Comparing the genetic variation in the prolactin gene between the Peking duck breed and ducks raised under local conditions in Iraq and studying the extent to which this variation affects productive and physiological performance

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Abstract

A flock of local ducks, selected from Babil Governorate and the Middle Euphrates region, was raised in the fields of the College of Agriculture, Al-Qasim Green University, Department of Animal Production, from October 1, 2023 to May 8, 2024. The experimental period lasted 217 days (31 weeks). The aim of this study was to investigate the genetic variation of the prolactin gene in duck groups raised in the Iraqi environment and the extent of its impact on productive and physiological performance. Fifty-nine female Iraqi local ducks and 41 female Peking ducks were raised. Regarding nutrition and management, the free-range feeding system was followed in this study. The following quantitative traits were measured: first egg weight, live body weight, age of sexual maturity, and number of eggs produced. After the experiment was concluded, the prolactin gene was investigated, in addition to measuring the prolactin hormone. There was a significant improvement among Peking duck flock members compared to local ducks.

Keywords: prolactin gene in duck, the genetic variation , physiological performance.

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Introduction

Since duck meat and eggs have high nutritional value for humans, ducks have been raised on local farms to improve economic livelihoods [6]. Ducks are of great economic importance in many countries [5]. Peking ducks (Anas platyrhynchos domestica), Muscovy ducks (Cairina moschata), and mallards (a cross between Muscovy and Peking ducks) are the main global duck meat producers [29]. Muscovy duck meat has a distinctive taste and low calories, making it of global economic importance [34]. Both Muscovy and mallard ducks have lower fat content and higher meat production than Peking ducks. Campbell ducks (Anas platyrhynchos) are considered a high-egg-producing breed [4]. Moreover, the nutritional value of duck eggs is higher than that of chicken eggs, in terms of their minerals, vitamins, and amino acids [30]. Traditional breeding methods of selection and crossbreeding have improved duck productivity and led to the development of new hybrids. While improvement using these methods is slow [7], duck productivity has been increased using modern molecular genetics methods by identifying candidate genes associated with quantitative traits to improve productivity and enhance breeding programs [10]. One of the most serious problems in duck breeding is low productivity and product quality. Therefore, genetic improvement aims to increase productivity, improve product quality, and raise economic value [14]. Genetic improvement programs using both traditional and modern methods for meat-producing ducks have succeeded in enhancing their production performance. In Peking ducks, genetic improvement increased meat production to 3.2 kg in seven weeks, compared to 1.7 kg at 11 weeks of age before improvement [37]. Therefore, the aim of this study was to investigate the genetic variation of the prolactin gene in duck populations. Breeding in the Iraqi environment and the extent of its impact on productive and physiological performance .

Materials and Methods

This study was conducted at the poultry farm of Al-Qasim Green University, College of Agriculture, Department of Animal Production, from 1,10, 2023 to 8,5, 2024. The aim was to investigate the genetic variation of the prolactin gene in duck populations raised in Iraq and its relationship to productive and physiological performance.

