



# Impact of male-female cohabitation period on behavioral aspects, fertility, hatchability, and hormonal estimates of Japanese quail

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**ABSTRACT** To evaluate the impact of male-female cohabitation period on the fertility, hatchability, injuries response, and some hormonal estimates in Japanese quails. A total of 288 mature Japanese quails were equally divided into 3 groups (3 groups × 8 replicates × 12 birds), with 1 Male: 2 Females sex ratio. In the first group (control), male and female quails were reared continuously together, while the males in the second and third groups were reared together with females once or twice/wk times (24 h/ time), respectively throughout the experiment. The obtained results showed that final body weight (FBW/g), fertility (%), and hatchability (%) in the second and third groups significantly ( $P \leq 0.01$ ) increased compared with the control group. Laying quails in the second and third groups significantly ( $P \leq 0.01$ ) produced more and heavier eggs, while the feed consumption and feed conversion ratio were significantly ( $P \leq 0.01$ ) decreased compared with the control group. The injuries response for both sex in

the second and third groups significantly ( $P \leq 0.01$ ) decreased compared with the control group. The cloacal size (mm<sup>2</sup>) for quails in the third group significantly ( $P \leq 0.01$ ) increased than those of the first and second groups, while the testes (%) were not affected. The testosterone hormone concentration for male chickens in the second and third groups significantly ( $P < 0.01$ ) decreased, while the female progesterone hormone concentration (ng/mL) significantly ( $P < 0.01$ ) increased compared with the control group. The means of red blood cells (RBC/106), white blood cells (WBC/103), and hemoglobin (g/dL) for quails in the second and third groups significantly ( $P < 0.01$ ) increased, while heterophil/lymphocyte (H/L ratio) significantly ( $P < 0.01$ ) decreased compared with the control group. Thus, it could be concluded that the reduction male-female cohabitation period of quails is recommended for improving the fertility and hatchability percentages as well as and some hormonal estimates.

**Key words:** male-female cohabitation, quails, fertility, hatchability, hormonal estimates

2022 Poultry Science 101:101530

<https://doi.org/10.1016/j.psj.2021.101530>

## INTRODUCTION

Aggression is a social behavior between bird individuals (Demas et al., 2007). Focusing on male-female sexual aggression; copulation, harassment, and intimidation are the main forms of male aggressiveness expressed toward a female (Clutton-Brock and Parker, 1995). High sexual aggressions incidence such as pain, injuries, and death in domestic birds are considered aberrant

behaviors that negatively affect the poultry industry and the economic compromise (Millman et al., 2000). The behavioral measurement related to welfare is associated with flock productivity (O'connor et al., 2011; Nasr et al., 2012).

In quails, head injuries and aggressive pecking behavior in the male quails are important welfare problems in quail farming (Wechsler and Schmid, 1998). For instance, in quail feather pecking induced high basal plasma corticosterone which negatively affects egg production (Marin et al., 2002). Also, feather pecking in chickens negatively affects egg weight, egg production, and feed efficiency (Buitenhuis et al., 2004). Therefore, beak trimming is considered necessary for routine management practice in commercial quails production to

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Received December 3, 2020.

Accepted October 7, 2021.

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prevent feather pecking and reduced social stress (Cloutier et al., 2000).

Adjusting the male-female mating ratio is another management procedure applied to minimize sexual aggressions within a flock. The sex mating ratio proposed to affect the productivity of the birds in terms of the fertility and hatchability of the eggs, few or many males in a flock may cause a higher percentage of infertile eggs (Haghighi et al., 2016). The numerous male can stress both sexes (Ophir and Galef, 2003) probably arising from the aggressive actions of the cocks toward the hen during forced copulation (Moyle et al., 2010). Typically for quails proposed male-female mating ratio for the best fertility and hatchability is 1:2 (Narinc et al., 2013).

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In quails, non-sexually aggressive pecking injuries are observed in mixed groups and sexually aggressive pecking injuries appear in the head as a consequence of both male-female and same-sex interactions (Millman et al., 2000). The sexual behavior in male-male interactions are grabs, mounts, chase, and cloacal contacts associated with strong aggressive pecks immediately after 2 males are reared together to establish dominance (Caliva et al., 2017).

