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Full Length Article

Diversity of Chicken Populations in Jordan Determined using Discriminate Analysis of Performance Traits

RAED AL-ATIYAT[1]
Animal Science Department, Faculty of Agriculture, Mutah University, Jordan
Corresponding author's e-mail: raedatiyat@yahoo.com; raedatiyat@gmail.com

ABSTRACT

Performance measurements were recorded for studying diversity of six-week old indigenous, commercial layer and commercial broiler chickens. The measurements were weights of live body, carcass, offal, feet, head, liver, spleen, small intestine, large intestine, heart, legs, thighs, drum steaks, breast, wings, tail, gizzard, back, neck and stomach. Different discriminant analysis methods (simple, cluster, canonical & stepwise) were applied on the 20 metric variables. The analysis showed that the three populations were distinct. The indigenous and the commercial layer populations were closer to each other than the broiler population. The expected performance characterization would complement with future conducting of genetic characterization. This would help to initiate a program for the preservation of genetic diversity of the indigenous chickens in Jordan. Findings suggested that canonical discriminant analysis was successful to find out chicken diversity based on performance data.

Key Words: Diversity; Chicken breeding; Performance traits; Discriminant analysis; Jordan

INTRODUCTION

The indigenous breed is a general terminology given to those animals or birds kept in the extensive system, scavenging in the free-range, have no identified description, multi-purpose and unimproved (Horst, 1989; Pedersen, 2002). The Indigenous chickens are supposed to be more adapted to local environmental conditions and diseases. Horst (1989) considered the indigenous chicken as genes reservoir, particularly, those genes that have adaptive values in the tropical conditions. Therefore, indigenous chickens contribute greatly to human supply of eggs and meat in tropical and subtropical areas. In Jordan, indigenous chickens are the only livestock, which could be kept by the poorest rural families. However, little information on productivity and adaptability of Jordan indigenous chickens are available. Moreover, no real efforts were done to the conservation of indigenous chickens' genetic resources. One of the important reasons to conserve indigenous chicken genetic resources is to keep genetic variation within and between indigenous breeds. The present and future improvement and sustainability of indigenous chicken production systems are dependent upon the availability of this genetic variation (Benitez, 2002). Therefore, the evaluation of indigenous chicken population as genetic resources includes the determinations of genetic distance between the available populations (Hammond, 1994). The total indigenous chicken population in Jordan was estimated to be one million (Abdelqader & Wollny, 2004); whereas, exotic commercial breeds population was 24 millions of (FAOSTAT, 2007). These commercial breeds (White Leghorn) are world wide known of layers (e.g., Lohmann®, Hi6®, ISA®, Hi-line®) and broilers (e.g., Lohmann®, Hubbard®, Ross®, Cobb®). On the other hand, the indigenous chickens breed in Jordan is composed of different non-descript types. Therefore, they were rather described as distinct ecotypes assigned to their geographical areas (Abdelqader *et al*., 2008). No clear information is available about their origin or introduction to Jordan. Furthermore, there is no information available on the diversity of different phenotypes and approximate performance potential. At present, Jordan has an action plan for conservation of livestock genetic resources, but this plan is more directed towards small ruminants and indigenous cattle than toward indigenous chicken breeds (FAO, 2004). On the other hand, the commercial exotic chickens of high-input high-output were introduced in a large scale system, which expanded rapidly due to the increase in the demand on eggs and meat. Some farmers in Jordan have been crossing indigenous chicken with the exotic ones to get advantage of heterosis effect, which reported to be higher under tropical and subtropical conditions (Horst & Mathur, 1992). The crossing of indigenous chickens has mainly occurred with commercial layer and Pakistani chickens (Al-Atiyat, 2006). This trend is currently being limited in favor of preserve characterization of indigenous breeds in a comparison with exotic breeds (Maijala, 1992). The differentiation between the Jordan indigenous chickens and

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exotic breeds except the commercial breeds has been previously studied with emphasis on morphological and adaptive traits (Abdelqader *et al*., 2008). No studies were so far carried out to provide basic information about the diversity of indigenous chicken from commercial breeds on the basis of performance traits.

