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Original Research Article

Social facilitation between commercial broilers and Nigerian indigenous chicks and its effect on their welfare

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Abstract

This study was undertaken to investigate how social facilitation between two chicken breeds could affect their welfare. Sixty chicks each of a commercial broiler (CB) and Nigerian indigenous chicken (NIC) breed were used for this study. At four days of age, the birds were randomly assigned into three treatments namely: T1 – single-strain CB (10 birds), T2 – single-strain NIC (10 birds) and T3 – mixed-strain (5 CB and 5 NIC) each having three replicates. Feed intake and weight gain were measured from the 1st to the 4th week of age. Behavioural observations were undertaken between 09:00 h–10:00 h for three consecutive days per week from the 2nd to 7th week of age. At the end of the 7th week, six birds per treatment were randomly selected for test of fear (tonic immobility) and level of stress (heterophil/lymphocyte ratio, H:L). Data collected were subjected to multivariate analysis using SPSS (version 21). A higher percentage ($P < 0.05$) of the CB displayed feeding, drinking and sitting compared to the NIC. However, higher percentage ($P < 0.05$) of the NIC displayed preening, foraging and standing behaviours compared to the CB. The percentage of birds drinking was greater in the mixed-strain (MS) compared to single-strain (SS). Also, there was a significant difference ($P < 0.05$) in breed × flock structure (FS) interaction on feeding and sitting behaviours specifically for NIC, where the percentage of NIC feeding was greater in the MS compared to SS. However, percentage of NIC sitting was greater ($P < 0.05$) in the SS compared to MS. CB were more fearful ($P < 0.05$) than NIC and chickens in the MS were less fearful ($P < 0.05$) compared to SS. The level of fear was reduced ($P < 0.05$) in the CB and NIC reared in MS compared to SS. H:L ratio was similar in CB and NIC reared either as SS or MS. Feed intake followed this trend T1 > T3 > T2. CB gained more weight compared to NIC. Body weight gain was similar in the SS compared to MS. In conclusion, MS management system had a positive influence on the welfare of both breeds.

Keywords: behaviour; feeding; drinking; sitting; heterophil/lymphocyte ratio; indigenous chickens; social facilitation; tonic immobility.

INTRODUCTION

Social facilitation in animals is when the performance of behaviour by an animal increases the probability of other animals engaging in that behaviour or increasing the intensity of the behaviour (Zajonc, 1965). Social facilitation has been reported in a wide variety of species such as domestic chicks (Tolman, 1964), pigeons (Zentall and Hogan, 1976) and pigs (Hsia and Wood-Gush, 1984). In the wild, social facilitation could be beneficial to animals living in groups by contributing to foraging success, anti-predatory defense and reproductive synchrony within social groups (Clayton, 1978). Social presence alone does not only inhibits certain behaviours but enhances their interest in engaging in other behaviours (Addessi and Visalberghi, 2001; Galloway et al., 2005; Voelkl et al., 2006).

On the basis of molecular genetics, the sole ancestor of the domestic fowl is the red jungle fowl (Baker et al., 1971). However, the process of domestication has changed the morphology and behaviour of birds, thus producing more docile, fearful (Kjaer and Mench, 2003) and less aggressive birds (Price, 1984). Broiler chickens have been genetically selected for rapid growth which is associated with increased feeding (Weeks et al., 2000) whereas laying hens that are not selected for rapid growth consume less feed (Barber, 2001). Reports indicated that the amount of food consumed by a subject bird was greater when there was another bird feeding in the adjacent cage or when a video or sound of bird feeding was displayed compared to when the video showed an empty cage

(Keeling and Hurnik, 1993). Keeling and Hurnik (1996) observed that birds ate more during the social facilitation test than the control when no stimulus bird was present. These studies have focused mainly on broilers and feeding behavior, neglecting other socially facilitated behaviours (Olsson et al., 2002; Lundberg, 2002).