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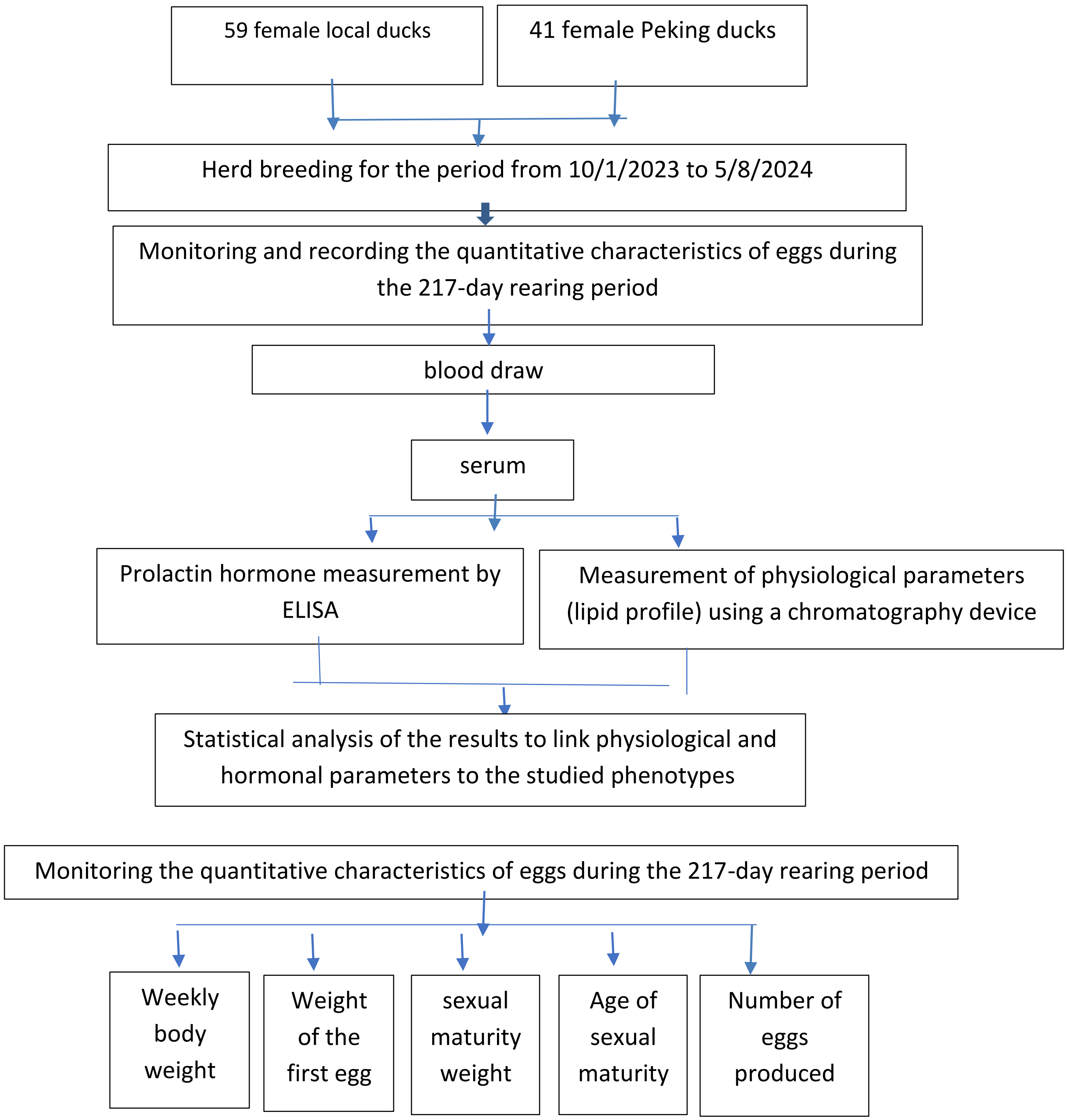

Experimental Plan

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Blood Sample Collection

This study was conducted in the Biotechnology Laboratory of the College of Agriculture/Al-Qasim Green University. Blood samples were collected from the wing vein using a sterile 5 ml medical syringe, with (20) samples from local ducks and (20) samples from Peking ducks, each with 5 ml. The samples were then divided into tubes as follows: A. Tubes containing anticoagulant. A portion of the blood sample, (0.5 ml), was placed in tubes containing EDTA anticoagulant. Each tube containing a blood sample was tightly closed and gently shaken to facilitate proper mixing of the blood with the anticoagulant. The blood samples were stored in the laboratory at a temperature of (-18) [4].

B- Gel-containing tubes for serum collection

Blood samples were placed in gel tubes to isolate serum (2-3 ml) from each bird's blood. The tubes were placed in an incubator at 37°C for 4 hours, then placed in an incubator at 22°C overnight. The gel tubes were centrifuged at 12,000 rpm for 20 minutes, and the precipitate was discarded. The resulting fluid was transferred to a microcentrifuge tube and stored at -20°C for measurement of lipoproteins [3].