Genetic characterization based on molecular assessment is reported to be most common and used method to evaluate genetic diversity between and within livestock breeds, but needs high technology and cost (Wimmers *et al*., 2000; Romanov & Weigend, 2001; Hillel *et al*., 2003). Researchers also used a method based on morphological characters that are easy to monitor, low cost and provide reliable racial discriminants. Such method is statistical multivariate discriminant analysis that does not limit the amount of monitored variables and at the same time confirm the discriminatory capacity point of view (Sneath & Sokal, 1973; SAS, 1999). The use of discriminant analysis has been successfully used to differentiate within and between livestock breeds (Jordana *et al.,* 1993; Herrera *et al*., 1996; Zaitoun *et al*., 2005). Recently, some interesting results have already been obtained on performance and breeding of chickens, demonstrating use of the multivariate discriminant approach (Pinto *et al*., 2006; Rosario *et al*., 2008). Therefore, the objectives of this study were to differentiate and localize the indigenous chicken in Jordan with commercial chicken populations using the multivariate discriminant analysis of performance traits.

MATERIALS AND METHODS

Chicken breeds. The objective of present study was to measure production diversity and differentiation of three most common chicken breeds, strains, ecotypes or populations available in Jordan. These chickens are indigenous, commercial broilers and commercial layer. Fertile hatching eggs were obtained from hobbyist and keepers of indigenous chickens from three distinct geographical areas of Jordan (Northern, Middle & Southern, named in the present research as Indigenous A, B & C, respectively). The broiler fertile eggs were brought from commercial broiler hatcheries for three broiler strains (for present research named as Broiler A, B & C strains). Eggs of these two breeds were hatched in the Agriculture Research Station at Mutah University and a 100 of one-day old chicks were sexed for female, leg banded and placed in floor pens. Females from each type were grown to 6 weeks of age for performance comparisons. All birds received feed and light regimes as recommended. On the other hand, the layer breeds, which were also three commercial strains (named for purpose of the present research as Layer A, B & C), were hard to be reared in same chicken house and were instead reared in a separated commercial farm under recommended rearing and feeding regime. At 6 weeks age, thirty chickens of each type were randomly selected, weighted and slaughtered for performance measurements (10 chickens from each commercial strain & Indigenous ecotype). The total sample size was 90 chickens. All work for this research using animals was performed with the permission of and in accordance with the guidelines set by Ethics Committee of Mutah University.

Data and performance measurements. The performance measurements were weight of live body, offal, carcass, feet, head, liver, spleen, small intestine, large intestine, heart, legs, thighs, drum steaks, breast, wings, tail, gizzard, back, neck and stomach (Proventiculus). Data of weights were taken by direct measurement using digital scale and then used for discriminant analysis.

Statistical analysis. SAS-program version 8 (SAS, 1999) was used for all statistical analysis. PROC MEANS procedure was used for the descriptive statistics of performance data. The simple discriminant analysis developed through the SAS DISCRIM procedure to calculate the probabilities of including an animal in determined breed, taking into account the error made in classification of the breed. Stepwise discriminant procedure (STEPDISC) was applied to determine, which performance traits will be used in the final clustering analysis, this procedure determine the variables that have more discriminated power than the others. The third type of analysis, canonical discriminant analysis (SAS CANDISC procedure), was used to perform uni-and multivariate analysis to derive canonical variables (CAN), which were used to match the breed groups until reached the satisfactory number of clusters (genetic groups) and to show the clustering groups among these three breeds. Mahalanobis distances, the canonical coefficients and a scatter gram for visual interpretation of the different groups were also generated during the canonical discriminant analysis. These distances were used to construct a dendrogram using the un-weighted pairs group method analysis implemented in SAS TREE procedure that prints the dendrogram based on the data of distances between the clusters introduced in PROC CLUSTER procedure.