Evidence abounds to show the possibility of social facilitation between chicken breeds. Zulkifli et al. (1998) reported a higher percentage of jungle fowl chicks feeding at day four when intermingled with broilers than jungle fowl chicks reared solely, resulting in an increase in their body weight at day seven. However, from day 25 upwards, the jungle fowl chicks displayed high level of feather pecking oriented towards broilers that induced in broilers stress attributed to being pecked (Zulkifli et al., 1998). In another study, intermingling reduced the level of fear in Castellana quail but not in the Black Castellana breed (Campo et al., 2005).

There are evidences that indigenous chickens are more fearful than the commercial strains (Zulkifli et al., 1999; De Marco et al., 2013). Red jungle (*Gallus gallus domesticus*) chickens selected for low level of fear had higher weight, laid larger eggs, produced larger chicks and had better plumage condition (Agnvall et al., 2014). The level of fear (tonic immobility) in birds is affected by both genotype and rearing system (Mugnai et al., 2011), therefore there is a possibility of reducing fear response in birds by rearing different breeds as a mixed-strain. Our hypothesis was that there will be differences in behaviour and fear response in chicks reared in a single-strain group as compared to a mixed-strain group. Hence, this study was undertaken to determine the differences in the behaviour and level of fear of commercial broilers (CB) and Nigerian indigenous chickens and secondly, to determine how the welfare of these chickens could be influenced when reared either as a single-strain or mixed-strain group.

MATERIALS AND METHODS

Experimental Site

This research work was carried out at a Poultry unit in Abeokuta, Ogun state, Nigeria. The location lies on latitude 7°10′N and longitude 3°2′E, 76m above sea level and located in the tropical rain forest vegetation zone with an average temperature of 28.5 °C.

Management of Experimental Birds

The Nigerian indigenous chicks (NIC) were sourced from the hatchery of the Department of Animal Breeding, Federal University of Agriculture Abeokuta. The indigenous chickens were originally gathered from villages around the Federal University of Agriculture about 15 years ago for breeding program in the Animal Breeding Department. Purity of the local chickens was assessed by gross characteristics such as plumage colour, shape and size. The commercial broiler chicks (CB) of the Arbor Acre breed were sourced from Ibadan, Nigeria. The pens (150 cm × 150 cm each) were thoroughly cleaned and disinfected prior to the arrival of the birds.

The chicks were vaccinated against Newcastle disease (Days 9 and 23) and infectious bursal disease (Days 4 and 20). Starter (23% CP and metabolisable energy of 2900 kcal/kg) and grower (20% CP and metabolisable energy of 3000 kcal/kg) diets were provided from day 1 to 21 and day 22 onwards, respectively. Dry wood shavings were spread on the floor of the pen (5cm deep) as litter material. Feed served in plastic feeders and water in bell drinkers were provided to the birds *ad libitum*.

Experimental Procedures

The CB and NIC chicks were kept in separate pens for the first three days. The chicks were leg ringed, weighed on the 4th day and randomly assigned to three treatments namely; single-strain CB (10 birds/pen), single-strain NIC (10 birds/pen) and mixed-strain (5 CB and 5 NIC). Each treatment was replicated three times. Daily feed intake and body weight gain per bird were monitored from the 1st to 4th week of age. To determine the daily feed intake, a known quantity of feed was measured into the feed trough and the left over at the end of the day was subtracted from the feed served. On a weekly basis, each bird per replicate pen was weighed using a sensitive weighing scale. Daily weight gain was derived using the formula: (current week weight-previous week weight)/7.

Behavioural observations were conducted three times per week between the 2nd and 7th week of the experiment. In the morning (09:00–10:00 h), the birds in each replicate pen were scanned at 5 minutes intervals and each bird was classified as performing one of the following behaviours: feeding, drinking, preening, foraging, standing and sitting. Description of these behaviours is presented in Table 1.

