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Effect of feather colour on productive performance, carcass traits and ileum histology of Mule ducks under free range system

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A total number of 492 one day old Mule ducklings, obtained from a commercial duck hatchery were used to elucidate the effect of feather colour on productive performance (body weight, body weight gain, mortality and defect percentage), carcass traits and ileum histology. According to the feather colour birds were sorted into four phenotypic groups; first group with 151 black feathered (BF) ducklings, second group with 173 white - black feather (WBF) ducklings, a third group with 132 dark brown feathers (DBF) ducklings and the fourth group with 36 light brown feather (LBF) ducklings. Results revealed that the BF ducks had significantly heavier body weight at 1 and 3 weeks of age compared to LBF, however the body weight of the WBF and DBF ducks was intermediate. At marketing age the differences in body weight among phenotypes were not significant. The DBF ducks had the lowest relative dressed carcass and edible meat parts compared to other phenotypes. Histological examination of ileum sections showed considerable increase in intestinal villi length and width accompanied by changes in the crypts of Lieberkuhn depth, between BF and WBF colour. It is concluded that duckling's feather colour may be used as a practical tool to predict the productive performance such as growth performance and carcass traits of ducks at marketing age.

KEY WORDS: carcass / ducks / feather / growth / histology

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Annually, over 3 billion ducks are slaughtered for meat across the world [FAOSTAT, 2019], with production centered in Europe in France, Asia in China, and Africa in Egypt. Mule ducks were raised throughout Europe and Asia for meat and liver fat, with Mule ducks accounting for 95% of liver fat production and Muscovy duck males accounting for the remaining 5% [Marie-Etancelin *et al.* 2008, Biswas et al., 2019]. White Mule ducks are popular in various locations, including China and Egypt, thus white Pekin ducks mated with white Muscovy males to produce white Mule ducks [Liu *et al*. 2015 and Makram 2016].

The production of ducks has the potential to have a substantial impact on the agricultural economy. Asian countries alone account for 84.2 percent of global duck meat production. The worldwide duck meat industry is anticipated to develop steadily in the next years, reaching a value of around $11.23 billion. China has eclipsed the rest of the globe as the top producer of duck meat, accounting for more than half of worldwide output [Biswas *et al*. 2019].

The duck production in developing countries such as Egypt is important in the rural economy, small farms and commercial farms. The number of ducks produced in Egypt is 100 to 150 million birds and this makes ducks the second largest group in the domestic poultry population. Most of commercial species raise in Egypt are French Muscovy, Pekin ducks and Mule ducks [Crawford 1990, Pingel 2004, FAO 2014, Kilany *et al*. 2016].

The White Mule duck is infertile hybrid and output of the crossbreeding between white Muscovy drakes with Pekin females [Akinlade and Sonaiya 1994, Adenowo *et al.* 1999, Adeyeye *et al.* 2012, Makram 2016]. Nowadays, in Egypt some commercial companies produce Mule ducks with different feather colours by using Tinted Muscovy males. The livestock characteristics may be observed through both quantitative and qualitative features, with the quantitative attribute being connected to the animal's economic properties. However the qualitative traits like body shape (body length, hank length, keel length and other body measurements) and feather color, may be associated with quantitative traits [Ismoyowati *et al.* 2017].

There have been few genes or pathways identification investigations in ducks, although it has been claimed that several genes exist at various loci influencing plumage colour in ducks. Tyrosinase and tyrosinase-related protein-1 were also found in black dorsal feathers and white-black dorsal plumage. The tyrosine kinase receptor was expressed in all of the feather samples, but the relative mRNA expression in black dorsal feather or white-black dorsal plumage was about ten times greater than that in white dorsal feather or white-black dorsal plumage. However, the identity and quantity of genes implicated in duck plumage colour regulation are unknown [Li *et al*. 2012]. The white plumage colour of Pekin ducks was caused by the microphthalmia related transcription factor gene [Tachibana 2000]. Additionally, the plumage colour inheritance patterns followed Mendel's genetic principles [Zhou *et al*. 2018].

