Research Note

Effects of stocking density on growth performance, carcass traits, and foot pad lesions of White Pekin ducks

M. Xie, Y. Jiang, J. Tang, Z. G. Wen, W. Huang, and S. S. Hou[1]

Institute of Animal Sciences, Chinese Academy of Agricultural Sciences, Beijing, China 100193

ABSTRACT Two experiments were conducted to study the effects of stocking density on growth performance, carcass yield, and foot pad lesions of White Pekin ducks from hatch to 14 d of age (experiment 1) and from 14 to 42 d of age (experiment 2), respectively. All ducks were reared in raised plastic wire-floor pens with a pen size of 30 m^2, and males and females were mixed at a ratio of 1:1 in each pen of both experiments. In experiment 1, a total of 10,200 ducks that were 1 d old were allotted to 20 pens according to the stocking densities of 13, 15, 17, 19, and 21 birds/m^2 (or 8.4, 9.7, 10.9, 11.9, and 13.0 kg of actually achieved BW/m^2), respectively, with 4 replicates per treatment. In experiment 2, a total of 3,150 ducks that were 14 d old were allotted to 15 pens according to the stocking densities of 5, 6, 7, 8, and 9 birds/m^2 (or 17.0, 20.3, 23.6, 26.9, and 29.9 kg of actually achieved BW/m^2), respectively, with 3 replicates per treatment. The stocking density had significant effects on final BW and weight gain of starter and growing ducks ($P < 0.05$), but not on feed/gain and mortality in both periods ($P > 0.05$). The final BW and weight gain of starter and growing ducks all decreased with increasing density ($P < 0.05$). Final BW and weight gain of starter ducks were reduced significantly as stocking density increased from 17 to 21 birds/m^2 ($P < 0.05$). In addition, final BW and weight gain of growing ducks decreased significantly when stocking density was 9 birds/m^2 ($P < 0.05$). On the other hand, increasing stocking density did not markedly influence the carcass, breast meat, leg meat, abdominal fat, and foot pad lesions of growing ducks ($P > 0.05$).

Key words: duck, stocking density, growth performance, carcass yield, foot pad lesion

2014 Poultry Science 93:1644–1648
http://dx.doi.org/10.3382/ps.2013-03741

INTRODUCTION

Stocking density is critical for poultry production and welfare. Higher economic returns can be obtained as the number of birds per unit of space increases, but economic profit may come at the cost of reduced bird performance, health, and welfare if densities are excessive. The effects of high stocking density on broilers was reviewed by Estevez (2007), and these negative consequences included reduced final BW, feed intake, and feed conversion, and greater incidence of foot pad dermatitis, scratches, bruising, poorer feathering, and condemnations. At present, duck production has been changed from conventional free range and open water outdoors to confinement in birdhouses. Duck houses mainly use water nipple lines, and the prevalent floor types are solid floors with wood shavings and raised wire floors, which is largely different from conventional duck production outdoors. Compared with the conventional duck production outdoors, the much higher stocking density is used in duck houses and thus the problems caused by high stocking density may take place in this situation. However, until now, the information on the stocking density for duck production is still very limited. Osman (1993) found that male Pekin ducks showed optimum live weight gain at 8 birds/m^2 until 4 wk old and at 4 birds/m^2 until slaughter at 10 wk old irrespective of floor pens or cages. In his study, the breast and leg meat yield also decreased when stocking density increased to 8 birds/m^2. Baeza et al. (2003) studied the effects of stocking density (7, 9, and 11 male ducks/m^2) on behavior, welfare, performance, and carcass quality in Muscovy ducks and found that the stocking density of 9 birds/m^2 gave the best results for all criteria. In the review of Rodenburg et al. (2005), the maximum stocking densities at the end of the fattening period were provided for Muscovy, mule, and Pekin ducks, respectively, but the stocking densities for starter period were missing. As genetic selection of duck developed continuously, the modern ducks may have a faster growth rate and higher carcass yield than before. Thus, stocking density may affect modern ducks differently. However, the information on the stocking density has not been renewed. Whether in broilers or ducks, the stocking density was investigated usually by

Received November 7, 2013.
Accepted March 26, 2014.
[1]Corresponding author: houss@263.net

small-scale experiments. However, when these conclusions from small-scale experimental study were extrapolated to commercial practice, one should be cautious because much larger group sizes and pen sizes were usually used in commercial poultry production. Therefore, large-scale pens with a pen size of 30 m^2 were used in our study and the objective of our study was to investigate the effects of different stocking densities on growth performance, carcass yield, and foot pad lesions of White Pekin ducks.

