Egypt.Poult. Sci.Vol (38)(I): (179-194)(2018) **(1782)**

Egyptian Poultry Science Journal

http://www.epsaegypt.com

ISSN: 1110-5623 (Print) – 2090-0570 (Online)

GENETIC AND PRODUCTIVE STUDIES ON EGYPTIAN LOCAL AND EXOTIC LAYING HEN BREEDS

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Received: 21/01/2018 Accepted: 18/02/2018

ABSTRACT : Poultry production plays an important role as a source of cheap and high quality animal protein in Egypt. A 30 laying hens at 34 weeks age from each of Fayoumi, RIR and WL chicken breeds were evaluated for body weight and egg production traits. RIR recorded a significant heavier body weight while WL chickens recorded the highest and significant mean for egg number during the period of study. Fayoumi recorded the highest values for yolk index and yolk percentage. Fayoumi showed higher and significant values for most of the external egg quality characteristics compared to RIR and WL breeds. Blood samples were collected from the wing vein of 25 hens from each breed for DNA extraction and microsatellite genetic analysis**.** The highest value of expected heterozygosity (0.617) was obtained for Fayoumi breeds. The inbreeding coefficient (F_{IS}) was ranged from 0.084 to 0.156 with an average 0.124. The neighbor-joining phylogenetic tree showed closer relation between Fayoumi and WL. The low production traits of Fayoumi breed might be improved by crossbreeding with exotic breeds such as RIR and WL chickens. We confirm the efficiency of microsatellites for genetic characterization of Egyptian chicken breeds.

Key words: Body weight – Chicken - DNA - Egg-production - Microsatellite

INTRODUCTION

Poultry production plays an important role as a source of cheap and high quality animal protein in Egypt (Hosny, 2006). Egg production is influenced by several factors such as breed, age, health and management (Rayan et al., 2013). Egg quality is an important criterion for consumer and for the economic success of the breeders. Parameters of egg quality have a genetic basis and vary between chicken breeds (Silversides et al., 2006). Therefore, it is very important to evaluate the differences between chicken breeds for the egg quality traits. Growth rate is an important and can be considered as a direct fitness trait. It cause increases in the production efficiency and consequently decreases the production costs (Iraqi et al., 2002). Blood plasma proteins and minerals are important indicators of animal health and performance because they affect many physical and physiological functions. Calcium and phosphorus play an important role for the laying hens (Bogusławska-Tryk et al., 2012).

Genetic diversity of local chickens as well as recording the phenotypes and breeding history are a very important issue and deserve to be evaluated and properly managed to maintain genetic variability (Hammond, 1994). Microsatellites are considered the marker of choice for estimating genetic diversity, genetic structure and relationships among populations and they are powerful tool for MAS and QTL research (Zhou et al., 2008). Significant associations of some microsatellites with chickens body weight and egg production traits were observed (Van Kaam et al., 1999; Chatterjee et al., 2008; Zhou et al., 2008). The selection of best parents for crossing-breeding programs has to be based upon the complete phenotypic and genetic information. Improvement in yield is normally attained through mating of the genetically distant parents in the breeding programs (Laxuman et al., 2012). For animal and plant breeding programs, crosses between diverged populations can result in hybrid vigor , due to improved heterozygosity of loci with over-dominance and decreased homozygosity of loci with deleterious recessive effects (Coulson et al., 1998). Therefore, microsatellite markers are considered as an efficient tool for predicting hybrid vigor and performance of the resultant hybrids (Fernandes et al., 2015).

Egypt possesses great variety of chickens including indigenous ones characterized by high disease resistance and good performance under poor environmental and nutritional conditions and also the imported exotic breeds such as White leghorn and Rhode Island Red (Hosny, 2006). For instance, Fayoumi is an indigenous breed possess increased resistance to coccidiosis (Pinard-Van Der Laan et al., 1998) and Marek's disease (Tixier-Boichard et al., 2009), and can be seen as a unique breed for disease resistance. Rhode Island Red (RIR) is an exotic American dual-purpose breed while white leghorn is Mediterranean egg producing breed. These two exotic breeds have been adapted to the Egyptian environmental condition for more than 20 years (Hosny, 2006).

