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Productive Performance and Hatchability of Alabio Ducks (*Anas platyrhynchos Borneo*) under Rural Feeding Management: Comparison of Different Dietary Protein Levels and Sex Ratios

Research Article

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ABSTRACT

An experiment was conducted to assess the optimum nutrient requirement and ideal mating ratios for Alabio ducks for production of fertile eggs and hatchability under rural feeding management. A total of 135 forty weeks old females and 27 males were used in the study. They were fed on low (17.5%), medium (19.5%) and high (21.5%) crude protein (CP) in diets containing approximately 3050 kcal of metabolizable energy (ME)/kg and maintained for 18 weeks in three mating ratios, each replicated three times. The ratios of natural mating were: 1:4, 1:5 and 1:6. A total of 450 selected hatching eggs per treatment were collected and stored for 4 to 6 days, then were incubated for hatching performance. Egg production (EP), feed conversion ratio (FCR) and egg weight (EW) were determined and it was found that feeding regimens influenced these parameters. Feeding 19.5% CP diet showed the highest values of egg production (EP), feed conversion ratio FCR, egg weight (EW) and egg mass production (EM) during 40 to 58 wks. The values of feed intake (FI), EP, FCR and EM were affected by sex ratios. The ratio of 1:4 was the best mating ratio for local ducks with higher productive performance. The 19.5% crude protein diet was adequate for hatching performance at sex ratio of 1:5.

KEY WORDS egg production, egg weight, fertility, natural mating.

INTRODUCTION

Alabio duck (*Anas platyrhynchos Borneo*) is one of local ducks dominating the leading duck egg producer in Indonesia. Under intensive system, egg production of Alabio ducks was about 200-240 eggs (Tabane, 1992). However, intensive system with a traditional feeding system, the genetic potential of local ducks for productive and reproductive performance may not be fully expressed. Low quality diet and underfeeding in rural feeding management in terms of substandard nutrient requirements of ducks are thought to be responsible for the low production and hatchability of this waterfowl. Many studies have shown the significant role of dietary protein or essential amino acids and energy in improving the productive performance in poultry (Thongwittaya and Tasaki, 1992; Shim *et al*. 2013; Fouad and El-Senousey, 2014). A high protein level (16.5%) offered considerably higher egg production in crossbred laying ducks than ducks fed on 13.5 and 15% protein diets (Thongwittaya and Tasaki, 1992). Feeding both 15 and 17% crude protein (CP) diets significantly improved egg production and feed conversion ratio (FCR) during the experimental period (26 to 49 wks) in Sudani ducks as local breeds in Egypt (Awad *et al*. 2013). Protein (Tyler and Bekker, 2012; Fazhana and Azhar, 2014) and energy levels (Tadondjou *et al*. 2013) of rooster's diet affected testicular

development and semen quality (Tyler and Bekker, 2012; Tadondjou *et al*. 2013), which further determined egg fertility and hatchability. Nahashon *et al.* (2007) found 2,800 kcal of ME/kg diet and 14% protein diet resulted in higher laying performance in pearl grey guinea fowl hens than 16 and 18% protein diets. Studies of Uğurlu *et al*. (2017) in pheasants (*Phasianus colchicus*) reported that increasing dietary protein (from 15 to 18%) increased egg production, egg and hatching weight and hatchability of fertile eggs. In other words, feeding strategies which provide particular protein and or energy levels determined body weight relating to hatchability and fertility (Silveira *et al*. 2014). In addition, the protein and energy levels necessary to increase performance was variable depending among poultry breeds (Filho *et al*. 2012; Kokoszyński *et al*. 2015).

Another problem affecting the low productivity of local ducks under rural production system is mating management. Our preliminary studies particularly in Lombok showed that the mating ratios of 1:10 to 1:15 were normally applied by smallholders to Alabio ducks. We assume that different breeds or species probably need different mating ratios. However, detailed information on ideal mating ratios of Alabio ducks are lacking. In the light of the above, a study, aimed at determining proper diets and sex ratios of local duck hens, which offered the high egg production and hatchability at village farm levels was conducted.

MATERIALS AND METHODS

The experiment was conducted at the duck farmer group in Mataram city, Indonesia. Its members are small scale farmers holding 50 to 100 birds per farmer. We used similar breed as farmers do and imitated their feeding and breeding management with a slight modification. A total of 135 forty-weeks-old local female and 27 male ducks were arranged in a completely randomized design. The treatments included factorial combinations of three dietary protein (CP) levels and three mating ratios. The birds were randomly allocated to the three dietary treatments, which were replicated four times.