In quails, there is an indication that courtship seems to be stressful for females as mating can be forced (Adkins-Regan, 1995), the aggressive activity of the male during copulation may injury female as well as the sexually experienced female quail, avoid the aggressive male (Ophir et al., 2005). Social and sexual female-male interactions increase the baseline corticosterone levels while the absence of corticosterone level rises in separated females from males (Rutkowska et al., 2011). The negative relationship between baseline corticosterone and production were observed in quails and other avian species (Schoech et al., 2007; Rutkowska et al., 2011).

This study aimed to assess the relationship between male-female cohabitation period and aggressive interactions, which certainly induce body wounds and injuries also to study the reproductive performance of quails subjected to different male-female cohabitation period for short term to determine the appropriate male-female cohabitation period for Japanese quails in an experimental condition using numerous managerial bird welfare traits.

## MATERIALS AND METHODS

This study was carried out at the Experimental Poultry Farm, Poultry Production Department, Agriculture Faculty, Assiut University, Assiut, Egypt.

## Quails, Diet, and Experimental Design

A total of 288 Japanese quails, 8 wk old, were used in an experiment of 16 wk, which equally classified into 3 groups, 8 replicates (8 females and 4 males /each), with (1 M: 2 F) sex ratio. All quails were equally divided into 3 experimental groups (3 groups  $\times$  8 replicates  $\times$  8 Females + 4 Males). In the first group, both male and female quails were raised continuously throughout the experiment and considered as a control group, while the males in the second and third groups were housed with females at 1 and 2 times per week for 24 h per time, respectively under similar environmental, managerial and hygienic conditions. All quails were fed on a mash basal ration. All quails were kept in wire galvanized cages (42 cmW  $\times$  50 cmL  $\times$  40 cmH), equipped with feeders and automatic nipples. Both male and female quails were raised under similar environmental conditions (18–26°C) and (55–65%) as well as daily exposure to 16 continuous light hours.

## Environmental Conditions

The newly hatched quail chicks were kept under similar recommended hygienic management conditions in brooding floor pens until they were 6 wk of age and then transferred to the breeding house. The lighting program was 23 h light:1 h dark during the first 3 d, which was gradually decreased (1 h/week) to reach 16 daily light hours at 8 wk of age and this regime lasted constantly till the end of the study (24 wk of age). An automatic clock was used to control the light period during the entire experiment. Light intensity during the rearing period was 50 lux and 40 to 50 lux during the experimental period at the head of birds as measured by lux meter. The ambient temperature (°C) and relative humidity (%) were recorded daily during the experimental period by using a thermometer and hygrometer located in the central part of the house. The quail chicks' brood room temperature was decreased gradually from 35–37°C (at hatch) to 20–23°C at 5 wk of age and the relative humidity average was 60 to 65% up to the end experiment. Water and feed were continuously provided during the study period. All chicks were fed on a standard starter ration (22.52% CP and ME 12.78 MJ kg<sup>-1</sup> of diet) during the growing period, while they were fed (21.0% CP and ME 13.56 MJ kg<sup>-1</sup> of diet) during the laying period (Abuoghaba et al., 2021).

## Measurements and Observations

**Productive Performance** The initial and final body weights (g) for males and females were recorded at 8 and 24 wk of age. Also, egg numbers and weights were recorded daily throughout the experiment. The averages of feed consumption were weekly measured. The egg weight was determined using an electronic digital balance. The egg numbers were recorded daily, while the egg mass was calculated by multiplying the egg numbers and weight (g) for all replicates within each group.

**Fertility, Hatchability, and Embryonic Mortality** A total of 5,760 fresh quail eggs were randomly collected at the different weeks of age that is, 480 eggs (3 groups × 8 replicates × 20 eggs) per time/week throughout the experiment. All eggs were collected from different experimental groups (continuous, 1, and 2). All eggs were incubated under the normal incubation conditions (37.5°C and 50–55% RH) from d 0 till hatching and they daily automatically turned 12 times (2 h/each). The eggs were regularly observed to verify their hatching; the unhatched eggs were examined to detect the embryonic mortality rate. The embryonic mortality percentages during incubation were determined at the end of the experiment throughout the broken unhatched eggs; and classified to the early embryonic mortality (E0–E6), middle embryonic mortality (E7–E14), and late embryonic mortality (E15–E17) according to the following equation: (Dead embryos number/whole viable egg numbers) × 100, the egg piping percentage was calculated as the number of piped eggs /whole viable egg number) × 100. At hatching, the hatchability percentages for set and fertile eggs were expressed as fertile egg percentages.