In spite of the importance of Egyptian local chickens, the information on their genetic variability and relationships are scanty (Roushdy et al., 2008; Eltanany et al., 2011; Ramadan et al., 2012). The objectives of the present study were as follows: first, to evaluate the performance of one native and two exotic Egyptian chicken breeds for egg production and growth traits; second, to perform the genetic characterization of these chicken breeds based on ten microsatellite markers.

MATERIALS AND METHODS

Experimental birds

A total of 90 laying hens at 34 weeks age were selected randomly from one native (Fayoumi) and two exotic (Rhode Island Red and Leghorn) chicken breeds; 30 hens from each breed. The thirty hens were divided into 3 replicate (10 hens / replicate) and wing-banded for their identification. The birds of each breed were housed in a litter floor with 10 birds /m^2 stocking density. They were reared under standard temperatures that were controlled by gas heaters for a period of three months in the poultry farm of Faculty of Agriculture, Ain Shams University. All hens were medicated similarly and regularly and they were subjected to the same managerial, hygienic and climatic conditions. The birds fed a commercial diet containing 18% crude proteins and 2920 Kcal ME/kg. The feed and water were provided ad libitum.

Production performance

Individual live body weights were recorded at 34, 38, and 42 weeks of age for each breed. Egg production (number and weight) was recorded during the experimental period (12 weeks). Egg mass was calculated by multiplying egg weight with numbers. To determine egg quality characteristics (internal and external), 30 eggs from each breed were randomly collected at 35 weeks of age. The dimensions of eggs (width and length) were measured using a digital caliper. Egg shape index was calculated by dividing egg width over length multiplying by 100 (Anderson et al., 2004).

The strength of eggshell was determined according to (Fathi and El-Sahar, 1996) using eggshell strength apparatus**.** To measure shell thickness; eggs were weighed to the nearest 0.1 g then broken. The shells of the broken eggs were washed gently under tap water to release albumen residues then air-dried and weighed. Shell thickness was determined for each breed without the shell membranes. The measure was carried out with a digital caliper with a sensitivity of 0.001 mm at three points of the egg shell (air cell, equator, and sharp end). The height of the albumen and yolk was measured using a micrometer mounted on a stand with a platform on which the liquid content was placed. Each egg yolk was separated from the albumen using a plastic egg separator, rolled on a tissue paper to remove any adhering albumen and then weighed. Albumen yield was determined by subtraction of the yolk and shell weight from the whole egg weight. The percentage of egg components (yolk, albumen and shell) was calculated as the ratio of egg components to the egg weight multiplied by 100. Yolk index (yolk height/yolk diameter) was also calculated. Based on egg weight and albumen height, Haugh units were calculated according (Vekić et al., 2011)**.** Egg volume was determined by measuring the quantity of the dislodged water in cm^3 after immersing the egg into known water volume.

Biochemical parameters

Ten females from each breed at 35 weeks age were randomly taken for measuring biochemical parameters. Blood samples were taken from the wing vein into heparinized tubes for all birds. Plasma was obtained from the blood samples by centrifugation for 10 minutes at 4000 rpm and was stored at -20°C until the time of analysis. The frozen plasma was allowed to thaw prior to analysis. Plasma calcium and phosphorus were determined by enzymatic colorimetric methods using available commercial kits (Mazur et al., 2017).

Microsatellite genetic analysis

Blood samples were collected from the wing vein of 25 hens from each breed into tubes with EDTA as anticoagulant. Genomic DNA was extracted from blood using AXYGEN kit (Axygen Scientific, inc. USA). Ten microsatellite markers (HUJ7, MCW222, ADL268, MCW154, LEI0234, MCW216, ADL278, MCW295, LEI094 and LEI166) were selected based on the chicken genome database (Pandey et al., 2005; Honkatukia et al., 2013; Wei et al., 2013; Goto et al., 2014). Four markers were in linkage with production traits; HUJ7 and MCW154 with egg production while LEI0166 and LEI0094 were associated with growth traits. DNA amplification was performed in 25 µl volume containing 12.5 µl of PCR Master Mix, 1 µl of each primer (10 pmol/ µl), 1 µl genomic DNA (50 ng/ µl) and 10.5 µl sterile deionized water. PCR reactions were achieved in thermal cycles that were differently programmed for each primer according the annealing temperature. The initial denaturation temperature of the first cycle was 94 C° for 4 min for all primers. The next 35 cycles varied in temperature settings according to each primer pair (55 C° to 60 C°). Final extension was 72 C° for 5 min. PCR products were separated in 12% acrylamide gel (29:1 acrylamide/bisacrylamide) supplemented with ethidium bromide. Gels were prepared in 1×TBE electrophoresis buffer, pH 8.0. The electrophoresis was run for 90 min at 70 volt with 50 bp DNA ladder (Larova GmbH- Germany). Gel was then visualized via UV trans-illuminator and then photographed. Molecular size of the amplified fragments separated on gels was measured by gel images with Gel Analyzer software version 2010 (Ahmed, 2008).

