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DIRECT AND CORRELATED RESPONSES TO SHORT-TERM INDEX SELECTION FOR SOME ECONOMIC TRAITS OF JAPANESE QUAIL.

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ABSTRACT: A selection experiment was conducted at the Poultry Research Center, Faculty of Agriculture, Fayoum University using a total number of 4923 birds of three successive hatches as a base population producing 655 females (333 for the selected line and 322 for the random bred control line) through four successive generations. The main results are summarized as follows:

1. There were significant differences due to generation effect for all BW's tested and all egg production-related traits studied, except at BW_{35} and AGE_{30}. All BW's from 7 up to 35 days of age and all egg production-related traits -except BW_1- were significantly affected by line favouring the selected line compared to the control line.
2. In the control line, average phenotypic response per generation for ASM and AGE_{10} showed fluctuations over generations, estimated by regression of phenotypic means on generation numbers were significantly positive for ASM and AGE_{10} (2.17 and 2.18 days). Significant positive changes for BW's at seven, 14, 21, 28 and 35 days of age being 0.79, 4.55, 6.84, 7.58 and 4.36g, respectively and AGE_{30} (1.96 days) however, negative significant changes were shown for EM_{10}, EM_{30} and EM_{60}(-3.10, -9.69 and -15.96g) .
3. In the selected line, the average phenotypic response per generation of multi-trait selection index estimated by the regression of generation means on generation number in ASM, BW_{SM}, DN_{10} and AGE_{10} were significantly negative being -0.86 day, -3.30g, -0.25 day and -0.99 day, respectively, but was positive for BW_{14} (+1.97g).
4. Negative correlated significant changes were shown for all egg production-related studied traits (EM_{30}, EM_{60}, DN_{30}, DN_{60}, AGE_{30} and AGE_{60} being -3.98,-8.55,-1.41,-3.26,-2.06 and -4.07, respectively), except EM_{10} (1.75g, $P \leq 0.01$). The average genetic response per generation in ASM, BW_{SM}, DN_{10} and AGE_{10} were -3.74days, -3.06g, -0.22day and -4.12 days, respectively.

Key Words: Selection, short–term, index selection, economic traits and Japanese quail.

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5. Both the phenotypic and genetic responses per generation for multi-trait index were better for ASM, DN_{10} and AGE_{10}.
6. Significant correlated positive phenotypic response changes in both of EM_{10} and EM_{30} being 4.96 and 6.36g, however there were negative significant responses for BW_{21}, DN_{60}, AGE_{30} and AGE_{60} (-3.97g,-2.16,-4.87 and -4.92 days, respectively).
7. The realized response was more than the expected since, higher negative average genetic response per generation than expected genetic response for ASM, DN_{10} and AGE_{10} were found. Positive expected genetic response for BW_{SM} was obtained whereas negative average genetic response per generation for this trait was found.
8. Realized heritabilities (Rh^2) of the multi-trait selection index across three-generation ranged from medium to high being 0.55, 0.36, 0.17 and 0.39, respectively for ASM, BW_{SM}, DN_{10} and AGE_{10}.

INTRODUCTION

The production potentialities of Japanese quail and its economic value depends on various traits like age at sexual maturity, body weight, number of eggs produced etc, some of which may be genetically antagonistic (e.g. egg number and egg weight). Effective selection on egg production in quails resulted in reduction of both egg weight and body size, however, an index of total performance involving many traits may not significantly harm body weight and egg size. The ultimate goal of a poultry breeder is to improve the overall genetic economic worth of the bird through multi-trait selection by considering maximum number of traits at a time (Sakunthala Devi and Ramesh Gupta, 2012). Actually, selection experiments provide the framework for the study of the inheritance of complex traits and allow the evaluation of theoretical predictions by testing observations against expectations since selection is one of the major methods to achieve this improve. The objectives of the selection experiments could differ depending on the time scale, short-term experiments, can be used to estimate genetic variances and covariances, test their consistency from different sources of information and estimate the magnitude of the initial rates of response to selection (Martinez et al., 2000). Genetic and environmental variation might vary among populations and environments then it should thus be estimated in different populations and environments (Khaldari et al., 2010). Gunes and Cerit (2001) and Camci et al. (2002) suggested that age at sexual maturity was fairly related to body weight and that quails with higher body weights at sexual maturity had higher egg production rate. Zelenka et al. (1984) reported that there are minimum ages, body weight and body composition values for attainment of sexual maturity in female birds. Thus, to select for good egg producers, it is important to establish the relationship between age and weight at first egg and egg production traits. This is supported by Oruwari and Brody (1988) who observed that chronological age alone is not a primary effecter of sexual maturity rather there is a complex relationship between age, body weight, body composition and sexual maturity.

Several investigations were made for growth, egg production and egg quality parameters in broiler and layer chicken (Bekele et al., 2010 and Amao et al., 2011). Such systematic extensive genetic studies on Japanese quail were not taken up (Narendra Nath et al., 2011) therefore, the present study was carried out to study the influence of multi-trait selection procedure including some egg production and body weight traits on the total performance of

Japanese quail and response to selection and some genetic parameters of the population.

