THE INFLUENCE OF DIETARY BORON SUPPLEMENTATION ON PERFORMANCE AND SOME PHYSIOLOGICAL PARAMETERS IN BANDARAH CHICKENS 2- LAYING PERIOD

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ABSTRACT: A total of one hundred hens and twenty cocks of Bandarah strain at 28 weeks of age were housed individually in single cages and distributed randomly among four treatment groups (25 hens and 5 cocks/ group) and the experiment ended at 44 wks of age. Birds in group 1 were fed a basal diet and served as control group, the other three groups 2, 3 and 4 were fed a basal diet supplemented with 100, 200 and 300 mg boron/kg feed, respectively. Results indicated that supplemental boron to hens’ diet had no significant effect on egg production, egg weight, egg mass, feed consumption and feed conversion compared with control group. Significant increases were observed for egg shell%, shell thickness and Haugh units with increasing the boron level. While shape index, albumen and yolk percentages were not affected by treatments. Supplemental boron significantly increased egg shell calcium, phosphorus and boron concentrations. Moreover, plasma minerals (Ca, P, Fe, Cu and B) were significantly increased with the increase of boron level. Hematological parameters (Hb, PCV, RBCs and WBCs) were improved by addition boron to layer diets. There was a significant increase in plasma total protein, globulin, glucose and serum T3 resulted from dietary boron. Lipid profile and liver function significantly improved for boron treatments. Additionally, semen quality, fertility and hatchability percentages significantly improved with boron at different levels compared with control value. It can be concluded that boron supplementation to layer diets had a positive effect on plasma minerals (Ca, P, Fe, Cu and B) and egg shell (Ca, P and B). However, egg quality, reproductive and physiological status were improved. It is suggested that up to 300 mg boron/kg diet could be used in layer diets without any adverse effect on laying hens performance.

INTRODUCTION

Boron, which bears the symbol B in the periodical table, is a semiconductive element with properties between that of a metal and a nonmetal (Kilic et al., 2009). This element is a chemically dynamic trace element that forms approximately 230 compounds, generally with other elements (World Health Organization, 1998; Kilic et al., 2009). Boron is released into the atmosphere from commercial uses, forest fires, coal combustion, and volcanoes. It reaches the ocean as a result of rock weathering, which constitutes another atmospheric source (Howe, 1998).

It is now known that boron is a necessary dietary component for humans and animals (Hunt, 1994; Nielsen, 1997; Kabu and Civelek, 2012). Boron meets most criteria as an essential nutrient (Hunt, 1998). Moreover, boron having adjacent hydroxyl groups (transferases) has a tendency to form complexes with organic molecules. It may have an interaction with important biological substances, containing polysaccharides, pyridoxine, riboflavin, dehydroascorbic acid, and the pyridine nucleotides (Samman et al., 1998; Deviran and Volpe, 2003).

Boron has an essential function that regulates parahormone activity (McDowell, 1992) and therefore, effects of Ca, P, Mg and cholecalciferol metabolism (Miljkovic et al., 2004; and Kurtoglu et al., 2001, 2005). Whereas, Cufadar et al. (2011) indicated that dietary boron supplementation has positive effects on mineral balance, and therefore improving egg shell breaking strength and bone strength parameters in aged laying hens. Several studies have indicated that B is an important mineral for egg weight and egg shell quality in laying hens (Qin and Klandorf, 1991; Wilson and Ruszler, 1996, 1998). Eren et al. (2004) investigated that dietary B supplementation (0, 10, 50, 100, 200 and 400 mg/kg diet) affected on egg production, interior and exterior egg quality in laying hens. Additionally, Yesilbag and Eren (2008) reported that adding boron to layer rations caused improving egg shell quality. Mizrak et al. (2008b) reported that the supplementation of boron (25, 50 and 75 ppm) into layer diets significantly increased the calcium accumulation in egg shell. Boron affects the activities of at least 26 different enzymes, most of which are necessary for energy substrate metabolism (Hunt, 1998). Therefore, boron affects the Krebs cycle, the glucose-alanine cycle, and methionine metabolism all of which reduce oxidative stress and positively affect the lipid profile (Basoglu et al., 2011). Eren and Uyanik (2008) pointed out for laying hen’s cholesterol levels were decreased by increasing levels of boron (0, 5, 10, 50, 100, 200 or 400 mg/kg) addition to diets. Likewise, Eren et al. (2006) reported that the amount of serum cholesterol levels of quails decreased as the levels of boron (10, 60, 120 and 240 mg/kg) increased.