Genetic diversity was assessed by calculating the observed and effective number of alleles (N_A and N_e), observed and expected heterozygosity (H_O, H_e) by using GENALEX version 6.0 (Peakall and Smouse, 2006). Polymorphic information content (PIC) was calculated by using CERVUS version 3 software (Kalinowski et al., 2007). F-statistics (F_{IS}, F_{ST}, F_{IT}), in addition to pairwise F_{ST} (Weir and Cockerham, 1984) across the three studied populations were calculated using the GENEPOP version 3.4 (Rousset, 1995). Genetic distances among the three populations were evaluated by Nei's genetic distance (Nei et al., 1983). A phylogenetic tree was constructed based on the Nei's genetic distance by using the neighbor-joining method (Saitou and Nei, 1987). These processes were conducted using POPULATIONS version 1.2.30 software (Langella, 1999).

Statistical analysis

Data of production performance and biochemical analysis were analyzed using SAS version 9.1.3 (SAS Institute Inc., Cary, NC, USA). The model of the analysis included the fixed effect of breed and experimental error. The following linear model for studied traits was used

$Y_{ij} = \mu + S_i + e_{ij}$ where; Y_{ij}: the performance traits, μ: the overall mean, S_i: the fixed effect of the i^{th} breed, e_{ij}: experimental error.

RESULTS AND DISCUSSION

Production traits

Body weight traits

Live body weight at different ages for Fayoumi, WL and RIR breeds are shown in **Table 1**. RIR recorded a significant heavier body weight compared to Fayoumi and WL breeds. This result was in agreement with Lemlem and Tesfay (2010) who reported that the pullet and mature body weight of RIR breed was significantly heavier compared to WL breed. Moreover, Barua et al. (1998) recorded heavier body weight of RIR than Fayoumi at both of sexual maturity and peak egg production stages.

Egg Production traits

Egg production is the yield of overall performance of a bird concerning many variables such as egg number, rate of lay, age of sexual maturity, egg weight, shell thickness, external and internal egg quality characteristics**.** The egg number, egg weight and egg mass of the three studied breeds were shown in Table 2.

In our study, WL chickens recorded the highest and significant mean for egg number (67.84) during the period of study compared to RIR (55.00) and Fayoumi (49.14) breeds. This result was in agreement with those obtained by Lemlem and Tesfay (2010) who found that maximum number of eggs per year was obtained from RIR (185 eggs) and WL (176 eggs) compared to Fayoumi. In this study, RIR produced a significant higher egg weight (56.29) compared to WL (49.80) and Fayoumi (48.06). Moreover, RIR and WL recorded higher and significant egg mass compared to Fayoumi breed. This trend is similar to that of Dottavio et al. (2005) who found that the mean egg weight was ranked in the same manner as hens' average body weight. RIR birds, with the heaviest body and egg weights followed by WL then finally Fayoumi breed.

The lesser egg weight of the Fayoumi hens correlates with their lower body weight as compared to RIR and WL hens. In addition, RIR is a well-established breed than Fayoumi and selection for better egg weight of RIR might have been made generation after generation (Khawaja et al., 2012). The previous trend of RIR regarding the relationship between body weight, egg number and egg size was in agreement with previous studies which showed that egg production decreased and egg weight and feed consumption increased as body weight increased. This because heavy birds such as RIR consume more feed and lays heavier egg with larger egg yolk than light hens (Lacin et al., 2008)**.**

Internal Eggs quality:

