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Investigating the importance of vision in poultry: comparing the behaviour of blind and sighted chickens[1]

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Abstract

Behaviour in poultry is predominately visually mediated and vision is important to the welfare of poultry. The relationship between vision, behaviour and welfare has primarily been investigated in relation to artificial lighting. Genetically blind chickens provide an alternative experimental paradigm for further investigating the importance of sight. The primary aim of the study was to investigate the importance of vision in the development and maintenance of behaviour in poultry by comparing the behaviour of 20 genetically blind chicks with that of 20 normally sighted chicks. Behaviour was assessed in a social isolation test post hatch and at 28-30 days old, and in the chicks' 8 home pens (4 blind; 4 sighted) at 42 days old. All birds were weighed at 0, 14, 28 and 42 days old. Analysis of home pen behaviour indicated that, compared to normally sighted chicks, blind chicks displayed increased preening and sitting behaviour, but reduced environmental pecking, behavioural synchrony and group aggregation. Blind chicks also exhibited abnormal behaviours - namely air pecking, star gazing, circle walking. Blind chicks weighed less than sighted chicks at 14, 28 and 42 days of age and appeared to be less stressed by social isolation compared to sighted chicks. It was concluded that blind chicks, as expected, have difficulty expressing behaviours that are normally visually mediated, and that their welfare is likely to be compromised as a result.

Keywords: vision; chicken; blindness; behaviour; social isolation; welfare

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1. Introduction[2]

Vision is important in poultry behaviour and welfare; poultry have highly specialised visual systems and the majority of their behaviour is mediated by vision (Prescott et al, 2003). Poultry rely heavily on visual cues when judging what is safe to eat and drink (Marples & Roper, 1996) and appropriate feeding and drinking behaviour is facilitated by an innate predisposition to peck at small particles and flat shiny surfaces (Hogan, 1973; Appleby et al, 2004). Vision is also important for navigation (Green et al, 1998a, 1998b) and social behaviour. Visual display features heavily in dominance and courtship in poultry (Mench & Keeling, 2001; Appleby et al, 2004), and visual characteristics - particularly those on the head and neck - are known to act as indicators of social status (Graves et al, 1985; Forkman & Haskell, 2004), individual familiarity (Guhl & Ortman, 1953; Dawkins, 1996; Hauser & Huber-Eicher, 2004; Porter et al, 2005) and genetic quality (Zuk et al, 1990).

Despite this, in the production environment poultry are sometimes maintained under conditions with the potential to impair their sight. For example, laying hens and turkeys have traditionally been housed in very low light intensities in an attempt to control the high levels of feather pecking and cannibalism associated with these birds (Lewis et al, 1998; Jones et al, 2004).

Given the importance of vision in poultry, there is concern that such practices may have adverse consequences for the behaviour and welfare of the birds (Manser, 1996; Prescott et al, 2003). For example, low light levels have been associated with reduced activity in poultry (Randall & McLachlan, 1979; Newberry et al, 1988), difficulties expressing behaviour such as social discrimination (D'Eath & Stone, 1999; Kristensen et al, 2009) and feeding (Pollock et al, 1982), lower body weight (Adams, 1992), decreased behavioural synchrony in groups (Alvino et al, 2009a, 2009b), heightened levels of fearfulness and stress (Hughes & Black, 1974; Newberry & Blair, 1993; Mashaly et al, 1988; Maddocks et al, 2001), and the expression of abnormal behaviour (Kjaer & Vestergaard, 1999). As social behaviour is predominately visually mediated, it is possible that poor visual ability could also affect factors such as social aggregation in groups and social reinstatement and distress behaviour when birds are individually isolated (Suarez & Gallup, 1983; Jones & Harvey, 1987; Jones & Merry, 1988; Jones & Williams, 1992).

The relationship between poultry vision, behaviour and welfare has primarily been investigated in relation to artificial lighting (Manser, 1996; Prescott et al, 2003). However, as a number of genetic abnormalities are known to affect the visual systems of chickens (Somes et al, 2003), genetically blind chickens provide an alternative experimental paradigm for further investigating the importance of vision in poultry.

Genetically blind chickens originally occurred in various commercial flocks and are now maintained for research to study eye development or as a model for ocular pathology in humans (e.g. Montiani-Ferreira et al, 2004; Finnegan et al, 2010). The Roslin Institute in Edinburgh maintains three strains of genetically blind chickens, including blindness enlarged globe (*beg*). *Beg* chickens are blind at hatch, due to an inherited autosomal recessive mutation (Pollock et al, 1982) and, in addition to impaired sight, are also known to exhibit a number of abnormal behaviours (Pollock et

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[2] Abbreviations: Bs, behavioural synchrony; NND, nearest neighbour distance.