MATERIALS AND METHODS

All procedures of our experiments were approved by the animal care and use committee of the Institute of Animal Sciences of the Chinese Academy of Agricultural Sciences. Two experiments with 5 stocking densities were conducted in experiment 1 and 2, respectively. In both experiments, all ducks were reared in raised plastic wire-floor pens with pen size of 30 m^2.

In experiment 1, a total of 10,200 mixed-sex 1-d-old White Pekin ducks from one commercial hatchery were allotted to 20 plastic wire-floor pens with a female/male ratio of 1:1 according to the stocking densities of 13, 15, 17, 19, and 21 birds/m^2, respectively (namely, 390, 450, 510, 570, and 630 birds/pen, respectively). Each stocking density treatment had 4 replications, which were balanced for average initial BW. All these ducks were reared with starter diets (Table 1) from hatch to 14 d of age.

In experiment 2, a total of 5,000 mixed-sex 1-d-old White Pekin ducks from one commercial hatchery were raised at 16 birds/m^2 in raised plastic wire-floor pens with starter diets (Table 1) from hatch to 14 d of age. At 14 d of age, after removal of the ducks with smallest and largest BW and the birds with leg problems, the remaining 3,150 birds were allotted to 15 plastic wire-floor pens with a female/male ratio of 1:1 according to the stocking densities of 5, 6, 7, 8, and 9 birds/m^2, respectively (namely, 150, 180, 210, 240, and 270 birds/pen, respectively). Each stocking density treatment had 4 replications, which were balanced for average initial BW. All these ducks were reared with grower diets (Table 1) from 14 to 42 d of age.

In both experiments, all ducks had free access to water and feed. Water was provided by drip-nipple water supply lines (6.5–10.5 birds/nipple for experiment 1 and 2.5–4.5 birds/nipple for experiment 2) and pelleted feeds were provided in feed troughs on the one side of each pen (1.0–1.6 cm/bird for experiment 1 and 2.3–4.2 cm/bird for experiment 2). In the birdhouse, lighting was continuous and the temperature was kept at 33°C from 1 to 3 d of age and then it was reduced gradually to approximately 25°C until 14 d of age and was kept at approximately 16 to 22°C thereafter. The birdhouse was ventilated by exhaust fans and the temperature control was achieved through a central hot water heating system. Every day, the litter under the wire-floor pens was removed by scraper machines. During the experimental period, the mortalities and BW of dead birds within each pen were recorded daily.

At the end of both experiments, the final BW, weight gain, feed intake, and total mortality from each pen were measured and feed intake and feed/gain were corrected for mortality. In experiment 2, at 42 d of age, after 12 h of feed deprivation, 10 ducks were randomly selected from each pen and were stunned electrically and then killed immediately by neck cut and eviscerated manually. The abdominal fat, breast meat (including pectoralis major and pectoralis minor), and leg meat (including thigh and drum stick) were all removed manually from carcasses and weighed and the percentages relative to the carcass weight were also calculated. Breast and leg meat were all skinless and boneless. The foot pad lesions of each of the aforementioned 10 birds selected from each pen were scored using a 3-point scales described by Zhu et al. (2012): 0 = no lesion; 1 = lesion does not extend over entire plantar pad; and 2 = greater surface beyond the entire plantar pad is affected, sometimes with lesions on toes.

Data were analyzed by one-way ANOVA procedure of SAS software (SAS Institute Inc., 2003), with pen used as the experimental unit for analysis. When density treatment was significant ($P < 0.05$), the means were compared using Tukey's multiple comparison procedure of SAS software (SAS Institute Inc., 2003).

