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Morpho-Biometric Characterization of the North African (Tunisian) Local Chicken Populations

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NEF, MA and JB designed the study and wrote the manuscript. NEF, MA, BS, MBL, SD and BJ performed the field work. NEF, MA and BJ analyzed the data.

Key words
Tunisia, Indigenous chickens, Morpho-biometric, Phenotypic, Sustainability

ABSTRACT

The present study aimed to determine the socio-economic and morpho-biometric characteristics of the local population of chickens in North Africa. A total of 250 chickens were sampled in three regions of the country of Tunisia. A complete description by direct observation, individual weighing, and body parts measurements were determined. The results of the study showed a significant diversity of plumage colors in the studied populations. Birds of the dominant yellow color represent the average proportion of 20 %. Birds with black, gray, and white plumage represent a low proportion (18%, 12%, and 12%, respectively). A great phenotypic diversity was noticed and the ascending hierarchical classification showed the existence of two different groups with differential body weight, body length, back length, comb length and width, ear lobe length and width, wing length, wattle length, neck length, thigh and breast length, shank length and diameter, and central toe length. This phenotypic and descriptive richness can be considered a starting point for categorizing local indigenous Tunisian chickens. Genetic, anatomic, and physiologic large-scale studies are warranted to establish a comprehensive database and improve the conservation and sustainable production of these indigenous chickens.

INTRODUCTION

Although the poultry industry supports the subsistence and food security of billions of people worldwide, it is facing several challenges at a global scale from a steep projected increase in international demand for high-quality animal proteins (meat and eggs) and the need to adapt to climate changes and limited natural resources (water, land, and energy) (Espino *et al*., 2022).

Over the last many years, there is growing public concern about the welfare of farm animals raised under intensive housing systems leading to an inclination towards natural and indigenous poultry products (Mlambo *et al*., 2022). Rural poultry production is an important sub-sector with better climate-resilient and disease-resistance chickens compared to imported modern commercial strains (Giller *et al*., 2022). Although their growth performances are limited, indigenous chickens can be additional sources of meat and eggs, revenue stream, and employment (Wilson *et al*., 2022).

In Tunisia, Indigenous chickens were introduced by the Phoenicians and the Carthaginians (Tixier-boichard, 2006). They are mainly distributed in rural regions such as the northwest, center, and south (Raach-Moujahed, 2011). They are categorized according to their geographical locations (race or population cradles) or phenotypes, with no information on the structure of their population. Although chickens constituted the predominant livestock production in Tunisia with nearly 88 million slaughtered heads in 2020 (Statista, 2020), the exact indigenous chicken population is currently not known and it is estimated to be approximately 12% of all Tunisian poultry production

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(Onagri, 2022). Additionally, the Indigenous Tunisian chickens are phenotypically heterogeneous, with plumage color multiplicity, and body conformation diversity. For instance, among other parameters, various types of crest (normal, dwarf, etc.) and peaks (simple, double, rosacea, etc.) were noticed, indicating a great degree of diversity that could be used as basis for a conservation genetic programs. It is, therefore, critical to characterize these local populations for subsequent development of conservation program and genetic improvement programs. In this context, the present study aims, as a first step, to characterize Tunisian local chicken populations on morpho-biometric levels.

MATERIALS AND METHODS

In the North West of Tunisia (Fig. 1), three regions (Kef, Jendouba, and Siliana) were visited to make samples as representatives as possible. Selected local farmers were interviewed with a questionnaire focusing on the socio-economic status of the breeders, the history and management of farms, and the productivity and destination of local poultry. Accordingly, 250 animals were sampled. Each animal has been the subject of a phenotypic, direct description, and the qualitative data described related to the characteristics of the plumage, the comb, the shank, and the skin. A morpho-biometric characterization was carried out, including the body weight, body length, back length, tail length, breast length, comb length, comb width, wattle length, beak length, ear lobe length, ear lobe width, neck length, Wing length, thigh length, shank length, and central toe length according to FAO Animal Production and Health Guidelines (FAO, 2013).

