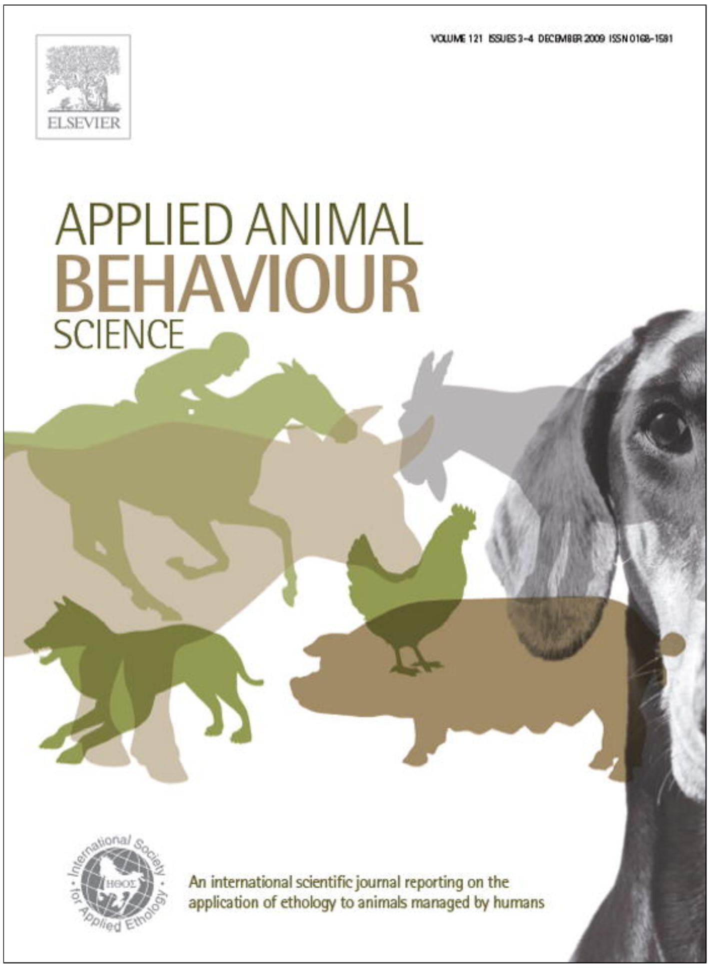
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Behaviour, synchrony and welfare of Pekin ducks in relation to water use

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ABSTRACT

The method of providing bathing water to commercially farmed ducks presents potential logistic, welfare and health issues. Welfare may be compromised if ducks do not have access to water in which they can at least dip their heads and spread water over their feathers. However maintaining hygiene and environmental standards is difficult with open water in which ducks can immerse themselves. Here we present evidence on the welfare implications of providing bathing water to ducks from baths, troughs, showers and nipples. We ask whether they allow ducks to exhibit the full range of bathing behaviours and examine synchrony of bathing behaviour.

The total time ducks spend at the resource during a bathing bout was not different between the bath, trough and shower but was least at the nipple (563–818 s compared to 243 s, $p = 0.004$). Most elements of the bathing sequence were displayed at all resources, although some behaviours were redirected at the straw in the nipple group. On the whole, there was no difference between the duration and frequency of the bathing elements for ducks at the bath, trough and shower, which were longer and more frequent than at the nipples. There was however, more resting under the shower than with the bath (214 s compared to 47 s, $p = 0.02$), and more wing-rubbing at the trough than the bath (7 s compared to 1.5 s, $p = 0.009$). There was no effect of resource on the time spent head rolling or the frequency of scratching and body shaking. Additionally, the sequence of behavioural elements within the bathing bout was more variable in the bath and under the shower than at the nipple (4.1 compared to 3.6, $p = 0.02$).

Finally, ducks at the nipples spent proportionally more time at the resource singly (61.2%, $p = 0.044$). Whereas ducks at the bath, trough and shower used the resources more socially, spending proportionally more time at the resource when two or more ducks were there simultaneously (52.1–67.6% for the three resources).

We conclude that (i) the expression of bathing behaviour, as measured by duration, frequency and sequence of bathing elements, was similar in showers and troughs to baths, but different in nipples, and (ii) bathing water resources need to allow for a degree of social bathing, but need not cater for all ducks simultaneously.