The means of egg quality characteristics for the three studied chicken breeds were shown in Table 2. RIR showed the highest and significant values for both of Hugh unit, yolk weight and albumin weight with lower values for yolk index and yolk percentage. Fayoumi recorded the highest values for yolk index and yolk percentage. WL birds showed in general, intermediate values compared to the other two breeds. These results were in agreement with those reported by (Dottavio et al., 2005; Khawaja et al., 2012; Kumar et al., 2014) who recorded higher weights for both of egg, yolk and albuemn in RIR breed. In contrast, Islam and Dutta (2010) reported lower yolk weight (11.20) for RIR breed in tropics. Albumin weight and yolk weight were significantly higher in the RIR and this matched with the higher egg weight of RIR breed. This because the egg components are proportionately correlated with egg weight (Khawaja et al., 2012). The Haugh unit is considered a typical measure of albumen quality. It is generally accepted that the higher value of the Haugh unit, the better the quality of the egg. In UK, some studies have shown that there is a consumer resistant to purchase eggs which have Haugh unit below 60 (Tadesse et al., 2015). In the present study, RIR showed the highest and significant mean for Haugh unit.

External Egg quality:

The external egg quality traits among the three breeds were shown in Table 2. Fayoumi showed higher and significant values for most of the external egg quality characteristics compared to RIR and WL breeds. Eggs have different shapes. These shapes can be differentiated using shape index. The most often encountered egg shapes are; sharp, normal (standard) and round, which were enumerated on the SI scale as <72, 72-76, and >76 respectively (Altuntaş and Şekeroğlu, 2008). In the present study, the SI of egg shapes for the three studied chicken breeds was higher than 76 (round shape). Kumar et al. (2014) reported round egg shape for RIR with 78.43 egg shape index. In contrast, Ali and Anjum (2014) recorded a standred shape with SI equal to 73.08 for RIR under intensive system in tropics. The egg shell quality is determined by thickness, weight, percentage and the strength. The differences in eggshell quality depend on the environmental factors, feed quality and on breed of the layers. The thickness of the eggshell is an important trait for hatchability. For best result of hatchability, egg shell thickness should be between 0.33 and 0.35 mm (Khan et al., 2004). In our study, the three breeds recorded shell thickness higher than o.35. Fayoumi recorded the highest thickness (0.41) while RIR was the lowest (0.37). Lower shell thickness (0.35mm) was reported in RIR under intensive managemental system (Monira et al., 2003). RIR and Fayoumi recorded higher values for shell weight and the shell percentage was the highest in Fayoumi breed. Higher mean of shell weight (9.10) was reported for RIR under intensive management in tropics (Islam and Dutta, 2010).

Biochemical parameters

The blood biochemical parameters of the three studied breeds were shown in table 3. Fayoumi showed the highest and significant value for globulin while WL recorded the highest value for albumen protein. The high globulin level of Fayoumi might be associated with high disease resistance and improved immunity of this native breed compared to other exotic breeds (Tixier-Boichard et al., 2009). The calcium and phosphorous showed no significant differences between the three studied chicken breeds. This results is similar to El-Kaiaty and Hassan (2004) who found no difference in calcium and phosphorous levels between three local breeds (Fayoumi, Golden Montazah and Matrouh).Moreover, Khawaja et al. (2012) found no differences of calcium level between RIR, Fayoumi and Desi hens. The level of blood biochemical parameters of our study are comparable with those found by Mert and Yildirim (2016) however they are higher than that reported by Albokhadaim et al. (2012) in Saudia Arabia chickens.

Marker polymorphisms and population diversity

Across the three studied chicken populations, the number of alleles per locus ranged from 3 (MCW222 & ADL278 and LEI166) to 5 (LEI234 & LEI094 and MCW 154) and the average number of observed alleles was 4. Locus MCW222 showed lower values for both of H_O (0.430), H_E (0.479) and PIC (0.457) while locus LEI234 recorded higher values for the same parameters; H_O (0.607), H_E (0.707) and PIC (0.806) as shown in Table 4. Locus MCW222 showed lower polymorphism in some previous studies (Eltanany et al., 2011; Ramadan et al., 2012). Across the 10 loci, the average numbers of alleles, observed and expected heterozygosity in addition to F_{IS} for each population are shown in Table 5. The lowest value of expected heterozygosity (0.582) was obtained for the WL while the highest (0.617) was recorded for Fayoumi breeds.

The allele frequency of the microsatellite loci that were in linkage with egg (HUJ7 and MCW154) and with growth (MCW154, LEI094 and LEI166) traits were shown in Figure 1a,b,c,d. For HUJ7 locus, allele 180 bp recorded high frequency (0.620) in WL while allele 164 bp showed high frequency in RIR (0.440) and in Fayoumi (0.350) breeds. Locus MCW154 showed high frequency for allele 198 bp in WL (0.621) and allele 200 bp in RIR (0.571). Allele 260 bp of locus LEI094 recorded the highest frequency in RIR (0.640) while allele 260 bp recorded high frequencies in WL (0.520) and RIR (0.420). The high frequency of the previous alleles might be attributed to the selection pressure applied on these loci because of the favorable associated egg and growth traits.