RESULTS

Performance characteristics. The descriptive statistics of the different performance variables studied in the chicken breeds are shown in Table I. The results show that the greatest average values from the weight variables corresponded to the broiler breed and the lowest to the Indigenous breed at 6 weeks of age. There was a wide range of variability in body size of the birds, ranged in live body weight from 369.50 g of Indigenous breed to 2152.50 g of broiler breeds. The same manner was shown for all studied performance traits, with the highest, middle and lowest values for broiler, layer and Indigenous chickens, respectively (Table I).

Diversity and discriminant analysis. The discriminant analysis showed that the three populations were characterized as three distinct clusters according to the

Mahalanobis distances (based on the covariance matrix, Rao, 1973) estimated between the three populations (Table II). The distances between all pairwise were highly significant (P<0.0001). The greatest distance value was between indigenous population and broiler population, whereas the lowest distance value was between indigenous chicken population and the layer population. It is important to note that the distance value between broiler populations and layer population was as high as that with Indigenous population (Table II). The measurements that were best able to separate the populations, as judged from stepwise discriminant analysis, were weight of live body, head, spleen and breast (Table III). More variables that significant discriminated between pairwise populations' comparisons are presented in Table III.

The dendrogram (Fig. 1) shows two large clusters, one formed by the indigenous and layer populations and the other by broiler population, which was far separated from the others. Layer population was being located in the intermediate area closer to Indigenous chicken population. The two large clusters of Fig. 1 were sub-clustered into groups as shown in Fig. 2. The first, Broiler cluster, was included two sub-clusters; the first of Broiler strain A and Broiler strain C, whereas Broiler strain B was in a separate group in another sub-cluster. The second, Indigenous and layer cluster, was also included two major sub-clusters; the sub-cluster of Indigenous population included ecotype A and a separate group of ecotypes B and C. In similar, the sub-cluster of layer population included layer strain A along with a separate group of strains B and C.

The evaluation of the individuals' diversity within each group and their relationship with other populations is shown in Fig. 3, with data obtained from canonical discriminant analysis whose structure is shown in Table IV. The CAN represent the highest possible correlation between linear combination of performance variables of chicken populations. Here, the most discriminating variables are live body, carcass, feet and neck weights in canonical correspondence with ordinate axis and the head weight and Gizzard weight in the coordinate axis. In the canonical analysis graph (Fig. 3), a wide discrimination between the indigenous and broiler continues, population discriminating mainly by the body weight (Table III), the variable that separates Broiler population from the other populations due to its extreme heaviest (Table I). Furthermore, variance of CAN1 and CAN2 are shown in Table IV in which CAN1 accounted for 93.6% of the total variation.

Table I. Descriptive statistics (mean±standard error) of twenty performance characters between chicken breeds of six-week old

Character	Indigenous	Layer	Broiler
Live body weight (g)	370±7.46	676±14.86	2153±49.80
Carcass weight (g)	239±4.37	434±4.84	1622±52.75
Offal weight (g)	58±1.76	87±2.05	328±8.51
Legs weight (g)	62.5±1.58	117.5±4.37	439.0±14.77
Thighs weight (g)	33.7±0.65	64.9±0.90	226.1±7.01
Drum steaks weight (g)	28.8±0.96	62.3±1.09	214.2±8.14
Breast weight (g)	51.4±1.41	101.8±2.81	425.3±15.57
Back weight (g)	52.9±1.31	82.5±2.27	301.3±10.32
Wings weight (g)	34.1±0.91	64.6±1.09	164.1±3.76
Neck weight (g)	21.7±1.14	35.5±1.02	116.2±2.69
Small intestine weight (g)	14.4±0.63	23.5±0.59	100.3±5.09
Large intestine weight (g)	8.2±0.29	14.3±0.53	60.0±2.99
Feet weight (g)	15.4±0.38	27.6±0.55	87.3±2.08
Head weight (g)	19.5±0.34	29.6±0.21	47.1±0.83
Liver weight (g)	11.2±0.64	19.3±0.74	61.6±1.94
Spleen weight (g)	0.8±0.05	1.6±0.09	3.4±0.13
Heart weight (g)	2.1±0.09	3.3±0.13	13.3±0.54
Tail weight (g)	3.4±0.23	6.3±0.21	12.7±0.87
Gizzard weight (g)	14.8±0.31	27.1±0.56	49.9±1.49
Stomach weight (g)	2.4±0.04	3.9±0.13	10.2±0.52