The three different protein levels in diets were: 17.5% (low protein, LP), 19.5% (medium protein, MP) and 21.5% (high protein, HP), containing approximately 3,050 kcal of ME/kg. The chemical composition of the experimental diet was analyzed according to the Association of Official Analytical Chemists (AOAC, 1990). The feedstuffs used in the study were ingredients traditionally used by the local duck farmers; but there are no particular standards. Ingredient and chemical composition of the experimental diets are presented in Table 1. The ratios of natural mating were: 1:4, 1:5 and 1:6, respectively.

A local commercial mineral produced by P.T. Medion was added to supply the trace minerals. The birds were reared on deep litter with rice husk and rice straw as litter in conventional open-sided house under natural day light. The ducks had drinking water access *ad libitum* without water pond. The density of one duck was 0.25, 0.20 and 0.19 m^2/bird for mating ratios of 1:4, 1:5 and 1:6, respectively.

For measuring hatching performance, a conventional incubation was applied using local incubators. There were three small incubators with capacity of 300 eggs and hatching eggs were collected starting at the 46th week and was carried out in the morning. A total of 450 hatching eggs per treatment were collected and then stored at room temperature (at 29 to 31 ˚C at day and 23 to 26 ˚C at night with 62 to 80% relative humidity) for 4 to 6 days. Prior to incubation, the eggs were washed with warm water and dried using a clean tissue. The eggs were then set in the incubators for hatching. The temperature and relative humidity of the incubator were maintained between 38 to 39 ˚C and 70 to75%, respectively. Egg turning was applied 3 times a day with 8 hour intervals. To determine fertility, dead in-germ and dead in-shell, candling was made on the day 5th, 17th and 24th, respectively. Abnormal ducklings as defined by Joseph and Moran (2005) and Rashid *et al*. (2009) that blindness, open navels, small in size (low post-hatching weight), defect in shape and other abnormalities were culled. The hatching process was replicated in three times. Fertility and hatchability were calculated using the formula:

Fertility (F)= (number of fertile eggs/total eggs set) × 100%
Hatchability (fertile egg basis) or HF= (number of hatched ducklings/number of fertile eggs) × 100%
Hatchability (egg set basis) or HS= (number of hatched ducklings/number of eggs set) × 100%
Dead in-germ or DG= (number of dead embryo/number of eggs set) × 100%
Dead in-shell or DS= (number of dead ducklings in shell /number of egg sets) × 100%
Normal ducklings= (number of normal ducklings/number of hatched ducklings) × 100%

Measurements

The following parameters were measured and analyzed to assess the productive performance. Feed intake (FI) was calculated by subtracting feed residue weights from feeders and drinking water from the total feed. Egg production was recorded daily and was calculated on weekly basis of cumulative production. Egg weight was recorded on individual egg basis. Egg mass production (EM) was calculated by multiplying average egg weight and egg production percentage.

Table 1 Composition of experimental diets

Ingredients	Low protein (g/kg)	Medium protein (g/kg)	High protein (g/kg)
Corn	300	350	275
Rice bran	475	350	350
Fresh water fish	190	240	290
Duckweed	25	50	75
Commercial mineral[1]	10	10	10
Total	1000	1000	1000
Calculated analysis			
Metabolizable energy (kcal/kg)	3,059	3,050	3,052
Crude protein (%)	17.5	19.5	21.5
Crude fiber (%)	12.7	11.1	11.6
Lysine (%)	1.62	1.92	2.30
Methionine (%)	0.73	0.80	0.92
Calcium (%)	2.5	2.4	2.3
Available phosphor (%)	1.0	1.0	1.0

[1] Commercial mineral supplied the trace minerals (per kg of diet) as follows: Steam bone meal:10000 mg; Calcium: 9744 mg; Manganese: 8 mg; Iodium: 1 mg; Iron: 60 mg; Copper: 4 mg; Zinc: 50 mg; Magnesium: 58 mg; vitamin D_3: 1500 IU and vitamin B_{12}: 0.01 mg.

Feed conversion ratio (FCR) was calculated by dividing the total of feed consumed with the total egg mass.

Body weight at the beginning and end of the study was recorded. The experimental feeding lasted for 18 weeks from 40 to 58 weeks of age.