All morpho-biometric data, principal component analysis (PCA), and hierarchical ascending classification (HAC) were developed to classify the Tunisian local poultry groups using XLSTAT software (Data Analysis and Statistical Solution for Microsoft Excel, Add in soft Inc., Paris, France 2017). Fisher exact tests were used to compare groups and a significant difference was set at $P < 0.05$.

RESULTS AND DISCUSSION

Socioeconomic status of the farmers

As depicted in Figure 2, the small-scale farmers (68.5% women and 31.5% men) interviewed were supposed to be the main managers of the farms. 47.9% of them were younger, and 52.1% were older than 50 years. With regards to education levels, 87.7% are illiterate and are generally old women over 60 years old, while 8.2% have received primary education. Generally, the above mentioned farmers have not received any agricultural or technical supervision, everything is either learned by experience or inherited from their parents and ancestors.

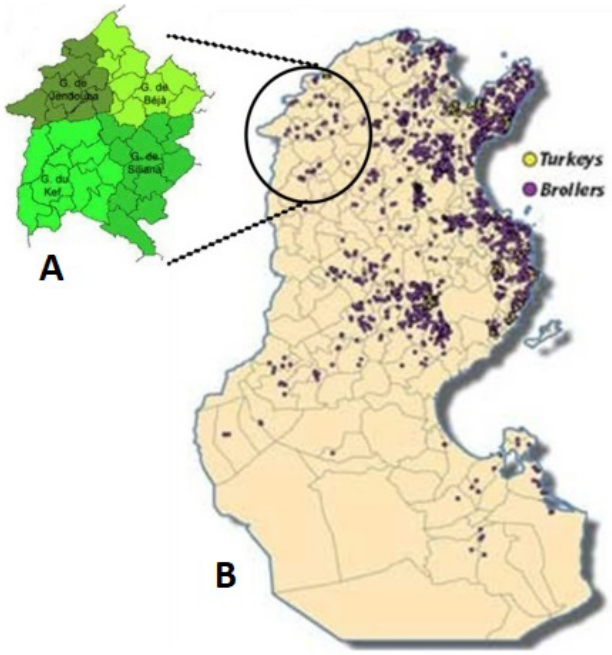

Fig. 1. Localization of study (A) and distribution of poultry (broilers and turkey) production in Tunisia (B).

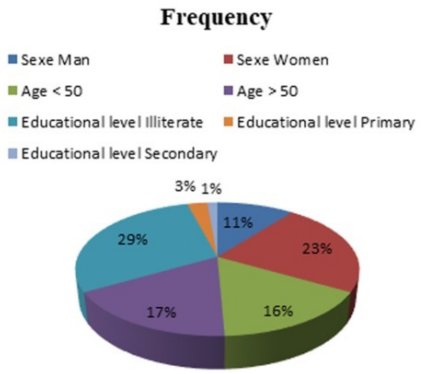

Fig. 2. Socio-economic status of small-scale farmers.

Local poultry management

In the present study, the Indigenous birds were mainly left to forage during the day and confined at night. After hatching, the chicks were allowed free access to forage (free range) with their mothers in open areas close to the house and surroundings. It is clear from the results that 87% of the chickens are managed under a traditional management system. 90% of farmers provided once a day supplementary feed to their chickens, including corn,

barley, wheat, and/or household waste. The age of onset of laying is estimated at 7 months. The data shows that the average body weight of local hens in three regions is around 1720 g (±251g).

