Social interaction of juvenile Japanese quail classified by their permanence in proximity to a high or low density of conspecifics

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ABSTRACT One challenge faced by ethologists in poultry welfare is helping birds to form functionally successful groups over time through the expression of appropriate behaviors. Searching for phenotypic variability, we developed in Japanese quail a density-related permanence (DRP) test that enables us to classify young birds (while in groups) according to their individual permanence in boxes containing a high or low density of confined conspecifics (HD or LD, respectively). This study addressed the question of whether contrasting DRP quail behavior may reflect underlying differences in social responses. Birds were classified at 11 d of age in an apparatus consisting of 2 boxes interconnected by a central region delimited by sliding doors. Each box contained at its distal end either 12 or 3 conspecifics confined behind a glass (high or low density, respectively). The doors were closed 9 times every 1 h, and positioning of 36 experimental birds was registered. If birds were found in the box containing high density, low density, or in the central region, they received a 1, −1, or a 0 score, respectively. Birds with final summed scores of ≥ 3 or ≤ -3 were categorized as HD or LD, respectively. Same category groups (HD or LD) were evaluated in their home box (undisturbed) and in a resident/intruder test when 38 d old. A higher proportion of LD than HD groups (5/6 vs. 1/6, respectively) showed at least one aggressive pecking event during a 1-h trial. The LD groups also showed a higher number of aggressive pecking events than HP groups. When an unfamiliar intruder (either HD or LD) was incorporated during 5 min in the HD or LD box, LD resident quail showed shorter latencies and a higher number of aggressive pecking events toward the intruder bird than their HD counterparts. The early individual permanence in the DRP test could be considered a consequence of a different adaptability strategy for group living. This novel test could be relevant for selection programs aiming to obtain birds better suited for rearing in high-density conditions.

Key words: stocking density test, agonistic behavior, social interaction

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INTRODUCTION

It is well known that individuals of various species differ consistently in their behavioral and physiological reactions to mild challenges, even when they are of the same size and age and belong to the same sex and population (Wilson, 1998; Gosling and John, 1999; Koolhaas et al., 1999; Bell, 2007a; Koolhaas et al., 2007). Consciously or unconsciously, an important part of the domestication process of animals and the development of modern strains of farm animals has been and is presently based on the identification and selection of animals according to their individual differences (Hale, 1962; Belyaev, 1979; Briggs and Briggs, 1980; Wood-Gush, 1983). However, there are complex traits that are difficult to quantify because of their multicausality, one of them being the ability of a given animal to live within a densely populated group of conspecifics. This trait would involve a trade-off among several underlying behavioral characteristics of individuals (aggression, territoriality, animals' environmental preferences, fearfulness, and the need for social contact, among others; Keeling, 1995; Jones, 1996). Thus, the social ability to live in a densely populated group of conspecifics would not be susceptible to being defined as a simple behavioral trait, but more appropriately, in our opinion, to be consider a complex response that could be associated with a behavioral syndrome or a coping style.

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In classic studies of behavioral syndromes or coping style, animals are subjected to a set of physiological or behavioral assessments, or both, and consecutively categories are defined using the individual set of results, to finally label each animal, for example, as bold or shy, more or less aggressive, active or passive, proactive or reactive, and so on (Wechsler, 1995; Sih et al., 2004; Bell, 2007b). Although this line of work has proven to be very useful in a large number of experiments, scientists working in this area (Webster and Ward, 2011) report a concern related to the general testing conditions. It is mentioned that in most of these studies, animals are tested in isolation or in individual boxes with only visual or tactile access to conspecifics, thereby failing to take into account social influences (such as conformity and facilitation) on the expression of their behavior. Interestingly, Albentosa and Cooper (2005) exposed the same concern in another area closely related to the animals' ability to live in a densely populated group of conspecifics: their studies on animals' environmental preferences.

Considering the above, and combining with elements of animals' personality and environmental preference studies, we developed a new behavioral test aimed to identify quail individuals (within a social group) differing in their permanence in boxes containing either a high or a low density (and number) of confined conspecifics. The test was named the density-related permanence (**DRP**) test. The main feature of this test is that individual social responses are evaluated while individuals are in groups. The classification apparatus (Figure 1) basically consisted of 2 boxes interconnected by a central region. Each box contained at its distal end either a high density (12 birds) or low density (3 birds) of conspecifics confined behind a glass. The boxes and the central region of the apparatus are separated by sliding doors, and therefore birds can temporarily be confined and identified at their locations. By registering throughout the day where they were found (box containing high density, low density, or in the central region), birds were categorized according to their permanence in proximity to either a high or a low density of conspecifics category (**HD** or **LD**, respectively; for further DRP procedural details, please refer to Materials and Methods section below).