Materials and Methods

This study was conducted at the Poultry Research Center, Faculty of Agriculture, Fayoum University. A selection experiment using a total number of 4923 birds as a base population producing 655 females (333 for the selected line and 322 for the random bred control line) through four successive generations through October 2010 to December 2012. Data of the base population consists of three successive hatches, then data were collected for the first hatch only to maintain discrete generations for four successive generations after formation avoiding mating of close relatives to decrease the rate of inbreeding depression. The selected breeders were housed (two females were randomly assigned to each male) in breeding cages with the dimensions 20x20x25 cm^3 with sloping floor for collecting the eggs. Eggs were collected daily in a pedigree system for each family depending on the shell color and patterns of each female when females were 11 to 14 weeks of age. The newly hatched chicks were wing banded by small size plastic bands, which were replaced by wing metal bands at 14 days of age. Chicks were brooded on floor until 10 days of age, at that time the young birds were transferred to an intermediate battery brooder. From hatch to five weeks of age, all quail fed ad libitum on a starter diet containing 24% CP and 2900 K cal/ME and water. From six weeks to the end of the study, a breeder diet containing 20% CP, 2900 K cal/ME 2.25% calcium and 0.43% available phosphorous were supplied according to NRC (1994). Birds were in continuous light for the first two weeks of age and then reduced to 16 hours of light day thereafter. All birds were kept under the same managerial hygienic and environmental conditions.

Statistical Analysis:

Selection index was constructed to select a female line including age at first egg (ASM), body weight at sexual maturity (BW_{SM}), days needed to produce the first ten eggs (DN_{10}) and age at the first 10 eggs (AGE_{10}). The index form was:

$$I = b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4$$

where: b_1, b_2, b_3 and b_4 are derived optimum weighing factors for traits X_1, X_2, X_3 and X_4, respectively. The b_i's values were obtained by solving a simultaneous equations represented in matrix notation as [P] [b] = [G] [a]

where:

[P] = Phenotypic variance and covariance matrix

[b] = a row vector of index coefficients to be computed

[G] = Genotypic variance and covariance matrix

[a] = a row vector of relative economic values

$[b] = P^{-1}Ga$

The relative economic values of the traits studied were calculated by estimating the change in the difference between cost and income per unit change in the trait as reported by Kolstad (1975) are shown in Table 1. These relative economic values for: 1 day earlier for ASM and BWSM,-½ day for the days needed to produce the first 10 eggs and -½ day for Age_{10}. Moreover, the relative economic values of the studied generation were calculated (Table 2).

Selection Differential:

ExSD : Expected selection differential $=\bar{X}_s - \bar{X}_0$

where, $\bar{X}_s$ and $\bar{X}_0$ are the means of selected group and the flock, respectively.

E_fSD: Effective selection differential $= \sum \frac{X_i n_i}{n_i} - flock\ mean$

where: X_i is the observation on the i^{th} parent

n_i is the number of progeny of i^{th} parent

Response to selection

To evaluate genetic responses, the realized heritability and the slopes of cumulative genetic responses for all traits were calculated. To do this, line means in each generation were first calculated. The line- and generation-specific means for all traits were calculated using the following model (PROC MIXED, SAS, 2011):

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

where: Y_{ijk} = the observations for a trait; μ is the overall mean; L_i = the fixed effect of i^{th} line; G_j = the fixed effect of i^{th} generation; $L_i \times G_j$ = the interaction of L_i and G_j; and e_{ijk} = the random error term. Means were compared for line, generations as main effects and interactions by Duncan's new multiple range test (Duncan, 1955). A probability of $P<0.05$ was required for significance.

Average phenotypic and genetic responses per generation:

Phenotypic and genetic responses were estimated for the studied traits: body weight (BW) at one, seven, 14, 21, 28 and 35 days of age, egg mass for the first ten eggs (EM_{10}), egg mass for the first 30 eggs (EM_{30}), egg mass for the first 60 eggs (EM_{60}), days needed to produce the first 30 eggs (DN_{30}), days needed to produce the first 60 eggs (DN_{60}), age at first 30 eggs (AGE_{30}) and age at first 60 eggs (AGE_{60}).

The average genetic response per generation was estimated by regressing the deviation of generation means of the selected line from the means of random bred control line on generation number (Singh and Kumar, 1994). The average phenotypic response per generation is estimated by the regression of generation means on generation number according to Singh and Kumar (1994).

Realized heritability:

Realized heritability was obtained as the ratio of cumulative response (CR) to cumulative selection differential (CS) for the selected trait (Hill, 1972).

RESULTS AND DISCUSSION

Means of body weight at different ages as affected by generation and line are shown in Table 3. There were significant ($P\leq0.000$) differences due to generation effect for all BW's tested, except at 35 days of age. Higher BW's at one, seven and 28 days of age (9.12, 31.44 and 151.76 g, respectively) were observed in G_3 which had numerically higher BW_{35} than other generations. The G_4 had the highest BW at 14 and 21 days of age (66.09 and 109.19g, respectively). All BW's from 7 up to 35 days of age were significantly affected by line ($P\leq0.000$) favoring the selected line which had heavier BW's at 7, 14, 21, 28 and 35 days of age (31.08, 65.61, 111.69, 153.63 and 202.01g, respectively) compared to the control line, except for BW_1. Similar significant generation effect on BW_7 and BW_{14} in Japanese quail was reported by Naser and Abbas (2012) whereas generation insignificantly affected BW_{28}.

Similarly, Okuda et al. (2014) found insignificant differences due to generation effect for body weight at 14 and 28 days of age (averaged 39 g, 96.66 g, respectively) generally increased at the end of the first and second generation after selection, when compared to the base generation, however body weight for generation 1 was slightly higher than that of generation 2.