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al, 1982; E. Raynor, unpublished results), have difficulty finding food (Pollock et al, 1982), and experience an increased rate of mortality as chicks (P. M. Hocking, unpublished observations).

Intriguingly an early study by Ali and Cheng (1985) found that blind hens (of the strain blindness, rods and cones; *rc*) had better feather coverage, less comb damage and produced more eggs than their sighted counterparts. It was also noted that blindness did not appear to interfere with feeding or other maintenance behaviours (except for mating); findings that led the authors to suggest the blind birds were perhaps under *less* stress than those that could see. Furthermore, Ali & Cheng (1985) go on to conclude "It is therefore worthwhile to explore further the potential for this mutation in egg-laying strains under cage systems." However, in this paper we are only concerned with the view, implicitly serving to underpin the conclusion made by Ali and Cheng, that the ability to see is not an essential prerequisite of poultry welfare. Thus the main aim of the present study was to use *beg* chicks to further investigate the importance of vision in social and other behaviours in poultry. A secondary aim of the study was to further characterise the behaviour of *beg* chicks, with a view to drawing preliminary conclusions on their welfare. Based on the findings outlined above, it was hypothesised that (a) blind chicks would display reduced activity, behavioural synchrony and group aggregation, and increased abnormal behaviour compared to their sighted counterparts; (b) blind chicks would exhibit reduced feeding behaviour and would be lighter in body weight; and (c) because of their lack of sight, blind chicks would be less stressed by social isolation and that this might increase with age

The conclusion reached by Ali and Cheng (1985) could and should give rise to ethical consideration because there are important ethical implications to breeding blind birds. Indeed the subject has been discussed in a number of papers on the ethics of breeding animals (Sandoe et al, 1999; Sandoe & Christensen, 2008; Star et al, 2008). Although the findings of this study are likely to have important implications for these ethical discussions it is beyond the scope of the present article to consider them here.

2. Methods

2.1. Ethical note

All flocks were maintained at the Roslin Institute, Edinburgh under a Home Office licence and after ethical review. The justification for their maintenance is primarily that they are used as animal models for human conditions. The minimum number of breeding birds is kept to maintain the lines. Special attention (training) is provided to ensure that the birds feed and drink after hatching and, as adults, after transfer to cages for pedigree mating.

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2.2. Animals and housing

A total of 24 blind (*beg* homozygotes) and 24 sighted (*beg* heterozygotes) White Leghorn type day old chicks were obtained from a single hatch. The birds were from the same parents to ensure similar genetic background except for inheriting the *beg* gene and this was achieved by mating *beg* heterozygote females x *beg* homozygote males. Blindness was determined on the basis of behaviour; unlike sighted birds, blind chicks display difficulties navigating their environment, will frequently fall when placed upon a low perch and exhibit characteristic abnormal behaviours, such as circle walking, air pecking and star gazing (E. Raynor, unpublished results). No chicks were recategorised during the 42 days of the study.

The chicks were wing-banded at hatch and randomly allocated to 8 pens in the home room in groups of 6 blind or 6 sighted chicks. Six of the pens were approximately (depth x width) 150 x 150 cm and 2 pens 150 x 100 cm arranged on both sides of a central passage. The pens were sufficiently high so that the birds could not see into the adjacent pens. Allocation of blind and sighted pens was balanced across the room. Each chick was individually marked using a marker pen to aid identification and reduce handling at test.

The home room was maintained at a temperature of 22-29°C, with extra warmth provided by heat lamps until 28 days of age. The photoperiod schedule was 24 hours light on day 0 with a gradual decrease to 14 hours light by day 5. The room was illuminated by wall mounted fluorescent lighting and light intensity, measured at chick eye level (~10 cm from the ground), ranged from 16-24 lux.

Chicks had *ad libitum* access to food (standard commercial layer chick crumbs provided in large dishes upon the floor) and water from bell drinkers in the home pens. During the first 14 days care was taken to ensure that the blind chicks were able to locate these resources, as recently hatched blind birds are known to experience difficulties finding food (Pollock et al, 1982).

All chicks were weighed at 0, 14, 28 and 42 days old and mean weights were calculated for each pen.

2.2. Social isolation

2.2.1. Animals, experimental design and observations

A random selection of 40 chicks (20 blind and 20 sighted) was used to investigate the effect of genotype (blind; sighted), age (post hatch; 28-30 d) and type of isolation (physical isolation; visual isolation) on behaviour during social isolation.