The inbreeding coefficient (F_{IS}) was calculated as a measure of deviation from Hardy-Weinberg equilibrium and found to be ranged from 0.084 WL to 0.156 (Fayoumi) with an average 0.124. The F_{IS} were positive for the three investigated chicken populations indicating a departure from random mating. There were 20 private alleles observed across the three studied populations. The number of breed specific alleles ranged from 5 WL to 9 (Fayoumi) as shown in Table 5. Genetic differentiation across the three populations was investigated by fixation indices (F_{IS}, F_{IT}, F_{ST}) for each locus (Table 4). The F_{ST} which indicate fixation coefficients of sub-populations within the total population for the 10 loci varied from 0.308 (MCW216) to 0.081 (LEI166), with a relatively moderate mean 0.192, which indicate that there is a genetic differentiation among the three studied populations. This means that about 19.2% of the total genetic variation is attributed to population's differences, while the remaining 80.2 % is due to variation among individuals. The F_{ST} value of our study is lower than (Ramadan et al., 2012) who reported value of 0.222 across six Egyptian and two exotic chicken breeds (WL and RIR) based on 21 microsatellites loci.

For the F_{IS} coefficient, positive F_{IS} value means deficit of observed heterozygosity, while, negative value might indicate an excess of heterozygous genotypes compared to the expected one. In this study, the average of F_{IS} (0.116) was higher than that of (Eltanany et al., 2011; Ramadan et al., 2012). The positive value of F_{IS} in addition to all loci except (MCW216) showed a deficiency of heterozygosity; this can be attributed to non-random mating and these loci might be under selection for some favorable productive traits.

Genetic relationship and population structure

The pairwise Nei's genetic distance between the three studied populations recorded the lowest value between Fayoumi and WL (0.619) while the highest was between Fayoumi and RIR breeds (0.711). Similarly, the pairwise F_{ST} which indicate genetic differentiation showed the same trend as Nei's genetic distance Table 6. This finding was supported by clustering pattern of the population neighbor-joining phylogenetic tree (Figure 1). The tree topology showed closer relation between Fayoumi and WL. On contrast, Ramadan et al. (2012) recorded lower pairwise F_{ST} (0.392) and lower Nei's genetic distance (0.501) between Fayoumi and RIR than with WL (0.399 and 0.506 respectively). The close relationship between Fayoumi and WL in our study might be attributed to gene flow between these two breeds through unintended crosses. Moreover, the different results might be explained by the linked markers which were used in this study.

IN CONCLUSION,

Although Fayoumi chickens are a unique breed for disease resistance; they recorded lower values for body weight and most of egg production traits than two exotic breeds (RIR and WL). Production traits of Fayoumi breed might be improved by crossbreeding with exotic breeds such as RIR and WL chickens. We confirm the efficiency of microsatellites for genetic characterization of Egyptian chicken breeds. The alleles of the microsatellite loci that were in linkage with egg and growth traits that showed high frequency might be useful for marker assisted selection (MAS) purposes for the improvement of production traits of Egyptian chickens. The information from this study would be useful for genetic improvement and conservation programs of this agriculturally and commercially valuable species.

ACKNOWLEDGEMENTS

We are grateful for Genetics Department, Faulty of Agriculture, Tanta University for providing help and technical assistance to perform the molecular genetic analysis.

Table (1): Means ± SE of body weight for three Egyptian chicken breeds.

Trait/breeds	**Fayoumi**	**White Leghorn**	**Rhode Island Red**
34-week weight (gm)	1564.50±64.86^{b}	1541.50±65.90^{b}	2207.25±98.82^{a}
38-week weight (gm)	1666.75±77.89^{b}	1695.25±63.10^{b}	2224.00±66.89^{a}
42-week weight (gm)	1696.50±79.60^{b}	1741.00±59.95^{b}	2299.73±70.7^{a}

Means with different superscripts within the same raw are statistically significant ($P < 0.05$)

Table (2): Means ± SE for egg production and egg quality traits for the three chicken breeds.

