The Old School, Brewhouse Hill, Wheathampstead,
Hertfordshire AL4 8AN, UK

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The effects of selection on low mortality and brooding by a mother hen on open-field response, feather pecking and cannibalism in laying hens

TB Rodenburg*†, KA Uitdehaag†‡, ED Ellen† and J Komen†

† Animal Breeding and Genomics Centre, Wageningen University, PO Box 338, 6700 AH Wageningen, The Netherlands
‡ Vencomatic BV, PO Box 160, 5520 AD Eersel, The Netherlands
* Contact for correspondence and requests for reprints: bas.rodenburg@wur.nl

Abstract

The aim of the present study was to investigate the effects of selection on low mortality in combination with brooding by a mother hen on open-field response at 5–6 weeks of age and on plumage and body condition at 42 weeks of age. Birds in the experiment were either selected for low mortality in group housing (low mortality line) or randomly selected (control line) for two generations. These lines originated from the same population. Twenty groups of 10 female birds from each line were used. Within each line, ten groups were brooded by a foster mother and ten groups were non-brooded. At 5–6 weeks of age, the chicks were tested in an open-field test for five minutes. At 42 weeks of age, plumage condition and incidence of comb lesions and toe wounds of all birds was recorded. It was found that both brooded chicks and chicks from the low mortality line were more active in the open-field test at 5–6 weeks of age, indicating that they were less fearful or had a stronger exploratory motivation. No interactions were found between selection on low mortality and brooding. Birds from the low mortality line also had a lower incidence of comb and toe wounds compared with the control line at 42 weeks of age. No effect of brooding on plumage condition or incidence of wounds was found. This study indicates that selection on low mortality is a promising way forward to reduce maladaptive behaviour in laying hens, especially if such an approach is combined with improved rearing conditions.

Keywords: *animal welfare, brooding, cannibalism, feather pecking, genetic selection, laying hens*

Introduction

Feather pecking is a major welfare problem in laying hens (*Gallus gallus domesticus*) (Sedlackova *et al* 2004). Severe feather pecking can result in feather damage and denuded areas. These denuded areas can attract tissue pecking, a form of cannibalism that can result in serious wounds and increased mortality rates (Savory 1995). Toe pecking is a separate form of cannibalistic behaviour. Although this behaviour is rarely reported, it can lead to an increase in mortality and a decrease in growth rates (Glatz & Bourke 2006). Glatz and Bourke (2006) report that toe pecking can be caused by hunger, excessive warmth and bright lighting. Leonard *et al* (1995) also found a relationship between feather damage and toe pecking, showing that birds with feather damage also received more toe pecks than undamaged birds.

Feather pecking is a maladaptive behaviour, developing from ground-pecking behaviour (Blokhuis 1986). There seems to be a certain threshold for this change from ground-pecking behaviour to feather-pecking behaviour to occur. The height of this threshold is determined, on the one hand, by the presence of environmental stressors and, on the other, by the animal's adaptive capacity. The animal's adaptive capacity is affected by its personality: for instance, how an animal copes with fear and stress, but also its social and exploratory motivation. It has been found that personality affects the propensity of an animal to develop feather pecking. Rodenburg *et al* (2004a) found that chicks that were less active in an open-field test at five weeks of age, were more likely to develop feather-pecking behaviour as adults. Similarly, Jones *et al* (1995) found that chicks from a low feather-pecking line were more active in an open-field test than birds from a high feather-pecking line. Low activity in the open-field test indicates fearfulness or a low exploratory motivation in laying hens (Forkman *et al* 2007). There may also be a relationship between fear and exploration, as exploratory behaviour may be inhibited by fear in fearful individuals. Further, it has been found that the development of feather pecking in itself can lead to increased fearfulness in a group of hens, as indicated by results from a tonic immobility test: damaged hens had a longer latency to stand up than undamaged hens (Hughes & Duncan 1972; Vestergaard *et al* 1993).