The social isolation tests were undertaken in a wooden test arena in a designated test room located in close proximity to the home room. The test room was maintained at approximately 21°C. It was illuminated by ceiling mounted fluorescent lighting and light intensity, measured at chick eye level, was 15 lux. The test arena (Figure 1) could be separated into two sections of equal size - a 'test' side containing the isolated test chick and a 'companion' side containing the test chick's pen

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mates - using one of two removable partitions: a wire mesh partition allowing visual, olfactory and auditory contact between the test chick and it's pen mates (physical isolation treatment) or a solid wood partition allowing auditory and olfactory but no visual contact between the test chick and it's pen mates (visual isolation treatment). The test arena was lined with wood shavings and the test side contained a wooden start box. The start box could be remotely removed by the experimenter using a rope and pulley system and it contained one wire mesh wall (facing the central partition) to allow the test chicks to familiarise themselves with the test environment prior to testing. The walls of the test arena were sufficiently high so that the sighted chicks could not see the experimenter while operating the pulley system or during the recording period.

Testing occurred between 10:00-16:00h. Chicks were removed from their home pen prior to testing as a group and carried to the test room in a poultry transfer box. Upon arrival all chicks were placed into the companion side of the test arena, where they remained for 1 minute habituation. Following this, the test chick was selected and positioned in the start box for 1 minute. Testing commenced once the experimenter had lifted the walls of the start box clear of the test arena and lasted for 2 minutes. At the end of testing the test chick was returned to the companion side of the arena and the next bird was selected. When all chicks had been tested they were returned to their home pen and the next pen group was collected.

All social isolation trials were recorded onto video tape using a video camera positioned directly above the test side of the arena. The following behavioural variables were recorded from the videos: latency to move (sec), number of peeps, number of jumps, number of environmental pecks i.e., pecks directed at the litter), activity and proximity to pen mates. Activity was assessed by counting the number of grid lines the test chick crossed on an acetate sheet placed over the video monitor screen. Grids corresponded to 25 cm x 25 cm squares of the floor of the test arena. Proximity to pen mates was recorded by 10 second instantaneous scan sampling, and test chicks were recorded as 'near' to pen mates if located in one of the 4 grid squares adjacent to the central partition and 'far' from pen mates if located in one of the 4 remaining squares. If the test chick was positioned so that it occupied more than one grid square, the grid in which its beak was located was recorded. From this the percentage of scans in which the test chicks was located near to pen mates (percentage time near pen mates) was calculated.

All chicks were tested under both isolation treatments. As it was not possible to complete all tests in a single day trials were split across 2 days. To avoid potential order effects, genotype and isolation treatment (visual and physical isolation) were balanced across days, i.e., on day 1 half of the blind and half of the sighted chicks experienced physical isolation whilst the other half experienced visual isolation and vice versa on day 2. The order of pens sampled and of chicks tested within pens was randomised. This order was repeated on both day 1 and 2 to ensure that the time period between successive treatments was similar. As all chicks were exposed to both isolation treatments, there was a possibility of carryover between the two test days. To estimate the importance of this, a third test day was introduced, in which day 2 trials were repeated. Therefore, in total, chicks were tested over a 3 day period at both ages, and in addition to the three factors of interest (genotype, age and type of isolation), the statistical model also included

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day (1, 2, 3) and carryover (carryover from physical isolation on the previous day; carryover from visual isolation on the previous day) as nuisance factors.

2.2.2. Data analysis

Data were analysed at pen level: the mean latency to move (sec), number of peeps, number of pecks, number of lines crossed and percentage time near pen mates was calculated for each pen for each isolation, day and age combination. Chicks were rarely seen to jump and for this reason number of jumps was excluded from the analysis. Inspection of the residual plots indicated that the remaining behavioural variables were normally distributed but did not display equal variance. Additionally a small number of pen means were zero for latency to move (sec), number of peeps and number of pecks. The data (x) were therefore transformed to approximate equal variance as follows: latency to move was transformed by taking the logarithm (x+0.1); number of peeps and pecks by the square root (x+0.2); number of lines crossed as the square root (x); and the percentage (p) time near pen mates as the empirical logistic (logit) defined as log(p+100/120)/(100-p+100/120).

Analysis of pen means was completed using Genstat (2009). Specifically, a nested analysis of variance between pens and within pens between days and ages resulting in 4 strata of variation was undertaken with treatment effects of genotype, isolation, age, day, one-day carryover and their interactions where estimable. Analysis of variance indicated that, in some instances, day and carryover significantly affected behaviour during social isolation. Furthermore, a number of significant interactions between these factors, genotype and age were detected. As day and carryover are not of direct relevance to the experimental aims and hypotheses however, further details of these findings are not presented. Both nuisance factors were accounted for during the experimental design and analysis stages of the study, and therefore the present results are robust against their effects.

