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Water off a duck's back: Showers and troughs match ponds for improving duck welfare

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ABSTRACT

The impact of production systems on the welfare of ducks grown for meat is becoming increasingly controversial. In the UK, approximately 18 million ducks (*Anas platyrhynchos*) were reared for meat in 2006 (British Poultry Council, 2008; http://www.poultry.uk.com/who_ducks01.htm). Despite the association between ducks and water in the wild, there are no legal requirements for them to have water for bathing or swimming. Some have troughs in which they dip their heads and splash water onto their bodies but for some, their only contact with water is drinking water from ball-bearing 'nipples'. The Council of Europe (1999) recommends that ducks should be able to dip their heads in water and spread water over their feathers.

We here provide clear evidence that duck welfare is related to the nature and extent of their access to water. We recorded body and plumage condition and undertook three behavioural techniques to assess the effect of water source on the welfare of ducks. Ducks were reared with access to one of five water sources: a bath (small pond), a trough, an overhead shower, nipple drinkers only or nipple drinkers until 5 weeks and a bath thereafter. Their behaviour was assessed by recording (i) the time spent with a single resource, (ii) rebound in water related behaviour when given access to a bath and (iii) their preference for water source when given a four-way choice of all resources.

The results showed that without the opportunity to at least dip their heads and splash their feathers with water, ducks were unable to keep their eyes, nostrils and feathers fully clean. Importantly, there was no difference in the time spent bathing from the bath, trough or shower, indicating resources were equivalent in their provision of bathing water. Very little time, however, was spent showing bathing movements at the nipples. Only ducks in the nipple-only group showed 'compensatory rebound' when finally given access to water in a bath, indicating previous bathing deprivation. There was no rebound in groups reared with a trough or shower, again indicating that the trough and shower were equivalent to the bath in its provision of bathing water. When given choice, the ducks preferred to rest and drink-dabble with the shower, and bathe with the bath; the shower was intermediate to the trough. Little time was spent with the nipples when the ducks were given access to other water sources and little time was spent swimming in the bath.

The results suggest that commercial farmers may be able to improve duck welfare as much by providing water in troughs or from overhead showers (both clean and economical of water) as from actual ponds (baths).

1. Introduction

In the UK, approximately 18 million ducks (*Anas platyrhynchos*) were reared for meat in 2006 (British

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Poultry Council, 2008). Despite the association between ducks and water in the wild, there is no legal requirement for commercially farmed ducks to have water for bathing or swimming. Some are provided, however, with troughs in which they dip their heads and splash water onto their bodies for bathing but for some, their only contact with water is drinking water from ball-bearing 'nipples'. The Council of Europe (1999) recommends that ducks should be able to dip their heads in water and spread water over their feathers.

There is a growing body of evidence (see Rodenburg et al., 2005) that suggests ducks prefer open water to water provided in the form of nipples, that their behavioural repertoire is enhanced with open water, and that body and plumage condition is also improved (Ruis et al., 2003; Knierim et al., 2004; Heyn et al., 2006). Ducks worked harder for troughs over bells and bells over nipples (Cooper et al., 2002), and preferred open water (shallow or deep) to guarded water (trough with grid on) (Ruis et al., 2003). Showers as alternative supplies of open water have been investigated, and Pekin strains were observed to exhibit the same behavioural repertoire under the showers as from a bath (Benda et al., 2004) or trough. Open water was not observed to affect the health of the ducks (Reiter et al., 1997) even though high bacterial counts were found in shallow and deep water (Kuhnt et al., 2004). However, longer term research and the use of daily water exchange systems is needed before conclusions can be made (Raud and Faure, 1994; Knierim et al., 2004).

The aim of this study was to test the hypothesis that duck welfare is related to the nature (type of resource) and extent of their access to water. We tested the effects of rearing ducks with four different water sources, chosen to cover a range of ways of providing water. These were: a bath in which they had full body access and could swim, a trough in which they could dip their heads and splash water over their bodies, a shower that covered their bodies with a spray from overhead, and nipple drinkers (i.e. no additional water) that ducks pecked and received water into their bill; all other groups also had nipple drinkers as a source of clean drinking water.