Morpho-biometric characterization

The results revealed that for the entire tested local hens, the plumage morphology was normal, the beak is curved and the comb is simple. The wattle and comb are red and the eyes are orange. The shank of all individuals lacks cuffs or vulture boots. Overall, 5 different phenotypes were distinguished: red, yellow, black, gray, and white (Fig. 3A). The distribution of these different groups showed that the dominant phenotype was the red plumage (38%). Birds of dominant yellow color, however, represent 20%, followed by black (18%), gray and white (12% each). There is an important interindividual variation that decreases the phenotypic group effect. Derouich (2003) found that 79.96% of the local hens in the Tunisian center-east region are characterized mainly by a normal distribution of feathers (Derouich, 2013). The wide variety of plumage colors observed in this study can be explained by multiple uncontrolled crossings over several decades between different phenotypes, which gives rise to other combinations existing in low proportions (Akouango, 2004).

Three main colors of the skin were observed, including white (84%), pink (6%), and yellow (8%). This confirms those reported in literature (Ouédraogo, 2018). The colors found on the shank are white (24%); green (30%); yellow (36%) and gray (10%) (Fig. 3B and C). Indeed, white shank corresponds to the absence of pigments in the dermis and the epidermis. Yellow shank coloration occurs with the deposition of food xanthophyll pigments in the epidermis (Dana *et al*., 2010; Eriksson *et al*., 2008). The presence of the mutation making the shank yellow is a partial consequence of the introduction of commercial strains of high production performance within West African populations (Guisso *et al*., 2022). Green coloration results, respectively, from the superpositions of a yellow and white epidermis onto a black dermis (Andersson *et al*., 2020).

The simple crest is very strongly represented with 86%, followed by the double form which represents 14%. The coloration of these ridges is essentially red 92%, but also pink 8%. The simple, red crest is the most present (Fig. 3D and E).

The high phenotypic variability observed in the local hens should be placed in the dynamic perspective of the gradual introduction of hens of industrial strains into village farms, where matings with the local strain take place either in an uncontrolled manner or to rapidly improve the growth performance of animals.

This color variation could have a certain advantage for breeders because, without means of labeling, the breeders use certain traits, such as feather color and structures to distinguish individuals.

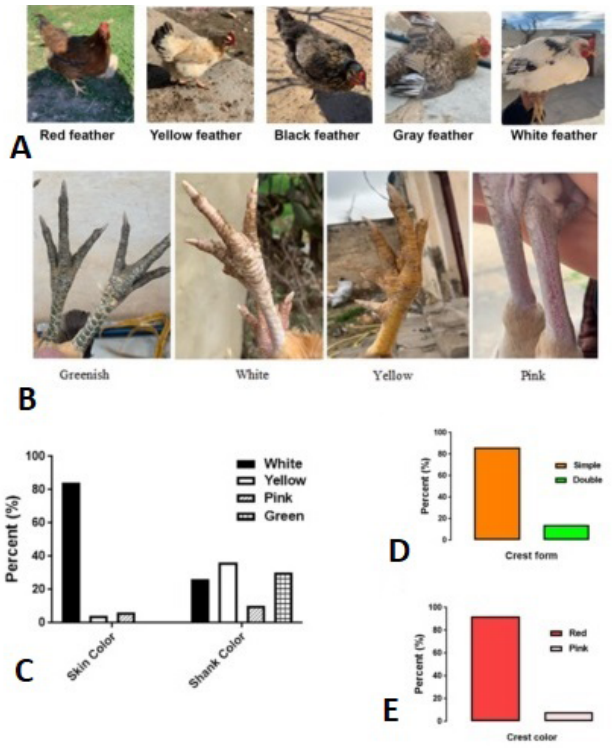

Fig. 3. Morpho-biometric characterization of Tunisian local chickens. (A) feather color, (B, C) shank color, and (D, E) crest form and color.