After applying the DRP test, we observed that the animals showed enough individual variation in this early social response (D. A. Guzmán and R. H. Marin, un-

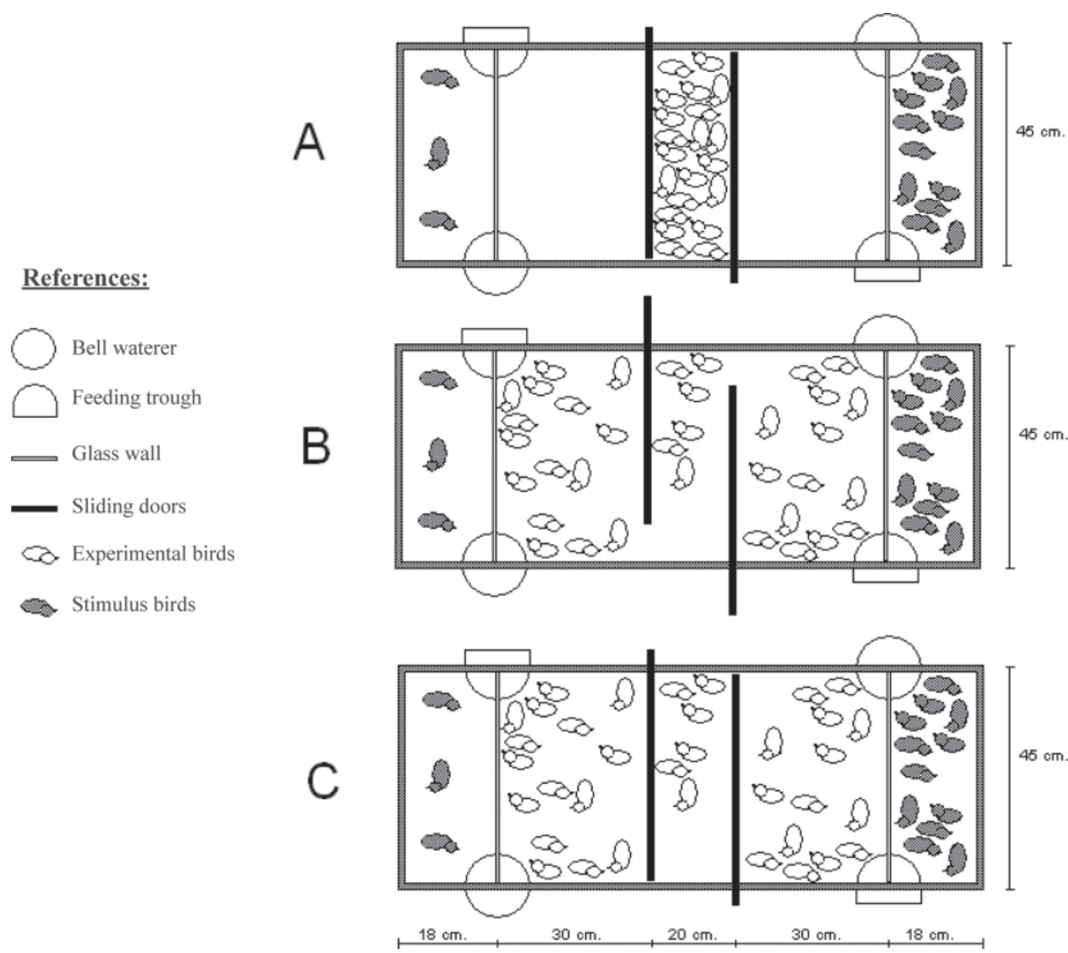

Figure 1. Schematic drawing of the apparatus used to categorize birds according to their permanence in proximity to a low or high density of conspecifics: A) sliding doors in closed position before the release of the birds, B) sliding doors in open position, and C) sliding doors in closed position after free ambulation of quail with the apparatus.

published data), and therefore, it could be considered a useful tool to discriminate subpopulations that differ in their social behavior. Considering the potential possibilities of occurrence of methodological problems faced by group-testing animals, the first question that arises is whether this early individual DRP is an isolated behavioral response to the particular experimental conditions (context-dependent), or if it could be considered part of a different adaptability of the birds for group living. Taking into account that if any different adaptability for group living between HD and LD birds exists, it should be reflected in different aspects of social interactions, this first study focuses on the evaluation of social cohesion and aggressive behaviors within same category undisturbed groups (HD or LD) and on the reaction of HD and LD groups toward the introduction of an unknown conspecific (either HD or LD).

MATERIALS AND METHODS

Birds and Rearing Conditions

This study was conducted with 1,224 Japanese quail (*Coturnix coturnix japonica*) taken from a larger population of animals obtained from 6 incubation series (6 batches). At hatch, chicks were leg-banded to maintain individual identification and housed in mixed-sex groups of 70 to 75 birds, in white wooden rearing boxes (90 × 90 × 60 cm, length × width × height, respectively). A wire-mesh floor (1 cm grid) was raised 5 cm from the base to allow the passage of excreta. Each box had a feeder covering the entire front of the box, 16 automatic nipple drinkers, and a lid to prevent birds from escaping and heat loss. Each box was also provided with a heating system that allowed maintaining brooding temperature at 37.5°C during the first week of life, with a weekly decline of 3.0°C. Quail were subjected to a daily cycle of 14L (300 to 320 lx):10D during the study. Lights were turned on at 0600 h and turned off at 2200 h. Leg bands were replaced with permanent wing bands at 21 d of age. A quail starter diet (28% CP; 2,800 kcal of ME/kg) and water were provided ad libitum throughout the study.