Statistical analysis

The data were subjected to analysis of variance (ANOVA) following the general linear model (GLM) procedure of SAS (SAS, 1985). The differences between the means of groups were identified by the test of Tukey at 5% significant level.

RESULTS AND DISCUSSION

Productive performance

Table 2 presents data on productive performance of the local ducks as influenced by factors such as diets with different levels of protein and sex ratios, besides their interaction effects. All parameters were affected by both levels of dietary protein and sex ratios ($P<0.0001$). There was also significant interaction among the tested factors ($P<0.0001$). The ducks fed with the protein level of 17.5% (LP) had the minimum feed intake and feed intake increased by 13.1% and 16.1% respectively for ducks fed with MP and HP diets. With the lowest feed intake in LP diet, egg production also was the lowest. Egg production increased by 19.3% and 6.4% respectively for ducks fed with MP and HP diets. MP diet group showed higher egg production (59.9 %) than LP (50.2%) and HP (53.4%) diets, indicating that maximum egg production may not be achieved by feeding HP diets.

Egg weight increased by 1.0% but it was reduced by 0.6% in hens fed with the medium and high protein diets compared to the low level of protein diet. MP diet group presented the heaviest egg weight (63.2 g/egg).

Feed conversion ratio (FCR) under different dietary protein regimens revealed the lowest value for groups provided with MP diet (4.111). Egg mass production also showed the highest value for MP diet. Overall, MP diet showed higher egg production than those of birds fed with LP and HP diets throughout the study. The trend of egg production in MP group was nearly steady on higher levels and a sharp at 52 wks compared to other groups (Figure 1). This demonstrates that 19.5% crude protein diet (MP) with 3050 kcal of ME/kg is adequate for local ducks to produce eggs. Tarasewicz *et al.* (2006) also noticed that in Japanese quail lower daily feed intake was shown by groups fed with low protein diet. Other consequences included low egg production, feed consumed/kg eggs laid as well as egg mass production were observed. Junqueira *et al.* (2006) in laying hens and Awad *et al.* (2013) in local laying ducks found that higher protein levels did not have any effect on laying performance.

Reduced performance in egg production of laying poultry fed with high protein and energy was associated with excessive caloric consumption (Fouad and El-Senousey, 2014), which leads to fatness. However, the fact that egg production improved at the lower level of dietary protein indicate that the requirement of dietary protein at this level is sufficient to meet the requirements of egg production (Junqueira *et al.* 2006). These results are in agreement with the report of Enting *et al.* (2007) who worked with broiler breeder demonstrating that low-density diets given during rearing increased egg weight. The review by Alagawany *et al.* (2016) clearly point out that adequate supply of protein is essential for maintaining productive performance and for protecting environment from negative effect of high protein diets as well as increasing the profit due to protein sources are expensive. Furthermore, the birds have also limited capacity to use the protein diets.

Table 2 Productive performance of laying Alabio ducks as influenced by varying dietary protein levels and sex ratios

Item	Feed intake (g/bird/day)	Egg production (%)	FCR (g of feed/g of egg mass)	Egg weight (g/egg)	Egg mass production (g/bird/day)
Dietary protein (%)					
LP (17.5)	137^{b}	50.2^{b}	4.396^{b}	62.6^{b}	31.2^{b}
MP (19.5)	155^{a}	59.9^{a}	4.111^{c}	63.2^{a}	37.7^{a}
HP (21.5)	159^{a}	53.4^{a}	4.800^{a}	62.2^{b}	33.1^{b}
SEM	2.7	3.0	0.442	0.5	1.8
Sex ratio (SR)					
1:4	158^{a}	57.1^{a}	4.398^{b}	63.5^{a}	35.9^{a}
1:5	152^{a}	53.7^{b}	4.418^{a}	64.5^{a}	34.4^{a}
1:6	142^{b}	52.7^{b}	4.483^{a}	59.9^{b}	31.7^{b}
SEM	2.7	3.0	0.442	0.5	1.8
Dietary protein × sex ratio interaction					
LP (17.5) -1:4	157^{a}	47.5^{b}	5.072^{a}	65.7^{a}	31.0^{a}
LP (17.5) -1:5	136^{a}	44.3^{b}	4.751^{a}	64.6^{a}	28.6^{b}
LP (17.5) -1:6	118^{b}	58.7^{a}	3.480^{b}	57.4^{b}	33.9^{a}
MP (19.5) -1:4	151^{a}	51.3^{a}	4.609^{a}	64.0^{a}	32.8^{a}
MP (19.5) -1:5	154^{a}	67.2^{a}	3.666^{b}	62.7^{ab}	42.0^{a}
MP (19.5) -1:6	160^{a}	61.2^{a}	4.171^{a}	62.8^{a}	38.4^{a}
HP (21.5) -1:4	166^{a}	72.5^{a}	3.768^{b}	60.9^{b}	44.1^{a}
HP (21.5) -1:5	165^{a}	49.7^{a}	5.064^{a}	66.2^{a}	32.6^{a}
HP (21.5) -1:6	147^{a}	38.2^{b}	6.467^{a}	59.6^{b}	22.7^{b}
SEM	4.7	5.2	0.766	0.8	3.1
Probability					
Protein	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Sex ratio	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Protein × SR	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001