1. Introduction

The provision of bathing water to commercially farmed ducks poses a potential problem for producers (Rodenburg et al., 2005). On the one hand, there is a widespread concern that duck welfare is compromised if ducks do not have access to water in which they can at least dip their heads and spread water over their bodies (The Council of Europe, 1999). Without this opportunity ducks show a loss of eye and plumage condition (Ruis et al., 2003; Jones et al., 2009; Jones and Dawkins, in press). On the other hand, providing ducks with sources of water large enough for them to immerse themselves or swim tend to have high bacterial counts (Kuhnt et al., 2004) as ducks defaecate frequently in the water. Cleaning the water sufficiently

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often to ensure that it is uncontaminated can mean that water use is uneconomical and contravenes environmental requirements (Rodenburg et al., 2005). High standards of welfare in commercial duck farming will therefore only be achieved if ducks can be farmed in a way that meets both the welfare needs of ducks and the requirements of producers to avoid bacterial contamination and to use water economically.

Troughs (in which ducks can dip their heads but not immerse their bodies) and overhead showers have been proposed as alternatives to baths (small ponds in which ducks can immerse their bodies and swim but not be out of their depth) for providing bathing water to ducks. Ducks spent similar amounts of time bathing from baths, troughs and showers (Jones et al., 2009), and earlier studies indicate that elements of the bathing sequence are similar for showers and ponds (Benda et al., 2004). Further information is required however, to assess whether showers or troughs allow the full expression of bathing behaviour and are therefore adequate substitutes from the ducks' point of view.

Here, we further examined the bathing behaviour shown by ducks at baths, troughs, showers, and nipple drinkers (included since a large percent of ducks are reared commercially with access to nipple drinkers only). Our first aim was to see whether we could detect any differences in bathing behaviour that might suggest that troughs and showers do not allow the full expression of bathing behaviour that is seen with baths. Since inadequate environments can result in a wide variety of changes in behaviour including loss of elements, inclusion of new elements, repetition, and even stereotypy (Grafen, 2002; Rutherford et al., 2004; Inglis and Langton, 2006), we applied a variety of different methods for detecting differences. These included measuring the frequency and duration of different behavioural elements and analysing the sequence with which they were shown.

Our second aim was to examine the extent to which ducks choose to use a water source at the same time as other ducks. Synchronous use of bathing water would suggest that to meet the behavioural needs of ducks, producers might have to provide water sources that were sufficiently extensive that all ducks could use them at once. Asynchronous or sequential use would suggest that less extensive resources might be adequate.

2. Methods

2.1. Animals and husbandry

In total 96 Cherry Valley Pekin strain ducks were used in this study of bathing behaviour, which was part of a larger previously reported experiment (Jones et al., 2009). Day old ducklings were reared to 24 days on an organic chicken starter diet with access to nipple and flat dish drinkers. They were taken off heat at 12 days and were provided with deep straw litter (>15 cm) which was topped up daily.

At 24 days ducks were allocated and moved to their treatment pens (4 treatment types, described below) and fed organic chicken finisher pellets. They 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. Pens were constructed inside a barn with a concrete floor and natural ventilation. They included a deep straw littered front section equipped with a nipple drinker line (2 nipples/pen), supplying clean drinking water at all times, and a feed hopper. The back section of the pen consisted of a raised solid wooden floor (20 cm) on which the bathing resource (allocated by treatment group) was located. The floor sloped downward to an external drainage pipe which removed excess water and maintained a dry pen; this section was free of straw. Each day the solid floor was cleaned of faeces and fresh straw was added to the front section of the pen. Hygiene and environmental conditions in the pen were considered to be very good.

2.2. Treatments and replication

There were four treatment groups differing by bathing resource, these included: (1) bath (950 mm × 650 mm × 250 mm deep) where ducks had full body access to bathing and swimming water, (2) trough (950 mm × 125 mm × 80 mm) where ducks could dip their heads in open water and toss it over themselves, but could not immerse their bodies, (3) shower (length 950 mm garden irrigation pipe, 4 nozzles/pen with a spray area equivalent to the area of the bath), where ducks had full body access to bathing water from overhead nozzles, and (4) nipple (no bathing resource), where ducks had access to water via nipple drinkers only (4 nipples/pen); the nipples were located on the single drinker line over the front section of the pen so that the solid floor at the back of the pen was clear of any resource. Ducks were reared with their allocated treatment resource to 49 days. Each treatment was replicated six times in total; three times in each of two production cycles with a new batch of ducklings per cycle.

