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RURAL CHICKEN FLOCKS IN THE NORTHWEST OF ALGERIA: THEIR HUSBANDRY, PERFORMANCE INDICES, AND MARKETING

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ABSTRACT

The present study was undertaken to contribute towards a better understanding of the production systems, productivity, and trait preferences of local chicken farmers in Algeria. Data were collected from a total of 160 randomly selected smallholder poultry farmers in 3 provinces of the northwest of Algeria. The free-range system of production was predominant and mainly managed by women (61.3%). For 91.9% of the smallholders, selling live birds was the main purpose for keeping chickens whereas eggs were used for both home consumption and income (56.2%). Flock capacity averaged 16.9 birds with an overall hen: cock ratio of 6.5:1. An average number of clutches per hen per year and the average number of eggs per clutch were 4.87 and 12.75, respectively. The mean annual egg production per hen was estimated at 45 eggs per year. Egg hatchability was 79.36% while the chick survivability rate was 61.5%. Predation (55%), diseases (19.4%), and cold temperature (16.2%) were the major causes of chick mortality. The average price of adult indigenous cocks and hens was about 7 USD/bird and 5.5 USD/bird, respectively, while the average selling egg price was about 0.14 USD/egg. Rural chickens and egg marketing appeared to be a profitable business, especially for middlemen. Therefore, more attention should be paid to promoting small-scale chicken production and marketing through involving women in various projects aimed at safeguarding and improving local chicken breeds through selection and cross-breeding.

Keywords: commercialization, consumer's preference, management system, native birds, productivity.
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INTRODUCTION

In Africa, nearly 80% of the estimated 1.3 billion chickens comprise indigenous breeds reared by village farmers extensively (Guèye 1998 as cited in Dana *et al.,* 2010). Although free-ranging local chicken is generally characterized by poor productivity compared to exotic chicken (Mafeni *et al.,* 2005; Dana *et al.,* 2011), they still make a significant contribution to poultry meat and egg production and consumption and might improve the rural economy in many developing and underdeveloped countries (Vali, 2008; Besbes, 2009). The native breed chickens are the reservoir of genomes and major genes for improvement of high-yielding exotic germplasm for tropical adaptability and disease resistance (Padhi, 2016). Indigenous breeds have better adaptability to the harsh climate, scarce feed resources, and a high level of disease tolerance compared to exotic breeds (Iqbal *et al.,* 2012; Gheisari *et al.,* 2016; Nhara *et al.,* 2020). Products derived from rural chicken are of higher biological value (Millward *et al.,* 2008), specifically eggs of the local chicken which have a higher consumption rate due to their distinctive features (Yaman *et al.,* 2020).

In Africa, following the introduction of exotic strains from developed countries, the genetic erosion of the indigenous chicken population will be expected, thereby affecting the purity of the native breeds (Thakur *et al.,* 2009; Melesse, 2014). Researches on indigenous chicken breeds are therefore necessary for elucidating their conservation and their sustainable development strategies (Nguyen *et al.,*2020). In Algeria, poultry production has registered the most notable development in recent years (Mouffok *et al.,* 2019) and a great phenotypic and phaneroptic diversity of local poultry genetic resources has been found in the rural areas (Dahloum *et al.,* 2016; Dahloum, 2017).

There is, however, a lack of information about indigenous poultry production characteristics in Algerian rural areas. Therefore, this study aimed at analyzing the small-scale poultry production systems in the northwest of Algeria in terms of management practices, performance indices, and marketing. This will permit the suggestion of appropriate breeding strategies for a

sustainable increase in rural chicken productivity and profitability.

MATERIALS AND METHODS

Study area: The study was conducted in three provinces, Chlef, Mascara, and Mostaganem, located in the northwest of Algeria, between the Mediterranean Sea and Saharan Atlas chain (Fig. 1). The study area is well known for its agricultural potential and livestock production compared to other provinces of the zone. Different landscapes can be found in the area, due to the influence of several topographic factors (latitude, altitude, and distance from sea) on climate, and consequently on geomorphological and pedological processes (Dahloum *et al*., 2016). Chlef (plains zone), which is located at 36°09′54″ N, 1°20′04″ E, at an altitude of 116 m, has an area of 4851 km^2, and is characterized by a semi-arid climate. Mascara (mountainous zone), located at 35°55′52″ N, 0°08′24″E, at an altitude of 590 m, with an area of 5135 km^2, and is characterized by a semi-arid climate. Mostaganem (littoral zone), is located at 35°55′52″N, 0°05′21″E, with an altitude of 85m, has an area of 2269 km^2 large, and is characterized by a Mediterranean climate. The average yearly temperatures and total precipitation amounts are 17.9°C and 347 mm for Mostaganem, 16.7°C and 347 mm for Mascara, and 18.6°C and 394 mm for Chlef, but maximal temperatures are higher by 3.4°C to 4.1°C.

