Research Article

Evaluating Body Weight and Carcass Traits in Six Hybrid Quail Varieties Over a Five Week Period

Amal Ahmed Abdel-Halim[1], Esteftah Mohamed El-Komy[2], Ahmed Mosaad Abdelsalam[2], Gomaa Said Ramadan[2]*

[1]*Department of Animal Production, Faculty of Agriculture, Cairo University, 12613 Giza, Egypt;* [2]*Animal Production Department, Agricultural and Biological Research Institute, National Research Centre, Dokki, Giza 12622, Egypt.*

Abstract | The objective of this study was to examine the body weight, growth performance and carcass characteristics of six different hybrid lines of Japanese quails. The research was conducted at the National Research Centre farm and Stino Quail Farm. The selection process for body weight was carried out for two generations, focusing on achieving higher body weight at five weeks of age. This resulted in the establishment of selected lines with superior body weight. The data collected from the study were analyzed using the xlstat software. One-way and two-way analysis of variance methods were applied to examine the differences in various parameters. The results revealed significant variations in the weekly mean body weight of the quail birds at weeks 0, 1, 2, 3, 4, 5, and 6 among the different hybrid lines. These differences imply varying growth rates and body weights throughout the study period. Furthermore, the average carcass characteristics displayed significant variation among the hybrid lines. It was observed that Hy5 Imported Quail, which represents hybrid line 5, consistently performed better in terms of carcass characteristics when compared to the other quail hybrids. In conclusion, the present study highlighted the significant differences in body weight growth and carcass characteristics among different hybrid lines of Japanese quails. The findings contribute to our understanding of the genetic traits and growth potential of these quail hybrids, with Hy5 Imported Quail demonstrating superior performance in carcass characteristics.

Keywords | Carcass characteristics, Growth performance, Japanese Quail, Quail, Selection

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***Correspondence** | Gomaa Said Ramadan, Department of Animal Production National Research Centre, 12622, Dokki, Giza, Egypt; **Email:** gomaasaid87@gmail.com
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INTRODUCTION

The economic viability of quail meat production has been extensively studied, and the findings indicate that this avenue holds immense potential. Compared to other types of poultry, raising quail is more cost-effective in terms of maintenance, feeding, and veterinary care (Lukanov and Pavlova, 2020; Hatab *et al*., 2024). Quail meat is considered a premium product that caters to a specific market niche, complementing the demand for other poultry meats (Bakoji *et al*., 2013; Kar *et al*., 2017; Sultana *et al*., 2007).

Quail birds have long been recognized as an important resource for both meat and eggs. They are known for their high nutritional value, with their meat being low in fat and cholesterol, making it a healthier alternative to other poultry products. Quail eggs are also highly valued for their rich protein content and unique taste. One of the remarkable characteristics of quail birds is their ability to thrive in harsh environmental conditions (Farahat *et al*., 2018). They are known for their resilience and adaptability, which makes them suitable for various geographical locations across different continents. This adaptability has contributed to the widespread distribution of quail populations worldwide (Mnisi *et al*., 2021).

Over the years, several lines, breeds, and variants of quail have been established to meet specific production requirements. These include laboratory strains used for research purposes and commercial strains bred for meat and egg production. The breeding and development of these different quail varieties have been driven by the demand for specific traits, such as higher meat yield or increased egg production (Ramadan *et al*., 2022; Elkhaiat *et al*., 2023). Interestingly, there are numerous domestic quail breeds or strains, estimated to be around 70, which exhibit visible variations in terms of their physical and genetic traits. It is essential to note that all domestic quails are ultimately descendants of wild strains. However, the exact origins of these domesticated quails and the specific wild population from which they originated remain unknown (Lukanov and Pavlova, 2020). A study conducted by Chang *et al*. (2005) examined the genetic diversity among quail populations and suggested that multiple wild populations may have contributed to the domestication process. The process of domestication involves selecting individuals with desired traits and breeding them to enhance those traits over generations. Through this process, the domestic quail breeds we see today have developed distinct characteristics that separate them from their wild counterparts.