Farrag (2011) reported highly significant differences for EN, ASM and EW between the selected line for high egg production until 90 days of age over three generation and the control lines in the third generation of selection. Narendra Nath et al. (2011) found significant higher body weights in selected population (8.87, 135.77, 76.53, 123.12, 160.05 and 181.62 g, respectively) over the control population (9.08, 1 30.91, 68.46, 118.27, 149.06 and 169.93 g, respectively) for body weights at hatch, 1, 2, 3, 4 and 5 weeks of age, respectively. Moreover, Tawefeuk (2001) reported significant improvement in body weights at hatch, two and four weeks of age through five generations of selection in the two lines. Conversely, line insignificantly affected BW_7, BW_{21} and BW_{35} of Japanese quail over three selection generations, and BW_1,$BW_{14}$and BW_{28} in the selected and control lines in the third generation ($P<0.01$).

Means of generation and line effects on related-egg production traits are presented in Table 4.There were fluctuations in all egg production-related traits studied across generations. All of these traits were significantly ($P\leq0.001$) affected by generation, except AGE_{30}. Higher estimates of DN_{30}, DN_{60} and AGE_{60} were shown for G_1 than other generations. G_2 had the heaviest BW_{SM}, EM_{10}, EM_{30} and $EM_{60,}$ whereas G_4 had the lowest BW_{SM}. G_3 had earlier ASM being 49.29 days and it had higher estimate of DN_{10} (13.22) but lower EM_{60} whereas the latest ASM and AGE_{10}however, lower DN_{10}, DN_{30}, $DN_{60}$and AGE_{60} were attained by G_4 than other generations. Similarly, Okuda et al (2014) who estimated genetic parameters of egg production, reproductive traits in Japanese quail and response to selection for egg production after two generations of selection, Okenyi et al. (2013) who investigated the effect of selection for short-term (30 days) egg production trait in Japanese quail over three generations (EN, BW_{SM}, EW) and Farrag (2011) who selected a line for high egg production until 90 days of age over three generation found significant generation effects on studied egg production traits (EN, ASM and EW) over three generations. Naser and Abbas (2012) found significant generation effect on body weight at maturation, egg mass in the first and second month, egg number in the first, second and the third month over two generation but generation insignificantly affected ASM and egg mass in the third month.

Line significantly ($P\leq0.01$) influenced all egg production-related traits studied, except EM_{30} and EM_{60} favoring selected line than control line (Table 4). The selected line had earlier ASM, DN_{10}, AGE_{10}, $DN_{30,}$ $DN_{60,}$ AGE_{30} and AGE_{60} by 7.45, 2.35, 9.66, 5.75, 7.55, 12.49 and 14.82 days, respectively, and heavier BW_{SM} and EM_{10} by 6.80g and 2.51g than the control line. Alkan et al. (2013) found significant line effect on egg mass, egg number, egg weight and BW_{SM} favoring the layer line for 120day egg production over 11 generations except BW_{SM} than the control line but insignificant line effect on ASM. Farrag (2011) reported significant line effect on both ASM and egg number favoring the selected line for high egg production until 90 days of age over three generation but insignificantly affected egg weight. However, Reddish (2004) reported insignificant differences due to the line for ASM, BW_{SM} and first egg weight neither the third nor the sixth generation. Narendra Nath et al. (2011) reported that ASM was significantly lower (46.2 vs. 52.4 day) and egg weight was significantly higher at 16 week of age in the selected population (13.78g vs. 12.66g) than the control population. Similarly, egg production was significantly higher at 18 and 24 weeks in the selected population than the control population. Tawefeuk (2001) reported that there were a significant ($P<0.001$) decrease in the days needed to produce the first 10 eggs in the selected line for age at sexual maturity and days needed to produce the first 10 eggs from 100% to 54.00% (relative to control line in the same generation) in the base population to the 4^{th} generations. He found that ASM in egg production line selected through index included age at sexual maturity (days) and the period needed to produce the first 10 eggs significantly decreased ($P<0.001$) during the studied five generations from 59.02 to 44.73, while in the control line this decrease was not found and the ASM ranged from 59.02 to 57.52 days, however, there were insignificant differences among lines or generations in absolute BW_{SM}. Bahie El-Deen (1994), Shalan (1998) and

Ali et al. (2002) reported that the quail line selected for high egg production were better for egg production traits (BW_{SM}, EW, ASM and EN) than other lines.

Generation x line interaction significantly (P≤0.000) affected BW at all studied ages (Table 5). The control line had the highest BW1 (9.77g) at G_3, while the selected line had heavier BW's at seven, 14, 21, 28 and 35 days of age being 32.96, 69.82, 115.19, 162.95 and 207.19 and 207.45g at G_3, G_4, G_1, G_3 and G_3, respectively. However, the control line had the lightest BW_1 at G_4, BW_7 at G1, BW_{14}, BW_{21}, BW_{28} at G_2 and BW_{35} at G_3 of 8.14, 23.66, 49.30, 80.95, 113.92 and 170.62g), respectively. However, Farrag (2011) reported insignificant Generation x Line interaction effect on BW at all ages except body weight at hatch.