Table 1. Composition of starter and growing diets in experiment 1 and 2 (%, as fed)

Item	Starter (0 to 14 d)	Grower (14 to 42 d)
Ingredient		
Corn	63.00	68.55
Soybean meal	33.00	27.40
Dicalcium phosphate	1.50	1.50
Calcium carbonate	1.00	1.00
Sodium chloride	0.30	0.30
Vitamin and mineral premix[1]	1.00	1.00
DL-Methionine	0.13	0.11
L-Lysine·HCl	0.07	0.14
Calculated composition		
ME,[2] kcal/kg	2,817	2,865
CP	20.0	18.0
Calcium	0.83	0.81
Nonphytate phosphorus	0.39	0.39
Methionine	0.45	0.40
Cysteine	0.35	0.32
Lysine	1.08	1.00

[1]Supplied per kilogram of total diet: Cu ($CuSO_4·5H_2O$), 10 mg; Fe ($FeSO_4·7H_2O$), 60 mg; Zn (ZnO), 60 mg; Mn ($MnSO_4·H_2O$), 80 mg; Se ($NaSeO_3$), 0.3 mg; I (KI), 0.2 mg; choline chloride, 1,000 mg; vitamin A (retinyl acetate), 10,000 IU; vitamin D_3 (cholcalciferol), 3,000 IU; vitamin E (DL-α-tocopheryl acetate), 20 IU; vitamin K_3 (menadione sodium bisulfate), 2 mg; thiamine (thiamine mononitrate), 2 mg; riboflavin, 8 mg; pyridoxine hydrochloride, 4 mg; cobalamin, 0.02 mg; calcium-D-pantothenate, 20 mg; nicotinic acid, 50 mg; folic acid, 1 mg; biotin, 0.2 mg.

[2]The values are calculated according to the AME of chickens.

RESULTS AND DISCUSSION

In our study, the increasing stocking density did not significantly affect total mortality of ducks from hatch-

Table 2. Effects of stocking density on growth performance of Pekin ducks from hatch to 14 d of age[1]

Stocking density[2]						
Birds/m^2	kg/m^2	Final BW (g/bird)	Weight gain (g/bird per d)	Feed intake (g/bird per d)	Feed/gain (g/g)	Mortality (%)
13	8.4	643.7^{a}	42.3^{a}	59.5^{a}	1.41	0.45
15	9.7	644.1^{a}	42.4^{a}	59.6^{a}	1.41	0.28
17	10.9	643.0^{a}	42.2^{a}	60.2^{a}	1.43	0.40
19	11.9	626.7^{ab}	41.1^{ab}	59.5^{a}	1.45	0.48
21	13.0	616.9^{b}	40.4^{b}	57.9^{b}	1.43	0.32
Pooled SEM		3.3	0.2	0.3	0.01	0.06
Probability		0.0051	0.0055	0.0437	0.1326	0.8535

[a,b]Means with different superscripts within the same column differ significantly ($P < 0.05$).

[1]Results are means of 4 replicates.

[2]Stocking densities are also expressed as actually achieved BW per meter^2 according to the final BW of ducks at 14 d of age.

ing to 14 d of age or from 14 to 42 d of age ($P > 0.05$, Tables 2 and 3) and similar results were also observed in starter or growing broilers (Thomas et al., 2004; Dozier et al., 2005, 2006; Buijs et al., 2009; Simsek et al., 2011), which showed that the dead birds during the experimental period could not markedly affect the accuracy of our results. When stocking densities were transferred from birds per meter^2 to actually achieved BW per meter^2 according to the final BW of ducks at 14 or 42 d of age, the stocking densities of ducks in present study were 8.4, 9.7, 10.9, 11.9, and 13.0 kg/m^2 for the starter period and 17.0, 20.3, 23.6, 26.9, and 29.9 kg/m^2 for the growing period, respectively. In Europe, the maximum density of Pekin ducks at the end of the fattening period ranged from 6 to 8 birds/m^2 or from 20 to 25 kg of BW/m^2 (Rodenburg et al., 2005). According to the minimum floor area for Pekin ducks raised in total confinement, the recommendation of FASS (2010) for the stocking densities at 1, 2, 3, 4, 5, 6, and 7-wk-old Pekin ducks in wire-floor pens were 43.1, 22.8, 15.4, 10.3, 8.4, 7.1, and 6.2 birds/m^2, respectively. The above ranges of stocking densities were covered in our study and the validity of these data was tested partially by our study.

