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# Use of space by domestic chicks housed in complex aviaries

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ABSTRACT

To improve the understanding of the development of locomotor capacity in layer hens, we measured how female laying hen chicks (n = 120) of four different strains (LSL-lite, Hyline Brown, Dekalb White, Lohmann Brown; 3 groups of 10 chicks per line) utilized the ground, the air, elevated horizontal (platforms and perches) and inclined surfaces (ramps and ladders) in an aviary until 9 weeks of age. We used infra-red video recordings to perform all-occurrences sampling of locomotive behavioural and perching events that occurred on the ground—where bedding material, food and water were provided, in the air, and on elevated horizontal and inclined surfaces within weekly 30-min sampling periods. Chicks preferred level ground during the first week of life compared to weeks 5–9 ($P < 0.0001$) and performed 52% of all behavioural events in this section. Elevated surface use began at 2 weeks of age and increased over time ($P = 0.003$), where most behaviour was performed in S2 (45% of all events). Chicks preferred horizontal to inclined surfaces, which were used from weeks 2–5 with maximum use occurring during weeks 2 and 3. Lohmann LSL chicks used the space above the ground most frequently ($P = 0.05$) and performed more aerial ascent/descent behaviour than other lines ($P < 0.0001$). Overall activity levels declined with age ($P < 0.0001$). In summary layer chicks almost exclusively locomoted on the ground but utilized elevated horizontal surfaces (perch, first platform) as early as 2 weeks. These results provide information for improving space use in rearing aviaries by introducing lower perches, platforms and ramps/ladders to accommodate age-dependent locomotor abilities.



## 1. Introduction

For most animals, the ability to move from one place to another is essential for survival (Higham, 2007). Precocial birds, such as the chicken, are covered in down feathers, open their eyes whilst hatching and predominantly rely on their mother for thermoregulation (Collias, 1952; King and Farner, 1961). Within hours after hatching, however, they are able to run and walk on planar (two-dimensional) and horizontal ground and display independent activity (Muir et al., 1996; Schaller and Elmen, 1962).

Locomotion in caged systems is often restricted to two-dimensional movements on horizontal and planar surfaces. However, a natural environment with complex vegetation and topography includes three-dimensional space and inclined surfaces, thereby allowing for locomotion of different types in all three dimensions (Higham and Russell, 2010). The third dimension complicates movement by making space much larger and requiring more intricate processing and interpretation of information (Birn-Jeffery and Higham, 2014). In addition, this dimension brings the added challenge of having to recruit the muscles to perform work against gravity (Roberts et al., 1997) and control motion during descent when the leg muscles actively lengthen in eccentric contractions (van Griethuijsen and Trimmer, 2009).

There is a general effect of body size upon the use of inclined surfaces in the environment. Many animals will move up slopes, climb steep branches, or navigate in the air to reach areas above the ground in order to protect themselves from predators, aggressors, and unpleasant climatic conditions or to reach a high value food resource (Hill and Hawkes, 1983; Kraft et al., 2014; Marzluff, 1988; Stewart et al., 2007). Terrestrial bipedal ground birds, such as the chicken, navigate elevated surfaces and aerial space mainly to escape predators (Drovetski, 1996; Tobalske and Dial, 2000;

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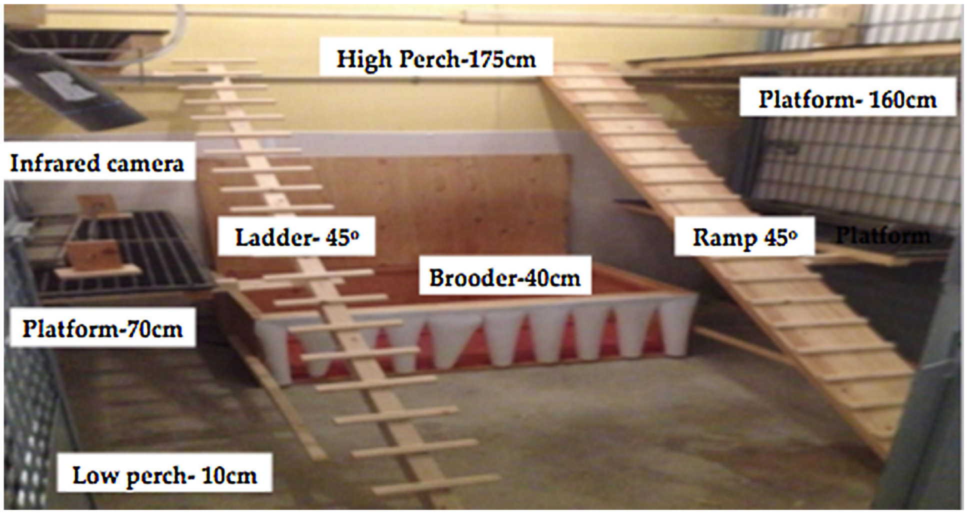


