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Broiler chickens: a tolerant social system?

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ABSTRACT. *Broiler chickens: a tolerant social system?* It was hypothesized that the social organization of commercial broiler chickens (*Gallus gallus domesticus*) kept in large groups (50 or more chickens) is based on the development of peck orders within sub-groups. Predictions of this hypothesis are (1) decreased use of space as group size is increased within a constant area, with the majority of birds restricting movement to avoid aggressive encounters with unfamiliar individuals, and (2) increased inter-individual variability in body weight of chickens with increasing group size due to monopolization of resources by despotic individuals. Groups of 50, 100, 150 and 200 chickens were kept in identical pens, with or without access to an outdoor patio. Use of space by focal individuals was analysed by the harmonic mean method, which is more sensitive than previously used methods to assess use of space by domestic fowl. The results showed that space use at the 30, 50 and 70% isopleth levels remained stable across group size. Space use increased at all group sizes when the birds were given access to the outdoor patio. Body weight decreased with increasing group size. However, the coefficient of variation in body weight was similar across group size, and the frequency of threats declined with increasing group size. The results suggest that access to resources was not impaired by agonistic behaviour in larger groups. The results do not support the sub-group hypothesis for broiler chickens under commercial conditions. The chickens showed plasticity of social behaviour according to environmental conditions, with increased tolerance at larger group sizes.

KEYWORDS: Broiler chickens; Social behaviour; Tolerance hypothesis

Introduction

The social system of the domestic fowl (*Gallus gallus domesticus*) under confined conditions has traditionally been regarded as a rigid hierarchical peck order system, with high-ranking birds delivering most threats and winning most fights. Benefits of high rank include greater freedom of movement than lower-ranking birds and priority of access to resources (Guhl, 1953; Wood-Gush, 1971). The practical implication of a peck order system is that inadequate access to resources can lead to high variability between flock members (McBride, 1970). On the other hand, it has been suggested that there are benefits to all members in a social hierarchy because, once established, there is relatively little agonistic behaviour among group members (Guhl, 1953). Thus, McBride and Foenander (1962) hypothesized that individuals in large flocks would remain within a limited area in which they could recognize their neighbours. This would lead to the formation of sub-groups in different locations within the barn, each with its own stable social hierarchy. Based on this hypothesis, they predicted that the area occupied by an individual would be determined by the number of birds it could recognize and would, therefore, be inversely related to group size.

This hypothesis is of particular relevance to the study of social behaviour in broiler chickens, domestic fowl bred for meat production, because they are typically reared in flocks of several thousand individuals. Little is known about the social behaviour of broilers kept in large flocks. Mench (1988) reported low levels of agonistic behaviour in groups of 15 broiler chickens provided with an ad libitum food supply. However, when food was limited, the broilers performed agonistic behaviour at rates comparable with those observed in young layer stock given food ad libitum. Dominance relationships were not evaluated in that study but it is possible that the agonistic behaviour was associated with the development of a peck order. Rushen (1982) reported that over 80% of agonistic interactions conformed to dominance relationships in 2- to 10-week-old layer-type chickens kept in small groups.

Newberry and Hall (1988, 1990) observed that individual broiler chickens in large flocks moved over a smaller amount of the available pen space with increasing age. This behaviour could potentially enable the development of sub-groups in different areas of the pen. Use of space was variable among individuals, suggesting that there was mixing occurring among individuals in different locations. However, it is possible that the larger-scale movements were made mainly by more aggressive individuals. In addition, some large-scale movements may have been associated with avoidance of humans performing daily husbandry chores. Data on adult broiler breeder hens (Appleby et al, 1985) and laying hens (Hughes and Wood-Gush, 1977) kept in large groups also indicate individual variability in space use.