Birds were tested for tonic immobility and blood samples collected were assessed for heterophil/lymphocyte ratio at end of the 7th week of age. Two birds per replicate pen were randomly chosen and subjected to tonic immobility test according to the method of Jones (1986) but with some modifications. For birds in the mixed-strain group, two birds from each breed were subjected to tonic immobility test. Tonic immobility was induced by gently restraining the bird on its back on a table for 10 seconds. The observer then retreated approximately 1 m and remained within the sight of the bird but made no unnecessary noise or movement.

Table 1. Definitions of recorded behaviours

Behaviour	Description
Feeding	Bird directs its beak on feed trough and pecks at food
Drinking	Bird direct its beak to water in a bell drinker
Preening	A bird manipulating its feathers with its beak
Foraging	Birds search for food resources in the litter
Standing	Standing on feet without performing any other activity
Sitting	Any position where a bird was on the floor not standing on its feet

Table 2. Effect of breed on the behaviour of domestic chickens

Behaviour category	CB	NIC	SEM
Feeding (%)	45.33[a]	34.89[b]	1.48
Drinking (%)	20.07[a]	14.12[b]	0.76
Preening (%)	7.46[b]	12.47[a]	0.96
Foraging (%)	1.72[b]	5.56[a]	0.94
Sitting (%)	30.07[a]	17.95[b]	1.29
Standing (%)	4.35[b]	15.70[a]	1.87

[ab] means with different letters within row differ significantly at $P < 0.05$. Values are means from the 2nd to 7th week of age. CB = commercial broiler chicken, NIC = Nigerian indigenous chickens.

Table 3. Effect of flock structure on the behaviour of domestic chickens

Behaviour category	Single-strain	Mixed-strain	SEM
Feeding (%)	38.45	41.78	1.48
Drinking (%)	15.77[b]	18.41[a]	0.76
Preening (%)	10.64	9.28	0.96
Foraging (%)	3.67	3.61	0.94
Sitting (%)	24.77	23.25	1.29
Standing (%)	9.55	10.50	1.87

[ab] means with different letters within row differ significantly at $P < 0.05$. Values are means from the 2nd to 7th week of age.

Direct eye contact between the observer and the bird was avoided as this may prolong tonic immobility duration. A stop watch was used to record the latencies until the bird righted itself. If the bird righted itself in <10 seconds, the restraining procedure was repeated. If the bird did not show a righting response over a five-minute period, a maximum score of 300 s was given for righting time.

Few drops of blood samples drawn from the wing vein were used to determine the heterophil to lymphocyte ratio. In this assay, one drop of blood sample was smeared on each of two glass slides. The smears were stained using May-Grünwald and Giemsa stains (Lucas and Jamroz, 1961), approximately 2 to 4 h after preparation with methyl alcohol fixation. One hundred leukocytes, including granular (heterophils, eosinophils and basophils) and non-granular (lymphocytes and monocytes) were counted on each slide and the heterophil to lymphocyte ratio (H:L) was calculated.

Statistical Analyses

The number of birds performing each behavior was converted into percentage before subjecting the data to analysis. Data on behavioural indicators, tonic immobility, H:L ratio and daily weight gain were subjected to General Linear Model (multivariate analysis) having breed (CB or NIC) and flock structure (single-strain or mixed-strain) as fixed factors using SPSS statistical package (version 21). Daily feed intake was analysed using General Linear Model (multivariate analysis) but having only treatment as fixed factor (single-strain CB, single-strain NIC and mixed-strain). Significant means were separated using Duncan Multiple Range Test.

RESULTS

The results showed significant ($P < 0.05$) effect of breed on the behaviour of domestic chickens. Higher percentage of CB were observed feeding ($F_{1,8} = 24.809$, $P = 0.001$), drinking ($F_{1,8} = 7.314$, $P = 0.027$) and sitting ($F_{1,8} = 43.906$, $P = 0.000$) compared to the NIC. On

