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Short-term and long-term movement patterns in confined environments by domestic fowl: Influence of group size and enclosure size

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ABSTRACT

The study of animal movement and space use plays an integral role in understanding the behaviour and habitat selection of free-ranging and captive animal populations. This investigation could lead to changes in facility design to better suit the biological needs of captive animals. The aim of this study was to investigate the specific effects of group size (GS), and enclosure size (ES) on the movement and use of space of captive animals. We used the domestic fowl (*Gallus gallus domesticus*) as our animal model. Eight groups of 40 male chickens were used for this study. Each group was temporarily divided into three GS (5, 10 and 20 birds) and tested in three different ES (5, 10 and 20 m^2). Locations of focal birds were collected through instantaneous scan sampling. From these we calculated net and total distance moved, mean, and maximum step-lengths, and sample angular dispersion of the path of movement. To calculate longer-term space use, three replications for each of three experimental GS were placed in nine 10 m^2 enclosures for 1 week. Locations of focal birds in each group were collected by *ad libitum* scan sampling for 1 h and data were used to calculate core areas by kernel estimates (freeware Octave). Our analyses showed that birds in larger ES of 20 m^2 had longer net distances ($P < 0.001$), and mean ($P < 0.001$) and maximum step-length ($P < 0.0001$) than individuals in 5 and 10 m^2 enclosures. Total distance travelled was longer ($P < 0.05$) in 20 m^2 enclosures when compared to 5 m^2. GS had fewer expected effects that were only reflected in longer net distances in GS 20 as compared with GS 5 ($P < 0.05$). Core areas at 30th (0.16 ± 0.01 m^2), 50th (0.43 ± 0.02 m^2) and 90th (1.65 ± 0.08 m^2) percentiles were similar across GS ($P > 0.05$). These results support the idea that the amount of available space has far larger effects in the short-term movement patterns of the domestic fowl as compare to the minor GS effects.

1. Introduction

The ability of domestic animals to move freely in their captive environment is crucial for their behaviour and welfare. Some of the factors known to have a major effect on the movement and use of space of confined animals are enclosure size, its shape, and the number of animals housed. Enclosure size and design has been shown to have a profound influence on movement and space use (Cornetto and Estévez, 2001; Mallapur et al., 2005a,b), behaviour (Newberry and Shackleton, 1997; Jensen et al., 1998; Cornetto et al., 2002; Buchwalder and Huber-Eicher, 2004) and welfare (Jensen et al., 1998; Arnould and Faure, 2004; Petherick, 2005).

In captivity, movement is restricted by the enclosure walls, which can lead to a response in which the animal is forced to change direction of movement as they encounter the edge (Haddad, 1999). Conversely, enclosure walls can

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also have a trapping effect (Erlandsson et al., 1999) where the animal stays close to the wall once encountered. This could be one reason why the edges of the enclosures are used preferentially especially for stereotypic pacing (Erlandsson et al., 1999; Mallapur et al., 2002). On the other hand, group size and density are known to have a major effect on the distribution of animals such as domestic fowl (Newberry and Hall, 1990; Estévez et al., 1997). However, few studies (Estévez et al., 1997; Leone et al., 2007) have focused on how enclosure size, group size and density affect patterns of movement and space use in the domestic fowl and no studies have been conducted to determine how all these factors may affect their short-term movement patterns.

A common measurement of long-term space use by animals is the calculation of home ranges (Jennrich and Turner, 1969; Worton, 1989), which provides information on the animals' overall space use. However, because captive animals have a marked preference to use edge areas, generally the home range calculation will be similar to the actual size of the enclosure and therefore will be little informative on how animals move through the space (Estévez et al., 1997; Estevez and Christman, 2006; Leone et al., 2007). Other calculations such as angular dispersion or tortuosity (Bovet and Benhamou, 1988; Fisher, 1993) can be used to determine short-term movement and to obtain an estimate of the sinuosity of the animal movement patterns. Through net distance calculations (Wu et al., 2000; Jeanson et al., 2003; Curtis, 2005) it is possible to determine how far the individual has moved in a given period of time. We can speculate that, for example, individuals maintained at high densities or in small enclosures would show a higher degree of sinuosity in their movement patterns than others in larger enclosures or lower densities and hence a shorter net distance. Likewise, in constrained environments individuals may have shorter net and total distance travelled (Estevez and Christman, 2006), may have longer pauses in their movement patterns (Jeanson et al., 2003) or shorter step lengths. All these parameters are of paramount importance to developing innovative design of facilities that best address the spatial requirements of captive animals.