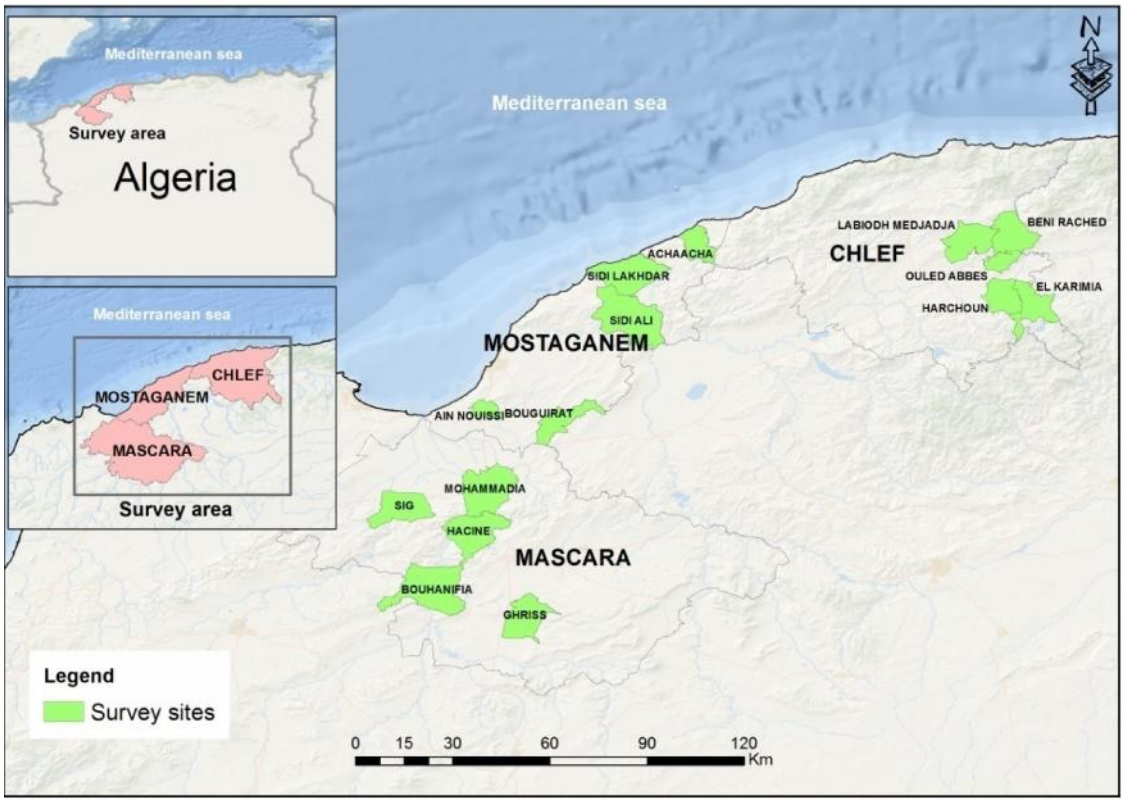

Figure 1. Map of survey sites in the northwest of Algeria.

Sampling of households and data collection: The sampling design involves four stages: Firstly, three provinces (Chlef, Mascara, and Mostaganem) were purposively selected based on their poultry production potential compared to other provinces of the zone. In the second stage of sampling, sixteen districts municipalities were purposively identified according to the following distribution: (1) El Karimia, Ouled Abbes, Harchoun, Beni Rached, and Medjadja from Chlef province, (2) Sig, Chorfa, Bouhanifia, Hassine, Ghriss, and Mohammadia from Mascara province, and (3) Sidi Ali, Sidi Lakhdar, Achacha, Bouguirat, and Ain Nouissy from Mostaganem province; In the third stage, three separate villages were purposively chosen within each district municipality based on the presence of poor and small scale farmer's who depend on chicken keeping for household's socioeconomic strength, and accessibility for transport services. Furthermore, villages in close proximity to large cities were avoided to keep at minimum the influence of urban-affiliated farming systems on a typical rural village based chicken management system (Desta *et al*., 2013 ; Dahloum *et al.*, 2016). In stage four, the respondents were randomly selected in each village from the list of the households where the indigenous chickens are kept in

the study areas. The list of households was established with local veterinarians and agriculture extension agents. The required sample size for this study was at least 150 chicken keepers. In order to take non-response into account, the target sample size was increased to 195 chicken smallholders, assuming a non-response rate of 30%. The sample size was estimated following the Yamane (1967) formula which is used when the population size is known.

$$n = \frac{N}{1+N(e)^2}$$

Where n is the sample size, N is the total population (in this study, *N*=554 chicken herders), and e is the confidence level (7%). However, during the field visits, some smallholder farmers refused to participate in the survey. Other farmers almost gave up raising local chickens (less than 3 chickens) and were therefore excluded from the study. Thus, the information provided in this study concerns only 160 smallholder farmers. This comprised 45 respondents from Chlef, 50 from Mascara, and 65 from Mostaganem. Data were collected using questionnaires and semi-structured based interviews. The information collected included some social characteristics of smallholder farmers, chicken flock structure, performance traits, health status, and breeding purpose. In order to evaluate chicken products' commercialization, 30 chicken owners selected from those who used eggs either for income only or for home consumption and income, and 30 traders/middlemen from 3 urban markets and 3 rural markets (5 traders/market/province) were asked on prices of village chickens' product. Furthermore, each traders at the market level was asked to rank traits/attributes and factors (previously identified) that influence consumer's choice and variation price of eggs and live rural birds, respectively from the most important (4) to the less important (1). Due to the small sample size of sellers, ranks from the three provinces were combined. The survey was undertaken between February and June 2019.