It is known that semen profile is directly affected by various environmental, physical and chemical factors (Oliva et al., 2001). Moreover, Naghii and Samman (1993) noted that the mechanism of boron action may be mediated by increasing the concentration of steroid hormones such as testosterone and beta-estradiol. Whereas, inclusion of boron to bucks’ rations resulted in a significant increase in sperm concentration, total sperm output, sperm motility and normal sperm (Elkomy et al., 2015).

Recent studies on the biological significance of boron to various metabolic, nutritional, hormonal, and physiological processes indicated that boron is essential for humans and animals (Nielsen, 1997; Basoglu et al., 2000, 2002; Kabu and Civelek, 2012; and Hunt, 2012). It is accepted that boron performs functions in mineral metabolism, in immune response and in the endocrine system. Unfortunately, the detailed
mechanism by which boron functions in animals has not yet been fully described. The present study was conducted to evaluate the effect of dietary boron on productive and reproductive performance and some blood constituents in Bandarah laying hens.

MATERIALS AND METHODS
The present experiment was carried out at El-Sabahia Poultry Research Station, Animal Production Research Institute, Agricultural Research Center, Egypt. A total of one hundred laying hens and twenty cocks of Bandarah strain at 28 weeks of age were housed in individual cages and distributed randomly in four treatment groups (25 females and 5 males in each one). Feed and water were supplied ad libitum throughout the experimental period which ended at 44 wks of age. Artificial lighting was used to provide birds 17 hrs lighting daily. The basal diet (control) was formulated to meet nutrient requirements of chickens. The composition of the basal diet is given in Table (1). Birds in group 1 were fed a basal diet and considered as control group, the other three groups 2, 3 and 4 were fed a basal diet supplemented with 100, 200 and 300 mg boron/kg feed respectively in the form of boric acid.

Productive parameters:
Egg weight (g) and egg number were recorded daily. Egg mass was calculated by multiplying egg number by average egg weight per hen (g/h/d). Feed conversion was calculated as the amount of feed consumed (g) required in order to produce a unit (g) of egg mass (g feed/g egg). Fifteen eggs from each treatment were randomly taken every four weeks to measure egg quality according to Romanoff and Romanoff (1949):

Egg shape index (%) = (width/length) x 100

Eggs were individually broken out, albumen, yolk, yolk color and shell weights were measured to the nearest 0.1 gm and their relative weights were calculated as percentage of egg weight.

Haugh units (H.U.) were calculated based upon the height of albumen determined by micrometer and egg weight according to the formula of Hough (1937):

HU = 100 log (H + 7.57 – 1.7 W^{0.37})

Where H = thick albumen height (mm).
W = egg weight (g).

Washed shells were left for 72 hrs at environmental temperature, dried, individually weighed, and their relative weights were calculated as percentage of egg weight. Egg shell thickness was measured for three equatorial regions of 15 eggs using a manual micrometer. The quantities of crude ash in egg shells were determined by burning at 550°C for one night in an ash oven. These ashes were analyzed for boron, calcium and phosphorus using spectrophotometric method (respectively, TSE 945.04, 958.01, 982.01, AOAC, 1990).

Blood constituents:
At 44 wks of age, blood samples were randomly taken from 10 hens from each treated group in heparinized tube from the brachial wing vein. A portion of the fresh blood was used to count the white blood cells (WBCs), red blood cells (RBCs), and measure hemoglobin (Hb) and packed cell volume (PCV). Plasma and serum were obtained from the blood samples by centrifugation for 15 min. at 3000 rpm and was stored at -20 °C until the time of analysis. Plasma calcium (Ca), phosphorus (P), iron (Fe), copper (Cu), boron (B), total protein, albumin, total lipids, cholesterol, low density lipoprotein (LDL), high density lipoprotein (HDL), glucose, alanine aminotransferase (ALT), and aspartate aminotransferase (AST) were determined spectrophotometrically using available commercial Kits. Serum triiodothyronine (T3) concentrations were measured using commercial ELISA kita.