**Hematological Parameters** At 24 wk of age, 96 blood samples (3 groups × 8 replicates × 4 chicks) that is 32 blood samples (16 male and 16 female) from each group were randomly equal taken from the brachial vein into heparinized and nonheparinized tubes. Blood samples were centrifuged at 4,000 rpm for 15 min to obtain plasma was stored at –20°C until analysis. The granular and nongranular ones based on the procedures of Gross and Siegel (1983). Briefly, one drop of blood being smeared on each of the glass slides. Wright's stain was used to stain the smears. Hundred leukocytes, including granular and nongranular, were counted on different microscopic fields representing 100 cells and the heterophil to lymphocyte ratio was calculated. Hemoglobin (Hb) concentration was determined by using a spectrophotometer, while the red blood cell (RBCs/10<sup>6</sup>) number was counted by using a hemocytometer according to Schalm et al. (1975). White blood cells (WBC/10<sup>3</sup>) count and the heterophils to the lymphocyte (H/L) ratio were estimated as described by Gross and Siegel (1983).

## Testicle and Cloacal Gland Evaluations and Carcass Percentage of Quails

At the end of the experiment, 48 male quails (3 groups × 8 replicate × 2 chicks) were selected and slaughtered using the cervical dislocation technique and dissected for removal of testis. Both of right and left testicles of quails were immediately weighed using a digital scale that weighed to the nearest 0.001 g to calculate the gonadosomatic index (GI = testicles weight / body weight × 100) (Khalil et al., 1989). The cloacal gland was evaluated at 112 d of age. The lateral width (LW) and ventral-dorsal height (VDH) of the cloacal gland were measured to calculate the area of the gland (AG = LW × VDH) (Fields et al., 1979).

## Hormonal Estimates

At the end of the experiment, 48 blood samples (3 groups × 8 replicate × 2 chicks) that is, 16 samples per group (8 males and 8 females), 2 mL each was drawn and used for the colorimetric estimation of progesterone and testosterone hormone concentrations.

## Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA) by applying the general linear model procedure of SAS software (SAS, 2003). All means were tested for significant differences using Duncan's multiple range procedure (Duncan, 1955). The following statistical model was used for ANOVA:  $Y_{ij} = \mu + T_i + e_{ij}$ ,  $Y_{ij}$  = an observation,  $\mu$  = the overall mean,  $T_i$  = treatment effect and  $e_{ij}$  = experimental random error. The replicate was the experimental unit in the present work.

## RESULTS

The findings in Table 1 showed that the means of final body weight, egg number, laying rate, and egg mass of quails in the second and third groups significantly ( $P \leq 0.01$ ) increased compared with the control group.

**Table 1.** Impact of male-female cohabitation period on the productive performance of quails.

Traits		Male-female cohabitation period			SEM	P-value
		Continuous	Once	Twice		
Initial body weight (g)	Male	256.19	254.47	255.31	5.98	0.9796
	Female	269.97	269.97	269.88	3.52	0.9998
Final body weight (g)	Male	232.00 <sup>b</sup>	249.48 <sup>a</sup>	243.71 <sup>a</sup>	3.40	0.0029
	Female	271.04 <sup>b</sup>	283.20 <sup>a</sup>	282.45 <sup>a</sup>	3.33	0.0129
Egg weight (g)		12.54	12.82	12.64	0.13	0.3409
Daily egg number (egg no./hen/day)		0.68 <sup>b</sup>	0.81 <sup>a</sup>	0.74 <sup>b</sup>	0.021	0.0027
Daily egg mass (g egg/hen/day)		8.53 <sup>c</sup>	10.34 <sup>a</sup>	9.36 <sup>b</sup>	0.86	0.0005
Ten (egg/hen/112 d)		76.19 <sup>b</sup>	90.27 <sup>a</sup>	83.03 <sup>b</sup>	2.31	0.0027
Laying rate (%)		68.03 <sup>c</sup>	80.62 <sup>a</sup>	74.13 <sup>b</sup>	2.06	0.0027
Daily feed consumption (g/hen)		37.35 <sup>a</sup>	32.20 <sup>b</sup>	31.01 <sup>b</sup>	0.86	0.0003
Feed conversion ratio(g feed/g egg)		4.38 <sup>a</sup>	3.11 <sup>b</sup>	3.31 <sup>b</sup>	0.16	0.0001
Mortality rate	Male	7.62	1.25	3.125	-	-
	Female	15.62	3.50	6.495	-	-

