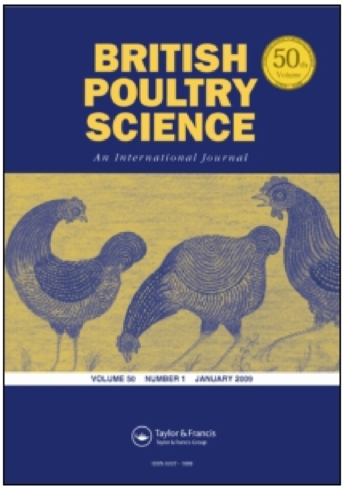

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Effect of environment on Pekin duck behaviour and its correlation with body condition on commercial farms in the UK

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Effect of environment on Pekin duck behaviour and its correlation with body condition on commercial farms in the UK

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Abstract 1. Forty-six flocks of commercially-reared Pekin ducks were studied to determine the effects of housing system and environment on the behaviour of farmed ducks and its correlation with physical condition. Houses differed predominantly in their ventilation, drinking, feeding and brooding systems, and were indicative of systems currently in use in the UK.

2. At 41 d of age ducks spent 1·5% of the time feeding, 6·7% drinking, 4·2% rooting and 15·5% dry preening. They spent large amounts of time relatively inactive, 43·5%, or performing comfort behaviours, 17%. On average 4·6% of their time was spent walking and only 1·8% wet preening.

3. A greater proportion of the maximum number of ducks able to use the drinker at any one time used the trough; nipple use was least and Plasson use intermediate. The proportion of ducks wet preening was not affected by drinker type but increased with increasing drinker space (mm/bird).

4. Duck behaviour was little affected by commercial production system and was influenced more by environment, age and physical condition. Activity at an older age incorporated more of the behaviours associated with thermal comfort (panting) and maintenance of plumage condition (dry and wet preening). These behaviours increased with increasing temperature, relative humidity and atmospheric ammonia. Poor walking ability was correlated to increased frequency of panting, reduced activity at the drinker, and longer resting bouts.

INTRODUCTION

Ducks reared commercially for meat in the UK are mostly Pekin strains, which are descended from the wild Mallard (*Anas platyrhynchos*). The Mallard spends much of its time in water and at the water's edge performing complex social behaviours, feeding, bathing, swimming, "up-ending" and diving, and resting (McKinney, 1975; Campbell & Lack, 1985). Domestication and selection for production traits have altered commercial strains of duck so they are now very different from the wild ancestor. For example, the domesticated duck is less aggressive, engages in more social contact, and is less fearful (Desforges & Wood-Gush, 1975*a*, *b*). Importantly, it has an altered bill so that it is better suited to pecking for food on land than sieving for food in the water (Kooloos & Zweers, 1991), and despite its size (3·5 kg) it is only a juvenile (42–53 d) when processed. It does, however, perform complex behavioural sequences usually of feeding followed by bathing, preening and sleep (Reiter *et al.*, 1997; Council of Europe, 1999).

Welfare concerns for commercially-reared ducks largely centres on their access to open water and ability to perform bathing behaviours required for the maintenance of plumage condition, and clean eyes and nostrils (Council of Europe, 1999). Important elements of bathing are considered to be the immersion of the head and wings, shaking water over the body, followed by an elaborate sequence of cleaning movements, such as preening and head and wing-rubbing, to distribute oil on the feathers from the uropygial gland (Campbell & Lack, 1985). The well-oiled feathers keep the feather structure flexible which

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is required for waterproofing and heat regulation (Rodenburg *et al.*, 2005).

Commercially, ducks are reared with access to troughs, Plasson drinkers (large bell drinkers) or nipple drinkers. Previous research has shown that ducks prefer sources of open water (Cooper *et al.,* 2002; Ruis *et al.,* 2003; Jones *et al.,* 2009), and that access to open water leads to improved production (Reiter *et al.,* 1997) and physical condition (Knierim *et al.,* 2004; Heyn *et al.,* 2009; Jones *et al.,* 2009; Jones & Dawkins, 2010). Some studies have investigated alternative sources of open water in commercial practice (Benda *et al.,* 2004; Knierim *et al.,* 2004; Heyn *et al.,* 2006), and pen trials have shown that troughs and showers match baths for amount of bathing activity (Jones *et al.,* 2009) and expression of behaviours within the bathing sequence (Waitt *et al.,* 2009).