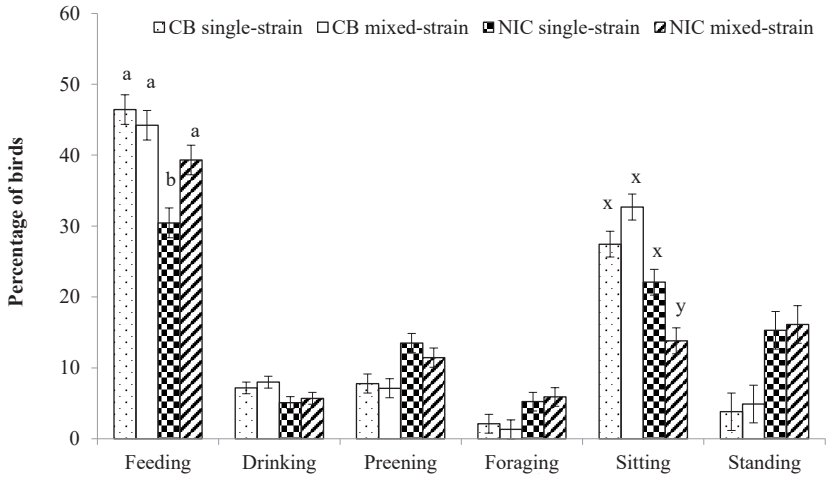

Figure 1. Effect of breed × flock structure interaction on the behavior of domestic chicks. [ab] means with different letters for feeding behaviour differ significantly at $P < 0.05$. [xy] means with different letters for sitting behaviour differ significantly at $P < 0.05$.

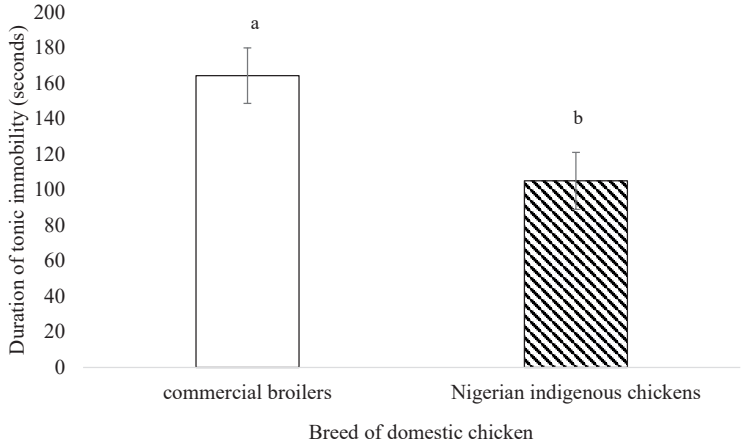

Figure 2. Effect of breed of domestic chicken on the duration of tonic immobility. [ab] means with different letter are significantly different at $P < 0.05$.

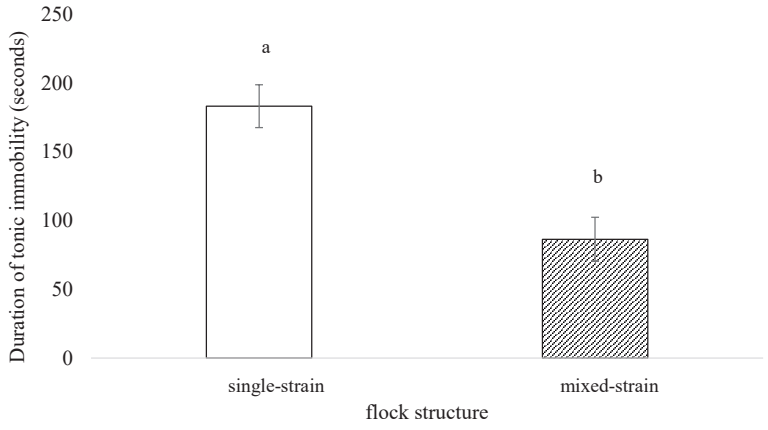

Figure 3. Effect of flock structure on duration of tonic immobility in domestic chickens. [ab] means with different letter are significantly different at $P < 0.05$

Table 4. Effect of breed × flock structure interaction on level of fear and stress of two breeds of domestic chickens