As research and genetic analysis continue to advance, there is hope that we will gain a better understanding of the origins and domestication history of quail birds. This knowledge can further contribute to the improvement of quail breeding programs, helping to enhance their production efficiency and adaptability to different environments (Eissa *et al*., 2014). Quail birds will continue to play a significant role in meeting the growing demand for poultry products, particularly in regions with challenging climates or limited resources (Arunrao *et al*., 2023). Genetic selection involves choosing animals with desirable traits, such as higher body weight, as breeding stock to produce the next generation. This method has been widely used and proven to be effective in animal breeding programmes (Hassan *et al*., 2011; Hassan and Fadhil, 2019). By selecting animals with higher body weight, the average body weight of the population can be increased over time. Another approach is the use of outbreeding mating systems, which involves mating individuals from different lines to create hybrid offspring. This can lead to the phenomenon of heterosis, where the hybrid offspring exhibit improved traits compared to their parents (Hassan *et al*., 2011; Hassan and Fadhil, 2019). By exploiting heterosis, breeders can further increase the body weight and growth performance of the next generation.

Body weight is highly heritable, meaning there is a strong genetic component to it. This allows for phenotypic selection, where animals with higher body weight are selected based on their observable characteristics. By choosing individuals with higher body weight as breeding stock, breeders can improve the overall body weight of the population. Overall, the study aimed to evaluate the impact of crossing and selection on body weight, growth performance, and carcass characteristics in chickens at a specific age (Numair *et al*., 2023)

This research is important for understanding and improving the breeding programs focused on meat production by selecting animals with desirable traits and optimizing hybridization strategies.

MATERIALS AND METHODS

Study site

This study was conducted in a poultry house at the Stino Quail Farm, Al-Hoda Cooperative Association, Cairo-Alexandria Desert Highway, 64 km, Egypt, and the Poultry Experiment Station, Department of Animal Production, National Research Centre.

Birds and management

Three base populations, consisting of 450 one-day-old chicks for each population, were reared in wooden boxes designed for this purpose. The three lines of quail were line S (white quail), line B (dark quail), and line Y (golden quail). These quails were reared until they reached adult sexual maturity. At sexual maturity, males from line S and females from lines B and Y were selected. The rationale for this selection was based on maximizing genetic diversity and enhancing specific desirable traits. The selected males and females were mated according to a sex ratio of 3:1 (three females to one male).

Selection procedure

The selection procedure prioritized body weight at five weeks of age and was conducted over two generations to establish selected lines. Both females and males with higher body weights at five weeks were individually selected for the high body weight line. The selection criteria were applied rigorously to ensure the propagation of these traits. Hatching eggs from each line were collected over a three-day period and transferred to the hatchery, following the protocol outlined by Hassan and Abd-Alsattar (2015). This procedure was replicated for three hatches. The hatched chicks were raised until five weeks of age, and measurements were recorded for body weight, growth performance, and carcass characteristics according to Ramadan *et al*. (2014).

Sample size and statistical considerations

The sample size of 450 chicks per population was determined based on preliminary studies and statistical power analysis to ensure the reliability and validity of the results. This size was deemed adequate for detecting significant differences in the traits under selection.

Statistical analysis

Data were analyzed using one-way and two-way analysis of variance (ANOVA) with the XLSTAT software (XLSTAT, 2014). The main factors examined were the quail line and sex. The traits analyzed included body weight at various ages and carcass characteristics. For the two-way ANOVA, the following model was used to analyze traits such as body weight at hatch, 7 days, 14 days, 21 days, 28 days, and 35 days of age across two generations:

$$Y_{ijk} = \mu + L_i + S_j + LSij + e_{ijk}$$

Where; Y_{ijk} is the observation of the k^{th} individual of the j^{th} sex within the i^{th} line. μ is the overall mean. L_i is the effect of the i^{th} line. S_j is the effect of the j^{th} sex. LSij is the interaction between the i^{th} lline and the j^{th} sex. e_{ijk} is the random error.

For the one-way ANOVA, which was used to analyze body weight at 35 days of age and carcass characteristics (carcass weight, liver, gizzard, heart, and giblet weights) in generation 1, the following model was used:

$$Y_{ijk} = \mu + L_i + e_{ijk}$$

Where: Y_{ij} is the observation of the i^{th} line. μ is the overall mean. L_i is the effect of the i^{th} line. e_{ij} is the random error.