The space use results obtained in the above studies were based on the area encompassing all sitings of a focal bird. Space use assessed by this method could be strongly biased by occasional movements by an individual away from its core area of activity. Animals do not utilize their entire home range with equal intensity but tend to spend most of their time in core areas (Dixon and Chapman, 1980). This factor should be taken into account when analyzing use of space (Harris et al., 1990), especially under the restricted spatial conditions of domestic farm animals, where movements are limited by the size of the enclosure and the animals have no opportunity for dispersal (Newberry and Hall, 1990; Newberry, 1993). Thus, it is possible that broilers kept in larger groups within the same available space restrict the majority of their movements to smaller core areas, in agreement with McBride and Foenander's (1962) prediction.

The measurements reported in this paper were used to obtain evidence about the underlying social structure of large flocks of broiler chickens. We manipulated group size to investigate the hypothesis that agonistic behaviour is associated with the development of peck orders among sub-groups of broilers. According to this hypothesis, we predicted that, in pens of a constant size, the birds' core areas of activity would decrease with increasing group size, with most birds restricting movement to minimize aggressive encounters with relatively unfamiliar birds. In addition, we predicted greater inter-individual variability in body weight among chickens in larger flocks due to monopolization of resources by despotic individuals.

Methods

We conducted two experiments from October to November of 1989 and 1990, respectively, in experimental pens at a commercial farm in the south of Spain. In each experiment, 500 crossbred Hubbard broiler chickens, obtained from a commercial hatchery, were divided into groups of 50, 100, 150 and 200 individuals. Each group was assigned at random to one of four identical, south-facing, 10.5 m^2 pens. Each pen contained two hanging tube feeders with circular feed troughs and a bell-shaped hanging drinker, providing feed and water ad libitum. All chickens were fed on a standard dietary regimen. Supplementary heat was supplied from 0-4 weeks of age by an infra-red heat lamp in the middle of the pen which kept the room at an ambient temperature of 25°C. Natural light entered the pens during the daytime. Artificial light °40 lux at floor level) was provided throughout the night from 0-4 weeks of age. The floor of each pen was covered with a 5-cm-deep layer of chopped corn cobs.

In experiment 1, chickens were confined in the indoor pens from 0-8 weeks. In experiment 2, the chickens in each pen were able to pass through a 0.5 m wide X 0.5 m high door, centred along the south wall of their pen, into an empty adjoining 9.6 m2 outdoor patio during the daylight hours from 4-8 weeks of age. The outdoor patio of each pen had a concrete floor without litter and was enclosed by a 0.5 m high concrete wall.

Thirty randomly selected birds per pen were marked with aniline dye on the back of the head for individual identification. Scans were performed at 15 min intervals over 2 h observation periods on three days per week from 2-8 weeks of age. Observation periods for each pen were balanced across time of day between 0800 and 2000 h. The location of each marked bird, and the total number of birds present in the outdoor area in the second experiment, were recorded at each scan time. The pen walls (both indoor and outdoor) were marked at 0.5 m intervals to facilitate the precise placement of each bird's location on a map of the pen. The location data were transferred directly from map to computer using a graphics tablet to digitize the X and Y coordinates of each bird.

Four levels of core area were calculated by the harmonic mean method (Dixon and Chapman, 1980), using the Spatial Ecology Analysis System (1989) (SEAS) personal computer software package. The core areas were defined by contour lines (isopleths) enclosing areas in which birds were observed in 30, 50, 70 and 90% of scans. The surface area at each isopleth level was calculated weekly for each marked bird. The distance travelled during each 15 min interval was estimated by SEAS as the straight line distance between successive points, and the average distance travelled per 15 min was calculated for the periods 3-4, 5-6, and 7-8 weeks.

The frequency of agonistic interactions, classified as threats or fights, was determined from focal samples of 15 birds randomly selected from among the 30 marked birds in each pen. A 5 min video recording of the behaviour of each focal bird within a pen was made during the 2 h observation periods. A threat was defined as a social encounter in which the focal bird stood face-to-face with another bird, with the neck erect and neck feathers raised. A fight was a dyadic face-to-face encounter in which the focal bird gave and/or received at least one peck at the head. On the last day of rearing (53 days of age), each bird was weighed individually, and its sex determined based on dichotomy of comb development between the sexes. In all groups, the sex ratio was approximately equal.