To date, few studies have investigated factors other than water provision that affect plumage condition, physical health (Raud & Faure, 1994; Jones & Dawkins, 2010) and behaviour. The aim of this study therefore was to investigate the effect of environment and house design on behaviour and to correlate physical condition and behaviour in the duck. Behaviour was examined via direct focal analysis and video records of ducks at feed and water resources; environment included measures of temperature, relative humidity, litter condition and atmospheric ammonia; whilst house design varied according to type of ventilation, feed and water resource, brooding system, orientation and size of house, and stocking density.

METHODS AND MATERIALS

Forty six commercial flocks of ducks reared through 23 houses (involving 448 011 ducks) belonging to three major duck companies in the UK and representing 5 non-discrete housing systems were used in the study. Housing systems were indicative of those currently in use in the UK and differed primarily in their ventilation, drinking, feeding, and brooding systems (Jones & Dawkins, 2010). Water was provided in the form of troughs in 10 of the 23 houses (average 5·3 mm/bird, range 4·1–5·9 mm/bird), turkey Plasson drinkers in 5 houses (average 6·1 mm/bird, no range), and nipple lines in 8 houses (average 5·8 mm/bird, range 2·5–10 mm/bird). Feed was provided from hoppers in most houses ($n = 17$, average 7·3 mm/bird, range 5·3–9·5 mm/bird), whilst three houses provided tube feeders (4·3 mm/bird no range) and three provided pan feeders (12 mm/bird, no range).

A wide range of environmental variables, body condition scores and production data were collected (Jones & Dawkins, 2010). Temperature and relative humidity (RH) were recorded hourly throughout the growth cycle (TinyTag Plus loggers, Chichester, UK). At 5 pre-determined random points litter moisture, temperature and pH (Hanna HI 991 000 combination probe), and atmospheric ammonia (Gastec pump-set GV-100s, Kanagawa, Japan) and light intensities (ISO-Tech digital meter), were measured. In addition, 10 ducks per grid were visually inspected and scored for the condition of their eyes, nostrils, feathers, posture and walking ability (gait), (score 0 = best, 1 = moderate, 3 = severe conditions). All measures were taken midway (23 d) and at the end of the growth cycle (41 d). Company data for percent mortality and flock weight at slaughter was collected and average flock growth rate and maximum stocking density calculated (kg/m^2 = total weight of ducks removed from house at slaughter/area of house).

Behaviour

Between 09:00 and 12:00 h and at 23 and 41 d of age, two ducks per flock (total 196 ducks) were randomly selected by pre-determined grid position and algorithm, and all behaviour over a 10 min period directly recorded according to the definitions in Table 1. The morning was chosen for our observations to ensure the behaviour was not affected by our physical and environmental assessments which occurred in the afternoon. Focal behaviour was summarised for the frequency and duration of stand, lie, feed, drink, root in straw, dry preen, rest (eyes closed/alert), bathe/wet preen, and walk/run (including the number of strides), and the frequency of stretching and comfort behaviours, such as wing lifts, wing flap, stretch head, shake tail, shake tail/body/head.

On the following day (between 09:00 and 12:00 h), wide angle CCTV cameras radio linked to a VCR (Computar CTR 3024) in the ante room of each house, were installed at two points in the house close to the feed and water resources. Ten-minute video records of each camera view were made in two cycles, so that in total 40 min of real time video was recorded per flock. Videos were subsequently scan sampled every 30 s for the number of ducks using the drinker or feeder over a 7 min period (equivalent to the maximum useable footage time across all camera switches), and the number of ducks bathing/wet preening at the water resource. In addition, the number of ducks joining and leaving the resource over a randomly allocated 2 min sub-sample period was recorded. The number of feeders and drinkers visible were noted and the maximum number of ducks that could feed or drink from each resource at any one time was noted where

Table 1. *Behavioural definitions for the direct observation of ducks in commercial systems*