<sup>abc</sup>Means with different superscripts in the same row are significantly different ( $P < 0.05$ ).

**Table 2.** Impact of male-female cohabitation period on the fertility, hatchability, and embryonic mortality of quails.

Traits	Male-female cohabitation period			SEM	P-value
	Continuous	Once	Twice		
Fertility (%)	80.60 <sup>c</sup>	86.52 <sup>b</sup>	92.63 <sup>a</sup>	1.04	0.0001
Hatchability of set eggs (%)	56.48 <sup>b</sup>	66.18 <sup>a</sup>	70.03 <sup>a</sup>	1.77	0.0001
Hatchability of fertile eggs (%)	70.04 <sup>b</sup>	76.36 <sup>a</sup>	75.58 <sup>a</sup>	1.54	0.0164
Embryonic mortality rate (%)					
Early 0–6 d	7.08	9.34	10.97	1.17	0.0861
Mid 7–14 d	3.37	3.43	2.43	0.53	0.3472
Late 14–17 d	11.48 <sup>a</sup>	6.57 <sup>b</sup>	7.37 <sup>b</sup>	0.57	0.0001
Piped eggs (%)	1.68	1.00	1.38	0.41	0.5200

<sup>abc</sup>Means with different superscripts in the same row are significantly different ( $P < 0.05$ ).

Male-female cohabitation period had a significant decrease ( $P = 0.0003$  &  $P = 0.0001$ ) in feed consumption and feed conversion for the second and third groups compared with the control group. The mortality rate percentages for both males and females in the second and third groups were remarkably lower than in the control group.

The findings in **Table 2** showed that the hatchability of set eggs and hatchability of fertile eggs percentages for quails in the first and second groups significantly ( $P < 0.0001$  &  $0.01$ ) increased compared with those in the control group. The fertility (%) of quails in the second and third groups significantly ( $P < 0.01$ ) increased compared with those in the control group. The highest fertility percentage of once and twice groups in terms of male-female cohabitation period amounted 86.52 and 92.63%, respectively compared with 80.6% in the control group.

The embryonic mortality rate (%) in the first and second groups during the late incubation period significantly ( $P < 0.01$ ) decreased compared with those in the first group.

The findings in **Table 3** demonstrated that there is no significant difference between the groups in percentages of the carcass, right testis weight, left testis weight, and gonadosomatic indexes. The cloaca size ( $\text{mm}^2$ ) had a

**Table 3.** Impact of male-female cohabitation period on testicle and cloacal gland evaluation and carcass percentage of quails.

Traits	Male-female cohabitation period			SEM	P-value
	Continuous	Once	Twice		
Carcass (%)	72.64	74.32	74.78	1.08	0.3554
Testicle and cloacal gland evaluation					
Right testis weight (%)	1.59	1.69	1.66	0.103	0.7800
Left testis weight (%)	1.46	1.49	1.76	0.12	0.2075
Gonadosomatic index	3.05	3.18	3.42	0.211	0.4758
Cloacal gland size ( $\text{mm}^2$ )	287.62 <sup>b</sup>	375.19 <sup>a</sup>	395.70 <sup>a</sup>	6.95	0.0001

Gonadosomatic index = Two testis (%).

<sup>ab</sup>Means with different superscripts in the same row are significantly different ( $P < 0.05$ ).

