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Design and evaluation of a lighting preference test system for laying hens

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ABSTRACT

Understanding the lighting needs of laying hens provides crucial implications on animal welfare regulations and production stewardship in commercial egg farms. A lighting preference test system (LPTS) that is used to explore hen's lighting preference was recently designed and developed by our research team. The objectives of this study were to (1) describe the design of the LPTS, and (2) validate two algorithms that automatically determine the number of hens in individual compartments of the LPTS, and identify the reasons of false recognitions by the two algorithms. The LPTS consisted of five light-proof compartments connected in tandem. Each compartment can be operated at a desired lighting environment (e.g. lighting type, color, and intensity). Hens can move freely through passing doors between two adjacent compartments. Two loadcells and a camera were installed in each compartment to continuously monitor, respectively, the hen weight and record hen activities. Two algorithms, by image analysis (using video data) and by weight (using loadcell data), were developed to determine the real-time hen numbers in each compartment; and the accuracy of the two algorithms was determined by comparing their results to visual observation. Eight hens were kept in the LPTS and used for the algorithm validation. The validation results show that the accuracy of image analysis algorithm was 71.23%, which was much lower than that of weight algorithm (99.70%). False recognition of hen numbers by the image analysis algorithm stemmed from a variety of hen activities (e.g. feeding, wing flapping, preening, etc.) that may cause significant changing in the representing areas (or number of pixels) of animals in the images. The weight method/algorithm, on the other hand, offered a simple and accurate way to determine animal occupancy in the LPTS compartments. The newly developed LPTS and algorithms could be useful tools to investigate the preference responses and time budget of hens at different lighting conditions.

1. Introduction

Animal productions have been focusing on housing designs and environment managements that may maximize production efficiency and profit. These practices may not necessarily reflect the animal natural needs and welfare requirements. Due to growing public concerns on living conditions of farm animals, markets are seeking more and more animal products from welfare housing systems and humane production environments. An example is the current transition from conventional cage housing system to cage-free housing system, where welfare elements are provided, for laying hens (Zimmerman et al., 2006). Accordingly, the actual needs of laying hens regarding the welfare elements and environmental stimuli have been increasingly considered for housing design, and in animal welfare and management guidelines (Ma et al., 2016).

Preference and motivation tests offer solutions to understand the requirements from the animal standpoint (Dawkins, 1999). Many studies have been carried out to investigate the poultry preferences for a variety of welfare elements and environmental stimuli, such as nest box (Freire et al., 1996), perches (Struelens et al., 2008), pecking and dustbathing (Sanotra et al., 1995), cage size (Lagadic and Faure, 1987), feeder space (Faure, 1986), air quality (Green and Xin, 2008), and light environment (Ma et al., 2016). Light (e.g. schedule, sources, intensity, color) is one of the most important environmental stimulis that affect poultry productivity, behavior, and health. Lewis et al. (1996) reported that the livability in laying hens may be improved by manipulating lighting schedules (e.g. intermittent vs. continuous). Boshouwers and Nicaise (1993) found that the artificial light sources (fluorescent vs.

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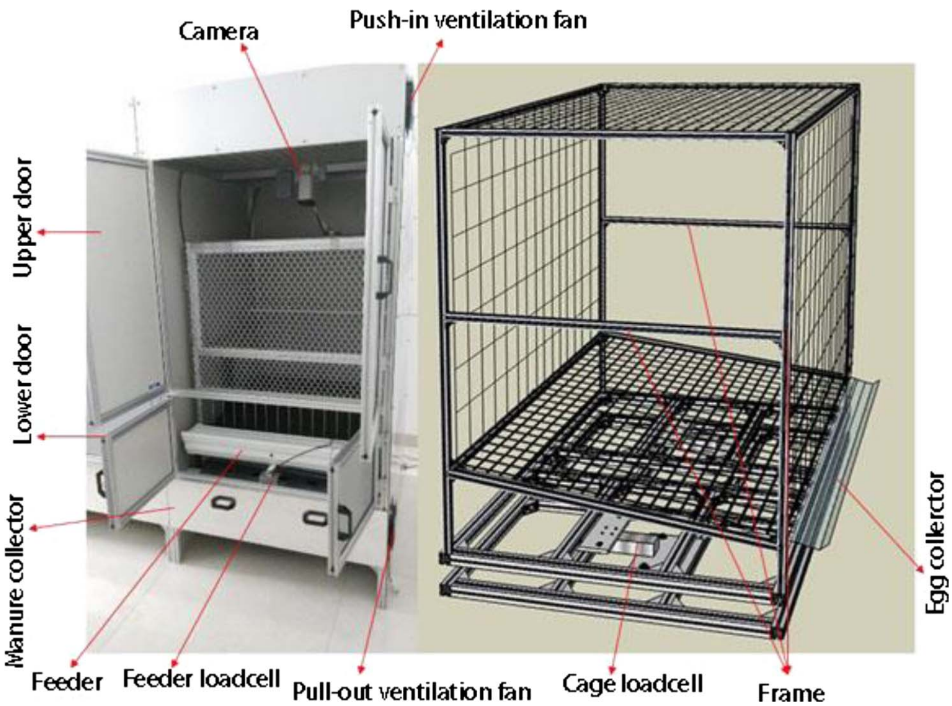