Quantitative measurements

The statistical processing of quantitative measurements shows that the average body weight (BW) of local hens in the three regions is 1,713±258g. The minimum recorded weight is 1,195 g, while the largest was 2,440 g (Table I). Regarding the body characteristics, the average body length (LC) is 47.8 ± 4.19 cm, back length (LD=15.3 ± 1.65 cm), tail length (LQ= 15 ± 2.35 cm), breast length (LP=13.4 ± 2.25 cm), while the average value of the breast girth (TP=32.2 ± 2.25 cm). Statistical analysis shows that at head level; comb length (Loc=4.5 ± 1.14 cm), comb width (LW=1.9 ± 0.89 cm), wattle length (LB=2.3 ± 0.56 cm), break length (LM=2.6 ± 0.41 cm), ear lobe length (LO=2.2 ± 0.44 cm), ear lobe width (LY=1.6 ± 0.36 cm). About the leg thigh length (LS=12.1 ± 1.45 cm), shank length (LT=7.5 ± 1.16 cm), shank diameter (DT=4.7 ± 0.86 cm), and Central toe length (LR=6.2 ± 0.78 cm) (Table I).

Table I. Characteristics of local hen classes identified.

Variable	Observations	Range	Mean±SD
PC (kg)	250	1.195-2.44	1.71±0.26
LC (cm)	250	37.00-57.00	47.88±4.19
LD (cm)	250	11.00-19.00	15.32±1.65
LQ (cm)	250	10.00-21.00	15.02±2.35
LP (cm)	250	9.50-20.00	13.49±2.25
TP (cm)	250	25.00-39.00	32.26±3.23
LoC (cm)	250	2.50-8.00	4.56±1.14
LW (cm)	250	0.25-4.00	1.96±0.89
LB (cm)	250	1.00-3.50	2.35±0.56
LM (cm)	250	2.00-3.50	2.61±0.42
LO (cm)	250	1.50-3.50	2.24±0.44
LY (cm)	250	1.00-2.50	1.65±0.36
LU (cm)	250	6.00-14.00	10.30±1.70
LA (cm)	250	46.00-78.00	66.46±6.39
LS (cm)	250	9.00-15.00	12.19±1.54
LT (cm)	250	4.00-12.00	7.50±1.16
DT (cm)	250	3.50-7.50	4.77±0.87
LR (cm)	250	4.00-8.00	6.28±0.79

PC, Body weight; LC, Body length; LD, Back length; LQ, Tail length; LP, breast length; TP, Breast girth; Loc, comb length; LW, comb width; LB, wattle length; LM, break length; LO, ear lobe length; LY, ear lobe width; LU, neck length; LA, Wing length wingspan; LS, Thigh length; LT, Shank length; DT, Shank diameter; LR, Central toe length.

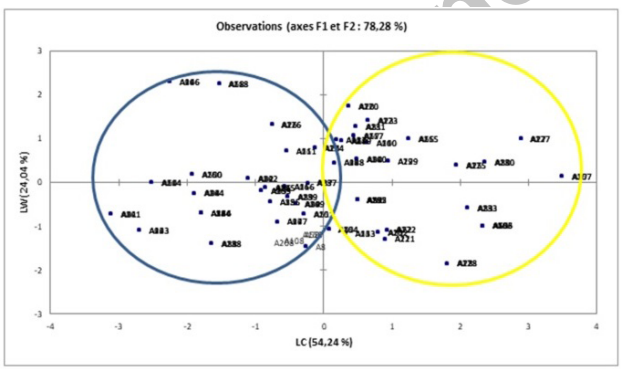

Fig. 4. Principal component analysis (PCA) showing distinct two Tunisian local chicken groups.

In an attempt to better understand the common origins of local hens reared in the visited regions, PCA was performed on the same quantitative variables. The Projection of the variables on the first two axes (LC and LW) of the PCA represents nearly 78.28 % of the total variability (Fig. 4). The special distribution of observation reveals the presence of two groups of Indigenous chickens, but the dissimilarity between them has not been determined. For this reason, a Hierarchical Ascending Classification (HAC) was established and confirmed the presence of two groups (Fig. 5, Table II).