The feather color of the ducks is produced in response to α-melanocytic stimulating hormone (αmsh) secreted by the pituitary gland [Davila *et al.* 2014]. Feather color is important in duck because it related to physical quality of carcass traits and the level of consumer preference [Ismoyowati *et al.* 2018]. Saatci *et al.* [2005] indicate that the feather colour in geese play a significant role in determining hatching weight of goslings.

There are few studies focused on the effect of feather color on growth performance in waterfowls and the little study found that no effect of feather color on carcass traits in geese [Saatci *et al.* 2009, Sarıca *et al.* 2015, Kırmızıbayrak and Boğa 2018]. However, there was another study detected a relationship between the color plumage and body weight of Padovana chickens [Rizzi 2018]. Houndonougbo *et al.* [2017] found that the native guinea fowl breeding in West Africa had varieties differing greatly in their feather color. Their morphological characteristics and growth performance, this different depend on the nutritional requirements and some recessive and dominant genes as well as genotypic differences were highlighted between varieties the different colors of guinea.

The duck ileum has a characteristic ileal digestion, as in chicken [Jamroz *et al.* 2002, Abdelfattah-Hassan and El-Ghazali 2019], which increase longer ileum and ileal villi implies that the benefit of feed is at its maximum, and this was reflected on the reared ducks weight.

While seasonal, nutritional and age-dependent changes in feather colour have been recorded previously, there are not enough studies to confirm an effect of feather colour on either growth performance or carcass characteristics. The present study aimed to investigate the impact of feather colour on growth performance, carcass characteristics, and Mule duck ileum histology.

Material and methods

This experiment was carried out on the poultry farm of the Faculty of Agriculture, Fayoum University. A total number of 492 one day old Mule ducklings, obtained from a commercial duck hatchery, were used in the present study. Upon arrival, they were grouped visually according to their pin feather color (Fig. 1) into four phenotypic categories: black- feathered, BF (151), 173 having white and black feather (WBF), 132 having dark brown feather (DBF) and 36 with light brown feather (LBF).

All ducklings were brooded in floor pens. The brooding temperature was 33°C for the first three days and then reduced gradually until it reached 26°C at two weeks of age. Birds were exposed to a continuous light during the first three days, then a light schedule of 16 L: 8 D till the end of the fattening period (7 weeks of age). The 16th lighting hours include 10 to 11 hours of natural daylight and then the artificial light was applied. They were reared under similar environmental, managerial and hygienic conditions from one day old to the end of the experiment.

The feed and water were supplied *ad libitum*. Composition and calculated analysis of the diet is shown in (Tab. 1). Beside the commercial diet, birds were given free access for raising (free range system) in the pasture for 10 hours daily (from 7 am to

Fig. 1. Feather colour of Mule ducks at one day old and marketing age. BF – Black Feather; WBF – White-Black Feather; DBF – Dark Brown Feather; LBF – Light Brown Feather.

Table 1. Feed ingredients, diets distribution and chemical composition of experimental diets (g/kg as-fed basis, except where otherwise stated)

Ingredient	Diets distribution		
	0-3 weeks	3-5 weeks	5-7 weeks
	Starter	Grower	Finisher
Yellow corn	587.4	670	734.4
Soybean meal 44%	304	240	160
Corn gluten meal 60%	75	60.4	76
Limestone	6.5	5.5	5.5
Di-calcium Phosphate	15	12	12
Table Salt (NaCl)	3	3	3
Premix*	5	5	5
Methionine	0.1	0.1	0.1
Dry Yeast	1	1	1
Dry mulases	1	1	1
Trigonella	1	1	1
Chamomile	1	1	1
Total	1000	1000	1000
Calculated chemical analysis			
crude protein	230.7	200.4	180
ME, MJ/kg**	12.45	12.59	12.98
calcium	7.5	6.2	6
avail. phosphorus	4.1	3.4	3.3
methionine	4.2	3.7	3.5
lysine	10.5	8.8	7
fiber	35.3	32.3	28.3

