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# STOCKING DENSITY EFFECTS ON PERFORMANCE AND PHYSIOLOGICAL CHANGES OF LAYING JAPANESE QUAIL

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## ABSTRACT

The current study was conducted to examine the effects of different cage stocking densities and sex on performance and physiological changes of laying Japanese quail reared under hot climate region for a period of 11 weeks (10 to 21 weeks of age). A total number of 600 Japanese quails (400 females and 200 males) at 10 weeks old were randomly distributed in a randomized block design with 4 treatments (71, 59, 50 and 43 quail per cage) or (140, 170, 200 and 233 $cm^2$/ bird) respectively. Each treatment group was represented by 3 replicates. During the experimental period all birds received 16 hrs of light and 8 hrs of dark. Results indicated that quails kept at low stocking density (233$cm^2$/ bird) recorded significantly ($P \leq 0.05$) higher live body weight, egg production, egg mass, feed intake, protein and energy intakes compared with quails kept at other stocking densities. Further, egg weight was not significantly affected by the experimental treatments. However, feed conversion ratio and mortality rate were progressively reduced ($P \leq 0.05$) with decreasing stocking density. There were significant reductions in plasma total protein fractions by lowering stocking density. Whereas, a significant increase in total lipids, cholesterol, ALT, plasma total calcium and phosphorous with increasing stocking density. While, insignificant differences were observed for HDL, LDL and AST. The results clearly indicated that decreasing stocking density was significantly ($P \leq 0.05$) decreased corticosterone level. While, IGg increased significantly ($P \leq 0.05$) due to decreasing stocking density, thus leading to increased susceptibility to resistance of infections. Other physiological traits (i.e., respiration rate, cloacal temperature, skin temperature and heart pulse rate) recorded higher values for quails kept at high stocking density (140$cm^2$/ bird) compared with those stocked at low stocking densities. On the other hands, sex had no effect on these traits. Traits of egg quality showed insignificant differences for the most, except for yolk index, shell thickness, yolk color and eggs with blood or meat spots. Also, insignificant differences were observed for all carcass characteristics except for live body weight, blood weight and carcass weight percentages. In conclusion based on the obtained results it could be concluded that egg production percentage, egg mass and immunological response improved as the cage space per quail increased. Therefore, it can be recommended that in order to minimize physiological stress in the cages of laying Japanese quail should raised at a density of 233 $cm^2$/bird to exhibited superior performance and lowering mortality rate.

**Keywords:** (Japanese quails, stocking density, blood constituents and immunological response).

## INTRODUCTION

It's well known that Japanese quails have been reared for obtaining egg and meat all over the world. Also quails production is a good alternative for animal protein production, because housing costs are not so high. Indeed quails have smaller body weight and space requirements are small. In addition to, less waste is produced as compared with other conventional livestock projects, and thus it is not so detrimental to the environment (Faitarone *et al., 2005)*. Laying hens todays are primarily housed in battery cages (also called conventional cages). Furthermore, battery cages provide some benefits to the hens such as maintaining a small stable group size, resulting in a low level of aggression and cannibalism, high egg production and hygienic (Vist *et al., 2005)*. However, Vanhonacker *et al. (2008)* indicated that stocking density considered as a top priority for animal welfare and are concerned with the stocking density used in commercial livestock production. The cage density required for optimal egg production by various avian species and varieties is highly variable (Nahashon *et al., 2006)*. There have been considerable efforts in evaluating the effect of cage density on hen performance (Hester *et al., 1996a)*. Increased density and group size were expected to increase conflicts between the birds, leading to an increase in stress, which would be expressed psychologically by increased fearfulness and physiologically by higher glucocorticoid levels and decreased bursa weight (Ravindran *et al., 2006)*. Even so, little is known of the required cage density for optimum performance of the laying Japanese quails. However Ozbey *et al., (2004)* indicated that increasing placement density of Japanese quails resulted in decrease of egg production, egg weight and egg shell thickness. Bhanja *et al., (2006)* reported that body weight of laying Japanese quails at 6 to 20 weeks of age increased with the increase cage floor space to 210 $cm^2$/ bird compared with those maintained at 100, 150 and 180 $cm^2$/ bird. However, quails placed with 210 $cm^2$/ bird cage floor space reached 50% egg production at a significantly ($P \leq 0.01$) earlier age (54 days). They added that the first phase egg production ($7^{th}$ -$13^{th}$ week) was significantly higher ($P \leq 0.05$) in birds kept at large cage floor space and such trend was also observed in the second phase (14 -20 weeks). The average egg weight and feed conversion ratio per Kg of egg produced was better ($P \leq 0.01$) for quails stocked at 210$cm^2$/bird. *Abdel-Azeem* (2010) indicated that mortality rate was significantly lower when quails kept at 77 bird/$m^2$ compared with those kept at 100 and 143 bird/$m^2$. Considerable research has focused on the effect of cage density on the performance of laying chickens, but little researches have focused on layer Japanese quails. Therefore, the main purpose of the present study was to investigate the effect of different cage stocking densities on production and physiological parameters of laying Japanese quails.

## MATERIALS AND METHODS

**Location and the aim of the experiment:** This experiment was carried out at the Experimental Poultry Research Station belonging to the Faculty of Agriculture, Al-Azhar University, Nasr City, Cairo, Egypt. The experimental period lasted 11 weeks of age. The main target of this study was to investigate the effects of stocking densities and sex on laying performance, some physiological traits, some blood constituents and immunological response, egg quality traits and carcass characteristics of Japanese quail reared under the hot climate region.