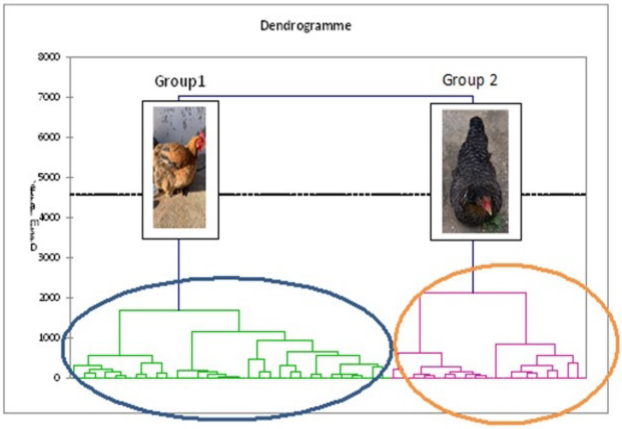

Fig. 5. Hierarchical ascending classification (HAC) of Tunisian local chickens.

Table II. Characteristics of local hen classes identified after CAH analysis.

Variable	Group 1 (61.6%)	Group 2 (38.4%)	Pr > F
PC (kg)	1.76±0.29	1.63±0.18	< 0.0001
LC (cm)	48.93±3.19	46.19±4.97	< 0.0001
LD (cm)	15.29±1.80	15.35±1.38	0.797
LQ (cm)	15.55±2.36	14.16±2.07	< 0.0001
LP (cm)	13.87±2.50	12.85±1.56	0.0004
TP (cm)	32.61±3.21	31.69±3.18	0.027
LoC (cm)	4.43±1.11	4.77±1.15	0.024
LW (cm)	1.97±0.97	1.96±0.75	0.926
LB (cm)	2.32±0.53	2.39±0.59	0.366
LM (cm)	2.63±0.42	2.58±0.40	0.341
LO (cm)	2.21±0.43	2.28±0.44	0.242
LY (cm)	1.63±0.36	1.68±0.38	0.355
LU (cm)	10.51±1.34	9.97±2.11	0.015
LA (cm)	67.37±5.04	65.00±7.85	0.004
LS (cm)	12.21±1.65	12.16±1.35	0.786
LT (cm)	7.33±1.27	7.78±0.87	0.003
DT (cm)	4.93±0.84	4.51±0.84	0.0001
LR (cm)	6.29±0.85	6.27±0.65	0.819

For abbreviation see, Table I.

The phylogenetic tree (Table II) obtained from the different morpho-biometric parameters illustrates the

relationships between two groups of local hens in the mountainous areas of northern Tunisia. This phylogenetic tree highlights the relationship between the two groups. The first group (n = 154) corresponds to large hens with the highest body weight 1,763 ± 286 g, body length 48.9 ± 3 cm, back length 15.2 ± 1.8 cm, tail length (15.5 ±2.3), breast length (13.8 ± 2.5 cm), breast girth (32.6 ± 3.2), comb length and comb width (4.4 ± 1.1 cm and 1.9 ± 0.9 cm), Wattle length (2.3 ± 0.5 cm), beak length (2.6 ± 0.4 cm), ear lobe length and ear lobe, ear lobe width (2.2 ± 0.4 cm and 1.6 ± 0.3 cm), neck length (10.5 ± 1.3 cm), Wing length wingspan (67.3 ± 5 cm), tight length (12.2 ±1.6 cm), length and diameter of the shank (7.3 ± 1.2 cm and 4.9 ± 0.8 cm) and central toe length (6.2 ±0.8 cm).

The hens of group two (n=96) are a small group having a body weight of 1,633 ± 176 g body length of 46.1 ± 4 cm, the back length of 15.3 ± 1.3 cm, tail length (14.1 ±2), breast length (12.8 ± 1.5 cm), breast girth (31.6 ± 3.8), comb length and comb width (4.7 ± 1.1 cm and 2.3 ± 0.5 cm), wattle length (2.3 ± 0.5 cm), beak length (2.5 ± 0.4 cm), ear lobe length and ear lobe, ear lobe width (2.2 ± 0.4 cm and 1.6 ± 0.3 cm), neck length (9.9 ± 2.1 cm), Wing length wingspan (65 ± 7.8 cm), tight length (12.1 ±1.3 cm), length and diameter of the shank (7.7 ± 0.8 cm and 4.5 ± 0.8 cm) and central toe length (6.2 ±0.6 cm).