All data are reported as least square means (LSM) ± standard errors (SE). When significant differences were found, mean values were separated using Duncan's multiple range test (Duncan, 1955). The significance level was set at 5%.

RESULTS AND DISCUSSION

Growth traits

Body weight

Table 1 displays the effects of various quail hybrids on live body weight (LBW) over two generations.

First generation

When hatching, hybrid 1 (HY1) had the highest LBW at 10.66 g, whereas HY3 had a slightly lower LBW of 9.40 g, followed by HY4 (9.21 g). HY5 had the lowest LBW, measuring 8.36 g. At 7 days, HY4 had the highest LBW (42.36 g, $p<0.01$). At 21, 28, and 35 days, HY5 showed the highest LBW with values of 187.77 g, 238.18 g and 295.15 g, respectively ($p<0.01$). At 35 days, HY5 maintained the highest LBW (295.15 g), followed by HY4 (263.02 g).

Second generation

Selection resulted in improved body weight in quail individuals of all ages, including majority of hybrids. Upon hatching, HY4 had the highest LBW (10.80 g), while HY5 had a slightly lower LBW (10.64 g), representing improvements of 17.3% and 27.3%, respectively, in comparison to the parent quails. HY5 consistently reported the highest LBW at 7, 21, 28 and 35 days, with weights of

Table 1: Live body weight (g) LSM and SE at different ages of two generation of 6 hybrid of quail.

Generation	Hybrid	Hatch	7 days	14 days	21 days	28 days	35 days
G1	HY1	$10.7^{a}\pm0.2$	$34.4^{b}\pm1.0$	$71.1^{d}\pm2.4$	$127.6^{cd}\pm4.8$	$184.54^{c}\pm5.5$	$219.8^{d}\pm5.8$
	HY2	$8.7^{d}\pm0.2$	$35.6^{b}\pm1.0$	$83.9^{b}\pm2.4$	$147.1^{b}\pm4.7$	$180.29^{c}\pm5.4$	$236.6^{cd}\pm5.7$
	HY3	$9.4^{b}\pm0.2$	$31.1^{c}\pm1.0$	$73.1^{cd}\pm2.3$	$121.7^{d}\pm4.6$	$186.42^{c}\pm5.3$	$226.7^{d}\pm5.6$
	HY4	$9.2^{bc}\pm0.2$	$42.4^{a}\pm0.9$	$104.2^{a}\pm2.2$	$177.4^{a}\pm4.4$	$221.31^{b}\pm5.1$	$263.0^{b}\pm5.4$
	HY5	$8.4^{d}\pm0.2$	$36.2^{b}\pm1.0$	$108.3^{a}\pm2.4$	$187.8^{a}\pm4.8$	$238.18^{a}\pm5.5$	$295.2^{a}\pm5.8$
	HY6	$8.8^{cd}\pm0.2$	$33.6^{bc}\pm1.0$	$78.6^{bc}\pm2.4$	$135.9^{bc}\pm4.8$	$187.72^{c}\pm5.5$	$247.9^{bc}\pm5.8$
	Probability	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
G2	HY1	$10.2^{b}\pm0.2$	$33.1^{c}\pm0.9$	$90.5^{c}\pm2.5$	$151.7^{c}\pm3.4$	$224.50^{c}\pm4.6$	$282.2^{c}\pm5.2$
	HY2	$10.2^{b}\pm0.2$	$38.0^{b}\pm0.9$	$99.9^{b}\pm2.5$	$167.7^{b}\pm3.4$	$218.20^{c}\pm4.6$	$295.2^{bc}\pm5.2$
	HY3	$10.4^{ab}\pm0.2$	$36.9^{b}\pm0.9$	$98.6^{b}\pm2.5$	$167.4^{b}\pm3.4$	$214.30^{c}\pm4.6$	$299.2^{b}\pm5.2$
	HY4	$10.8^{a}\pm0.2$	$38.2^{b}\pm0.9$	$116.1^{a}\pm2.5$	$180.7^{a}\pm3.4$	$241.80^{b}\pm4.6$	$333.6^{a}\pm5.2$
	HY5	$10.6^{ab}\pm0.2$	$43.2^{a}\pm0.9$	$113.6^{a}\pm2.5$	$189.0^{a}\pm3.4$	$286.40^{a}\pm4.6$	$347.7^{a}\pm5.2$
	HY6	$10.1^{b}\pm0.2$	$28.7^{d}\pm0.9$	$73.1^{d}\pm2.5$	$130.9^{d}\pm3.4$	$194.06^{d}\pm4.6$	$249.8^{d}\pm5.2$
	Probability	0.05	0.00001	0.00001	0.00001	0.00001	0.00001

