ABSTRACT Access to open water is considered good for the welfare of Pekin ducks. These studies investigated the effect that the type of water resource, provided over either straw bedding or a rubber mesh, had on measures of duck health. Pekin strain ducklings (n = 2,600) were managed in pens of 100 on straw over a solid concrete floor. In study 1, one of two water resources (nipple, n = 5 pens; wide-lip bell drinker, n = 5 pens), was located directly over the straw. In study 2, one of three water resources (narrow-lip bell drinker, n = 6 pens; trough, n = 5 pens; and bath, n = 5 pens) was located over a rubber mesh. On d 16, 24, 29, 35, and 43, (study 1) or d 21, 29, 35, and 43 posthatch (study 2), 10 birds were selected from each pen and weighed, and then feather hygiene, footpad dermatitis, eye health, gait score, and nostril condition scores were taken. Treatment had no effect on BW in either study, but in study 2, ducks in the open water treatments had higher scores (P < 0.001) than those in the narrow-lip bell drinker treatment by d 43. In study 1, treatment had no effect on hygiene scores, but scores increased over time (P < 0.001). In study 2, ducks in the narrow-lip bell drinker treatment were dirtier than those in the bath treatment (P = 0.01), with those in the trough treatment being intermediate. In both studies, ducks with bell drinkers had worse gait scores than those in the other treatments (study 1, P < 0.01; study 2, P < 0.05). Treatment had no effect on eye health scores. However, ducks were less likely to have dirty nostrils when provided with more open water resources in both studies (P < 0.01), or were less likely to have blocked nostrils in the trough and bath treatments than in the narrow-lip bell drinker treatment in study 2 (P = 0.01). Provision of open water, particularly over a properly constructed drainage area, improved some aspects of duck health (improved feather hygiene and BW, and fewer dirty and blocked nostrils). However, further work is needed to investigate these treatments on a commercial scale.

INTRODUCTION

In the United Kingdom, ducks are primarily raised for meat consumption. The species most commonly used is the domesticated mallard duck, *Anas platyrhynchos*, which is a type of waterfowl. The market for duck meat is steadily increasing, and consumption has doubled in the past 15 yr (Scottish Agricultural College, 2009). In 2006, 18 million ducks were slaughtered in the United Kingdom, and duck accounts for 5% of the poultry meat market (British Poultry Council, 2008). Ducks are usually housed in large sheds, and the types of flooring used include straw bedding on solid floors, wire mesh, and slats. Current UK government recommendations state that ducks should be provided with adequate fresh feed and drinking water (Department for Environment, Food and Rural Affairs, 1987). The Council of Europe (1999) recommends that ducks should also be able to dip their heads in water and spread water over their feathers. Although the Department for Environment, Food and Rural Affairs (1987) has published recommendations stating that “consideration should be given to the provision of water troughs which are deep enough to allow the ducks to get their heads completely under water,” there are no legal requirements for duck farmers to provide this. Thus, nipple drinkers, which do not provide an opportunity for ducks to immerse any parts of their body, can still be used to manage ducks through the entire life cycle.

A key aspect of welfare is health because any increase in disease or injury means that welfare becomes poorer (Broom, 2006, 2008). Access to open water is consid-
ered good for duck health, particularly for eye and nostril health and hygiene of the plumage (Knierim et al., 2004). Jones et al. (2009) found evidence that duck welfare is related to the nature and extent of their access to water: ducks that were provided with only nipple drinkers were unable to keep their eyes, nostrils, and feathers fully clean. Access to open water is necessary for ducks to perform several behaviors that are part of their natural behavior (e.g., head dipping and wing flapping in association with water). Some of these behaviors have a direct effect on duck health because they are part of the duck’s repertoire of preening behaviors, and the quality and quantity of preening behavior is likely to affect plumage hygiene.

However, the provision of open water that ducks can enter to perform preening behaviors could have negative consequences for bird health. In the United Kingdom, the maximum stocking rate recommended for commercially reared ducks on solid floors is 7 ducks/m² between 3 and 8 wk of age (Department for Environment, Food and Rural Affairs, 1987). At this stocking density, an open water resource could quickly become highly contaminated with bedding and feces. This could lead to bacterial growth, which in turn could have a negative effect on duck health. An economic cost is also associated with the provision of open water because of the labor required to clean the receptacles, the cost of increased water use, and the treatment and disposal of dirty water. Thus, a method of providing open water that reduces any risk to health and that reduces the volume of water used should be investigated.

It is unclear whether the presence and appearance of open water in itself, or the bird’s contact with water by the bill or on the feathers stimulates preening behavior and a consequent improvement in feather hygiene. It is possible that an open water resource that permits head-only or bill-only access, as opposed to whole-body access, could be sufficient to promote a level of preening behavior that keeps feathers clean. Thus, chicken and turkey bell drinkers, which allow the bird to dip its bill into the water, or a narrow trough, which permits head and bill access, could promote preening behavior at a level that is sufficient to maximize bird hygiene, satisfy the needs of birds to display certain behaviors, and minimize contamination and use of water and moistening of the litter.