Phenometric Traits

The study included several phenotypic traits related to the hormone under study, including:

Quantitative Traits / Weight Gain

Weight gain /g = Average live weight at the end of the period – Average live weight at the beginning [2].

First Egg Weight

The first egg was weighed individually for all ducks at the age of sexual maturity using a sensitive balance according to the average egg weight, by adding the weights of the laid eggs and dividing them by their number.

Physiological Measurements

A- Determination of Serum Cholesterol Level Serum cholesterol levels were determined using a ready-made test kit from the French company Biolabo, which is a colorimetric enzymatic method. Samples were read at a wavelength of (500) nanometers using a spectrophotometer, according to the company's supplied method.

B- Lipoprotein Measurement

This measurement includes both high-density lipoproteins (HDL), based on [13], and low-density lipoproteins, based on [8].

C- Determination of Serum Triglyceride Level

Triglyceride levels were measured based on [33].

The Statistical Analysis System (SAS) [31] program was used to analyze the data to study the effect of different treatments on the studied traits according to a completely randomized design (CRD). Significant differences between means were compared using the Duncan (1955) multinomial test[15].

Results and Discussion

Through Table No. (1), which indicates a comparison of quantitative traits and their relationship to the prolactin hormone between the Iraqi local duck and the Peking duck, we find that there is a significant difference in all the quantitative traits studied between the local duck and the Peking duck. As shown in Table No. (1), these are: sexual maturity weight, age of sexual maturity, weight of the first egg, total weight gain (during the experimental period), and number of eggs produced (during the experimental period) in favor of the Peking duck (commercial breed duck). The results of the Peking duck for sexual maturity weight were recorded at (2304.375 g), which was significantly superior to its counterpart in the local duck, which recorded (1666.864 g). As for the age of sexual maturity, the results of the local duck recorded a significant superiority (26.084 weeks) over the Peking duck, which recorded (22.45 weeks). At this point, the age of sexual maturity for the local duck is relatively greater than that of the Peking duck. If this is interpreted from an economic and productive perspective for breeders, it will be considered a characteristic. Negative due to the advanced age of sexual maturity, which leads to increased feeding and rearing costs for the breeding flock at the expense of production . Therefore, the remaining results of the commercial breed are superior and preferable to the quantitative traits of local ducks in terms of production. Consequently, the economic feasibility of the commercial breed under study is superior to that of its local counterpart. For the remaining traits (number of eggs produced, weight of the first egg, and total weight gain), the results showed a significant superiority in favor of the commercial breed (Peking duck) (178.825, 39.925, and 1111.625),

respectively, over the local ducks, which recorded (148.745, 39.694, and 838.220, respectively).

Table 1: Comparison of quantitative traits and their relationship to prolactin between Iraqi local ducks and Peking ducks (arithmetic mean ± standard error)

Attributes / The lineage	Sexual maturity weight (g)	Age of sexual maturity	Number of eggs produced	Weight of the first egg (g)	Total weight gain
local	1666.864 ± 13.134	26.084 ± 0.145	148.745 ± 0.428	39.694 ± 0.160	838.220 ± 10.290
bikini	2304.375 ± 22.430	22.450 ± 0.189	178.825 ± 0.545	39.925 ± 0.209	1111.625 ± 5.757
sig	0.000	0.000	0.000	0.000	0.000

* means there are significant differences at the level (P≤0.05)

Peking ducks recorded a higher weight at sexual maturity (2304.375 g) than domestic ducks (1666.864 g), reflecting a higher growth rate and better feed conversion