*Provided the following per kg of diet: Vit. C (Ascorbic acid), 3 mg; Vit. A (trans-retinyl acetate), 3.60 mg; Vit. E (all-rac-α-Tocopheryl acetate), 90 μg; Vit. D3 (Cholecalciferol), 3 mg; Vit. B12 (Cyanocobalamin), 0.03 mg; Vit. B3 (nicotinic acid), 40 mg; Vit. B2 (Riboflavin), 3 mg; Vit. B1 (Thiamine), 3 mg; Vit. B9 (Folic acid), 2 mg; Vit. K3 (Menadione sodium bisulfite complex), 4 mg; Vit B6 (pyridoxamine), 5 mg; Vit. B7 (Biotin), 0.20 mg; Vit. B5 (Pantothenic acid; (D-calcium pantothenate)), 15 mg; iron (FeSO4), 60 mg; Cobalt ($Co(SO_4)_2 \cdot 6H_2O$), 0.05 mg; Copper ($CuSO_4 \cdot 5H_2O$), 10 mg; Zinc (ZnO), 70 mg; Selenium (Na_2SeO_3), 0.20 mg; Iodin (CaI), 50 mg and Manganese (MnO), 90 mg.

**ME – Metabolizable Energy; MJ/kg – Megajoule/Kilogram.

5 pm) from the 16th days of age, after they have been trained to grazing in the pasture from the 4th day of age (Fig. 2). There were many variaties of grass and trees in the pasture as recorded in the Table 2. The pasture itself was divided into two parts; where the ducks go to the pasture at one day and the alternative day go the second part of the pasture. The dimensions of the pasture were 1400 m2 (56 x 25) and 1410 m 2 (47 x 30) for the part 1 and 2 respectively. the birds reared together without pens with same diets and the pasture.

Fig. 2. The system of raising the duck during the experimental period.

Table 2. Types of the grasses and trees in pasture

Type of grasses			Type of trees			
No	Common name	Binomial name	No	Common name	Binomial name	No of Trees
1	*Field Bindweed*	*Convulvulus arvensis L*	1	Date Palm	*Phoenix dactylifera*	5
2	*Jungle Rice*	*Echinochloa colonum*	2	Berry	*Morus rubra*	2
3	*Bermuda grass*	*Cynodon dactylon*	3	Guava	*Psidium guajava*	2
4	*Nutsedge*	*Cyperus longus L*	4	Mango	*Mangifera indica*	2
5	*Annual Sowthistle*	*Sonchus oleraceus L*	5	Fig	*Ficus carica*	9
6	*Chicory*	*Cichorium pamilum L*	6	Drumstick tree	*Moringa oleifera*	3
			7	Grapes	*Vitis vinifera,*	3
			8	Lemon	*Citrus aurantifolia*	1
			9	Orange	*Citrus X sinensis*	6
			10	Zapota	*Manilkara zapota*	3
			11	Ficus	*Ficus retusa*	2

Measurements

Body weight and body weight gain: the live body weight was taken at 1, 3, 5 and 7 weeks of age and then body weight gain was calculated for different periods. Feed consumption was not recorded because of all ducks were fed together in the pasture.

Mortality and defect

Mortality was recorded during the experimental period, while the observed defects (in the legs, dwarf, beak, neck) were recorded for the birds which didn't die.

Carcass traits

At the end of the experimental period, thirty ducks from each phenotypic group were taken randomly and slaughtered for carcass evaluation. Dressed carcass weight, non-edible parts, edible parts (dressed carcass - gizzard - liver - heart), and head were recorded.