	Sole		Mixed	
	CB	NIC	CB	NIC
Tonic immobility (seconds)	210.22±21.41[a]	156.13±22.71[b]	118.63±22.63[b]	54.13±22.71[c]
H:L	0.42±0.05	0.45±0.05	0.47±0.05	0.51±0.05

[ab] means with different letter for each breed are significantly different at $P < 0.05$, CB = commercial broiler and NIC = Nigerian indigenous chicken

Table 5. Effect of flock structure on the feed intake/bird/day (g) of domestic chickens

Age (week)	Single-strain (CB)	Single-strain (NIC)	Mixed-strain	SEM
1	41.595[a]	25.552[b]	36.629[ab]	3.714
2	66.576[a]	30.833[c]	46.690[b]	1.808
3	78.233[a]	49.524[c]	64.781[b]	3.352
4	93.405[a]	56.986[c]	78.629[b]	3.538

[abc] means with different letters within each row differ significantly at $P < 0.05$. Values are means

Table 6. Effect of breed on the daily body weight gain per bird (g) of domestic chickens

Age (week)	CB	NIC	SEM
1	25.064[a]	11.633[b]	0.845
2	35.888[a]	13.20[b]	2.336
3	27.605[a]	10.433[b]	2.773
4	33.993[a]	15.881[b]	1.607

[ab] means with different letters within each row differ significantly at $P < 0.001$. Values are means

Table 7. Effect of flock structure on daily body weight gain per bird (g) of domestic chickens

Age (week)	Single-strain	Mixed-strain	SEM
1	18.207	18.490	0.845
2	26.169	22.919	2.336
3	21.719	16.319	2.773
4	24.679	25.195	1.607

Table 8. Effect of breed × flock structure interaction on daily body weight gain per bird (g) of domestic chickens

Age (week)	CB		NIC		SEM
	Single-strain	Mixed-strain	Single-strain	Mixed-strain	
1	24.138	25.99	12.276	10.990	1.196
2	37.586	34.190	14.752	11.648	3.304
3	30.571	24.638	12.867	8.000	3.922
4	32.833	35.152	16.524	15.238	2.272

the other hand, higher percentage of NIC displayed preening ($F_{1,8} = 13.710$, $P = 0.006$), foraging ($F_{1,8} = 8.42$, $P = 0.002$) and standing ($F_{1,8} = 13.391$, $P = 0.003$) behaviours compared to the CB (Table 2). There was also a significant ($P < 0.05$) effect of flock structure (FS) on drinking behaviour. The percentage of birds drinking was higher in mixed-strain (T3) compared to single-strain (T1, T2) group (Table 3).

Breed × FS interaction was significant on feeding ($F_{1,8} = 7.000$, $P = 0.029$) and sitting behaviours ($F_{1,8} = 13.635$, $P = 0.006$) Figure 1, higher percentage of the NIC was feeding in the mixed-strain (T3) when compared to the single-strain (T2) group. However, the percentage of NIC sitting was reduced in the mixed-strain (T3) compared to single-strain (T2) flock.

The duration of tonic immobility was longer ($P < 0.05$) in CB than NIC chickens (Figure 2). The duration of tonic immobility was longer ($P < 0.05$) when the birds were reared as single-strain compared to mixed-strain (Figure 3). There was a significant effect of breed × FS interaction ($F_{1,29} = 8.433$, $P = 0.007$) on the duration of tonic immobility such that both the CB and NIC reared as a mixed-strain displayed

lower duration of tonic immobility compared to those reared as single-strain (Table 4). There was no significant effect of breed, FS or their interaction on H:L ratio (Table 4).

At the 1st week, feed intake was higher ($P < 0.05$) in single-strain CB compared to single-strain NIC, while the mixed-strain had intermediate value. However, from the 2nd to the 4th week of age, feed intake was higher ($P < 0.05$) in the single-strain CB compared to the mixed-strain which was in turn greater compared to the single-strain NIC (Table 5).