Behaviour	Definition
Root	Duck digs and moves straw around with beak
Root-dab	Duck performs dabble motions (rapid nibbling with head moving side to side) in straw
Alert	Duck lies or stands stationary but is alert to surroundings and watchful
Feed	Ducks eats food from the feed trough, hopper or pan
Drink	Duck drinks from the water resource
Drink-dab	Duck performs dabbling motions with its head in the water
Rest	Duck lies down with eyes closed
Settle to rest	Duck lies down and closes and opens its eyes every few seconds as it settles into rest
Dry Preen	Duck nibbles at or strokes its feathers, maintaining its plumage; no water is involved
Wet preen	Duck nibbles at feathers with the application of water by either taking water into its bill and preening (from trough or nipple) or head ducking (into trough) & tossing water over its body then preening. 'Duck/dive' and wing rub are also included as part of the bathing sequence.
Groom	Duck dry preens another duck
Lie stretched out	Duck lies down with one or two legs fully stretched out behind its body, neck is usually elongated on the floor
Peck object	Duck pecks at any object other than a feeder or drinker
Shake tail	Duck stands and wags its tail independent of a preening act
Walk	Locomotion, the number of strides were also counted
Small body movements	Includes: head scratch; stretch wing, leg or wing & leg; shake body, shake head, shake tail – body – head (complex all over feather ruffle), wing flap, lift wing (small wing raises performed as the duck settles), vocalise, defecate, yawn (jaw stretch), small mandible movements (open/close). The number of incidents were recorded.
Pant	Duck hyperventilates with open beak to aid evaporative cooling

possible, or calculated (as 15 cm/duck for troughs, hoppers, Plasson or pans; two ducks per nipple drinker). The proportion of that maximum present at the resource, or joining or leaving the resource was then calculated. Finally, the number of ducks wet preening at the resource was given as a proportion of the number of ducks at the water resource.

Statistical analysis

The independent statistical unit was the flock. Repeat data between the two ages were not amalgamated and were analysed separately, however the effect of age was tested simply using a paired *t*-test. Frequency and duration of direct focal behaviour were analysed for the effects of system and season by ANOVA (General Linear Model, GLM). Since there were few, if any, effects of system on behaviour, detailed analysis of the effect of the component types were not conducted. Instead, univariate linear correlations between behavioural outcomes and continuous environmental and duck variables (with Pearson correlation at $P<0{\cdot}001$), in line with Dawkins *et al.* (2004) were constructed. Each model was tested for normality of residuals and appropriate transformations made where necessary (Grafen & Hails, 2002). Significant effects were examined by *post hoc* Tukey comparison (for categorical predictors) and fitted line regression analysis (for continuous predictors).

Behaviour at the feed and water resources was analysed for the effect of feeder and drinker type by ANOVA (GLM) with the inclusion of significant (at the $P<0{\cdot}001$) univariate linear correlations. Table 2 describes the components of the housing systems used in the study and the number of flocks represented for each type of component. At 41 d, data from 44 flocks were included in the analysis of direct focal behaviour and 33 flocks included in the analysis of behaviour at the resource. Missing data occurred in flocks where ducks were unable to settle at the presence of the observer or the camera within a 30 min time frame, where the view of the resource was obstructed, or where equipment failed.

Table 2. *Components of the different housing systems included in the study along with the number of flocks of each type used for direct and indirect behavioural analysis at 41 d*

Component	Type	Number of flocks Direct observation	Number of flocks Resource use
Ventilation	Natural	24	
	Forced side-inlet	10	
	Forced drop-down	10	
Drinker system	Trough	20	11
	Plasson	10	9
	Nipple	14	13
Feeder system	Hopper	32	22
	Pan and tube	12	11
Brooding system	Nursery	5	
	Circle	15	
	Half house	8	
	Whole house	16	
House orientation	North-South	24	
	East-West	20	