**Birds management and experimental design:** The experiment was conducted on 600 Japanese quails (400 females and 200 males) at 10 weeks of age, which were housed in naturally ventilated house 5 × 3m$^2$ equipped with laying cages. The birds were randomly assigned to laying cages (143 × 70 × 30cm$^2$) at densities of 71, 59, 50 and 43 quails per cage equivalent to cage-space allowances of 140, 170, 200 and 233 cm$^2$/bird respectively. Each treatment was represented by three replicates. Quails were weighed individually at the beginning of experiment with keeping approximately similar initial live body weight. All birds were reared under similar managerial and hygienic conditions. The batteries were provided with tube feeders and drinker equipments, which hanging on the outside part of batteries. Temperature degree and humidity percentage were recorded daily through the experiment and were ranged between 33.6°C to 37 °C and 75 to 80 % respectively as average. The laying quails were fed *ad-libitum* on a basal commercial diet containing 20.0% CP and 2900.0 ME Kcal / Kg from start of the experiment until the end based on the requirements of laying Japanese quail outlined in NRC (1994). Diet specifications and composition analysis are given Table (1). A photoschedual program of (16 hrs L vs. 8 hrs D) was used along the duration of experiment. In order to adjusting and correct stocking density along the laying experiment and to investigate the effect of stocking density on mortality rate, where the stocking density changed due to mortality occurred during the experiment, out group was formed to provided the same stocking density during the experimental time.

**Table (1): Formulation and diet composition of laying Japanese quail.**

| Ingredients | % |
|---|---|
| Ground yellow corn (8.5%). | 59.90 |
| Soybean meal (44.0%). | 21.90 |
| Wheat bran (15.7%). | 01.78 |
| Layer concentrates (50.0%)* | 10.00 |
| Calcium carbonate ($CaCO_3$). | 04.46 |
| Sodium chloride (NaCl). | 00.20 |
| Sun flower oil. | 01.40 |
| Pre-mix** | 00.30 |
| Lysine-Hcl | 0.06 |
| Total (Kg) | 100.00 |
| Calculated diet composition: | |
| Crude protein %. | 20.01 |
| Metabolizable energy (Kcal ME/Kg). | 2903 |
| Lysine %. | 01.04 |
| Methionine + Cystine%. | 00.74 |
| Calcium %. | 02.50 |
| Available phosphorus %. | 00.37 |
| Analyzed: | |
| Crude protein%. | 19.05 |

*Layer concentrate contains: CP 50%, CF 1.6%, Ca 8.30%, Available phosphorus 3.10%,Methionine 1.4%, Methionine +Cystine 2.3%,Lysine 2.3%, Sodium 1.76%, and ME 2580 Kcal/Kg .

**The premix (Vit& Min) was added at a rate of 3kg per ton of diet and supplied as following (as mg or I.U. per kg of diet): Vit A 12000 I.U., Vit D3 2000 I.U., Vit E 40 mg, Vit. K 34 mg, Vit. B I 3 mg, Vit. B2 6 mg, Vit. B6 4 mg, Vit. B12 0.03 mg, Niacin 30 mg, Biotin 0.08, mg, Pantothenic acid 12 mg , Folic acid 1.5 mg, Choline chloride 700 mg, Mn 80 mg , Cu 10 mg, Se. 0.2 mg, Fe 40 mg, Zn 70 mg and Co . 0.25mg.

**Data collection:** Experimental birds were observed for hen-day egg production, egg weight, egg mass, feed intake, protein intake, energy intake, feed conversion ratio for eggs (Kg feed /Kg egg produced) and mortality rate. For collection blood samples at the end of experiment, quails were fasted for 16 hrs and blood samples were taken from 6 birds (3 females and 3 males) from jugular vein into heparinized tubes for each group alone. Plasma was isolated by centrifugation at 3000 rpm for 15 minute. Total plasma proteins, globulin, albumin. A/G ratio, lipids, cholesterol, high density lipoproteins (HDL), low density lipoproteins (LDL), alanine aminotransferase (ALT), aspartate aminotransferase (AST), calcium and phosphorus. Blood biochemical traits were determined calorimetrically on spectrophotometer by using the suitable commercial kits made in Diamond Company, Stanbio Laboratory, Pastier Lab. Diagnostic and Biodiaquastic Company. The constituents of blood were determined i.e., total protein (Gornal *et al., 1949),* albumin (Doumas and Biggs,1972*)*, lipids (Zollner and Kirsch, 1962), cholesterol (Allain *et al., 1974)*, HDL (Warnick *et al., 1982)*, LDL (Assmann *et al., 1984)* AST and ALT (Reitman and Frankel, 1957), total plasma calcium (Gindler and King, 1972*)* and phosphorus (El-Merzabani *et al., 1977).* The globulin values were obtained by subtracting the values of albumin from the corresponding values of total proteins. Albumin/ globulin (A/G ratio) values were obtained by dividing the values of albumin on the values of globulins.

Other blood samples (serum) were taken from 4 females and 4 males to determine corticosterone hormone and immunoglobulin G (IgG) at $2^{nd}$ and $10^{th}$ week of experiment. Corticosterone concentration was assayed with Coat-A-Count Rat Corticosterone $^{124}I$ radioimmunoassay kit, catalog number: TKRC1 (100 tubes) according to Al-Dujaili *et al., (1981)* using Automatic Mini Gamma Counter LKB 1275. Serum IgG levels were measured using single radial immuno diffusion technique, as described by Fahey and Mckelvey (1965). The method of IgG quantification involves antigen diffusing radially from a cylinder well through an agrose gel containing a monospecific antibody. Antigen-antibody complexes are formed as a precipitin ring. The ring size increases until equilibrium.

Other (physiological) thermoregulation parameters (i.e., respiration rate, cloacal temperature, skin temperature and heart pulse rate) were measured through the experimental period. At 21 weeks of age (end of experiment) ten quails (5 females and 5 males) from each treatment with equal numbers in terms were taken in order to study the carcass characteristics. Also, at the end of experimental period a total number of 120 eggs (laid on consecutive days) were taken for measuring egg quality traits. Eggs were collected from each treatment alone and weighed individually to nearest 0.1g. Egg specific gravity was determined by the flotation method as described by Holder and Bradfford (1979). Albumin and yolk heights were measured using a micrometer (B.C. Ames Co., altham, A.M.). The egg shells were washed and dried in a hot air oven at 105°C ± 3°C. After that shells were cooling to room temperature and shell thickness together with the shell membranes was individually measured from three different positions using an Ames shell thickness gauge (S.P.I Ames Co. P 09452). Yolk color was visually assessed using the Roche Yolk Color Fans (Romanoff and Romanoff 1949).