Feather pecking, cannibalism and open-field response have a partly genetic background (Muir 1996; Kjaer *et al* 2001; Rodenburg *et al* 2003; Ellen *et al* 2008), which offers possi-

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bilities for genetic selection on these traits. Direct selection on reduced feather pecking has been shown to be feasible (Kjaer *et al* 2001), but offers limited possibilities for application in commercial breeding schemes, focused on production performance. Regarding application in practice, group selection methods may hold more promise. Muir (1996) used group selection to reduce mortality due to cannibalism, by selecting successful groups (ie non-cannibalistic) instead of successful individuals. More recently, Ellen *et al* (2007) developed a novel method of group selection against mortality, including information on individual performance in the group selection scheme. Although these methods were very successful in reducing mortality (Muir 1996; Ellen *et al* 2007), very little is known about the effects of group selection on behaviour.

Apart from genetic background, rearing conditions, such as rearing chicks with or without a mother hen (brooding) have major influences on the chicks' behavioural development (Rodenburg *et al* 2004b; Riber *et al* 2007). Riber *et al* (2007) found that mortality due to feather pecking and cannibalism was higher for non-brooded birds than for brooded birds. Brooded chicks were also found to be less flighty than non-brooded chicks in response to a moving person (Roden & Wechsler 1998). Perré *et al* (2002) studied the effect of brooding on fear responses later in life. In their study, brooded pullets went nearer to a novel object in the home pen than non-brooded pullets. No differences were found, however, when pullets were placed individually in a novel situation outside the home pen (tonic immobility test, open-field test).

The aim of the present study was to investigate the effects of selection on low mortality in association with brooding by a mother hen on open-field response at 5–6 weeks of age and on plumage and body condition at 42 weeks of age. It was hypothesised that birds from a low mortality line, that are brooded, would be more active in an open-field test at a young age and would have a better plumage and body condition at an adult age, compared with birds from the control line or birds that are not brooded.

Materials and methods

Animals and housing

For the experiment, birds from two different selection lines were used: a low mortality line and a control line. These two lines originate from the same pure-bred selection line. The low mortality line was selected on low mortality in a group housing system (non beak-trimmed) for two generations, using a novel form of group selection (Ellen *et al* 2007). The selection decision was based on the individual performance and on mortality levels of its sisters, housed in a family group of four birds. In the control line, selection was based only on individual performance, and not on mortality levels of sisters. Cases of mortality were assessed daily at individual level. Causes of mortality were not recorded, but the fact that these birds were not beak-trimmed meant that the majority of cases of mortality were due to cannibalistic pecking. The birds used for this experiment were birds from the second generation of selection. Six-hundred fertilised eggs from the low mortality line and 600 fertilised eggs from the control line were obtained from ISA BV, Boxmeer, The Netherlands. Eggs were produced in one week by about 15 males and 90 females per line, using artificial insemination. Eggs were marked per line, but not per family. Eggs were transported to the incubation and hatching facilities of Wageningen University, Wageningen, The Netherlands, and incubated in a HT-combi incubator with a maximum setting capacity of 4,800 eggs (Hatchtech BV, Veenendaal, The Netherlands).

After hatching, 520 female chicks (260 per line) were randomly assigned to one of four different treatment groups: ten groups of 13 birds per line were provided with a conventional heating lamp with a 100 W ceramic bulb. The other ten groups of 13 birds per line were provided with a broody hen. In each group, ten focal birds were marked with Swiftacks (http://www.nrg-co.com/uk/ identification.htm), attached through the neck skin. The light, plastic tags (1.5 × 3 cm; length × breadth) had an ID number and a unique colour, to allow individual recognition. The four treatments were equally distributed over 40 pens in two different houses (28 groups in one house, 12 groups in the other). Each group was housed in a floor pen measuring 1.9 × 1.2 m with wood shavings (2/3 of the surface) and sand (1/3 of the surface) on the floor. The areas were separated by a 10-cm high perch. A nest box was also provided. In groups provided with a heating lamp, the top of the nest box was removed and the heating lamp suspended over the nest box. Food and water were available *ad libitum*. The food supplied was a commercial mash diet (Rijvallei BV, Wageningen, The Netherlands), supplying a starter 1 diet (week 1–5), a starter 2 diet (6–16 weeks) and a laying diet (from 17 weeks onwards). Loose grains were supplied once a day around 0800h in the sand area.