Statistical analysis: Pearson's chi-square ($\chi 2$) test with Bonferroni's adjustments was used to compare categorical variables between provinces. To estimate the strength of the association between categorical variables and locations, Phi and Cramer's V tests were used. Comparisons of mean ranks of traits that influence consumer's preference and those of factors influencing variation price of indigenous chicken products were performed using the Friedman test followed by Wilcoxon's pairwise post hoc test with Bonferroni correction. The level of statistical significance was set at $p \leq 0.05$. All statistical analysis was carried out using SPSS version 22.0 (SPSS Inc., Chicago, IL, USA).

RESULTS AND DISCUSSION

Socio-economic characteristics of farmers: The household characteristics of indigenous chicken producers are presented in Table 1. The survey results showed that the gender of the respondents and education level were highly different ($p<0.001$) among the studied provinces. In Mascara and Mostaganem provinces, women were highly involved (61.3%) in indigenous chicken management followed by men (29.7%). These findings are in agreement with previous studies (Fotsa *et al.,* 2007; Mahammi *et al.,* 2014; Letebrhan *et al.,* 2015; Nebiyu, 2016; Mugumaarhahama *et al.,* 2016; Mahoro *et al.,* 2017; Kejela, 2020) where the majority of the free-range chicken's owners were women. However, the reverse was found to be the case in Chlef province where men appeared to play the major role in indigenous chicken management responsibilities followed by women. This is in line with the previous report in Batna State (Alloui and Sellaoui, 2015). Despite regional differences observed in the current study with regard to the proportions of men and women involved in the family poultry production, it should be indicated that the day-to-day care and management of chickens are nearly always the task of women even if sometimes they have limited decision-making power on chicken production. A greater proportion of men producers compared to women producers was reported in other African countries such as Cameroun (Djitie *et al.,* 2015), the Democratic Republic of the Congo (Katunga *et al.,* 2020), and Niger (Moussa *et al*., 2018).

Farmers' age proportions observed in this study were not different ($p>0.05$) between the three provinces. Rural chicken farmers are usually adults aged 20-65 years. The farmers' age group of 40-55 years old was the most represented and accounted for 39.4% of the total respondents. In Sudano-sahelian zone of Cameroon, more than half (52%) of the indigenous chickens' keepers were in middle age (30-50 years) (Haoua *et al.,* 2015). Similarly, in western Kenya, the farmer's overall average age was 43 years (range 21 to 80) (Ochieng *et al.,* 2013). However, the current study showed that children had no participation in village chicken management, maybe because they are generally more involved in other livestock activities especially cattle and sheep rearing which require more care compared to rural birds. This result was different from observations made in many African countries (Yakubu, 2010; Yusuf *et al.,* 2014; Mahoro *et al.,* 2017) where children were actively involved in the chicken husbandry practices such as the provision of supplementary feed and water and chicken house cleaning. There was a difference ($p<0.001$) between the three study zones about the education level. Although there were some smallholder's farmers (1.9%) who had a university degree in Mascara and Chlef, the global education level in the study area was low as almost

half of smallholders (46.9%) has never gone to school and nearly 25% had attained only primary school level. The findings of the present study are similar to those obtained in Nigeria (Yakubu *et al.,* 2019), Cameroon (Djitie *et al.,* 2015; Haoua *et al.,* 2015), and Senegal (Nahimana *et al.,* 2016). However, the results are different from what was reported in Rwanda by Hirwa *et al.,* (2019) that 25% and 43% of farmers were of university level in Kigali city and the north zone, respectively. Additionally, in Bishoftu, Ethiopia, Ebsa *et al.* (2019) reported that 53.8% of poultry producers had tertiary education. Access to education could be important in improving farmers'decision-making skills and developing favorable mental attitude towards new technologies which may significantly enhance productivity and farmers' incomes.

Table 1. Some characteristics of the sampled households in Chlef, Mascara, and Mostaganem provinces.

Characteristics	Province				Pearson χ^2	p-value	Phi and Cramer's values
	Chlef	Mascara	Mostaganem	All			
	No. (%)	No. (%)	No. (%)	No. (%)			
Gender of the respondents[1]							
Males	33^{a} (53.2%)	6^{c} (9.7%)	23^{b} (37.1%)	62 (38.8%)			
Femals	12^{c} (12.2%)	44^{a} 44.9%)	42^{b} (42.9%)	98 (61.2%)	38.06	<0.001	0.48, 0.48***
Age (years)							
20-40	10 (27%)	12 (32.4%)	15 (40.5%)	37 (23.1%)			
40-55	16 (25.4%)	24 (38.1%)	23 (36.5%)	63 (39.4%)			
55-65	13 (33.3%)	10 (25.6%)	16 (41.0%)	39 (24.4%)			
65 and above	6 (28.6%)	4 (19.0%)	11 (52.4%)	21 (13.1%)	3.89	0.691	0.15, 0.11^{ns}
Education level[2]							
No school	21^{a} (28.0%)	22^{a} (29.3%)	32^{a} (42.7%)	75 (46.9%)			
Primary	8^{a} (21.6%)	12^{a} (32.4%)	17^{a} (45.9%)	37 (23.1%)			
Middle school	13^{a} (52%)	0^{b} (0%)	12^{a} (48.0%)	25 (15.6%)			
Secondary	1^{a} (5.0%)	15^{b} (75.0%)	4^{a} (6.2%)	20 (12.5%)			
University	2^{a} (66.7%)	1a (33.3%)	0^{a} (0.0%)	3 (1.9%)	35.16	<0.001	0.47, 0.33***
Experience in raising chickens (years)							
Below 10	8 (19.0%)	17 (40.5%)	17 (40.5%)	42 (26.2%)			
10-20	14 (23.7%)	21 (35.6%)	24 (40.7%)	59 (36.9%)			
Above 20	23 (39.0%)	12 (20.3%)	24 (40.7%)	59 (36.9%)	7.86	0.097	0.22, 0.16^{ns}