Although the daily body weight gain was consistently higher in CB compared to NIC from the 1st to the 4th week of age (Table 6), there was neither a significant effect of FS (Table 7) nor breed × FS on weight gain (Table 8).

DISCUSSION

Findings of the present study demonstrated that behavioural characteristics differed between CB and NIC raised in deep litter pen. The increased percentage of CB birds feeding, drinking and sitting could be attributed to their genetic make-up. Broilers have been genetically selected for rapid growth and this has led to an increase in their appetite for food (Siegel and Wisman, 1966) arising from the changes in both the central and peripheral mechanisms controlling hunger (Lacy et al., 1985; Denbow, 1989). The larger proportion of time spent feeding in the CB could be associated with higher weight gain. Consequently, the rapid increase in body weight of CB rendered them extremely inactive and spent 75% of their time sitting/lying down (Bessei, 1992).

On the other hand, the NIC displayed greater levels of preening, foraging and standing behaviours compared to the CB which is in line with reported of Ito et al. (2010) that the time spent preening by Gifu native fowl was greater than that of commercial laying hens under cage system. Despite the fact that the NIC were provided with readily available feed in the feed trough like the CB, it was observed that the NIC displayed less feeding from the trough but were foraging in the litter, a phenomenon known as *contra freeloading* (Osborne, 1977). Larger contra freeloading was observed in red jungle fowl than White Leghorn layers which suggests that jungle fowls have a genetically different feeding strategy (Lindqvist et al., 2002). According to Dawkins (1989), despite *ad libitum* availability of food, red jungle fowl spent a major portion of their time on foraging activities such as ground pecking and scratching which is their natural behaviour.

The increase in the percentage of NIC feeding when reared as a mixed-strain (T3) with the CB, could be attributed to *social facilitation* phenomenon described as an increase in the frequency or intensity of responses when shown in the presence of others engaged in the behavior at the same time (Clayton, 1978). The increased feeding behaviour of the NIC in the mixed-strain did not accrue into an increased weight gain and this probably suggested that the NIC though satiated were motivated to approach the feeder in response to the social facilitation effect of CB feeding but were eating relatively little. This agrees with the report of Keeling and Hurnik (1996) that social facilitation seems to act more on the appetitive phase than consummatory phase of feeding. Increased feeding behaviour in red jungle chicks was accompanied by increased body weight only at the early stage of life (Day 7) but not afterwards (Zulkifli et al., 1998).

The CB chicks in the current study were more fearful compared to NIC. The level of fear can be influenced by the genetic make-up, unpredictable and uncontrollable life experiences, associative learning experiences (Barlow, 2000) and social environment (Clément and Chapouthier, 1998). One interesting finding from the current study was that chickens (CB and NIC) reared as mixed-strain were less fearful compared to their counterparts reared as single-strain which suggests that social interaction between chicken breeds could influence their level of fearfulness. Other studies have reported contrary findings: Rhode Island Red hens were less fearful compared to White Leghorns (Uitdehaag et al., 2008). However, when housed together, the Rhode Island Red hens became more fearful compared to White Leghorn (Uitdehaag et al., 2008). Fear responses by single birds can spread to other group mates (de Haas et al., 2012). A reduction in the level of fear recorded in the current study could serve as an indicator of improved welfare for the chickens according to the definition of animal welfare by FAWC (1992) using the five freedoms, one of which is the freedom from fear and distress. The increased fearfulness in CB was not transferred to the NIC; rather the fear was reduced in the two breeds when reared as a mixed-strain.

Finally, the H:L ratio was used as an indicator of stress (Gross and Siegel, 1983), mixing CB and NIC did not induce any form of stress in either breeds through pecking or transmission of diseases. This result contradicts some previous studies that intermingling commercial and jungle fowl chicks was stressful to the broilers and not the jungle fowl (Zulkifli et al., 1998 and Gvaryahu et al., 1996), as it was observed that the red jungle fowl started pecking the broiler chickens from day 25 upwards. Probably the NIC used in the current study were less aggressive than the red jungle fowls mentioned above because they have been kept under intensive management system for a few years with some unconscious selection for tameness. This suggests that NIC can be reared with CB without having any negative consequence.