The broody hens were housed in one group prior to the experiment, in a large pen (3 × 5 m) with wood shavings on the floor, perches, nests and *ad libitum* access to food and water. The hens were Silky hens (n = 20) and Wyandottes (n = 10) and had been obtained from four different breeders. They were stimulated to develop broodiness by increasing day length to 16 h and the placing of additional nest boxes, each of them containing three non-fertilised eggs. One week prior to hatching, 20 hens that showed broodiness (sitting on the eggs) were housed individually in one of the 40 experimental pens. They were placed on the nest, filled with three non-fertilised eggs. After hatching, the eggs were replaced with 13 female chicks. To be comparable with commercial practice, male chicks were excluded. Not all hens were sufficiently broody, as shown by their interactions with the chicks. Hens that had no or only negative interactions with the chicks were removed from the experiment and their groups excluded from the data. Hence, two groups from the control line and four groups from the low mortality line were excluded. From the hens that remained, ten were Silky hens and four were Wyandottes.

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Open-field test

At five or six weeks of age, each focal bird was tested in an open-field test for 5 min. The open field consisted of a 1.25 × 1.25 m observation pen, which was divided into 5 × 5 squares by white markings, measuring 25 × 25 cm each. The front wall was made of Perspex, through which a camera recorded the area of the pen. The observer could then record the behaviour from a video screen in an adjacent room. Behaviour was recorded using The Observer software package (Noldus Information Technology BV, Wageningen, The Netherlands). The latencies to vocalise, stand up and walk, as well as the number of distress calls and the number of steps were recorded using focal sampling. Birds were tested in a random order, alternating between the different pens. To test all birds, eight days were needed. On the first six days the birds in house 1 were tested, on the last two days the birds in house 2 were tested. Houses had to be tested subsequently, because the open field had to be moved from one house to the other. To avoid causing unnecessary stress to the individual bird before the test, it was transported to the observation pen in a box. The bird was placed in the middle of the observation pen. The room with the observation pen was dark until the start of the test. A single person conducted all tests and behavioural observations. Birds were tested between 0830 and 1630h. Treatments were equally distributed over testing times.