All ducks in the pen were able to use the resource simultaneously and their access was constant. 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. Showers were left on continuously, at low pressure during the night and high pressure by day. Ducks in the nipple and shower groups were protected under Home Office Licence (PPL 30/2310).

2.3. Data collection

Data for this study were collected when ducks were 47 days old. Behaviour was recorded for 12 h per pen (9 am to 9 pm) using CCTV cameras linked to Computar CTR 3024 and Daewoo DV-K611 VCRs. The videos were analysed specifically for bathing behaviour at each resource in two ways. The behavioural elements of the bathing sequence are defined in Table 1.

Firstly JWatcher 1.0 software (Blumstein et al., 2006) was used to continuously code the behaviour of focal ducks during bathing bouts. Ten bathing bouts were sampled at random per pen, unless there were less than ten bouts

Table 1
Behavioural definitions for ducks observed during a bathing bout at the water resource.

Behavioural states	Definition
Drink/dabble	Ingesting water via down and up strokes at open water or rapid nibbling whilst the head moves from side to side; or pecking at the nipple drinkers
Head-dip	Dipping head into open water and shaking it from side to side, or directing this motion at the straw for ducks with access to nipples
Duck/dive	Rapid dipping and raising of head and body at, in or under water resource
Swim	Moving around on the surface of the bath water, being propelled by the legs
Head roll	Rubbing sides of head over body, designed to spread oils over the feathers
Wet preen	Nibbling at feathers whilst applying water either directly with the bill or after tossing water over the body
Wing-rub	Rapid rubbing action with wings, designed to spread oils over the feathers
Resting on/under resource	Pausing bathing movements and remaining stationary on bath or under shower
Events	
Head toss	Flicking head back or from side to side to spread water over body
Scratch	Rapid rubbing of body with feet
Shake body	Rapid movement of whole body to and fro
Wing flap	Beating the air with the wings, designed to dry the feathers

occurring for that pen. This occurred for three of the 24 pens; one in the shower treatment (where $n = 5$ bouts), and three in the nipple treatment (where $n = 3$ bouts, $n = 9$ bouts, and $n = 7$ bouts). A bout was defined as starting at the time the focal duck approached the resource and engaged in any behaviour considered part of the bathing sequence (Table 1), until the time it left the resource. This meant that a bathing bout could include non-bathing behaviours, such as resting or drinking, which occurred within the bathing sequence. If there was more than one duck at the resource, the resource was divided into quadrants and the bird within or closest to a predetermined randomly selected quadrant was used as the focal animal. The duration of behavioural states and the number of incidents of behavioural events were recorded. The total duration of each bathing bout and the total time spent bathing within that bout were also recorded.

Secondly, the bathing bouts identified above were further analysed to measure synchrony of bathing behaviour between the ducks in the pen. For this, the number of ducks within one body length of the resource during the focal duck bathing bout was recorded. The percent of time that 1, 2, 3, or 4 ducks were at the resource was then calculated.

Due to the nature of the different resources, some behaviours were not able to be expressed in all resources. ‘Swimming’ and ‘resting on/under resource’ were therefore only recorded for the bath, and the bath and shower, respectively. In addition, in the absence of an open water source (nipple treatment), the head-dip behaviour was redirected at the straw near the nipple drinker whilst wing-rub and duck/dive were performed at the nipple.

2.4. Statistical analysis

In total 224 bathing bouts were analysed. For the analysis of bathing behaviour the statistical unit was the pen; duration and frequency of behaviours within the bathing sequence were therefore averaged across the bouts per pen. In addition, this average pen data were inserted into a separate 8×8 first order transition matrix showing preceding (x) and following behaviours (y) (Lehner, 1996). The eight behaviours were duck/dive, wet preen, head roll, wing-rub, head toss, scratch, shake body, and wing flap (Table 1). For each matrix, an uncertainty value U, was calculated where $U_{(x,y)} = -\sum_{x,y} \log_2 P_{x,y}$ (Dingle, 1969; Dawkins and Dawkins, 1976) giving 6 U values/treatment. Data were log transformed where the assumptions of normality were not met, and analysed by univariate ANOVA for the fixed effect of treatment (SPSS 14.0). Significant treatment effects were further investigated using a post hoc Tukey comparison.