It is important to increase knowledge on the effect that access to water has on duck health, to develop sustainable systems that ensure high standards of bird welfare across the industry. The aim of this study was to investigate the effect that access to water has on duck health, depending on the level of access that is provided. Specifically, the study used 5 different resource types (nipple, chicken bell drinker, turkey bell drinker, trough, and bath) provided over 2 types of flooring (straw bedding or rubber mesh). We investigated the effects of the level of access to water on eye, nostril, and plumage hygiene; gait score; footpad dermatitis (FPD); and BW.

**MATERIALS AND METHODS**

**Birds and Husbandry**

**Study 1: Nipples and Wide (Turkey) Bell Drinkers.** One thousand male and female Cherry Valley Pekin breed ducklings (Cherry Valley Ducks, Market Rasen, UK) were hatched on January 6, 2009, and then managed in groups of 100 ducklings (n = 10 groups) in pens constructed on a concrete floor in a shed with forced ventilation. Ducklings had access to a gas heater until 12 d posthatch and were managed on straw litter that was topped up daily. Pens measured 8.01 × 3.05 m (total floor area, 24.43 m²). Ducklings were restricted to a subsection of the pen for the first 14 d posthatch. From d 1 to 14 posthatch, they had access to red bell drinkers that sat directly on the straw bedding [diameter, 230 mm; height, 120 mm; water depth (to lip), 40 mm; water width, 45 mm], and hopper-style feeders (88.90 × 144.78 cm, width × length) with a feed space of 284.4 cm (i.e., 2.84 cm/bird). At 14 d, the ducklings were provided with access to the entire pen. They were fed a standard commercial duck feed appropriate for their age. Throughout the experiment, drinkers were located above a perforated drainage pipe sunk into a channel in the concrete floor, which ran the width of each pen.

**Study 1: Treatments and Replication.** Each pen was assigned to 1 of 2 treatments relating to access to water: access to 1) a nipple line (NIP; n = 5) or 2) wide bell drinkers (WID; n = 5). Birds in the NIP treatment had access to water through a single nipple line (n = 15 nipples/pen), with red drip trays under each nipple. The nipple line was available to the birds from d 1 to 14 posthatch. Water was provided to birds in the WID treatment through 2 turkey bell drinkers [diameter, 460 mm; height, 380 mm; water depth (to lip), 70 mm; water width, 90 mm] that were installed in the pens from d 14. The circumference of each bell drinker was 1,445 mm, providing a space allowance of 29 mm/bird. Each bell drinker was individually connected to the main water supply and was self-filling, with the water level controlled by ball cocks. They were emptied, cleaned, and refilled with clean water each day.

**Study 2: Chicken (Narrow) Bell Drinker, Trough, and Bath.** One thousand six hundred male and female Cherry Valley Pekin ducklings were hatched on January 6, 2009, and then managed in groups of 100 ducklings (n = 16 groups) in a shed with forced ventilation. Pens measured 7.47 × 3.05 m (total floor area, 22.78 m²). Each pen had a straw bedded area on a solid concrete floor (5.66 × 2.95 m = 16.70 m²), as well as a grooved concrete ramp (0.7 × 2.95 m = 2.07 m²) that led to a drainage area with a rubber slatted floor (1.25 × 2.95 m = 3.69 m²). The total floor area was 22.45 m². Ducklings had access to a gas heater until 12 d posthatch and were managed on straw litter that was topped up daily. They were restricted to a subsection of the pen for the first 14 d posthatch. Immediately after hatching, ducklings had access to red bell drink-
ers that sat directly on the straw bedding [diameter, 230 mm; height, 120 mm; water depth (to lip), 40 mm; water width, 45 mm] and hopper-style feeders (88.90 ×144.78 cm, width × length) with a feed space of 284.4 cm (i.e., 2.84 cm/bird). At 14 d, the ducklings were provided with access to the entire pen. They were fed a standard commercial duck feed appropriate for their age. Throughout the experiment, drinkers were located above the rubber drainage area.

Study 2: Treatments and Replication. At 21 d posthatch, each pen was assigned to 1 of 3 treatments relating to access to water: access to 1) a chicken bell drinker (NAR), 2) a trough (TRO), or 3) a bath (BTH). Birds in the NAR treatment had access to water through 2 bell drinkers [diameter, 350 mm; height, 375 mm; water depth (to lip), 40 mm; water width, 45 mm] per pen. The circumference of each bell drinker was 1,010 mm, providing a space allowance of 20 mm/bird. Each bell drinker was individually connected to the main water supply and was self-filling, with the water level controlled by ball cocks. They were emptied, cleaned, and refilled with clean water each day. Birds in the TRO treatment had access to water via a single trough (width, 150 mm; length, 1,600 mm; total height, 140 mm; water depth (to lip), 100 mm] per pen. Because of the ball cock fitting, it was not possible for ducks to access the water from one end of the trough; thus, there was a space allowance of 34 mm/bird. Birds in the BTH treatment had access to water via a bath [width, 550 mm; length, 1,000 mm; total height, 150 mm; water depth (to lip), 100 mm]. Access to part of one side was blocked by the ball-cock housing (205 mm). Thus, the space allowance around the perimeter of the bath was 29 mm/bird. Water resource equipment in each pen was located over the rubber-slatted drainage area.