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efficiency. This is due to genetic improvement in commercial breeds such as Peking ducks, which have been selected over generations to improve production traits such as rapid growth and high final weight [9]. Meanwhile, domestic ducks showed a longer age at sexual maturity (26.084 weeks) than Peking ducks (22.45 weeks). Sexual maturity is linked to levels of sex hormones and prolactin. Domestic ducks often have a slower physiological response or are less sensitive to maturation-stimulating hormones, such as GnRH (gonadotropin-releasing hormone) and LH/FSH. From an economic perspective, a longer age at sexual maturity is negative because it increases the rearing period and feed costs before production begins [16]. Peking ducks also outperformed in egg production (178,825 eggs during the trial period) and first egg weight (39,925 g). This reflects the influence of prolactin, one of the most important hormones influencing egg production, as it influences yolk formation and follicular maturation. Peking ducks typically exhibit regular and balanced hormonal levels, allowing for earlier and higher egg production [23]. Peking ducks also demonstrated a higher total weight gain (1,111,625 g). These results are attributed to the high feed consumption and feed conversion efficiency of commercial breeds. Peking ducks also tend to accumulate muscle and fat more rapidly due to genetic selection [1]. Prolactin plays an important role in regulating incubation and egg-sitting behavior, inhibiting ovulation when levels are high, and promoting sexual development at certain stages. Local ducks may have higher levels of prolactin or greater sensitivity to it, causing delayed sexual maturation and reduced egg production [11, 32]. The bottom line is that the commercial breed (Peking duck) outperforms local ducks in most of the quantitative traits studied due to continuous genetic selection, higher physiological efficiency, and better hormonal regulation, particularly of prolactin. This makes them more economically viable in terms of reducing rearing costs and increasing production.

There is a highly significant direct relationship ($P \leq 0.01$) between the amount of weight gain and each of the number of eggs produced, cholesterol, VLDL, and sexual maturity weight. There is also a significant direct relationship ($P \leq 0.05$) between weight gain and each of triglycerides, HDL, and LDL. There is also a highly significant inverse relationship between the amount of weight gain and the age of sexual maturity weight. There is also a significant inverse relationship ($P \leq 0.05$) between the amount of weight gain and the weight of the first egg. There is a highly significant direct relationship between the number of eggs produced and each of the weight of the first egg and the weight of sexual maturity. There is also a significant direct relationship ($P \leq 0.05$) with the number of eggs produced and prolactin. There is also a highly significant inverse relationship between the number of eggs produced and each of the age of sexual maturity, triglycerides, Cholesterol, VLDL, LDL, and there is a significant inverse relationship ($P \leq 0.05$) between the number of eggs produced and HDL, as well as a significant direct relationship ($P \leq 0.05$) between the age of sexual maturity with cholesterol and VLDL, and there is also a highly significant inverse relationship between the age of sexual maturity and the weight of the first egg as well as with the weight of sexual maturity, as well as there is a highly significant direct relationship between triglycerides with each of cholesterol and VLDL, and there is also a highly significant inverse relationship between triglycerides and the weight of sexual maturity, as well as a significant inverse relationship ($P \leq 0.05$) between triglycerides and the weight of the first egg, while there is a highly significant direct relationship between cholesterol and each of VLDL, HDL, LDL, while when comparing cholesterol with prolactin, the weight of the first egg, and the weight of sexual maturity, there was a highly significant inverse relationship between them, while when comparing VLDL with each of LDL and HDL, there was a highly significant direct relationship There was a significant inverse relationship ($P \leq 0.01$) between them, as well as a highly significant inverse relationship between VLDL and each of prolactin, the weight of the first egg, and the weight of sexual maturity, as well as an inverse relationship between HDL and prolactin, and a significant inverse relationship ($P \leq 0.05$) between HDL and each of the weight of the first egg

and the weight of sexual maturity. There was also a significant inverse relationship ($P \leq 0.05$) between LDL and each of prolactin, the weight of the first egg, and the weight of sexual maturity. There was also a highly significant direct relationship ($P \leq 0.01$) between the weight of the first egg and the weight of sexual maturity.