For the analysis of synchrony in bathing behaviour, the percent of time that 1, 2, 3, or 4 birds were at the resource was analysed for the effect of treatment by a one way ANOVA with post hoc Tukey comparison to identify individual treatment differences. Data were log transformed to normalise the distribution. Furthermore, data were analysed by a repeated measures ANOVA to assess the overall percent of time that each number of birds were at the resource (the within subjects factor or the repeated measure) by resource type and its interaction with the number of ducks present.

3. Results

3.1. Bathing elements and sequence

The duration and frequency of the behavioural elements of the bathing sequence are given in Table 2 along with the effects of treatment. Most behavioural elements were expressed at all resources, so that with the exception of swim and rest on/under resource, the only behaviour not expressed was head-dip under the shower. Resting under showers was significantly greater than average resting time on baths ($t_{10} = -2.7$, $p = 0.02$).

Overall ducks spent significantly less time at the nipple than any other resource and there was no difference between the total time spent at the bath, trough or shower. Total time bathing was also least with the nipple than at the trough or shower, but intermediate in the bath, despite average bathing levels to be twice that of the nipple (179 s in bath compared to 85 s at nipple).

Table 2
Mean (standard deviation) duration of behavioural states and counts of behavioural events within the bathing sequence for ducks at the four water resources, along with the total time spent at the resource and the total time bathing.

Behaviour	Bath	Trough	Shower	Nipple	Treatment effect
Total time at resource (s)	563.3^{a} (79.7)	555.4^{a} (54.7)	817.7^{a} (71.8)	243.0^{b} (67.9)	$F_{3,20}=11.6$; $p=0.000$
Total time bathing (s)	179.4^{ab} (33.7)	298.3^{a} (53.0)	255.9^{a} (22.6)	84.9^{b} (33.3)	$F_{3,20}=6.3$; $p=0.004$
Drink/dabble (s)	212.2^{ab} (45.0)	163.2^{ab} (55.0)	270.6^{a} (22.2)	108.4^{b} (24.7)	$F_{3,20}=4.4$; $p=0.016$
Head-dip (s)	11.4^{ab} (1.3)	28.9^{a} (6.9)	–	2.4^{b} (2.2)	$F_{3,20}=6.1$; $p=0.016$
Duck/dive (s)	42.5^{a} (7.1)	54.8^{a} (12.5)	27.7^{ab} (6.4)	1.4^{b} (0.8)	$F_{3,20}=8.5$; $p=0.001$
Swim (s)	12.2 (5.1)	–	–	–	–
Head roll (s)	5.0 (1.6)	9.1 (1.9)	15.2 (2.4)	8.0 (3.4)	$F_{3,20}=2.9$; $p=0.060$
Wet preen (s)	119.0^{ab} (26.9)	198.6^{a} (37.0)	209.7^{a} (21.0)	72.4^{b} (30.5)	$F_{3,20}=5.0$; $p=0.01$
Wing-rub (s)	1.5^{a} (0.7)	7.0^{b} (2.6)	3.4^{ab} (1.1)	0.7^{a} (0.3)	$F_{3,20}=5.1$; $p=0.009$
Rest in/on resource (s)	46.8 (23.7)	–	214.6 (57.3)	–	–
Head toss (n)	13.7^{ab} (0.9)	18.5^{a} (3.1)	17.0^{a} (1.7)	5.4^{b} (2.7)	$F_{3,20}=6.5$; $p=0.003$
Scratch (n)	1.7 (0.3)	0.53 (0.2)	0.8 (0.2)	1.2 (0.5)	$F_{3,20}=2.3$; $p=0.104$
Shake body (n)	2.2 (0.1)	6.4 (4.1)	3.5 (0.6)	1.2 (0.4)	$F_{3,20}=3.1$; $p=0.050$
Wing flap (n)	1.6^{a} (0.2)	1.4^{a} (0.1)	1.9^{a} (0.3)	0.5^{b} (0.2)	$F_{3,20}=8.7$; $p=0.001$

Values within row with different superscripts are significantly different.

Table 3
Mean (standard deviation) uncertainty values in the bathing sequence for ducks at the four water resources.

Bath	Trough	Shower	Nipple	Treatment effect
4.11^{a} (0.29)	4.02^{ab} (0.22)	4.07^{a} (0.34)	3.55^{b} (0.36)	$F_{3,20}=4.1$; $p=0.02$

Values within row with different superscripts are significantly different.