As measures of welfare, we highlighted two as being of most importance to both ducks and people: the condition of the ducks and what the animals themselves wanted (Dawkins, 2006). The ducks' own responses were measured by (i) their behaviour at the different water sources throughout rear. (ii) The extent to which ducks without swimming water could be said to be 'deprived', by using the same techniques as have been used to assess sleep deprivation in humans (Borbely and Achermann, 1999; Olsson and Keeling, 2005) and dustbathing deprivation in chickens (Vestergaard, 1982), namely 'postinhibitory rebound'—the extent to which a person or animal subsequently compensates for something of which it has been deprived by doing more of it (Nicol, 1987). (iii) By giving them a choice between different sources of water (bath, trough, shower, nipple drinker) so that we could assess what they themselves wanted.

2. Methods

2.1. Animals and husbandry

One hundred and twenty day-old Cherry Valley Pekin strain ducklings were reared to 24 days with access to nipple and flat dish drinkers; they were fed an organic chicken starter diet and were off-heat at 12 days. They were provided with straw litter which was topped up daily.

Within week 3, ducks were allocated and moved to their treatment pens and fed organic chicken finisher pellets. The ducks were housed in groups of four in pens measuring 7.5 m^2 (2.5 m wide × 3.0 m deep), providing 1.9 m^2/duck and a maximum stocking density of <3 kg/m^2. There were 15 pens in total constructed inside a barn with a concrete floor and natural ventilation; two cycles of 60 ducks were used. All pens were equipped with nipple drinkers supplying clean drinking water, a feed hopper, deep straw bedding and a solid sloped section at the back of the pen for the bathing resource according to treatment group. A drainage pipe ran external to the back of the pen, removing excess water and assisting with the maintenance of dry pens. The solid floor was cleaned daily and fresh straw provided.

2.2. Treatments and replication

Five treatment groups differing in their bathing resource and access levels were included in the study. Treatments were: 1. Bath (small pond) (*B*) (950 mm × 650 mm × 250 mm deep) where ducks had full body access to bathing and swimming water, 2. Trough (*T*) (950 mm × 125 mm × 80 mm) where ducks could dip their heads in open water and splash it over their bodies but could not immerse their bodies, 3. Nipple-bath (*N*/*B*), where ducks had access to nipple drinkers only until 5 weeks of age, then were provided with a bath and full body access to water, 4. Nipple (*N*), where ducks had no access to bathing water, and 5. Shower (*S*) (length 950 mm garden irrigation pipe, 4 nozzles/pen), where ducks had full body access to bathing water from overhead nozzles. Each water source was of sufficient size to allow all ducks in the pen, simultaneous and constant access. The *N*/*B* group were included to assess the effect of early deprivation.

Each water resource was individually connected to the mains water supply with on/off pressure control taps. Baths and troughs were self-filling, controlled by ballcocks, and were emptied, cleaned and refilled with clean water each day. The shower jets delivered spray over a large area and were left on continuously, at low pressure during the night and high pressure by day. All pens were supplied with nipple drinkers delivering clean drinking water at all times. Ducks in *N*/*B*, *N*, and *S* groups were protected under Home Office Licence (PPL 30/2310).

Each treatment was replicated six times; three times in cycle 1 and three times in cycle 2, using new batches of 60 ducks for each cycle. The experiment ran from the end of April to the end of August 2007.

2.3. Experiments

All ducks underwent three sequential experiments. Experiment 1 assessed the effect of type of bathing resource on plumage and physical condition, growth rate and behaviour from 4 to 6 weeks, and compared this with ducks reared with no access to bathing water. Experiment 2 detected signs of deprivation to bathing water when provided in the form of the bath (small pond), for ducks with no previous access (*N*) and ducks with access to other sources (*T*, *S*) at 7 weeks. Baths were installed in all pens, showers turned off and troughs removed. Experiment 3 assessed what form of water resource the ducks themselves preferred at 8 weeks. All pens were provided with a bath, trough and shower simultaneously.