Ileum histology

Representative specimens from the ileum of ten randomly chosen ducks were dissected, immediately fixed at 10% formal saline solution before preparing histological sections by using the paraffin histological technique. The transverse sections were examined by using an electric microscope (MNP- 1, PZO, Warszawa, Poland) provided with computerized camera.

Statistical analysis

Data were subjected to the one-way analysis of variance by using general linear model procedure of SAS 9.1 (2004). According to the following model:

$$Y_{ij} = \mu + S_i + e_{ij}$$

where:

Y_{ij} – the jth observations of the ith treatment;

μ – overall means;

S_i – feather color effect;

e_{ij} – random error.

Differences among treatment means were detected by using duncan's multiple range tests. Secondly, live body weight and body weight gain were used a covariate in the analysis the ANCOVA procedures of SAS 9.1 (2004). Because the initial body weight differed across the phenotypes, a covariate analysis investigated the influence of feather colour on body weight after correcting mean at initial weighing among the phenotypes.

Results and discussion

Body weight and body weight gain

Mean and adjusted mean body weight and body weight gain for different phenotypes of Mule ducks are presented in Table 3 and 4. With respect to body weight, the present results showed that the LBF duck group had significantly lower

Table 3. Effect of feather colour on body weight (g) of Mule ducks (SE) analysed by ANOVA and ANCOVA

Age (week)	Phenotypic				*P-value*
	BF	WBF	DBF	LBF	
	Mean (ANOVA) (g) (SE)				
1	178.00^{a} (2.24)	165.58^{ab} (4.38)	168.17^{ab} (4.64)	156.32^{b} (5.97)	0.0502
3	1162.35^{a} (20.11)	1141.49^{ab} (19.21)	1080.71^{bc} (27.32)	1042.50^{c} (35.97)	0.0111
5	2286.76^{a} (34.51)	2310.81^{a} (56.76)	2285.90^{a} (32.29)	2131.25^{b} ±52.42	0.0521
7	3804.29 (63.36)	3741.08 (106.83)	3788.0 (44.70)	3748.08 (63.46)	0.8881
	Adjusted mean (ANCOVA) Least square mean (g) (SE)				
1	168.58	168.58	168.58	168.58	
3	1101.15 (23.30)	1113.89 (22.92)	1103.88 (21.33)	1102.30 (38.80)	0.6747
5	2189.38 (37.45)	2256.07 (36.85)	2296.40 ±34.36	2146.20 (57.69)	0.5673
7	3636.33^{b} (41.90)	3794.37^{Ab} (41.75)	3881.06^{a} (38.86)	3674.33^{b} (61.39)	0.0016

$^{ab\cdots}$Means within the same row bearing different superscripts differ significantly at p≤05.
BF – Black Feather; WBF – White-Black Feather; DBF – Dark Brown Feather; LBF – Light Brown Feather.

Table 4. Effect of feather colour on body weight gain (g) of Mule ducks (SE) analysed by ANOVA and ANCOVA

Age (week)	Phenotypic				*P-value*
	BF	WBF	DBF	LBF	
	Mean (ANOVA) (g) (SE)				
1-3	984.35^{a} (15.26)	975.91^{a} (13.12)	912.54^{ab} (26.97	886.18^{b} (31.21	0.0324
3-5	1124.41^{ab} (16.96)	1169.32^{ab} (43.46	1205.19^{a} (6.93)	1088.75^{b} (9.25	0.0121
5-7	1517.71^{ab} (27.91)	1430.27^{b} (56.81)	1502.10^{ab} (27.91)	1616.83^{a} (24.79	0.0451
1-7	3626.29^{a} (55.80)	3575.50^{b} (32.55)	3619.83^{a} (44.25	3591.76^{b} (33.44	0.5423
	Adjusted mean (ANCOVA) Least square mean (g) (SE)				
1-3	947.40	947.40	947.40	947.40	
3-5	1095.53 (68.13)	1170.06 (80.13)	1128.1 (86.17	1030.92 (127.58	0.1634
5-7	1449.19 (65.12)	1531.62 (76.60)	1619.86 (82.37	1507.95 (121.95	0.5321
1-7	3492.12^{b} (29.54)	36490.07^{ab} (34.74)	3694.80^{a} (37.36	3486.24^{b} (55.32	0.002