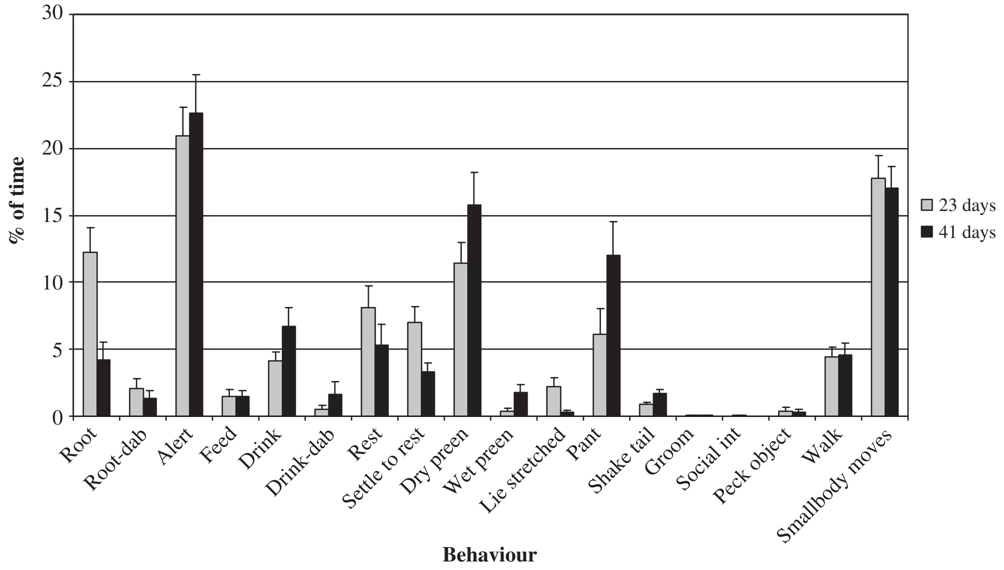

Figure 1. *The percentage of time (+ standard error bars) ducks spend performing various activities at 23 d and 41 d of age.*

RESULTS

Focal behaviour

The way in which ducks proportion their time at 23 and 41 d of age is given in Figure 1. When younger, ducks spent less time standing (19·4% at 23 d compared to 46·1% at 41 d, $t = -5{\cdot}2$ $P < 0{\cdot}001$), and more time rooting in the straw ($t = 2{\cdot}9$ $P < 0{\cdot}01$), settling to rest ($t = 2{\cdot}4$ $P < 0{\cdot}01$), and lying stretched out ($t = 2{\cdot}8$ $P < 0{\cdot}01$). When older, ducks spent more of their time wet preening ($t = -3{\cdot}1$ $P < 0{\cdot}01$), panting ($t = -2{\cdot}4$ $P < 0{\cdot}01$) and shaking their tail ($t = -2{\cdot}9$ $P < 0{\cdot}01$). Ducks at this age (average 41 d) spent a mean 1·5% of the time feeding, 6·7% drinking, 4·2% rooting and 15·5% dry preening. They spent large amounts of time relatively inactive, (43·5% in total), either remaining stationary but alert, resting, settling to rest, or panting; most of the rest of the time (17%) they performed comfort behaviours such as leg, wing, or head stretches, shaking their body or head; wing flapping, wing lifting, and small mandibular movements. On average 4·6% of their time was spent walking and only 1·8% (range 0–15.1%) wet preening.

There were few effects of housing system or season on behaviour. Ducks performed more comfort behaviours in winter at both ages (23 d: $F = 10{\cdot}8$ $P < 0{\cdot}01$, 43 d: $F = 26{\cdot}5$ $P < 0{\cdot}001$), and shook their tails more in winter at an older age ($F = 16{\cdot}8$ $P < 0{\cdot}001$). At 23 d ducks rested more in houses with natural ventilation and troughs (16·1%) and drop-down ventilation with nipple drinkers (13·5%) than the other houses studied (2·8–6·1% $F = 5{\cdot}7$ $P = 0{\cdot}001$). When older, wet preening was significantly lower in houses with nipple drinkers <1·0% ($F = 3{\cdot}4$ $P < 0{\cdot}05$) and averaged 2·4 and 3·9% in houses with troughs and Plasson drinkers, respectively.

The average bout length for behaviours at the two ages is given in Figure 2. Ducks stood for longer periods (56·2 s at 23 d compared to 215·5 s at 41 d, $t = -6{\cdot}5$ $P < 0{\cdot}001$), and lay down for shorter periods (325 s compared to 247 s, $t = 2{\cdot}1$ $P < 0{\cdot}05$) when they were older. They also had longer bout lengths of dry ($t = -2{\cdot}1$ $P < 0{\cdot}05$) and wet preening ($t = -2{\cdot}7$ $P < 0{\cdot}05$) when older. When younger, they had longer bout lengths of rooting ($t = 3{\cdot}0$ $P < 0{\cdot}01$), settling to rest ($t = 2{\cdot}1$ $P < 0{\cdot}05$), and lying stretched out ($t = 2{\cdot}4$ $P < 0{\cdot}01$).