2.4. Measures

Ducks were visually inspected at the end of each week and scored for the condition of their eyes, nostrils, feathers, posture, and walking ability, as defined in Table 1; body weight was also measured at 24, 36 and 53 days of age. Behaviour was recorded once a week for 10–12 h (from 9.00 a.m.) using CCTV cameras linked to Computar CTR 3024 and Daewoo DV-K611 VCRs. Behaviour was analysed, according to the ethogram given in Table 2, by scan sample every 5 min for experiments 1 and 2, and every 3 min for experiment 3 (due to the increased activity in the pen). The percent incidence of each activity was calculated, and behaviour directed at the water resource was summarised as the total time spent with resource, and the time spent resting, drinking and dabbling, and bathing

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Table 1
The scoring system used for the assessment of duck condition

Condition	Score	Definition
Eye condition	0	Eyes are clear, clean and bright
	D	There is a crust or dirt around the outside of the eye
	1	Eyes are wet and weepy or are red rimmed
	2	Eyes are closed or half closed permanently, or there is conjunctivitis
Nostril condition	0	Nostrils are clear and clean
	D	Nostrils are dirty
Feather condition	0	Feather cover is even and the feathers are clean
	D	The feathers are dirty
	1	Feather cover is patchy on wings
	2	Feather cover is patchy to bare on wings and patchy on the back
Posture	0	The duck lifts its body on standing and stands straight
	1	The duck does not fully raise body on standing, it adopts a horizontal posture or is stooped or twisted
	2	Includes severe postures outlined above or the duck will not lift off ground
Walking ability	0	The duck waddles and walks freely
	1	The duck walks with a slight limp, or has excessive cross over of the feet or slightly deformed legs (bowed), causing it to walk awkwardly
	2	The duck is reluctant to walk and walking is laboured, mostly due to severe cases of 1 above

at/in/under resource (Desforges and Wood-Gush, 1975; McKinney, 1975; Campbell and Lack, 1985).

2.5. Statistical analysis

Across all experiments, the percent incidence of physical condition scores and behaviour, and average pen body weight and growth rate were analysed by ANOVA (General Linear Model) with the fixed effects of cycle and treatment; significant treatment effects were subjected to a Tukey *post hoc* comparison to determine significant differences between treatment groups. For ease of presentation, behavioural results for experiment 1 have been averaged across weeks (4–6). In addition to the analysis for experiment 2, assessing rebound effects, bath related behaviour in week 7 was compared to resource directed behaviour in week 6 by paired *t*-test, to establish whether bathing water related behaviour differed between resource types. Where data did not conform to the conditions of normality (Grafen and Hails, 2002) in experiment 3, assessing preference, the non-parametric Friedman test (Siegel and Castellan, 1988) was used to assess the rank order of preference for resource.

3. Results

On the whole, the ducks were reared under good environmental conditions and their physical health in all treatments groups was high. There were no signs of morbidity and no mortality. The percent incidence of clean eyes, nostrils and feathers, of best walking and of average body weight and growth rate are given in Table 3. At 6

Table 2
The behavioural ethogram used for the scan observation of ducks in Experiments 1–3

Behaviour	Definition
Rest under/on water resource	Stand or lie on bath or under shower, doing nothing in particular, with or without eyes closed
Rest adjacent to water resource	Stand or lie adjacent to the water resource (bath, trough or shower), doing nothing in particular, with or without eyes closed
Dry rest	Lie down away from water resource, eyes may be open or closed or the duck may be sleeping whilst standing up
Stand still	Stationary in standing posture, not engaged in any other behaviour
Feed	Eat food from feed hopper
Drink (nipple)	Nibbles at nipple drinker and swallows water; may include pauses less than 10 s
Drink resource[a]	Drinks from bath or trough by beak dipping-head raise-swallow, or from shower by head raise and nibble or nibble along floor under shower
Bathe	Any element of the bathing sequence, including wet preen, head roll, duck & dive, wing rub (flick wings up and forward); may include pauses less than 10 s
Dry preen	Any element of the preening sequence, including stroking, head rolls and shaking that do not involve water
Root straw	Digging & moving straw around with beak
Dabble water[a]	Rapid nibbling with head moving side to side in the bath or trough
Stop (alert)	Duck stops what it is doing due to some external distraction
Walk	Locomotion
Peck object	Duck pecks at walls and fittings of pen
Social interaction	Any interaction between ducks which may include grooming, pecking at each other, social dominance aggression
Wing flap	Rapid beating of the wings
Stretch	Any stretching movements of the head, wing, or leg
Shake tail	Tail wagging independent of the preening action
Swim	Duck swims on surface of bath water
Other	Any other behaviour not listed above

[a] Since it was difficult to dissociate drinking and drink-dabble at the shower, drink and dabble behaviours were combined for bath, trough and shower resources.