$^{ab\cdots}$Means within the same row bearing different superscripts differ significantly at p≤05.
BF – Black Feather; WBF – White-Black Feather; DBF – Dark Brown Feather; LBF – Light Brown Feather.

body weight at 1, 3 and 5 weeks of age compared to other duck groups, however, there is no significant differences at the end of the experimental period (7 weeks of age) among the different phenotypes. This trend was also observed for body weight gain, where the same groups recorded the highest values from 1-3 and 3-5 weeks of age. The opposite trend was noticed from 5-7 weeks of age, the LBF duck group recorded a higher body weight gain compared to other duck groups. However, the LBF recorded the lowest body weight gain from 1-7 weeks of age compared to the remain phenotypes.

The mean of live body weight and body weight gain had changed when analysed by ancova. No significant differences were found among phenotypes at 3 and 5 week of age and for live body weight gain from 1-3 and 3-5 weeks of age. However, the DBF ducks group was significantly higher for body weight and body weight gain at 7 and from 1-7 weeks of age compared to BF and LBF duck groups, the WBF ducks group was intermediate.

Mortality and defect percentage

The total number of the dead ducks, mortality percentage and defective ducks as influenced by feather colour are presented in Table 5. Results showed that mortality and defects of BF were higher than those observed in the WBF and DBF groups. The corresponding values were 0, 0.76, 1.16 and 1.99% of the mortality percentage and 0, 2.27, 2.31 and 3.3% for the defect percentage of LBF, DBF, WBF and BF, respectively.

Table 5. Mortality and defect of Mule ducks phenotypes

Phenotypic	Number of birds□ flock	Mortality (count) 1-3 week	4-7 week	Total mortality	Mortality (%)	Defect (count) 1-3 week	4-7 week	Total defect	Defect (%)
BF	151	1	2	3	1.99	1	4	5	3.3
WBF	173	1	1	2	1.16	0	4	4	2.31
DBF	132	1	0	1	0.76	1	2	3	2.27
LBF	36	0	0	0	0	0	0	0	0
Total	492	3	3	6	1.22	2	10	12	2.44

BF – Black Feather; WBF – White-Black Feather; DBF – Dark Brown Feather; LBF – Light Brown Feather.

Carcass traits

Relative weight of carcass traits as affected by feather color are summarized in Table 6. It should be mentioned that the body weight of the slaughtered ducks from all groups was similar to alleviate the differences in carcass trait that may be due to differences in the initial weight at slaughtering. Thus, there were non-significant differences among different phenotypes in live body weight before carcass evaluation (marketing age).

Concerning dressed carcass weight (%), the present results depicted significantly higher relative carcass weight in ducks from LBF group followed by BF and WBF ducks, while the DBF ducks group had the lowest value. On the other hand, the other parts of carcasses did not show any consistent trend, where the head % was significantly higher in WBF ducks, whereas in the LBF ducks, it is the lowest. However, there were no significant differences among phenotypes in the liver, gizzard and total giblets. The DBF was significantly higher for non-edible meat parts compared with either BF or LBF, while, the WBF was intermediate.

Opposite result was noticed for relative edible meat parts, the LBF and BF were significantly higher relative edible meat parts weight compared to DBF, however the WBF was intermediate.