Birds in both studies were managed to have a target BW at slaughter of 3.7 kg. This meant that the maximum stocking density in each pen was 15.16 kg/m² (i.e., at the time of slaughter).

Environmental Measures

Temperature and RH. Ambient air temperature and RH were recorded using Gemini Tinytag Extra Data loggers [TGX-3580, Gemini Dataloggers (UK) Ltd., Chichester, West Sussex, UK] between February 10 and 19. A data logger was suspended at a height of 180 cm at 4 points distributed throughout the shed in both experimental sheds (study 1: between pens 1 and 2, pens 4 and 5, pens 6 and 7, and pens 9 and 10; study 2: between pens 1 and 2, pens 7 and 8, pens 9 and 10, and pens 15 and 16). Data were recorded at 1-min intervals.

Bedding DM Percentage. Straw bedding samples were taken from each replicate pen in study 1 on d 16, 24, 29, 35, and 43 posthatch, and in study 2 on d 21, 29, 35, and 43 posthatch. Samples were collected from 3 areas of the pen in study 1 (bed area, feed area, and water resource area) and from 2 areas of the pen in study 2 (feed area and bed area). Samples were gathered into sealable plastic bags using latex gloves and frozen on the day of collection at −20°C until analysis. Five to six grab samples were used in each total sample.

For analysis of DM, samples were defrosted entirely and then mixed in a plastic bowl. A portion of each sample was placed in a foil tray, weighed, and then placed in a convection oven at 100°C for 24 h (before analysis; this amount of time was determined to be sufficient to obtain a constant weight). Samples were reweighed immediately on removal from the oven, and proportion of DM was calculated.

Bird Measures

All experimental measures were recorded in the home pen of the bird. Measures were recorded in study 1 on d 16, 24, 29, 35, and 43 posthatch. Measures were recorded in study 2 on d 21, 29, 35, and 43 posthatch. Ten birds were randomly selected and confined together in a corner of the pen. Each bird was individually inspected for feather hygiene, FPD, eye health, and nostril blockage according to the scores listed in Table 1. Birds were then weighed (accurate to 0.2 g) and placed back in the home pen, where they were gait scored. Gait scoring was carried out using a modified version of the scoring system developed by Kestin et al. (1992; Table 1). The same 2 observers scored all birds on all occasions. When observers disagreed on scores, the scores were discussed and consensus was reached. Total percentage of mortality for each pen during the experimental period was also calculated.

Statistical Analysis

Data were analyzed using the Statistical Analyses System (version 9.1, SAS Institute, Cary, NC). Prior to analysis, all data were examined for normality by examination of histograms and normal distribution plots (UNIVARIATE procedure).

Straw DM percentage, temperature, and RH were analyzed using the MIXED procedure of SAS. For analysis of DM percentage, fixed effects were treatment, date, area of the pen, and their interactions. Date was considered a repeated effect, and pen was considered a random effect. Temperature and RH recordings were averaged for each hour of each day to create 1 recording per hour. Fixed effects in the analyses were location (in the shed), date, and hour and their interactions. Hour was considered a repeated effect.

Mean values per pen for bird BW, feather hygiene score, and FPD score were calculated before analysis, and the pen was considered the experimental unit. Data were analyzed using the MIXED procedure of SAS. Fixed effects were treatment, age (d), and their interaction. Recordings from d 16 were used in analysis as a covariate in study 1, and those from d 21 were used in study 2. Age was considered a repeated effect.
Gait scores were square root transformed. Models were rerun using raw data to obtain least squares means for presentation, but \( P \)-values were calculated using transformed data.

Differences in eye and nostril health scores were investigated using a logistic regression model (GENMOD procedure of SAS). Eye scores of greater than 1 were classified as severe, and scores of 0 and 1 were classified as nonsevere. Nostril scores were categorized in 1 of 2 ways. First, any dirt in either nostril (i.e., scores of 1 and 2) was classified as 1 and clean nostrils were classified as 0, and then blocked nostrils were classified as 1 and nonblocked nostrils were classified as 0. The cumulative logit of the probability that severe eye scores, dirty nostrils, or blocked nostrils was greater in each treatment was investigated. Odds ratios (OR) and 95% CI were calculated as the exponent of the model solutions. The pen was included as a repeated effect. Treatment and test day were forced into the model as class variables. The initial inspection day and nipple treatment were used as the reference classes in study 1, and the initial inspection day and narrow bell drinker were used as the reference classes in study 2. Mortality in each pen was recorded but was not statistically analyzed.