Statistical analysis: Data were subjected to analysis of variance using one way analysis of variance (SPSS, 2009, version 19.0), INC., Chicago, For Windows), with cage density as a main treatment effect. All percentages were first transformed to arcsine coefficients before analysis to approximate normal distribution before ANQVA. Significant differences among means were determined by Duncan's multiple range tests (Duncan's 1955) at 5.0% level of significant. All obtained data were analyzed using the following Model:

$Y_{ij} = u + T_i + e_{ij}$

Where, Y= the observed value, u = population means, $T_i$= the effect of stocking density and $e_{ij}$ = the standard error. The significant differences between males and females were analyzed by *t* – tests. The differences were also significant at 5.0 % level.

# RESULTS AND DISCUSSION

**Laying performance:** Results of live body weight, egg production %, egg weight, egg mass, feed intake, protein intake, energy intake, feed conversion ratio and mortality rate are given in Table 2.

**Table (2): Effect of different stocking densities on performance and mortality rate of laying Japanese quails.**

| Traits | Stocking density | | | | |
|---|---|---|---|---|---|
| | 140cm$^2$/bird | 170cm$^2$/bird | 200cm$^2$/bid | 233 cm$^2$/bird | PooledSEM± |
| Body weight of females at start of experiment, (g) | 180.80 | 180.60 | 180.90 | 180.57 | 0.17 |
| Body weight of females at end of experiment, (g) | 210.47d | 230.50c | 241.17ab | 246.27a | 1.71 |
| Chang in body weight, (g) | 29.67 | 49.90 | 60.27 | 65.70 | 0.66 |
| Egg production, (%) | | | | | |
| 10-15 weeks | 48.12d | 66.91c | 71.53b | 73.89a | 1.55 |
| 16-21 weeks | 69.01d | 78.16c | 85.93ab | 86.82a | 2.71 |
| 10-21 weeks | 58.57d | 72.54c | 78.73ab | 80.36a | 1.04 |
| Egg weight, (g) | | | | | |
| 10-15 weeks | 10.46 | 10.68 | 10.74 | 10.44 | 0.12 |
| 16-21 weeks | 11.27 | 11.43 | 11.20 | 11.27 | 0.09 |
| 10-21 weeks | 10.87 | 11.06 | 10.97 | 10.86 | 0.14 |
| Egg mass, (Kg) | | | | | |
| 10-15 weeks | 0.2173d | 0.2640c | 0.2910ab | 0.2970a | 0.045 |
| 16-21 weeks | 0.3263d | 0.3750c | 0.4040ab | 0.4110a | 0.027 |
| 10-21 weeks | 0.5436d | 0.6390c | 0.6950ab | 0.7080a | 0.012 |
| Feed intake, (g/bird/period) | | | | | |
| 10-15 weeks | 1051.89d | 1135.39c | 1273.55b | 1329.08a | 15.35 |
| 16-21 weeks | 1151.39d | 1264.17c | 1363.63b | 1407.70a | 18.08 |
| 10-21 weeks | 2203.28d | 2399.56c | 2637.18b | 2736.78a | 28.44 |
| Protein intake, (g) | | | | | |
| 10-15 weeks | 210.38d | 227.08c | 254.71b | 265.82a | 2.60 |
| 16-21 weeks | 230.28d | 252.83c | 272.73b | 281.54a | 2.74 |
| 10-21 weeks | 440.66d | 479.91c | 527.44b | 547.36a | 7.12 |
| Energy intake, (Kcal) | | | | | |
| 10-15 weeks | 3054.69d | 3283.82c | 3297.17b | 3859.65a | 37.66 |
| 16-21 weeks | 3343.64d | 3656.28c | 3671.15b | 4087.96a | 36.51 |
| 10-21 weeks | 6398.33d | 6940.10c | 6968.32b | 7947.61a | 72.33 |
| Feed conversion ratio (Kg feed/Kg eggs) | | | | | |
| 10-15 weeks | 4.84a | 4.30b | 4.38b | 4.48b | 0.51 |
| 16-21 weeks | 3.53a | 3.37b | 3.38b | 3.43b | 0.25 |
| 10-21 weeks | 4.05a | 3.76b | 3.79b | 3.87b | 0.28 |
| Mortality rate, (%) | | | | | |
| 10-15 weeks | 1.86a | 1.72b | 0.24c | 0.23c | 0.04 |
| 16-21 weeks | 2.49a | 1.71b | 1.55c | 1.54c | 0.12 |
| 10-21 weeks | 4.35a | 3.43b | 1.79c | 1.77c | 0.23 |

**a,b,c,d ..... Means within the same row with no common superscript differ significantly at (P≤ 0.05)**

**Live body weight (LBW):** Averages of LBW at the beginning of experiment were ranged between 180.57 to 180.90 g with insignificant differences were observed among the experimental groups. While at the end of experiment birds stocked at low stocking density (233 $cm^2$/ bird) recorded significantly ($P\leq0.05$) higher LBW followed by quails stocked at 200,170, and 140$cm^2$/bird. It is interesting to note that the decrease of LBW for quails stocked at high stocking density may be due to chronic stress results in activation of the hypothalamic pituitary adrenal system (Siegel, 1980) which causes the hypothalamus to produce corticotrophin releasing factor, which in turn stimulates the pituitary gland to release adrenocorticotropin (Holmes and Phillips, 1976). The presence of ACTH in the blood stream causes the adrenal to secret corticosterone. One of the most important effects of corticosterone is its ability to alter metabolic processes (Siegel, 1995).The former metabolic alterations are accompany with decreasing of LBW as a result of physiological stress (Post *et al., 2003)*. Indeed, the decrease of LBW attributed to increase competition of fed and water, elevation of house temperature, microbial activity and ammonia production. These results are in agreement with Reiter and Bessei (2000) which reported that there was a linear increase in growth rate of broiler chickens with decreasing stocking density at $5^{th}$ weeks of age. However, Bhanja *et al., (2006)* indicated that body weight of Japanese quail at $6^{th}$ to $20^{th}$ weeks of age was increased when floor space increased. Also Skrbic *et al., (2007)* indicated that there was a tendency of increase final body weight with the decrease of stocking density of broilers chickens.