Experimental Details and Procedures

DRP Test. Classification of quail in the DRP test was conducted when they were 11 d of age. The classification apparatus consisted of 2 boxes interconnected by a central region (Figure 1). Each box contained at its distal end a high or low density (and number; 12 and 3 birds, respectively) of conspecifics (stimulus birds) confined behind a glass. The boxes and the central region of the apparatus were separated by sliding doors, and therefore birds could be temporarily confined at their location. When birds were 10 d old, groups of 36 experimental birds and 15 stimulus birds were positioned in each of 4 identical apparatuses as shown in Figure 1A. Immediately, the sliding doors were opened to allow the experimental birds to freely ambulate through the boxes of the apparatus (Figure 1B).

At 11 d of age and every 1 h (starting at 0800 h), the sliding doors were closed and the experimental birds were confined (Figure 1C). All birds were individually and gently removed for identification (see below), and immediately placed in the central region of the apparatus (Figure 1A). According to where they were found (box containing high density of conspecifics, low density of conspecifics, or in the central region of the apparatus), each bird, respectively, received a 1, −1, or a 0 score. After all experimental birds were scored and placed in the central region, the sliding doors were opened and quail were again able to freely ambulate within the apparatus for another hour (Figure 1B). This procedure took less than 4 min and was repeated 9 times throughout the day, and the scores for each animal were summed. Birds with final values ≥ 3 or ≤ -3 were respectively categorized as HD or LD. After the classification process, all birds (except those used as stimulus birds) were randomly housed back in their rearing boxes. Stimulus birds were not further used in the study and were donated to a quail farm.

After classification of all experimental quail, a total of 208 birds were categorized as HD and 220 birds were categorized as LD.

Home Box Housing. At 31 d of age, birds were sexed by plumage coloration and rehoused in white wooden home boxes. Boxes measured 115 × 43 × 44 cm (length × width × height, respectively), and contained a bell waterer, a feeding trough and two 8-W helical fluorescent lamps (placed at 40 cm high) in one of their ends (Figure 2). Lamps provided between 300 to 320 lx illumination at ground level.

The sectorized location of food, water, and light was provided with the intention to produce a gradient of resources in the test arena to increase potential competition (Leone and Estevez, 2008). About one-third of the total box area contained the water, food, and highest intensity of light and was termed the area of high concentration of resources.

Birds to be tested as “residents” (see below) were allocated in same-category groups of 6 HD or 6 LD quail (3 males and 3 females within each group; HD or LD home boxes). Birds to be tested as “intruders” (see below) were housed in identical boxes as their resident counterparts to avoid the added novel environmental effects when placed in those boxes for testing. Assuming that HD and LD quail could differ in their social cohesion or aggressive behaviors, or both, intruders were maintained in mixed-category-sex groups (110 cm^2/bird density) to avoid conditioning them to leave in a particular social situation (either with less or high level of aggressions) that could affect (exacerbate) their behavior when tested in the resident-intruder test. These housing conditions were similar to those often used in commercial breeding scenarios (Shanaway, 1994) .

Ten home boxes were used to assess the social interaction of classified birds for each batch. Two boxes

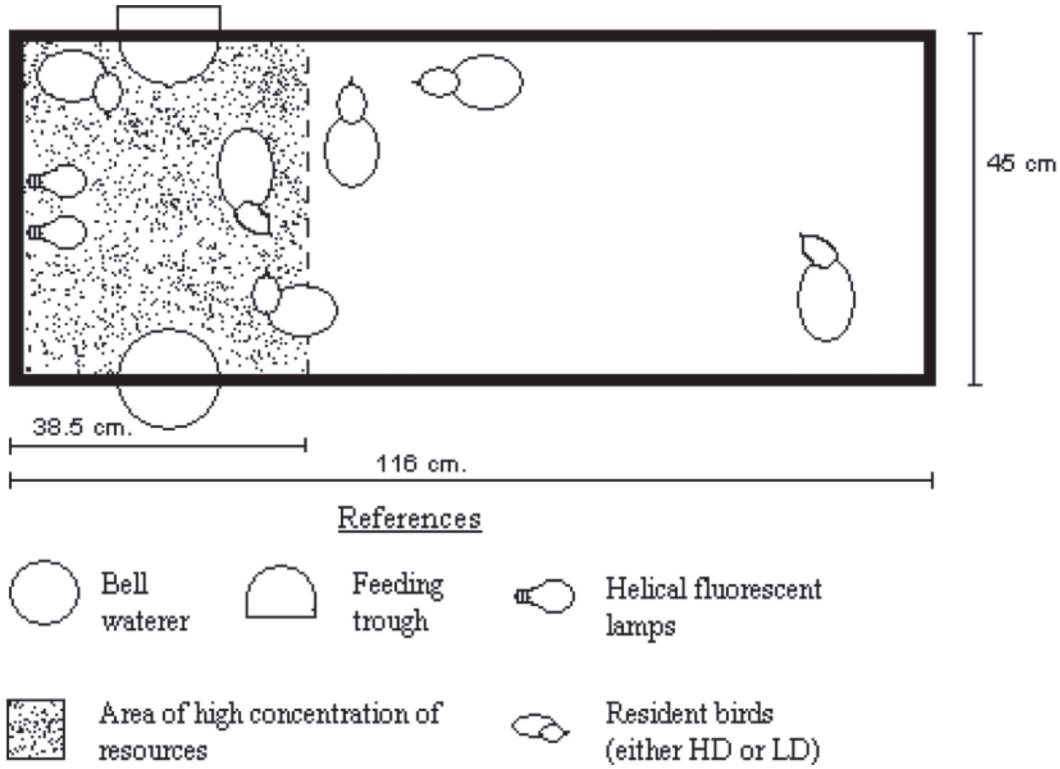

Figure 2. Home cage used to assess social interaction of birds classified by their permanence in proximity to a high or low density of confined conspecifics (HD or LD, respectively).

were used to evaluate the HD and LD home cage social interaction and the other 8 remaining boxes were used for the intruder-resident test (see below).