Table 6. Effect of feather colour on carcass traits of Mule ducks (SE) analysed by ANOVA

Traits	Phenotypic				*P-value*
	BF	WBF	DBF	LBF	
LBW (g)	4005 (119)	3970 (60)	3872.73 (89)	3775 (105)	0.8712
Head (%)	3.83^{ab} (0.06)	3.94^{a} (0.04)	3.79^{b} (0.03)	3.61^{c} (0.05)	0.0002
Dressed carcass (%)	71.89^{a} (0.56)	70.32^{a} (0.34)	66.73^{b} (2.08)	72.7^{a} (0.68)	0.0040
Liver (%)	2.65 (0.08)	2.49 (2.49)	2.76 (0.20)	2.46 (0.07)	0.4327
Gizzard (%)	2.62 (0.07)	2.52 (2.53)	2.64 (0.04)	2.59 (0.03)	0.6521
Heart (%)	0.71^{a} (0.02)	0.65^{b} (0.65)	0.60^{c} (0.01)	0.61^{bc} (0.02)	0.0004
Giblets (%)	5.98 (0.15)	5.67 (0.17)	6.00 (0.25)	5.67 (0.11)	0.7632
Non- edible meat parts (%)	22.13^{b} (0.55)	24.0^{ab} (0.42)	27.27^{a} (2.29)	21.63^{b} (0.68)	0.0101
Edible meat parts (%)	77.87^{a} (0.55)	75.99^{ab} (0.42)	72.73^{b} (2.29)	78.37^{a} (0.68)	0.0101

$^{ab\cdots}$Means within the same row bearing different superscripts differ significantly at p≤05.
BF – Black Feather; WBF – White-Black Feather; DBF – Dark Brown Feather; LBF – Light Brown Feather.

Ileum histology

The normal histological structures of the ileum of all phenotypes were shown in Fig. 3. Tissue structure in the ileum of DBF ducks showed long villi with thin width. The villi were long with thin width but with many short villi in the field in LBF. The ileum of BF ducks showing an increase in villi height and width indicating the greatest absorption area, the ileum of WBF ducks had medium long villi with thin width.

In birds, the colour of plumage has been a significant feature, often deciding the assignment to a certain breed or species, in addition to provide the basis for creating such biological paradigms as the diversity theory. The functional relevance of feather colour plays primary role of birds communication, an important role in much behaviours and in adapting to environmental circumstances [Makarova *et al*. 2019]. Birds have a number of patterns of feather colour, which contributed to the pressure of natural selection [Roulin, 2004, Roulin and Ducrest 2013].

In the current study the feather colour significantly affected productive performance, where there was an effect of feather color on live body weight and body weight gain, the BF was higher in all experimental ages except the marketing age. These results were consistent with the results of the histological section, where the histological examination of ileum sections showed considerable improvement in the intestinal villi number and size accompanied by changes in the crypts of lieberkulhn width, in response to BF and WBF feather color. Several studies have demonstrated that plumage colour has a significant influence on the live body weight of adult Muscovy ducks [Barnejee, 2013, Oguntunji and Ayorinde 2014].