Table II. Mahalanobis distance between the chicken breeds and probability values for the contrasts

Type	Broiler	Indigenous	Layer
Broiler	0	433.88371	429.87460
Indigenous	<.0001*	0	38.31390
Layer	<.0001	<.0001	0

*Prob > Mahalanobis Distance for Squared Distance to type

Table III. The significant weight variables that discriminated between chicken breeds using stepwise discriminant analysis

	Layer	Indigenous
Broiler	Back , Breast, Carcass, Drum Steaks, Head, Heart, Spleen, Large Intestine, Live Body, Small Intestine, Tail, Thighs, Wings,	Back, Breast, Carcass, Drum steaks, Feet, Gizzard, Head, Heart, Large intestine, Live body, Liver, Small intestine, Spleen,
Layer		Breast, Feet, Gizzard, Neck, Head, Live body, Spleen, Thigh, Wing,

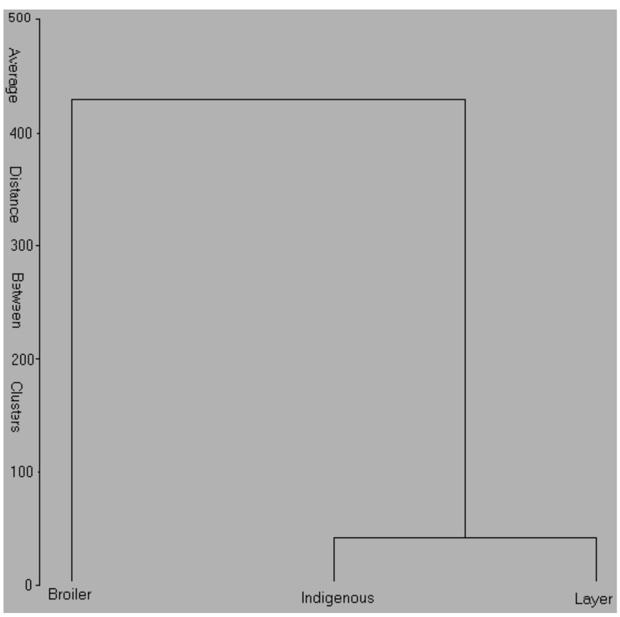
DISCUSSION

The commercial chickens were introduced to Jordan by companies and private sectors sometimes after 1956 (Jordan Ministry of Agriculture, 2005). The commercial layer chickens have larger body size than Jordan indigenous, whilst Broiler chickens have a very large body size, heavy bone and muscles. Current breeding strategies for worldwide commercial poultry industry concentrate on specialized production strains derived from a few breeds and very large populations with a great genetic uniformity of traits by intense selection (Notter, 1999). On the other hand, many indigenous populations throughout the world characterized by medium or low performance, are often maintained in small populations with no selection. The Jordan indigenous chicken was characterized by smaller body size when compared to the other commercial populations (Table I). The present study showed a considerable genetic variability among the three populations in Jordan (Table I). Great performance variations among populations were expected, because each population has been selected for different purposes long time ago. For instance live body weight has values of 369.5, 674.4 and

Table IV. Total-sample standardised canonical coefficients, and total variations explained by each canonical variable (Can)