2.3. Home pen behaviour

2.3.1. Animals, experimental design and measurements

A total of 39 chicks (20 blind and 19 sighted) were used to investigate the effect of genotype (blind; sighted) on home pen behaviour. The frequency of different behaviours, behavioural synchrony and group aggregation was assessed in the chick's home pens at 42 days old. Video cameras were positioned above the 8 home pens and behaviour was recorded for 1 hour periods starting at 09:00h, 13:00h and 17:00h.

Frequency of behaviour (%) was recorded by 5 minute instantaneous scan sampling of each video tape using an ethogram (Table 1). Behavioural synchrony (B_s) was calculated using Simpson's Diversity Index, which is a simple index that measures diversity within categorical data (Peet, 1974; Krebs, 1989; King & Cowlishaw, 2009). For each scan behavioural synchrony was calculated as

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$$Bs = \sum_{i}^{S} \frac{n_i (n_i - 1)}{N (N - 1)}$$

where n_i is the number of individuals exhibiting the ith behaviour, N is the total number of individuals in the scan and S is the total number of behaviours in the ethogram. B_s values near 0 reflect group behaviour that is asynchronous, whereas values approaching 1 reflect group behaviour that is highly synchronous (King & Cowlishaw, 2009). Finally, group aggregation was assessed at each 5 minute scan by calculating the mean nearest neighbour distance (NND) between chicks (e.g. Sibbald et al, 2009). NND refers to the distance in cm between each bird and the nearest part of its closest neighbour.

2.3.2. Data analysis

As a number of behaviours were performed only very rarely, some behaviours (Table 1) were merged to form a total of 9 classes: feeding, drinking, sitting, standing, walking and running, environmental pecking, preening, abnormal (circle walking, air pecking, star gazing), and other (lie, gentle feather peck, severe feather peck, aggressive peck, dust bathe, stretch, chase and display).

All statistical analyses were completed using Genstat (2009). Mean time spent in the different behaviours (%) was calculated for each pen at each time period. As the inspection of residual plots revealed % feeding, drinking, sitting, standing, walking and running, environmental pecking and preening to have approximately equal variance in this data set, a nested analysis of variance with Genotype (between pens) and Time of day (within pens) was conducted on each behaviour. Any serial correlation between observations at the 3 times of day would have negligible effect due to the low number of repeated observations and their time apart and was therefore ignored in this analysis. Due to the high number of zero values for % other behaviour and % abnormal behaviour, and the lack of normality of the distribution of the residuals in different strata, these behaviours were analysed using permutation tests with 5000 replications.

Mean pen B_s and NND were calculated for each pen at each time period. Inspection of residual plots revealed that both variables were normally distributed with approximately equal variance. Analysis of the untransformed data was therefore conducted using a nested analysis of variance between and within pens as described above.

3. Results

3.1. Social isolation

Significant (P<0.001) genotype x isolation interactions were detected for all traits except the number of pecks (Table 2). For the blind chicks the latency to move did not differ between the two

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isolation treatments. For the sighted birds it was lower under physical isolation compared to visual isolation. Overall, blind chicks displayed a greater latency to move in both isolation treatments and at both ages (Table 2). Similarly, whereas the sighted chicks crossed more lines under physical isolation compared to visual isolation, the number of lines crossed did not differ between the two isolation treatments in the blind chicks. Furthermore, sighted chicks were found to cross more lines under physical isolation compared to the blind chicks, but a similar number of lines when also visually isolated (Table 2).

The percentage time near pen mates was found to differ between the two isolation treatments for both the blind and sighted chicks, with a higher percentage associated with physical isolation. It is important to note however that, in relation to the variability (maximum SED), the difference between physical isolation and visual isolation means is relatively small with respect to the blind chicks. Furthermore, blind chicks spent less time near to pen mates under physical isolation compared to the sighted chicks, whereas time spent in close proximity to pen mates was similar for both genotypes under visual isolation (Table 2).

Whereas the number of peeps did not differ between the two isolation treatments for the blind chicks, it was greater under visual isolation compared to physical isolation in the sighted birds. Furthermore, sighted chicks were found to peep more under visual isolation but less under physical isolation compared to their blind counterparts (Table 2). The number of peeps decreased with age in both genotypes ($F_{1,4}$ = 54.0, $P<0.01$). In contrast to the number of peeps, the number of pecks was greater under physical compared with visual isolation in both blind and sighted chicks: means for physical and visual isolation respectively were 2.12 vs. 1.17, sed 0.314, ($F_{1,4}$ = 9.2, $P<0.05$)

No variables were affected by genotype x age interactions, and the number of lines crossed was the only variable for which a significant genotype x isolation x age interaction was found. Inspection of the means indicated that this interaction was detected due to a greater difference between the numbers of lines crossed by sighted chicks in the two isolation treatments at 28-30 days compared to that at 1-3 days (Table 2). Subclass means for genotype, age and isolation and summary of the analyses for the social isolation traits are presented in Table 2.