**Fig. 1.** Each experimental aviary provided a dark brooder, two platforms at each of two heights, a ramp and ladder between the ground and these platforms and two low perches. An infrared Samsung video camera was fixed overhead.

Dial, 2003). The safety risk associated with acquiring high valued resources above the ground could result in injuries and/or death, especially as a consequence of falling (Hewlett et al., 1986).

For chicks to successfully navigate and minimize the risks associated with using the third dimension, they must first obtain locomotor stability and equilibrium ability on the ground, a process which may take up to seven days post-hatch (Muir et al., 1996; Muir, 2000). Performing exaggerated locomotive behaviours (play) may aid in refining the chicks' locomotor abilities. However, such behaviour is best performed on a large flat surface, not in a complex three-dimensional system (Wells and Turnquist, 2001). Successful foraging abilities are similarly developed on the ground during the first week of life, a process that is highly dependent on social interactions with the mother hen or same-age chicks in commercial settings (Bourgon et al., 2014; Collias, 1952; Gajdon et al., 2001; Suboski and Bartashunas, 1984). Chicks also rely on the mother hen for thermoregulation and protection, which requires remaining in close proximity to her for the first week of life (King and Farner, 1961; McBride et al., 1969; Sherry, 1981). In the second week of life, chicks begin to increase their distance from the mother hen and to explore the third dimension (Muir et al., 1996; Wood-Gush, 1971).

When housing commercial hens for egg production, there are three common rearing systems used: cages (conventional or furnished), predominately two-dimensional non-cage floor systems, and three-dimensional aviary systems. These systems differ in their environmental complexity in ascending order, particularly in how much freedom of locomotion in the horizontal and vertical dimensions that they offer to the birds. Complex environments allow for chicks to express a full range of locomotion; however, they can also increase the risk of bone damage in adult laying hens (up to 80% in adult birds; Harlander-Matauschek et al., 2015; Wilkins et al., 2004), which may be detrimental to their welfare. One overarching goal of our research is to improve the understanding of how to better design and manage non-cage systems. The present research is the first step in revealing how chick's locomote when given full access to the third dimension from one day of age onwards. Previously it has been shown how juveniles of wild-type species utilize the third dimension to engage in escape behaviour (Jackson and Dial, 2011), however, the goal in the current study was to measure locomotive behaviour in the third dimension of non-distressed chicks.

Therefore, we measured the chicks' use of horizontal surfaces (ground floor and elevated surfaces) and inclined surfaces (ladders and ramps) within a complex three-dimensional environment (aviary) until 9 weeks of age. To examine potential differences in level and inclined locomotor performance, we hypothesized the following: (1) chicks would locomote more frequently on the ground level than on elevated surfaces because members of the phasianidae family are typically terrestrial (Tobalske and Dial, 2000), (2) chicks would locomote more frequently on horizontal surfaces than on inclined surfaces due to being initially top heavy (Berger et al., 2007), and (3) there would be age and strain dependent differences in the chicks' preferences for (a) locomotion on horizontal ground versus horizontal elevated surfaces and (b) for level versus incline locomotion. Based on Jackson et al. (2009), we expected that with increasing age and experience there would be an increase in three-dimensional use (air, horizontal elevated and inclined surfaces) due to maturation of morphological characteristics required to properly utilize the third-dimension.