Variables (Weight)	Can1	Can2
Live body	0.98	0.16
Carcass	0.98	0.10
Offal	0.96	0.13
Feet	0.97	0.16
Head	0.91	0.37
Liver	0.95	0.15
Spleen	0.87	0.27
Small intestine	0.92	0.09
Large intestine	0.92	0.10
Heart	0.94	0.09
Legs	0.96	0.13
Thighs	0.96	0.15
Drum steaks	0.94	0.17
Breast	0.96	0.12
Wings	0.96	0.23
Tail	0.77	0.27
Gizzard	0.89	0.34
Back	0.96	0.11
Neck	0.97	0.14
Stomach	0.89	0.17
Total variance	0.936	0.064

Fig. 1. Dendrogram showing relationship among Indigenous chicken, Broiler and layer breeds populations in Jordan



2152.5 g for the indigenous, layer and broiler populations, respectively. The average value of performance traits of the indigenous populations was lower than that obtained for the other chicken populations. Although, indigenous chickens in Jordan were reported to be highly heterogeneous in morphological appearance and reproductive performance, they characterize by low productivity (Abdelqader & Wollny, 2004). In agreement, Demeke (2003) observed that, of all the performance variables, body weight showed the greatest variability between Ethiopian indigenous chicken

Fig. 2. Dendrogram showing relationship among Indigenous chicken ecotypes, Broiler strains and layer strains in Jordan

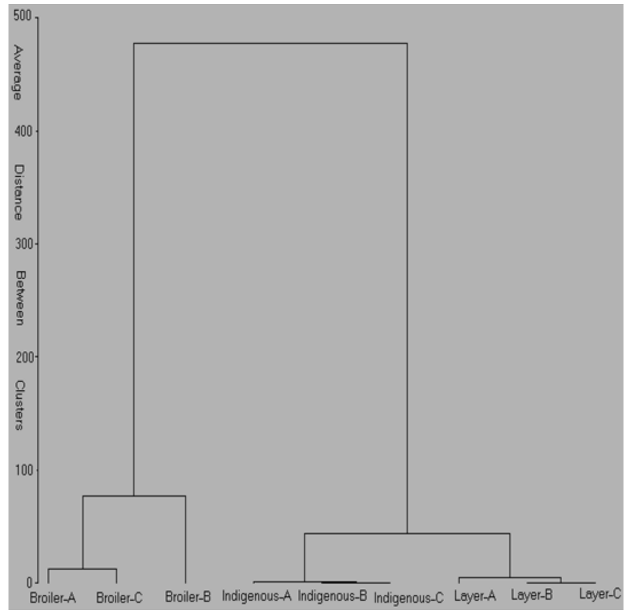
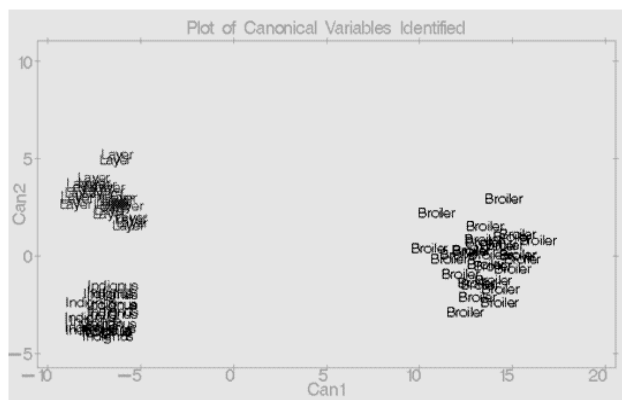


Fig. 3. Canonical representation of the three chicken breeds in Jordan using performance traits, where Indignus is Indigenous chicken, Layer is layer chicken and Broiler is broiler chicken



and White leghorn chickens. In general, the low performance was the main characteristic of indigenous chickens over the world comparative with commercial populations (Wimmers *et al.*, 2000; Pedersen, 2002). Overall, the high variations in performance observed in this study were in general agreement with previous findings of Mwalusanya *et al.* (2002) in Tanzania, Tadelle *et al.* (2003) in Ethiopia and Benabdeljelil and Arfaoui (2001) in Morocco.