LP: low protein; MP: medium protein and HP: high protein.
The means within the same column with at least one common letter, do not have significant difference (P>0.0001).
SEM: standard error of the means.

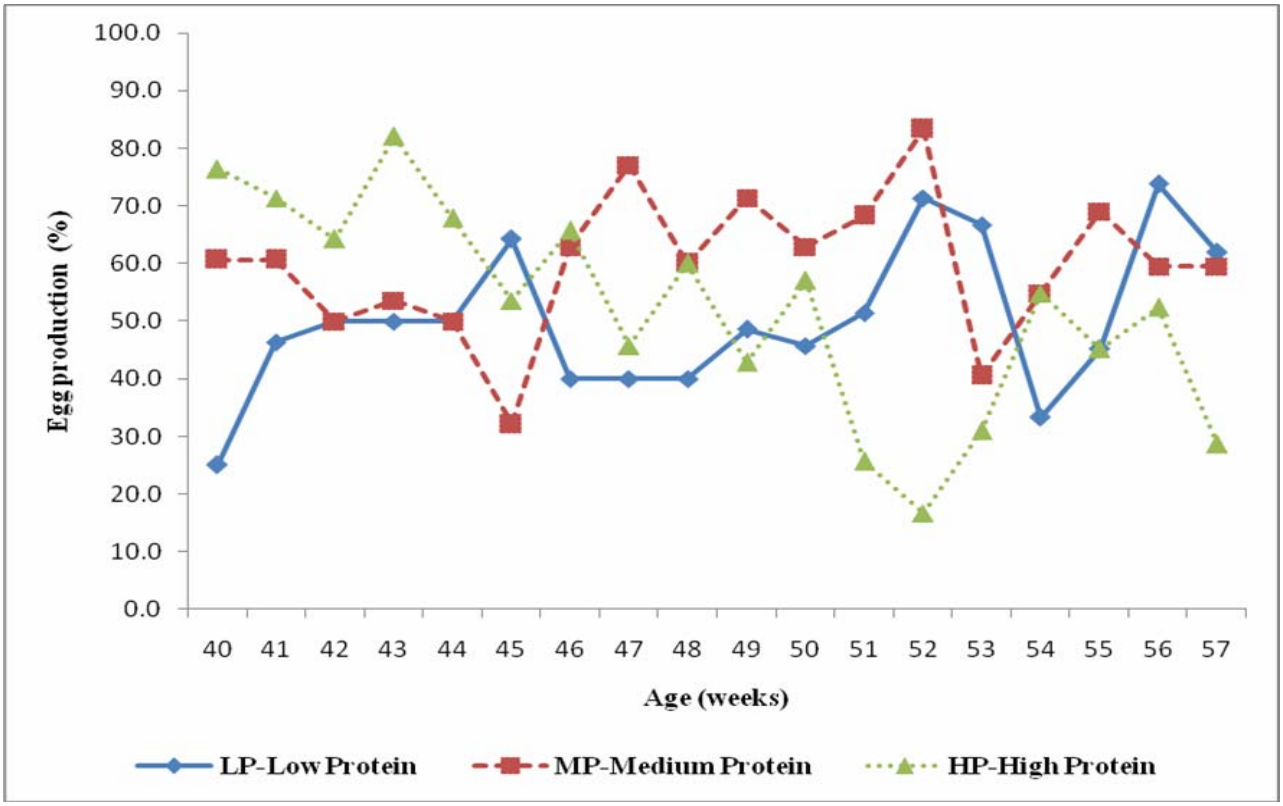

Figure 1 Weekly hen day production of local ducks subjected to different levels of protein from 40 to 58 weeks of age