Effects of generation x line interactions on some egg production-related traits were presented in Table 6. There were significant effects for all egg production-related traits studied across generations, except BW_{SM}. The control line had later ASM, AGE_{10} and AGE_{30} of 60.97, 73.19 and 98.17, at G_4 respectively, and it had significant later AGE_{60} ranged from 130.08 for G_2 to 131.78 days for G3 than other generation x line groups. The control line had significant heavier EM_{10}, EM_{30} and EM_{60} at G_2 (122.47, 380.15 and 770.36g, respectively) however, the selected line at the fourth generation had insignificant different EM_{10} than the control line at G_2 and had significant lower ASM, DN_{10}, AGE_{10}, DN_{30}, DN_{60}, AGE_{30}, and AGE_{60} (46.54, 11.06, 57.58, 31.91, 64.39 , 78.81 and 111.11days, respectively). Higher DN_{10}, DN_{30} and DN_{60} were shown for the control line at G_3 (15.28, 41.76 and 79.59 days, respectively). Lower EM_{10}, EM_{30} and EM_{60} were obtained for the control line at G_4being 109.05, 334.62 and 691.46g, respectively. Tawefeuk (2001) reported that the overall means of egg weight increased generally through generations, with significant (P<0.05) differences among generations within lines, and no significant differences were observed in egg production after five generations in the selected lines.

Genetic parameters:

Heritability, genetic and phenotypic correlations are shown in Table 7. Heritability estimates for each of ASM, BW_{SM} and AGE_{10} were moderate ranging between 0.21 and 0.27, similar results were reported (Sezer et al., 2006 and Sezer, 2007) for ASM and Okenyi et al. (2013) for BWsm, whereas DN_{10} had the lowest estimate of 0.09.

A high range of genetic correlations (0.47 to 0.95) was shown among multi-index traits,

a wider range of positive phenotypic correlations ranged from 0.09 to 0.86 was found among multi-index traits, except rp between DN_{10} and BW_{SM} being -0.03.

Response to selection:

Control line:

Average phenotypic response per generation for ASM and AGE_{10} showed fluctuations over generations, regression of phenotypic means on generation numbers were significantly positive for ASM and AGE_{10} (2.17 and 2.18days) but were statistically insignificant for each of BW_{SM} and DN_{10} (Table 8). Significant positive changes in the control line for BW's at seven, 14, 21, 28 and 35 days of age being 0.79, 4.55, 6.84, 7.58 and 4.36g, respectively and AGE_{30} (1.96days) however, negative significant changes were shown for EM_{10}, $EM_{30}$and EM_{60} (-3.10, -9.69 and -15.96g) as shown in Table 9. Significant systematic changes in performance of the control line had been reported in some of the earlier selection experiments (Nestor et al., 1982). Environmental variations as influenced by season of hatching could account for this variation among generations since quails were hatched twice a year in different seasons. However, the pattern of changes in means of control over generations fairly matched with those observed for the two selected lines indicating possibly these to be of the environmental origin (Brah et al., 2001).

Selected line:

The realized average phenotypic and genetic responses due to three generations of multi-trait selection index that was applied to select a female line (M) according to the age at first egg (ASM), body weight at sexual maturity (BW_{SM}), days needed to produce the first ten eggs (DN_{10}) and age at 10 eggs (AGE_{10}) are presented in Table 8. The average phenotypic response per generation estimated by the regression of generation means on generation number in ASM, BW_{SM}, DN_{10} and AGE_{10} were significant negative being -0.86day, -3.30g, -0.25day and -0.99day, respectively. There were insignificant average phenotypic response per generation for all BW's tested, except at 14 days of age (1.97g, P≤0.000). Negative correlated significant changes were shown for all egg production- related studied traits (EM_{30} , EM_{60}, DN_{30}, DN_{60}, AGE_{30} and AGE_{60}being -3.98,-8.55,-1.41,-3.26,-2.06 and -4.07, respectively), except EM_{10} (1.75g, P≤0.01).

The average genetic response per generation estimated by the regression of the deviation of generation means of selected flock from the means of random bred control on generation means in ASM, BW_{SM}, DN_{10} and AGE_{10} were -3.74days, -3.06g, -0.22day and -4.12days, respectively (Table 8). It could be seen that the mean phenotypic and genetic response for multi-trait index were negative. Both the responses were better for ASM, DN_{10} and AGE_{10}, the genetic response indicating maximal estimates than the phenotypic response at the age at which selection was carried out whereas the phenotypic response in BW_{SM} was higher than the genetic response.

The expected genetic response to the selection was negative for ASM, DN_{10} and AGE_{10} traits involved in the construction of index for base population while positive response was observed for BW_{SM} (Table 8). The present results reflect higher negative AGR per generation than expected genetic response for ASM, DN_{10} and AGE_{10}, while positive expected genetic response for BW_{SM} whereas negative AGR per generation for this trait. Clearly, the realized genetic gains from this experiment did measure up to expectations. The realized response was more than the expected and it might be due to the construction of selection index for only females. Though we have selected the male parents it was only by indirect method of index selection and merit of the males was not taken in to the expected genetic response. The realized genetic response may also depend on number of chicks from the superior parents (Narendra Nath et al., 2011).Similarly, they reported lower expected genetic response for ASM than a realized genetic response of -0.02 vs -6.2 days however, larger expected genetic response than realized genetic response values for egg weight at 12 weeks of age (0.39 vs 0.03g) was observed. Raj Narayan et al. (2000) predicted an undesirable increase of 0.43 days in ASM, increase of 3.4eggs for EP18 in Japanese quail and noticed decrease of -0.098 g in egg weight at 18 weeks of age in Japanese quail. The genetic progress achieved after four generations of selection on the main index was –11.08 for age at sexual maturity and –10.26 days for DN_{10}. The expected genetic change per generation ranged between –0.85 to -1.73 days for ASM and from –0.62 to –1.22 days for DN_{10} (Tawefeuk, 2001). Punya Kumari (2007) predicted a genetic gain of - 0.0455 days for ASM and a genetic gain of 0.0731 eggs per one percent increase in Japanese quail for EP16.