**RESULTS**

**Study 1: Environmental Measures**

**Temperature and RH.** Temperature and RH results are presented in Table 2. There were no interactive effects, but there was an effect of time of day (\( P < 0.001 \); Figure 1).

**Bedding DM Percentage.** The DM percentage of the bedding in the WID treatment was lower than that in the NIP treatment (47.0 ± 1.3% vs. 51.6 ± 1.3%; \( P < 0.05 \)). There was also an effect of area within the pen (\( P < 0.001 \)). Dry matter percentage of bedding was lowest in the water resource area (37.2 ± 1.2%), and this was lower than in either the feed area (54.7 ± 1.2%; \( P < 0.001 \)) or the bed area (56.1 ± 1.2%; \( P < 0.001 \)).

There was an effect of date on bedding DM percentage (\( P < 0.001 \)). Dry matter percentage was higher on the first inspection day (January 22; 60.8 ± 1.2%) than

<table>
<thead>
<tr>
<th>Measure</th>
<th>Score</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feather hygiene</td>
<td>0</td>
<td>Minor soiling on less than 10% of feathers, or one small patch of heavy soiling</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>10 to 40% of feathers affected, soiling minor to moderate; up to 25% affected with heavy soiling</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>40 to 75% of feathers affected, soiling minor to moderate; 25 to 60% affected with heavy soiling</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>More than 75% of area affected, soiling minor to moderate; more than 60% of area affected with heavy soiling</td>
</tr>
<tr>
<td>Gait</td>
<td>0</td>
<td>Perfect gait</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Detectable but unidentified abnormality (e.g., uneven gait)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Identifiable abnormality; but little effect on overall function (e.g., lame in 1 leg or crossed legs, but normal speed)</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Identifiable abnormality and impaired function; obvious gait defect, and bird has difficulty moving</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Severely impaired gait; movement is extremely slow, and only after much encouragement, bird sits at first opportunity</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Completely lame, mobility severely affected; bird cannot walk, and is mobile only by shuffling on hocks or wings</td>
</tr>
<tr>
<td>Footpad dermatitis</td>
<td>0</td>
<td>Skin intact with no lesions; slight roughness, but no evident inflammation or discoloration</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Minor lesions: some small areas (&lt;1 cm in diameter) of discoloration or redness</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Moderate lesions: obvious swelling and much discoloration, roughness; lesions &gt;1 cm diameter</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Severe lesions: severe swelling, scabbing, and ulcers</td>
</tr>
<tr>
<td>Eye</td>
<td>0</td>
<td>Eye clean, normal color, no inflammation</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Eye red rimmed, weeping slightly, slight crustiness</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Severely red around rim, much weeping, very crusty</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Eye not able to open fully, eye closes</td>
</tr>
<tr>
<td>Nostril hygiene</td>
<td>0</td>
<td>Clean and clear</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Some blockage visible when viewed from side</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Nostrils entirely blocked on at least 1 side</td>
</tr>
</tbody>
</table>

Table 1. Scoring systems used for recording of bird health parameters

Table 2. Temperature and RH recordings for studies 1 and 2

<table>
<thead>
<tr>
<th>Item</th>
<th>Data logger location (^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Study 1</td>
<td></td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>8.8 ± 0.2(^a)</td>
</tr>
<tr>
<td>RH (%)</td>
<td>89.9 ± 0.4(^a)</td>
</tr>
<tr>
<td>Study 2</td>
<td></td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>8.7 ± 0.2</td>
</tr>
<tr>
<td>RH (%)</td>
<td>89.9 ± 0.4(^a)</td>
</tr>
</tbody>
</table>

\(^a\)Means within a row without matching superscripts indicate significant differences.

\(^1\)Data loggers were suspended at a height of 180 cm at 4 points in both experimental sheds. Study 1: between pens 1 and 2, pens 4 and 5, pens 6 and 7, and pens 9 and 10 (locations 1, 2, 3, and 4, respectively); study 2: between pens 1 and 2, pens 7 and 8, pens 9 and 10, and pens 15 and 16 (locations 1, 2, 3, and 4, respectively).
on January 30 (51.9 ± 2.1%; P < 0.05), February 4 (44.1 ± 2.1%; P < 0.001), February 10 (41.3 ± 2.1%; P < 0.001), or February 18 (48.9 ± 2.9%; P = 0.001). Dry matter percentage on January 30 tended to be higher than that on February 4 (P = 0.08), and was higher than that on February 10 (P = 0.01). There were no other differences between dates.