Table 4
Mean percent of time and (standard deviation) that ducks use the water resource by the number of ducks at the resource at any one time and type of resource.

Number of ducks	Bath (%)	Trough (%)	Shower (%)	Nipple (%)	Treatment effect
1	39.9 (6.5)	47.9 (15.1)	32.4 (14.6)	62.2 (25.5)	$F_{3,20}=3.0$; $p=0.056$
2	28.9 (6.2)	28.6 (7.3)	25.3 (7.2)	21.9 (9.8)	$F_{3,20}=1.4$; $p=0.357$
3	18.9 (3.9)	12.9 (5.3)	18.9 (7.3)	9.7 (10.0)	$F_{3,20}=2.6$; $p=0.079$
4	12.3^{ab} (7.8)	10.6^{ab} (10.2)	23.4^{a} (6.9)	7.2^{b} (11.0)	$F_{3,20}=3.6$; $p=0.032$

Values within rows with different superscripts are significantly different.

Ducks at the nipple spent the least time drinking, head-dipping, duck/diving, and wet preening and performed the least incidences of head toss and wing flap. Ducks at the shower spent the most time drink/dabbling, whilst ducks at the trough spent most time head-dipping and performing wing-rubbing. Ducks at the bath and trough spent most time duck/diving and at the trough and shower most time wet preening; the latter resources performed more head tosses. The bath was intermediate for the time spent head-dipping and wet preening, whilst the shower was intermediate for duck/diving and wing-rubbing. There was no difference between resources in the time spent head rolling, or in the frequency of scratching and body shaking.

The uncertainty associated with bathing sequences are given in Table 3 along with the effect of treatment. Uncertainty values were highest in the bath and shower and least with the nipple; values were intermediate in the trough.

3.2. Synchrony of bathing

The percent of time ducks used the water resource when there was 1, 2, 3 or 4 ducks at the resource, is given in Table 4, along with treatment effects. There was no difference in the proportion of time ducks spent at the resource when 1–3 ducks were present. However when all 4 ducks were present, ducks spent more time with the shower, least time with the nipple and intermediate time with the bath and trough. Overall, there was a significant effect of the number of ducks at the resource on the percent of time that 1, 2, 3, or 4 ducks used the resource ($F_{3,60}=33.5$, $p=0001$), and a significant interaction between the number of ducks and resource type ($F_{9,60}=2.8$, $p=0.008$). The percent of time ducks used the resource decreased as the number of birds increased for troughs, baths and nipples. For showers, ducks also decreased the time they spent using the resource as the number of birds increased up to 3, but when 4 birds were present the time at the resource increased (Table 4).

As another way of investigating if ducks had a greater tendency to bathe socially rather than on their own, data were sub-divided into instances where only one duck was using the resources compared to 2 or more ducks. Overall there was no effect of treatment ($F_{1,20}=1.3$, $p=0.275$), but there was a significant interaction between the number of ducks and resource type ($F_{3,20}=3.24$, $p=0.044$). For nipples, ducks used this resource more singly, whereas for showers, troughs and baths, ducks used the resources

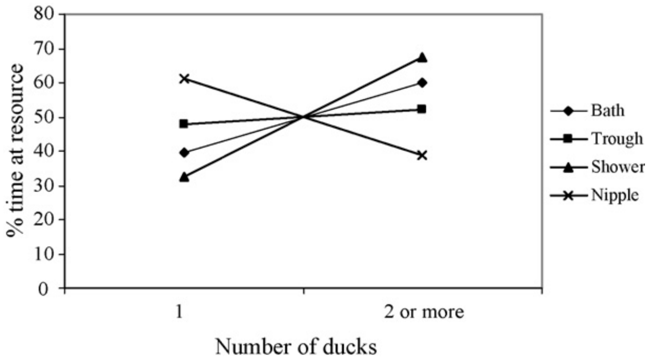

Fig. 1. Mean percent of time ducks use the water resource singly or when two or more ducks are at the resource simultaneously.

more socially. This effect is most marked for showers (Fig. 1).

4. Discussion

Our first aim was to investigate whether there were detectable differences in the bathing behaviour shown by ducks at troughs and showers that might suggest that they are not adequate substitutes for the expression of bathing behaviour from baths. The results indicate little difference in the duration and frequency of the behavioural elements of the bathing sequence for ducks with access to baths, troughs and showers. Bathing durations and frequencies were, however, least at the nipple. Interestingly, all elements of the bathing sequence (except rest with resource and swim) were represented with the nipple, although some were performed in the absence of water (duck/dive) or redirected at the straw (head-dip). Both behaviours were performed exactly as those at open water, so head-dip should therefore not be confused with rooting in the straw as the action is very different.