**Table 4.** Impact of male-female cohabitation period on injuries responses of quails.

Sex	Organ	Male-female cohabitation period			SEM	P-value
		Continuous	Once	Twice		
Male	Head	2.41 <sup>a</sup>	1.75 <sup>b</sup>	1.48 <sup>b</sup>	0.15	0.0001
	Neck	2.22 <sup>a</sup>	1.66 <sup>b</sup>	1.13 <sup>c</sup>	0.11	0.0001
	Back	2.52 <sup>a</sup>	1.59 <sup>b</sup>	1.42 <sup>b</sup>	0.12	0.0001
	Wing	2.41 <sup>a</sup>	1.41 <sup>b</sup>	1.29 <sup>b</sup>	0.12	0.0001
	Tail	2.15 <sup>a</sup>	1.16 <sup>b</sup>	1.39 <sup>b</sup>	0.11	0.0001
Female	Leg	1.48 <sup>a</sup>	1.09 <sup>b</sup>	1.06 <sup>b</sup>	0.13	0.0452
	Head	2.21 <sup>a</sup>	1.35 <sup>b</sup>	1.43 <sup>b</sup>	0.09	0.0001
	Neck	2.04 <sup>a</sup>	1.38 <sup>b</sup>	1.26 <sup>b</sup>	0.09	0.0001
	Back	2.85 <sup>a</sup>	1.97 <sup>b</sup>	1.72 <sup>b</sup>	0.09	0.0001
	Wing	2.10 <sup>a</sup>	1.35 <sup>b</sup>	1.22 <sup>b</sup>	0.08	0.0001
	Tail	2.21 <sup>a</sup>	1.23 <sup>b</sup>	1.16 <sup>b</sup>	0.08	0.0001
	Leg	2.31 <sup>a</sup>	1.30 <sup>b</sup>	1.24 <sup>b</sup>	0.12	0.0001

<sup>abc</sup>Means with different superscripts in the same row are significantly different ( $P < 0.05$ ).

significant ( $P < 0.001$ ) increase in the second and third groups compared with the control group.

Data presented in **Table 4** showed that the less male-female cohabitation period had a significant decrease ( $P < 0.001$ ) in injuries of the head, neck, back, wing, tail, and leg in males and females of the second and third groups compared with the control group. Head, neck, back, wing, tail, and leg injury for male and female quails in the control group are partly caused by mating, especially damage to the back. The findings suggest that reduction of male-female cohabitation period may reduce male aggression against females than the continuous presence of males with females in control groups.

The hematological parameters of female and male quails are presented in **Table 5**. The data showed that the means of WBC ( $10^3$ ) and Hb (g/dL) for male and female quails significantly ( $P \leq 0.01$ ) increased in the second and third groups compared to the control group. The results showed a significant ( $P \leq 0.01$ ) decrease in the H/L ratio for the second and third groups compared with the control group. The highest testosterone hormone concentration for male quails was observed in the control group compared with the second and third groups. The obtained finding showed a significant increase in progesterone concentration for female quails in the second and third groups compared with the control group.

## DISCUSSION

The findings revealed that the means of final body weight, egg number, laying rate, and egg mass of quails in the second and third groups significantly ( $P \leq 0.01$ ) increased compared with the control group. The significant ( $P \leq 0.01$ ) increase in the final body weight and laying rate for quails in the first and second groups may be due to reducing the feather pecking between the quails, which are considered as social stress. These findings agreed with those of [Pizzolante et al. \(2007\)](#), who noted that an increase in stress levels induce an increase in adrenaline, oxytocin, and vasopressin levels, which may increase oviduct contraction, causing the egg undergoing