**Study 1: Bird Measures**

Treatment had no effect on bird BW, but there was an effect of time (P < 0.001; Figure 2). There was no difference in feather hygiene score between the WID (2.94 ± 0.09) and NIP (2.75 ± 0.09; P = 0.16) treatments, but there was an effect of time (P = 0.001). In general, feather hygiene scores increased (i.e., feathers got dirtier) over time, and scores on d 43 (3.31 ± 0.12) were higher than those on d 35 (2.76 ± 0.12; P < 0.05), d 29 (2.77 ± 0.12; P < 0.05), and d 24 (2.54 ± 0.12; P < 0.001).

Ducks in the WID treatment had higher gait scores (0.32 ± 0.03) than ducks in the NIP treatment (0.20 ± 0.03; P < 0.01; Figure 3). There was also an effect of time (P < 0.01) on gait score. In general, gait scores increased over time, and scores on d 43 (0.38 ± 0.04) were higher than those on d 29 (0.18 ± 0.04; P < 0.01).

Both treatment (P = 0.1) and time (P = 0.08) tended to have an effect on FPD score. Ducks in the NIP treatment tended to have higher dermatitis scores (0.97 ± 0.11) than ducks in the WID treatment (0.72 ± 0.11). However, dermatitis scores showed no difference between any pair of days. There was an interaction between treatment and time (P < 0.05), and on d 35, the dermatitis scores of ducks in the NIP treatment (1.22 ± 0.16) tended to be higher than those in the WID treatment (0.48 ± 0.16; P = 0.06).

Ducks in the WID treatment had higher gait scores (0.32 ± 0.03) than ducks in the NIP treatment (0.20 ± 0.03; P < 0.01; Figure 3). There was also an effect of time (P < 0.01) on gait score. In general, gait scores increased over time, and scores on d 43 (0.38 ± 0.04) were higher than those on d 29 (0.18 ± 0.04; P < 0.01).

Both treatment (P = 0.1) and time (P = 0.08) tended to have an effect on FPD score. Ducks in the NIP treatment tended to have higher dermatitis scores (0.97 ± 0.11) than ducks in the WID treatment (0.72 ± 0.11). However, dermatitis scores showed no difference between any pair of days. There was an interaction between treatment and time (P < 0.05), and on d 35, the dermatitis scores of ducks in the NIP treatment (1.22 ± 0.16) tended to be higher than those in the WID treatment (0.48 ± 0.16; P = 0.06).

Treatment had no effect on eye score, but there was an effect of time (P = 0.05). In particular, the odds of a duck having a severe eye score tended to be lower on d 29 than on d 16 (OR = 0.37, CI = 0.12 to 1.18; P = 0.09). However, ducks were more likely to have a severe eye score on d 43 than on d 16 (OR = 13.15, CI = 4.55 to 38.02; P < 0.001).

There was an effect of treatment (P < 0.01) but no effect of time (P > 0.05) on the odds of a duck having dirty nostrils. The percentage of ducks in each treatment that had dirty nostrils on each day is shown in Table 3. The odds of dirty nostrils were lower in the WID than in the NIP treatment (OR = 0.44, CI = 0.31 – 0.62; P < 0.001). There was no effect of treatment or time (P > 0.05) on the odds of a duck having blocked nostrils. Average mortality in the NIP and WID treatments was 1.4 and 2.4%, respectively.

**Study 2: Environmental Measures**

**Temperature and RH.** Temperature and RH results are presented in Table 2. There were no interactive effects, but there was an effect of time of day (P < 0.001; Figure 1).

**Bedding DM Percentage.** Treatment had no effect on bedding DM percentage (P > 0.05). Dry matter percentages in the NAR, TRO, and BTH treatments were 50.9 ± 0.9, 49.5 ± 1.0, and 50.4 ± 1.0%, respectively. However, DM percentage in the bed area (47.1 ± 0.8%) was lower than that in the feed area (53.4 ± 0.8%; P < 0.001). Likewise, there was an effect of date (P < 0.001). Dry matter percentage on January 27 (59.3 ± 1.1%) was higher than that on February 4 (51.9 ± 1.1%; P < 0.001), February 10 (45.4 ± 1.1%; P < 0.001), and February 18 (44.4 ± 1.1%; P < 0.001). Dry matter percentage on February 4 was higher than

![Figure 1](image_url). Least squares mean temperature (°C) and RH (%) in both studies between February 10 and 19. Temperature 1 and RH 1 refer to data from study 1, and temperature 2 and RH 2 refer to data from study 2.
that on February 10 \((P < 0.001)\) and February 18 \((P < 0.001)\), but there was no difference in DM percentages between the latter 2 dates.

**Study 2: Bird Measures**

Time had an effect on bird BW \((P < 0.001; \text{Figure 2B})\) and on the interaction between time and treatment \((P < 0.001; \text{Figure 2B})\). Although ducks in the NAR treatment had the highest BW at 29 and 35 d, at 43 d they had lower BW than ducks in the other 2 treatments.