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Table 3
The effect of rearing ducks with different types of, or no access to bathing water on the incidence of clean eyes, nostrils and feathers, and walking ability in week 6 of life, and on average weight and growth rate to 53 days

Measure	Bath ($N = 6$)	Trough ($N = 6$)	Nipple/bath ($N = 6$[1])	Nipple only ($N = 6$)	Shower ($N = 6$)	Treatment effects
Clean eye (%)	100[a]	100[a]	100[a]	54.2[b] (15)	100[a]	$F_{2,24} = 9.0$; $p = 0.0001$
Clean nostril (%)	100[a]	100[a]	100[a]	37.5[b] (18.0)	100[a]	$F_{2,24} = 14.1$; $p = 0.0001$
Clean feather (%)	95.8[a] (4.2)	66.7[ab] (21.1)	91.7[a] (8.3)	16.7[b] (16.7)	95.8[a] (4.2)	$F_{2,24} = 6.9$; $p = 0.001$
Best posture (%)	100	100	100	95.8	95.8	$F_{2,24} = 0.7$; $p = 0.587$
Best walking (%)	91.7 (5.3)	100	100	100	91.7 (5.3)	$F_{2,24} = 1.9$; $p = 0.144$
Weight (kg; 53 days)	4.59 (0.06)	4.59 (0.07)	4.60 (0.07)	4.60 (0.11)	4.61 (0.08)	$F_{2,24} = 0.2$; $p = 0.927$
Growth rate (g/d; 24–53 days)	74.4 (1.9)	74.3 (1.0)	74.6 (0.9)	74.1 (2.1)	74.8 (1.3)	$F_{2,24} = 0.04$; $p = 0.996$

[1] Access to bath given in week 5.

weeks of age, only ducks in the nipple (N) group had crusty or dirty eyes (45.8%) and dirty nostrils (62.5%); ducks in the B, T, S and N/B groups all had clear, clean eyes and nostrils. No ducks attained scores 1 or 2 for body and plumage condition. Ducks in the N group had the lowest incidence of clean, smooth feathers (16.7%), whereas ducks in the T group were intermediate (66.7%) and ducks in the B, S, and N/B groups had the highest incidence of clean smooth feathers (>90%). All ducks, except those in the N group, were well oiled (seen as a yellow tinge to the feathers and felt as a waxy coating). There was no effect of treatment on posture, walking ability, body weight or growth rate; most ducks had an upright posture and walked well, and on average attained 4.6 kg at 53 days growing at an average 74.6 g/d (24–53 days).

Water related activity is summarised in Fig. 1 for weeks 4–6 during experiment 1. Ducks reared with access to baths or showers spent more time resting with their water source (11.1% and 8.0%, respectively) than ducks reared with troughs (5.0%) or the nipple-bath (2.0%) ($F_{4,24} = 16.0$, $p < 0.001$); ducks did not rest in association with the nipple drinkers. Ducks in the S group also drank and dabbled more from the resource (10.7%) than ducks in the T, N/B or N groups (5.5–6.7%); ducks in the B group were intermediary (7.9%) ($F_{4,24} = 26.8$, $p < 0.001$). There was no difference in bathing levels between ducks from the different bathing resource groups (2.6–3.5%), only with ducks from the N group ($F_{4,24} = 9.8$, $p < 0.001$); these ducks spent little time bathing (wet preening) from the nipples (0.6%). Ducks with swimming access (B and N/B) spent a very small amount of their time swimming; 0.04% (range 0–0.19%) for the B group and 0.06% (0–0.35%) for the N/B group.

There were few effects of treatment in weeks 4–6 on non-water related behaviour. Ducks rested more when reared with nipples (65.9% N group and 62.1% N/B group) than with baths or showers (52.3% and 51.3%, respectively); ducks reared with troughs were intermediate (59.2%) ($F_{4,24} = 7.5$, $p < 0.001$). They also stretched their heads (0.9% compared to 0.5%, $F_{4,24} = 5.3$, $p = 0.003$) and performed other behaviours (0.7% compared to 0.07%, $F_{4,24} = 5.1$, $p = 0.004$) more often. Ducks in the N/B group did not show compensatory rebound bathing when they gained access to the bath in week 5; they bathed for 3.6% of the time compared to 3.3% for ducks in the B group.