**Egg production (EP), egg weight (EW) and egg mass (EM):** Throughout the experiment, means of EP and EM were significantly ($P\leq 0.05$) increased proportionately with decreases of cage density, such that females at a cage density of 233 $cm^2$/bird produced high EP followed by those stoked at 200 $cm^2$/bird while quails stocked at 170 or 140 $cm^2$/bird recorded lower values. Concerning EW the analysis of variance showed that insignificant differences were observed among the experimental groups. The decrease of performance due to increasing stoking density may be a result of physiological stress Hester *et al., (1996 a, b)*. In this regard, Roush and Cravener (1990), Carey and Kuo (1995), Hashemi and Pourreza (1998), Sohail *et al., (2001)* and Özbey *et al., (2004)* found that the increase of cage density resulted in a significant reduction in egg production and egg mass. Also Anderson *et al., (1995) and* Gharib *et al., (2005)* showed that increased bird cage density resulted in a significant decreased in egg mass. However Bhanja *et al., (2006)* reported that the first phase of egg production ($7^{th}$ -$13^{th}$ week) was significantly higher ($P\leq0.05$) in quails kept at higher floor space and the same trend was also observed in the second phase (14 -20 week). Moreover, Brake and Peebles (1992) observed that cage density had no effect on egg weight. While, Faitarone *et al., (2005)* found that there was a linear reduction ($P\leq 0.05$) in egg weight, percent of egg production and egg mass of quails with the increase of stocking density.

**Feed intake (FI), protein intake (PI) and energy intake (EI):** Data of FI, PI and EI during the experimental period showed that there was a significant ($P\leq 0.05$) increases of these measurements for quails stocked at low stocking density (233cm$^2$/bird) compared with quails stocked at high stocking densities. The reduced feeder space per hen in each individual cage, coupled with increased competition of feed, may have caused reduction in feed intake. The decrease of feed intake accompanied by decreasing of protein and energy intakes, led to decline in egg production observed during the experiment. The obtained results are in a consistent with previous reports that cage density has also been reported to influence feed consumption. Lee and Moss (1995), Gharib *et al., (2005)* and Nahashon *et al., (2006)* indicated that mean of feed consumption significantly decreased with increases of cage density. Also, Faitarone *et al., (2005)* found that there was a linear reduction ($P \leq 0.05$) in feed consumption of quails with the increase of stocking density. Beloor *et al. (2010)* indicated that average daily feed intake significantly increased of chickens stocked at low density (0.166 m$^2$/bird) compared with those stocked at high (0.0578 m$^2$/bird) and standard (0.077 m$^2$/bird) stocking density.

**Feed conversion ratio (FCR):** Obviously, the analysis of variance indicated that FCR was worst for laying quails stocked at 140 cm$^2$/bird, while better values were recorded for quails stocked at 170, 200 and 233 cm$^2$/bird. Its clearly indicating that high stocking densities were associated with decreasing FI and attributed to increase competition for feeding space (Carey, 1987) or reduction in floor space (Davami *et al., 1987)* and consequently lead to a decrease in FCR. In this connection (Sandoval et al., 1991) found that increasing cage density has been reported to reduce feed efficiency. In other studies reported by Bhanja *et al., (2006)* found that FCR per kg of egg produced was better ($P \leq 0.05$) for layer quails stocked at higher floor space. Also Nahashon *et al., (2006)* observed that FCR was low in birds reared in cages at 1394 cm$^2$/birds than those stocked at (697 and 465 cm$^2$/bird). While, Faitarone *et al., (2005)* found that there were no significant differences among treatment of quails for FCR (kg feed: kg eggs), when stocked at 246, 211, 176 and 151cm$^2$ per quail.

**Mortality rate (MR):** It's apparent from the obtained results MR rate was significantly ($P \leq 0.05$) reduced with increase space of cage area from 140 to 233 cm$^2$/bird during the experimental periods. The increases of mortality rate for birds given less cage space due to the high stress or elevation of heat stress, which increased with increasing cage density (Pettit-Riley and Estevez, 2001) and (Gharib *et al.,2005)*. On other words, increased mortality can be explained by decreasing welfare, such as bad air and litter quality, poor immune response and poor feed intake. This observation was consistent with earlier reports of Cunningham and Ostrander (1982) reported that greater density in White Leghorn chickens increased mortality rate of heavy type chickens and White Leghorn in wire cage respectively. Furthermore, Nahashon *et al., (2006)* found that mortality rate was lower in Guinea fowl reared in cages at 1394 cm$^2$/bird than those reared in cages at 697 and 465 cm$^2$/bird. Also, Beloor *et al., (2010)* indicated that health and welfare of broiler were compromised when space allowances drop below 0.062 to 0.07m$^2$/bird. In contrary, Mehmet (2008) indicated that mortality rate not affected by increasing stoking density in broiler from 15, 20 and 25 bird/m$^2$.

***Blood plasma and serum constituents:*** *Data of blood plasma and serum* constituents as affected by different stocking densities and sex are given in Table 3.

**Total plasma protein (TPP), albumin (TPA), globulin (TPG), and (A/G) ratio:** It is interesting to note that birds stoked at low stocking densities have low ($P \leq 0.05$) values of TPP, TPA and TPG. While insignificant differences were detected for A/G. The increase of protein fractions for birds stocked at low cage space area (140 or 170 $cm^2$/bird) may be attributed to physiological stress due to crowding (Hester *et al., 1996 a, b)*. Concerning the effect of sex on these parameters females recorded significantly ($P \leq 0.05$) higher TPP and TPG than males while males has higher A/G ratio than females. The results are in disagreement with those obtained by Tollba *et al., (2006)* manifested that total plasma proteins as well as albumin, globulin and A/G ratio were not affected in laying chickens by different stock densities. Also El-Deek and Al-Harthi, (2004) indicated that stocking density had no effect on blood plasma constituents of broiler chicks. While Erisir and Erisir (2002) reported that no significant differences were observed for albumin and total proteins of quails stocked at different stocking density.