As shown in Table 9, there were insignificant average phenotypic response per generation for all BW's tested, except at

14 days of age (1.97g, P≤0.000). Also, there were insignificant average genetic response per generation for all BW's tested, except at 21 days of age (-3.97g, P≤0.01) . Significant positive changes in all egg production-related traits (EM_{30}, EM_{60}, DN_{30}, DN_{60}, AGE_{30} and AGE_{60} being -3.98g, -8.55g, -1.41, -3.26, -2.06 and -4.07days, respectively), except $EM_{10.}$ Significant positive changes in both of EM_{10} and EM_{30}were found being 4.96 and 6.36g, however there were negative significant average genetic response per generation for DN_{60}, AGE_{30} and AGE_{60} (-2.16,-4.87 and -4.92 days, respectively).

Selection Differentials:

The expected (E_xSD) and effective (E_fSD) selection differentials for the multi-trait selection index traits are given in Table 8. E_xSD's were higher than E_fSD's. The values of selection intensity for the multi-trait selection index: ASM, BW_{SM}, DN_{10} and AGE_{10} were 0.57, 0.12, 0.30 and 0.67, respectively. The ratio of E_fSD to E_xSD's was lower than unity indicating that natural selection and/or chance did influence selection for ASM, DN_{10}, AGE_{10} and BW_{SM} with the ratios being 0.94, 0.89, 0.47 and 0.34, respectively in a descending order (Table 8). Differences in natural selection differential, fertility and/or genetic environment interaction might be resulted in such irregularities in selection response (Aboul-Seoud, 2008) especially in such small numbers of generations as it was the case in the present study

Realized heritability was obtained as the ratio of cumulative response (CR) to cumulative selection differential (CS) for the selected trait (Hill, 1972). Heritabilities of the multi-trait selection index pooled on three-generation ranged from medium to high being 0.55, 0.36, 0.17 and 0.39, respectively for ASM, BW_{SM}, DN_{10} and AGE_{10} with ASM had the highest Rh^2 whereas the lowest estimate was shown for DN_{10} are presented in Table 8.

Table (1): Economic values of the multi-index traits studied.

Item	Selected line	Item	Control line
G1 (ASM and BW_{SM})			
Initial price of one quail at 1-day	100 Piasters (P)	Initial price of one quail at 1-day	100 Piasters (P)
Feed for the first 42 days (650g)	650*300 P/Kg diet =195P	Feed for the first 42 days	650*300 P/Kg diet =195P
Feed for(48.83-42) days x 25 g day x 270 P/kg diet	6.83*25g*270 P/Kg diet =46P	Feed for (52.72-42) days x 25 g day x 270 P/kg diet	10.72*25*270 P/Kg diet =70.336P
Other cost (0.5 total feed cost)	=(46+195)*.05=120.5P	Other cost (0.5 total feed cost)	=(70.33+195)*0.5= 132.68P
Total	461.5P	Total	498P
Income price of quail at sexual maturity (600P)			
Gain	=600-461.5=138.5P		=600-498=102P
Total gain for decreased age at sexual maturity for 2 SD = income of (Selected S – Control C) =138.5-102=36.5P			
Gain for decreased age ate sexual maturity for –1 day = 36.50 x (-1) / 15 = -2.433 P			
G1 (DN10)	Selected line	Item	Control line
Feed cost	11.86*25*270 P/Kg diet=80.12P	Feed cost	13.95*25*270 P/Kg diet=94.16
Other cost (0.5 total feed cost)	40.06P	Other cost (0.5 total feed cost)	47.08P
Total	120.18P	Total	141.24P
Income 10 egg x 15 P price for one egg	150P	Income 10 egg x 15 P price for one egg	150P
Gain	=150-120.18=29.82P	Gain	=150-141.24=8.76P
Gain for decreased DN_{10} for –0.5 day for 2 SD = (29.82-8.76) x (-0.5) / 8.2 = -1.284 P			
G1 (AGE10)	Selected line	Item	Control line
Feed cost	60.19 days x 25 g x 270 P /kg diet=406.28	Feed cost	65.70 days x 25 g x 270 P /kg diet=443.47
Other cost (0.5 total feed cost)	203.14P	Other cost (0.5 total feed cost)	221.735P
Total	609.42P	Total	665.2P
Income =10 egg x 15 P price for one egg + Price of quail at sexual maturity = 750 P			
Gain	=750-609.42=140.58	Gain	=750-665.2=84.8P
Gain for decreased AGE10 for ½ day for 2 SD =(140.58-84.8)*.05/18.36= -1.519P			

Table (2): Economic values (EV) and relative economic values (REV) of the studied generation.

Gen.	ASM		DN_{10}		AGE_{10}	
	EV	REV	EV	REV	EV	REV
G_1	-2.433	-1.00	-1.28	-0.526	-1.519	-0.624
G_2	-4.219	-1.73	-1.72	-0.706	-1.999	-0.821
G_3	-2.42	-0.99	-2.586	-1.06	-2.58	-1.068
G_4	-9.74	-4.00	-0.719	-0.295	-4.30	-1.767

Table (3): Means and standard errors (SE) for generation and line effects on body weight at different ages.