[1]Numbers in rows followed with different letters are significantly different at Bonferonni adjusted significance level p≤0.008
[2] Numbers in rows with different are significantly different at Bonferonni adjusted significance level p≤0.0033
*** Significance at p<0.001
^{ns} Not significant p>0.05

In this study, most of the smallholders interviewed (73%) have more than 10 years of experience in local chicken breeding and management which is in line with previous reports (Mekonnen, 2007; Shahjahan and Bhuiyan, 2016). In Kamuli plains in Uganda, Natukunda *et al.* (2011) stated that the level of profit obtained by the farm poultry producers was significantly influenced by both education level and experience in indigenous chicken rearing. However, in the current study, the number of years in raising indigenous chicken did not differ (p>0.05) between the three provinces.

Management practice and breeding purposes: The survey results revealed that supplemental income from the sale of live birds was the main objective of keeping chickens in all study areas (Table 2). The findings contradict those of Mugumaarhahama *et al.* (2016) where indigenous chickens were reared exclusively for household consumption. However, differences (p<0.05) were observed between provinces with regard to the primary purpose of egg production. In Mostaganem and Chlef, eggs were primordially produced for both income and home consumption while in Mascara, eggs were mainly used for household consumption. Higher house consumption of chicken and eggs, according to Kejela (2020), is expected to have a positive effect on the health of the members of the family specifically children and nursing mothers. In this survey, only 18% of the smallholders interviewed provided appropriate housing to their birds but the majority of them (85.7%) said that they cleaned their chicken house twice weekly. All the farmers surveyed provided water to birds but only 40.6% of them offered some additional feed at least once a day. Birds mostly acquired their feed by scavenging which cannot provide enough nutrition for growth and egg production (Henry, 2019). The results of the current study confirmed those reported previously (Dahloum *et al.,* 2016). However, the present findings are in contrast with those reported in Ethiopia (Meseret, 2010; Ebsa *et al.,* 2019) and Uganda (Natukunda *et al.,* 2011) where more than 90% of farmers provided supplementary feeding to their birds and most of them utilized commercial ration. According to smallholders, supplementary feed included

mainly household waste products, couscous, bread, and minimal amounts of cereal grains (wheat and crushed barley) and commercial concentrate feed. In recent years, progress in the role of insects as an alternative source of protein source in poultry feed has been reported (Khan, 2018; Zegeye, 2020). Sankara *et al.* (2018) mentioned that 78% of the farmers from Burkina Faso used termites to feed their poultry.

Chicken flock size and composition: As shown in Table 3, there was a very high difference ($p<0.001$) in terms of flock size and flock composition among the three study zones. The average flock size, the average number of hens and an average number of growers of various ages were highest ($p<0.001$) in Chlef and Mostaganem. Regarding the mean number of cocks, Mostaganem recorded a higher mean value ($p<0.001$) followed by Chlef and Mascara. The average overall mean of flock size in the current study was 16.9 (ranging from 4 to 60). A similar result was reported in North Gondar Zone, Ethiopia by Getu and Birhan (2014) with a mean flock size per household of 16.1. However, the average flock size obtained in this study is higher compared to 5.6, 11.8, and 13.9 reported in Bangladesh (Shahjahan and Bhuiyan, 2016), Rwanda (Mahoro *et al.,*2017), and Nigeria (Yakubu, 2010), respectively, but lower than the 17.5 and 24.3 recorded in Ghana at coastal savannah and rain forest zones, respectively (Hagan *et al.,* 2013). The flock structure consisted of 71.2% adult hens, 9.7% adult cocks, and 19% of growers of various ages. Cocks' proportion was the lowest mainly because cocks and cockerels are more sold in the market for their tastier meat than females which are often left for production. According to Yakubu (2010), the proportion of adult hens in the flocks is used to estimate flock productivity. The overall hen: cock ratio of 6.5:1 obtained in the current study is higher than the 3.4:1 and 3.9:1 reported in Nasarawa State, Nigeria (Yakubu, 2010) and Sheka zone, Ethiopia (Assefa *et al.,*2019), respectively. There was a difference ($p<0.001$) in sex ratio across the three locations of the current study. It was higher in Chlef (9.2 :1) and lower in Mostaganem (5.5:1). It would therefore be necessary to determine the optimal hen: cock ratio to achieve the best reproductive performance specifically fertility and hatchability.

Table 2. Breeding purposes and some management practices of local chickens according to the province.