**Table 5.** Impact of male-female cohabitation period on the hematological parameters of quails.

Sex	Traits	Male-female cohabitation period			SEM	P-value
		Continuous	Once	Twice		
Male	RBCs ( $10^6$ )	3.40	3.748	3.66	0.103	0.0691
	WBCS ( $10^3$ )	19.06 <sup>b</sup>	22.50 <sup>a</sup>	21.75 <sup>a</sup>	0.610	0.0010
	PCV (%)	41.62	43.68	44.188	0.846	0.0927
	Hemoglobin (g/dL)	12.75 <sup>b</sup>	14.06 <sup>ab</sup>	14.93 <sup>a</sup>	0.594	0.0457
	H/L ratio	0.424 <sup>a</sup>	0.243 <sup>c</sup>	0.311 <sup>b</sup>	0.0059	0.0001
	Testosterone (ng/mL)	3.24 <sup>a</sup>	2.86 <sup>b</sup>	2.06 <sup>c</sup>	0.08	0.0001
Female	RBCs ( $10^6$ )	3.20	3.39	3.55	01.799	0.8063
	WBCS ( $10^3$ )	17.625 <sup>b</sup>	23.94 <sup>a</sup>	22.25 <sup>a</sup>	0.894	0.0001
	PCV (%)	41.50	42.87	44.00	0.668	0.2842
	Hemoglobin (g/dL)	12.25 <sup>b</sup>	13.25 <sup>b</sup>	15.125 <sup>a</sup>	0.439	0.0013
	H/L ratio	0.415 <sup>a</sup>	0.263 <sup>c</sup>	0.326 <sup>b</sup>	0.0019	0.0001
	Progesterone (ng/mL)	4.08 <sup>b</sup>	5.23 <sup>a</sup>	4.31 <sup>a</sup>	0.24	0.0077

Testosterone and progesterone concentrations (ng/mL) in male ( $n = 16$ ) and female ( $n = 16$ ).

<sup>abc</sup>Means with different superscripts in the same row are significantly different ( $P < 0.05$ ).

calcification to be expelled, therefore increasing the incidence of eggs with no shells or with soft shells. Additionally, in Japanese quail feather pecking and stress-induced basal corticosterone rise, negatively affects egg production (Marin et al., 2002). Moreover, in avian species, high corticosterone level is associated with enhancing proteolysis (Shini et al., 2009). Concerning protein metabolism, high corticosterone leads to an increased net breakdown of protein, especially in muscle tissue (Mumma et al., 2006; Dong et al., 2007). Albumen and yolk weight are decreased due to protein lack by enhanced proteolysis causing egg weight reduction. Retention of the time in the oviduct may restrict the formation of both egg yolk and albumen (Moran, 1987). Similar results were also found by (Abdelfattah, 2018) that no significant differences between beak trimming and nontrimming on egg weight of quails during the egg production period.

The decreased feed consumption in the second and third groups may be due to the decrease in the stress on the quail as a result of the competition between males and females, where the presence of males with females for long periods leads to females' fear of feed consumption and waste by males and thus reduce the feed consumption in the treated groups. This is in harmony with the results of Pizzolante et al. (2007), who reported that the beak trimming variant had a significant effect on lay percentage, egg mass, feed intake, and feed conversion ratio in nontrimmed and one-third trimmed of the beak quails. Also, (Mertens et al., 2009) illustrated that the higher feed consumption in nontrimmed birds is a combination of a higher metabolic energy requirement for birds, as a result of increased body activity and the deterioration of the feather conditions. As the stress response negatively affects bird production performance (Barnett et al., 1992). Taken together, these findings indicate that aggression and stress in a control group negatively affect the quail's production performance.

The expectation was that injuries resulted from the aggressive behavior of males and feather pecking during mating would negatively affect quails production. Indeed, for both males and females in the treated groups, the mortality rates were lower than in the control group. A possible explanation for the expected positive relationship

between less male-female cohabitation period and mortality is that quail in second and third groups with fewer head injuries and feather pecking. These findings are in line with that quail's beak trimming resulted in reduce feather pecking, cannibalism, and injuries caused by male quail's aggressive behavior toward females and thus reducing the mortality rate (Cheng and Muir, 2007).

Egg fertility is an outcome of successful copulation and semen quality (McGary et al., 2003). The highest fertility of once and twice mating /week groups in terms of male-female cohabitation period amounted 86.52 and 92.63%, respectively. These results are in good agreement with the findings that the lower mating ratio might enhance the quail's ability to be fertilized (Narinc et al., 2013). This is in line with other studies in hens that the highest egg fertility with a low mating ratio (Chotesangasa, 2001). Additionally, these findings are in agreement with the higher fertility percentage for quails in the individual cage than the colony cages. The reduction of fertility and hatchability percentages in colony cages the most probably due to stress, pain, cannibalism, and high aggression behavior among males (Narinc et al., 2013).