3.2. Home pen behaviour

3.2.1. Frequency of behaviours

Blind chicks exhibited significantly more sitting, preening and abnormal behaviour, and significantly less environmental pecking compared to their sighted counterparts (Table 3). It is interesting to note that sitting was the most frequently observed behaviour in the blind chicks, whereas environmental pecking was the most frequently observed behaviour in the sighted chicks. Time spent feeding, drinking, standing, walking and running, and in other behaviours did not differ significantly between genotypes. Inspection of the means, however, does indicate that there was a trend for less feeding behaviour and more walking and running in the blind compared to sighted chicks.

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Sitting was the only behaviour to be significantly affected by time of day: time spent sitting was greatest towards the beginning and the end of the day (9:00h = 30.1%; 13:00h = 25.6 %; 17:00h = 32.7; SED = 3.38, $F_{2, 12}$ = 8.0, P=0.006). No significant genotype x time of day interactions were observed.

3.2.2. Behavioural synchrony

Blind chicks were significantly less synchronous in their behaviour than sighted chicks (0.3 vs. 0.4, SED = 0.02, $F_{1, 6}$ = 26.6, P=0.002). Synchrony was not affected by time of day ($F_{2, 12}$ = 0.30, P>0.05), and there was no genotype x time of day interaction ($F_{2, 12}$ = 0.1, P>0.05). This result is consistent with our hypothesis that the social behaviour of visually impaired chicks is adversely affected.

3.2.3. Group aggregation

Blind chicks showed less group aggregation than sighted birds as measured by mean nearest neighbour distance (43.0 vs. 28.4 cm, SED = 1.21, $F_{1, 6}$ = 147.3, $P<0.001$). This was not affected by time of day ($F_{2, 12}$ = 2.7, $P>0.05$), and there was no genotype x time of day interaction ($F_{2, 12}$ = 0.4, $P>0.05$). Group aggregation, like behavioural synchrony, is similarly adversely affected in blind chicks, in agreement with the conclusion that sight is important for normal behaviour, and that normal social behaviour requires sight and visual acuity.

3.3 Mortality and body weight

At 5 and 6 days of age 5 blind chicks in the same pen died and were replaced by one randomly selected blind chick from the other 3 pens and an additional blind bird (previously surplus to the needs of the study). As the above changes to pen groups occurred during the first week - before social hierarchies are likely to have been firmly established - any potential adverse affects on group dynamics were considered to be negligible. In order to achieve equal group sizes (n = 5), one randomly selected chick was removed from each of the four sighted pens at 21 days old. On day 41 it became necessary to remove 1 sighted male chick from its home pen due to aggression from the other, larger males in the group. Data collected from chicks that subsequently died or were removed were excluded from later analyses.

Blind and sighted chicks were of similar weight at hatch (40 vs. 40 g, SED 0.84g, not significant) whereas blind chicks were significantly (P<0.05) lighter than sighted chicks at 14, 28 and 42 days old (Table 4). The differences in body weight between blind and sighted birds increased proportionally with age from 4.7 % at 14 days to 7.4 % at 42 days of age.

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4. Discussion

4.1. Social Isolation

Chickens find social isolation aversive (Jones & Williams, 1992; Marx et al, 2001) and they will increase ambulation (active search), jumping and peeping (Jones & Harvey, 1987; Jones & Merry, 1988) in order to reinstate social contact. However, as social behaviour is known to be highly visually mediated in poultry (Graves et al, 1985; Zuk et al, 1990; Dawkins, 1996), it was hypothesised that blind chicks would be less stressed by social isolation compared to sighted chicks, and that this effect may depend upon age and the type of isolation that was enforced.

Overall the results indicate that in the social isolation test, and compared to the sighted chicks, blind chicks took longer to move, were less active, and spent less time in close proximity to their pen mates throughout the test, i.e. the blind chicks exhibited reduced social reinstatement behaviour at both ages. There are at least two explanations for this: very high levels of distress can inhibit social reinstatement behaviour in poultry (Jones, 1977) and, contrary to the original hypothesis, blind chicks could be more stressed by social isolation than their sighted counterparts. Alternatively blind chicks may simply be less motivated for social contact due to their lack of sight. Although it is not possible to distinguish between these two alternatives, a number of factors in the results imply that the latter explanation is more probable. Whereas the blind chicks behaved similarly under both isolation treatments, the sighted chicks took longer to move, crossed fewer lines, peeped more, and spent less time in close proximity to their pen mates under visual isolation. Thus, unlike the sighted birds, the blind chicks did not discriminate between the different social isolation treatments, a finding that likely reflects a lack of awareness of their social surroundings. If blind chicks are less aware of their social environment, it is less likely that they would be more stressed by isolation or motivated to regain social contact.