## 2. Materials and methods

### 2.1. Ethical approval

This study was approved by the University of Guelph Animal Care Committee (Animal User Protocol Number 2501) prior to the chicks being hatched.

### 2.2. Animals and housing

This study involved the use of 30 female laying hen chicks each of Hyline Brown, Lohmann Brown, Lohmann LSL Lite, and Dekalb White (n = 120) from hatch until 9 weeks of age, whose average weights at 9 weeks were 888, 954, 815, and 776 g, respectively. The chicks were individually identified at one day of age with plastic neck-tags printed with consecutive numbers (5 × 2 cm; Ketchum, Brockville, Canada) and attached using 5-cm fasteners. They were placed into 12 identical aviary pens (10 chicks of the same line per pen) at the Arkell Research Station in Guelph Ontario, Canada. Researchers were blinded to what line of laying hen strain was in which pen to avoid biased results. Each pen (Fig. 1) (183 L × 244 W × 290 H cm) contained four elevated platforms, two on each side (122 × 31 at 70 and 160 cm above ground), with a lad-

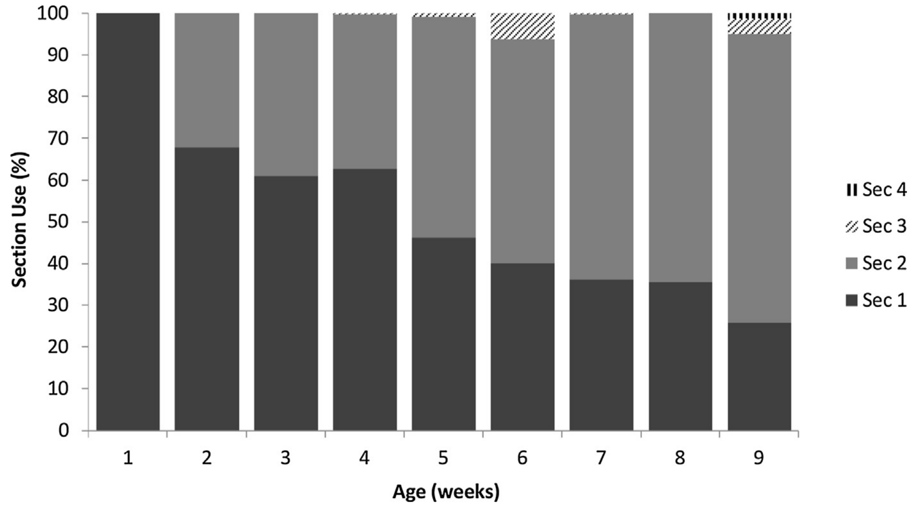


**Fig. 2.** Total percentage of all behavioural events performed by laying hen chicks in each section of elevation within the aviary throughout the 9-week trial. Percentages were calculated from a total of 4455 behavioural events and n = 120 chicks among all four strains.

der leading up to the platforms on one side (245 × 18 cm, slope 45°, 8.8 cm distance between rungs and 2.5 cm in diameter (Ø)), and a ramp leading up to the platforms on the other side (same dimensions, slope and material as the ladder but with no gaps between rungs). The sides of the ramp and ladder, respectively, were counterbalanced across the pens. On the ground was a small round perch (87 × 1 cm (L × Ø); 5 cm off the ground) and a dark brooder (98.5 × 73 × 39 cm) containing a heating pad (turned on during the first week of age), white curtains (to allow freedom of movement in and out while providing complete darkness to mimic a mother hen), and two small round perches extending past the brooder entrance (74 × 2.5 Ø × 15 cm off the ground). An elevated, spring mounted (to imitate a tree-branch landing) perch spanning the width of the pen, was mounted 14 cm above the highest platform towards the rear end of the pen, with the two halves of the perch different in diameter (2.5 cm Ø vs. 5 cm Ø). The halves of the perch were counterbalanced across the pens based on the ramp and ladder. Each of the pens contained thin white cardboard panels mounted onto the aviary's walls, which were used as visual barriers to prevent chicks from observing and learning from chicks in adjacent/opposite pens. One Samsung SNO-5080 R security camera (Samsung SNO-5080R, IR, Samsung Techwin Co., Gyeongi-do, Korea) was mounted in each pen to record the chicks' behaviour. At 4 weeks of age, the cameras were moved to the top of the pen to capture the chicks using the entire pen. Thirty-minute video recordings were taken of each pen, once per week (on different days of the week), 7 h after the lights had turned on (5:00 h sunrise daily) using Samsung Net-I-Ware software (v1.41, Samsung Techwin CO., Gyeongi-do Korea). The chicks were offered water and food ad-libitum (grower feed from Arkell Poultry Research Station) via five nipple drinkers and round metal feeders (38 Ø cm), which were available on the ground. The floors of the pens were covered in wood shavings. The chicks were provided with a 30-min sunrise and sunset each day. The chicks were provided with 23 h of light on day 1, which gradually decreased over time to 10 h in week 9.