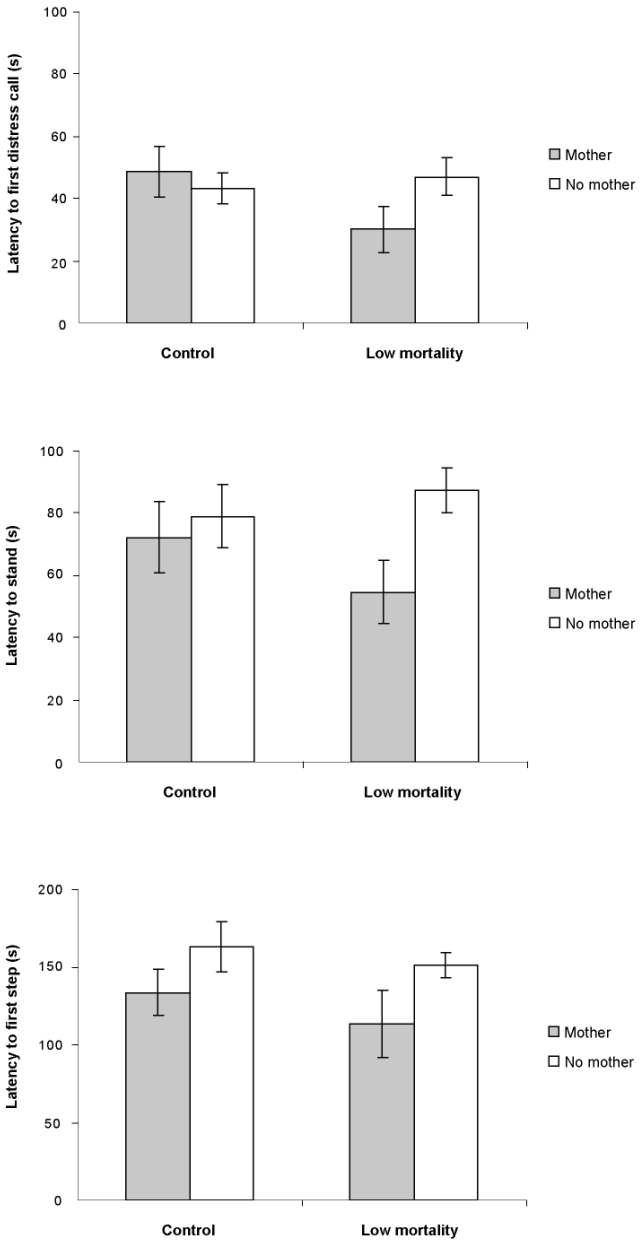
Plumage and body condition

At 42 weeks of age, all birds were subjected to an assessment of plumage and body condition. All birds were assessed by the same person, using the method described by Tauson *et al* (2005). Plumage condition in the neck, breast, vent, back, wing and tail regions were assessed on a four-point scale: (4) no damage; (3) feather damage; (2) area partly denuded and (1) completely denuded area. The sum of these six regions was used as plumage condition score. Additionally, pecking damage to the comb region was recorded on a four-point scale: (4) no damage; (3) a few lesions; (2) multiple lesions and (1) severe wounds. In addition to the method described by Tauson *et al* (2005), the incidence of wounds to the toes was assessed as well on a 0–1 score (absent or present).

Statistical analysis

For the analysis, group means were calculated for each group, as group was considered as the experimental unit. The data were analysed in SAS 9.1 (2002). The number of steps in the open-field test was not distributed normally, therefore a square-root transformation was applied. The latencies to vocalise, stand up and walk, the number of distress calls, the number of steps in the open-field test at 5 and 6 weeks of age and the total plumage condition score and comb score at 42 weeks of age were analysed as dependent variables. They were analysed using the GLM procedure with line (low mortality or control), mother (yes or no) and house (1 or 2) included as independent class effects. The interaction between line and mother was included as well. Significant interactions were further analysed using *post hoc* tests with Bonferroni adjustments for multiple comparisons. The incidence of toe wounds was analysed using a chi-square test. Data are presented as means (± SEM).

Figure 1



Latencies to vocalise (upper), to stand up (middle) and to walk (lower) in the open-field test at 6 weeks of age in chicks from the control and the low mortality line reared with or without a mother.

Results

Open-field test

There were no significant differences in the latency to vocalise between treatment groups (Figure 1). Brooded chicks had a shorter latency to stand up ($F_{1,33}$ = 5.34; $P < 0.05$) and to walk ($F_{1,33}$ = 8.20; $P < 0.01$) in the open field compared with non-brooded chicks. There were no significant line differences or interactions between line and brooding in the latency to stand up or to walk.

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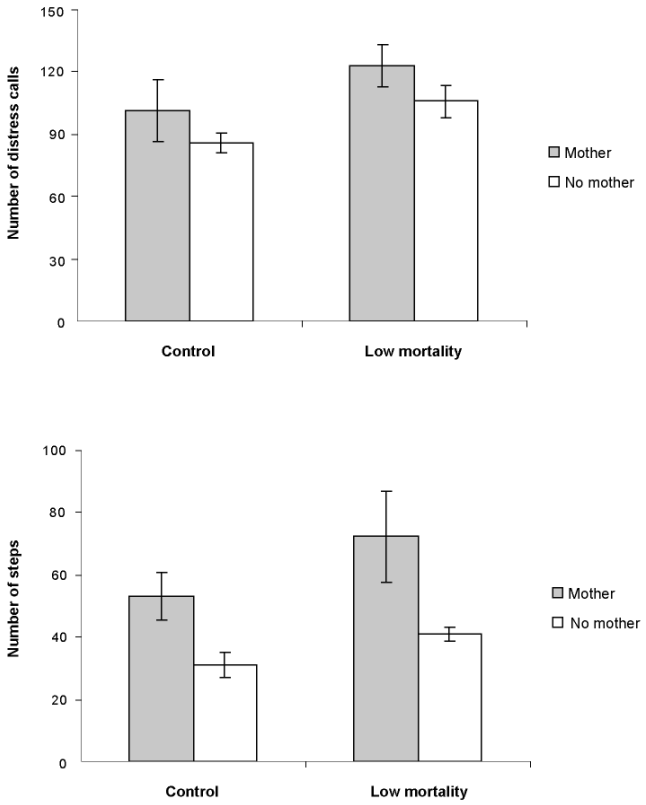
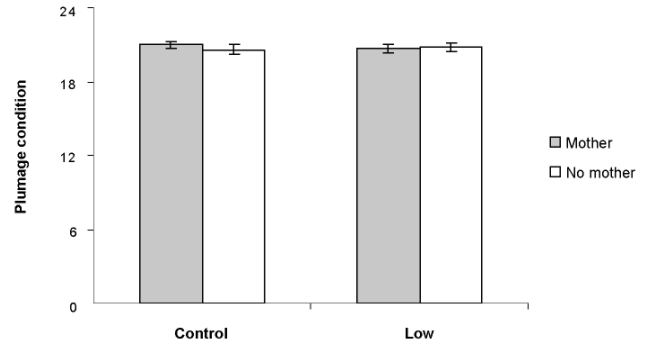
Figure 2