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Table (2) Type of correlation between the studied traits of the studied local duck flock

		Number of eggs produced (7 months(	Age of sexual maturity (week(	Triglycerides	Cholesterol	VLDL	HDL	LDL	Prolactin	Weight of the first egg (g)	sexual maturity weight
Total body weight gain (g)	Pearson Correlation	0.807**	-0.59**	0.331*	0.416**	0.416**	0.274*	0.310*	-0.255	-0.247*	0.727**
	Sig. (2-tailed)	0.000	0.000	0.010	0.001	0.001	0.036	0.017	0.051	0.014	0.000
Number of eggs produced (7 months)	Pearson Correlation		-0.909**	-0.392**	-0.443**	-0.443**	-0.278*	-0.349**	0.295*	0.280**	0.985**
	Sig (2-tailed)		0.000	0.002	0.000	0.000	0.033	0.007	0.024	0.005	0.000
Age of sexual maturity (week)	Pearson Correlation			0.222	0.318*	0.318*	0.206	0.242	-0.221	-.483**	-0.947**
	Sig.(2-tailed)			0.091	0.014	0.014	0.118	0.065	0.092	0.000	0.000
Triglycerides	Pearson Correlation				0.634**	0.634**	0.491**	0.382**	-0.182	-0.327*	-0.340**
	Sig.(2-tailed)				0.000	0.000	0.000	0.003	0.167	0.011	0.008
Cholesterol	Pearson Correlation					1.000**	0.772**	0.605**	-0.506-**	-0.403**	-0.420**
	Sig.(2-tailed)					0.000	0.000	0.000	0.000	0.002	0.001
VLDL	Pearson Correlation						0.772**	0.605**	-0.506**	-0.403**	-0.420**
	Sig. (2-tailed)						0.000	0.000	0.000	0.002	0.001
HDL	Pearson Correlation							-0.040	-0.488**	-0.293*	-0.303*

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	Sig.(2-tailed)							0.764	0.000	0.025	0.020
LDL	Pearson Correlation								-0.184	-0.267*	-0.281*
	Sig. (2-tailed)								0.163	0.041	0.031
Prolactin	Pearson Correlation									0.244	0.285*
	Sig. (2-tailed)									0.063	0.028
Weight of the first egg (g)	Pearson Correlation										0.407**
	Sig. (2-tailed)										0.000
**. Correlation is significant at the 0.01 level (2-tailed).											
*. Correlation is significant at the 0.05 level (2-tailed).											

Table (2), which shows the type of correlation between the studied quantitative and physiological traits and their relationship with each other for Iraqi local ducks, shows the following results:

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The scientific interpretation of the correlations between quantitative and physiological traits in Iraqi local ducks, as shown in Table (2), depends on the physiological understanding and metabolism of birds, in addition to the hormonal and genetic influences that govern the productive and metabolic processes. This table shows highly significant direct relationships between the amount of weight gain and the number of eggs, cholesterol, VLDL, and the weight of sexual maturity. This can be explained on the basis that the increase in weight reflects the efficiency of growth and fat deposition, and is usually linked to high levels of lipids in the blood (such as VLDL and cholesterol). Also, birds with a higher weight are more mature and able to enter production. Likewise, weight gain is also linked to improving the physiological condition of the female, which is reflected in egg production [36]. There is also a significant direct relationship between the amount of weight gain and triglycerides, HDL, and LDL. This can be explained by the fact that triglycerides and HDL/LDL are related to nutritional status and metabolic activity. Weight gain is often associated with elevated triglycerides and elevated HDL/LDL cholesterol as a result of increased energy intake and fat accumulation [19]. There is also a highly significant inverse relationship between the amount of weight gain and the age at sexual maturity. The greater the weight gain, the earlier the maturation, which means a shorter age at reaching sexual maturity [21] There is also a significant inverse relationship between the amount of weight gain and the weight of the first egg. In some cases, rapid weight gain negatively affects the quality of early eggs, leading to lower weight eggs at first laying due to the allocation of resources to growth rather than egg formation [25]. This table also shows a direct relationship between the number of eggs laid, the weight of the first egg, the weight at sexual maturity, and prolactin. This can be explained by the fact that increased egg production is associated with the stimulation of the reproductive system and improved hormonal performance, especially prolactin, which regulates ovulation and reproductive behavior. A higher weight at maturity indicates full physical maturity, which supports more egg production [27]. There is also an inverse relationship between the number of eggs produced and the age at sexual maturity, triglycerides, cholesterol, VLDL, LDL, and HDL. This can be explained by the fact that delayed sexual maturity often negatively affects overall productivity. High levels of fat and cholesterol negatively affect reproductive performance and may hinder ovulation [17]. Regarding the relationships associated with age at sexual maturity, there is a direct relationship with cholesterol and VLDL. This can be explained by the fact that birds that mature late tend to accumulate greater fats in the blood during long growth periods [12]. There is also an inverse relationship between the age of sexual maturity and both the weight of the first egg and the weight at sexual maturity. Birds that mature early reach higher weights more quickly and produce larger eggs [27] .