Effect	BW_1	BW_7	BW_{14}	BW_{21}	BW_{28}	BW_{35}
Generation						
1	8.73^b	27.34^c	60.67^b	103.07^b	143.08^b	186.40
2	9.07^a	29.57^b	52.99^c	91.57^c	123.41^c	185.76
3	9.12^a	31.44^a	65.75^a	104.94^b	151.76^a	192.12
4	8.48^c	27.55^c	66.09^a	109.19^a	148.67^a	191.54
SE	0.096	0.529	0.975	1.554	2.135	2.264
P value	P≤0.000	P≤0.000	P≤0.000	P≤0.000	P≤0.000	P≤0.241
Line						
Control	8.87	26.76^b	56.37^b	92.73^b	128.16^b	175.09^b
Selected	8.86	31.08^a	65.61^a	111.69^a	153.63^a	202.01^a
SE	0.061	0.339	0.648	0.989	1.389	1.460
P value	P≤0.922	P≤0.000	P≤0.000	P≤0.000	P≤0.000	P≤0.000

$^{a,b\ and\ c}$:Means having different superscripts within each generation and line effect in the same column are significantly different at specified P.

Table (4): Means and standard errors (SE) for generation and line effects on some related-egg production traits.

Effect	**Multi-trait index**				**Egg production-related traits**						
	ASM	**DN$_{10}$**	**BW$_{SM}$**	**AGE$_{10}$**	**EM$_{10}$**	**EM$_{30}$**	**EM$_{60}$**	**DN$_{30}$**	**DN$_{60}$**	**AGE$_{30}$**	**AGE$_{60}$**
Generation											
1	50.78^{b}	12.91^{a}	237.94^{bc}	62.95^{b}	112.53^{c}	349.25^{b}	712.75^{b}	39.18^{a}	76.38^{a}	88.60	127.33^{a}
2	52.49^{a}	12.12^{ab}	250.57^{a}	63.96^{a}	121.72^{a}	376.13^{a}	759.33^{a}	36.03^{bc}	72.64^{b}	87.76	124.90^{a}
3	49.29^{c}	13.22^{a}	240.97^{b}	62.51^{b}	112.81^{c}	342.39^{c}	697.58^{c}	37.90^{b}	73.73^{b}	87.19	122.89^{b}
4	53.50^{a}	11.64^{b}	235.32^{c}	65.55^{a}	115.48^{b}	344.25^{bc}	702.78^{bc}	35.22^{c}	68.76^{c}	88.49	121.41^{b}
SE	0.54	0.36	2.44	0.65	0.98	2.42	4.93	0.67	1.12	0.94	1.31
P value	P≤0.000	P≤0.000	P≤0.000	P≤0.001	P≤0.000	P≤0.000	P≤0.000	P≤0.000	P≤0.000	P≤0.578	P≤0.009
Line											
Control	55.19^{a}	13.65^{a}	237.80^{b}	68.57^{a}	114.38^{b}	352.19	716.44	39.96^{a}	76.65^{a}	94.25^{a}	131.25^{a}
Selected	47.74^{b}	11.30^{b}	244.60^{a}	58.91^{b}	116.89^{a}	353.82	721.20	34.21^{b}	69.10^{b}	81.76^{b}	116.43^{b}
SE	0.33	0.22	1.51	0.40	0.60	1.51	3.11	0.43	0.75	0.59	0.89
P value	P≤0.000	P≤0.000	P≤0.001	P≤0.000	P≤0.003	P≤0.436	P≤0.395	P≤0.000	P≤0.000	P≤0.000	P≤0.000

^{a,b} and ^{c}:Means having different superscripts within each generation and line effect in the same column are significantly different at specified P.

Table (5): Means and standard errors (SE) for generation x line body weight at different ages.

Generation	Line	BW1	BW7	BW14	BW21	BW28	BW35
1	Control	8.56^{c}	23.66^{e}	51.58^{e}	88.76^{d}	121.37^{d}	173.32^{d}
	Selected	8.86^{bc}	30.29^{b}	67.06^{ab}	115.19^{a}	160.05^{ab}	196.63^{b}
2	Control	9.02^{b}	27.51^{cd}	49.30^{e}	80.95^{e}	113.92^{d}	170.89^{d}
	Selected	9.13^{b}	32.57^{a}	58.34^{d}	107.36^{b}	136.95^{c}	207.19^{a}
3	Control	9.77^{a}	29.41^{bc}	63.93^{bc}	94.65^{c}	134.98^{c}	170.62^{d}
	Selected	8.66^{c}	32.96^{a}	67.13^{ab}	112.41^{ab}	162.95^{a}	207.45^{a}
4	Control	8.14^{d}	26.44^{d}	60.86^{cd}	106.55^{b}	142.37^{c}	185.55^{c}
	Selected	8.81^{bc}	28.59^{bc}	69.82^{a}	111.80^{ab}	154.56^{b}	196.78^{b}
SE		0.144	0.788	1.454	2.307	3.199	3.393
P value		$P\leq0.000$	$P\leq0.000$	$P\leq0.000$	$P\leq0.000$	$P\leq0.000$	$P\leq0.000$

$^{a,b,c\text{ and }d}$:Means having different superscripts within the generation x line interaction in the same column are significantly different at specified P.

Table (6): Means and standard errors (SE) for generation by line interaction on some egg production related traits.