### 2.3. Video recording and analysis

Videos were analyzed by one individual using Mangold Interact software (v9.7.4, Mangold International GmbH, Arnstorf, Germany, 2014). The pens were visually divided into four sections: ground (S1); low perch to first platform (S2; 15–69 cm); in-between the first and second platform (S3; 70–159 cm); and the second platforms and high perch (S4; 160+ cm). Throughout the entirety of each 30-min video, each locomotive and perching event was counted as one occurrence until the chick performed another locomotive or perching behaviour. Our criterion was based on second-by-second changes in locomotor or perching events (Ex: if a bird walks for 3 s, stops for 2 s, and then begins to walk again, this would count as two locomotor events). Locomotor events required a change in position, whereas perching events required no change in position and therefore could not simultaneously be recorded. Behavioural patterns were individually counted for in each section (S1–S4) and for the ramp and ladder. Each section was individually analyzed and for analysis purposes was additionally grouped into five variables: ground (S1) locomotion (walking, running, or jumping on the ground); elevated locomotion (S2–S4) (walking, running, or jumping on surfaces above the ground, including ramp and ladder); aerial locomotion (behaviour performed in-between two surfaces such as between two elevated surfaces or between the ground and an elevated surface) which included jumping and controlled aerial ascent/descent (use of wings to guide transition) (Dial, 2003); behaviour performed exclusively on the ramp and ladder, and perching behaviour. We computed the relative frequency of events by dividing the locomotive events on a given level by the total number of events in all sections and multiplying by 100 to yield a percentage.

### 2.4. Statistical analysis

Statistical analysis was performed using the generalized linear mixed model procedure (PROC GLIMMIX) in SAS version 9.4 (SAS Institute Inc., Cary, NC, USA, 2012). Plots of studentized residuals were used to assess normality and confirm the best fitting distribution. Full models with all fixed and random effects were then fit to the appropriate distribution and model fitting criteria (AIC) were used to select the best fitting model.

The frequency of locomotive and perching behavioural events per pen and behavioural events performed on the inclined ladder/ramp or in the air within 30-min were tested for significant differences using a generalized linear mixed model procedure with a negative binomial distribution. The line and week (age of chicks) and interactions were included as fixed effects, and lines were nested within pens as a random effect. Parameters were estimated using LAPLACE integral approximation (METHOD = LAPLACE). A first order autoregressive covariance structure (TYPE = AR(1)) was used with pen as the repeated measure subject. All dependent variables (count outcomes) were fit with log link (LINK = LOG)

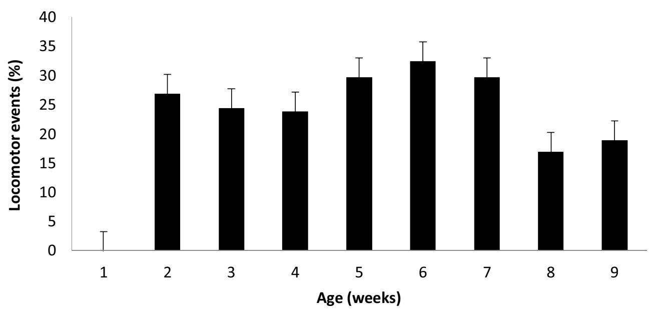


**Fig. 4.** Percentage of all locomotor events from all behavioural events (n = 120 birds, and total behavioural events = 4455) classified as aerial (jumping and controlled aerial ascent/descent).