Home Box Social Interaction. At 38 d of age, from 0800 h, behaviors of undisturbed same-category groups (within HD or LD home boxes) were evaluated during 1 h. For behavioral video analysis, a camcorder was placed 1.5 m above each home cage 1 wk before assessment to avoid any disturbances on the experimental day. Through direct observation of the video recordings, the number of aggressive pecking events (an individual pecking another in some area of its body) was registered. Repeated pecks directed at the same animal within 3 s were considered part of the same aggressive event. Videos were also analyzed using Behavior Collect software (Tietjen, 1981), providing the location of the 6 birds within the home box (coordinates on the test arena). The coordinates were registered every 30 s during the 60-min time period. Based on these coordinates and using the Matlab program (MathWorks Co., Natick, MA), we calculated the average distance between HD and LD birds and also estimated the percentage of birds found in the home box area with a high concentration of resources.

After completion of the study, a total of 6 HD and 6 LD experimental groups were evaluated.

Intruder-Resident Social Interaction. At 38 d of age, from 1000 h, the behavioral reactions of same-category (either HD or LD) birds (residents) toward the introduction of an unknown conspecific (HD or LD; intruder), as well as the reactions of the intruder toward the residents, were assessed. Thus, there were 4 resident-intruder group combinations: HD intruder birds placed in HD resident home boxes, HD intruder birds placed in LD resident home boxes, LD intruder birds placed in HD resident home boxes, and LD intruder birds placed in LD resident home boxes. The sex of the intruder birds was also annotated for subsequent consideration in the data analysis. A total of 21 HD and 21 LD intruder birds were individually, and only once, placed for 5 min in either an HD or LD home box. Thus, in total, 21 HD and 21 LD resident groups were evaluated.

For behavioral video analysis, a camcorder was placed 1.5 m above each cage 1 wk prior to assessment to reduce disturbances during the experimental day. Through direct observation of the video recordings, the latency to the first aggressive pecking event among residents, the number of aggressive pecking events among residents, the latency to the first aggressive pecking event from residents toward the intruder bird, the number of aggressive pecking events performed from residents toward the intruder bird, the latency to the first aggressive pecking from the intruder toward the resident birds, and the number of aggressive pecking events from the intruder toward the resident birds were registered. The videos were also analyzed using the Behavior Collect program (Tietjen, 1981), providing every 3 s (and during a 5-min trial) the coordinates on the test arena of the 6 resident birds and also the location of the intruder bird. Based on these coordinates and using the Matlab program (MathWorks Co., Natick, MA), we

Table 1. Home box social interaction behaviors (mean ± SEM) of birds categorized by their permanence in proximity to a high or low density of confined conspecifics (HD or LD, respectively)

Variable	HD home box	LD home box	*P*-value
Average distance among resident birds (cm)	44.87 ± 1.89	45.22 ± 3.27	0.92
Percentage of birds found in the home box area with high concentration of resources (%)	48.2 ± 8.1	38.4 ± 6.1	0.35
Number of aggressive pecking events among residents[1]	0.02 ± 0.02	0.30 ± 0.15	0.05
Proportion of home boxes in which aggressive pecking events between birds were verified	1/6	5/6	0.002

[1]Values were collected during a 1-h test period and expressed per 5-min intervals to facilitate comparisons between data from this test and the intruder-resident test (see Table 2).

calculated the average distance among resident birds, the percentage of resident birds found in the home box area with a high concentration of resources, the percentage of test time the intruder bird spent in the home box area with a high concentration of resources, the percentage of test time that the intruder bird spent ambulating, and the total distance ambulated by the intruder bird within the box during the test.

Statistical Analysis

A one-way ANOVA was used to examine the effects of the category of the birds (HD and LD) in the average distance among birds, the average percentage of time the birds spent in the area of high concentration of resources, and the number of aggressive pecking events within their home boxes. The number of aggressive pecking events was transformed to ranks to better fit the ANOVA assumptions (Shirley, 1987). A proportion test (Statistix, Analytical Software Co., Tallahassee, FL) was used to assess differences in the proportion of HD and LD home boxes in which at least one aggressive pecking event was observed.

Continuous variables registered in the resident-intruder test were analyzed by 3-way ANOVA. The tests evaluated the effects of the category of the resident birds (HD and LD), the effects of the sex and the category of the intruder bird (HD and LD) as well as their interactions. Analysis of variance assumptions were verified. A proportion test (Statistix, Analytical Software Co.) was used to assess differences in the proportion of HD and LD boxes in which at least one aggressive pecking event was observed. Because one resident bird escaped from a HD box during testing, data from that box were not considered in the analysis.

In all cases, a *P*-value of ≤ 0.05 was considered to represent significant differences.