At 23 d, ducks rested more in houses with an east-west orientation ($F = 10{\cdot}6$ $P < 0{\cdot}01$) and were observed to settle to rest more under conditions of increasing RH (week 3, $F = 7{\cdot}5$ $P < 0{\cdot}01$). Increasing RH variation was correlated to increased dry preening (week 4 $F = 13{\cdot}8$ $P = 0{\cdot}001$) and comfort behaviours (week 3 RH variation $F = 15{\cdot}1$ $P < 0{\cdot}001$). Ducks panted more and for longer duration with increasing levels of atmospheric ammonia ($F = 10{\cdot}8$ $P < 0{\cdot}01$, bout length $F = 7{\cdot}5$ $P < 0{\cdot}01$) and with a higher incidence of severe gait abnormalities ($F = 11{\cdot}9$ $P = 0{\cdot}001$, bout length $F = 8{\cdot}1$ $P < 0{\cdot}01$). Average panting rate occurred at 6·6 ppm ammonia ($\text{pant} = -6{\cdot}8 + 1{\cdot}96\,\text{ppm}$) and 1·2% severe gait abnormality ($\text{pant} = 1{\cdot}5 + 3{\cdot}9$ gait 2). Panting at 23 d started when average weekly temperature (week 4) reached 17·7°C. Bout lengths for stand ($F = 7{\cdot}7$ $P < 0{\cdot}01$), root ($F = 5{\cdot}2$ $P < 0{\cdot}05$), and walk ($F = 5{\cdot}9$ $P < 0{\cdot}05$) were all positively correlated to birds with an upright posture.

At 43 d, the proportion of time standing was positively correlated to drinking ($F = 7{\cdot}5$ $P = 0{\cdot}01$) and walking ($F = 5{\cdot}1$ $P < 0{\cdot}05$). Settling to rest and comfort behaviours were negatively

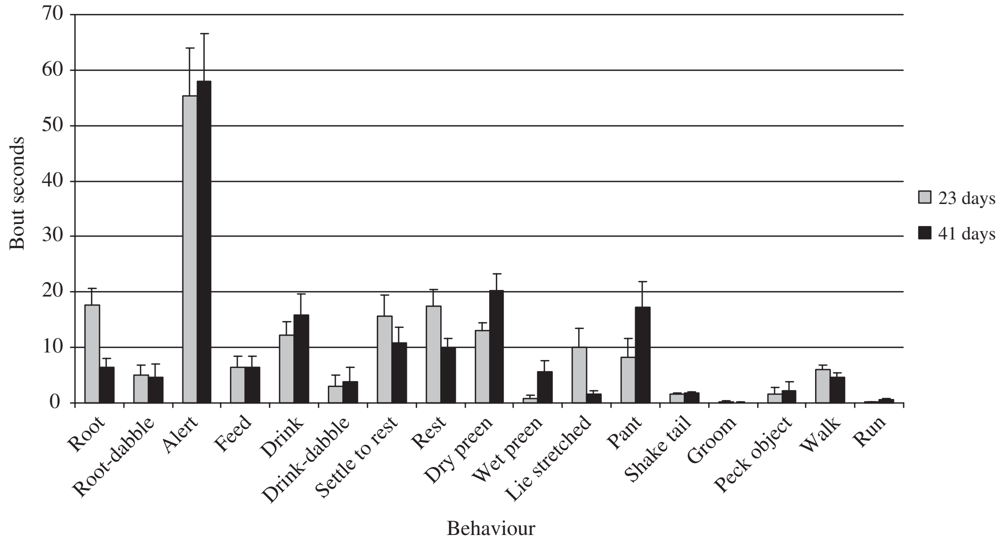

Figure 2. *Average activity bout length (+ standard error bars) for ducks at 23 d and 41 d.*