**Total plasma lipids (TPL), cholesterol (TPC), high density lipoproteins (HDL) and low density lipoproteins (LDL):** Results of TPL, TPC and HDL showed that there were significant ($P \leq 0.05$) increase of these parameters due to decrease of stocking density (200 or 233 $cm^2$/bird) compared with those stocked at high stocking density (140 or 170 $cm^2$/bird). While LDL was not significantly affected due to different stocking density. Regarding the effect of sex, the analysis of variance indicated that TPL was higher in females than meals, while HDL recorded the conversed trend. However insignificant differences were observed for TPC and LDL for both sexes. Skrbic *et al., (2007)* reported that no significant differences were observed of broiler chickens for cholesterol concentration when stocked at 10, 13 or 16 bird/$m^2$. Simsek *et al., (2009)* displayed that serum HDL and cholesterol levels were reduced for broiler chickens stocked at lower densities (7.5bird/m) compared with those stocked at higher levels (22.5,18.75,15 and 11.25 bird/m).

**Aspartate transaminase (AST) and Alanine transaminase (ALT):** The data of AST revealed that insignificant differences observed among stocking densities groups. While the values of ALT recorded significant ($P \leq 0.05$) higher values for quails stocked at 233 $cm^2$/ bird than those stocked at 200, 170 and 140 $cm^2$/bird respectively. However insignificant differences were appeared between both sexes for these parameters. In this connection El-Deek and Al-Harthi (2004) expressed that stock density had no effect on plasma constituents of broiler chicks especially with ALT and AST activity. Also Tollba *et al., (2006)* denoted that total plasma ALT and AST for Egyptian laying chickens were not affected by different stocking densities.

**Total plasma calcium (TPCA) and phosphorus (TPPH):** Table 3 shows the values of TPCA and TPPH, indicated that birds stocked at low stocking densities 200 or 233 $cm^2$/bird have significantly ($P \leq 0.05$) higher values of TPCA and TPP compared with birds stocked at other stocking densities.

Table (3): Effects of different stocking densities and sex on some blood constituents and immunological response of laying Japanese quail.

| Traits | Stocking density | | | | | Sex | | |
|---|---|---|---|---|---|---|---|---|
| | 140$cm^2$/bird | 170$cm^2$/bird | 200$cm^2$/bid | 230 $m^2$/bird | Pooled SEM± | Males | Females | Pooled SEM± |
| Biochemical analysis: | | | | | | | | |
| Total plasma proteins g/dl. | 6.06a | 5.93b | 4.73c | 4.52d | 0.23 | 5.20b | 5.41a | 0.15 |
| Total plasma albumins g/dl. | 2.58a | 2.27b | 1.92c | 1.96c | 0.09 | 2.17 | 2.20 | 0.09 |
| Total plasma globulins g/dl. | 3.48a | 3.66a | 2.81b | 2.56c | 0.12 | 3.03b | 3.46a | 0.05 |
| A/G ratio. | 0.74 | 0.62 | 0.68 | 0.77 | 0.002 | 0.72 | 0.64 | 0.008 |
| Total plasma lipids mg/dl. | 1061.9c | 1465.7b | 1551.5a | 1550.7a | 73 | 1369b | 1457.2a | 51.5 |
| Total plasma cholesterol mg/dl | 180.7c | 188.6b | 203.3a | 200.93a | 12.5 | 188.98 | 190.2 | 4.87 |
| High density lipoproteins mg/dl. | 38.91c | 47.23b | 56.36a | 52.65ab | 1.38 | 51.12a | 46.45b | 3.36 |
| Low density lipoproteins mg/dl. | 85.05 | 83.80 | 84.38 | 83.76 | 1.40 | 84.20 | 84.28 | 0.09 |
| AST U/l* | 36.50 | 38.16 | 38.0 | 36.50 | 1.41 | 36.66 | 37.91 | 0.44 |
| ALT U/l** | 7.38b | 6.38c | 7.71b | 8.31a | 0.33 | 7.65 | 7.24 | 0.11 |
| Total plasma calcium mg/dl. | 10.26d | 12.20c | 13.24b | 17.41a | 0.97 | 12.30b | 14.26a | 1.03 |
| Total plasma phosphorus mg/dl. | 7.23c | 7.26bc | 9.32ab | 9.98a | 0.43 | 8.00b | 8.91a | 0.12 |
| Hormonal assays and immunological response: | | | | | | | | |
| Corticosterone hormone(ng/ml) | | | | | | | | |
| At 2 weeks of experiment | 24.40a | 22.45ab | 19.87c | 18.50c | 0.66 | 23.04a | 19.58b | 0.66 |
| At 10 weeks of experiment | 20.15a | 18.20a | 17.56a | 14.37b | 0.66 | 15.60b | 19.55a | 0.66 |
| IgG (mg/ml)*** | 2.17c | 3.26b | 4.04a | 4.11a | 0.18 | 3.22 | 3.57 | 0.18 |

a,b,c,d .... Means within the same row with no common superscript differ significantly at ($P \leq 0.05$)
*AST = aspartate transaninese
**ALT = alanine transaminese
***Immunological response type IgG

Concerning the effect of sex, results showed that females have higher values of both parameters than their males. These results are similar with results obtained by Gharib *et al., (2005)* signified that increasing cage density significantly reduced serum calcium and phosphorus, which could explain the improvement in shell thickness observed. Erisir and Erisir (2002) signaled that with increasing stocking density of quails resulted in an increased in inorganic phosphate and calcium levels.