	Province				Pearson χ^2	p-value	Phi and Cramer's values
	Chlef	Mascara	Mostaganem	All			
	No. (%)	No. (%)	No. (%)	No. (%)			
a. Breeding objectives[1]							
Birds							
Home consumption Only	2 (25%)	1 (12.5%)	5 (62.5%)	8 (5.0%)			
Income only	43 (29.3%)	49 (33.3%)	54 (37.4%)	147 (91.9%)			
Income and home consumption	0 (0.0%)	0 (0.0%)	5 (100%)	5 (3.1%)	11.45	0.075	0.268, 0.189^{ns}
Eggs							
Home consumption Only	13^{a} (21.3%)	29^{b} (47.5%)	19^{a} (31.1%)	61 (38.1%)			
Income only	2^{a} (31.1%)	1^{a} (11.1%)	6^{a} (66.7%)	9 (5.6%)			
Income and home consumption	30^{a} (47.5%)	20^{b} (22.2%)	40^{a} (44.4%)	90 (56.2%)	13.85	0.008	0.294, 0.208**
b. Supplementary feeding[2]							
Yes	16^{a} (24.6%)	15^{a} (23.1%)	34b (52.3%)	65 (40.6%)			
No	29^{a} (30.5%)	35^{b} (36.8%)	31a (32.6%)	95 (59.4%)	6.51	0.039	0.202, 0.202*
c. Chickens housing							
Adequate housing	10 (35,7%)	4 (14.3%)	14 (50%)	28 (18%)			
Poor housing	35 (26.5%)	46 (34.8%)	51(38.6%)	132 (82%)	4.55	0.103	0.169, 0.169^{ns}
d. Cleaning of chicken houses[3]							
Yes	34^{a} (24.6%)	50^{b} (36.2%)	54^{a} (39.1%)	138 (85.7%)			
No	11^{a} (50%)	0^{b} (0%)	11^{a} (50%)	22 (13.7%)	12.85	0.002	0.284, 0.284**

[1]Numbers in rows with different letters are different at Bonferonni adjusted significance level $p\leq0.0055$
[2] Numbers in rows with different letters are different at Bonferonni adjusted significance level $p\leq0.0083$
[3]Numbers in rows with different letters are different at Bonferonni adjusted significance level $p\leq0.0083$
* Significance at $p<0.05$; ** Significance at $p<0.01$, respectively
^{ns} Not significant $p>0.05$

Table 3. Local chicken flock composition in Chlef, Mascara, and Mostaganem provinces (Mean± SE).

Variables	Province			All	F value	p-value
	Chlef	Mascara	Mostaganem			
	n=45	n=50	n=65			
Flock size	20.2±1.55[a] (5-60)	10.2±0.78[b] (4-40)	19.7±1.37[a] (5-55)	16.9± 0.82 (4-60)	27.71	<0.001
Hens	13.6±0.94[a] (4-36)	7.34±0.40[b] (3-17)	12.1±0.88[a] (4-50)	11.0±0.5 (3-50)	26.05	<0.001
Cocks	1.4±0.13[b] (0-4)	1.04±0.09[b] (0-2)	1.9±0.17[a] (0-6)	1.47± 0.09 (0-6)	9.57	<0.001
Chicks and growers	4.9±0.85[a] (0-24)	1.8±0.83[b] (0-22)	5.76±0.87[a] (0-30)	4.3± 0.48 (0-30)	7.17	<0.001
Hen to cock ratio	9.2:1±16.6[a]	6.6:1±9.1[ab]	5.5:1±6.2[b]	6.57:1±8	6.83	<0.001

SE : standard error
Ranges in parentheses

Production and reproduction performance: The performance characteristics of free rural chickens in the three provinces studied are presented in Table 4. A large proportion of smallholder farmers (91.2%) stated that the age of indigenous pullets at first laying was between 6 and 7 months. The maturity of birds coincides with the age at first egg-laying (Kejela, 2020). There were differences ($p<0.001$) among provinces in terms of age at sexual maturity. This could be explained mainly by differences in feeding and health management practices (Alem, 2014). Overall, these findings indicate a late sexual maturity of indigenous chicken compared to the commercial lines. The reason for the low productive and reproductive performance of indigenous birds could be as a result of the non-availability of an organized and well-coordinated selection and breeding programmes to produce superior birds. This is congruous to the submission of Nguyen Van *et al.* (2020) where the low productivity of the indigenous chickens was attributed to the absence of an organized selection program, partly because of the small population size, and the difference in selection objectives between indigenous and specialized lines obtainable in commercial companies. The age at first egg observed in the current study is similar to the 6.31 ± 0.53 and 6.10 ± 0.30 months, respectively recorded both within and between locations in Ethiopia (Kejela, 2020). The results obtained from the current study are also comparable with other previous reports (Akouango *et al.,* 2010; Letebrhan *et al.,* 2015; Nahimana *et al.,* 2016).

The overall average clutches/hen/year obtained in this study was 3.52 (range 2 to 6). Similar values ranging from 3.11 to 3.97 were reported in other African countries (Getu and Birhan, 2014; Letebrhan *et al.,* 2015; Nahimana *et al.,* 2016). However, the results deviate from those of Yakubu *et al.* (2010) who reported a mean value of 4.87 clutches/hen/year. The average egg production per clutch of 12.75 (range 8 to 20 eggs) obtained in this study was lower than 18.7, 14.7, 13.5, and 13.0 eggs/clutch reported in Kenya (Kamau *et al.,* 2018), Democratic Republic of Congo (Katunga *et al.,* 2020), Bangladesh (Shahjahan and Bhuiyan, 2016) and Rwanda (Francis *et al.,* 2016), respectively. In the present study, the number of clutches per bird per year and clutch size did not differ ($p>0.05$) between the three locations. The mean annual egg production per hen was estimated at 45 eggs/year (range 28-80). A similar value was recorded by Guni *et al.* (2013). However, the result of the current study is higher than the mean value of 40.8 eggs/year reported by Assefa *et al.* (2019) but lower than 87 eggs/year recorded by Kouadio *et al.* (2013) in the semi-intensive system of production.

