination at which the egg rolls and breaks by impact on the egg collecting channel. In this respect four combination of bottom dimensions were used.

The test apparatus was also equipped for dropping the egg on the collecting channel from gradually increasing height until it was broken. The minimum breakage height H was recorded for each egg of the test replicates of 15 eggs.

In all tests, replicates of 15 eggs composed of 3 eggs from each of the mass classes of <50, 50-55, 56-60, 61-65 and >65 g were used. The eggs were of the variety Golden Komet. The egg shape index (diameter/length) 100 ranged 74-76 % . The thickness of the egg shell averaged 0.358 mm.

Theoretical approach for calculating the breakage angle $\bar{\alpha}$

A. Work w_1 exerted by forces that affect the egg in its rolling on the cage bottom (Fig. 2) for a roll distance L.

The following forces have effect on the egg:

1. Egg weight W component in the direction of motion $W \sin\bar{\alpha}$, its work $=W \sin\bar{\alpha} L$.
2. Egg weight component perpendicular to the direction of motion $W \cos\bar{\alpha}$, its work $=0$.
3. Resistance of the moment of rolling *-en* which is relatively small and can be neglected.
4. Resistance of the friction force F_{fr}, its work $=0$ provided that the egg is rolling without sliding.

Thus, the first component $W \sin\bar{\alpha}$ was only considered.

B. Work w_2 exerted by forces affecting the free fall of the egg on the channel from a height h. Neglecting air resistance, only the weight of the egg exerts a work $w_2 = Wh$.

C. Energy E at which the egg breaks by impact on the channel from a height H. Neglecting air resistance, we consider only the egg weight W.

$$E = WH \quad (1)$$

$$E = w_1 + w_2 \quad (2)$$

$$WH = W \sin\bar{\alpha} L + Wh \quad (3)$$

$$\sin\bar{\alpha} = (H - h) / L$$

$$\bar{\alpha} = \sin^{-1} (H - h) / L \quad (4)$$

RESULTS AND DISCUSSION

Effect of the wire diameter and spacing on the rolling angle ∅

As it is shown in Figs 3 and 4 the rolling angle increased at least significantly by the decrease of wire diameter from 2.5 to 1.5 mm. The angle $\bar{\varnothing}$ is at least significantly higher han the angle ∅ due to the braking action of the cross wire at the initial egg position before rolling. The rolling angles ∅ and $\bar{\varnothing}$ were not significantly affected by the tested spacing *c* between the cross wires. The spacing *b* of 25 cm between the longitudinal wires tended to show greater rolling angle than the spacings of 25 cm. The difference between the two spacings is at least significant at wire diameter 1.5 and 2 mm.

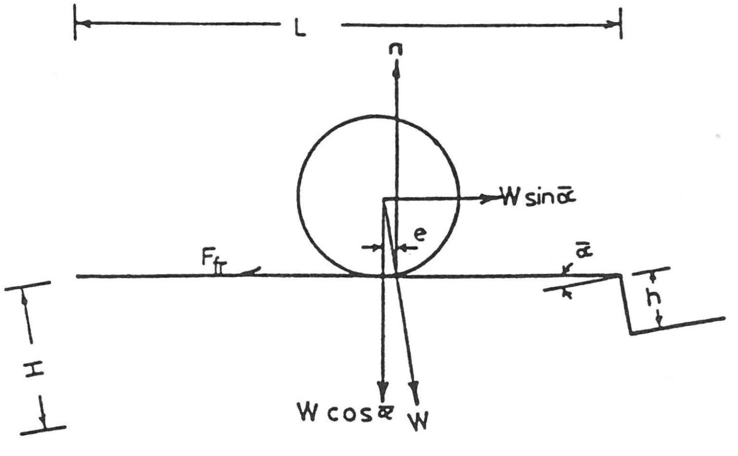

Fig. 2. Forces that affect egg rolling and breakage.

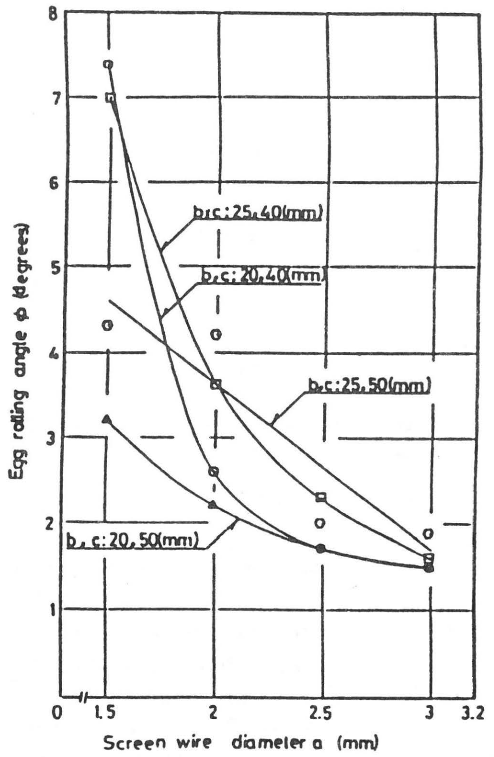

Fig. 3. Egg rolling angle ∅ versus wire diameter and spacing.