We analysed the effects of experiment (with or without access to the outdoor patio), group size and sex on the size of core areas at each isopleth level, and the distance travelled per 15 min interval, by analysis of variance with repeated measures for age (ANOVAR) (Potvin et al., 1990). Analysis of variance (ANOVA) was performed to assess effects of group size on final body weight and the frequencies of threats and fights. Polynomial contrasts were applied to examine the shape of responses to group size. The coefficient of variation in body weight for each group size was also determined. A two-way ANOVA was applied to evaluate the influence of group size and age on the proportion of birds using the outside patio. Tukey tests were used for a posteriori means comparison. All statistical analyses were performed using the general linear model program of the Statistical Analysis Systems (1985) package. Transformations of data were performed where necessary to meet assumptions for parametric tests (Zar, 1984).

Results

Core areas at the 30, 50, 70 or 90% isopleth levels were not significantly affected by group size ($P>0.05$). As expected, core areas increased in size with increasing isopleth level. At all isopleth levels, the core areas were larger when chickens had access to the outdoor patio in experiment 2 (Fig. 1; ANOVAR, age X experiment, $P<0.001$; 30%, $F_{5,825}=9.98$; 50%, $F_{5,825}=17.95$; 70%, $F_{5,825}=24.93$; 90%, $F_{5,825}=38.74$). At the 90% isopleth level only, the core areas of birds in the 150 and 200 group sizes dropped in size during the last week of experiment 1 (Fig. 2; ANOVAR, age X experiment X group size; $F_{15,825}=1.94$, $P<0.05$). No significant differences in use of space were detected between males and females.

The distance travelled per 15 min period increased with age (ANOVAR, $F_{2,316}=28.40$, $P<0.001$). There was a significant interaction between age and group size (ANOVAR, $F_{6,316}=2.17$, $P<0.05$), with distance travelled continuing to increase with age after six weeks in the 50 and 100 group sizes and decreasing after six weeks in the 150 and 200 group sizes (Fig. 3). When the available space was increased by providing access to the outdoor patio, the distance moved per 15 min period increa-

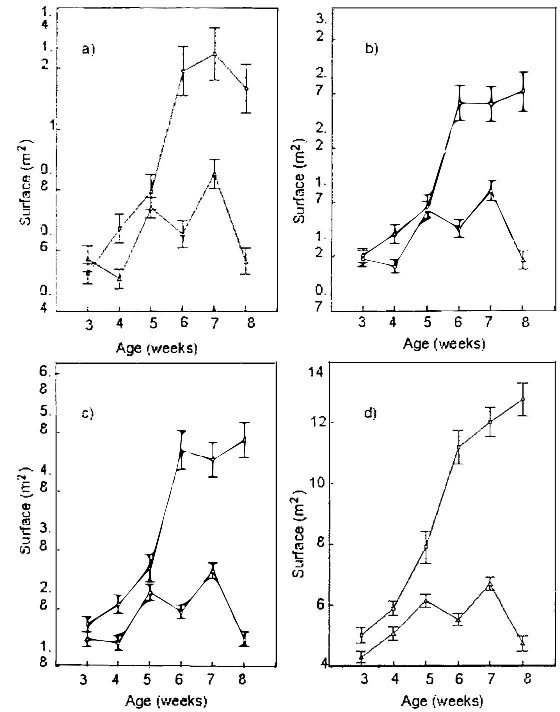

FIGURE 1. Superficie de las areas core (media ± SE) utilizadas por los pollos con (() o sin (() acceso al parque exterior, para cuatro niveles de isopletas (a) 30%, (b) 50%, (c) 70%, (d) 90%.