Moreover, the survey revealed that none of the interviewed farmers had any kind of egg incubator and only natural incubation and hatching by a broody hen are practiced in the study area. The results are consistent with earlier findings (Markos *et al.,* 2014; Milkias, 2018). On average, 73.4% hatchability was found in the study area. This finding is lower compared to reports by Nahimana *et al.* (2016), Guni *et al.* (2013), and Melesse *et al.* (2013) whose findings revealed 88.0%, 79.1%, and 79.4% on hatchability rate, respectively, but much higher than the 22% obtained in southwest Ethiopia (Meseret, 2010). There were differences ($p<0.05$) between the three provinces in terms of hatchability; it was higher in Mascara and Mostaganem and lower in Chlef. This could be explained by differences in care and treatments given to broody hens. According to Addo *et al.* (2018), improperly storing eggs can greatly reduce fertility, hatchability, and chick quality. Therefore, the introduction of artificial egg incubators at the farm level could enhance egg production and hatchability rate. Similarly, Kugonza *et al.* (2012) reported that the use of a box for incubating and brooding hens resulted in significantly higher egg hatchability, lower live weight loss of the hens, and higher chick survival rates.

A high chick's mortality rate of 39.5% (61.5% survived) was found in this study. Slightly the same results were obtained from different agro-ecological zones in Ethiopia (Melesse *et al.,* 2013; Chebo and Nigussie, 2016). The current study revealed that the major causes of chicks mortality were predators mainly dogs, cats, and rats (55%) followed by diseases (19.4%) and cold weather (16.2%) (Table 5). Other mortality causes were also signaled by less than 10% of the respondents including mainly feed unavailability, lack of housing, and drowning. However, it seems that cold weather causes more mortality in Mascara province although there were no differences ($p>0.05$) between locations in terms of major factors of bird death. Overall, these causes of chicken mortalities were the most common in Africa (Fosta, 2008; Selam and Kelay, 2013; Alem, 2014; Djitie *et al.,* 2015; Haoua *et al.,* 2015; Waktole *et al.,* 2018). The most common diseases that cause considerable losses in poultry production in Algeria according to several investigations (Alloui and Sellaoui, 2015; Berghiche *et al.,* 2018; Debbou-Iouknane *et al.,* 2018) are Colibacillosis, Mycoplasmosis, Salmonellosis, Newcastle (local name: Ettaoun), Gumburo, infectious bronchitis, and Coccidiosis. Other more frequent diseases such as the appearance of cysts in the eyelid of chickens (local name: Etellis) and that affecting the feather (local names: Eldjedri, Elkhabcha, Elgomila) have also been mentioned in a previous study (Halbouche *et al.,* 2009). However, apart from some medicinal herbs and vegetable extracts (wild onion, black pepper, and essential oils) incorporated in the supplementary feed, nearly all the smallholders questioned (99.4%) claimed that they had never used any kind of prophylactic drugs such as antibiotics or vaccination for the health management of their birds and mentioned they had never received vaccination from the veterinary service teams. This may partly explain the high mortality rate observed in the current study. Providing training for farmers to adopt better disease management practices and carry out periodic vaccination exercises could significantly reduce the damage caused by devastating diseases and thus increase productivity and family farm income. Therefore, there is a dire need for government and non-governmental interventions to embark on an enlightenment campaign and also make available cheap and easily assessed vaccines of high potency and efficacy for the use of the smallholder farmers. Farmers should also have good knowledge of such vaccines and be able to use them with minimal supervision. This will go a long way in boosting chicken production in the studied area. According to Lindah *et al.*(2019), knowledge is a veritable component of extension support that facilitated high levels of uptake of vaccines. On another hand, exploiting the genetic variability to assess and select genotypes associated with great disease resistance remains an interesting alternative. In this context, the study of Dakpogan *et al.* (2012) revealed that naked neck bird was the most tolerant phenotype to Coccidiosis followed by normal feathered, silky, and frizzle birds whereas the dwarf phenotype was the most sensitive. The current findings are in contrast with what was reported in Zimbabwe by Nhara *et al.*(2020) that the availability of vaccines and their acceptance by farmers was higher.

Table 4. Some production and reproduction performance of local chickens in Chlef, Mascara, and Mostaganem provinces.