Table (3), which translates the type of correlation between the studied quantitative and physiological traits and their relationship with each other for the commercial Peking duck breed, indicates a highly significant inverse relationship between the age of sexual maturity and the weight at sexual maturity, in addition to the weight at sexual maturity and body weight gain. We also note that the weight at sexual maturity forms a highly significant direct relationship with both the number of eggs

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produced and the weight of the first egg. When we correlate the age of sexual maturity with the weight of the first egg and the number of eggs produced, we find a highly significant inverse relationship. The results also indicate a highly significant direct relationship between the age of sexual maturity and body weight gain, while the total number of eggs formed a highly significant direct relationship with the weight of the first egg, and vice versa, with body weight gain, a highly significant inverse relationship (P≤0.01). As for the weight of the first egg, a highly significant inverse relationship was recorded with body weight gain.

Table 3: Type of correlation between the studied traits for the commercial (Peking) duck flock studied

		Age of sexual maturity/week	Number of eggs produced (7 months)	Weight of the first egg (g)	Total body weight gain (g)
Sexual maturity weight/g	**Pearson Correlation**	**.861-**0**	**.937**0**	**.924**0**	**-.617**0**
	Sig. (2-tailed)	**00.000**	**0.000**	**0.000**	**0.000**
Age of sexual maturity/week	**Pearson Correlation**		**-**0.794**	**-.833**0**	**.480**0**
	Sig. (2-tailed)		**0.000**	**0.000**	**.0020**
Number of eggs produced (7) months	**Pearson Correlation**			**.871**0**	**-.527**0**
	Sig. (2-tailed)			**0.000**	**0.000**
Weight of the first egg (g)	**Pearson Correlation**				**-0.533****
	Sig. (2-tailed)				**0.000**
****. Correlation is significant at the 0.01 level (2-tailed).**					

Table (3) shows a significant inverse relationship between the age at sexual maturity and the weight at sexual maturity. This can be explained by the fact that the older a bird is at sexual maturity, the lower its weight at that age. Birds that reach sexual maturity at an earlier age are still growing and therefore weigh less [21; 26]. This table also shows an inverse relationship between the weight at sexual maturity and body weight gain. This can be explained by the fact that the total body weight gain after sexual maturity is lower in birds that reach a higher weight at sexual maturity, because they have completed a large portion of their growth before the onset of egg production [28;17]. This table also shows a direct relationship between the weight at sexual maturity, the number of eggs produced, and the weight of the first egg. This can be explained by the fact that birds that reach a higher weight at maturity often have more

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developed reproductive systems, which is reflected in their ability to produce more eggs and the onset of larger egg production [35]. There is also an inverse relationship between the age of sexual maturity and the weight of the first egg and the number of eggs produced. This can be explained by birds that reach sexual maturity earlier producing more eggs during the production period and starting with larger eggs because their reproductive systems are active and developing early [22]. There is also a direct relationship between the age of sexual maturity and body weight gain. The later the age of sexual maturity, the more time the birds have to grow and gain body weight before they begin expending energy on egg production [20]. There is also a direct relationship between the total number of eggs and the weight of the first egg. This can be explained by the fact that a higher total egg number is often associated with higher productivity, which is accompanied by earlier reproductive activity, meaning that the first egg is larger [18] This table also shows an inverse relationship between the total number of eggs and body weight gain. Birds that focus their energy on egg production typically exhibit less physical growth after sexual maturity, due to energy being diverted toward reproduction rather than growth [25]. There is also an inverse relationship between the weight of the first egg and body weight gain. Heavier birds often lay their first egg late or are not fully functionally prepared, resulting in a relatively small first egg [17].