[a,d] Means, within trait and source of variation, followed by different superscripts, differ significantly (Duncan, 1955).

43.20 g, 116.62 g, 188.98 g, 286.40 g, and 347.72 g, respectively (p<0.01). These values represented improvements of 19.30%, 0.08%, 0.01%, 20.2%, and 17.81%, respectively, compared to the first generation. The selection process resulted in a 28.35% improvement in body weight for hybrid HY1, a 24.75% improvement for hybrid HY2, a 31.97% improvement for hybrid HY3, a 26.83% improvement for hybrid HY4, a 17.81% improvement for hybrid HY5, and a 0.008% improvement for hybrid HY6, all at 35 days of age compared to the first generation.

Carcass characteristics

The findings, as outlined in Tables 2 and 3, demonstrate significant impacts of hybrid quail lines on various parameters. The HY5 group had the greatest values for LBW, carcass weight, gizzard weight and giblet weight (p<0.01), with measures of 332.50 g, 242.50 g, 6.00 g and 14.20 g, respectively. The results align with prior studies on quails, indicating that higher body weights are associated with greater carcass production. The heart and liver weights did not show any significant variations across the quail hybrids, suggesting that the hybrid lines did not have a major effect on these parameters. These findings emphasize the significance of hybrid lines in influencing morphological characteristics, including LBW and carcass traits. This information is extremely helpful for breeding programs and the careful selection of high-performance quail lines.

Table 2: Least square means and SE percentages of carcass parts of two generation of 6 hybrid of quail.

Generation	Hybrid	Carcass %	Heart %	Liver %	Gizzard %	Giblet %	Edible part %
G1	HY1	73.16	0.86	1.99	1.91^{a}	4.71	77.86
	HY2	68.94	0.67	1.97	1.52^{bc}	4.17	73.12
	HY3	72.93	0.82	2.22	1.72^{abc}	4.78	77.71
	HY4	70.93	0.64	1.89	1.46^{c}	4.00	74.82
	HY5	73.17	0.71	1.78	1.80^{abc}	4.29	77.47
	HY6	72.79	0.86	2.21	1.87^{ab}	4.95	77.74
	SE	2.65	0.07	0.23	0.11	0.29	2.80
	Probability	0.85	0.22	0.78	0.04	0.17	0.77
G2	HY1	71.81	0.91	2.54	2.43	5.89	83.61
	HY2	69.71	0.90	3.30	2.60	6.80	83.33
	HY3	71.46	0.76	2.79	2.30	5.78	83.04
	HY4	71.05	0.76	2.87	2.15	5.78	82.62
	HY5	72.94	0.81	3.13	2.20	6.15	84.74
	HY6	71.18	0.94	3.11	2.67	6.47	84.67
	SE	2.70	0.08	0.22	0.17	0.35	3.19
	Probability	0.99	0.42	0.17	0.23	0.14	0.99

a...c. Means, within trait and source of variation, followed by different superscripts, differ significantly (Duncan, 1955).

Table 3: Least square means and SE of carcass parts weights (g) 5-week-old males and females 6 hybrid of quail in generation 2.