In our study, increasing stocking density had a negative effect on growth performance of starter and growing Pekin ducks. For ducks fed either from hatch to 14 d of age or from 14 to 42 d of age, the final BW and weight gain all decreased ($P < 0.05$) when stocking density was too high (Tables 2 and 3). For ducks fed from hatch to 14 d of age, the final BW and weight gain were both reduced significantly as stocking density increased from 17 to 21 birds/m^2 ($P < 0.05$). The final BW and weight gain of ducks fed from 14 to 42 d of age were decreased significantly when stocking density was 9 birds/m^2 ($P < 0.05$). According to these changes of growth rate, the maximum stocking densities for ducks from hatch to 14 d of age and from 14 to 42 d of age should not exceed 19 and 8 birds/m^2 (11.9 and 26.9 kg of actually achieved BW/m^2), respectively. Our results for the starter period were lower than the recommendation of FASS (2010) for the stocking densities of 2-wk-old Pekin ducks in wire-floor pens (22.8 birds/ m^2), but our results for growing period were similar to the recommendation of FASS (2010) for the stocking densities of 6-wk-old Pekin ducks in wire-floor pens (8.4 birds/ m^2) and the maximum density of Pekin ducks (8 birds/m^2) at the end of the fattening period reviewed by Rodenburg et al. (2005). However, the maximum stocking densities for ducks estimated by us were much higher than the data provided by Osman (1993). In his study, male Pekin ducks showed optimum live weight gain was at 8 birds/m^2 until 4 wk old and 4 birds/m^2 until slaughter at 10 wk old irrespective of floor pens or cages. The reason for these differences between his results and ours may be that the stocking density of

Table 3. Effects of stocking density on growth performance of Pekin ducks from 14 to 42 d of age[1]

Stocking density[2]						
Birds/m^2	kg/m^2	Final BW (g/bird)	Weight gain (g/bird per d)	Feed intake (g/bird per d)	Feed/gain (g/g)	Mortality (%)
5	17.0	3,406.6^{a}	102.6^{a}	230.8	2.25	2.67
6	20.3	3,385.0^{ab}	101.7^{ab}	228.5	2.25	2.78
7	23.6	3,375.2^{ab}	101.3^{ab}	229.7	2.27	2.22
8	26.9	3,361.7^{ab}	100.8^{ab}	231.0	2.29	2.81
9	29.9	3,322.4^{b}	99.4^{b}	230.4	2.31	3.58
Pooled SEM		9.1	0.3	1.6	0.02	0.38
Probability		0.0286	0.0175	0.9919	0.6918	0.9075

[a,b]Means with different superscripts within the same column differ significantly ($P < 0.05$).

[1]Results are means of 3 replicates.

[2]Stocking densities are also expressed as actually achieved BW per meter^2 according to the final BW of ducks at 42 d of age.

4 birds/m^2 was not included in our study and fewer ducks (80 birds for floor pens and 160 birds for cages) were used in his study compared with our study.

In present study, high stocking density only reduced feed intake of starter ducks ($P < 0.05$) but not for growing ducks (Tables 2 and 3), which was partly in agreement with the results of Osman (1993) and Baeza et al. (2003) in which the reduction of feed intake was observed at high stocking density for Muscovy duck in the finisher period and Pekin ducks in the whole period. On the other hand, increasing stocking density had no effects on feed/gain of ducks during either period ($P > 0.05$, Tables 2 and 3). Our results were similar to those of Baeza et al. (2003), but were different from the results of Osman (1993) who observed that the feed/gain decreased significantly as stocking density increased. In our study, the effects of stocking density on growth performance of starter and growing ducks were examined separately, but the previous studies dealt with the whole rearing period, which may be the reason for the difference between our results and previous studies.

On the other hand, increasing stocking density did not significantly influence the yield of carcass, breast meat, leg meat, and abdominal fat ($P > 0.05$, Table 4), which was different from the results of Osman (1993) in which the breast meat yield of Pekin ducks decreased as stocking density increased irrespective of floor pens or cages. Such nonsignificant effects of stocking density on meat yield of carcass were also observed in Muscovy ducks (Baeza et al., 2003) and broilers (Thomas et al., 2004; Dozier et al., 2005; Simsek et al., 2011; Zuowei et al., 2011).