Such differences between bathing at nipples and the other sources are not unexpected. Baths, troughs and showers may appear functionally different, but they commonly allow large quantities of water to be tossed or run over the duck's body wetting the feathers. Nipple drinkers, on the other hand, give only a few drops of water which the ducks have to work into their feathers and do not allow water over the eyes and nostrils. Bathing at the nipple is therefore less effective at maintaining eye, nostril and plumage condition (Jones et al., 2009).

There were some variations in the behavioural elements shown at baths, troughs and showers which may be attributable to the functional differences in the resource use. For instance, there was no head-dipping in the shower and less time was spent duck/diving, presumably because standing under the shower allows the head and body to be successfully wetted. Additionally, most head-dip, head toss and wing-rub occurred at the trough, which was narrow (125 mm) compared to troughs used commercially (Jones and Dawkins, in press), and potentially limited the amount of water the duck could toss over its body in one movement of the head. The fact that there was no difference in the frequency of wing flapping however, which helps to dry the feathers, indicates that the feathers were equally wetted from the three sources. Where permitted, ducks incorporated a period of rest on the bath or under the shower, which was not possible with the trough. Retaining contact with water during pauses in bathing is therefore important to the ducks.

For the sequence analysis, bathing behaviour shown at baths and showers was very similar, but different to that seen at nipple drinkers; behaviour at the trough was intermediate. The high uncertainty of the sequence with the bath and shower implies that the ducks are showing relatively variable and unpredictable behaviour. The lower uncertainty of the sequence with nipples, on the other hand, implies more predictability in the behavioural pattern. This maybe due to the fact the resource is more limiting; the shower provided a source of running water that spread the width of the bath, whilst the trough was narrow and the nipple only allowed droplets of water into the bill at anyone time.

The criteria of duration, frequency and sequence of behaviour, therefore, indicate showers to be a very adequate substitute for a bath. They allowed the ducks to show their full range of bathing behaviour and are also highly preferred by the ducks themselves (Jones et al., 2009). Whilst there may still be logistical problems to overcome with providing showers on commercial farms, these are not insuperable. Drainage problems could be overcome with a separate, well drained shower area that ducks could enter when they chose. The problems of water use could be overcome by further studies designed to define exactly how long each day the showers need to be on or automated switches. The great advantage of showers, even over troughs, is that the bathing water is always completely clean and hygienic.

Our second aim was to look at the extent to which ducks synchronise their bathing behaviour. Proportionally, ducks tended to bathe for longer when using the nipple singly, and for longer with the bath, trough and shower when more than one duck was at the resource, i.e. more socially. The proportion of time at the resource did decrease however with sequentially increasing numbers of ducks at the resource and only with showers did the time at the resource increase when 4 ducks were present. Showers may have given the ducks an impression of more available space, since the wetted area was not confined by the lip of the bath, which may have been awkward getting in and out of when other ducks were present. Additionally, due to the high resting element of the sequence with the shower, which is considered a social behaviour, one may expect to see a greater degree of sociability with the shower than the bath.

Our results suggest that although ducks are social animals, it is not particularly important for them to be able to bathe synchronously. This means that if producers provide water resources for ducks, such as showers, it is not necessary for those resources to be able to accommodate all ducks simultaneously. Further work is required however to ascertain the proportion of ducks in a flock that would use the resource at the same time, in order to calculate the appropriate ratio of water sources to ducks (mm/bird).

5. Conclusions

The expression of bathing behaviour, as measured by duration, frequency and sequence of bathing elements, was similar in showers and troughs to baths, but different in nipples. Bathing at the nipple was characterised by shorter durations and fewer frequencies, with some behaviours redirected at the straw in the absence of open water. The behaviour was also more predictable and performed more singly. There were some differences in bathing behaviour between baths, showers and troughs, primarily due to the functionality of the resource or restrictions in their dimensions. Bathing was largely more social at these resources. Baths may not be a necessary source of open water for bathing in the duck, as showers and troughs match their provision for the expression of bathing behaviour. Some degree of social bathing is required.

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