and denominator degrees of freedom were determined using the residual method (DDFM = RESIDUAL) in the GLIMMIX procedure (Littell et al., 2006). Planned comparisons using orthogonal contrasts were used to test for differences between the first week where the specific behaviour occurred and the following weeks using Fisher's protected *t*-test. The least square estimates and their standard errors were converted to the data scale using the inverse link (ILINK) option in the least square means (LSM) statement. The number of locomotive and perching events are presented as LSM ± standard error of the mean (S.E.M).

## 3. Results

The chicks chose to remain low within the pen. During the observation periods, an average of 52% of all locomotive events was performed on the ground (S1) and 46% of all locomotive and perching events occurred within S2, mostly because chicks started using the low elevated perches after one week of age. Only 1.3% of all locomotive and perching events were performed in S3 and 0.1% were performed in S4 across the entire 9-week trial (Fig. 2**).** Locomotive and perching events that occurred on elevated surfaces (S2–S4) increased over time from a total of 0% in week 1 to 74% of all events in week 9. Locomotive and perching events on inclined surfaces (ramps/ladders) peaked between weeks 2 and 5, while their use was not observed at all in the first week of life as well as from week 6 to 9 (Fig. 3). Aerial behavioural events declined over time from 27% to 19% of all locomotive events from weeks 2 to 9 (Fig. 4).

### 3.1. Space use over time

Chicks preferred leveled ground (S1) significantly ($F_{1,72}$ = 75.8, P < 0.0001) more during their first week of life (33.7 ± 6.3) compared to weeks 5 (13.3 ± 2.7, P = 0.001), 6 (15.8 ± 3.1, P = 0.006), 7 (12.9 ± 2.6, P = 0.0007), 8 (8.2 ± 1.7, P < 0.0001) and 9 (7.1 ± 1.5, P < 0.0001), presented as percentage of all behavioural events performed by laying hen chicks in each section of elevation in Fig. 2.

Locomotive and perching events were not performed in S2 during week 1 (Fig. 2); however, there was no significant effect of week on the number of behavioural events performed during weeks 2–9 ($F_{1,64}$ = 0.65, P = 0.42). Behavioural events performed in S2 can be attributed to use of the low elevated perches located within this section, which were used after the initial week of age. There was no effect of week on the number of perching behavioural events during weeks 2–9 ($F_{1,72}$ = 0, P = 0.99).

Apart from weeks 2 to 5, chicks did not perform any locomotive or perching behavioural events on the inclined surfaces of the ramp or ladder (Fig. 3). Ladder events ($F_{1,32}$ = 0, P = 0.986) peaked in week 2, while ramp events significantly ($F_{1,32}$ = 5.2, P = 0.03) peaked in week 3. Ramp behavioural events significantly (P = 0.05) declined over time from 3.2 ± 1.4 in week 2 to 0.8 ± 0.5 in week 5.

Locomotor and perching behavioural events on elevated surfaces increased over time ($F_{1,64}$ = 9.4, P = 0.003) from 13.4 ± 2.5 in week 2 to 21.1 ± 3.8 in week 9 (P = 0.08).

Chicks performed significantly more aerial behavioural events (Fig. 4) (behaviour performed between two surfaces) (S1–S4); controlled aerial ascent/descent or jumping ($F_{1,64}$ = 157.03, P < 0.0001) in week 2 (4.2 ± 1.2) compared to weeks 5 (0.02 ± 0.02, P < 0.0001), 8 (0.5 ± 0.33, P = 0.0001) and 9 (0.04 ± 0.05, P = 0.001).

Overall activity levels demonstrated a significant decline in locomotor behavioural events ($F_{1,72}$ = 32.9, P < 0.0001) from 33.2 ± 6.9 in week 1 to 11.2 ± 2.5 in week 8 (P = 0.0007) and 14.8 ± 3.7 in week 9 (P = 0.01).