**Hormonal assays and immunological response:** Blood serum corticosterone is one of the most important parameters used to measure the level of stress. Indeed stocking density is one of the most environmental factors that affecting on stress reaction. The obtained data indicated that quails that were stocked at low stocking densities (200 or 233 $cm^2$/bird) recorded significantly ($P \leq 0.05$) lower concentration of cortiocosterone hormone compared with those kept at other stocking densities. When a bird encounters a stressor, its first line of defense involves activation of the neurogenic system (Siegel, 1980). It is interesting to note that the increase the corticosterone level of quails stocked at high stocking density may be due to chronic stress results in activation of the hypothalamic pituitary adrenal system (Siegel, 1980 and 1995) which causes the hypothalamus to produce corticotrophin releasing factor, which in turn stimulates the pituitary gland to release adrenocorticotropin. The presence of ACTH in the blood stream causes the adrenal to secret corticosterone (Holmes and Phillips, 1976). Further, the elevation of the cortiocosterone level due to increasing stocking density was reported to indicate that high stocking density is stressful. In general, the use of battery cage system increase stress due to overcrowded. However, males of quail have higher level of corticosterone concentration than their females at 2nd week of experiment. These results are correspondence with the results obtained by Mashaly *et al., (1984)* pointed to that corticosterone concentration were consistently higher in the serum of laying hens housed five per cage than birds housed three or four per cage. However, Ravindran *et al., (2006)* displayed that density and group size were expected to increase conflict between the birds, leading to increases in stress, which would be expressed psychologically by increased fearfulness and physiologically by higher glucocorticoid level. Mehmet (2008) found although there was a trend toward increasing cortiocosterone concentration with higher stocking density, no statistical significant was found in blood cortiocosterone concentration of broiler chickens stocked at 15, 20 and 25 birds/ $m^2$. In contrary, Buijs *et al., (2009)* indicated that density did not affect on concentration of corticosterone metabolites of broiler chickens. Pohle and Cheng (2009) revealed that corticosterone level increased in hens housed in the battery cages, but not in those housed in the furnished cages at 50 to 60 weeks of age. Mehmet (2008) implied that mean corticosterone concentration on day 42 indicated an increase from 3.81 to 4.39 ng /ml with increasing stocking density of chickens, but this increases was not significant.

Concerning the immune response of immunoglobulin G (IgG, table 3) is *another parameter* that has also been widely used in assessing the stress level. Immune response such as antibody IgG is affected by social environment (Cunnick *et al., (1991)* and Baumgarth *et al.,* (2005*)*. Results showed that as stocking density decreased IgG level significantly ($P \leq 0.05$) increased, lead to decrease mortality occurred during the experiment period. Obtained results clarified that female of quail exhibited increase of IgG response compared with their males. It's apparent that the avian neuroendocrine system responds to stimuli similar to mammalian system (Segovia *et al., 2008)*. In addition immunity, such as producing antibody IgG is affected by social environments (Tuchscherer *et al., 1998)*. We hypothesize that changes in the endogenous level of IgG may underline the differential reactions of quails to the battery cages. Erisir and Erisir (2002) showed that there was a significant decrease in immune response with an increases stocking density of Japanese quail. Also, Tufft and Nockels (1991) indicated that a decrease in space allowances made broilers more susceptible to infection. Mehmet (2008) registered that stocking density had no significant effect on immune response of broiler chickens at different stocking density in summer.

**Physiological (thermoregulation) measurements:** Table (4) shows the physiological measurements including respiration rate, cloacal temperature, skin temperature and heart pulse rate measured during the experimental time. Results indicated that there were significant ($P \leq 0.05$) decreases of these parameters due to decreasing stocking densities. Quails stocked at 233cm$^2$/bird recorded significantly ($P \leq 0.05$) low values, followed by quails stocked at 200, 170, and 140 cm$^2$/bird respectively. The decrease of these parameters in birds stocked in low stocking density may be attributed to the decreases of physiological stress (Hester et al., 1996a, b). Concerning the effect of sex on these traits, the obtained data showed that insignificant differences were detected between both sexes. These observations are inconsistent with those showed by Tollba *et al., (2006)* marked that body temperature and respiration rate were not significantly affected, when stocking density of laying hens increased from 8, 12 and 16 bird/m$^2$.

**Table (4): Effects of different stocking densities and sex on some physiological (thermoregulation) parameters of laying Japanese quail.**

| Traits | Stocking density | | | | | Sex | | |
|---|---|---|---|---|---|---|---|---|
| | 140cm$^2$/bird | 170cm$^2$/bird | 200cm$^2$/bid | 233 cm$^2$/bird | Pooled SEM± | Males | Females | Pooled SEM± |
| Respiration rate. | 34.0a | 34.0a | 32.0b | 30.0c | 0.45 | 32.0 | 33.0 | 0.49 |
| Cloacal temperature. | 42.1a | 41.8b | 41.7b | 41.0c | 0.32 | 41.7 | 41.9 | 0.88 |
| Skin temperature. | 41.9a | 41.3b | 41.3b | 40.5c | 0.17 | 41.2 | 41.3 | 0.63 |
| Heart pulse rate. | 333.0a | 328.0a | 311.0b | 301.0c | 3.96 | 318.0 | 319.0 | 2.09 |

a,b,c……Means within the same row with no common superscript differ significantly at ($P \leq 0.05$)

**Egg quality traits:** Results of egg quality traits including external and internal are given in Table (5). Data of external egg quality i.e., egg weight, specific gravity, egg shape index, shell weight and shell percentage recorded insignificant differences among the experimental groups. These reports are also agree with Sohail *et al., (2001)* showed that there were no significant *effects of the different densities on egg quality traits in chicken such as egg* weight, specific gravity, shell weight, shell percent at 81 weeks of age.