It has been observed, as a result of low performance of indigenous chicken, the genetic resources of the indigenous population were threatened by improper management particularly crossbreeding with layers in order to increase egg production (Abdelqader & Wollny, 2004). Therefore, there is a need to plan a conservation program for indigenous chicken knowing before hand its diversity and compare it with commercially available populations and strains. In general, the diversity of the indigenous chickens was mostly reported on phenotypes including adult body weight, reproduction performance and immune responses to various diseases (Gueye, 1998; Msoffe *et al.*, 2004). It is very rare to find comparative study stated on basis of performance traits as reported in the present study. In the present study, the pairwise squared Mahalanobis' distances and the probability of a significant effect of contrasts, by the F-test ($P<0.05$), between populations show such diversity. The smallest and largest distances were observed between indigenous and layer and between indigenous and broiler, respectively. This demonstrates that Indigenous and Layer populations presented dissimilar results when the performance traits were analyzed, as confirmed by the F-test, with a significant probability ($P<0.0001$). In addition, Indigenous and Broiler populations presented the largest dissimilarity as evidenced by their multivariate means. The other contrast, Layer and Broiler populations, were significantly dissimilar, according to the squared Mahalanobis' distances (Table II). These large distances between broiler commercially selected population for meat and non-selected meat populations are supported by the work of Berri *et al.* (2001), who studied the effect of selection for improved body composition on muscle and meat characteristics. Furthermore, Rosario *et al.* (2008) reported that an experimental strain of broiler showed lower multivariate performance than the commercial broiler strains, indicting that strategy to select the former had been based on the univariate analysis, not multivariate as for the latter for high breast and leg weights.

The large discriminant values of the performance variables confirmed the influence of the body weight as a differentiating element (Table III). The large distance separation between broiler in one side with indigenous and layer as shown in Fig. 3 confirmed that hypothesis that indigenous population somehow related to the original base for commercial layers. The high discriminant values of the two populations from broiler were due to the degree of selection and the superior productive ability. In agreement, Reddish and Lilburn (2004) reported that genetic selection within commercial broiler strains continues to generate improvement in body weight and breast meat yield. The closeness of Indigenous and layer populations was explained by the fact both have been inclined towards egg production as well as crossing of the two populations by the farmers (Al-Atiyat, 2006). However, in stepwise discriminant analysis (Table III), the differentiation of those two populations, indigenous and broiler, was based on the weights of live body, feet, head, spleen, thigh, breast, wings, gizzard and neck. On the other hand, lack of confluence between layer population and indigenous population does not correspond with what was assumed for the two populations as originated from same commercial source. In contrast, broiler population proved to be a good discriminator and showed significant differences in performance traits. This confirms that the two populations were of a high degree of similarity as egg production populations, given the large differences with broiler in discrimination metric weight variables of live body (98%) and carcass (98%) (Table IV). The Table IV presents the total-sample standardised canonical coefficients and total variation explained by each canonical variable. The first canonical variable (Can1), or Fisher linear discriminant function, explained 93.6% of total variation, which can be considered reasonable and Can2 explained 6.4% of total variation. From the twenty performance traits, only Can1 was necessary to explain most of total variation. Indeed, the number of traits facilitated the evaluation of the chicken performance, because each original trait was weighted according to its contribution on each canonical variable. It is important to point out that the body weight proved to be the variable that most frequently showed a significant discrimination between the populations, (many times in the stepwise analysis). Higher weighing of the average live body and carcass weight was demonstrating that these traits were very important both to discriminate and to classify populations. Average live weight was the most reported trait to cluster many chicken populations and strains (Reddish & Lilburn, 2004; Rosario *et al.*, 2008). Other variables like feet, neck, legs, back, wings, breast and offal weights had 95% of discriminating power and therefore might be reliable in morphometeric studies directed towards racial characterization. On the other hand, weights of tail and spleen had limited discriminating power in such studies. They showed rather better discriminating power (27%) in the comparisons of layer and indigenous population; Can2 (Table IV). In particular, the best variables that discriminate those two populations were Head (37%) and Gizzard (34%).