The aim of our study was to determine the basic principles that govern the short-term movement patterns of the domestic fowl under a variety of environmental conditions. In addition, we looked at how these short-term movement patterns translated in overall space use by calculation of core areas. We chose to vary enclosure size and group size as these are factors that are often modified under commercial conditions. Information from previously published literature and our experience in movement and space use research has led us to hypothesise that distance travelled would be less and movement more tortuous (higher angular dispersion) for large groups in small enclosures, and that distances moved would increase with increased group and enclosure size. We also predicted that core areas, which estimate long-term space use, would be smaller for smaller group sizes. This knowledge is of relevance to animal welfare. However, as indicated previously, this study aimed at determining basic principles of animal movement under diverse environmental conditions, not at establishing potential implications at a welfare level per se or to simulate commercial conditions.

2. Methods

2.1. Study animals and site

This study was conducted at the University of Maryland Applied Poultry Research Laboratory, College Park, MD, USA, from August through October 2006. Three-hundred-and-thirty-six, 1-day-old, male broiler chicks (Ross 708) were obtained from a commercial hatchery. Domestic fowl (*Gallus gallus domesticus*) was chosen as an animal model as they move slowly and rarely fly and so can be easily observed. The birds were randomly divided into eight groups of 42, each composed of 35 experimental birds plus seven extra birds per enclosure in the event of mortalities. Each group of 42 birds was housed in a 5 m^2 (2.5 m × 2 m) home enclosure. Floors were covered with 5 cm of wood shavings; feed and water were provided *ad libitum* by tubular feeders (one per enclosure) and nipple drinkers (one per 10 birds). To promote slow growth rate and leg health the lighting program was set to 12 L:12 D (from 8:00 to 20:00 h). Although we did not conduct a formal evaluation of birds' leg health status we did not observe major problems during the study. The temperature, ventilation programs and diets followed commercial practices. All birds were tagged for individual recognition with the Swiftack identification system for poultry (Heartland Animal Health, Inc., Fair Play, MO, USA) on both sides of their neck. The tags were laminated paper tags, 2.5 cm in diameter, identifying individuals in each experimental GS.

2.2. Ethical note

The methods followed in this experiment were approved by the University of Maryland, Institutional Animal Care and Use Committee (Protocol Number: R-05-24).

2.3. Movement patterns

2.3.1. Experimental design

The birds were maintained in their home enclosures but were temporarily transferred to the testing enclosures for the experimental trials. Three testing enclosure sizes (ES) of rectangular shape were used: 5 m^2 (2 m × 2.5 m), 10 m^2 (4 m × 2.5 m) and 20 m^2 (8 m × 2.5 m). These enclosures were divided into a 0.25 m × 0.25 m square grid system to facilitate recording of bird locations. The grid was established by marks on three walls of the testing enclosures with numbers on the longitudinal (1–8, 1–16 or 1–32 for the 5, 10 and 20 m^2 testing enclosure respectively), and letters (A–J) on the vertical axes (Cornetto and Estévez, 2001). The floors of the testing enclosures were covered with 5 cm of wood shavings as in the home enclosures. Feed was not provided to the birds during the 1-h trials, but they had access to water supplied by nipple drinkers. Provision of food in the testing arena would have exponentially increased the complexity of movement patterns and in this initial phase of study we determined that simplicity was a better and a more effective choice. To habituate the birds to handling and transportation (located across the room from the home enclosures), and to minimise any stress that could alter the results of this study, birds from each home enclosure were transferred to the testing enclosures every weekday during the first 2 weeks of age. During training birds stayed in the testing enclosures for a 30-min period and then returned to their home enclosures. All experimental groups were trained in all three enclosure sizes.

2.3.2. Method of observation

The actual experiments began at 3 weeks of age and ended at 5 weeks. Animal locations were recorded for 3 h/day between 15:00 and 19:30 h. Each sampling period lasted for 1 h during which three experimental group sizes (GS) of 5, 10 and 20 birds from a randomly selected home enclosure were placed in three experimental testing enclosures of the following dimensions: 20, 10, and 5 m^2 (Table 1). We chose to work at low densities because conditions closer to commercial densities may have restricted movement of birds too much, perhaps precluding us from finding more subtle differences between treatments. Each experimental GS was tested once per ES following a randomised observation schedule that was constructed before the commencement of the experiment.

Birds from each experimental GS were gently captured in their home enclosures and together transferred in crates to the corresponding ES. All