Number of distress calls (upper) and number of steps (lower) in the open-field test at 6 weeks of age in chicks from control and the low mortality line reared with or without a mother.

Figure 3



Plumage condition for birds from the control and low mortality lines reared with or without a mother hen at 42 weeks of age.

Chicks from the low mortality line uttered more distress calls ($F_{1,33}$ = 6.50; $P < 0.05$; Figure 2) and walked more ($F_{1,33}$ = 5.07; $P < 0.05$) in the open field than chicks from the control line. Similarly, brooded chicks tended to utter more distress calls than non-brooded chicks ($F_{1,33}$ = 3.48; $P < 0.10$) and walked more in the open field than non-brooded chicks ($F_{1,33}$ = 14.19; $P < 0.001$). No significant interactions between line and brooding were found.

Plumage and body condition

There were no differences in plumage condition at 42 weeks of age between the treatments and plumage damage was limited (Figure 3), but there was a line difference in incidence of toe wounds (Figure 4). In the control line, the percentage of birds wounded due to toe pecking was higher than in the low mortality line (35 vs 20% ; χ^2 = 4.09, $P < 0.05$).

Birds from the control line also had a lower comb score than birds from the low mortality line (3.0 vs 3.2; $F_{1,19}$ = 14.65; $P < 0.01$; Figure 5), which indicates a higher level of damage to the comb in the control line.

Discussion

The aim of the present study was to investigate the effects of selection on low mortality and of brooding by a mother hen on open-field response at 5–6 weeks of age and on plumage and body condition at 42 weeks of age. It was hypothesised that birds from a low mortality line, that are brooded, would be more active in an open-field test at a young age and have a better plumage and body condition at an adult age, compared with birds from the control line or birds that are not brooded.

Indeed, it was found that both brooded chicks and chicks from the low mortality line were more active in the open-field test at 5–6 weeks of age than non-brooded and non-selected ones, respectively. Birds from the low mortality line also had a lower incidence of comb and toe wounds compared with the control line at 42 weeks of age. No effect of brooding on plumage and body condition was found. This may be due to the fact that quite a large number of brooded groups (four from the low mortality line and two from the control line) had to be excluded from the experiment due to a lack of broodiness in the mothers. This resulted in only six brooded groups for the low mortality line and eight for the control line. Riber *et al* (2007) did find significant effects of brooding on mortality due to feather pecking and cannibalism. In their study, mortality was 15% lower in brooded groups compared with non-brooded groups.

Regarding the effects of brooding, only an effect on open-field response was found in the present study. Brooded chicks had a shorter latency to stand up and to walk in the open field and walked more compared with non-brooded chicks, indicating that they were less fearful or had a stronger exploratory motivation (Gallup & Suarez 1980; Forkman *et al* 2007). Previously, similar results were found by Roden and Wechsler (1998) in chicks and by Perré *et al* (2002) in pullets, using fear tests in the home pen in groups of birds. This is the first paper to report differences in fearfulness between brooded and non-brooded chicks using an individual fear test.

Line differences in fearfulness between the low mortality and the control line were also found. In the open-field test, inhibition of walking and uttering distress calls is a measure of fear in laying hens (Ginsburg *et al* 1974; Gallup & Suarez 1980). Chicks from the low mortality line uttered more distress calls, indicating a stronger social motivation, and walked more in the open field than chicks from the control

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line. These results fit well with results found in high and low feather pecking lines, where low feather peckers were found to vocalise and walk sooner in the open-field test at young age compared with high feather peckers, indicating decreased fear, increased social motivation or increased exploration (Jones *et al* 1995; Rodenburg *et al* 2004a).