Application of once or twice male-female cohabitation period resulted in an increase of the hatchability of set eggs and hatchability of fertile eggs percentages than those of the control group. The increased hatchability percentages could be attributed to the increase in the fertility of treated groups, which coincided with by lower aggressive activity of males toward females during mating. Besides, there are no significant differences in the percentage of the piped egg between the groups. The increased cloacal size in the second and third groups may be due to the increase in the progesterone levels on the quail and the improvement in egg production.

Head, neck, back, wing, tail, and leg injuries in male and female quails in the control group are partly caused by mating, especially damage to the back. The findings suggest that reduction of male-female cohabitation period may reduce male aggression against females than the continuous presence of males with females in control groups. The findings fit with the higher feather pecking for the hens during mating (Savory, 1995). Body injuries can originate from feather pecking, thus high levels of

injuries were related to high mortality rates due to cannibalism (Savory, 1995). A possible explanation for the expected positive relationship between male-female cohabitation period and feather pecking in the control group is that birds with high circulating testosterone levels. In quails, it has been demonstrated that male castrations reduce male aggressive behavior and testosterone treatment recovers male aggression (Adkins and Pniewski, 1978).

The results showed that male-female cohabitation period significantly affected some hematological traits. The improved hemoglobin concentration in the second and third groups indicated the absence of anemia and improve health conditions of the birds (Wagh and Grant, 2014). Also, the increased hemoglobin concentration of the quail could reflect the oxygen-carrying capacity of the blood (Fasuyi and Arire, 2015). These results agreed with the findings of Abdelfattah (2018) who reported that beak trimming had significant effects on the hemoglobin concentration of Japanese quails. The H/L ratio is generally an indicator of stress in fowls (Gross and Siegel, 1983; Al-Murrani et al., 1997) and quails (Nazar and Marin, 2011). It can, therefore, be inferred from the findings that the birds with the control group were more stressed than treated groups.

The highest testosterone concentration was observed for quails in the control group compared with the treated groups. These results indicated that male quail's testosterone concentrations aren't elevated after short-time interactions with females, but are increased after prolonged house with the female (Delville et al., 1984). Generally, in avian males, the effect of female presence leads to raising testosterone concentration (Gwinner et al., 2002; Pinxten et al., 2003). These results are consistent with Abdelfattah (2018), who found that the testosterone concentration for trimmed beak quails leads to improving quail productivity. Moreover, the high amount of progesterone hormones belonged to the second and third groups, which means fewer male-female cohabitation periods may produce a high number of ovarian follicles. In laying birds the largest preovulatory follicle produces a high concentration of progesterone, which is associated with the high concentration of steroidogenic acute regulatory protein expression inside the follicle granulosa layer. It is reported that the greater number of ovarian follicles displayed the higher production of the egg (Johnson, 2015). It is well reported that the total number of follicles indicates the levels of steroid hormones (Gilbert et al., 1980). These results are consistent with the results of (Abdelfattah, 2018) who reported that the concentration of progesterone is affected by beak trimming behavior, thereby increasing quail productivity.

## CONCLUSIONS

These findings could be summarized as follows:

- (i) Application of once or twice male-female cohabitation period resulted in an increase of the fertility and hatchability percentages compared with the control group.

- (ii) Minimizing the male-female cohabitation period significantly decreased injury responses for quails in the second and third groups compared with control.
- (iii) Adjusting the male-female cohabitation period could be a management procedure to minimize sexual aggression within a quail flock.
- (iv) Thus, the reduction of male-female cohabitation period in quails is recommended for improving the production and some hormonal estimates of quails.

## ACKNOWLEDGMENTS

The authors thank the colleagues of the Poultry Production Department, Faculty of Agriculture, Assiut University, Assiut, Egypt for their contributions and encouragement.

Ethics statement: The experiment was carried out according to Assiut University Ethics Committee for the Care and Using Experimental Animals. All Japanese quails were monitored 5 times daily during the experimental period to detect any stress signs and suffering birds. Humane endpoints could not be used due to the continuous severity assessment within the procedure of the study showed that all aspects of the study don't cause quails severe pain or suffering or lasting harm.

## DISCLOSURES

The authors certify that the material discussed in the manuscript was not conflicting of interest with any financial organization.

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