As regards effect of sex ratios on productive performance, sex ratios of 1:4 or 1:5 showed better feed intake, egg number, egg weight and egg mass with improved FCR. The differences in egg weight as a function of different sex ratios could be explained by the increase in feed intake for the sex ratios 1:4 and 1:5, as a result of the variation in number of birds per group (Ayoola *et al*. 2017). This tendency was reflected in the egg mass production, egg production and FCR (Table 2). There is also an interaction between dietary regimens and sex ratios on productive performance (P<0.0001). In this study, local ducks that were fed with MP diet regardless of the sex ratios recorded the highest egg production. For better performance in terms of improved FCR, higher egg number and egg mass production, the diet containing 19.5% protein was adequate for productive performance.

Hatching performance

Table 3 presents data on hatching performance (fertility, hatchability, dead in-germ, dead in-shell and normal chicks) of local ducks as influenced by dietary protein intake and sex ratios and their interactions. LP diet showed 18.1% and 7.7% higher fertility than those of MP and HP diets (P<0.0001), respectively. Fertility and hatching records of HS, DG, normal chicks (NC) were higher but DG and DS were lower in local ducks fed with LP diet than those fed with MP and HP diets. Higher fertility and hatching percentage in local ducks fed with 19.5% protein is probably related to the higher body weight arising from larger hatching eggs (Tables 3 and 4). Body weight increased in all groups during 18 weeks of study as shown in Table 4. Our results support the finding of Polat *et al*. (2003), who found that in ostriches (*Struthio camelus*) high protein (23% dietary protein) produced lower fertility (61.1±5.35%) than those of groups fed 20% protein diet (81.2±2.84%). Lotfi *et al*. (2018) found high levels of energy and protein increase performance on egg quality and hatchability in quail breeder.

Fazhana and Azhar (2014) observed that in red jungle fowl male (*Gallus gallus*), medium levels of dietary protein (16%) resulted in better semen quality than those fed with 10 and 20% protein diets. This relates to protein levels effect on body weight required for testis development (Tadondjou *et al*. 2013). Orunmuyi *et al*. (2013) also provided evidence to show that there is positive correlation between body weight and semen quality.

As for sex ratio effect (Table 3), highest percentage of fertility, HF, HS, NC with the lowest DG were observed in the sex ratio 1:4 (P<0.0001). An improvement in fertility by about 4.3% and 10.5% compared to sex ratios of 1:5 and 1:6 respectively was due to the higher chance for the male to mate with females.

HF and HS of sex ratio of 1:4 were improved by 2.2% and 10.1% and by 9.5% and 20.7% compared to sex ratios of 1:5 and 1:6, respectively. The results were also consistent with those of Narinc *et al*. (2013), who noted that the percentage fertility increased with decreasing mating ratios. Bakst (2009) reported that fertilization process was affected by semen quality, which influences the mobility and survival of sperm in the female sperm-storage tubules. However, semen quality was not evaluated in the present study and this in turns points to the need to evaluate the semen quality of local ducks under rural feeding regimes. Another possibility is that the rearing system in this study affects the fertility percentage of the ducks. The cage system may have restricted mating behavior and freedom of males to mate with females, as explained by Karousa *et al*. (2015). Females are dependent on one male only in the same cage indicating that aggressiveness of male is very crucial in determining mating behavior. Ducks belongs to antidae group where the females or males exhibit preferences in mating (Denk, 2005), therefore high fertility is determined by the accomplishment in mating.

Interaction effects between protein levels of diet and sex ratio were significant for all parameters of hatching performance. LP and MP diets showed higher fertility and number of normal chicks than those of HP when the sex ratio was 1:4. However, when mating ratios increased from 1:4 to 1:5 or 1:6, fertility decreased. This could be explained by the fact that the high protein diets were essentially needed to increase egg weight when the ratio of mating increases because egg weight affected fertility (Alpay and Petek, 2016). Uğurlu *et al*. (2017) observed similar results in pheasant *(Phasianus colchicus*). Although egg weight was not considered and grouped based on protein levels in the diet in the present study when eggs were incubated, some authors reported that diet with high protein and high energy had a positive effect on egg weight (Thongwittaya and Tasaki, 1992; Saleh *et al*. 2017). Lower egg weight was found for low crude protein diets (Nahashon *et al*. 2007; Shim *et al*. 2013).