The results show that, except for the (LD, LW, LB, LM, LO, LY, LS, and LR), the other measurement's parameters are significantly different between the two chicken groups. All averages are higher in the first group, for this reason, group one is the most reared chickens in Tunisia and a genetic amelioration for this group is well recommended.

Body weight varied between phenotypes, with an average of 1,713±150 g. The hens with red plumage presented in group 1 have the highest weight with 1,784g, on the other hand, the hens with beige and black plumage presented in the second group are the lightest with 1,700 g and 1,648 g, respectively. The 18 weeks old hens obtained in this study are heavier than those reported by Raach-Moujahed (2011) in Tunisia (1,620g), or even in some African countries such as Cameroon (Keambou *et al*., 2007) or Chad (Hasaballah *et al*., 2015). On the other hand, they are close to native breeds in South Africa or Tanzania, where the values indicated varied from 1,621 to 2,915g. Moula *et al*. (2009b) indicated on their part that the average weight of the Kabyle hen (Thayazit lekvayel) is 1,820 g. However, Tixier-Boichard *et al*. (2006) has reported heavier weights of French and American breeds respectively.

CONCLUSION

Taken together, the present descriptive study found that Tunisia indigenous chickens have large morpho-biometric variabilities. Discriminant factor analysis and ascending hierarchical classification highlight 2 different types of groups according to quantitative measurements. Genetic characterization would therefore be a very important next step to support such a classification. Studies on a larger scale, and different Tunisian regions as well as molecular genetic analyses, are however necessary to have a more complete database on the local hens in the country.

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IRB approval

Research activities were approved by the ESA Kef Doctoral Committee (2019).

Ethical statement

This study was approved by the Ethics Committee of ESAM, Tunisa (Approval No: 04-2021).

Statement of conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Akouango, F., Mouangou, F. and Ganongo, G., 2004. Phénotype et performances d'élevage chez des populations locales de volailles du genre *Gallus gallus* au Congo Brazzaville. *Cahiers Agric.,* **13**: 257–262. https://revues.cirad.fr/index.php/cahiers-agricultures/article/view/30444

Andersson, L., Bed'hom, B., Chuong, C.M. and Tixier-Boichard, M., 2020. In avancees en génétique et génomique avicoles. The genetic basis for pigmentation phenotypes in poultry. In: *Advances in poultry genetics and genomics: 1ère éd*. pp. 40.

Dana, N., Dessie, T., van der Waaij, L.H. and van Arendonk, J.A.M., 2010. Morphological features of indigenous chicken populations of Ethiopia. *Anim. Genet. Resour.*, **46**: 11–23. https://doi.org/10.1017/S2078633610000652

Derouich, S., 2013. *Ressources zoogénétiques: Etude des systèmes d'élevages et caractérisation*

morphologique de la population des poules autochtones dans le Centre-Est de la Tunisie-Mémoire de Mastère en Agriculture Durable. Institut Supérieur Agronomique de Chott Mariem. Université de Sousse-Tunisie

Eriksson, J., Larson, G., Gunnarsson, U., Bed'hom, B., Tixier-Boichard, M., Strömstedt, L., Wright, D., Jungerius, A., Vereijken, A. and Randi, E., 2008. Identification of the *yellow skin* gene reveals a hybrid origin of the domestic chicken. *PLoS Genet*., **4**: e1000010. https://doi.org/10.1371/journal.pgen.1000010

Espino, M.E., Gacelos, A.J. and Cabauatan, R., 2022. An analysis on the production of livestock and its impact on food security. *Int. J. Soc. Manag. Stud*., **3**: 71-91.