4.2. Home pen behaviour and body weight

Blind chicks were less active, exhibiting more sitting but less environmental pecking than their sighted counterparts and the results are consistent with research into the effects of low light intensity in poultry (e.g. Randall & McLachlan, 1979; Arbi et al, 1983; Boshouwers & Nicaise, 1987, 1993). However, it must be noted that blind chicks also displayed a non-significant trend for more walking and running behaviour. It is likely that this reflects the decreased proportion of time spent in environmental pecking compared to the sighted chicks. In contrast the blind chicks engaged in minimal exploration, instead appearing to walk aimlessly around their home pens, a behaviour that was not seen in the sighted birds (personal observation). The blind birds were also observed to collide frequently with other birds, pen walls and feeding and drinking equipment.

As expected the blind chicks displayed abnormal behaviours recorded as air pecking, star gazing and circle walking (Pollock et al, 1982; E. Raynor, unpublished results). Interestingly however, they also displayed increased levels of preening in comparison to the sighted chicks, a change that may indicate frustration in poultry (Duncan, & Wood-Gush, 1972; Hughes & Black, 1974).

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In addition to these behavioural differences, the blind chicks were characterised by reduced behavioural synchrony and group aggregation. Dim lighting is known to reduce the synchrony of preening, eating, resting and foraging in poultry (Alvino et al, 2009a). However, as behavioural synchrony and group aggregation have not previously been investigated with respect to genetically blind chicks, we believe this is a novel finding.

Finally, blind chicks weighed less than their sighted counterparts, an observation that might be associated with the trend for less feeding behaviour and is in contrast with the finding in adult hens of a different line that body weight was not affected (Ali & Cheng, 1985).

4.3. Welfare consequences of blindness

The present study has demonstrated that, compared to normally sighted birds, genetically blind chicks were less stressed by social isolation, less active, showed reduced behavioural synchrony, group aggregation and body weight, and exhibited a number of abnormal behaviours. The study serves to further demonstrate the importance of vision in key behaviours such as feeding and social behaviour in poultry.

The development of appropriate feeding behaviour in chickens primarily depends upon vision: they possess an innate predisposition to peck at small particles upon the ground (Hogan, 1973) and they are encouraged to feed by the sight of feeding conspecifics (Tolman & Wilson, 1965). It is not surprising therefore that there was a trend for a smaller proportion of time feeding, and significantly lower body weights, in blind compared with sighted chicks. Reduced social aggregation could also lead to increased energy loss by decreasing the beneficial effects of huddling, or less efficient identification of the warm brooder area, and contribute to the lower body weight of blind compared with sighted chicks.

Social behaviour in poultry appears to be almost entirely dependent upon access to visual cues (D'Eath & Stone, 1999; Hauser & Huber-Eicher, 2004; Porter et al, 2005; Kristensen et al, 2009), and the results of this study reinforce these findings. Despite the availability of both auditory and olfactory cues in the social isolation test arena, when sighted chicks were visually isolated from conspecifics they behaved as if they were unaware of their pen mates on the other side of the central divide, i.e. were not comforted by the sound and smell of the other birds, and they did not spend more time in close proximity to their pen mates, than they did when separated by wire mesh.

Although the study represents only a preliminary investigation into the behaviour of blind *beg* strain chicks, a number of findings suggest that the birds may experience lower welfare as a result of their lack of sight. Firstly, welfare is likely to be reduced by difficulties in finding food which in turn may give rise to negative subjective experiences such as frustration and hunger. Secondly, although the blind chicks appeared to experience lower levels of distress under social isolation, the fact that blind chicks were apparently less aware of their social environment, as shown by reduced behavioural synchrony and group aggregation, could have important negative consequences for

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their welfare. Chickens are social animals. Under normal circumstances they are highly motivated to reinstate social contact when isolated (Suarez & Gallup, 1983) and, in addition to preferences for familiarity (Hughes, 1977; Dawkins, 1982), they are also known to show preferences for particular individuals within the flock (Mench, 1996). Although in comparison to negative feelings evidence for positive subjective experience in poultry is relatively sparse, it is possible that chickens are capable of experiencing such feelings (Duncan, 2002). For example, when chickens rest they tend to do so in physical contact (Lill, 1968). Social contact is known to be positively reinforcing in other species (Cabanac, 2005) and if this is also true of poultry, then blind chicks displaying reduced group aggregation are likely to miss positive experiences normally enjoyed by sighted birds.