RESULTS

Home Box Social Interaction

Results of social interaction behaviors registered within home boxes of HD and LD birds are depicted in Table 1. Analysis of variance showed a significantly higher ($F_{1,10} = 4.76$; $P = 0.05$) number of aggressive pecking events among LD residents than among their HD counterparts. The proportion of home boxes in which at least one aggressive pecking event was verified was also significantly higher ($P < 0.002$) in the LD home boxes (5 of 6 boxes showing aggressive pecking encounters) than in the HD home boxes (only 1 of 6 boxes showing aggressive pecking encounters).

Significant differences were not found in the average distance among HD and LD birds ($F_{1,10} = 0.008$; $P = 0.92$) or in the percentage of birds found in the home box area with a high concentration of resources ($F_{1,10} = 0.92$; $P = 0.35$).

Intruder-Resident Social Interaction

No effect of the category or the sex of the intruder birds (HD or LD) was observed on the variables analyzed in this test. No interactions were observed either in any of the variables measured between the sex and the category of the intruder birds or between the sex of the intruders and the category of the resident group where they were introduced. Therefore, results of social interaction behaviors among residents and among residents and an intruder bird within home boxes of HD and LD birds are depicted in Table 2 by pooling male and female data.

Significant main effects of the category of the resident birds were found in the latency to the first aggressive pecking event among residents (HD > LD; $F_{1,37} = 5.54$; $P = 0.02$), the number of aggressive pecking events among residents (HD < LD; $F_{1,37} = 9.88$; $P = 0.003$), the latency to the first aggressive pecking event from residents toward the intruder bird (HD > LD; $F_{1,37} = 5.42$; $P = 0.02$), the number of aggressive pecking events performed from residents toward the intruder bird (HD < LD; $F_{1,37} = 4.02$; $P = 0.05$), the average distance among resident birds (HD < LD; $F_{1,37} = 4.79$; $P = 0.03$), and in the total distance ambulated by the intruder bird within the box during the test (HD < LD; $F_{1,37} = 6.47$; $P = 0.01$). The proportion of home boxes in which at least one aggressive pecking event among resident birds was verified was significantly higher ($P = 0.01$) in the LD boxes (12 cases out of 21) than in the HD boxes (3 cases out of 20). A higher proportion ($P = 0.05$) of LD compared with HD resident groups also performed at least one aggressive pecking event toward the intruder bird (8 of 21 LD groups vs. 3 of 20 HD groups).

Table 2. Social interaction behaviors (mean ± SEM) among residents and among residents and an intruder bird within home boxes of birds categorized by their permanence in proximity to a high or low density of confined conspecifics (HD or LD, respectively)

Variable[1]	HD resident box	LD resident box	*P*-value
Latency to the first aggressive event among residents (s)	259 ± 19	186 ± 24	0.02
Number of aggressive events among residents[2]	0.03 ± 0.02	0.49 ± 0.14	<0.01
Latency to the first aggressive event from residents toward the intruder bird (s)	280 ± 12	206 ± 27	0.02
Number of aggressive events toward the intruder bird	0.20 ± 0.11	1.85 ± 0.76	0.05
Average distance among resident birds (cm)	40.74 ± 2.33	48.09 ± 2.23	0.03
Total distance ambulated by the intruder bird (cm)	441 ± 48	819 ± 134	0.01
Latency to the first aggressive event from the intruder toward the resident birds (s)	295 ± 3.9	275 ± 14	0.18
Number of aggressive events from the intruder toward the resident birds	0.1 ± 0.06	0.33 ± 0.21	0.31
Percentage of test time that the intruder bird spent ambulating (%)	51.7 ± 3.8	61.3 ± 3.8	0.08
Percentage of time the intruder bird spent in the home box area with high concentration of resources (%)	47.9 ± 8.8	43.4 ± 7.6	0.74
Percentage of resident birds found in the home box area with high concentration of resources (%)	52.4 ± 5.8	44.9 ± 4.8	0.30
Proportion of home boxes in which aggressive events among resident birds were verified	3/21	12/21	0.01
Proportion of home boxes in which aggressive events toward intruder bird were verified	3/21	8/21	0.05

[1]Behaviors were collected during a 5-min test period.

[2]Values are expressed as an average per resident bird.

No significant main effects of the category of the resident birds (HD or LD) were found in the latency to the first aggressive pecking event from the intruder bird toward residents ($F_{1,37} = 1.78$; $P = 0.18$), the number of aggressive pecking events from the intruder bird toward residents ($F_{1,37} = 1.05$; $P = 0.31$), the percentage of test time that the intruder bird spent ambulating ($F_{1,37} = 3.05$; $P = 0.08$), the percentage of test time the intruder bird spent in the home box area with a high concentration of resources ($F_{1,37} = 0.10$; $P = 0.74$), or in the percentage of resident birds found in the home box area with high concentration of resources ($F_{1,37} = 1.07$; $P = 0.30$; Table 2).