Activity at the bath in week 7 during the rebound experiment (experiment 2) is summarised in Fig. 2. There was no difference in the total time (20.7–24.5%) or time spent resting (0.8–9.3%) with the bath between treatment groups, however, ducks with previous access to showers had the highest levels of drink-dabble (18.0% compared to 9.1–14.3%, $F_{4,24} = 3.9$, $p = 0.015$). Ducks with previous access to nipple drinkers only (N) spent 7.6% of their rebound test day bathing in or at the bath, which was significantly higher than that for ducks reared with the bath (3.4%, Tukey comparison, $T = 3.0$ $n_1 = 6$, $n_2 = 6$, $p = 0.04$). There was no significant increase in bathing levels during the rebound test in ducks reared with other resources (T, S, N/B). Swim levels were low (0.4% range 0–0.2%) and not affected by previous rearing resource.

Only ducks previously reared with showers exhibited different levels of water related behaviours in week 7 with

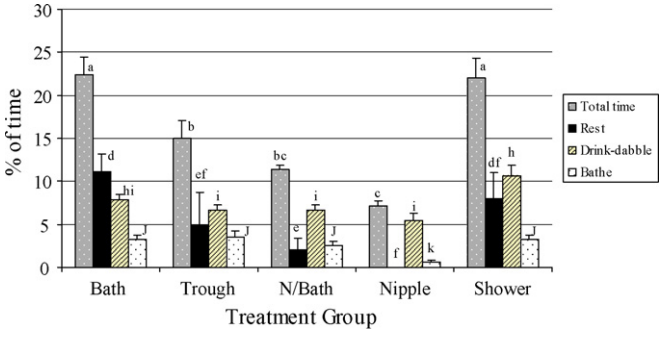

Fig. 1. *Experiment* 1: water related behaviour of ducks reared with access to different types of water resource and averaged for weeks 4–6. Data are expressed as the total percent of time engaged in water related behaviour and the percent of time resting, drink-dabbling, and bathing at the resource. Values with different superscripts are statistically different.

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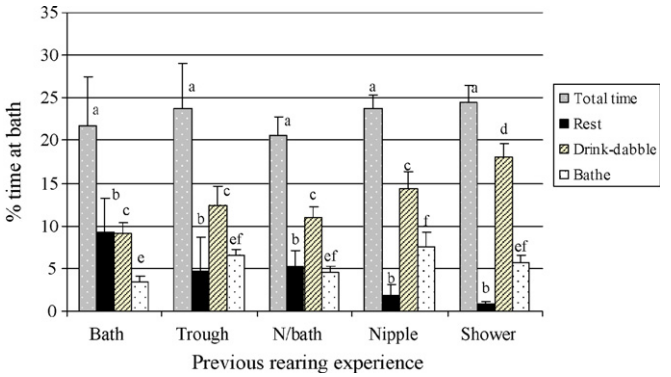

Fig. 2. *Experiment* 2: water related behaviour of ducks given access to a bath at week 7 after being reared with different water resources. Data are expressed as the total percent of time engaged in water related behaviour and the percent of time resting, drink-dabbling, and bathing at the resource. Values with different superscripts are statistically different.

the bath than the preceding week with the shower; they rested less (0.8% compared to 6.8% $t = 4.2$ $p = 0.004$), and drank-dabbled more (18.0% compared to 10.7% $t = -5.0$ $p = 0.002$) from the bath than the shower. All ducks in the *N* group had clear eyes and nostrils, and clean feathers, after the introduction of the bath; feathers were fully oiled within 3 days.

Water related activity at all four resources given simultaneously in the preference test (experiment 3) are shown in Fig. 3. Ducks from all treatment groups spent significantly more time with the shower (Friedman test 3 d.f. $S = 12.8$ $p = 0.005$). They rested more (10.1% compared to 1.1% (*B*) and 0.6% (*T*), Friedman test 2 d.f. $S = 10$ $p = 0.007$), and drink-dabbled more from the shower (7.8% compared to 4.5% (*B*, *T*) $F = {}_{4,24}$ 51.2 $p < 0.001$). Most bathing was performed at the bath (4.6%) with the shower use (2.7%) intermediate to the trough (1.3%) ($F_{4,24} = 47.9$ $p < 0.001$). Little time was spent with the nipple drinkers (0.7%). Time spent bathing from/at the bath and shower were not significantly different for ducks with previous access to the bath (weeks 4–6, *B* and *N*/*B* groups), whilst ducks with previous access to nipples-only (*N* group) showed no difference in drink-dabble levels from the bath or shower. Ducks reared in the *T* group showed no preference for resource (*B*, *S*, *T*) for drink-dabbling or bathing, and ducks reared in the *S* group showed no preference for resource (*B*, *S*, *T*) for drink-dabbling.