Semen evaluation:
At 36 weeks of age, semen samples were collected from cocks of each treatment once weekly by abdominal massage technique. Physical properties of semen (ejaculate
volume ml, sperm motility %, sperm abnormality % and sperm concentration) were determined. Sperm motility index (SMI) was calculated according to Howard et al. (1986):

\[
\text{SMI} = (\text{Sperm motility percentage} + \{\text{Forward progressive motility x 20}\})/2
\]

Forward progressive motility graded by the Scale of 0 to 5 where 0= no forward movement, 1= slight movement (1-20%), 2= undulatory movement (20-40%), 3= progressive and slow moving (40-60%), 4= progressive motility (60-80%) and 5= rapid linear forward progressive (80-100) (Melrose and Laing, 1970).

**Fertility and Hatchability percent:**
At 38 wks of age, hens were inseminated twice a week with diluted semen (1:1) from cocks that received the same treated diets. Hatching eggs were collected daily from each group at 40, 42 and 44 wks of age. A total of 800 hatching eggs representing the four experimental dietary groups were incubated in Egyptian-made incubator at 37.8 C and 55% RH during incubation and transferred to hatcher operated at 37.2˚C and 65%RH. Egg fertility and hatchability were determined.

**Statistical analysis:**
Data were statistically analyzed according to SAS program (SAS, 2004) using GLM Procedure. All the data were subjected to one way analysis of variance model. Mean differences were tested by Duncan’s multiple range (Duncan, 1955).

**RESULTS AND DISCUSSION**

**Productive performance**
Egg production, egg weight, egg mass, feed consumption and feed conversion ratio are given in Table 2. Results showed that, boron supplementation did not affect egg production, feed consumption, egg mass and feed efficiency. While, egg weight was increased by increasing boron level by 2.29, 3.09 and 5.20% for 100, 200 and 300 mg boron, respectively over the control group but these increases were not significant. Results are in agreement with those reported by Mizrak et al. (2010) who found that, supplementation of 25-200 mg boron/kg to hens during a period of 4-64 weeks of age did not affect the productive performance of the layers. Similarly, Sizmaz et al. (2014) showed no significant effect in the egg production, feed intake and feed efficiency of laying hens fed diet added with 60 and 180 mg boric acid/kg. Olgun and Bahtiyarea (2015) indicated that, egg production, egg mass, feed intake and feed conversion ratio were not affected by dietary boron at 60 and 120 mg boron/kg in the laying hens. It was previously reported that, dietary boron up to 250 mg/kg did not have any detrimental effect on productive performance of laying hens while, 400 mg boron/kg decreased body weight gain and feed intake (Rossi et al., 1993; Wilson and Ruszler, 1996, 1998; Kurtoglu et al., 2002; and Eren et al., 2004).

Regarding the egg weight, the improvement in egg weight for treated groups in the present result is consistent with finding of Yesilbag and Eren (2008) who revealed that, the addition of boric acid (25, 50 and 100 mg/kg) to the diets caused a significant increase in egg weight for layers. Opposite results were found by Kucukyilmaz et al. (2014), they reported that supplemental boron (57 and 150 mg/kg) significantly decreased the feed consumption and egg weight for laying hens.

**Egg quality traits**
Table 3 shows the effect of dietary boron on egg quality traits of Bandarah laying hens. Results recorded that, there was a significant (p<0.05) increase in shell % by 5.2, 5.4 and 6.8 % over the control value. Likewise, shell thickness and Haugh unit % (HU) significantly (p<0.01) improved for laying hens fed diet with boron by 5.4, 8.1 and 8.1 % for shell thickness and 5.2, 6.5 and 12.1% for HU above the control value for 100, 200 and 300 mg boron/kg, respectively. The Haugh unit is a known indicator of egg freshness and is related to shelf life. The improvement in HU may indicate that boron supplementation can improve egg quality by increasing its shelf life. These results are in...
agreement with Yesilbag and Eren (2008) who observed that improvement of eggshell thickness in laying hens fed diets supplemented with boric acid (25, 50 and 100 mg/kg). Mizrak et al. (2008a; 2010) showed a significant increase of HU for laying hens fed diets that included 25 and 50 mg boron/kg. While, Shape index, yolk color score, albumen % and yolk % were not affected by supplemented boron. Similar results were confirmed by Sizmaz et al. (2014).