**Table (5): Effects of different stocking densities on egg quality traits of Japanese quail at the end of the experiment period (Means ± SE).**

| Traits | Stocking density | | | | |
|---|---|---|---|---|---|
| | 140cm²/bird | 170cm²/bird | 200cm²/bid | 233 cm²/bird | Pooled SEM± |
| Egg weight (g). | 10.81 | 10.80 | 10.81 | 10.82 | 0.12 |
| Specific gravity. | 1.074 | 1.074 | 1.074 | 1.074 | 0.04 |
| Egg shape index. | 0.79 | 0.79 | 0.80 | 0.79 | 0.06 |
| Albumin weight (g). | 6.15 | 6.08 | 6.09 | 6.11 | 0.11 |
| Albumin weight (%). | 56.86 | 56.39 | 56.34 | 56.48 | 0.15 |
| Yolk weight (g). | 3.28 | 3.37 | 3.29 | 3.31 | 0.09 |
| Yolk weight (%). | 30.32 | 31.16 | 30.43 | 30.55 | 0.22 |
| Shell weight (g). | 1.38 | 1.35 | 1.43 | 1.40 | 0.04 |
| Shell weight (%). | 12.82 | 12.45 | 13.23 | 12.97 | 0.25 |
| Yolk index. | 0.35b | 0.35b | 0.36ab | 0.38a | 0.02 |
| Shell thickness (mm). | 0.21a | 0.18b | 0.19b | 0.16c | 0.08 |
| Yolk color. | 4.97b | 5.0ab | 5.33a | 5.50a | 0.33 |
| Eggs with blood or meat spots (%). | 20.12a | 18.08b | 15.61c | 10.22d | 1.11 |

**a,b,c.... Means within the same row with no common superscript differ significantly at (P≤ 0.05)**

Results from quails stocked at 140 cm²/bird recorded significantly (P≤0.05) high values of shell thickness, followed by those stocked at170, 200 and 233cm²/bird respectively. This finding may be attributed to higher egg production for quails housed in high stocking density (140cm²/bird) led to more calcium is available per egg. These results were disagreement with the reports of Bhatt and Aggarwall (1989), Lee and Moss (1995), Sharaf (1996) and Gahrib *et al., (2005)* illustrated that shell thickness increased, when the number of birds per cage decreased. However Özbey *et al., (2004)* elucidated that the increase in placement density of laying Japanese quail from 72 to 90 and 120 cm²/bird resulted to decrease of egg shell thickness. Concerning internal egg quality i.e., albumin weight, albumin percentage, yolk weight, yolk percentage, yolk index, yolk color and eggs with blood or meat spots, the analysis of variance indicated that there were insignificant effect of different stocking densities on albumin weight, yolk weight and their percentage. While there were significant (P≤0.05) differences were observed among the experimental groups for yolk index, yolk color, shell thickness and eggs with blood or meat spots. Eggs produced from quails stocked at 233 and 200 cm²/birds exhibited the highest values of yolk index and yolk color compared with eggs produced from quails kept at 140 or 170 cm²/bird. The improvements in yolk index and color might be indication of lower stress and improved liver function which led to that yolk material synthesized in the liver and mobilized to the ovary prior to ovulation (Nagarajan *et al., (1991)*. The percentage of eggs with blood or meat spots were significantly (P≤0.05) lower for quail stocked in low cage densities than those stocked in high stocking density due to the higher stress of birds given less cage space. In review reported by Hashemi and Pourreza (1998) and Tollba *et al., (2006)* denoted that egg quality traits were not affected, when stocking density of laying hens increased from 8 to 12 and 16 bird/m². Also these results are agreed with observation of Gharib *et al., (2005)* found that decreasing cage density or increasing area per birds resulted in a significant decrease in egg with blood or meat spots. Also, Gharib (2006) displayed that increasing bird density resulted in a significant negative effect on yolk color scores compared to birds stocked at lower cage density, however housing birds at low cage density improved egg quality. On the other hand, Sarica *et al., (2008)* reported that increasing cage density in chickens to 5 bird/cage reflected no affect on egg shell quality and egg weight.

**Carcass characteristics:** Data of carcass characteristics of laying Japanese quail at 21 weeks of age as a percentage of live body weight are given in Table (6). Results revealed that there were insignificant differences for most carcass traits, except body weight, blood weight and carcass weight percentages, where quails stocked at 233cm/bird have higher values than quails stocked at other stocking densities. Regarding with the effect of sex on carcass organs, the results showed that females recorded significantly ($P \leq 0.05$) higher values of body weight, blood, liver, giblets, front, hind parts and carcass weight percentage than their males. While insignificant differences were observed for feather, head, neck, wing, leg, gizzard and heart weight percentage. The reports of Tollba *et al., (2006)* showed that increasing stocking density of laying hens did not significantly effect on giblets. Cravener *et al., (1992)* showed that stocking density at $0.05m^2$/bird decreased significantly carcass weight compared to those stocked at 0.07, 0.09 and $0.11m^2$/bird. Beg *et al., (2011)* manifested that the dressing % was significantly higher when stocked broiler at 8 and 10 birds/$m^2$ compared with those stocked at 12 or 14 birds/$m^2$.

**Conclusions and applications:**

1- A lower stocking densities provided more movement space for quails; this led to decrease the competition of feed, space and led to be comfort areas for birds.

2- The recommended area for laying Japanese quail is 233 $cm^2$/bird to obtain maximum egg production and egg mass.

3- Elevation of the corticosterone level with increasing stocking density was reported to indicate that high density in quail production is stressful.

4- In order to minimize physiological stress in cages of laying Japanese quail was raised at a density of 233 $cm^2$/bird to increases immunity response and subsequently lowering mortality rate.

Table (6): Effects of different stocking densities and sex on relative carcass characteristics of Laying Japanese quail at the end of experiment.