However, such tendencies in other parameters were not consistent. Data on incubation studies (Table 3) indicate low hatchability, high embryonic mortality and dead in-shell for ducks fed with high protein diets. Relatively long storage of hatching egg in room temperature under village conditions may also be causes of these unexpected results. Interaction involving dietary protein and sex ratios was significant for all parameters of hatching performance implying that the level of dietary protein is critical to have a good fertility and hatchability. The low dietary protein (LP) for all sex ratios performed higher value in fertility than those of MP and HP diets. However, MP diet for all sex ratios showed higher value in hatchability.

Table 3 Hatching performance of laying Alabio ducks as influenced by varying dietary protein levels and sex ratios

Item	Hatching performance					
	F	HF	HS	DG	DS	NC
Dietary protein (%)						
LP (17.5) (n=450)	90.4[a]	83.3[b]	75.6[a]	3.9[c]	13.3[b]	86.9[a]
MP (19.5) (n=450)	72.3[c]	85.0[a]	62.9[b]	9.3[b]	0.0[c]	84.6[b]
HP (21.5) (n=450)	82.7[b]	47.3[c]	39.2[c]	24.6[a]	19.1[a]	74.2[c]
SEM	0.06	0.03	0.06	0.05	0.06	0.06
Sex ratio						
1:4	86.1[a]	75.0[a]	66.0[a]	14.0[b]	8.6[c]	84.2[a]
1:5	82.4[b]	73.3[b]	59.6[b]	10.0[c]	13.0[a]	77.6[c]
1:6	77.1[c]	67.4[c]	52.3[c]	14.0[a]	11.0[b]	83.9[b]
SEM	0.06	0.03	0.06	0.05	0.06	0.06
Dietary protein × sex ratio interaction						
LP (17.5) -1:4	93.2[b]	85.9[c]	80.0[a]	6.9[f]	13.0[d]	91.9[b]
LP (17.5) -1:5	83.2[f]	80.0[e]	66.9[c]	0.0[i]	17.0[c]	75.0[f]
LP (17.5) -1:6	95.0[a]	84.1[d]	80.0[a]	5.0[g]	10.0[e]	93.9[a]
MP (19.5) -1:4	90.0[c]	89.0[b]	80.0[a]	10.0[e]	0.0[f]	93.9[a]
MP (19.5) -1:5	77.0[g]	95.0[a]	73.1[b]	3.9[h]	0.0[f]	80.0[d]
MP (19.5) -1:6	50.0[i]	71.0[f]	35.9[f]	14.2[d]	0.0[f]	80.0[d]
HP (21.5) -1:4	75.0[h]	50.0[g]	35.8[f]	25.0[b]	12.8[d]	66.9[g]
HP (21.5) -1:5	87.0[d]	45.0[i]	39.0[e]	26.0[a]	21.9[b]	77.9[e]
HP (21.5) -1:6	86.2[e]	47.0[h]	41.0[d]	22.9[c]	22.9[a]	77.9[e]
SEM	0.098	0.06	0.11	0.09	0.11	0.10
Probability						
Protein	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Sex ratio	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Protein × SR	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001

F: fertility; HF: hatchability (fertile egg basis); HS: hatchability (egg set basis); DG: dead in-germ; DS: dead in-shell; NC: normal chicks; LP: low protein; MP: medium protein and HP: high protein.
The means within the same column with at least one common letter, do not have significant difference (P>0.0001).
SEM: standard error of the means.

Table 4 Body weight changes during the experimental period (from 40 to 58 weeks)

Protein levels (%)	17.7	19.5	21.5	SEM
Initial body weight (40 wks)	1550	1515	1542	18
Final body weight (58 wks)	1615	1640	1620	20

SEM: standard error of the means.

Therefore, when the feeding system under village conditions is considered, the ratio of male and females in mating management becomes a critical factor. Improvement in a rearing system for breeding stocks which provides more space to mate should be considered under small scale production system. This is associated with limited knowledge of breeding practices of small growers.

CONCLUSION

The diet containing 19.5% protein was appropriate for the local ducks to maintain optimal productivity during laying period from 40 to 58 weeks of age. For the best value of hatching performance, sex ratio 1:4 was suitable. The low dietary protein (LP) for all sex ratios performed was adequate for high fertility. Medium protein diet for all sex ratios showed high hatchability. A rearing system for breeding stocks should be improved. Further studies on semen quality of local ducks in a rural feeding management regime are necessary.

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