Treatment had an effect on bird dirtiness scores \((P < 0.05)\). The dirtiness score of birds in the NAR treatment \((2.31 \pm 0.13)\) was higher than that of birds in the BTH treatment \((1.69 \pm 0.14; P = 0.01)\), with birds in the TRO treatment \((2.05 \pm 0.14)\) being intermediate. There was also an effect of time \((P < 0.01)\), with the dirtiness score on d 35 \((2.36 \pm 0.12)\) being higher than that on d 29 \((1.95 \pm 0.12; P < 0.05)\) and d 43 \((1.74 \pm 0.12; P < 0.01)\).

Treatment \((P < 0.01)\) and time \((P < 0.001)\) had an effect on gait scores. Ducks in the NAR treatment had higher scores \((0.28 \pm 0.03)\) than ducks in either the TRO \((0.15 \pm 0.04; P < 0.05)\) or BTH \((0.11 \pm 0.04; P < 0.01)\) treatment, although no differences were observed between individual treatments. No difference was found between gait scores on examination at d 29 \((0.09 \pm 0.04)\) or d 35 \((0.10 \pm 0.04; P > 0.05)\), but the gait score on d 43 \((0.35 \pm 0.04)\) was higher than that on either of these days \((P < 0.001 \text{ for both})\).

Treatment had no effect on FPD scores \((P > 0.05)\). However, there was an effect of time \((P < 0.001)\). Dermatitis score tended to be lower on d 29 \((0.58 \pm 0.10)\) than on d 35 \((0.84 \pm 0.10; P = 0.1)\) and was lower than on d 43 \((1.30 \pm 0.10; P < 0.001)\). The dermatitis score on d 43 was also greater than that on d 35 \((P < 0.01)\).

Treatment had no effect on the odds of a duck having a severe eye score \((P > 0.05)\). However, there was an effect of time \((P < 0.01)\). The odds of a duck having a severe eye score were lower on d 29 than on d 21 \((OR = 0.09, CI = 0.01 \text{ to } 0.75; P < 0.05)\). However, ducks tended to be more likely to have a severe eye score on d 43 than on d 21 \((OR = 2.51, CI = 0.81 \text{ to } 7.77; P = 0.1)\).

Treatment had an effect \((P < 0.01)\) and time tended to have an effect of \((P = 0.07)\) on the odds of a duck having dirty nostrils. The percentage of ducks in each treatment that had dirty nostrils on each day is shown in Table 4. The odds of dirty nostrils were lower in the TRO than in the NAR treatment \((OR = 0.44, CI = 0.31 \text{ to } 0.63; P < 0.001)\) and were lower in the BTH than in the NAR treatment \((OR = 0.31, CI = 0.20 \text{ to } 0.48; P < 0.001)\). The odds of dirty nostrils were lower on d 43 than on d 21 \((OR = 0.37, CI = 0.17 \text{ to } 0.81; P = 0.01)\). Treatment also had an effect \((P = 0.01)\) on the odds of a duck having blocked nostrils, although time had no effect \((P > 0.05)\). The odds of having blocked nostrils was less for ducks in the TRO than in the NAR treatment \((OR = 0.30, CI = 0.16 \text{ to } 0.56; P < 0.001)\) and was less for ducks in the BTH than in the NAR treatment \((OR = 0.27, CI = 0.12 \text{ to } 0.59; P = 0.001)\). Average mortality in the BTH, TRO, and NAR treatments was 1.6, 4.2, and 2.8% respectively.

**DISCUSSION**

Although ducks are waterfowl, few peer-reviewed experimental papers have examined the effect of water resource type on duck health, particularly in commercial systems. Other recent studies have focused on small groups of ducks \((e.g., n = 4; \text{Jones et al., 2009})\); thus, the results may not be transferable to situations in which birds are managed with much less space per duck at the resource \((e.g., \text{in that study, ducks had a space allowance of 800 mm/bird at a bath and 538 mm/bird at a trough})\). The Department for Environment, Food and Rural Affairs \((1987)\) and the Royal Society for the

Figure 2. Body weight (means ± SE) of birds in study 1 (A) and study 2 (B). Letters (a, b) indicate a significant difference \((P < 0.05)\).
Prevention of Cruelty to Animals (2009) state that a space of at least 5 mm/duck must be provided at the water resource, and Dawkins (2008) reported an average of between 5.3 and 6.1 mm/duck currently in use in the United Kingdom duck industry. Birds in our study were managed at a stocking density that is more similar to commercial conditions than in the studies by Dawkins et al. (2008). Thus, our studies, in which findings are similar to those reported by Dawkins et al. (2008), are an important contribution to the growing body of work investigating how facilities that are currently in use in the United Kingdom duck industry could affect the health, and consequently the overall welfare, of the birds.

Although location in the shed had a significant effect on temperature and RH in both studies, the actual differences were so small that they probably had a limited biological effect on the ducks in the different areas. The temperature and RH recordings were taken during wk 6 of the growth period, and the recorded values are similar to average temperatures during wk 6 in winter, as calculated by Dawkins (2008; approximately 10°C and 81% RH). Thus, conditions in the sheds during these studies were comparable to industry norms.