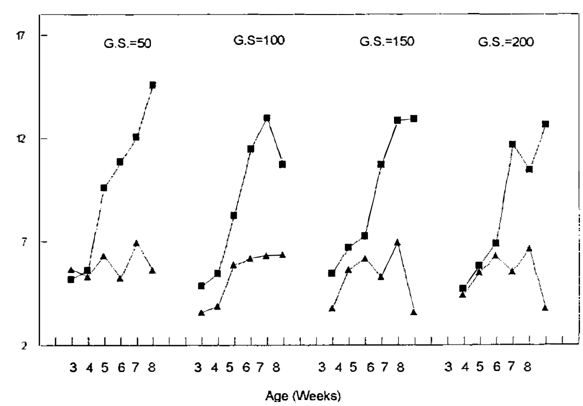

FIGURE 2. Mean size of core areas at the 90% isopleth level for each group size (G.S.) with (() and without (() access to an outdoor patio.
Superficie media de las areas core al 90%, para cada tamaño de grupo (G.S.) con (() o sin (() 0al parque exterior.

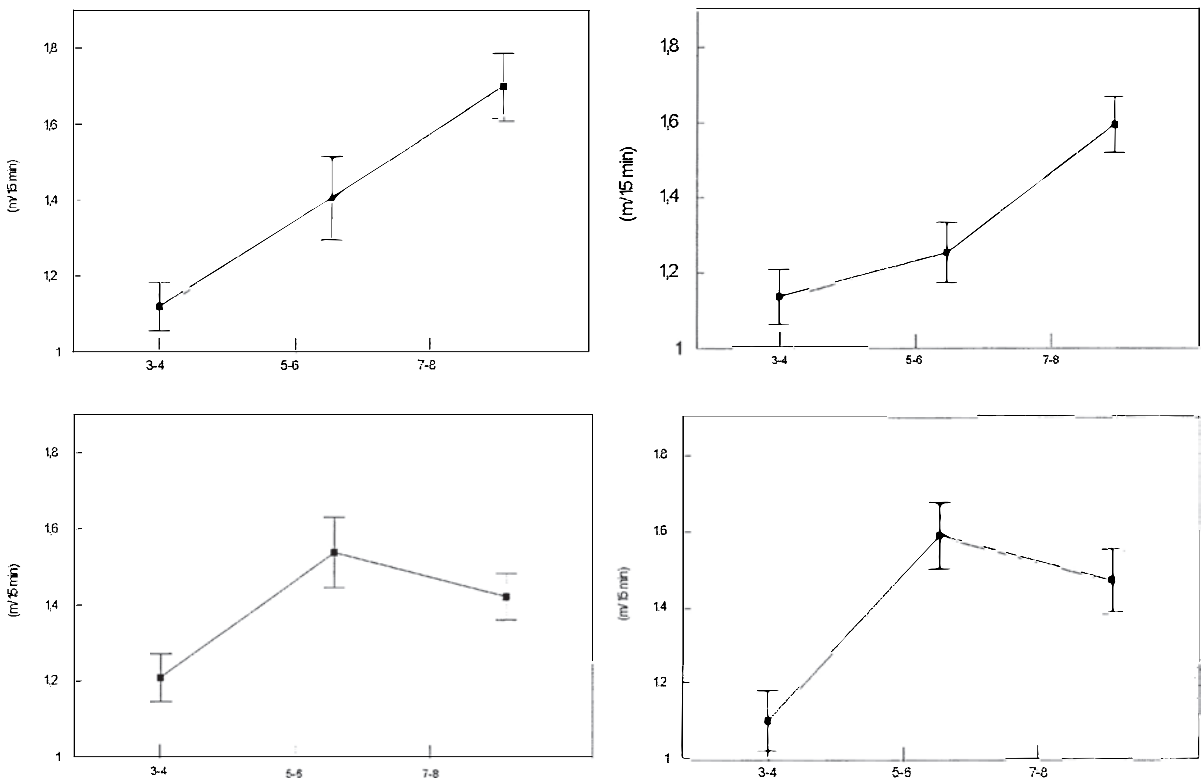

FIGURE 3. Mean (± SE) distance travelled per 15 min period for group size (a) 50, (b) 100, (c) 150, (d) 200 in weeks 3-8 (experiments 1 and 2 combined).
Distancia recorrida media (± SE) en 15 minutos para cada tamaño de grupo (a) 50, (b) 100, (c) 150, (d) 200, entre la tercera y la octava semana de edad (experimentos 1 y 2 combinados).

sed at all group sizes (ANOVAR, age X experiment; $F_{2,316}=5.39$, $P<0.005$). No sex effects were found for distance travelled.

The proportion of chickens using the outdoor patio during weeks 5-8 in experiment 2 was low for all group sizes, with high variability occurring across weeks from a low of 0.3% in week 5 to a high of 4.9% in week 6 (ANOVA, age; $F_{3,246}=33.04$, $P<0.001$). Use of the patio was affected by group size (ANOVA, $F_{3,246}=17.07$, $P<0.001$), with highest use occurring in the largest group size (Tukey Test, $P<0.05$). This effect occurred as a result of differences in use during week 6 (ANOVA, age X group size; $F_{6,246}=16.39$, $P<0.001$; Fig. 4).