4. Discussion

The results of the different rearing treatments showed that a lack of bathing water, without the opportunity to at least dip heads and splash water onto their bodies, adversely affected duck body and plumage condition. The best plumage condition was observed with the bath and shower treatments, which had full body access to water. It should be noted however that the trough dimensions used in this study were narrow and shallow compared to those used in industry (Jones, personal observation) which may have affected the ducks ability to keep their feathers fully clean. There was no difference in bathing levels for ducks reared with baths, troughs or showers, indicating that troughs and showers matched the bath in their provision of bathing water.

There were few signs of frustration in ducks reared with out bathing water; they exhibited increased head stretching and other behaviours (mostly directing attention to adjacent pens), and ducks at the young age did not show compensatory rebound when given access to the bath at week 5. However the rebound test in week 7 suggests that ducks reared with access to nipples only were behaviourally deprived and were compensating for previous deprivation by bathing from the bath more than ducks reared with the bath.

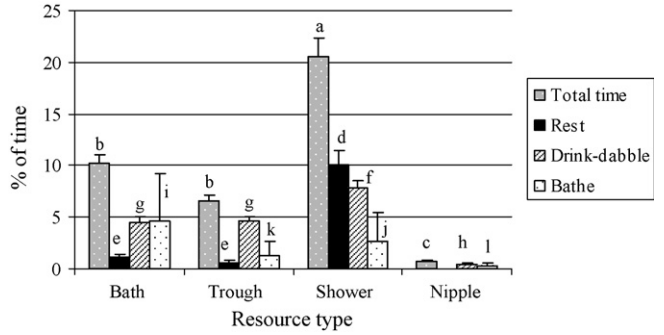

Fig. 3. *Experiment* 3: preferences of ducks for different types of bathing water provision. Data are expressed as the percent of time engaged in resting, drink-dabbling, and bathing with each resource when given access to all resources simultaneously. Values with different superscripts are significantly different.

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Importantly, such compensation was not being shown by ducks reared with troughs or showers. These differences (better condition and rebound bathing) are particularly striking in view of the fact that ducks reared with access to baths, showers or troughs did not spend much of their time actually bathing at their water source. In fact, they spent less than 5% of their time bathing. This suggests that it may not be necessary to provide constant access to bathing water throughout the day (Heyn et al., 2006); although this should be considered in relation to other behaviours directed at the water source, namely resting and drink-dabbling, which increase the total association to 15–22%.

The results also showed that, when given a choice, ducks preferred open water sources to nipple drinkers, and that overall showers were a favoured resource as ducks spent more time resting and dabbling from them. That said, they preferred to bathe from the bath with the shower intermediate to the trough.

None of the measures we used (body and plumage condition, behaviour, rebound, choice) allowed us to say that duck welfare was any better with the bath that allowed swimming and full body immersion than with a trough that allowed just head-dipping or a shower. What mattered was some access to water in which the birds could wet their heads and splash water (bath/troughs) or have it sprayed (showers) onto their bodies (Cooper et al., 2002; Ruis et al., 2003; Benda et al., 2004; Heyn et al., 2006). This too has implications for the commercial farming of ducks as troughs and showers would be much easier to keep clean than ponds and would be more economical of water. Duck ponds can easily become contaminated with *Campylobacter* and other organisms that can affect human and duck health unless they are kept scrupulously clean. This can involve using a great deal of water, which in turn has adverse environmental implications (Rodenburg et al., 2005).

Taken together, our results suggest that improvements could be made to duck welfare (in terms of physical condition and what the animals want) on commercial farms by relatively simple means. Ponds may not be necessary, and troughs, which are currently used in some commercial systems in the UK, or even showers could provide a relatively trouble-free way of keeping ducks in good health and giving them what they want. What is needed now is for these ideas to be taken up and tested on a flock basis commercially.

5. Conclusions

Access to some form of open water, possibly in addition to nipples for drinking, improves duck body and plumage condition even though the ducks spend relatively little of their time actually bathing (less than 5%). Access to bathing water is something that ducks want, as shown both by the compensatory 'rebound' in ducks reared with nipples-only and by the clear preference of all rearing groups for showers, baths, or troughs over nipples when given a four-way choice. Baths (ponds) however may not be a necessary source of open water as troughs and showers match their provision for bathing water.