Even though bedding was topped up daily, in both studies the DM percentage of the bedding decreased over time, probably because of a buildup of fecal matter. However, in study 1, no difference was observed in DM percentage on dates subsequent to February 4, and in study 2, no difference was observed subsequent to February 10, indicating that the practice of providing fresh bedding each day was sufficient to prevent further deterioration in bedding DM percentage. In study 1, DM percentage of bedding located in the water resource area was lower than those in both other areas, which could have implications for duck hygiene because ducks spend time resting in the vicinity of the water resource (Jones et al., 2009). No interaction was found between treatment and area of the pen, indicating that even in the pens provided with nipples, the straw near the water resource was significantly wetter than the straw in the other pen areas. Overall, however, DM percentage of straw in the NIP treatment was higher than that in the WID treatment in this study. These results illustrate the negative effect that a water resource that permits even limited access to water can have on bedding DM percentage. The lack of a treatment effect in study 2, in which treatments ranged from whole-body access to bill-only access to water, shows how a properly constructed drainage area can greatly reduce the contamination of bedding with water, even from an open water resource.

During both studies, BW in all treatments increased to approximately 4 kg, and mortality rates were below 5%. Thus, none of the treatments appeared to have a negative effect on production compared with industry norms (Dawkins, 2008). Although treatment had no effect on BW in study 1, in study 2, birds with access to both of the resources that permitted at least whole-head access to water (i.e., trough and bath) increased above the NAR treatment with regard to BW so that by the end of the study, BW in the TRO treatment was significantly higher than that in the NAR treatment. Erisir et al. (2009) also found that ducks that had access to a water pool (similar in dimensions to the bath in our study) had a higher BW after 6 wk than ducks without access to open water. In particular, this was the case when ducks had access to an outdoor exercise area. That paper concluded that a management system that was more natural (i.e., with outdoor access), combined with a facility that permitted expression of normal water-associated behaviors, had resulted in the increased growth. However, the numerical and relative differences in BW between the treatments in our stud-

### Table 3. Percentage of ducks in each treatment in study 1 that had dirty or blocked nostrils at each examination

<table>
<thead>
<tr>
<th>Treatment</th>
<th>d 16 D (%)</th>
<th>d 16 B (%)</th>
<th>d 24 D (%)</th>
<th>d 24 B (%)</th>
<th>d 29 D (%)</th>
<th>d 29 B (%)</th>
<th>d 35 D (%)</th>
<th>d 35 B (%)</th>
<th>d 43 D (%)</th>
<th>d 43 B (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nipple</td>
<td>74</td>
<td>38</td>
<td>72</td>
<td>38</td>
<td>70</td>
<td>34</td>
<td>66</td>
<td>28</td>
<td>68</td>
<td>38</td>
</tr>
<tr>
<td>Bell drinker</td>
<td>70</td>
<td>22</td>
<td>60</td>
<td>40</td>
<td>46</td>
<td>24</td>
<td>24</td>
<td>12</td>
<td>56</td>
<td>34</td>
</tr>
</tbody>
</table>

1D = dirty nostrils (including blocked nostrils); B = blocked nostrils. The odds of dirty nostrils were lower in the bell drinker treatment than in the nipple treatment (P < 0.01).

### Table 4. Percentage of ducks in each treatment in study 2 that had dirty or blocked nostrils at each examination

<table>
<thead>
<tr>
<th>Treatment</th>
<th>d 21 D (%)</th>
<th>d 21 B (%)</th>
<th>d 29 D (%)</th>
<th>d 29 B (%)</th>
<th>d 35 D (%)</th>
<th>d 35 B (%)</th>
<th>d 43 D (%)</th>
<th>d 43 B (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bell drinker</td>
<td>38</td>
<td>8</td>
<td>48</td>
<td>17</td>
<td>48</td>
<td>20</td>
<td>35</td>
<td>15</td>
</tr>
<tr>
<td>Trough</td>
<td>44</td>
<td>10</td>
<td>26</td>
<td>2</td>
<td>22</td>
<td>8</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Bath</td>
<td>30</td>
<td>4</td>
<td>8</td>
<td>2</td>
<td>28</td>
<td>4</td>
<td>10</td>
<td>8</td>
</tr>
</tbody>
</table>

1D = dirty nostrils (including blocked nostrils); B = blocked nostrils. The odds of dirty nostrils were lower in the trough and bath treatments than in the bell drinker treatment (P < 0.001).
ies were very small and thus should be investigated further to determine whether access to open water results in a biologically significant increase in BW.