The frequency of threats and fights was low in all experimental conditions, with peak levels occurring in week 4 (Fig. 5). A significant effect of group size on frequency of threats was detected (linear contrast, $F_{1,78}=4.33$, $P<0.05$), with more threats occurring in smaller than larger groups (Fig. 6). The frequency of fights was not significantly affected by group size but was higher in the first than the second experiment (ANOVA, experiment; $F_{1,78}=5.10$, $P<0.05$). No significant age or sex differences in agonistic behaviour were detected.

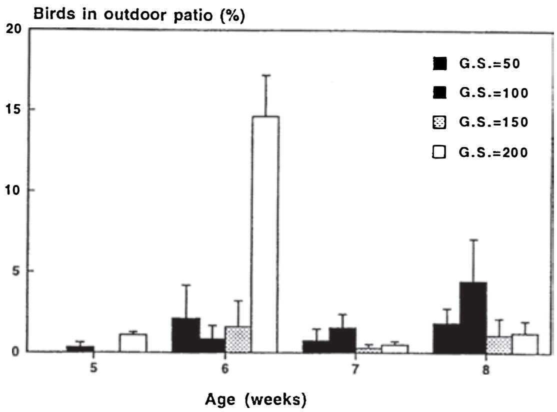

FIGURE 4. Percentage of chickens in the outdoor patio (mean ± SE) for each group size (G.S.) during instantaneous scans in weeks 5-8 of experiment 2.
Porcentaje de pollos en el parque exterior (media ± SE) para cada tamaño de grupo (G.S.), semanas 5 a la 8 del experimento 2.

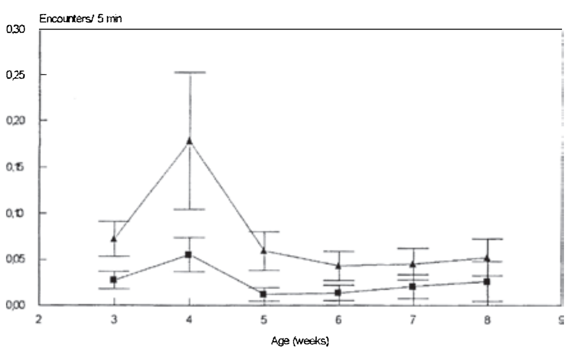

FIGURE 5. Number of threats (() and fights (() per 5 min period (mean ± SE) at different ages (experiments 1 and 2 combined).
Frequencia de amenazas (() y combates (()(media ± SE) en 5 minutos de observaci(n, (experimentos 1 y 2 combinados).