In our study, the foot pad lesions of ducks were not affected significantly by stocking density ($P > 0.05$, Table 4), which was different from the results in broilers in which the foot pad lesion scores increased as stocking density increased (Thomas et al., 2004; Dozier et al., 2005, 2006; Buijs et al., 2009; Zuowei et al., 2011). In broilers, the foot pad dermatitis is mainly caused by the fact that higher density leads to dirtier and wetter litter, which in turn causes dermatitis. However, this link did not exist in our study because no litter was present in wire-floor pens, which may explain the nonsignificant effects of stocking density on foot pad lesions of ducks raised on wire-floor pens. In present study, the foot pad lesions were scored using a 3-point scales and a higher score indicated a more severe foot pad lesion. When stocking density was 6 ducks/m^2 and above, the foot pad lesion scores of ducks were all above 1 (Table 4). On the scale of 0 to 2, the average score of the pens would be above 1 if most of the ducks in the pen had mediocre foot pads or if half of the ducks had very good foot pads and the other half had very poor foot pads. Therefore, the average foot pad lesion score of 1 and above may indicate that the management practice for duck production in wire floor pens in our study still needed to be improved further from the point of view of bird welfare.

In the present study, the reasons for duck growth depression caused by high stocking density may be associated with the decreased feeding and drinking space at high density because the numbers of drinkers and feeder were the same at all stocking densities, but the bird numbers increased as stocking density increased in our study. The decreasing feeding and drinking space may influence the eating and drinking behaviors of ducks and then the feed intake and growth rate were affected by them, which was supported by significant and simultaneous reduction of feed intake, final BW, and weight gain of starter ducks at high stocking density of 21 birds/m^2 (Table 2). However, in the growing period, the significant reduction of final BW, and weight gain of ducks at high stocking density did not accompany the simultaneous change of feed intake because the feed intake during this period was not influenced by stocking density ($P > 0.05$, Table 3). At present, it is still very difficult to explain the reasons for the growth depression of poultry associated with stocking density from the point of eating and drinking behavior. In early years, stocking density was reported to adversely affect the behaviors of chicks. In broilers, Beilmann et al. (2005) found a significant inverse correlation between stocking density and number of eating or drinking events per bird. In hens, as stocking density increased, drinking behavior decreased significantly and more unsuccessful

Table 4. Effects of stocking density on carcass yield and foot pad lesion score of Pekin ducks at 42 d of age[1]

Stocking density[2]						
Birds/m^2	kg/m^2	Carcass[3] (%)	Breast meat[4] (%)	Leg meat[4] (%)	Abdominal fat[4] (%)	Foot pad lesion score
5	17.0	76.2	13.6	10.6	1.14	0.83
6	20.3	75.5	13.7	10.5	1.14	1.20
7	23.6	76.3	13.6	10.4	1.20	1.06
8	26.9	75.9	13.6	10.3	1.25	1.04
9	29.9	75.0	13.4	10.6	1.23	1.08
Pooled SEM		0.2	0.1	0.1	0.04	0.06
Probability		0.3598	0.9671	0.4809	0.8218	0.5272

[1]Results are means of 3 replicates of 10 birds each.

[2]Stocking densities are also expressed as actually achieved BW per meter^2 according to the final BW of ducks at 42 d of age.

[3]Calculated as a percentage of live BW.

[4]Calculated as a percentage of carcass weight.

attempts to reach the feeder occurred at high stocking density (Albentosa et al., 2007). However, at present, Iyasere et al. (2012) and Son (2013) found that the eating and drinking behaviors of broilers were not influenced significantly by stocking density, and the feeding behavior of 7-wk-old broilers even increased significantly at high stocking density in the study of Iyasere et al. (2012). In addition, Feddes et al. (2002) found that the feed and water consumption of broilers both increased significantly as stocking density increased and water nipple density had no effect on broiler performance or carcass quality. Therefore, additional research in feeding behavior at different stocking densities needs to be conducted in the future in broilers or ducks.

In conclusion, high stocking density could cause growth depression of White Pekin ducks but did not affect carcass yield or foot pad lesions. Under our experimental conditions, to avoid growth depression, the maximum stocking densities from hatch to 14 d of age and from 14 to 42 d of age should not exceed 19 and 8 birds/m^2 (or 11.9 and 26.9 kg of actually achieved BW/m^2), respectively.

ACKNOWLEDGMENTS

Our research was sponsored by National Scientific and Technical Supporting Program (2012BAD39B04, Beijing, China) and Agricultural Science and Technology Innovation Program (ASTIP-IAS09, Beijing, China), and we thank Inner Mongolia Saifeiya Agricultural Science and Technology Development Co., Ltd (Chifeng, China) for provision of White Pekin ducks and duck houses.