Mineral contents of the eggshell
Data of Figure 1 illustrate that there was a significant effect (p<0.01) of adding boron to layer diets at different levels on calcium, phosphorus and boron contents of the eggshell. This effect was in a level-dependent manner, whereas, Ca accumulation in eggshell significantly increased with increasing dietary boron level. The same trend was shown with eggshell phosphorus, which showed a significant (p<0.01) increase by increasing boron level. These findings are confirmed with those previously reported by Mizrak et al. (2008b) who reported that the supplementation of boron to layer diets significantly increased the calcium accumulation in eggshell as compared to the control value. In addition, Mizrak and Ceylan (2008) recorded that adding organic or inorganic boron to laying hens rations (25, 50 and 75 ppm) increased Ca and P in eggshell.

With respect to boron accumulation in eggshell, it could be speculated that eggshell B significantly (p<0.01) increased by increasing boron level in the diets. This result was in harmony with finding of Mizrak and Ceylan (2008) who revealed that eggshell B was significant increase with increasing dietary boron.

The improvement in eggshell quality resulted in dietary boron could be attributed to increase the calcium deposition in the eggshell and effects of boron on metabolism of Ca, P, Mg and vitamin D (Nielsen and Shuler, 1992; Naghii and Samman, 1993; Nielsen, 1988a).

Blood parameters
Plasma minerals: Data of figure 2 illustrate that plasma minerals (Ca, P, Cu, Fe, and B) were significantly (p<0.01) increased by addition boron at different levels. Whereas, plasma Ca, Fe and B concentrations increased (p<0.01) with the increase of boron levels. Additionally, plasma P and Cu concentrations increased resulted from supplemental boron compared to control value. The increase of these minerals in plasma may be attributed to boron can interact with the metabolism of some macro-elements such as Ca, P and Mg, thereby modifying their concentration in the serum of chickens (Kurtoglu et al., 2001, 2005; Bozkurt et al., 2012). According to Nielsen (1988a), Boron’s unique chemistry allows it to react with many other metabolites and enzymes, and thus may be capable of modifying mineral and energy metabolism in humans and animals.

These results are in corresponding with Kurtoglu et al. (2001) who reported that boron addition at level 25 mg/kg had a positive effect on plasma Ca and P of chicks. Olgun et al. (2012) concluded that the addition of boron (60, 120 and 240 mg/kg) to layer ration significantly increased plasma B and Cu concentrations especially with levels of 120 and 240 mg/kg. Moreover, Kucukyilmaz et al. (2016) confirmed that the addition of boron to the diet resulted in significant increase in the boron concentration of serum.

Hematological parameters: Values of Hb, RBC’s, PCV% and WBC’s for Bandarah laying hens fed diet supplemented with boron are presented in Table 4. Data showed that all previous parameters were significantly increased by dietary boron. Whereas, Hb concentration was significantly increased by 9.3, 25.6 and 27.6% above the control group. The same trend was shown in the RBC’s counts which showed a significant (p<0.01) increase by
increasing boron level. The highest value of PCV was recorded for laying hens fed high level (300 mg/kg) of boron. The present results concerning the increasing of plasma Fe and Cu concentrations may be reflected on significant improving of blood picture. Similar results were confirmed by Ali et al. (2014) noticed that adding of boron to broiler diets at doses (75, 150 and 250 mg/kg) increased Hb, PCV%, RBCs and WBCs. Additionally, boron increase the response of cell membrane of blood cell to erythropoietin and this hormone synthesized in the kidney which plays an essential role in the maturation of red blood cell precursors in bone marrow (Nielsen et al., 1991).

Biochemical parameters:
Results of Table 5 indicated that plasma total protein, albumin and globulin were increased by adding boron to layer diets. Total protein and globulin were significantly increased while increase in albumin was not significant. Thus, these increases were 17.4, 17.6 and 18.2% of total protein, 7.1, 8.0 and 8.6% of albumin and 34.9, 33.9 and 34.4% of globulin concentration above the control value for 100, 200 and 300 mg boron/kg diet, respectively. The same finding was found by El-Saadany et al. (2016) when they fed male chicks on 100, 200 and 300 mg boron/kg feed. Likewise, our findings were confirmed upon examination of boron on rabbits (Elkomy et al., 2015). As a result, supplemental boron had a beneficial effect on hens’ health.