Trait	**Fayoumi**	**White leghorn**	**Rhode Island Red**
a- Egg production			
Egg number	49.14±2.72^{b}	67.84±1.33^{a}	55.00±1.42^{b}
Egg weight(g)	48.06±1.26^{b}	49.80±1.04^{b}	56.29±0.99^{a}
Egg mas (g)	2361.67±153.81^{b}	3378.43±62.61^{a}	3095.95±86.86^{a}
b- Internal egg quality			
Hugh unit	83.57±1.59^{b}	84.62 ±0.46^{b}	87.96±0.70^{a}
Yolk index	41.02±0.94^{a}	40.82±0.50^{a}	38.33±0.71^{b}
Yolk weight (gm)	17.3±0.24^{b}	15.49±0.30^{c}	18.8±0.34^{a}
Yolk percentage (%)	34.95±0.79^{a}	31.05±0.40^{b}	31.8±0.66^{b}
Albumin weight (gm)	27.19±0.84^{b}	29.57±0.76^{b}	34.95±0.87^{a}
Albumin percentage %	54.61±0.57^{b}	59.20±0.47^{a}	58.90±0.81^{a}
c- External egg quality			
Shape Index	79.31±0.88^{a}	77.07±0.58^{b}	76.74±0.45^{b}
Shell strength (kg/cm²)	4.64±0.42^{a}	4.23±0.22^{a}	3.95±0.17^{a}
Shell weight(g)	5.22±0.25^{ab}	4.95±0.10^{b}	5.45±0.12^{a}
Shell percentage (%)	10.44±0.32^{a}	9.92±0.11^{a}	9.20±0.19^{b}
Shell thickness(mm)	0.41±0.02^{a}	0.38±0.01^{b}	0.37±0.01^{b}
Egg volume (cm^{3})	39.41±0.37^{b}	53.51±0.44^{a}	54.4±0.37^{a}

Means with different superscripts within the same raw are statistically significant ($P < 0.05$)

Table (3): Blood biochemical parameters of the three studied chicken breeds

Traits	**Fayoumi**	**White leghorn**	**Rhode Island Red**
Total protéine (g/dl)	5.91^{a} ±0.11	5.86^{a} ±0.10	5.84^{a} ±0.14
Albumen (g/dl)	3.11^{b} ±0.13	3.51^{a}±0.11	3.14^{b}±0.09
Globulin (g/dl)	2.80^{a}±0.07	2.35^{b}±0.07	2.70^{a} ±0.04
Calcium (mg/dl)	21.19^{a} ±1.12	19.22^{a} ±0.55	21.98^{a}±1.22
Phosphorus (mg/dl)	9.39^{a} ±0.52	9.14^{a} ±0.32	10.10^{a}±0.63

Means with different superscripts within the same raw are statistically significant ($P < 0.05$)

Table (4): Observed (N_A) and effective (N_e) number of alleles, observed (H_O) and expected (H_e) heterozygosities, polymorphism information content (PIC), and F-statistics (F_{IS} , F_{ST}, and F_{IT}) across the three chicken breeds.

Loci	**N_A ± SD**	**Ne ± SD**	**Ho ±SD**	**He ± SD**	**PIC ± SD**	**F_{IS} ± SD**	**F_{IT} ± SD**	**F_{ST} ± SD**
MCW222	3.0	1.902	0.430	0.479	0.457	0.081	0.234	0.166
MCW216	3.3	1.802	0.477	0.438	0.554	-0.114	0.229	0.308
ADL278	3.0	2.338	0.443	0.537	0.622	0.157	0.339	0.216
LEI166	3.0	2.414	0.477	0.598	0.558	0.185	0.251	0.081
ADL268	4.0	2.518	0.527	0.593	0.731	0.092	0.320	0.251
MCW295	3.7	2.411	0.560	0.586	0.683	0.023	0.227	0.208
HUJ7	5.0	3.270	0.533	0.693	0.816	0.213	0.362	0.190
MCW154	5.0	3.079	0.524	0.662	0.741	0.190	0.326	0.167
LEI234	5.0	3.356	0.607	0.707	0.806	0.123	0.267	0.165
LEI094	5.0	3.470	0.529	0.688	0.772	0.214	0.347	0.169
Total	4±0.423	2.656±0.160	0.511±0.026	0.598±0.024	0.674±0.058	0.116±0.032	0.290±0.017	0.192±0.019