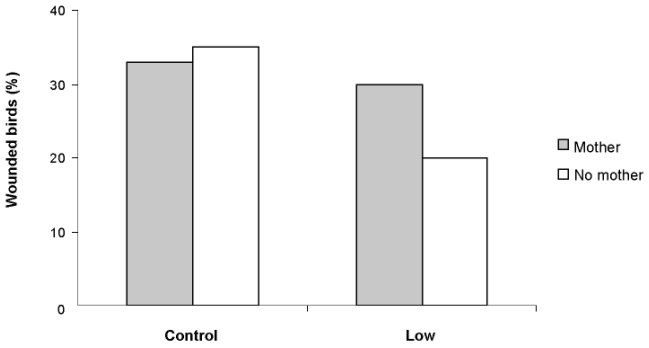
Until now, little has been known about the effect of group selection on behaviour. Recently, Bolhuis *et al* (2009) studied the same lines as used in the present study in a manual restraint test at 30-weeks of age, using birds housed in conventional cages. They found that birds selected for low mortality struggled and vocalised more in the manual restraint test than birds from the control line, indicating that they were less fearful or at least had a different way of coping with the stressor.

In addition to the effects on the open-field response, selection on low mortality also resulted in a lower incidence of toe wounds and comb lesions. Toe pecking is not regularly reported (Glatz & Bourke 2006), but was a major problem in this study. It is a form of cannibalistic pecking that can result in considerable damage and increased mortality rates. Glatz and Bourke (2006) reported that toe pecking can be caused by hunger, excessive warmth and bright lighting, but these factors are unlikely to play a role in the present study. Birds were fed *ad libitum*, temperature was maintained at 20ºC and light intensity was low. A major risk factor may have been the relatively low perches, which enabled birds standing on the floor to peck at the toes of birds on the perches. Comb lesions are usually the result of aggressive head pecking (Tauson *et al* 2005). Hence, the lower incidence of comb lesions could be interpreted as a lower incidence of aggressive pecking in the low mortality line. These differences in toe pecking and aggression fit well with the difference in mortality of approximately 10% found between the control line and the low mortality line in the first generation of the selection experiment, using the method described by Ellen *et al* (2007). No line differences in feather damage were found in the present study. This may be due to the enriched environment in the floor pens: the presence of sand and wood shavings may have prevented the development of severe feather pecking, as feather pecking develops from ground pecking behaviour (Blokhuis 1986; Huber-Eicher & Wechsler 1997).

Conclusion and animal welfare implications

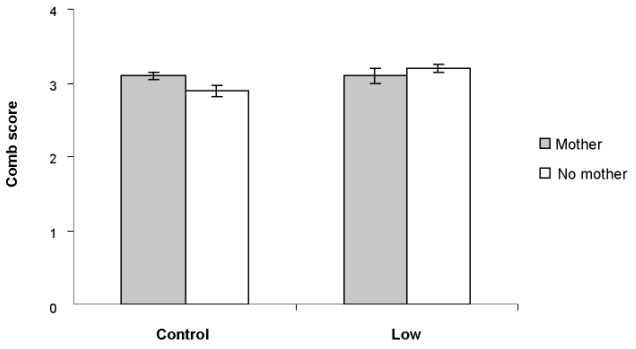
After only two generations of selection, selection for low mortality has resulted in birds that were less fearful at 6 weeks of age (present study) and at 30 weeks of age (Bolhuis *et al* 2009) and that showed less cannibalistic pecking and less aggression. These results confirm that fearfulness plays a key role in the development of feather pecking and cannibalism. This study indicates that selection for low mortality is a promising way forward to reduce maladaptive behaviour in laying hens, especially if such an approach is combined with improved rearing conditions. This knowledge can then be used further to improve breeding programmes and rearing conditions for laying hens for large-group housing systems. These improvements will help to ensure high welfare standards in these systems and enable the poultry industry to meet the societal demands for animal-friendly production systems.

Figure 4



Percentage of birds wounded due to toe pecking for birds from the control and low mortality lines reared with or without a mother hen at 42 weeks of age.

Figure 5



Comb scores for birds from the control and low mortality lines reared with or without a mother hen at 42 weeks of age.

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