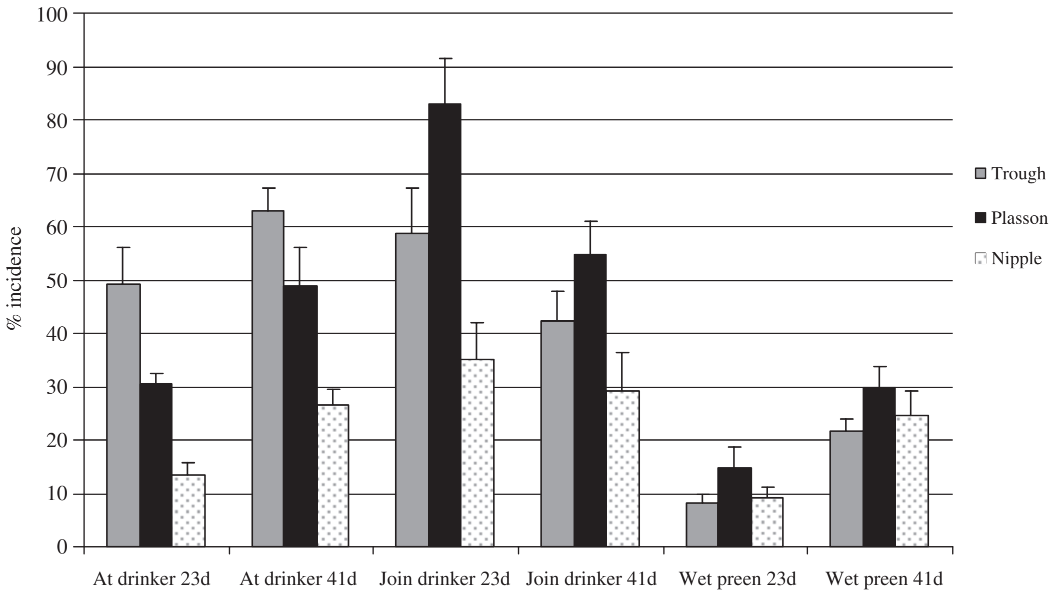

Figure 3. *The proportion of ducks using and joining the water resource, as a percentage of the maximum that can use the resource at any one time, and the proportion of ducks at the resource performing wet preening (+ standard error bars).*

correlated ($F = 10{\cdot}5$ $P < 0{\cdot}01$) and ducks shook their tails more with increasing temperature and RH variation in weeks 3 and 2, respectively (minimum $F = 9{\cdot}9$ $P < 0{\cdot}01$). Ducks panted more with increasing week 5 temperatures ($F = 7{\cdot}9$ $P < 0{\cdot}01$) and started to pant when average weekly temperature reached 14·8°C (pant = $-10{\cdot}8 + 1{\cdot}54T$). Panting bout length (average 17·3 s, maximum 123 s) increased with increasing stocking density ($F = 11{\cdot}6$ $P < 0{\cdot}01$) and was negatively correlated the incidence of clean eyes ($F = 19{\cdot}4$ $P < 0{\cdot}001$). Resting bout length (average 10·8 s, maximum 88·8 s) was shorter in ducks with the best gait, score 0 ($F = 8{\cdot}9$ $P < 0{\cdot}01$) and dry preen bout length (average 20·2, maximum 110·5) was longer with increasing ammonia levels ($F = 15{\cdot}6$ $P < 0{\cdot}001$).

Activity at the water and feed resource

Activity at the water resource is shown in Figure 3. A greater proportion of the maximum number of ducks able to use the resource at any one time used the trough (49·3% at 23 d and 63·0% at 41 d, minimum $F = 6{\cdot}8$ $P < 0{\cdot}01$), with Plasson use (30·4% at 23 d and 48·9% at 41 d) intermediate to the nipple (13·6% at 23 d and 26·4% at 41 d) at both ages. Increasing light at 23 d ($F = 40{\cdot}1$ $P < 0{\cdot}001$) and ammonia concentrations at 41 d ($F = 7{\cdot}3$ $P < 0{\cdot}05$) were positively correlated to this proportional use of the water resource. The proportion of ducks joining (and leaving) the Plasson drinkers was higher at 23 d than the trough or nipple (82·9 vs. 58·7% trough and 35·0% nipple, $F = 3{\cdot}5$ $P < 0{\cdot}05$), and was negatively correlated to moderately poor posture, score 1 ($F = 6{\cdot}0$ $P < 0{\cdot}01$) and positively correlated to the proportion of ducks at the feeder ($F = 4{\cdot}3$ $P < 0{\cdot}05$). The proportion of ducks joining and leaving the water resource was not significantly different between resource at 41 d, but was less with increasing ammonia ($F = 9{\cdot}4$ $P < 0{\cdot}01$) and more with increasing RH variation in week 5 ($F = 5{\cdot}4$ $P < 0{\cdot}05$). The proportion of ducks at the water resource performing wet preening (22–30%) was not affected by resource type, but increased with increasing temperature in week 4 at 23 d ($F = 5{\cdot}0$ $P < 0{\cdot}05$) and drinker space (mm/bird) at 42 d ($F = 7{\cdot}1$ $P < 0{\cdot}05$). Analysis of the regression equation for drinker space shows wet preening rates are higher when space at the water source was 6 mm/bird or more. Ducks were observed to queue at the trough when space was reduced to 4·6 mm/bird on one farm.