The increased frequency of abnormal behaviour and preening in the blind chicks has been associated with reduced welfare from stress or a lack of appropriate stimulation in the domestic environment (Mason, 1991; Hosey et al, 2009). Although very little is known about the development and causes of abnormal behaviour in these genetically blind birds, both factors may contribute to reduce welfare. As indicated above, blind chicks may suffer increased stress from numerous sources; they may experience difficulties feeding, have a reduced ability to express social behaviour, and have difficulty navigating their environment. In addition, chickens are known to display a preference for visual complexity (Berryman et al, 1971), and as they are normally highly visual animals, it is likely that lack of sight will mean that the birds will miss a number of positive experiences which serve to enrich the life of a normal chick. In light of this, it is possible that the abnormal behaviours observed in the blind chicks are attempts to increase stimulation that is lacking from their external environment. We note that low light intensity may have similar effects on the welfare of chickens in commercial flocks and suggest that observations like those used here could be used to study this aspect in future research.

Finally, the suggestion by Ali and Cheng (1985) that blind birds may be less stressed than sighted birds, based on adult laying hens, may not stand up to wider scrutiny. The differences between their results and the present data may be a consequence of the reported aggression in their sighted laying hens as demonstrated by increased physical damage to the integument. The findings by Ali and Cheng may only serve to show that in some production systems the level of social stress is so high that living with the problems related to blindness is the lesser of two evils. However, a more thorough study of welfare related behaviours at older ages will be necessary to draw a final conclusion on the welfare of blind chickens.

5. Conclusions

The findings of the present study that blind birds demonstrate less social aggregation and behavioural synchrony, and exhibit changes in behaviour that probably reflect frustration, compared with sighted birds, serve to reinforce existing research into the negative effects of poor visual ability in sighted poultry. Chickens are highly visual animals and the majority of their behaviour is visually mediated. Impairment of vision, therefore, may lead to difficulties expressing key behaviours such as feeding and social discrimination. Based on the current findings, blind *beg*

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chickens appear to experience compromised welfare as a result of their lack of sight and are likely to miss out on a number of positive states linked to vision in normally sighted birds The results do not support the suggestion by Ali and Cheng (1985), based on adult laying hens, that blind birds may be less stressed than sighted birds.

Acknowledgements

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Table 1. Ethogram for blind and sighted chick home pen behaviour.

Behaviour		Description
Inactive	Sit	Motionless, both the feet and abdomen are on the ground.
	Stand	Motionless, both feet are on the ground.
	Lie	Lays motionless, both the feet and abdomen are on the ground. Wings are splayed out against the substrate.
Active	Feed	Pecks and/or scratches at food substrate in the feeder.
	Drink	Lowers head to water in the drinker. Tilts head back to swallow.
	Peck (environmental)	Pecks and/or scratches at any substrate outside of the feeder.
	Peck (gentle feather)	Pecks gently at another bird. The recipient bird does not react.
	Peck (severe feather)	Pecks at another bird. Pecking is of high intensity, aimed at the body area of the bird. The recipient bird reacts and may attempt to move away.
	Peck (aggressive)	Pecks at another bird. Pecking is rapid, of high intensity, and aimed at the head or neck area. Pecking may be initiated from a position in which the head is held up high. The recipient bird reacts and may attempt to move away.
	Preen	Manipulates own feathers with beak.
	Dust bathe	Sits in the substrate ruffling feathers so that the substrate is moved across the wings and back.
	Stretch	Extends both or one of the wings out away from the body. May be accompanied by the extension of a leg.
	Walk/run	Moves about the pen. Head is held upright. May include extension of wings.
	Chase	Moves quickly about the pen following another bird.
	Fly	Flies about the pen. Both feet are clear of the ground.
	Display	Aggressively confronts another bird. Gaze is focused intently upon the other bird. May be accompanied by raised neck feathers, forward lunges, and jumps in which both feet are directed at the other bird.
Abnormal	Circle walk	Walks in a circle.
	Air peck	Pecks at the air. Pecks appear not to be directed at any substrate.
	Star gaze	Orients head towards the ceiling, moving head from side to side.
Out of sight		Cannot be observed.

Table 2. The transformed (back transformed) mean latency to move, number of lines crossed, % of scans near pen mates, number of peeps and environmental pecks for blind and sighted chicks in physical or visual isolation when tested at 1-3 and 28-30 days old.

