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Feed-restricted broiler breeders: State-dependent learning as a novel welfare assessment tool to evaluate their hunger state?

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ABSTRACT

This paper reports three experiments that aimed to validate the use of state-dependent learning (SDL) as a novel welfare assessment tool to evaluate the hunger state of feed-restricted broiler breeders.

In each experiment, birds alternated every 2 days between two food rations: quantitative feed restriction (QFR) and ad libitum access to the same feed (AL). Each food ration was paired with a different, end of day, coloured food reward. It was predicted that the reward associated with hunger (QFR FR) would be preferred to the food reward associated with AL (AL FR) in a subsequent choice test. The SDL preference testing took place after 4 and 8 days of training. Each bird was tested twice (once per food ration fed on the test day).

In experiment 1 (pilot, $n = 4$), birds preferred the QFR-associated reward during both tests (mean (±S.E.M.) preference: QFR FR: 35.0 (±3.5) g; AL FR: 2 (±1.3) g, but differential food reward intake between hunger states during training confounded the results.

In experiment two ($n = 12$) a smaller food reward was used during training to try and equalise intake. The birds preferred the QFR FR in test 1 only (least significant difference (L.S.D.) = 15.08, $P < 0.05$). The mean (±S.E.M.) consumption in test 1 was: QFR FR: 31.6 (±4.3) g; AL FR: 9.41 (±2.3) g. However, differential reward intake continued to confound the findings.

In experiment three ($n = 8$), the food reward was made more palatable by feeding moist and food reward intake during training was equalised between hunger states. During testing, birds continued to show a significant preference in test 1 only (L.S.D. = 13.73, $P < 0.05$).

It was concluded that SDL-derived preferences observed do exist but are not a robust phenomenon. Therefore, further research is needed to quantify factors influencing SDL development and maintenance before using SDL as a tool to assess hunger in feed-restricted broiler breeders.

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1. Introduction

State-dependent learning (SDL) is the phenomenon in which an animal shows a preference for something based on the context in which it originally encountered it. An animal that experiences a stimulus linked to a food reward

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when in a state of high deprivation and another stimulus linked to an identical food reward when in a state of low deprivation will often show a preference for the stimulus associated with a state of high deprivation (Pompilio and Kacelnik, 2005). Furthermore, this preference has been shown to be independent of the animal's current state at the time of the two-way preference testing (e.g. Kacelnik and Marsh, 2002; Kurtz and Jarka, 1968). A state of high deprivation can be induced external to the training situation by food restriction (Vasconcelos and Urcuioli, 2008; Pompilio et al., 2006; Capaldi et al., 1994; Kurtz and Jarka, 1968; Revusky, 1967), by making the animal work hard to access the food reward within the training situation (Gipson et al., 2009; Friedrich and Zentall, 2004; Kacelnik and Marsh, 2002; Clement et al., 2000) or by making the animal wait longer to access the reward (Pompilio and Kacelnik, 2005).

These seemingly irrational preferences are thought to occur because the animal values the same reward differently dependent on its value to the animal at the time that it originally encountered it (Pompilio and Kacelnik, 2005). This may occur due to the increased contrast between hedonic states before and after receiving the food reward in a state of high deprivation during training relative to that experienced when in a state of low deprivation (Clement et al., 2000) and/or due to a perceptual distortion (Pompilio et al., 2006). It has been observed in a wide range of species (fish, Aw et al., 2009; locusts, Pompilio et al., 2006; pigeons, Gipson et al., 2009; Friedrich and Zentall, 2004; rats, Capaldi et al., 1994, 1991; Kurtz and Jarka, 1968; and starlings, Pompilio and Kacelnik, 2005; Marsh et al., 2004) indicating that it is a robust phenomenon. This has led researchers to conclude that it must be evolutionarily beneficial or rational in the natural environment (Pompilio et al., 2006) despite this leading to irrational preferences in the laboratory setting.

The phenomenon of preferences caused by SDL has not thus far been applied to animal welfare assessment. It is proposed here to assess the use of SDL as a novel welfare assessment tool to evaluate hunger state in the feed-restricted broiler breeder. Quantitative feed restriction is a widely recognised welfare problem for fast-growing broiler breeders (de Jong et al., 2003). Experimentally researchers have tried to improve welfare by adjusting the quality of the diet by either reducing the energy density, adding appetite suppressants or by a combination of both approaches (e.g. Nielsen et al., 2011; Sandilands et al., 2006, 2005; Hocking et al., 2004; Nielsen et al., 2003; Savory and Lariviere, 2000; Rozenboim et al., 1999). However, whilst these are successful at increasing time taken to consume the ration, it is not clear whether these diets achieve this by improving satiety (a positive affective state) in the broiler breeder (D'Eath et al., 2009). Direct choice test methodologies in which the broiler breeder chooses between either qualitative or quantitative feed restriction have so far not proved successful (Buckley et al., 2011a). Whilst this may be because hungry birds find it more difficult to learn food quality discrimination tasks (Buckley et al., 2011b) it is possible that some other factor affected the lack of preference. Further, choice tests may not actually be measuring preferences determined by altered states of satiety. Thus, there is a need for alternative approaches to identify which, if any, of these alternative diets is more satiating than conventional quantitative restriction.

The aim of this series of three related experiments was to identify whether the phenomenon of SDL could be reproduced in broiler breeders that alternated between two feeding levels designed to induce a state of high deprivation (quantitatively feed restricted, QFR) or of low deprivation (fed ad libitum, AL). It was hypothesised that there would be an effect of hunger state on bird preference for an end of day, coloured, food reward associated with either high deprivation (very hungry) or low deprivation (close to satiety). It was predicted that the birds would show SDL and learn to prefer the food reward associated with being in a state of high deprivation over one associated with being in a state of low deprivation. Furthermore, it was predicted that this preference would be independent of current state of deprivation (i.e. the preference would be the same, regardless of whether the bird was very hungry or almost satiated at the time of testing). The ultimate purpose was to validate a methodology that could be used as a 'probe of hunger state' to compare the relative states of deprivation induced by QFR and other alternative diets such as qualitative dietary restriction. Data from the pilot study (experiment 1) is included as it informs the rest of the study. Differences in housing arrangements between experiments 2 and 3 reflect practical facility considerations resulting from a change of research institute.

2. Methodology

2.1. Subjects

This study used four broilers (as a more readily available model for broiler breeders) aged 28 days. All four birds followed the same dietary treatment and acted as their own control.

Prior to the study the birds had been group reared on a 14:10 h light: dark schedule (days 1–28) and spot-brooded (day 1: 31 °C, reduced gradually to 21 °C on day 21 and then maintained at this temperature thereafter). The birds were fed a commercial starter chick crumb (Farmgate, BOCM Pauls Ltd., Ipswich, Suffolk, UK) ad libitum from 1–14 days and thereafter feed restricted in line with the recommended daily feed requirements for broiler breeders (Aviagen, 2007). The mean (±S.D.) bodyweight of the birds at the beginning of the study at 28 days of age was 551 (±92) g, which was approximately 20% heavier than the target bodyweight for broiler breeders at 28 days (440 g). They had no previous experimental history.

2.2. Housing and husbandry

Each bird was individually housed in a floor pen (1.05 m × 0.45 m) with visual access to one other conspecific through a mesh divider. A solid barrier by the feeding area prevented each bird from seeing what food the other bird was eating. Each pen contained wood shavings and a perch. Birds were fed once daily at 09:00 h and any food remaining was removed at 16:00 h, weighed and the birds' daily feed intake recorded. Water was available ad libitum.

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