Body weight decreased with increasing group size in both experiments (ANOVA, $F_{3,784}$ = 65.02, P<0.001). However, the coefficient of variation was similar for all group sizes (Fig. 7).

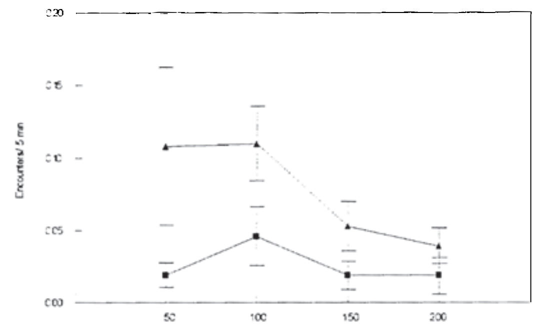

FIGURE 6. Effect of group size on mean (± SE) number of threats (() and fights (() per 5 min period (experiments 1 and 2 combined).
Efecto del tamaño de grupo sobre la frecuencia media de amenazas (() y combates (() (± SE), en periodos de 5 minutos.

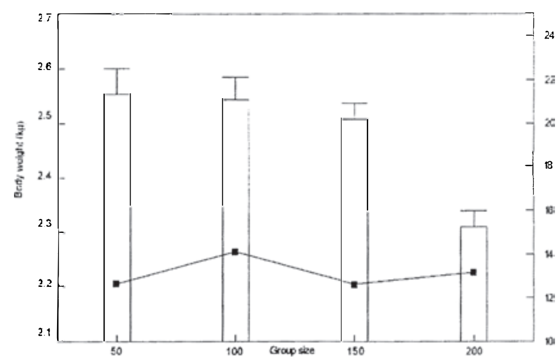

FIGURE 7. Group size effect on body weight at 53 days of age (mean ± SE) and coefficient of variation (() (experiments 1 and 2 combined).
Efecto del tamaño de grupo sobre el peso corporal a los 53 dias de edad (media ± SE) y el coeficiente de variación (().

Discussion

The increase in size of core areas with increasing isopleth level indicates that use of space was not constant over time. This result stresses the importance of examining patterns of intensity of space use over time rather than relying on measures of total area used as done previously for domestic fowl in large flocks (e.g. Appleby et al., 1985; Newberry and Hall, 1990). The finding that the core areas expanded at all isopleth levels analysed, and at all group sizes, when the outdoor area was made available indicates plasticity in use of space by chickens according to the total amount of space available. This result also suggests that the birds were not using the outdoor patio only for brief monitoring events.

The effect of access to the outdoor patio on use of space is consistent with Newberry and Hall's (1990) observation that pen size had a large impact on the total area of space used by individual birds. These results justify the approach taken in this work to manipulate group size at a constant pen size rather than adjusting pen sizes to maintain a constant stocking density. In addition, we were interested in evaluating the McBride and Foenander (1962) prediction, which is based on manipulation of group size within a constant area. Because our results were influenced by both group size and stocking density, we discuss the impact of both factors.

The low overall use of the outdoor patio and absence of consistently higher use by birds in larger groups suggests that use of the patio was not motivated by social avoidance behaviour. Furthermore, the absence of an increase in use of the patio during the final weeks of rearing when the physical space occupied by each individual was greatest, suggests that movements to the patio were not motivated by high stocking density in the indoor area. Because chickens spend more time in familiar than novel environments (Dawkins, 1976), it is possible that use of the patio would have been greater if the chickens had had access to it from an earlier age. Variability in patio use across weeks could have been related to differences in outdoor weather conditions. The reason for the high use of the patio by birds in the largest group size during week 6 is unclear. However, if some birds went outdoors, others could have been attracted by their presence. From an evolutionary perspective, increased numbers of birds outdoors should provide a benefit by reducing predation risk when distant from cover (Lima and Dill, 1990). In the domestic fowl, Keeling et al. (1988) reported a positive correlation between the number of hens outdoors and the mean distance of the flock from the hen house. Perceived safety in large groups could also explain why the birds generally chose to remain indoors even at high stocking densities.