CONCLUSIONS

The two breeds of domestic chickens used in this study showed distinct behavioural repertoires. CB displayed optimal levels of feeding, drinking and sitting whereas the NIC exhibited higher levels of preening, foraging and standing. Rearing NIC with CB increased their feeding behaviour but reduced the sitting behavior of the NIC. However, mixing the NIC and CB reduced the level of fear in both breeds thus improving their welfare.

REFERENCES

Adessi E., Visalberghi E. (2001): Social facilitation of eating novel food in tufted capuchin monkeys (*Cebus paella*): input provided by group members and responses affected in the observer. Animal Cognition 4: 297–303.

Agnvall B., Ali A., Olby S., Jensen P. (2014): Red jungle (*Gallus gallus*) selected for low fear of humans are larger, more dominant and produce larger offsprings. Animal 89: 1498–1505.

Baker C. M. A., Manwell C., Jayaprakash N., Francis A. M. (1971): Molecular genetics of avian proteins-X. Eggwhite protein polymorphism of indigenous Indian chickens. Comparative Biochemistry Physiology Part B: Comparative Biochemistry 40: 147–153.

Barber J. C. E. (2001): Social influences on the motivation of laying hens. D. Phil. Thesis, University of Oxford, UK.

Barlow D. H. (2000): Unravelling the mysteries of anxiety and its disorders from the perspective of emotion theory. American Psychologist 55: 1247–1263.

Bessei W. (1992): The behaviour of broilers under intensive management conditions. Archiv für Geflügelkunde 56: 1–7.

Campo J. L., Gil M. G., Davila S. G. (2005): Effect of intermingling chicks and bird density on fear and stress responses in chickens. Archiv für Geflügelkunde 69: 199–205.

Clément Y., Chapouthier G. (1998): Biological bases of anxiety. Neuroscience and Biobehavioral Reviews 22: 623–633.

Clayton D. A. (1978): Socially Facilitated Behavior. The Quarterly Review of Biology 53: 373–392.

Dawkins M. S. (1989): Time budget in red jungle fowl as a baseline for the assessment of welfare in domestic fowl. Applied Animal Behaviour Science 24: 77–80.

de Haas E. N., Kops M. S., Bolhuis E., Groothuis T. G. G., Ellen E. D., Rodenburg T. B. (2012): The relation between fearfulness in young and stress-response in adult laying hens, on individual and group level. Physiology and Behavior 107: 433–439.

De Marco M., Mirò S. M., Tarantola M., Bergagna S., Mellia E., Gennero M. S., Schiavone, A. (2013): Effect of genotype and transport on tonic immobility and heterophil/lymphocyte ratio in two local Italian breeds and ISA Brown hens kept under free-range conditions. Italian Journal of Animal Science 12: 481–485.

Denbow D. M. (1989): Peripheral and central control of food intake. Poultry Science 68: 938–947.

FAWC (1992): Second report on priorities for research and development inf arm animal welfare. Tolworth, UK: MAFF.

Galloway A. T., Addessi E., Fragaszy D. M, Visalberghi E. (2005): Social facilitation of eating familiar food in tufted capuchins (*Cebus apella*): does it involve behavioral coordination? International Journal of Primatology 26: 181–189.

Gross W. B., Siegel H. S. (1983): Evaluation of heterophil/lymphocyte ratio as a measurement of stress in chickens. Avian Diseases 2: 972–979.

Gvaryahu G., Shalev B., Robinzon B., Snapir N. (1996): Intermingling heavy and light strain chickens may cause social stress. Poultry Science 75 :849–851.

Hsia L. C., Wood-Gush D. G. M. (1984): Social facilitation in the feeding behaviour of pigs and the effect of rank. Applied Animal Behaviour Science 11: 265–270.

Ito S., Eguchi Y., Yayou K., Tanaka T. (2010): Behaviour of Gifu native fowl and commercial laying hens under battery cage condition. Journal of Warm Regional Society of Animal Science 53: 75–78.