A smaller proportion of the maximum number of ducks able to use the feed resource at any one time, used the pan feeders at 23 d (15·5% compared to 35·0% for hoppers, $F = 8{\cdot}7$ $P = 0{\cdot}001$) and the proportion joining the feeders was negatively correlated to drinker space ($F = 34{\cdot}5$ $P < 0{\cdot}001$). There were no effects of feeder type on the proportion of birds at or joining the feeder at 41 d; the former was negatively correlated however to litter temperature ($F = 5{\cdot}8$ $P < 0{\cdot}05$).

DISCUSSION

Duck behaviour was little affected by commercial production system and was influenced more by environment, age and physical condition of the ducks themselves. Activity at an older age incorporated more of the behaviours associated with thermal comfort (panting) and maintenance of plumage condition (dry and wet preening). Ducks were observed to pant at relatively low ambient temperatures with average rates occurring at average weekly temperatures of ~15°C, indicating the requirement for relatively low ambient temperatures in duck houses, achieved with good ventilation and low commercial stocking densities.

Increasing air temperatures led to increased panting and the proportion of ducks wet preening, whilst increased litter temperatures led to a reduced proportion of ducks feeding. Ducks are known to alter their feeding pattern with age, so that the number of meals decreases but the duration and rate of eating increases thereby increasing feed intake (Bley & Bessei, 2008). Increasing temperature not only reduced the proportion of ducks eating, but also led to a reduction in growth rate (Jones & Dawkins, 2010), suggesting a reduction in feed intake also.

Increasing RH and RH variation were correlated to increasing rest, dry preening and comfort behaviours at a young age and increased activity at the drinkers when older. Increasing concentrations of atmospheric ammonia, which may indicate a deterioration in the quality of the environment, were also correlated to increased panting (when young), dry preening, and proportion of ducks at the drinking resource, but reduced activity at the drinker (numbers joining and leaving) when older. The latter suggests that once at the drinker, ducks stayed there for longer periods under higher ammonia conditions.

Temperature, RH and ammonia concentrations were all correlated to the physical condition of the ducks (Jones & Dawkins, 2010) and condition of the duck was further correlated to its behaviour. For instance, a worsening of the walking ability, correlated to increased ammonia and higher temperatures, and was further correlated to increased panting when young, and reduced activity at the drinker when older. In addition, resting bout length was shorter with increasing amounts of best walking. Good posture was positively correlated to walking ability and to standing, walking and rooting activities when young, whilst moderate posture problems were negatively correlated to good walking and activity at the drinker. The data suggest that ducks with impaired walking and posture modify their behaviour by increasing the length of water related behaviour and resting periods.

Welfare concerns centre on the provision of bathing water for commercially-reared ducks. In this study, it was noticeable that bathing/wet preening was observed with all drinker types (including "duck and dive" and "wing rub"), but that the percent of time spent "bathing" was lowest with nipple drinkers despite the proportion of ducks wet preening being unaffected by drinker type. This "bathing" from nipples can be considered significantly less effective than bathing from sources of open water, as the condition of the eyes and feathers were poorer (Reiter *et al.,* 1997; Heyn *et al.,* 2009; Jones *et al.,* 2009; Jones & Dawkins, 2010). It was also noticeable that ducks with access to water sources other than nipple drinkers spent relatively little of their time engaged in "bathing" activities (less than 5·0%). Troughs appeared to attract the most ducks to use the resource at any one time, with the Plasson intermediate to the nipple. Interestingly, increasing space at the water source of 6 mm/bird or more allowed for more ducks to perform wet preening, and so drinker allocation should be noted, particularly in warm weather conditions when the ducks are more likely to bathe.

We conclude that ducks modify their behaviour in response to the environmental conditions (temperature, humidity and ammonia concentrations) in which they are reared, particularly for behaviours associated with thermal regulation, bathing and maintenance of plumage condition, as well as feeding and drinking. They also modify their behaviour according to their physical condition, particularly that related to walking ability and posture.

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