Table (5): Mean observed (MN_A) and effective (N_e) number of alleles, private alleles, observed (H_O) and expected (H_E) heterozygosities, and fixation coefficient of an individual within a subpopulation (F_{IS}) per breed

Breed	**MN_A ± SD**	**Ne ± SD**	**private alleles**	**Ho ± SD**	**He ± SD**	**F_{IS} ± SD**	**HWE**
Fayoumi	4.200	2.853	9	0.506	0.617	0.156	***
White leghorn	3.400	2.527	5	0.522	0.582	0.084	*
Rhode Island Red	4.400	2.587	6	0.505	0.595	0.131	***
Total	4±0.230	2.656±0.160		0.511±0.026	0.598±0.024	0.124±0.031	

Table (6): Nei's genetic distance (above diagonal) and pairwise F_{ST} (below diagonal) estimates for the10 microsatellite loci between the three studied chicken breeds

	White leghorn	Rhode Island Red	Fayoumi
White leghorn		0.662	0.619
Rhode Island Red	0.151		0.711
Fayoumi	0.136	0.155	

Figure (1): Alleles frequency of linked loci with productive traits (a) HUJ7 locus, (b) MCW154 locus, (c) LEI094 locus (d) LEI166 locus.

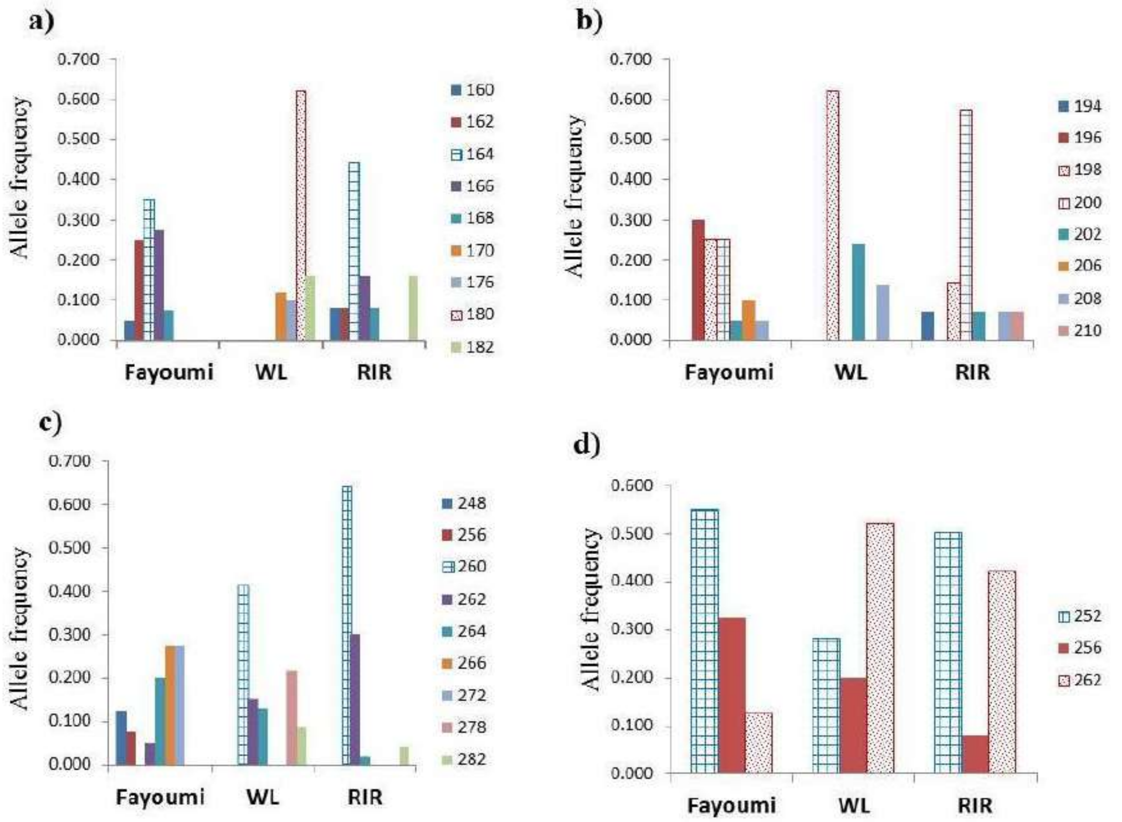
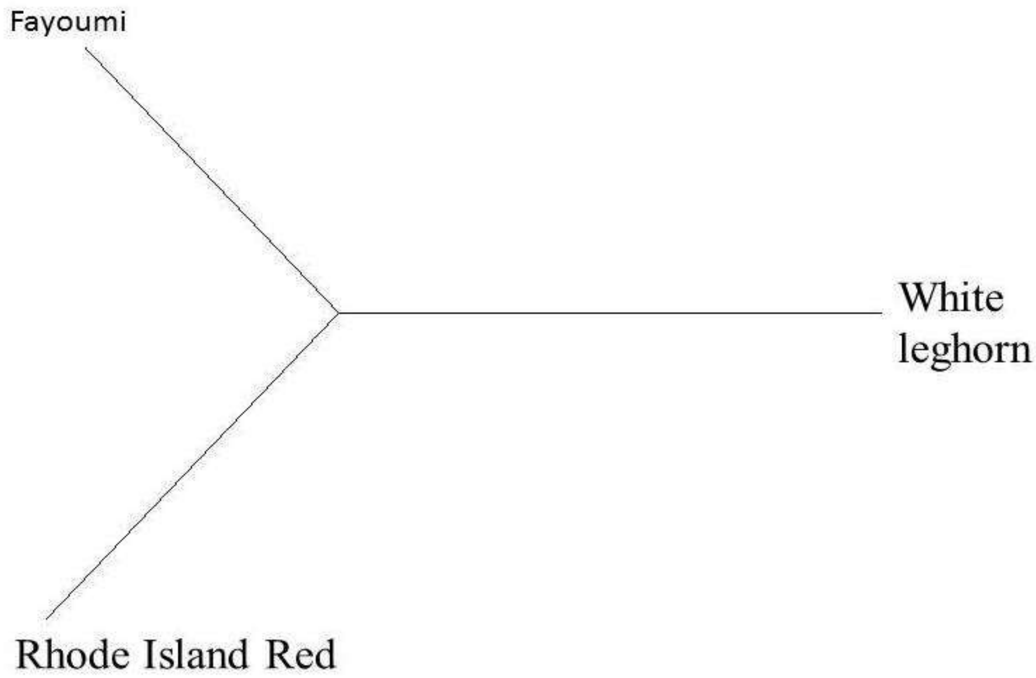