REFERENCES

Albentosa, M. J., J. J. Cooper, T. Luddem, S. E. Redgate, H. A. Elson, and A. W. Walker. 2007. Evaluation of the effects of cage height and stocking density on the behaviour of laying hens in furnished cages. Br. Poult. Sci. 48:1–11.

Baeza, E., P. Chartrin, and C. Arnould. 2003. Effects of stocking density on welfare, growth performance and carcass quality in Muscovy ducks. Sci. Tech. Avi. 45:4–8.

Beilmann, T., J. Thaxton, W. Dozier III, W. Roush, D. Miles, B. Lott, and Y. Vizzier-Thaxton. 2005. Evaluation of stocking density on eating and drinking behavior of broilers. Poult. Sci. 84(Suppl. 1):100. (Abstr.)

Buijs, S., L. Keeling, S. Rettenbacher, E. Van Poucke, and F. A. M. Tuyttens. 2009. Stocking density effects on broiler welfare: Identifying sensitive ranges for different indicators. Poult. Sci. 88:1536–1543.

Dozier, W. A. III, J. P. Thaxton, S. L. Branton, G. W. Morgan, D. M. Miles, W. B. Roush, B. D. Lott, and Y. Vizzier-Thaxton. 2005. Stocking density effects on growth performance and processing yields of heavy broilers. Poult. Sci. 84:1332–1338.

Dozier, W. A. III, J. P. Thaxton, J. L. Purswell, H. A. Olanrewaju, S. L. Branton, and W. B. Roush. 2006. Stocking density effects on male broilers grown to 1.8 kilograms of body weight. Poult. Sci. 85:344–351.

Estevez, I. 2007. Density allowances for broilers: Where to set the line. Poult. Sci. 86:1265–1272.

FASS (Federation of Animal Science Societies). 2010. Guide for the care and use of animals in agricultural research and teaching. 3rd rev. ed. Fed. Anim. Sci. Soc., Champaign, IL.

Feddes, J. J. R., E. J. Emmanuel, and M. J. Zuidhof. 2002. Broiler performance, body weight variance, feed and water intake, and carcass quality at different stocking densities. Poult. Sci. 81:774–779.

Iyasere, O. S., J. O. Daramola, M. N. Bemji, O. O. Adeleye, R. A. Sobayo, E. Iyasere, and O. M. Onagbesan. 2012. Effects of stocking density and air velocity on behaviour and performance of Anak broiler chickens in South-Western Nigeria. Int. J. Appl. Anim. Sci. 1:52–56.

Osman, A. M. A. 1993. Effect of stocking rate on growth performance, carcass traits and meat quality of male Peking ducks. J. Agric. Rural. Dev. Trop. 94:147–156.

Rodenburg, T. B., M. B. M. Bracke, J. Berk, J. Cooper, J. M. Faure, D. Guémené, G. Guy, A. Harlander, T. Jones, U. Knierim, K. Kuhnt, H. Pingel, K. Reiter, J. Servière, and M. A. W. Ruis. 2005. Welfare of ducks in European duck husbandry systems. World's Poult. Sci. J. 61:633–646.

SAS Institute Inc. 2003. SAS User's Guide: Statistics. Version 9.0. SAS Institute Inc., Cary, NC.

Simsek, U. G., M. Ciftci, I. H. Cerci, M. Bayraktar, B. Dalkilic, O. Arslan, and T. A. Balci. 2011. Impact of stocking density and feeding regimen on broilers: Performance, carcass traits and bone mineralization. J. Appl. Anim. Res. 39:230–233.

Son, J. H. 2013. The effect of stocking density on the behaviour and welfare indexes of broiler chickens. J. Agric. Sci. Technol. 3:307–311.

Thomas, D. G., V. Ravindran, D. V. Thomas, B. J. Camden, Y. H. Cottam, P. C. H. Morel, and C. J. Cook. 2004. Influence of stocking density on the performance, carcass characteristics, and selected welfare indicators of broiler chickens. N. Z. Vet. J. 52:76–81.

Zhu, Y. W., M. Xie, W. Huang, L. Yang, and S. S. Hou. 2012. Effects of biotin on growth performance and foot pad dermatitis of starter White Pekin ducklings. Br. Poult. Sci. 53:646–650.

Zuowei, S., L. Yan, L. Yuan, H. Jiao, Z. Song, Y. Guo, and H. Lin. 2011. Stocking density affects the growth performance of broilers in a sex-dependent fashion. Poult. Sci. 90:1406–1415.