Data of Table 5 represent the influence of dietary boron on lipid profile (total lipids, cholesterol, HDL and LDL) for Bandarah layer hens. Whereas, plasma total lipids, cholesterol and LDL were significantly (p<0.01) decreased by adding boron to layer diets. While, plasma HDL was significant increased compared with control value. The lowest total lipids, cholesterol and LDL were recorded for hens fed basal diet with addition 200 mg boron/kg. These findings were confirmed upon examination of boron on laying hens (Eren and Uyanik, 2008) and rabbit (Basoglu et al., 2010). Results revealed that the hypocholesterolemic due to the effect of boron may be a result of either a direct effect on the liver or an indirect effect through thyroid hormones which may affect the reactions in almost all the pathways of lipid metabolism.

Glucose concentrations for Bandarah laying hens fed different levels of boron are shown in Table 5. It can be observed from data of this table that plasma glucose concentrations were significantly (p<0.05) increased resulted in dietary boron compared with control value while, there were no significant differences among boron groups. The results of significant increase of plasma glucose could be attributed to increased thyroid gland activity, whereas, the T3 concentration was significantly increased with increase boron level in the current study. These results are in agreement with Hunt et al. (1994) who mentioned that supplemental dietary boron increased plasma glucose concentrations, particularly when vitamin D deficiency existed in chicks.

It appears from the results of Table 5 that supplemental boron significantly (p<0.01) decreased liver aminotransaminase enzymes activities (AST and ALT). Thus, these decreases were 4.4, 10.0 and 9.7% of AST, 7.3, 10.0 and 9.3% of ALT activities less than the control value for 100, 200 and 300 mg boron/kg diet, respectively. The improvement in liver function may be attributed to protective effects of the boron on normal liver metabolism (Hunt and Herbel, 1991a; and Ince et al., 2012). The present results concerning the decreasing of the serum transaminases activities are in agreement with the results obtained by Eren and Uyanik (2007) when they adding boron in layer diets. Likewise, our findings were confirmed upon examination of boron on broiler chicks (Eren et al., 2012) and rabbits (Elkomy et al., 2015). Results concerning the effect of supplemental boron on thyroid hormone secretion (T3) concentration in laying hens

are presented in Table 5. It could be speculated that the boron supplementation significantly (p<0.01) increased serum T3 concentration compared with control value and this increasing was in a level-dependent manner. These results are correspondence with Cinar et al. (2015) who stated that serum T3 and T4 activities increased with higher boron (60 mg/kg) supplementation in broiler chickens. The improvement in thyroid hormone secretion in current study may be due to the effect of boron on stimulate energy metabolism. According to Hunt (1998), boron affects the activities of at least 26 different enzymes, most of these enzymes are necessary for energy substrate metabolism.

Semen traits

Table 6 shows the effect of dietary boron on semen quality characteristics (ejaculate volume, sperm concentration, sperm motility, sperm abnormality, and sperm motility index), fertility and hatchability of eggs fertile. Boron supplementation to cocks diet significantly improved semen quality. Whereas, a significant increase (p<0.01) was observed in ejaculate volume by 32.3, 35.5 and 41.9% above the control value for 100, 200 and 300 mg boron/kg diet, respectively. This increase was in a level-dependent manner. The same trend was shown in the sperm concentration, sperm motility and sperm motility index. The increased sperm concentration in the boron groups was reflected on significant increase in semen ejaculate volume. According to Kamel et al. (2009), increase in ejaculate volume was necessary for sperm to provide them by nutritious elements that are needed for their live. On the other hand, the percentage of abnormal sperm was significantly decreased with increasing boron level to reach, and % less than the control group. These results are in agreement with Elkomy et al. (2015) who concluded that adding boric acid to bucks’ ration (100, 200 and 400 mg/kg) improved semen quality characteristics.

The improvement in semen quality reported in the present study may be attributes to the boron affects several enzymes that stimulate the spermatogenesis to produce a complete sperm. Whereas, boron affects the activities of at least 26 different enzymes, most of these enzymes are necessary for energy substrate metabolism (Hunt, 1998).

Fertility and hatchability percentage

Boron supplementation significantly (p<0.05) increased fertility and hatchability of fertile eggs percentage (Table 6). This increase was in a level-dependent manner. This result is in contrast with Rossi et al. (1993) who reported that fertility and hatchability were not affected when broiler breeder fed on two sources of boron at level (0-250 mg/kg).The beneficial effect of boron on fertility and hatchability in the present result may be due to the mechanism of boron action by increasing the concentration of steroid hormones such as testosterone and beta-estradiol (Naghii and Samman, 1993). Likewise, Benderdour et al. (1998) confirmed that supplemental boron caused increasing in the serum concentration of 17 beta-estradiol and testosterone. Indeed, thyroid hormones are involved in numerous physiological processes thus increase of serum T3 concentration by adding boron in the current study may be reflected on fertility.