| Traits | Stocking density | | | | | Sex | | |
|---|---|---|---|---|---|---|---|---|
| | 140cm²/bird | 170cm²/bird | 200cm²/bid | 233 cm²/bird | Pooled SEM± | Males | Females | Pooled SEM± |
| Live body weight, g | 226.02b | 222.0b | 223.43b | 231.63a | 4.66 | 209.30b | 242 .26a | 3.33 |
| Blood weight,% | 7.53 b | 6.53c | 8.11b | 9.28a | 0.41 | 7.20b | 8.53a | 0.44 |
| Feather weight, % | 12.65 | 12.62 | 12.88 | 11.93 | 0.80 | 12.11 | 12.43 | 0.48 |
| Head weight,% | 8.54 | 8.23 | 8.12 | 8.24 | 0.22 | 8.17 | 8.40 | 0.10 |
| Neck weight,% | 10.83 | 9.59 | 10.47 | 11.03 | 1.70 | 10.64 | 10.32 | 0.15 |
| Wing weight,% | 6.11 | 5.91 | 5.75 | 5.60 | 0.33 | 5.84 | 5.84 | 0.008 |
| Leg weight,% | 4.67 | 4.83 | 4.84 | 5.40 | 0.12 | 4.50 | 5.37 | 0.58 |
| Liver weight,% | 4.05 | 4.86 | 5.15 | 5.23 | 0.89 | 3.28b | 6.38a | 0.26 |
| Gizzard weight,% | 3.62 | 3.46 | 3.25 | 3.60 | 0.11 | 3.15 | 3.82 | 0.16 |
| Heart weight,% | 1.86 | 1.69 | 1.82 | 1.98 | 0.09 | 1.82 | 1.86 | 0.12 |
| Giblets weight,% | 9.49 | 10.05 | 10.27 | 10.85 | 1.04 | 8.26a | 12.05a | 0.75 |
| Front weight,% | 86.30 | 81.20 | 83.16 | 84.86 | 2.16 | 78.81b | 88.95a | 1.02 |
| Hind weight,% | 54.36 | 54.01 | 54.47 | 55.37 | 1.77 | 53.72 | 55.39 | 1.13 |
| Carcass weight,% | 136.47cb | 135.23cb | 138.46b | 143.25a | 3.22 | 132.99b | 144.35a | 2.14 |

a,b,c.... Means within the same row with no common superscript differ significantly at ($P \leq 0.05$)

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## تأثيرات معدلات التسكين المختلفة على الأداء الإنتاجى والتغيرات الفسيولوجية فى السمان اليابانى ألبياض

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أجريت هذة التجربة لاختبار تأثيرات معدلات التسكين المختلفة والجنس على الأداء الإنتاجى ، وبعض التغيرات الفسيولوجية فى السمان اليابانى البياض والمربى تحت ظروف الجو الحار لمدة ١١ اسبوعا من (١٠- ٢١ أسبوع من العمر). استخدم عدد ٦٠٠ طائر سمان (٤٠٠ انثى +٢٠٠ ذكر( عند الأسبوع العاشر من العمر. قسمت الطيور عشوائيا إلى أربع معاملات للكثافة بأعداد ٧١، ٥٩، ٥٠، و ٤٣ طائر/ قفص، أو ١٤٠، ١٧٠، ٢٠٠ و ٢٣٣سم٢ / طائر على الترتيب. وكل معاملة تم تكرارها ثلاث مرات. وأثناء فترة التجربة كانت فترة ألإضاءة اليومية المستخدمة ١٦ ساعة. وغذيت الطيور على غذاء أساسى يحتوى على ٢٠% بروتين خام و ٢٩٠٠ كيلو كالورى طاقة ممثلة /كجم من الغذاء تبعا لتوصيات NRC.

والنتائج المتحصل عليها أشارت الى أن صفات وزن الجسم عند نهاية فترة التجربة وإنتاج البيض وكتلة البيض والغذاء المأكول وكذلك البروتين والطاقة المأكولة كانت أعلى معنويا للسمان الذى تم تسكينة عند معدل ٢٣٣ سم$^{٢}$ / طائر بالمقارنة بالسمان المربى تحت معدلات الكثافة الأخرى. بينما لم يتأثر وزن البيض معنوياً بين جميع معاملات التجربة.

إنخفضت كفاء ة تحويل الغذاء ومعدل الوفيات معنويا بإنخفاض معدل الكثافة. ومن جهة أخرى وجد أن هناك إنخفاضا معنويا لكل من بروتينات البلازما بإنخفاض معدل الكثافة. زادت معنوياً قيم كلاً من الدهون الكلية، الكوليسترول، البروتين الدهنى العالى الكثافة، ALT، والكالسيوم والفوسفور بإنخفاض معدلات الكثافة.بينما لم تؤثر معدلات الكثافة على البروتين الدهنى المنخفض الكثافة والــ AST.

إرتفع معنوياً تركيز هرمون الكورتيكوستيرون فى الدم كلما زادت معدلات الكثافة بينما زاد معنوياً تركيز الأمينوجلوبيلين نوع جــ (IGg) فى البلازما كلما إنخفضت معدلات كثافة التسكين.
الصفات الفسيولوجية والتى تشتمل على معدل التنفس، درجة حرارة المجمع، درجة حرارة الجلد

ومعدل ضربات القلب كانت أعلى معنويا للسمان المربى عند مستوى كثافة ١٤٠ سم/طائر بالمقارنة بالسمان المربى عند مستويات منخفضة من الكثافة. بينما لم يوجد هناك تأثيرات للجنس على الصفات الفسيولوجية المدروسة.

لم تلاحظ هناك إختلافات معنوية لمعظم صفات جودة البيضة بين المعاملات المختلفة والتى أشتملت على وزن البيضة، الكثافة النوعية، دليل شكل البيضة، وزن الألبيومين، ونسبة الألبيومين، وزن الصفار،ونسبة الصفار، وزن القشرة ونسبة القشرة. بينما كانت هناك إختلافات معنوية ملحوظة لكل من دليل الصفار، سمك القشرة، لون الصفار والبيض المحتوى على بقع من الدم أو اللحم.

لم تلاحظ أى إختلافات معنوية ما بين المجاميع التجريبية لمعظم صفات الذبيحة والمقاسة عند نهاية فترة التجربة فيما عدا وزن الجسم ونسبة وزن الدم ووزن الذبيحة الفارغة. وعموما نستخلص من هذة الدراسة وبناءً على النتائج المتحصل عليها أن نسبة إنتاج البيض وكتلة البيض الناتجة تزيد مع زيادة مساحة القفص لكل سمانة مرباة. ولذا فان إناث السمان البياض أظهرت تفوقاً ملحوظاً فى الأداء الأنتاجى حينما تم تسكينها عند معدل كثافة ٢٣٣سم٢/طائر بالمقارنة بالسمان المربى عند معدلات الكثافة الأخرى ٢٠٠،١٧٠،١٤٠ سم٢/ طائر على الترتيب.

**قام بتحكيم البحث**

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