However, in an intensive system, access to a pool had a numerically negative effect on duck BW (Erisir et al., 2009). The authors hypothesized that provision of open water in this situation resulted in negative environmental consequences, such as increased ammonia concentration and poor litter quality, which caused this result. Dawkins et al. (2004) concluded that the environmental factors most likely to have a negative effect on broiler chicken welfare, including growth rate, are litter moisture and ammonia concentration. Our finding that the bedding in study 1 became very wet indicates that environmental conditions could have been less favorable for these birds than in the dryer NIP treatment. Thus, any positive effect on bird health of increased access to water, compared with nipples, must be carefully monitored when the water resource is located directly on the bedding. In study 2, no difference was found in bedding DM, even between the BTH and NAR treatments, probably because the water resources were all located over a drainage area separate from the bedding.

In study 1, our finding that ducks with access to the wide-lip bell drinkers were less clean than ducks in the NIP treatment was unexpected because we hypothesized that the greater access to water would enable the birds to preen more effectively. However, the lower DM of the straw in this treatment could have contributed to higher (i.e., poorer) hygiene scores. Behavioral observations carried out in a study similar to this one indicated that ducks spend much time resting in the vicinity of the water resource. This is in agreement with the report of Jones et al. (2009), who found that ducks with access to nipples only did not rest near the water resource, whereas ducks with access to showers, baths, and troughs did. Wet bedding has also been linked to increased dirtiness in dairy cattle (O’Driscoll et al., 2008) and was probably the cause of the poorer plumage hygiene in the WID treatment. Moreover, the dirtiness of birds in both treatments in study 1 increased over time, which indicates that the level or quality of preening activity was not sufficient to maintain a constant level of hygiene throughout the study, and that dirt continued to accumulate on the feathers over time.

During study 2, however, an increase in access to water resulted in a corresponding reduction in the feather dirtiness score. This could be because the position of the water resources over a drainage area meant that when ducks rested next to the resource, they were not exposed to wet bedding. Moreover, dirtiness scores in all 3 treatments were lower on d 43 than on d 35, again in contrast to results from study 1, in which dirtiness scores continued to increase over time. Briese et al. (2009) found that preening bout duration and percentage of ducks interacting with a water resource, either a shower or a modified bell drinker, increased with age, as also shown in preliminary results from a study similar to this one using similar treatments. It is likely that increased interaction with the water resource as ducks aged could explain the improvements in duck hygiene over time.

In both studies, birds that were provided with water by bell drinkers had worse gait scores than birds in the other treatments. It is not intuitively clear why this should be the case. However, what is evident is that gait scores in these treatments did not appear to be related to FPD scores because treatment had no significant effect on these scores in either study. The bell drinkers in both studies were suspended by an individual support and thus were able to swing from side to side, which could possibly have injured some birds. However, further work is necessary to determine whether this is the case.

Contact dermatitis is a skin condition in poultry that is associated with wet bedding and the chemical effect of ammonia, which is generated from urea in the bedding (Martland, 1985; Haslam et al., 2007). The disorder manifests itself as ulcerations to the feet (FPD), hocks

![Figure 3. Gait scores (means ± SE) of birds in study 1 (A) and study 2 (B).](image-url)
(hock burn), and breast (breast burn) and is likely to cause pain because of tissue trauma. During this study, we did not see any evidence of hock or breast burn, and lesions were usually scored as 1. In fact, during study 1, in which birds in the WID treatment had a tendency to have higher average scores than birds in the NIP treatment, the frequency of score 2 was 10 in the WID treatment and 9 in the NIP treatment. This is out of a total of 1,000 feet examined. Thus, none of the water facilities within the management systems used appeared to result in bedding conditions that could have an important adverse effect on skin health.

Treatment had no effect on eye score in either study, which was unexpected, because we hypothesized that birds that had access to open water would have better eye health than birds with limited access, as has been reported in previous studies (Graham and Sandilands, 2001; Jones et al., 2009). In both studies, average eye scores decreased (improved) on the second examination day, and then gradually increased (deteriorated) until the end of the experiment. When scoring the birds, we noted that eye score could have been affected by the emergence of adult plumage.

In both studies, more ducks had dirty nostrils in the treatments with the most restricted access to water (i.e., the NIP and NAR treatments). However, in study 2, ducks in the NAR treatment also had more blocked nostrils than birds in the other 2 treatments, which permitted whole-head access to water. Moreover, in that study, more ducks had clean nostrils as the study progressed, implying that overall, these treatments improved the ability of the birds to keep their nostrils clean, and thus healthy. Although chicken and turkey bell drinkers provided the birds with an opportunity to wet their bills, it seems that immersion of the head under water is necessary to ensure that nostrils remain unblocked, and improves nostril cleanliness over time. Jones et al. (2009) also found that ducks with access to only nipples had dirtier bills than ducks that had access to troughs, baths, and showers.

Conclusion

Provision of water in a trough or bath appeared to improve duck welfare, as indicated by improved feather hygiene, fewer blocked and dirty nostrils, and increased BW. However, access to open water resources should be provided over a properly constructed drainage area to minimize contamination of bedding with excess water. Further work should be carried out to investigate the feasibility of providing water in troughs and baths on a commercial scale.

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REFERENCES