DISCUSSION

Individual quail were classified as HD or LD at 11 d of age while remaining in groups of 36. At 38 d of age, and after 1 wk of rehousing in same-category groups of 6 HD or 6 LD quail, their home box (undisturbed environment) behavior was evaluated. In comparison with the number of groups composed of HD birds, a significantly higher proportion of groups composed of LD birds showed at least one aggressive pecking event during observations (5/6 LD groups vs. 1/6 HD groups). Furthermore, within LD groups, a higher number of aggressive pecking events (aggressive pecking) was observed. When kept in small groups, domestic fowl form pecking orders that, once established, are characterized by a low frequency of aggressive interactions among group members (Guhl, 1953; Maier, 1964). At first glance, 2 possible explanations for these behaviors would be that a) LD birds, at least at the age tested, are inherently more aggressive than HD birds (e.g., they require or perform more aggressive pecking interactions to maintain their hierarchy ranges), and b) it takes longer for LD birds than HD birds to stabilize a social group, and thus, in the time window in which we conducted this study, the higher number of aggressive pecking events observed within the LD groups were still a consequence of the continued attempts to establish their social hierarchies. It is known that both adult quail and chicken in small groups increased aggressive pecking interaction as a consequence of regrouping (possibly tending to establish hierarchy ranges); however, it is considered that this phenomenon mainly occurs in the first 24 h after birds are being exposed to this social stress situation (Wood-Gush, 1971; Edens et al., 1983; Zayan, 1987a; Bradshaw, 1992; Odén et al., 2000). In our study, HD and LD groups were evaluated after they had remained together undisturbed in groups of 6 for a full week. Interestingly, when an unknown HD or LD conspecific (intruder) was incorporated during 5 min within established groups of same HD or LD category birds (residents), LD residents showed a shorter latency to initiate aggressive pecking events and performed a higher number of these events toward the intruder bird than their HD counterparts. Thus, the literature on this subject and the set of results mentioned above would suggest that the main explanatory scenario is that LD birds are inherently more aggressive than HD birds. Nevertheless, Estevez et al. (1997) hypothesized in a study with domestic fowl that social organization to establish dominances within large group is established through a tolerant social system characterized by low aggression. Indeed, using a cost-benefit argument, Pagel and Dawkins (1997) suggested that a dominance hierarchy will only be established when the chances of reencountering the same bird are relatively high, which will be more likely in small rather than large social groups. In subsequent studies, it was also proposed that aggression is a dynamic process, with decisions about aggressive behavior being made facultatively according to the relative costs and benefits of different behavioral strategies at a given time and place (Estevez et al., 2002). Interestingly, in this study the higher aggression reported for LD quail when tested in their home-box small group is showing a behavioral characteristic that is associated with their social performance when initially tested in the DRP apparatus at a much younger age and within a much larger social group (36 experimental plus 15 stimulus birds), where a tolerant organizational system would be operating. Indeed, even though not systematically measured, it is important to mention our subjective impression that no aggressions were evident during DRP testing or in other studies where we have worked with quail at this age.

Retreat from an aggressive pecking encounter is considered one of the strategies to minimize physical damage and end a potentially dangerous contention (Rushen, 1984; Odén et al., 2004). Consistently, intruders exposed to the LD group of residents also showed an increased distance ambulated compared with the intruders exposed to the HD group of residents, suggesting that within LD boxes, higher efforts were made by the intruders to escape from chases of their aggressive conspecifics and to avoid or minimize physical encounters. The frequency of chases may indicate the degree to which the dominant individual does not accept the subordinate's appeasement behavior (McBride, 1964).

Social competition is potentiated in gallinaceous birds by factors such as unfamiliarity, crowding, and frustration (Guhl, 1968; Craig et al., 1969; Duncan and Wood-Gush, 1971), and individually, these factors can evoke an increase in the frequency of aggressive pecking. It is noteworthy that in the resident-intruder test (that includes the presence of 6 resident birds plus an intruder), the number of aggressive peckings observed among the residents (both in the HD and in the LD boxes) showed numerical values of about an order of magnitude higher than the observed in the HD and LD home boxes (that remained undisturbed during observations—without an intruder). Interestingly, the number of aggressive pecking events also remained higher in the LD groups than in the HD groups. These findings suggest that the presence of a strange bird was also able to destabilize both the LD and the HD resident group structure, or at least stimulate behaviors consistent with the reinforcement of the birds' hierarchy (Edens, 1987; Cloutier and Newberry, 2002).

The observed aggression on intruder-resident social interactions were independent of the category (HD or LD) of the intruder. These results suggest that at least on a short-term social interaction basis, individual recognition of physical or behavioral characteristics that would allow resident birds to respond differentially between LD or HD intruders are not evident. Although the study of submissive, defensive, or retreating behavior of birds categorized as HD or LD exceeded the purposes of this study, future similar tests with larger home boxes, increased scan time, and appropriate filming techniques possibly will allow us to explain the lack of difference found in relation to the category of the intruder birds. Considering that density and group size could influence aggression behavior (Nicol et al., 1999), further studies should be performed to determine if the observed birds' behavior in the DRP test are specifically related to the density of the stimulus birds, or whether the different group sizes of the stimulus bird could be an influential variable.

Absence of discrimination or social interactions would suggest that individual recognition does not occur (Barnard and Burk, 1979). In the resident-intruder test, although values of aggressive pecking interactions among residents and from residents toward the intruder bird are not susceptible to be directly statistically compared, more than 6 times numerically higher values were observed both in the HD and LD home boxes from the residents toward the intruder birds than on average among each of the 6 residents. These data are fully in line with revisions describing that agonistic interactions are more frequent toward unfamiliar than toward familiar conspecifics (Hughes, 1977; Zayan, 1987b) and are also consistent with the hypothesis that the resident birds (regardless of their DRP category) recognize each other as members of a group.