Figure (2): Neighbor-joining phylogenetic tree of the three studied chicken breeds based on the 10 microsatellite lociz



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الملخص العربى

انتاج الدواجن فى مصر يلعب دور هام كمصدر رخيص وعالى الجوده للبروتين الحيوانى

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فى هذه الدراسه تم اختيار عدد 30 دجاجه بياض من كلا من سلاله الفيومى والرود ايلاند رد واللجهورن الابيض عند عمر 34 اسبوع. وتم تقييم صفات انتاج البيض ووزن الجسم .سجلت سلاله الرودايلاند رد أوزان جسم اثقل ومعنويه بينما سجلت سلاله اللجهورن الابيض متوسط عدد بيض أعلى ومعنويه أثناء الدراسه. سجلت سلاله الفيومى قيم أعلى ومعنويه لدليل صفار البيض والنسبه المئويه للصفار وأظهرت معنويه أعلى فى معظم قياسات جوده البيض الخارجية بالمقارنه بسلاله الرودايلاند رد واللجهورن الأبيض. تم تجميع عدد 25 عينه دم من كل سلاله لاستخلاص الحامض النووى DNA وتم التحليل الوراثى الجزيئى باستخدام التوابع الوراثية الدقيقة. كانت أعلى نسبة خلط متوقعة (0.617) فى سلالة الفيومى وتراوحت قيمه معامل التربية الداخلية (F_{IS}) من (-0.08 0.156) بمتوسط 0.124 . اتضح من الDendogram أن سلالة الفيومى على درجة عالية من القرابة من سلالة اللجهورن الأبيض. انخفاض الصفات الأنتاجية لسلاله الفيومى ربما يمكن تحسينه عن طريق الخلط الوراثى مع السلالات الأجنبيه مثل سلاله اللجهورن الأبيض وسلاله الرودايلاند رد كما تؤكد الدراسة على كفاءة التوابع الوراثية الدقيقة فى التوصيف الوراثى بين سلالات الدجاج المصري