Generation	Line	ASM	DN_{10}	BW_{SM}	AGE_{10}	EM_{10}	EM_{30}	EM_{60}	DN_{30}	DN_{60}	AGE_{30}	AGE_{60}
1	C	52.72[c]	13.95[b]	234.27	65.70[b]	112.81[b]	346.83[b]	702.63[de]	41.46[a]	78.19[ab]	92.26[b]	131.23[a]
	S	48.83[d]	11.87[cd]	241.60	60.19[c]	112.25[bc]	351.67[b]	722.87[c]	36.89[b]	74.56[bc]	84.94[c]	123.44[b]
2	C	55.00[b]	13.09[bc]	246.52	67.98[b]	122.47[a]	380.15[a]	770.36[a]	38.11[b]	75.55[abc]	92.79[b]	130.08[a]
	S	48.78[d]	11.16[d]	254.61	59.94[cd]	120.98[a]	372.10[a]	748.30[b]	33.94[c]	69.72[de]	82.73[cd]	117.37[c]
3	C	52.08[c]	15.28[a]	235.90	67.28[b]	113.27[b]	347.69[b]	702.03[de]	41.67[a]	79.59[a]	93.67[b]	131.78[a]
	S	46.49[e]	11.09[d]	246.30	57.91[d]	112.36[bc]	337.08[c]	695.35[e]	34.03[c]	67.65[ef]	80.51[de]	113.67[cd]
4	C	60.97[a]	12.22[cd]	235.00	73.19[a]	109.05[c]	334.62[c]	691.46[e]	38.54[b]	73.13[cd]	98.17[a]	131.71[a]
	S	46.54[e]	11.06[d]	235.64	57.58[d]	121.91[a]	353.88[b]	714.10[cd]	31.91[c]	64.39[f]	78.81[e]	111.11[d]
SE		0.78	0.52	3.35	0.94	1.43	3.56	7.36	0.98	1.70	1.35	2.09
P value		P≤0.000	P≤0.002	P≤0.325	P≤0.000	P≤0.000	P≤0.000	P≤0.000	P≤0.016	P≤0.018	P≤0.000	P≤0.001

C: control line, S: selected line.

Table (7): Heritability (on diagonal), genetic (above the diagonal); phenotypic (below the diagonal) correlations (± standard errors) for the multi-index traits studied.[1]

	ASM	BW_{SM}	DN_{10}	AGE_{10}
ASM	0.21±0.12	0.50±0.10	0.47±0.315	0.95±0.03
BW_{SM}	0.17±0.04	0.24±0.10	0.57±0.41	0.54±0.20
DN_{10}	0.09±0.04	-0.03±0.04	0.09±0.06	0.65+0.03
AGE_{10}	0.86±0.01	0.18±0.03	0.23±0.03	0.27±0.09

[1]ASM: age at first egg, BW_{SM}: body weight at sexual maturity, DN_{10}: days needed to produce the first ten eggs and AGE_{10}: age at first 10 eggs.

Table (8): Direct response to selection as average phenotypic, genetic responses per generation, expected, effective selection differentials, its ratio and realized heritability for the multi-index traits studied.

Item	Control	Selected line						
	APR/G	Expected genetic response	APR/G	AGR/G	ExSD	E_fSD	Raito	Rh^2
ASM	2.17±0.42***	-0.60	-0.86±0.19***	-3.74±0.40***	-6.76	-3.34	0.94	0.55±0.17
BW_{SM}	-1.93±0.49ns	+4.88	-3.30±1.45*	-3.06±1.88ns	-8.41	-2.87	0.34	0.36±0.10
DN_{10}	-0.25±0.28ns	-0.09	-0.25±0.09*	-0.22±0.29ns	-1.30	-1.16	0.89	0.17±0.10
AGE_{10}	2.18±0.49***	-0.94	-0.99±0.21***	-4.12±0.47***	-10.61	-4.95	0.47	0.39±0.13

APR/G: Average Phenotypic Response per Generation, AGR/G: Average Genetic Response per Generation, ExSD :Expected selection differential,,E_fSD: Effective selection differential and Rh^2: Realized heritability.

Table (9): Response to selection for correlated traits: body weight, egg mass, days needed to produce eggs and ages of hens during studied periods of egg production.

	Average Phenotypic Response per Generation	**Average Phenotypic Response per Generation**	**Average Genetic Response per Generation**
Line	**Control line**	**Selected line**	
Correlated traits:			
Body weight at different ages:			
BW_1	-0.11±0.07ns	-0.09±0.05ns	0.15±0.11ns
BW_7	0.79±0.05*	-0.51±0.30ns	-0.68±0.46ns
BW_{14}	4.55±0.69***	1.97±0.56***	-0.41±1.01ns
BW_{21}	6.84±1.04***	-0.13±0.74ns	-3.97±1.42**
BW_{28}	7.58±1.42***	1.19±1.12ns	-1.99±1.01ns
BW_{35}	4.36±1.58**	-0.07±1.1ns	0.04±0.001ns
Egg production-related traits:			
EM_{10}	-3.10±0.64***	1.75±0.59**	4.96±0.84***
EM_{30}	-9.69±0.18***	-3.98±1.49**	6.36±2.26**
EM_{60}	-15.96±3.54***	-8.55±2.92**	2.68±5.00ns
DN_{30}	-0.36±0.52ns	-1.41±0.24***	-1.00±0.55ns
DN_{60}	-0.74±0.92ns	-3.26±0.45***	-2.16±0.98*
AGE_{30}	1.96±0.72**	-2.06±0.32***	-4.87±0.68***
AGE_{60}	0.47±1.06ns	-4.07±0.52***	-4.92±1.04***

*:Significant at P≤0.05, **: Significant at P≤0.01, ***: Significant at P≤0.001 and ns: Not significant.