### 3.2. Behavioural differences between lines

Above the ground in S2, Lohmann LSL Lite chicks (27.9 ± 4.5) performed a higher number of locomotor events ($F_{3,64}$ = 4, P = 0.01) compared to Dekalb White chicks (17.6 ± 2.9, P = 0.05), Lohmann Brown chicks (15.9 ± 2.6, P = 0.02) and Hyline Brown chicks (12.7 ± 2.1, P = 0.001).

Lohmann LSL Lite chicks (19.5 ± 2.5) performed locomotive and perching events on elevated surfaces (S2–S4) significantly more often ($F_{3,64}$ = 2.7, P = 0.05) than Lohmann Brown chicks (13.5 ± 1.9, P = 0.04), Dekalb White chicks (12.9 ± 1.7, P = 0.02) and Hyline Brown chicks (12.1 ± 1.7, P = 0.01).

Lohmann LSL Lite chicks (2.93 ± 3.22) performed significantly more aerial behavioural events ($F_{3,64}$ = 29.77, P < 0.0001) than Dekalb White chicks (1.35 ± 1.22, P = 0.0145) and Lohmann Brown chicks (0.38 ± 0.28, P < 0.0001), and Dekalb White chicks performed significantly more aerial behavioural events than Lohmann Brown chicks (P < 0.0001).

## 4. Discussion

This study demonstrated chicks' preferential use of the ground and lowest level (S2) of an aviary with enhanced access to the third dimension of an aviary system given horizontal and inclined elevated surfaces. S1 (ground) locomotive behavioural events declined over time and chicks began to perform more locomotive and perching behaviour in the third dimension (S2) as early as 2 weeks of age. Over time, the proportion of third dimension events (S2–S4) increased, however overall activity levels declined. Overall, the LSL Lite chicks utilized the third dimension more than the other three lines under these circumstances.

### 4.1. Ground use (S1)

There are several explanations for why *Gallus gallus domesticus* chicks performed 52% of all behavioural events on the ground. Relevant resources, including food, water and a dark brooder (allowing for undisturbed rest), were provided on the ground, which is also the largest horizontal surface of pen space available. Large leveled space permits chicks to safely explore and experiment with exaggerated motions and play behaviour. Extensive movements on the ground during the first few weeks of life give chicks the experience they require to refine their locomotor behaviour and to allow for muscle development that is essential to navigate their environment as they mature (Brownlee, 1954; Muir et al., 1996; Muir, 2000). Furthermore, through play behaviour and remaining in close proximity to other conspecifics, chicks are able to develop successful foraging strategies and social skills (Bourgon et al., 2014; Collias, 1952; Gajdon et al., 2001; Suboski and Bartashunas, 1984). Thus, remaining on the ground may be attributed to foraging, learning indispensable locomotor skills and social opportunities.

There are also morphological explanations as to why chicks and chickens mainly reside on the ground. *Gallus gallus domes-*

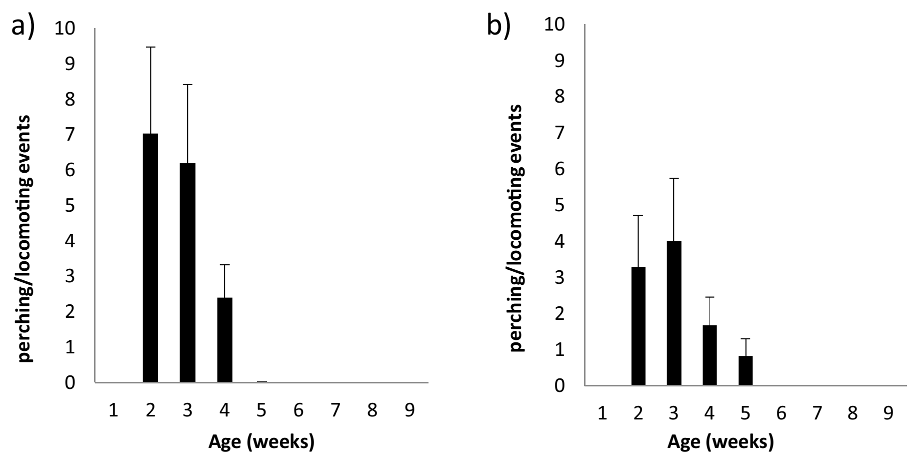


**Fig. 3.** Mean number (LS Means ± SEM) of locomotive and perching behavioural events performed by laying hen chicks (n = 120) occurring on inclined surfaces (ramp (a) and ladder (b)) over time.