Hybrid	LBW	Carcass Wt.	Heart Wt.	Liver Wt.	Gizzard Wt.	Giblet Wt.
HY1	253.0^{e}	184.0^{d}	2.0	5.0	4.8^{b}	11.8^{b}
HY2	296.0b^{c}	203.4^{bc}	2.0	5.8	4.5^{b}	12.3^{ab}
HY3	280.0^{cd}	203.0^{b}	2.3	6.1	4.8^{b}	13.2^{ab}
HY4	311.0^{b}	218.5^{b}	2.0	5.8	4.5^{a}	12.3^{ab}
HY5	332.5^{a}	242.5^{a}	2.4	5.8	6.0^{a}	14.2^{a}
HY6	268.0^{de}	194.6^{cd}	2.3	6.0	5.0^{a}	13.3^{ab}
SE	7.32	6.20	0.21	0.6	0.34	0.74
Probability	0.00001	0.00001	0.58	0.87	0.03	0.02

a... d, Means, within trait and source of variation, followed by different superscripts, differ significantly (Duncan, 1955).

Table 4 displays the least square means and standard errors for the percentage of carcass components in two generations of six hybrid quail lines. In the first generation, all hybrid individuals exhibited no notable variations in terms of carcass percentage, heart, liver, giblet, or edible portion percentages. HY1 exhibited the largest proportion of gizzard weight relative to its total weight. The second generation did not exhibit any notable differences in these traits. However, HY2 had the highest liver percentage.

Phenotypic correlations

Table 5 displays the correlations between different features for the six-hybrid quail throughout both generations. Significant positive correlations were seen between live body weight (LBW) and both carcass weight and the proportion of edible parts. The carcass weight exhibited favorable associations with LBW, gizzard weight, giblet weight, and edible part percentage. The weight of the heart showed positive correlations with LBW, the weight of the carcass, and the weight of the giblets. There was a favorable correlation between liver weight and LBW. The weight of the gizzard showed positive correlations with LBW, carcass weight, heart weight, giblet weight, and the percentage of edible parts. The weight of giblets exhibited positive correlations with LBW, carcass weight, heart weight, liver weight, gizzard weight, and the proportion of edible parts. There was a positive correlation between the percentage of edible parts and LBW, carcass weight, heart weight, liver weight, giblet weight, and gizzard weight.

Table 6 displays the phenotypic correlation between shank length, LBW and carcass weight in the second generation of six hybrid quail. Hybrid 1 had no discernible correlation between shank length and both LBW and carcass weight. Hybrid 2 demonstrated a direct correlation between LBW and the weight of the carcass. The study of Hybrid 3 did not find any correlation between the length of the shank and both the LBW and the weight of the carcass.

Table 4: Least square means and SE of carcass parts weights (g) 5-week-old males and females 6 hybrid of quail in generation 2.

	LBW	Carcass Wt.	Heart Wt.	Liver Wt.	Gizzard Wt.	Giblet Wt.	Shank length
Hybrid							
HY1	299.0^{bc}	212.5^{b}	2.8	7.7^{b}	7.3	17.8^{b}	3.9^{ab}
HY2	313.0^{bc}	215.5^{b}	2.8	10.2^{a}	8.1	21.1^{a}	3.8^{bc}
HY3	288.5^{c}	204.5^{b}	2.2	7.8^{b}	6.6	16.6^{b}	3.9^{ab}
HY4	316.0^{b}	224.0^{b}	2.4	9.0^{ab}	6.8	18.2^{b}	4.0^{ab}
HY5	344.5^{a}	248.5^{a}	2.8	10.6^{a}	7.6	21.0^{a}	4.1^{a}
HY6	250.0^{d}	177.1^{c}	2.4	7.8b	6.6	16.8^{b}	3.7^{c}
SE	8.85	6.46	0.26	0.57	0.44	0.88	0.07
Sex							
Male	287.8^{b}	204.4	2.39	7.6b	6.5^{b}	16.5b	3.9
Female	315.8^{a}	217.9	2.73	10.1a	7.8^{a}	20.7a	3.9
ES	5.11	3.73	0.15	0.33	0.28	0.51	0.04
Interaction							
HY1 Male	273.0^{cd}	203.0^{de}	2.0^{b}	6.2d	6.2bc	14.4f	3.9ab
HY1 Female	325.0^{ab}	222.0^{bcd}	3.6^{a}	9.2^{bc}	8.4^{ab}	21.2^{bc}	3.8^{bc}
HY2 Male	311.0^{abc}	218.0^{bcd}	3.2^{ab}	6.8^{cd}	8.0^{abc}	20.0^{bcd}	3.9^{abc}
HY2 Female	315.0^{ab}	213.0^{cd}	2.4^{ab}	11.6^{ab}	8.1^{abc}	22.1^{ab}	3.8^{bc}
HY3 Male	275.0^{cd}	199.0^{def}	2.4^{ab}	7.2^{cd}	6.0^{c}	15.6^{ef}	3.9^{abc}
HY3 Female	302.0^{bcd}	210.0^{cd}	2.0^{b}	8.4^{cd}	7.20^{abc}	17.6^{cdef}	4.0^{ab}
HY4 Male	290.0^{bcd}	210.0^{cd}	2.4^{ab}	8.4^{cd}	6.0^{c}	16.8^{def}	4.2^{a}
HY4 Female	342.0^{a}	236.0^{abc}	2.4^{ab}	9.6^{bc}	7.60^{abc}	19.6^{bcde}	3.9^{abc}
HY5 Male	345.0^{a}	253.0^{a}	2.4^{ab}	8.4^{cd}	6.0^{c}	16.8^{def}	4.2^{a}
HY5 Female	344.0^{a}	244.0^{ab}	3.2ab	12.8^{a}	9.2^{a}	25.2^{a}	3.9^{ab}
HY6 Male	233.0^{e}	173.2^{f}	2.0^{b}	6.4^{d}	6.8^{bc}	15.2^{f}	3.60^{c}
HY6 Female	267.0^{de}	180.6^{ef}	2.8^{ab}	9.2^{bc}	6.4^{bc}	18.4^{bcdef}	3.8^{bc}
SE	12.52	9.13	0.37	0.81	0.70	1.25	0.10
Probability							
Hybrid	0.00001	0.00001	0.46	0.0008	0.23	0.00009	0.005
Sex	0.0003	0.113	0.122	0.0001	0.002	0.0001	0.318
Interaction	0.003	0.003	0.022	0.003	0.003	0.05	0.003