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References

Benda, I., Reiter, K., Harlander-Matauschek, A., Bessei, W., 2004. Preliminary observations of the development of bathing behaviour of Pekin ducks under a shower. Book of abstracts of the XXII World's Poultry Science Congress. Istanbul, Turkey, p. 349.

Borbely, A.A., Achermann, P., 1999. Sleep modulation and models of sleep regulation. J. Biol. Rhythms 14, 557–568.

British Poultry Council, 2008. http://www.poultry.uk.com/who_-ducks01.htm.

Campbell, B., Lack, E.T. (Eds.), 1985. A Dictionary of Birds. A.D. Poyser Ltd., Waterhouse, Staffs.

Cooper, J.J., McAfee, L., Skinn, H., 2002. Behavioral responses of domestic ducks to nipple drinkers, bell drinkers and water troughs. Brit. Poult. Sci. 43, S17–S18.

Council of Europe 1999. Standing Committee of the European convention for the protection of animals kept for farming purposes. Recommendations concerning Muscovy Ducks (*Cairina moschata*) and hybrids of Muscovy and Domestic ducks (*Anas platyrhynchos*), adopted by the Standing Committee on 22 June 1999 (http://www.coe.int/t/e/legal_affairs/legal_cooperation/biological_safety,_use_of_animals/farming/Rec).

Dawkins, M.S., 2006. Through animal eyes: what behaviour tells us. Appl. Anim. Behav. Sci. 100, 4–10.

Desforges, M.F., Wood-Gush, D.G.M., 1975. A behavioural comparison between domestic and mallard ducks. Habituation and flight responses. Anim. Behav. 25, 692–697.

Grafen, A., Hails, R., 2002. Modern Statistics for the Life Sciences. Oxford University Press (Chapters 8, 9).

Heyn, E., Damme, K., Manz, M., Remy, F., Erhard, M.H., 2006. Water supply for Peking ducks—possible alternatives for bathing. Dtsch. Tierarztl. Wochenschr. 113, 90–93.

Kuhnt, K., Bulheller, M.A., Hartung, J., Knierim, U., 2004. Hygienic aspects of provision of bathing water for Muscovy ducks in standard housing. Book of Abstracts of the XXII World's Poultry Science Congress. Istanbul, Turkey, p. 694.

Knierim, U., Bulheller, M.A., Kuhnt, K., Briese, A., Hartung, J., 2004. Water provision for domestic ducks kept indoors—a review on the basis of the literature and our own experiences. Dtsch. Tierarztl. Wochenschr. 111, 115–118.

McKinney, F., 1975. The behaviour of ducks. In: Hafez, E.S.E. (Ed.), The Behaviour of Domestic Animals. third ed. Bailliere Tindall, London, pp. 490–519.

Nicol, C.J., 1987. Behavioral responses of laying hens following a period of spatial restriction. Anim. Behav. 35, 1709–1719.

Olsson, I.A.S., Keeling, L.J., 2005. Why in earth? Dustbathing behaviour in jungle and domestic fowl reviewed from a Tinbergian perspective. Appl. Anim. Behav. Sci. 93, 259–282.

Raud, H., Faure, J.M., 1994. Welfare of ducks in intensive units. Rev. Sci. Tech. 13, 119–129.

Reiter, K., Zernig, F., Bessei, W., 1997. Effect of water bath and free range on behaviour and feathering in Pekin, Muscovy, and Mulard duck. In: The 11th European Symposium on Waterfowl, Nantes, France, pp. 224–229.

Ruis, M.A.W., Lenskens, P., Coenen, E., 2003. Welfare of Pekin-ducks increases when freely accessible open water is provided. In: The Second World Waterfowl Conference, Alexandria, Egypt, p. 17.

Rodenburg, T.B., Bracke, M.B.M., Berk, J., Cooper, J., Faure, J.M., et al., 2005. The welfare of ducks in European duck husbandry systems. World's Poult. Sci. J. 61, 633–646.

Siegel, S., Castellan, N.J., 1988. Nonparametric Statistics for the Behavioral Sciences. McGraw-Hill, New York.

Vestergaard, K., 1982. Dustbathing in the domestic fowl: diurnal rhythm and dust deprivation. Appl. Anim. Ethol. 8, 487–495.

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