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الملخص العربى

الاستجابات المباشرة والمصاحبة لدليل الانتخاب قصير المدى لبعض الصفات الاقتصادية فى السمان اليابانى

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أجريت تجربة انتخاب فى مركز بحوث الدواجن ،كلية الزراعة ، جامعة الفيوم واستخدم فيها عدد ٤٩٢٣ طائر فى ثلاث فقسات من العشيرة القاعدية والتى نتج عنها ٦٥٥ أنثى (٣٣٣من الخط المنتخب و ٣٢٢ من خط المقارنة) فى ٤ أجيال متعاقبة. وتتلخص أهم النتائج المتحصل عليها فى التالى:

١. وجدت اختلافات معنوية نتيجة تأثير الجيل لكل صفات وزن الجسم المختبرة وكذلك كل الصفات المتعلقة بانتاج البيض المدروسة، ماعدا وزن الجسم عند ٣٥ يوم من العمر و العمر عند انتاج ٣٠بيضة. تأثرت معنويا أوزان الجسم من ٧ الى ٣٥ يوم من العمر و كذلك كل الصفات المتعلقة بانتاج البيض المدروسة بتأثير الخط لصالح الخط المنتخب بالمقارنة بخط المقارنة.
٢. فى خط المقارنة أظهر متوسط الإستجابة المظهرية للجيل تذبذبات خلال الأجيال لعمر النضج الجنسى ، العمر عند إنتاج العشر بيضات الأولى والمحسوب كانحدار للمتوسط المظهرى للجيل على رقم الجيل وكان موجبا ومعنويا لعمر النضج الجنسى ، العمر عند إنتاج العشر بيضات الأولى (٢.١٧ و ٢.١٨ يوم). ظهرت تغيرات موجبة ومعنوية لأوزان الجسم عند ٧، ١٤، ٢١، ٢٨ و ٣٥ يوم من العمر وكانت ٠.٧٩، ٤.٥٥، ٦.٨٤، ٧.٥٨، ٤.٣٦جرام على التوالى و العمر عند إنتاج الـ٣٠ بيضة الأولى (١.٩٦يوم) بالرغم من ظهور تغيرات سالبة ومعنوية فى صفات كتلة البيض للـ١٠ و الـ٣٠ و الـ ٦٠ بيضة الأولى (- ٣.١، -٩.٦٩ و -١٥.٩٦ جرام).
٣. فى الخط المنتخب ، كان متوسط الإستجابة المظهرية للجيل لصفات دليل الانتخاب المتعدد والمحسوب كانحدار للمتوسط المظهرى للجيل على رقم الجيل سالبا ومعنويا لصفات لعمر النضج الجنسى ، الوزن عند النضج الجنسى ، عدد الأيام اللازمة لإنتاج أول ١٠ بيضات والعمر عند إنتاج العشر بيضات الأولى وكانت -٠.٨٦يوم، -٣.٣٠جرام، -٠.٢٥يوم،-٠.٩٩يوم على التوالى بينما كان موجبا لوزن الجسم عند ١٤ يوم من العمر (+١.٩٧جرام).
٤. وأظهرت الصفات (المرتبطة) المتعلقة بإنتاج البيض المدروسة تغيرات مصاحبة سالبة ومعنوية (كتله البيض ل٦٠،٠ يوم الأولى، عدد الأيام اللازمة لإنتاج أول ٣٠،٦٠ بيضة، العمر عند إنتاج ٣٠،٦٠ بيضة وكانت -٣.٩٨،-٨.٥٥ جرام ،-١.٤٤،-٣.٢٦،-٢.٠٦،-٤.٠٧ يوم على التوالى) ماعدا كتلة العشر بيضات الأولى (+١.٧٥ جرام). كان متوسط الإستجابه الوراثى للجيل فى صفات العمر ، الوزن الجسم عند النضج الجنسى، عدد الأيام و العمر اللازمة لإنتاج أول عشر بيضات -٣.٧٤ يوم ،-٣.٠٦ جرام،-٠.٢٢ و -٤.١٢ يوم على التوالى.
٥. كان كل من الإستجابه المظهرية والوراثية للجيل لصفات دليل الانتخاب المتعدد هو الأفضل لـعمر النضج الجنسى، عدد الأيام و العمر اللازمة لإنتاج أول عشر بيضات.
٦. وجد عائد مظهرى موجب ومعنوى للتغيرات المصاحبة لكل من كتلة البيض للـ١٠ و الـ٣٠ الأولى وكانت +٤.٩٦،+٦.٣٦ جرام ، بينما كانت هناك عائدات سالبة ومعنوية لكل من وزن الجسم عند ٢١ يوم من العمر،عدد الأيام اللازمة لإنتاج أول ٦٠ بيضة،والعمر عند إنتاج أول ٣٠و ٦٠ بيضة(-٣.٩٧ جرام ، -٢.١٦ ،-٤.٨٧ و -٤.٩٢ يوم على التتابع).
٧. وجد أن الإستجابه المحققة أعلى من المتوقعة حيث أن متوسط الإستجابه الوراثية للجيل كان أعلى وسالبا عن الإستجابة الوراثية المتوقع لـعمر النضج الجنسى، عدد الأيام و العمر اللازمة لإنتاج أول عشر بيضات. وجد أن الإستجابة الوراثية المتوقعة لوزن الجسم عند النضج الجنسى كان موجبا بينما كان متوسط الإستجابة الوراثية للجيل سالبا لتلك الصفة.
٨. تراوحت قيم العمق الوراثى المحقق لصفات دليل الانتخاب المتعدد خلال ثلاثة أجيال من متوسط إلى عالى وكانت ٠.٥٥، ٠.٣٦، ٠.١٧ و ٠.٣٩ على التوالى لكل من العمر والوزن عند النضج الجنسى و عدد الأيام اللازمة لإنتاج أول ١٠بيضات وكذلك العمر عند إنتاج أول ١٠ بيضات.