There was no consistent reduction in use of space with increased group size, contrary to the McBride and Foendander (1962) prediction. We suggest that the reductions in use of space and movement in the larger groups at the end of the rearing period were not due to social inhibition to avoid aggression. Firstly, the broiler chickens observed in this study performed very low levels of agonistic behaviour. Secondly, agonistic behaviour peaked during week 4 whereas the decline in use of space and movement occurred several weeks later. Thirdly, the decline in rate of movement also occurred in the second experiment although the birds had the opportunity to avoid others by going outdoors. Fourthly, although there were more fights in the first than the second experiment, there were no significant interactions between age, experiment and group size corresponding to the space use and movement results.

We suggest that our results are better explained by an effect of physical barriers created by the presence of other chickens in the path of movement (Newberry and Hall, 1988, 1990). When the birds were young, only small detours were needed to pass around groups of individuals lying in the path of movement. However, towards the end of the rearing period, the relatively large body size of individuals resulted in less unoccupied space within the pen, especially in larger groups. Thus, movements may have been limited by the physical obstacle presented by groups of chickens lying in the path of movement, similar to the effect of pen walls in limiting locomotion and use of space with decreasing pen size (Newberry and Hall, 1990).

Our results on agonistic behaviour are consistent with the findings of Mench (1988) for groups of 15 broiler chickens provided with food ad libitum. Her results indicate that low rates of agonistic behaviour, with an early peak, occurred even at small group sizes in which individual recognition should not be a constraint on the development of a peck order. By contrast, small groups of broilers fed limited amounts of feed (Mench, 1988), and small groups of layer-type chickens fed ad libitum (Rushen, 1982), showed much higher levels of agonistic behaviour, with levels increasing with increasing age. Thus, it is apparent that the ontogeny of social behaviour in domestic fowl varies according to environmental conditions as well as genetic background.

There was a significant reduction in the frequency of threats as group size increased, contrary to the results of Banks and Allee (1957) and Al-Rawi and Craig (1975), who observed higher levels of agonistic behaviour with increasing group size in small groups of adult laying hens. They suggested that their results were due to the hens having difficulty in recognizing flockmates. Also, Guhl (1953) reported higher rates of pecking and threatening in small groups when establishment of a stable hierarchy was prevented by frequent removal of familiar birds and replacement with strangers. Our results, in combination with those of Mench (1988), suggest that individual recognition may not be an important factor influencing the frequency of agonistic behaviour in young broilers.

At high stocking densities, an increase in agonistic behaviour with an increase in available space has been reported for laying hens (Polley et al., 1974; Al-Rawi and Craig, 1975; Hughes and Wood-Gush, 1977). The latter authors suggested that agonistic encounters among hens may be triggered only when an individual approaches another hen from a distance and not when hens are in continuous proximity. We suggest that our finding of reduced threats in larger groups of broilers was not due to lack of sufficient space to perform this activity. Firstly, the frequency of threats was no higher in the second experiment when the birds had access to additional space outdoors. Secondly, the group size effect on frequency of threats was evident throughout the rearing period and not just in the final weeks when unoccupied space was reduced due to the larger body size of the birds.

Although there was a decrease in body weight with increasing group size, this was not associated with increased variability in final body weight. In addition, time spent at the feeders and the drinker did not differ according to group size (Estevez, 1994). Therefore, the lower body weights of chickens in the larger groups cannot be explained as an effect of greater restriction of resources in larger flocks due to monopolization of resources by despotic individuals. Cravener et al. (1992) reported growth restriction in broilers with increased group size within the same pen area despite increasing the length of feeder space to maintain a constant amount of feeder space per bird. Other factors, such as reduced thermoregulatory capacity, and an increased level of disturbances when resting (Estevez, 1994), may have been responsible for the reduced growth in the larger groups.