Variables	Province				Pearson χ^2	p-value	Phi and Cramer' values
	Chlef	Mascara	Mostaganem	All			
	No. (%)	No. (%)	No. (%)	No. (%)			
Categorical variables							
Age at first egg, months[1]							
6-7	44^{a} (30.1%)	50^{a} (34.2%)	52^{b} (35.6%)	146 (91.2%)			
>7	1^{a} (7.1%)	0^{a} (0.0%)	13^{b} (92.9%)	14 (8.8%)	17.50	0.001	0.33, 0.33***
Contiious Variables	Mean±SE	Mean±SE	Mean±SE	Mean±SE	F value	*p* value	
Clutches/hen/year	3.42±0.09	3.64±0.07	3.49±0.11	3.52±0.05	1.19	0.305	
No. of eggs/ clutch	13.04±0.27	12.52±0.26	12.78±0.23	12.75±0.14	0.98	0.378	
Hatchability, %	69.42±1.63^{b}	75.31±1.54^{a}	74.66±1.37^{a}	73.40±0.87	4.16	0.017	
Mortality, %	40.78±1.93^{ab}	43.02±1.83^{a}	35.87±1.63^{b}	39.50±1.05	4.52	0.012	

[1]Numbers in rows with different letters are different at Bonferonni adjusted significance level $p\leq0.0083$

*** Significance at $p<0.001$

Mean values in rows with different superscripts are significantly different ($p<0.05$).

SE: standard error

Table 5. Major causes of local chicken mortality according to province.

Factor	Province				Pearson χ^2	p-value	Phi and Cramer' values
	Chlef	Mascara	Mostaganem	All			
	No. (%)	No. (%)	No. (%)	No. (%)			
Cold weather	6 (23.1%)	14 (53.8%)	6 (23.1%)	26 (16.2%)			
Diseases	9 (29.0%)	6 (19.4%)	16 (51.6%)	31 (19.4%)			
Predators	24 (27.3%)	26 (29.5%)	38 (43.2%)	88 (55.0%)			
Others	6 (40.0%)	4 (26.7%)	5 (33.3%)	10 (6.2%)	10.27	0.246	0.25, 0.18^{ns}

^{ns} Not significant

Status of commercialization of indigenous chickens: As presented in Table 6, the average selling price of the indigenous mature hen was 720 DZD (about USD 5.5) ranging from 400 to 1100 DZD (3-8 USD) and that of adult cock was 900 DZD (about USD 7) ranging from 500 to 1300 DZD (4-10 USD) while the average price of eggs from local hens was 18 DZD/egg (about USD 0.14) ranging from 10 to 30 DZD (from 0.08 to 0.23 USD). The survey showed that indigenous chicken's products were mainly sold in both urban and weekly rural markets (Friday souk), but also at home and on roadsides. Marketing of indigenous poultry products was often unregulated and unorganized in all provinces studied, thus, more attention is needed to improve the marketing system of rural birds mainly through investing in market infrastructures and ensuring optimal hygienic and sanitation conditions. The current findings are partially in agreement with the previous study by Mahammi *et al.* (2014). The prices of live village chicken are often 1.5 to 2 times higher than that of exotic chicken whatever the year. This may be due to the high demand for their tasty meat and intensive yellow-orange egg yolk. Moreover, most consumers consider that eggs from indigenous chicken are free of disease and drugs, compared to those from exotic and commercial hens (Queenan, 2016). The findings of the current study align with what was earlier reported in many African countries such as South Africa (Mtileni *et al.,* 2009), and Uganda (Emuron *et al.,* 2010) Rwanda (Hirwa *et al.,* 2019) where people were willing to pay an increased price for rural poultry products. Similarly, Bett *et al.* (2013) mentioned that Kenyan consumers are prepared to pay 23% per kg more for indigenous chicken meat and 41.5% for eggs. Moreover, the results of the current study showed that live rural birds and eggs sold by middlemen at the market cost nearly 60% and 74% higher than at the farm level, respectively. The current findings are in conformity with those reported in most developing countries (Abdelqader *et al.,* 2007; Owuor and Bebe, 2009; Emuron *et al.,* 2010; Mailu *et al.,* 2012; Bwalya and Kalinda, 2014; Queenan *et al.,* 2016). Middlemen, according to Mlozi *et al.* (2003) benefited more and earned 65% of the total profit generated in the local chicken market chain. Moreover, the average number of live indigenous birds and free-range eggs sold per middlemen were 44.4 mature hen/month (range 2-250), 100.4 cock/month (range 3-375), and 59.7 egg/day (range 40-100) while the average quantities sold per smallholders at household level were 1.66 mature hen/month (0-8), 2.43 cock/month (range 1-5) and 8.34 egg/day (range 4-45). These figures show that indigenous chicken marketing is a profitable business, especially for middlemen and traders. Further research is solicited to better analyze the marketing system for indigenous chickens and to propose an effective plan with the hope to increase the profitability of indigenous birds. Rural chicken owners according to Natukunda *et al.* (2011) have to understand the concept of profitability to take up commercial indigenous chicken rearing.

Table 6. Selling prices and average number of village chickens and eggs sold at farm gate and in the market (Mean±SE).