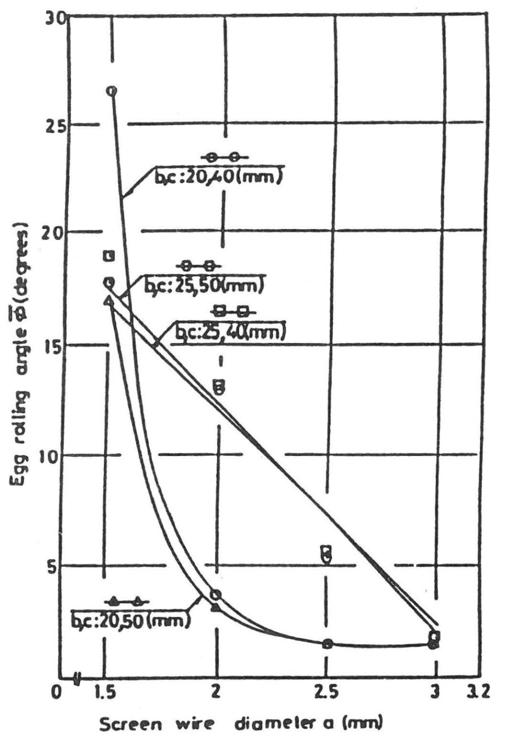

Fig. 4. Egg rolling angle $\bar{\varnothing}$ vs wire diameter and spacing.

Through the spacing of 20 cm, between the longitudinal wires, the egg is less subjected to the braking action of the cross wires.

Measurement of breakage height H

Figure 5 shows that the mean breakage height increases by the decrease in wire diameter, probably due to the damping action of thinner wires. No significant effects of *b* spacing is observed. By applying Eq. (4), the breakage angle $\bar{\alpha}$ can be calculated as a function of *H*, the roll distance *L* and fall distance *h* (Fig. 1).

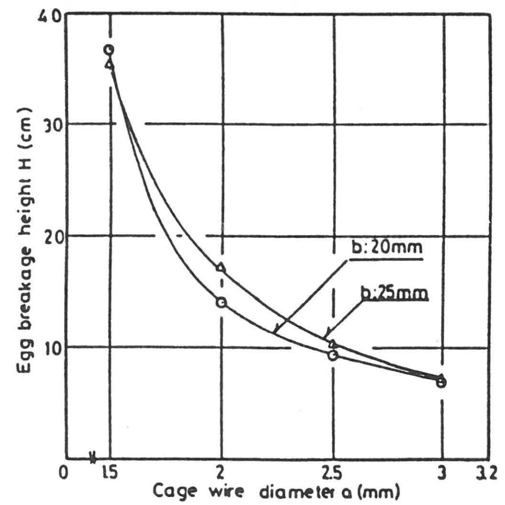

Fig. 5. Egg breakage height H vs wire diameter and spacing b.

Measured and calculated breakage angle (α and $\bar{\alpha}$, respectively)

Figure 6 shows that the calculated breakage angle increased at least significantly by the decrease in wire diameter and is not significantly affected by the spacing b between the longitudinal wires. The statistical analysis did not show significant difference

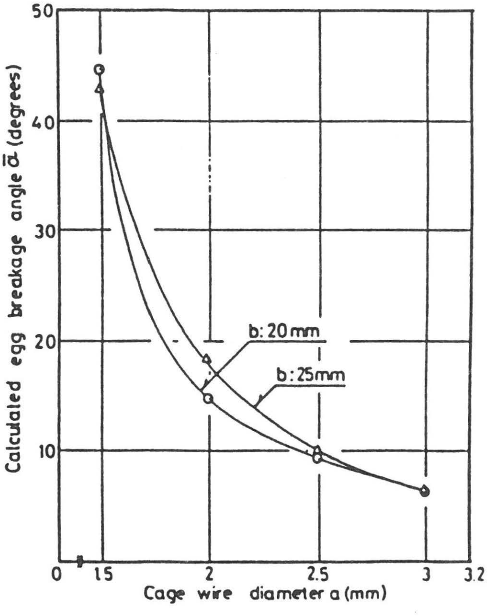

Fig. 6. Calculated egg braekage angle $\bar{\alpha}$ vs wire diameter and spacing b.

between calculated and measured values of the breakage angle. Thus the Eq. (4) could be considered as reliable.

CONCLUSIONS

1. Due to the relatively high egg rolling angle in case of the screen wire diameter of 1.5 mm, the inclination of the cage bottom has to be about 15° which may be uncomfortable to the hens. In addition, the mentioned diameter may be harmful to the hen legs.

2. In layer cage design it may be recommended to have a relatively low egg rolling angle and a high breakage angle. The optimum requirements may be obtained at best through the 2 and 2.5 mm wire diameter and spacing between the longitudinal wires of the cage bottom.

3. The rolling and breakage angles are not affected by the tested spacing between the cross wires. Hence the 50 mm spacing may be chosen for material saving.

4. In general, the rolling angle and cracking angles have to be considered in the design of layer hen cages.

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