Contrary to the sub-group hypothesis, there was no evidence that use of different areas of the pen was limited by agonistic encounters. From an energetic point of view, an animal should spend time and energy interacting with others only when this yields greater net benefits than an alternative behavioural strategy, such as ignoring others in the population and spending the time exploiting resources (Davies and Houston, 1984). We suggest that it is uneconomical for broiler chickens in large groups with unlimited food and water to expend energy to defend resources from other individuals when the number of competitors is high and depletion of resources by others has little cost. Under these conditions, broiler chickens should be tolerant of their flockmates.

In conclusion, our results do not support the hypothesis that the social organization of broiler chickens is based on the development of peck orders within sub-groups in different regions of the pen. We propose the alternative hypothesis that broiler chickens with unlimited resources have a tolerant social system. Benefits of a tolerant social system include freedom of movement unrestricted by agonistic encounters, and minimal expenditure of time and energy in agonistic behaviour. Furthermore, our data suggest that tolerance increases under conditions of increasing group size.

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Resumen

El sistema de organización social del gallo doméstico (*Gallus gallus domesticus*) en condiciones de confinamiento se ha considerado, tradicionalmente, como un rígido orden de picoteo, en el cual los individuos de elevado orden social profieren la mayoría de las amenazas y ganan la mayor parte de los combates. McBride y Foenander (1962) indicaron que los individuos que se mantienen en grandes grupos permanecen en areas limitadas del recinto dentro de las cuales pueden reconocer a todos sus congéneres, lo que conlleva a la formación de subgrupos en diferentes areas dentro del recinto, cada uno de los cuales mantiene su propia jerarquia estable. De acuerdo a ésta hipotesis, predijeron que el area ocupada por un individuo estaría determinada por el número de aves que puede reconocer y por tanto estaría inversamente relacionado con el tamaño de grupo.

La cría comercial de pollos broiler se caracteriza por el elevado número de individuos (varios miles) que se mantienen en un espacio mas o menos reducido. Por tanto, según la hipótesis de McBride y Foenander, las aves en estas condiciones de cría tenderían a la formación de subgrupos dentro de los cuales establecerían su propio orden jerárquico. Las predicciones de ésta hipótesis son 1) reducción del uso del espacio a medida que el tamaño de grupo aumenta en un área constante, para evitar encuentros agresivos con individuos no familiares, y 2) aumento de la variabilidad del peso corporal de los pollos con incrementos del tamaño de grupo debido a la monopolización de recursos por animales déspotas.

Para realizar éste trabajo 1000 pollos broiler, no sexados, de un día de edad se dividieron al azar en grupos de 50, 100, 150 y 200, y se colocaron en recintos idénticos. Durante el primer experimento las aves se mantuvieron en condiciones habituales de cría comercial desde la primera a la octava semana de vida, mientras los individuos utilizados en el segúndo experimento tuvieron libre acceso a un recinto exterior desde la quinta semana hasta el final del periodo de cría (8 semanas).

Los resultados obtenidos indican que la superficie de las areas core al 30, 50 y 70 % se mantiene estable a través del tamaño de grupo. El uso del espacio para todos los tamaños de grupos analizados aumenta cuando las aves tienen acceso al parque exterior. Sin embargo, el coeficiente de variación del peso corporal al término del periodo de cria fué similar para todos los tamaños de grupo, y ademas, la frecuencia de amenazas se redujo significativamente con incrementos del tamaño de grupo. Los resultados obtenidos en este trabajo no apoyan la hipótesis de formación de subgrupos para pollos broiler en condiciones de cria comercial. Por el contrario, los pollos muestran gran plasticidad en su comportamiento social en función de las condiciones de su entorno, con incrementos de la tolerancia en grupos grandes.

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