Jones R. B. (1986): The tonic immobility reaction of the domestic fowl: a review. World's Poultry Science 42: 82–97.

Keeling L. J., Hurnik J. F. (1993): Chickens show socially facilitated feeding behaviour in response to a video image of a conspecific. Applied Animal Behaviour Science 36: 223–231.

Keeling L. J., Hurnik, J. F. (1996): Social facilitation acts more on the appetitive than the consummatory phase of feeding behavior in domestic fowl. Animal Behaviour 52: 11–15.

Kjaer J. B., Mench J. A. (2003): Behaviour problems associated with selection for increased production. In: Poultry Genetics, Breeding and Biotechnology (W. M. Muir and S. E. Aggrey, eds). CAB International, chapter 5, pp. 67–82.

Lacy P. M., Van Krey H. P., Skewes P. A., Denbow D. M. (1985): Effect of intrahepatic glucose infusions on feeding in heavy and light breed chicks. Poultry Science 64: 751–756.

Lindqvist C. E. S., Schutz K. E., Jensen P. (2002): Red jungle fowl have more contra-freeloading than White Leghorn layers: Effect of food deprivation and consequences for information gain. Behaviour 139: 1195–1209.

Lucas A. M., Jamroz C. (1961): Atlas of Avian Hematology. Agriculture Monograph 25. USDA, Washington, DC.

Lundberg A. (2002): Social influences on the behaviour of laying hens: competition during nesting and social facilitation of feeding and dust-bathing. Ph.D. thesis, Swedish University of Agricultural Sciences.

Mugnai C., Dal Bosco A., Moscati L., Battistacci L., Castellini C. (2011): Effect of genotype and husbandry system on blood parameters, oxidative and native immune status: welfare and implications on performance of organic laying hens. Open Veterinary Science Journal 5: 12–18.

Osborne S. R. (1977): The free food (contra-freeloading) phenomenon: A review and analysis. Animal Learning and Behavior 5: 221–235.

Olsson I. A., Duncan I. J. H., Keeling L. J., Widowski T. M. (2002): How important is social facilitation for dustbathing in laying hens? Applied Animal Behaviour Science 79: 285–297.

Price E. O. (1984): Behavioural aspects of animal domestication. The Quarterly Review of Biology 59: 1–32

Siegel P. B., Wisman E. L. (1966): Changes in appetite and feed utilization. Poultry Science 45: 1391–1397.

Tolman C. W. (1964): Social facilitation of feeding behaviour in the domestic chick. Animal Behaviour 1: 245–251.

Uitdehaag K. A., Rodenburg T. B., van Hierden Y. M., Bolhuis J. E., Toscano M. J., Nicol C. J., Komen J. (2008): Effects of mixed housing of birds from two genetic lines of laying hens on open field and manual restraint responses. Behavioural Processes 79: 13–18.

Voelkl B., Schrauf C., Huber L. (2006): Social contact influences the response of infant marmosets towards novel food. Animal Behaviour 72: 365–372.

Weeks C. A., Danbury T. D., Davies H. C., Hunt P., Kestin S. C. (2000): The behaviour of broiler chickens and its modification by lameness. Applied Animal Behaviour Science 67: 111–125.

Zajonc R. B. (1965): Social facilitation. Science 149: 269–274.

Zentall T. R., Hogan D. E. (1976): Imitation and social facilitation in the pigeon. Animal Learning and Behaviour 4: 427–430.

Zulkifli I., Babjee S. A., Vidyadaran M. K., Ramlah A. H. (1998): Relationship among growth, behaviour and stress response in broilers and red jungle fowl when reared separately or intermingled. Archiv für Geflügelkunde 62: 150–155.

Zulkifli I., Dass R. T., Che Norma M. T. (1999): Acute heat stress effects on physiology and fear related behavior in Red jungle fowl and domestic fowl. Canadian Journal of Animal Science 79: 165–170.

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