On the other hand, Fig. 3 explains this 93.6% of total variation, based on the mean classes of Can1 and Can2, in a clear discrimination of three chicken groups: indigenous, layer and broiler. Can1 had higher discriminant power than Can2, because Can1 axis showed higher distinction and dispersion of values between populations than Can2 axis. Consequently, if Can1 mainly weighs the average live weight and carcass weight (Table IV), then we were able to infer that these traits allowed for a clear distinction between populations. In turn, the classification of populations was possible through Can2, which weighed between average weight of head and average weight of Gizzard as mentioned earlier (Table IV). The Canonical discriminant analysis allowed an understanding of the chicken population performance taking into account the total (co) variation between traits. In a comparison with previous studies of discriminant analysis in chicken populations (Pires *et al.*, 2002; Carneiro *et al.*, 2002; Barbosa *et al.*, 2005; Rosario *et al.*, 2008), present study was considering indigenous population along with both broiler and layer populations rather than strains of one population.

The dendrograms obtained in this study showed the degree of relationship and similarity among indigenous chicken population in Jordan and with the other studied populations (Fig. 1 & 2). The two large clusters, one formed by the indigenous and layer populations and the other by broiler population, may assign each population to two systems or productive merit; egg producers and meat producers. The indigenous and layers populations in one cluster are especially egg producers in scavenging and intensive systems, respectively. On the other hand, broiler population has meat merit and assigned to the other cluster. Nevertheless, it is important to consider that the performance traits of broiler and layer have been subjected for along time of a commercially artificial selection. Inclusion of the indigenous population in the present study showed that its productive ability lies clearly in egg production it was linked more closely to layer population. The indigenous chickens also have been subjected to natural selection towards better adaptability and egg production and the fact that there existed genetic migration from exotic egg producer populations; Commercial layers and Pakistani populations (Abdelqader & Wolleny, 2004; Al-Atiyat, 2006). The formation of two large groups seen in Fig. 2 could correspond to correlations that exist between the different performance traits. The distribution of the populations in the dendrogram showed the influence of two possible factors, on the one hand different productive ability and on the other hand different population origins. Therefore it can be assumed that the differentiation was especially influenced by the body weight, which matches that of the broiler population. Therefore, in agreement with Tunon *et al.* (1989), classification of populations should take into account not only the genetic aspect, but also the ecological, morphological and productive aspects. As a consequence it would be better to leave the door open whether the Jordan indigenous chickens are egg producers population or dual purpose-breed as reported by Abdelqader and Wolleny (2004). The productivity type of the Jordan indigenous population needs further morphology and genetic studies. Finally, this study demonstrates the viability of canonical discriminant analysis to evaluate chicken performance, discriminating and classifying populations and strains with the highest productive potential. Thus, researchers in the animal science are encouraged to analyze chicken performance data using the canonical discriminant analysis.

CONCLUSION

Jordan indigenous, commercial Layer and Broiler chickens were characterized as distinct populations in Jordan. Significant performance variations among the three populations were detected, where broiler population presented the highest multivariate performance mean. Average live body weight and carcass weight were the most important traits to discriminate among the populations. The high diversity in indigenous chicken performances was a major evidence for genetic discrimination from the other populations. The indigenous chickens were found to be closer to layer populations. There is rather a need for more study to be considered as dual-purpose breed (meat & egg) or egg producing breed. Further research should investigate the on-farm performance of each breed. Genetic characterization based on molecular assessment should be run to evaluate genetic diversity between and within indigenous chicken ecotypes.

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