$^{a...f}$ Means, within trait and source of variation (S.O.V), followed by different superscripts, differ significantly (Duncan, 1955).

Table 5: Phenotypic correlations between the studied traits for 6 hybrid of quail for two generation.

	L.B. W	Carcass	Heart	Liver	Gizzard	Giblet	Edible part
L.B. W	1	0.594	-0.078	0.160	0.180	0.068	0.582
Carcass	0.681	1	0.091	0.065	0.413	0.293	0.997
Heart	0.320	0.380	1	-0.174	0.111	0.827	0.160
Liver	0.364	0.223	0.149	1	0.015	0.143	0.076
Gizzard	0.291	0.473	0.503	0.221	1	0.580	0.451
Giblet	0.411	0.497	0.879	0.420	0.807	1	0.372
Edible part	0.684	0.979	0.533	0.291	0.597	0.663	1

Generation 1 above diagonal., generation 2 blow diagonal Values in bold are different from 0 with a significance level alpha=0.05 N= 30 per line, combined sexes.

The Hybrid 4 study demonstrated a strong correlation between the length of the shank and LBW. There was no correlation between the weight of the carcass and the occurrence of LBW in Hybrid 5. The Hybrid 6 study did not find any correlation between the length of the shank and both LBW and carcass weight.

Table 6: Phenotypic correlations between the shank length, LBW and carcass weight 6 hybrid of quail in 2th generation.

		SH	LBW	CW
HY1	SH	1	0.313	-0.458
	LBW	0.313	1	0.026
	CW	-0.458	0.026	1
HY2	SH	1	-0.167	0.026
	LBW	-0.166	1	0.854
	CW	0.026	0.854	1
HY3	S H	1	0.296	0.306
	LBW	0.296	1	0.157
	CW	0.306	0.157	1
HY4	SH	1	0.767	-0.567
	LBW	0.767	1	-0.558
	CW	-0.567	-0.558	1
HY5	SH	1	0.552	0.182
	LBW	0.552	1	0.653
	CW	0.182	0.653	1
HY6	SH	1	0.438	0.522
	LBW	0.438	1	0.256
	CW	0.522	0.256	1

Values in bold are different from 0 with a significance level alpha=0.05, N= 30 per line, combined sexes; SH= Shank length, CW= carcass weight