Table (4), which examines the type of correlation between the studied traits and weekly body weight during the rearing periods, shows that there were only direct increases, including significant increases, with weekly body weight from the first week to the ninth week. The results also showed a significant direct increase with prolactin only for the weeks from the thirteenth to the seventeenth week. Prolactin also recorded a significant direct relationship with body weight in the final week of rearing, week (31). From the above, we find that the significant relationship recorded between the physiological traits of interest is the relationship between prolactin and both quantitative and physiological traits, in addition to body weight. Note that there was a significant direct increase with body weights throughout the rearing periods.

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Table 4: The type of correlation between prolactin and weekly body weight in domestic ducks

	attribute/two weeks	The amount and significance of the correlation	Prolactin hormone International unit/picomoles		Attribute/Two Weeks	The amount and significance of the correlation	Prolactin hormone International unit/picomoles
1	Body weight for week 1	Pearson Correlation	0.285*	9	Body weight for week 17	Pearson Correlation	0.282*
		Sig. (2-tailed)	0.028			Sig. (2-tailed)	0.030
2	Body weight for week 3	Pearson Correlation	0.294*	10	Body weight for week 19	Pearson Correlation	0.255
		Sig. (2-tailed)	0.024			Sig. (2-tailed)	0.052
3	Body weight for week 5	Pearson Correlation	0.298*	11	Body weight for week 21	Pearson Correlation	0.235
		Sig. (2-tailed)	0.022			Sig. (2-tailed)	0.074
4	Body weight for week 7	Pearson Correlation	0.328*	12	Body weight for week 23	Pearson Correlation	0.209
		Sig. (2-tailed)	0.011			Sig. (2-tailed)	0.111
5	Body weight for week 9	Pearson Correlation	0.302*	13	Body weight for week 25	Pearson Correlation	0.226
		Sig. (2-tailed)	0.020			Sig. (2-tailed)	0.085
6	Body weight for week 11	Pearson Correlation	0.215	14	Body weight for week 27	Pearson Correlation	0.244
		Sig. (2-tailed)	0.103			Sig. (2-tailed)	0.063
7	Body weight for week 13	Pearson Correlation	0.278*	15	Body weight for week 29	Pearson Correlation	0.255
		Sig. (2-tailed)	0.033			Sig. (2-tailed)	0.051
8	Body weight for week 15	Pearson Correlation	0.282*	16	Body weight for week 31	Pearson Correlation	0.278*
		Sig. (2-tailed)	0.031			Sig. (2-tailed)	0.033

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Table (4) shows a significant direct relationship between weekly body weight during the rearing period (week 1 to week 9). It is normal for a linear or direct growth in weight to appear during the first weeks of rearing, as the period of rapid early growth (Rapid Growth Phase) is during this period when the body is in the process of structural and muscular formation, and weight increases regularly, especially if ideal conditions of nutrition and management are provided [26]. There is also a significant direct relationship between the hormone prolactin and body weight from week (13) to week (18). In weeks 13-17, the birds are approaching the stage of sexual maturity, and at this stage, prolactin begins to rise in response to physiological changes related to sexual maturity [11; 32]. There is also a significant direct relationship between prolactin and body weight in week (31). Week 31 represents the stage of peak production or physiological stability. In birds, if prolactin levels remain high at this stage, this may indicate its continued support for metabolic and reproductive processes, which is reflected in body weight. In some studies, it has been observed that prolactin levels may rise near or during the period of high egg production. The positive correlation between prolactin and body weight at this stage means that birds with higher body weight exhibit better physiological control of reproductive processes [24].

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