Fig. 1. Photo of an individual compartment ("IC", left) and illustration of the cage in IC (right).

incandescent) may influence physical activity and energy expenditure of laying hens. Prayitno et al. (1997) concluded that light color may affect chicken activities. Other research showed that hens displayed preferences to certain light types (Widowski and Duncan, 1996; Widowski et al., 1992), colors (Huber-Eicher, 2004; Khosravinia, 2007), and intensities (Davis et al., 1999; Ma et al., 2016). In commercial production, hens are provided with continuous light and dark schedules. Such lighting regime facilitates farm operations, however, might be not optimal from hen standpoint. Ma et al. (2016) reported that hens preferred to rest in dark intermittently throughout the day, averaging 25 min per hour. This hourly light-dark rhythm differed from the typical commercial practice of providing continuous dark period at night, but endorsed the intermittent lighting strategies for various purposes, e.g. minimizing heat stress (Lin et al., 2006) and improving production performance (Lewis et al., 1992). There are clearly economic and welfare implications to study the lighting requirements of hens under controlled conditions.

Poultry light preference tests have been performed in light tunnels/chambers. The light tunnels/chambers were typical partitioned into several identical compartments, each of which can be operated at a desired lighting environment. Birds may move among compartments and select their preferred lighting environment(s). The challenges in design, development and application of high quality light tunnels/chambers lie in preventing light interference among compartments, reducing human involvement, and accurately determining bird numbers in the compartments. Some lighting preference tests for poultry were performed in light apparatuses adopted from tests for other animal species, which do not fulfill the light tightness requirement for poultry (Davis et al., 1999; Jones et al., 1996). Simply designed light chambers utilize minimal sensors and require frequent human involvement that may interfere animal behaviors during the test periods. Moreover, most previous preference tests determined bird numbers in experimental systems based on visual observations (Sherwin, 1998), which is laborious, subjective, and prone to human errors. Recently, Ma et al. (2016) developed a light tunnel to investigate hen preference at different light intensities. A < 1 lx intensity in a compartment was achieved when adjacent compartments were provided with higher light intensities (5–100 lx), proving a great lightproof design. Egg and manure belts were installed in the light tunnel where egg and manure can be cranked out without interfering the animals. Hen occupancy in compartments was determined by processing images that recorded by a camera installed in each of the compartment. With four birds kept in this light tunnel, accuracy of bird counting through image analysis was greater than 98%. The authors suggested the accuracy of bird counting would, however, decrease when more birds were kept in the light tunnel because of complexity in bird segmentation in the images.

The objectives of this study were: (1) to design and develop a lighting preference test system (LPTS) with higher capacity (eight hens), better light tightness, less human interruption, and flexibility in compartment arrangement; and (2) to develop, compare, and validate two algorithms (by image analysis vs. by hen weight) that automatically determine the bird numbers in each compartment, and to identify the reasons of false recognitions by the two algorithms.

2. Materials and methods

2.1. Design of lighting preference test system (LPTS)

The system was designed and developed following industry practices and recommendations (including feeder space, number of drinker, stocking density etc.). The lighting and thermal environment in the chamber can be set to commercial conditions and adjusted according to the experimental needs.

Depending on research goals, preference tests may require different arrangements of compartments (e.g. tandem, crossing, pentagon etc.). We built five identical compartments that can be arranged independently to form desired patterns of LPTS. The LPTS can accommodate up to eight hens simultaneously. The capacity and corresponding dimension of the LPTS/compartment were designed so that lighting and thermal environments in each compartment can be readily managed.

2.1.1. Individual compartment

The individual compartment (IC) was built with an aluminum profile frame and 3-mm-thick Polyvinyl chloride (PVC) boards (Fig. 1). The IC had an overall dimension of 0.96 m L × 1.2 m W × 2.0 m H. An