Production traits

Table 7 presents the variations in egg production characteristics across various mating groups. The weight of the eggs did not demonstrate any major impact of the hybrid. The age at sexual maturity (ASM) in days was significantly influenced by the hybrid type. HY5 exhibited the highest average maximum sustainable egg production, followed by HY1, HY4, HY3, HY6, and HY2. The body weight at sexual maturity (BWSM) in grams exhibited a significant hybrid impact, with HY5 displaying the greatest mean BWSM, followed by HY4, HY1, HY2, HY3, and HY6. There were no significant changes observed in other traits, such as laying rate at two weeks, the laying rate at ten weeks after sexual maturity, the percentage of fertility, and the percentage of hatchability. The hybrid choice significantly impacts ASM (days) and BWSM (g), however, it does not have an impact on egg weight, laying rates, fertility, or hatchability percentages.

Growth traits

Body weight

This study examines the growth traits of quails, with a specific emphasis on the live body weight (LBW) in several hybrid generations. Table 1 demonstrates significant variations in LBW among the different hybrids and throughout generations, suggesting the influence of selective breeding on the overall growth performance.

The first generation

The Hybrid 5 (HY5) consistently had the highest LBW during the later phases of development, indicating a strong growth advantage. The improvements in LBW in HY5 align with the broader understanding that certain hybrids possess genetic advantages that enhance growth rates.

The second generation

The second generation showed enhanced LBW in comparison to the first generation, therefore indicating the effectiveness of selective breeding techniques. The findings align with prior studies conducted by Boon *et al.* (2000) and Maiorano *et al.* (2009), which observed significant differences in body weight gain, carcass weight, and carcass yield between fast-growing and normal-growing quail lines. The study corroborates the findings of Taskin *et al.* (2017) and El-Attrouny *et al.* (2020), who showed that selected lines had larger body weights compared to control groups, especially in the second selected generation. Marks (1975) also noted that genetic improvements in quails are more pronounced in early generations. Further, Ramadan *et al.* (2022) found that Stino quails, due to their efficient metabolic rate from successive generations of selective breeding, exhibited higher body weights compared to other genotypes. These findings emphasize the significant role of selective breeding in improving growth traits in quails.

Table 7: Means of egg production and reproductive traits among the different mating groups ±SE.

Mating groups	EW (g)	ASM(Days)	BWSM (g)	TEN 2w (g)	TEN 10w (g)	FP%	HP%
HY1	12.92±0.59	38.66^{ab}±1.08	324.16^{abc}±14.8	9.00±0.63	45.27±3.35	62.96±5.12	72.41±5.57
HY2	12.45±0.59	34.50^{c}±1.08	302.50^{bcd}±14.8	8.83±0.63	45.59±3.35	64.63±5.12	74.32±5.57
HY3	12.92±0.59	36.16^{bc}±1.08	286.66^{cd}±14.8	8.83±0.63	46.33±3.35	70.61±5.12	81.30±5.57
HY4	13.39±0.59	36.83^{bc}±1.08	336.66^{ab}±14.8	8.66±0.63	38.71±3.35	74.95±5.12	86.23±5.57
HY5	12.22±0.59	41.50^{a}±1.08	348.33^{a}±14.8	8.16±0.63	41.26±3.35	72.25±5.12	83.09±5.57
HY6	12.12±0.59	35.00^{c}±1.08	273.00^{d}±14.8	8.16±0.63	48.49±3.67	68.12±5.16	72.41±5.57
Probability	0.545	0.0009	0.0007	0.554	0.382	0.556	0.555

$^{a...d.}$ means, within age and source of variation, with different superscripts are significantly different (Duncan, 1955).
EW= Egg weight, ASM = Age at sexual maturity, BWSM= Body weight at sexual maturity, TEN 2w = Total egg number produced among the first 2 weeks of egg production, TEN 10w = Total egg number produced among the first ten weeks of egg production, FP%= Fertility percentage, HA%= Hatchability percentage.