CONCLUSION

As a result of the current study, it can be concluded that boron supplementation in layer diets had a positive effect on plasma minerals (Ca, P, Fe, Cu and B) and minerals of egg shell (Ca, P and B). However, shell thickness, Haugh unit, physiological status, semen quality, fertility and hatchability were improved by adding boron at different studied level. It is suggested that up to 300 mg boron/kg diet could be used in layer diets without any adverse effect on laying hens performance.
**Table (1):** Composition* and the nutritive value of the basal diets

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>%</th>
<th>Calculated Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>yellow Corn</td>
<td>63.55</td>
<td>Crude Protein, %</td>
</tr>
<tr>
<td>Soybean M. (CP44%)</td>
<td>25.10</td>
<td>ME, Kcal/kg</td>
</tr>
<tr>
<td>Premix**</td>
<td>0.30</td>
<td>Crud fiber, %</td>
</tr>
<tr>
<td>NaCl</td>
<td>0.40</td>
<td>Ca, %</td>
</tr>
<tr>
<td>Di. Ca. phosphate.</td>
<td>1.45</td>
<td>P (va), %</td>
</tr>
<tr>
<td>Limestone</td>
<td>8.10</td>
<td>Ly, %</td>
</tr>
<tr>
<td>Mineral supplementations</td>
<td>1.00</td>
<td>Meth, %</td>
</tr>
<tr>
<td>DL-methionine (Meth)</td>
<td>0.10</td>
<td>Total sulphur amino acids %</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>


**Composition of premix in 3 kg is: Vit. A, 10,000,000 IU; Vit. D₃, 2,000,000; Vit. E, 10,000 mg; Vit. K₃, 1,000 mg; Vit. B₁, 1,000 mg; Vit. B₂, 4,000 mg; Vit. B₆, 1,500 mg; Vit. B₁₂, 10 mg; Niacin, 20,000 mg; Pantothenic acid, 10,000 mg; Folic acid, 1,000 mg; Biotin, 50 mg; Choline chloride, 500,000 mg; Cu, 3,000 mg; Iodine, 300 mg; Fe, 30,000 mg; Mn, 40,000 mg; Zn, 45,000 mg; Selenium, 100 mg.

**Table (2):** Productive performance of Bandarah laying hens fed diets supplemented with different levels of boron

<table>
<thead>
<tr>
<th>Parameters</th>
<th>boron levels (mg/kg diet)</th>
<th>SEM</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>Egg weight (g)</td>
<td>51.17</td>
<td>52.34</td>
<td>52.75</td>
</tr>
<tr>
<td>Egg production (%)</td>
<td>52.18</td>
<td>52.75</td>
<td>53.02</td>
</tr>
<tr>
<td>Egg mass (g/h/d)</td>
<td>26.69</td>
<td>27.62</td>
<td>27.97</td>
</tr>
<tr>
<td>Feed consumption(g/h/d)</td>
<td>117.37</td>
<td>117.59</td>
<td>117.54</td>
</tr>
<tr>
<td>Feed conversion ratio(g feed/ g egg)</td>
<td>4.40</td>
<td>4.27</td>
<td>4.21</td>
</tr>
</tbody>
</table>

Sig. = Significance, NS = Not Significant. SEM = Standard error mean.
### Table (3): Egg quality of Bandarah laying hens fed diets supplemented with different levels of boron

<table>
<thead>
<tr>
<th>Parameters</th>
<th>boron levels (mg/kg diet)</th>
<th>SEM</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>Shell ( % )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>11.18^b</td>
<td>11.76^a</td>
<td>11.78^a</td>
</tr>
<tr>
<td>Shell thickness (mm)</td>
<td>0.37^b</td>
<td>0.39^a</td>
<td>0.40^a</td>
</tr>
<tr>
<td>Haugh unit %</td>
<td>80.16^c</td>
<td>84.31^b</td>
<td>85.33^b</td>
</tr>
<tr>
<td>Shape index (%)</td>
<td>74.84</td>
<td>74.58</td>
<td>74.93</td>
</tr>
<tr>
<td>Yolk color score</td>
<td>6.6</td>
<td>6.4</td>
<td>6.4</td>
</tr>
<tr>
<td>Albumen (%)</td>
<td>56.59</td>
<td>55.96</td>
<td>56.00</td>
</tr>
<tr>
<td>Yolk (%)</td>
<td>32.23</td>
<td>32.28</td>
<td>32.22</td>
</tr>
</tbody>
</table>

a, b, c Means in the same row with different superscripts, differ significantly (p<0.05). Sig. = Significance, *(p<0.05), **(p<0.01). NS = Not Significant. SEM = Standard error mean.