Variable	Directly from household	Trader or middlemen	T value	p-value
	n=30	n=30		
Sale price of unit egg, DZD	14.33±0.39 (10-20)	26.00±0.81 (15-30)	12.94	<0.001
Sale price of mature Hen, DZD	583.33±17.99 (400-700)	910.00±19.68 (700-1100)	12.25	<0.001
Sale price of cock, DZD	723.33±17.07 (500-900)	1151.00±22.29 (900-1300)	15.25	<0.001
No. of eggs sold/week	8.07±1.37 (4-45)	59.33±2.61 (40-100)	17.38	0.001
No. of mature hens sold /month	1.67±0.41 (0-8)	37.77±10.24 (2-250)	3.52	0.001
No. of cocks sold/month	2.43±0.18 (1-5)	104.81±19.13 (3-375)	3.52	0.001

Consumer's preferences towards indigenous chicken products: Based on the opinion of sellers, live body weight and sex of bird were identified as the main parameters that influence consumer's preference towards

village chicken followed by the health status of the bird whereas the age of the bird and phenotype ranked lower (Table 7). However, Bekuma *et al.* (2019) highlighted the influence of feather colour on consumers' preferences; white, red, and mixture of white and red plumage colours were more preferred by consumers in Dedo District (Ethiopia). For eggs, the sellers interviewed in the present study deemed the egg size and eggshell integrity to be the most important traits influencing consumer's choice. The present results are partially in line with what was reported in Kenya by Bett *et al.* (2013) and Ngeno (2017) were the most important attributes influencing consumer's choice and consumption were egg size and yolk colour. In addition, Ndenga *et al.* (2017) reported that Kenyan consumers preferred small and medium-sized eggs and were willing to pay premium prices for brown shelled, non-oval eggs. Other attributes including size, price, shell colour, and freshness of the eggs have been reported by Sodjinou *et al.* (2015). Knowledge of consumer's preference is therefore crucial and important not only for household farmers but also for merchants and especially public authorities in establishing efficient strategies that can be used to enhance rural smallholder poultry production and marketing.

Table 7. Seller's ranking free-range chickens' products traits/attributes influencing consumer's preference.

Parameter /Trait	Mean rank[1]
a. Live rural birds[2]	
Healthy birds	3.02[b]
Live weight	4.60[c]
Age	1.90[a]
Sex	3.92[c]
Phenotype	1.56[a]
Friedman test (chi-square)	133.8
Asymptotic significance	0.000
b. Free-range eggs[3]	
Egg size	3.56[b]
Eggshell colour	1.82[a]
Eggshell cleanliness	1.22[a]
Intact eggshell	3.40[b]
Friedman test (chi-square)	121.1
Asymptotic significance	0.000

[1]The highest weight= most important trait. The lowest weight= least important trait

[2]Means with different superscripts are different at the Bonferroni-adjusted significance level p≤0.015

[3]Means with different superscripts are different at the Bonferroni-adjusted significance level p≤0.00036

Table 8. Sellers' ranking of factors most influencing variation price of indigenous chicken products.

Parameter/ Trait	Mean rank[1]
a. Rural Birds[2]	
Live body weight	5.22[c]
Sex of bird	2.57[ab]
Age of bird	2.76[b]
Phenotype of bird	1.63[a]
Market price	4.58[c]
Special occasions	4.24[c]
Friedman test (chi-square)	136.9
Asymptotic significance	0.000
b. free-range eggs[3]	
Market price	3.52[b]
Productivity level	1.95[a]
Egg weight and shape	1.45[a]
Season	3.08[b]
Friedman test (chi-square)	85.0
Asymptotic significance	0.000

[1]The highest weight= most important trait. The lowest weight= least important trait

[2]Means with different superscripts are different at the Bonferroni-adjusted significance level p≤0.00016

[3]Means with different superscripts are different at the Bonferroni-adjusted significance level p≤0.000018

Price variation of indigenous chicken products: In this study, live body weight, prices of other meat types, and religious events (Mawlid Enabawi, Achoura) were ranked as the major parameters affecting the price of live rural chickens (Table 8). However, the age of the bird, sex, and phenotype were ranked lower. These findings are slightly different from those of Abdelqader *et al.* (2007) where the major price-determining factors were age, sex, and phenotype of the bird and season. Other factors such as live weight, plumage colour, and general body condition have been reported (Bett *et al.,* 2011; Yakubu *et al.,* 2020). Additionally, the rose comb has strong cultural significance in Ethiopia and increases the market price of chickens (Dana *et al.,* 2010; Bettridge *et al.,* 2018). On the other hand, Sodjinou *et al.* (2015) reported in order of importance breed of the bird, plumage colour, meatiness, and the age of the bird as the main factors which significantly influenced the price of local chicken in Benin. It should be noted that the weighing scale is never used by the sellers (producers, middlemen, and traders) in all study zones; the live weight of the bird is often estimated from its size and conformation and by handling the bird. This could influence directly the household farmers and indirectly the productivity of the birds. These findings are in agreement with a previous report (Gondwe *et al.,* 2005). Regarding free-range egg cost, it was mainly prone to price variation of eggs from commercial layers and season. All farmers interviewed in the study

area mentioned the seasonal variation of egg production which decreased in winter leading to higher egg prices. This is in consonance with the report of Abdelqader *et al.* (2007) that egg production and survival rate were higher during the summer season compared to winter. However, the findings contradict those of Bekuma *et al.* (2019) where the market price of eggs decreased during the rainy season.

Conclusion: The study revealed that the majority of scavenging village chickens owners in the studied three provinces of Algeria are women. In general, even if the flock size is relatively large in some rural families, the management conditions are rudimentary which explain partially the low production performance observed. The commercialization of rural birds is informal and highly underdeveloped, similar to other developing countries. The current study provides additional basic information which is essential to put in place an appropriate strategy for the conservation of poultry resources that are well adapted to various environmental challenges and to improve their relatively low level of production and reproduction which can lead to an increase in both household food security and incomes.

Conflict of interest statement: The authors certify that there is no conflict of interest in the manuscript.

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