Carcass characteristics

The findings, as presented in Tables 2 and 3, demonstrate the significant influence of hybrid lines on carcass characteristics. Specifically, Hybrid HY5 consistently had the greatest values for LBW, carcass weight, gizzard weight, and giblet weight. The results of this study align with the findings of previous studies conducted by Maiorano *et al.* (2009) and Caron *et al.* (1990), which observed that quails with larger body weights tend to have enhanced carcass yield. The study found no notable variations in the weights of the heart and liver among the hybrids, indicating a limited impact on these parameters. There were clear differences between genders in the characteristics of carcasses among hybrids. Specifically, HY5 females had greater values for LBW, carcass weight, and various organ weights compared to other hybrids. HY5 males exhibited greater values for carcass, heart, liver, gizzard and giblet weights and shank length. These findings highlight the impact of physiological differences between male and female quails on the characteristics of their carcasses. The study's findings align with prior studies, suggesting that the chosen strains exhibit greater body weights and superior carcass traits in comparison to the control groups.

Phenotypic correlations

Table 5 displays the correlations between several traits of hybrid quails. The presence of positive correlations between LBW and both carcass weight and edible part percentage, emphasizes the strong association between body size and carcass yield. The carcass weight exhibited positive correlations with LBW, gizzard weight, giblet weight, and edible part percentage, suggesting strong associations between these traits. The results are consistent with the findings of Raji *et al.* (2009), who discovered strong positive associations between body weight and zoometric measurements in ducks. This supports the notion that there is a connection between body weight and linear measurements.

Table 6 displays the phenotypic correlations among shank length, LBW and carcass weight in the second generation of hybrids. Some hybrids, including HY2 and HY4, exhibited relationships between these traits, although others did not. The findings align with Alkan *et al.* (2010) in terms of carcass percentage but diverge from Inci *et al.* (2015) in relation to body percentage. Earlier studies conducted by Minvielle *et al.* (2005) and Yilmaz and Çaglayan (2008) observed that white line quails have lower body weights compared to brown lines. However, Tarhyel *et al.* (2012) discovered that white line quails have larger percentages of breast and thigh meat.

Production traits

Table 7 demonstrates significant differences in egg production characteristics among hybrid quails. Egg Weight: The hybrid combinations did not have a substantial impact on Average Maximum Sustainable Egg Production (ASM) and Body Weight at Sexual Maturity (BWSM). Noticeable significant variations were noted among the different hybrids. HY5 exhibited the highest ASM and BWSM, which suggests superior egg production and body weight at sexual maturity. In contrast, HY2 had the lowest ASM and HY6 had the lowest BWSM. The study did not find any significant differences in laying rate at ten weeks, fertility and hatchability percentages. This indicates that the hybrid had minimal influence on these characteristics. The results of this study are consistent with previous research conducted by Vali *et al.* (2005), Rehman (2006), and Jatoi *et al.* (2013), which found that strain and generation had a substantial impact on body weight. Nevertheless, Moritsu *et al.* (1997) and Baik and Marks (1993) presented divergent findings regarding body weight in crossbred lines. In their study, Khurshid *et al.* (2004) discovered that there was a positive correlation between egg weight and hatchability in Japanese quails.

CONCLUSIONS AND RECOMMENDATIONS

The study confirms that the process of selective breeding greatly improves growth features and carcass characteristics in quails, especially in hybrids such as HY5. The results are consistent with previous studies and emphasize the significance of focused breeding programs to improve quail performance. Additional investigation should focus on elucidating the physiological and genetic factors that contribute to these improvements, with the aim of optimizing breeding strategies.

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NOVELTY STATEMENT

This study uniquely assesses body weight and carcass traits in six hybrid quail varieties, highlighting the benefits of selective breeding for improved meat production.

AUTHOR'S CONTRIBUTION

This study was done in collaboration with all authors. G.S. Ramadan conceived the idea, designed the experiments and supervised the research. A.A. Abd El-Halim, A.M. Abdelsalam and E.M. El-Komy, performed the experiments and co-wrote the paper. G.S. Ramadan analyzed the data. A.A. Abd El-Halim, A.M. Abdelsalam and E.M. El-Komy critically revised the manuscript. All authors read and approved the final manuscript.

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Ethical approval

The present study has been conducted by the guidelines of the Ethics Committee of the National Research Centre. Approval number 130504010323.

Data availability statement

All data generated or analyzed during the current study are included in this published article.

Conflict of interest

The authors have declared no conflict of interest.

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