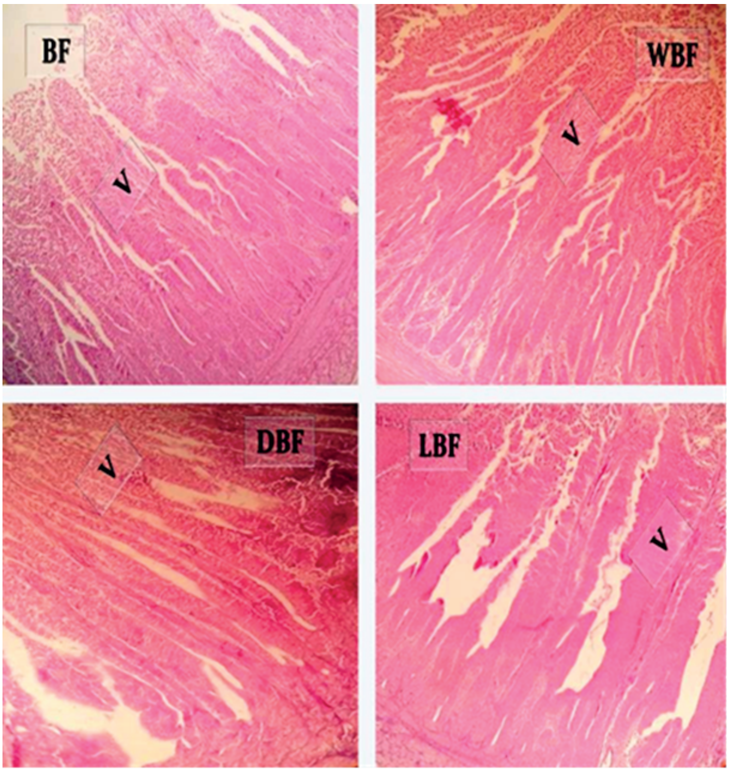

Fig. 3. Photomicrograph of the ileum from the phenotypes of Mule ducks showing normal villi (V). Scale bar – 200 µm. Haematoxylin and Eosin stain. Magnification 100×. BF – Black Feather; WBF – White-Black Feather; DBF – Dark Brown Feather; LBF – Light Brown Feather.

Due to the various environmental conditions, which result in diverse biological effects, this might explain the inconsistency in the outcomes of current research compared the findings by Silva *et al.* [2003] and Oguntunji and Ayorinde [2014] stated that the higher mean body weight of the lighter coloured plumaged ducks (white and mottled) might be attributed to their stronger physiological adaptation to heat stress, which is linked with higher ambient temperatures in tropical settings. Lighter surfaces reflect heat better than darker surfaces, and animals with lighter coats reflect more light, and absorb 40 to 50 percent less radiation than those with dark coats [McManus *et al.* 2011]; as a result, reduced thermal absorption and body thermal load, giving them a physiological advantage over those with colored/dark surfaces. Ozoje and Kadri [2001] asserted on possible reasons for the highest body weight of white West African Dwarf (WAD) sheep, stated that the effect of white coat on body weight of extensively-reared WAD sheep may be influenced by its role in temperature regulation and body metabolism under conditions of high ambient temperatures prevalent in the study area. These studies, however, agreed with our findings that the feathers color had an influence on the different aspects of production. The improvement in growth might be attributed to the improvement in social behaviors and the absence of aggressiveness and fear found in dark colored ducks when compared to light colored ducks. Another study by Karlsson *et al*. [2010] found a relationship between plumage color and behavior, with different feather colors having an effect on aggressive pecking. Additional, Nile *et al*. [2019] discovered a relationship between feather color and aggressive behavior on a hybrid of Rhode Island and Leghorn chickens, with the white feather chicken being more aggressive than the red feather, but there was significantly effect on live body weigh in the same study.

Concerning the present study, the BF were characterised by higher body weight, which may be due to the interlaced or tortuous configuration of villi stated in the current study indicates that a more efficient absorpting nutrients; as nutrients will have more bind time with the epithelium villus of intestinal [Abdelfattah-Hassan and El-Ghazali 2019]. Also, the length and width of villi effect on absorptive capacity, which reflected on growth performance [Hamedi *et al*. 2011, Laudadio *et al*. 2012, Prakatur *et al*. 2019]. In addition to wider microvilli, more microvilli at the apex in early age may contribute to the faster growth rate [Yamauchi and Isshiki 1991]. Since the smooth surface of ileaum shelters microorganism, the ileum may have a function in absorbing nutrients. It enhances the growth of effective microflora which is reflected on gut health and production performance. A possible explanation for these changes in the arrangement of the villi could be due to either increased villus length (as seen in the Fig. 3), where villi are long with thin width and many short villi in LBF and increase in villi height and width was observed. It has been previously been noticed that the intestinal villi shape and length differed between ducks with black feather color and ducks with light feather color. The growth and increase of the gastrointestinal tract stimulate the feed intake, however, slower growing breeds are known to have a slow development of the gastrointestinal tract compared to the fast growing broiler chickens [Gracia *et al.* 2003, Mabelebele *et al*. 2014, Mabelebele *et al*. 2017]. In another study by Houndonougbo *et al.* [2017] found the grey guinea fowl higher body weight at 5 weeks and 28 weeks compared to black guinea fowl under the same rearing conditions, he also indicated the plumage differences. Genetic variations seem to affect birds performances, as different varieties differ also in terms of production traits. From Table 3 LBF ducks group had higher body weight gain from 5-7 weeks compared to the remain duck groups, which reduced the difference at the marketing age and there were no significant differences at 7 weeks of (marketing age) among duck groups.