*ticus* have large and dominant hind limbs, which may be due to a trade-off associated with the ability of precocial chicks to almost immediately walk and run, allowing for their leg muscles to build quickly before forelimb maturation (Heers et al., 2014; Jackson et al., 2009). Their primary flight muscles are also glycolytic and rapidly fatigue, only allowing small bouts of controlled aerial ascent/descent (Crabtree and Newsholme, 1972). Overall, these morphological characteristics lead to *Gallus gallus domesticus* being non-steady, explosive fliers and maladapted for controlled aerial ascent and descent in complex environments, all of which limits their use of vertical habitat.

### 4.2. Elevated surface use (S2–S4)

After week 1, chicks performed 46% of all locomotive and perching events in S2 by mainly utilizing the perches. Gunnarsson et al. (2000) found that chicks began to use perches 10 cm above the ground at 8 days of age, and Riber et al. (2006) found that chicks began to use perches 20 cm high at 9 days of age. Under natural conditions, hens often lead chicks to low tree branches during the day at 4 weeks of age to promote roosting behaviour (McBride et al., 1969). It is likely that the low branches were much higher than the perches in the current study (15 cm off the ground) prompting a later start date for perching. It is recommended to provide chicks with easily accessible perches as soon as possible to allow them to gain the essential spatial cognitive abilities they require to navigate the third dimension (Faure and Jones, 1982; Gunnarsson et al., 2000). To further address the benefits of early three-dimensional access, at 37 weeks of age the birds in the current study were assessed for injuries and keel bone deformities; however, very few birds contained either (personal observation). This suggests that having access to three-dimensional space earlier in life provides opportunities to develop complex locomotion skills earlier in life, which in turn, decreases the likelihood of injuries associated with learning these same skills at a later age. Other benefits of early access to perches include: increased bone mineral deposition and bone strength (Enneking et al., 2012), improved muscle composition by promoting endurance exercise (Holloszy and Coyle, 1984; Levan et al., 2000), fewer floor eggs later in life (Appleby et al., 1983, 1988; Colson et al., 2008), less cloacal cannibalism (Gunnarsson et al., 1999) and reduced contact with manure.

There was an increasing trend in elevated surface (S2–S4) use over time, where S3 and S4 were first used at 4 and 9 weeks of age; however, only 1.3% and 0.1% of all locomotive and perching events were performed in these sections. Neither food nor water was provided in S2, S3 or S4, therefore chicks were possibly reaching these higher areas to roost (Gunnarsson et al., 2000; Newberry et al., 2001; Riber et al., 2006), due to social attraction (Bertram, 1978; Hill et al., 1986; Washburn and DeVore, 1961), to escape aggressive chicks (Duncan, 1992; Tauson, 1984) or due to curiosity and exploratory behaviour, which are connected with cognitive development (Lancy, 1996; Wells and Turnquist, 2001). Studies have shown that chickens are highly motivated to access elevated areas to roost, where the highest accessible area is preferred (McBride et al., 1969; Olsson and Keeling, 2002; Schrader and Müller, 2009; Wood-Gush and Duncan, 1976). Roosting is considered an anti-predator behaviour, providing a feeling of security and can be observed during the first few days of life, where less escape behaviour is seen at greater heights (Keeling, 1997; Newberry et al., 2001). However, other research suggests that such costly anti-predator behaviour in chickens is diminishing due to genetic selection with domestication (Håkansson and Jensen, 2005).