Trait and genotype	Mean proportion of observations (%)				Max SED[a]	F-ratios[b] and significance[c]					
	1-3 days		28-30 days			Genotype (G)	Isolation (I)	Age (A)	G x I	G x A	G x I x A
	Physical isolation	Visual isolation	Physical isolation	Visual isolation							
Log latency to move (sec)											
Blind	3.1 (22.7)	3.0 (21.1)	2.9 (18.8)	3.4 (29.5)	0.42	362.9	84.8	0.4	69.1	0.9	0.0
Sighted	-1.2 (0.3)	2.3 (9.7)	-1.8 (0.17)	2.2 (9.01)		**	***	ns	***	ns	ns
Sqrt no. of lines crossed											
Blind	2.6 (6.8)	2.3 (5.4)	2.4 (5.6)	2.3 (5.3)	0.48	165.1	153.6	0.0	128.7	0.1	14.1
Sighted	6.3 (39.4)	3.0 (9.1)	7.0 (49.1)	2.3 (5.5)		***	***	ns	***	ns	**
Logit % near pen mate scans											
Blind	1.1 (74.6)	-0.2 (44.9)	0.6 (63.8)	0.2 (55.2)	0.58	51.1	64.7	2.8	24.9	3.7	0.1
Sighted	3.7 (97.7)	-0.4 (39.6)	3.5 (96.9)	0.6 (65.4)		**	***	ns	***	ns	ns
Sqrt number of peeps											
Blind	10.6 (113.3)	12.1 (146.5)	2.6 (6.6)	3.6 (12.9)	1.36	2.5	160.3	54.0	85.5	4.0	4
Sighted	7.4 (54.5)	14.6 (211.8)	1.9 (3.5)	10.6 (112.1)		ns	***	**	***	ns	ns
Sqrt number of pecks											
Blind	1.7 (2.9)	1.4 (2.1)	2.0 (3.9)	1.3 (1.6)	0.52	0.5	9.2	5.5	2.4	4.2	0.2
Sighted	1.8 (3.4)	0.8 (0.6)	3.0 (8.9)	1.2 (1.3)		ns	*	ns	ns	ns	ns

[a] Maximum standard error of a difference for transformed means.

[b] Variance ratios, and significance levels are indicated for the main effects and associated interactions; degrees of freedom are 1,4 for G, A and G x A, and 1,8 for I, G x I and G x I x A.

[c] $*=P<0.05$, $**=P<0.01$, $***=P<0.001$, ns=not significant.

Table 3. The mean percentage of scans of different behaviours for blind (*beg*) and sighted chicks during home pen observations at 42 days old.
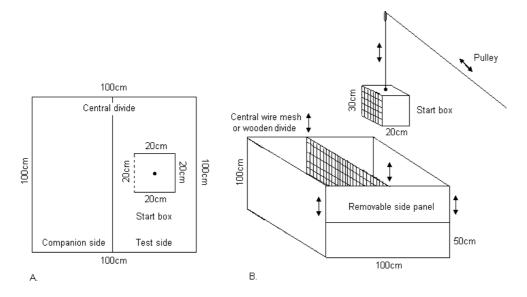
Behaviour	Genotype		SED[b]	F-ratio	Significance[c]
	Blind	Sighted			
Feeding	9.0	13.7	2.50	3.5	ns
Drinking	3.4	3.3	1.11	0.0	ns
Sitting	30.1	21.6	2.21	14.8	**
Standing	6.9	7.2	2.38	0.0	ns
Walking/running	15.8	8.1	3.49	4.8	ns
Environmental pecking	12.0	34.7	2.60	76.0	***
Preening	19.2	9.2	2.48	16.4	**
Abnormal[a]	3.0	0.0	n/a	14.6	*
Other	1.0	2.2	n/a	0.8	ns

[a] Air pecking, star gazing, circle walking
[b] Standard error of the difference between blind and sighted chicks; degrees of freedom are 1,6.
[c] *=$P<0.05$, **=$P<0.01$, ***=$P<0.001$, ns=not significant.

Table 4. Mean body weight (g) of blind (*beg*) and sighted chicks at 0, 14, 28 and 42 days.

Age, d	Blind	Sighted	SED[a]	F-ratio	Significance
0	40	40	0.84	0.230	ns
14	101	106	2.02	0.028	*
28	239	256	6.11	0.034	*
42	452	488	14.30	0.045	*

[a] Standard error of the difference between blind and sighted chicks; degrees of freedom are 1,6.
[b] *=$P<0.05$, ns=not significant.

Figure 1. Diagram of the social isolation test arena used in Experiment 1. Plan view (A). Lateral view (B).