For carcass traits, we detected the significant effect of feather color on some carcass traits like relative head, dressed carcass, heart, edible and nonedible meat parts. This result is in accordance with Saatci *et al.* [2009], however Sarıca *et al.* [2015] confirmed that the effect of the different feather color of geese on slaughter traits such as, head, feet weight, abdominal fat weight, but they did not find an effect of feather color on blood, liver, hot and cold carcass weight. In another study done by Yakan *et al*. [2012] and Kırmızıbayrak and Boğa [2018] pointed that there was no significant effect of feather color on geese carcass traits. Economic traits such as carcass traits and growth performance are very significant in duck production. These traits are controlled by sets of genes [Richards *et al.* 2005, Hassan *et al*. 2018]. The birds have two forms of melanin, first the eumelanin which give the dark brown and black and phenomelanin which give rise to lighter yellow to reddish, the structure of melanin depends on the aromatic amino acid tyrosine, and the level of melanin control by tyrosinase. Melanogenesis may be affected by environmental or physiological factors, in addition to genetic regulation. on the other hand, the process of melanogenesis involves many loci, part of the complex expression of plumage color genes [Makarova *et al*. 2019].

Ismoyowati *et al.* [2018] reported that the birds with white black feather in Indonesian Muscovy had heaviest body weight higher as compared with the white feather Muscovy ducks. The melanocortin 1 receptor (MCIR) gene was observed in the white black feather Muscovy, while the genes controlling the feather color could have an effect on growth performance and carcass traits. The melanocortin 1 receptor (MCIR) gene found also in the black birds affected tyrosinase function, so the feather color form is a complex process affect by genes and physiological processes [Makarova *et al*. 2019, Ismoyowati *et al*. 2018]. The present findings indicated the effect of feather color on productive performance, carcass traits and ileum histology of Mule ducks.

Pingel [1999] confirmed that the breast muscle was decreased and the skin area was increased in Muscovy, Pekin and mulard before marketing age. In the present study the DBF was significantly lower for edible meat parts, therefore the DBF ducks, maybe need to be slaughtered at a later age to improve their carcass traits. The findings of this study may be attributable to the fact that four classes of hormones affect melanogenesis: pituitary hormones (luteinizing hormones), estrogen and androgen thyroid hormones, which also directly or indirectly influence various development processes, such as growth performance. In addition the availability and consumption of tree leaves and grasses may have antioxidant properties that reflect on the gut health, thereby improving the growth and production efficiency.

Current results require more studies to investigate the effects of the genes responsible on colour and their relationship to production.

It could be conclude that, there was a significant effect of feather color in live body weight at marketing age (7 weeks) and some carcass traits. However, the LBF recorded lower body weight in 1, 3 and 5 weeks of age and the DBF recorded lowest edible meat parts. So, the ducklings' feather colour may be used as a practical tool to predict the productive performance such as growth performance and carcass traits of ducks at marketing age. Such findings may explain the relationship between feather colour and productive efficiency. It may enhance the growth performance of the ducks by improving the length and width of the intestinal villi and by changing the depth of the crypt of Lieberkuhn in response to the color of the feather. We propose the feather colour as an instrument to predict the ducks productive efficiency and carcass characteristics, helpful in the selection and improvement programmes.

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