The theory of genetic selection against anti-predator (three-dimensional use and perching) behaviour may explain why all lines, except LSL lite, did not utilize S4 during the daytime (personal observations also demonstrated that they did not use S4 at night either). Faure and Jones (1982) also observed a strain effect with perching behaviour, where White Leghorns, Rhode Island × Light Sussex cross hens, and Brown Leghorn hens perched in decreasing order respectively, suggesting perching behaviour has high genetic variance. Furthermore, Brown Leghorns only perched on wire mesh, refusing wood perches, indicating that perch material preferences may differ between strains. It is possible that the hens in the current study preferred different perching material and generations of genetic selection might have affected their motivation to perch. Another possibility could be that strains with heavier body weights have a more difficult time accessing elevated space. Strain preferences should be considered with housing design.

There are morphological reasons as to why elevated surface use increases over time. Initially when the chicks hatch, their tails, which are essential for support and balance for climbing and controlled aerial ascent/descent, are short and almost non-existent (Norberg, 1986). Chicks also have porous, fluffy feathers that inadequately aid in controlled aerial ascent/descent and balance especially with wing assisted incline running (WAIR) (Dial and Jackson, 2010; Heers and Dial, 2012). Additionally, they have a center of mass that is unlike a mature hens' (Muir et al., 1996), toes that are small with uncurved claws that hinder proper climbing (Birn-Jeffery et al., 2012; Norberg, 1986), and ground locomotive behaviour that is not yet refined, all of which are essential to use a complex three-dimensional environment (Muir et al., 1996;

Muir, 2000). Over time, many of these morphological characteristics begin to mature into a more suitable state for flight and three-dimensional activity. However, it is important to remember that such characteristics that define the chicken do limit their three dimensional locomotor capabilities, even at a mature age.

### *4.3. Incline surface use and aerial behaviour*

Chicks were using the ramp and the ladder, during weeks 2–4 and 2–5 respectively. In wild chukars, WAIR has been observed as early as 8 days of age to assist with accessing the third dimension and flight development (Dial, 2003). LeBlanc et al. (2016) found that domestic chicks performed WAIR at 50° inclines but not at 40° inclines, and therefore it is possible the chicks in the currently study performed WAIR on the ramp and ladder (45°) to help climb against gravity (Dial, 2003). Chicks/infants are initially top heavy, making it harder to descend than ascend, which may cause a challenging ramp/ladder experience and thereby discourage further use for the rest of the trial until the birds obtain mature aerial locomotive characteristics and abilities (Berger et al., 2007).

Aerial behavioural events along with overall activity levels (overall locomotive behavioural events) declined over time. A decrease in locomotive events over time has been observed in chickens as well as in other species, including humans, to conserve energy (Dial and Jackson, 2010; Sallis, 2000). A general biological pattern is that large size is associated with a decline in mass-specific power (e.g. Jackson and Dial, 2011; Tobalske and Dial, 2000). However, with the decline in ramp, ladder and aerial behavioural events, and an increase in the number of events performed on elevated surfaces, it is possible that the chicks were reaching these higher sections and remaining there, making it difficult to capture ramp/ladder and aerial locomotive events during the 30-min video observation period.

Further studies are currently being completed to observe locomotor and three-dimensional preferences to bridge the gap in knowledge of transitions in capacity among chicks, pullets, and mature laying hens. Future research in adult laying hens kept in complex multi-tier environments should test the interactions between physical impairments (keel bone damage, foot pad dermatitis, and poor feather cover) and horizontal/incline surface preferences. Based on personal observations in this study, early access to the third dimension revealed minimal injuries when the birds were 37 weeks of age. Implications of reducing injuries include improving bird welfare and health, feed conversion, egg output, etc. (Nasr et al., 2012, 2013). However, birds with injuries may have locomotive preferences that best accommodate their condition. The implications of these results are that introducing lower perches/platforms and ramps/ladders to rearing environments might improve and train chicks to use the third dimension during rearing and this may impact space use later in life.

## 5. Conclusions

In this study we tested the preferences of chicks within a multi-tier environment. The main result was that chicks preferred the ground, but from two weeks of age onwards the chicks progressively increased the number of locomotive and perching events on elevated surfaces. Elevated incline surface events were observed during intermediate weeks. Three-dimensional access to low elevated perches, platforms and ramps/ladders should be provided as early as possible to allow for proper development and may prevent a high incidence of injuries observed later in life by accommodating chicks' basic locomotor abilities and removing flight as a requirement to access the third dimension.

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