### Table (4): Hematological parameters of Bandarah laying hens fed diets supplemented with different levels of boron

<table>
<thead>
<tr>
<th>Parameters</th>
<th>boron levels (mg/kg diet)</th>
<th>SEM</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>Hb (g/dl)</td>
<td>10.10^c</td>
<td>11.03^b</td>
<td>12.69^a</td>
</tr>
<tr>
<td>RBCs (10^6/mm³)</td>
<td>2.15^c</td>
<td>2.90^b</td>
<td>3.26^a</td>
</tr>
<tr>
<td>PCV ( % )</td>
<td>28.83^c</td>
<td>31.38^b</td>
<td>31.50^b</td>
</tr>
<tr>
<td>WBCs (10³/mm³)</td>
<td>6.43^b</td>
<td>7.58^a</td>
<td>7.43^a</td>
</tr>
</tbody>
</table>

a, b, c Means in the same row with different superscripts, differ significantly (p<0.05). Sig. = Significance, **(p<0.01). SEM = Standard error mean.

Hb= hemoglobin; RBC= red blood cells; PCV= packed cell volume; WBC= white blood cells.
Table (5): Some blood constituents of Bandarah laying hens fed diets supplemented with different levels of boron

<table>
<thead>
<tr>
<th>Parameters</th>
<th>boron levels (mg/kg diet)</th>
<th>SEM</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>Total protein (g/dl)</td>
<td>5.17&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.07&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.08&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Albumin (g/dl)</td>
<td>3.25</td>
<td>3.48</td>
<td>3.51</td>
</tr>
<tr>
<td>Globulin (g/dl)</td>
<td>1.92&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.59&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.57&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Total lipids (mg/dl)</td>
<td>423.13&lt;sup&gt;a&lt;/sup&gt;</td>
<td>401.18&lt;sup&gt;b&lt;/sup&gt;</td>
<td>381.16&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Cholesterol (mg/dl)</td>
<td>160.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>145.94&lt;sup&gt;b&lt;/sup&gt;</td>
<td>140.77&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>HDL (mg/dl)</td>
<td>33.60&lt;sup&gt;c&lt;/sup&gt;</td>
<td>39.12&lt;sup&gt;b&lt;/sup&gt;</td>
<td>42.73&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>LDL (mg/dl)</td>
<td>88.35&lt;sup&gt;a&lt;/sup&gt;</td>
<td>84.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>79.96&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Glucose (mg/dl)</td>
<td>163.95&lt;sup&gt;b&lt;/sup&gt;</td>
<td>173.92&lt;sup&gt;a&lt;/sup&gt;</td>
<td>174.46&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>AST (U/L)</td>
<td>66.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>63.12&lt;sup&gt;b&lt;/sup&gt;</td>
<td>59.38&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>ALT (U/L)</td>
<td>29.09&lt;sup&gt;a&lt;/sup&gt;</td>
<td>26.97&lt;sup&gt;b&lt;/sup&gt;</td>
<td>26.27&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>T3 (ng/ml)</td>
<td>1.90&lt;sup&gt;d&lt;/sup&gt;</td>
<td>2.16&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.58&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