Aggressive pecking events in home boxes (without disturbance) were an order of magnitude greater among LD resident birds than among HD resident birds. Differences of this magnitude were also found by Chang et al. (2009) when they compared home cage aggressiveness within groups composed by wild Japanese quail versus groups conformed by a domestic strain of Japanese quail. These important range differences between HD and LD groups can be considered an evidence that at least within Japanese quail populations, there is still enough genetic variability to modulate this character. Thus, a breeding program that incorporates the HD-type behavior in the DRP test as a selection criterion could be worthy to help minimize aggression within bird populations.

In many species of precocial birds, social attraction and the maintenance of social cohesion are important behavioral features (Lorenz, 1935; Wood-Gush, 1971). In domesticated species, social attraction has important influences on a wide variety of behavior patterns that can be related to both economic performance and animal welfare (Carmichael et al., 1998). Interestingly, when a strange conspecific was introduced in the environment, HD residents presented a more compact social group (smaller interindividual distances among resident birds) that the LD group, which suggests that HD are more sociable than their LD counterparts. This result is consistent with the criteria used to categorize our HD and LD subpopulations in the DRP test. Alternatively, smaller interindividual differences (or enhanced social proximity) could also reflect a fear response toward a frightening or stressful stimulus that in this case could be the presence of an unfamiliar intruder conspecific (Marin et al., 2001; Guzmán and Marin, 2008). However, open-field, tonic immobility, and plasma corticosterone response studies performed with HD and LD quail suggest that the contrasting response in their interindividual distances was unlikely to have reflected differences in underlying fearfulness or stress susceptibility but that sociality was probably a highly influential variable (D. A. Guzmán and R. H. Marin, unpublished data).

The preferences shown by HD birds to remain in areas with a high density of congeners during the bird's categorization process at 11 d of age, together with observed social interaction responses of the HD and LD group of residents at 38 d of age, both while undisturbed in the home cage or when in the presence of an intruder counterpart, suggest that the HD quail would be most suited for rearing in high-density breeding conditions that are currently often used both at the small and industry-scale level. However, further studies with birds at older ages and in other production system situations would be worthwhile to confirm that proposal. The results further suggest that the early individual social permanence in close proximity to an area with a given density of conspecifics (either high or low), is not an isolated behavioral response (context-dependent) to one particular experimental conditions, but could rather be considered part of a different adaptability strategy of the birds for group living. Further studies are currently underway to help evaluate this hypothesis.

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REFERENCES

Albentosa, M. J., and J. J. Cooper. 2005. Testing resource value in group-housed animals: An investigation of cage height preference in laying hens. Behav. Processes 70:113–121.

Barnard, C. J., and T. Burk. 1979. Dominance hierarchies and the evolution of "individual recognition". J. Theor. Biol. 81:65–73.

Bell, A. M. 2007a. Evolutionary biology: Animal personalities. Nature 447:539–540.

Bell, A. M. 2007b. Future directions in behavioural syndromes research. Proc. Biol. Sci. 274:755–761.

Belyaev, D. K. 1979. Destabilizing selection as a factor in domestication. J. Hered. 70:301–308.

Bradshaw, R. H. 1992. Conspecific discrimination and social preference in the laying hen. Appl. Anim. Behav. Sci. 33:69–75.

Briggs, H. M., and D. M. Briggs. 1980. Modern Breeds of Livestock. 4th ed. Macmillan Publishing Co., New York, NY.

Carmichael, N. L., R. B. Jones, and A. D. Mills. 1998. Social preferences in Japanese quail chicks from lines selected for low or high social reinstatement motivation: Effects of number and line identity of the stimulus birds. Appl. Anim. Behav. Sci. 58:353–363.

Chang, G. B., X. P. Liu, H. Chang, G. H. Chen, W. M. Zhao, D. J. Ji, R. Chen, Y. R. Qin, X. K. Shi, and G. S. Hu. 2009. Behavior differentiation between wild Japanese quail, domestic quail, and their first filial generation. Poult. Sci. 88:1137–1142.

Cloutier, S., and R. C. Newberry. 2002. A note on aggression and cannibalism in laying hens following re-housing and re-grouping. Appl. Anim. Behav. Sci. 76:157–163.

Craig, J. V., D. K. Biswas, and A. M. Guhl. 1969. Agonistic behaviour influenced by strangeness, crowding and heredity in female domestic fowl (*Gallus gallus*). Anim. Behav. 17:498–506.

Duncan, I. J. H., and D. G. M. Wood-Gush. 1971. Frustration and aggression in the domestic fowl. Anim. Behav. 19:500–504.

Edens, F. W. 1987. Agonistic behavior and neurochemistry in grouped Japanese quail. Comp. Biochem. Physiol. A Comp. Physiol. 86:473–479.

Edens, F. W., S. J. Bursian, and S. D. Holladay. 1983. Grouping in Japanese Quail. Poult. Sci. 62:1647–1651.

Estevez, I., R. C. Newberry, and L. A. De Reyna. 1997. Broiler chickens: A tolerant social system? Etologia 5:19–29.

Estevez, I., R. C. Newberry, and L. J. Keeling. 2002. Dynamics of aggression in the domestic fowl. Appl. Anim. Behav. Sci. 76:307–325.

Gosling, S. D., and O. P. John. 1999. Personality dimensions in nonhuman animals: A cross-species review. Curr. Dir. Psychol. Sci. 8:69–75.