FAO, 2013. *Caractérisation phénotypique des ressources génétiques animales*. Directives FAO surla production et la santé animales No. 11. Rome. https://www.fao.org/publications/card/fr/c/I2686F/

Giller, K.E., Andersson, J., Delaune, T., Silva, J.V., Descheemaeker, K., van de Ven, G., Schut, A.G.T., van Wijk, M., Hammond, J., Hochman, Z., Taulya, G., Chikowo, R., Narayanan, S., Kishore, A., Bresciani, F., Mancini, T.H. and van Ittersum, M., 2022. The future of farming: Who will produce our food? *IFAD Res. Ser. 83. Rome: IFAD*. https://doi.org/10.1007/s12571-021-01184-6

Guisso-Taffa, A., Moula, N., Issa, S., Mahamadou, C. and Detilleux, J., 2022. Phenotypic characterization of local chickens in west Africa: systematic review. *Poultry*, **1**: 207-219. https://doi.org/10.3390/poultry1040018

Hassaballah, K., Zeuh, V., Mopate, L. and Yet-Sembene, M., 2015. Caractérisation morpho-biométrique de poule (*Gallus gallus*) locales dans trois zones agro-écologiques du Tchad. *Livest. Res. Rural Dev*., **27**: Article No. 53.

Keambou, T.C., Manjeli, Y., Tchoumboue, J., Teguia, A. and Iroume, R.N., 2007. Caractérisation morphobiométrique des ressources génétiques de poules locales des hautes terres de l'ouest Cameroun. *Livest. Res. Rural Dev*., **19**: 1-12.

Mlambo, V., Mnisi, C.M., Matshogo, T.B. and Mhlongo, G., 2022. Prospects of dietary seaweeds and their bioactive compounds in sustainable poultry production systems: A symphony of good things? *Front. Anim. Sci*., **3**: 998042. https://doi.org/10.3389/fanim.2022.998042

Moula, N., Antoine-Moussiaux, N., Farnir, F., Detilleux, J. and Leroy, P., 2009b. Réhabilitation socioéconomique d'une poule locale en voie d'extinction : la poule Kabyle (*Thayazit lekvayel*). *Annls Méd. Vét*., **153**: 178-186. http://www.facmv.ulg.ac.be/amv/articles/2009_153_3_05.pdf

Observatoire National de l'Agriculture Intranet, ONAGRI, 2022. *Flash sur la filiere avicole janvier 2022*. www.onagri.nat.tn/uploads/avicole/Flash_avicole_janv-2022.pdf

Ouédraogo, W.R., 2018. *Caractérisation socioéconomique, phénotypique et zootechnique de la poule locale du Burkina Faso*. Mémoire de fin de cycle d'ingénieur, Institut Polytechnique Rural de Formation et de Recherche Appliquée (IPR / IFRA) de Katibougou, pp. 57.

Raach-Moujahed, A., 2011. Local poultry populations in Tunisia: Present and alternatives. A review. *Livest. Res. Rural Dev*., **23**: 4. https://www.lrrd.org/lrrd23/4/raac23096.htm

Satista, 2022. *Livestock production in Tunisia in 2020 by species.* https://www.statista.com/statistics/1289512/stock-of-live-animals-in-tunisia-by-species/

Tixier-Boichard, M., Audiot, A., Bernigaud, R., Rognon, X., Bethouly, Magdelaine, P., Coqueletuerelle, G., Grinaud, R., Boulay, M., Ramanantseheno, D., Amigues, F., Legros, H., Guintar, C., Lossouarn, J. and Verrier, E., 2006. Valorisation des races anciennes de poulets: Facteurs sociaux, technico-économiques, génétiques et règlementaires. *Les Actes du BRG*, **6**: 495-520.

Wilson, W.C., Slingerland, M., Oosting, S., Baijukya, F.P., Smits, A.J. and Giller, K.E., 2022. The diversity of smallholder chicken farming in the Southern Highlands of Tanzania reveals a range of underlying production constraints. *Poult. Sci*., **101**: 102062. https://doi.org/10.1016/j.psj.2022.102062