a, b, c, d, Means in the same row with different superscripts, differ significantly (p<0.05). Sig. = Significance, *(p<0.05), ** (p<0.01). NS = Not Significant. SEM = Standard error mean.
HDL= High density lipoprotein; LDL= Low density lipoprotein; T3= Triiodothyronine.
**Table (6):** Physical semen traits, fertility and hatchability of Bandarah cocks fed diet supplemented with different levels of boron.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Boron levels (mg/kg diet)</th>
<th>Pooled SEM</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>Ejaculate volume (ml)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.31&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.41&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.42&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sperm concentration (10&lt;sup&gt;9&lt;/sup&gt;/ml)</td>
<td>1.93&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.18&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.49&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sperm motility (%)</td>
<td>89.16&lt;sup&gt;c&lt;/sup&gt;</td>
<td>91.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>94.04&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sperm abnormality (%)</td>
<td>11.74&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10.06&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.76&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sperm motility index</td>
<td>94.50&lt;sup&gt;c&lt;/sup&gt;</td>
<td>95.51&lt;sup&gt;b&lt;/sup&gt;</td>
<td>97.04&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fertility (%)</td>
<td>87.53&lt;sup&gt;d&lt;/sup&gt;</td>
<td>90.27&lt;sup&gt;c&lt;/sup&gt;</td>
<td>91.59&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Hatchability of fertile eggs %</td>
<td>86.41&lt;sup&gt;d&lt;/sup&gt;</td>
<td>89.33&lt;sup&gt;c&lt;/sup&gt;</td>
<td>90.81&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

a, b, c, d Means in the same row with different superscripts, differ significantly (p<0.05). Sig. = Significance, *(p<0.05), **(p<0.01). SEM = Standard error mean.
Fig. 1: Eggshell calcium, phosphorus and boron of Bandarah laying hens fed diet supplemented with different levels of boron.
Fig. 2: Plasma minerals of Bandarah laying hens fed diet supplemented with different levels of boron.
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تأثير إضافة البورون على الأداء وبعض القياسات الفسيولوجية في دجاج البندرة

2- فترة إنتاج البيض

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القسم:
قسم بحوث تربية الدواجن، معهد بحوث إنتاج الحيوان، مركز البحوث الزراعية، وزارة الزراعة

تهدف هذه الدراسة إلى تقييم تأثير إضافة البورون إلى المغذي على الأداء وдинاميات وبعض الصفات الفسيولوجية. استخدم في هذه الدراسة 100 دجاجة بندرة و20 ديدك عمر 28 أسبوع وتمت التربيه في أقفاص فردية ووزعها عشوائيا على أربع مجموعات كل مجموعة بـ25 دجاجة و5 ديدك واستمرت التجربة حتى عمر 44 أسبوع. استنمت طيور المجموعة الأولى كالكمنة مقارنة (كنترول) وغذيت على العلائق الأساسية بدون إضافة وثلاث مجموعات تتالي غذيت على العلائق الأساسية مضافة إليها البورون بـ 1.11، 2.11 و 3.11 ملجم/كجم من العلف.

أشارت النتائج إلى أن إضافة البورون في علائق الدجاج البياض ليس له تأثير معنوي على كل من إنتاج البيض - كتلة البيض - استهلاك العلف والفائدة التي تمثلت بمجموعة الكمترول. لوحظ زيادة غير معنوية في وزن البيض في المجامع المعاملة ووجدت زيادة معنوية في نسبة الملونة للقشرة وكمية القشرة ووحدات هيموغرام مع زيادة مستوى البورون في العلف، بينما لم تتأثر كل من نPLAYER النبضات ونسبة البدانة والعديد من الصفات المذكورة.

إضافة عنصر البورون إلى علائق الدجاج البياض أدى إلى زيادة معنوية في تركيز كل من الكالسيوم والفسفور والبورون في قشرة البيضة وأيضاً زادت نسبة كل من عنصر الكالسيوم والفسفور والحمض النووي في فوستون البورون في بلازما الدم. وсталت زيادة معنوية في تركيز البورون في بلزما الدم، حيث أظهرت النتائج تأثيرًا إيجابيًا على نسبة المولعين في البلازما، حيث أن زيادة مستوى البورون في العلف أثرت بشكل إيجابي على تركيز كل من عنصر الكالسيوم والفصوف والبورون والكحول في الدم، بينما لم تتأثر كل من تركيز الجلوكوز والهيموغرام وعدد كرات الدم الحمراء والبيضاء.

ووجدت النتائج تأثيرًا إيجابيًا على تركيز كل من عنصر الكالسيوم والفصوف والبورون والكحول في الدم، بينما لم تتأثر كل من تركيز الجلوكوز والهيموغرام وعدد كرات الدم الحمراء والبيضاء.

ومن المقترح أن يمكن إضافة البورون في علائق الدجاج البياض حتى مستوى 3.00 ملجم/كجم بدون أي تأثير سلبي على أداء الدجاج البياض.

122