Guhl, A. M. 1953. Social behavior of the domestic fowl. Kansas State Agricultural Experiment Station Technical Bulletin. 73:3–48.

Guhl, A. M. 1968. Social inertia and social stability in chickens. Anim. Behav. 16:219–232.

Guzmán, D. A., and R. H. Marin. 2008. Social reinstatement responses of meat-type chickens to familiar and unfamiliar conspecifics after exposure to an acute stressor. Appl. Anim. Behav. Sci. 110:282–293.

Hale, E. B. 1962. Domestication and the evolution of behaviour. Pages 22–42 in The Behaviour of Domestic Animals. E. S. E. Hafez, ed. Bailliere, Tindall & Cassel, London, UK.

Hughes, B. O. 1977. Selection of group size by individual laying hens. Br. Poult. Sci. 18:9–18.

Jones, R. B. 1996. Fear and adaptability in poultry: Insights, implications and imperatives. World's Poult. Sci. J. 52:131–174.

Keeling, L. 1995. Spacing behaviour and an ethological approach to assessing optimum space allocations for groups of laying hens. Appl. Anim. Behav. Sci. 44:171–186.

Koolhaas, J. M., S. F. de Boer, B. Buwalda, and K. van Reenen. 2007. Individual variation in coping with stress: a multidimensional approach of ultimate and proximate mechanisms. Brain Behav. Evol. 70:218–226.

Koolhaas, J. M., S. M. Korte, S. F. De Boer, B. J. Van Der Vegt, C. G. Van Reenen, H. Hopster, I. C. De Jong, M. A. Ruis, and H. J. Blokhuis. 1999. Coping styles in animals: Current status in behavior and stress-physiology. Neurosci. Biobehav. Rev. 23:925–935.

Leone, E. H., and I. Estevez. 2008. Space use according to the distribution of resources and level of competition. Poult. Sci. 87:3–13.

Lorenz, K. 1935. Der Kumpan in der Umwelt des Vogels. J. Ornithol. 83:137–215.

Maier, R. A. 1964. The role of the dominance-submission ritual in social recognition of hens. Anim. Behav. 12:59.

Marin, R. H., P. Freytes, D. Guzman, and R. B. Jones. 2001. Effects of an acute stressor on fear and on the social reinstatement responses of domestic chicks to cagemates and strangers. Appl. Anim. Behav. Sci. 71:57–66.

McBride, G. 1964. A General Theory of Social Organization and Behaviour. University of Queensland Press, St. Lucia, Qld., Australia.

Nicol, C. J., N. G. Gregory, T. G. Knowles, I. D. Parkman, and L. J. Wilkins. 1999. Differential effects of increased stocking density, mediated by increased flock size, on feather pecking and aggression in laying hens. Appl. Anim. Behav. Sci. 65:137–152.

Odén, K., C. Berg, S. Gunnarsson, and B. Algers. 2004. Male rank order, space use and female attachment in large flocks of laying hens. Appl. Anim. Behav. Sci. 87:83–94.

Odén, K., K. S. Vestergaard, and B. Algers. 2000. Space use and agonistic behaviour in relation to sex composition in large flocks of laying hens. Appl. Anim. Behav. Sci. 67:307–320.

Pagel, M., and M. S. Dawkins. 1997. Peck orders and group size in laying hens: 'Futures contracts' for non-aggression. Behav. Processes 40:13–25.

Rushen, J. 1984. Frequencies of agonistic behaviours as measures of aggression in chickens: A factor analysis. Appl. Anim. Behav. Sci. 12:167–176.

Shanaway, M. M. 1994. Quail production systems. FAO, Rome, Italy.

Shirley, E. A. 1987. Application of ranking methods to multiple comparison procedures and factorial experiments. Appl. Stat. 36:205–213.

Sih, A., A. Bell, and J. C. Johnson. 2004. Behavioral syndromes: An ecological and evolutionary overview. Trends Ecol. Evol. 19:372–378.

Tietjen, W. J. 1981. An inexpensive microcomputer-based image digitizer. Behav. Res. Meth. Instrum. 13:347–350.

Webster, M. M., and A. J. Ward. 2011. Personality and social context. Biol. Rev. Camb. Philos. Soc. 86:759–773.

Wechsler, B. 1995. Coping and coping strategies: A behavioural view. Appl. Anim. Behav. Sci. 43:123–134.

Wilson, D. S. 1998. Adaptive individual differences within single populations. Philos. Trans. R. Soc. Lond. B Biol. Sci. 353:199–205.

Wood-Gush, D. G. M. 1971. The Behaviour of the Domestic Fowl. Heineman, London, UK.

Wood-Gush, D. G. M. 1983. Elements of Ethology. Chapman and Hall, London, UK.

Zayan, R. 1987a. An analysis of dominance and subordination experiences in sequences of paired encounters between hens. Pages 182–320 in Cognitive Aspects of Social Behaviour in the Domestic Fowl. R. Zayan and I. J. H. Duncan, ed. Elsevier, Amsterdam, the Netherlands.

Zayan, R. 1987b. Recognition between individuals indicated by aggression and dominance in pairs of domestic fowl. Pages 321–438 in Cognitive Aspects of Social Behaviour in the Domestic Fowl. R. Zayan and I. J. H. Duncan, ed. Elsevier, Amsterdam, the Netherlands.