Traditional poultry farming in Morocco: management practices and flock performance in Khemisset and Skhirate-Temara

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Summary

Background: Traditional poultry farming plays a vital role in rural Morocco. However, management systems are informal and there is limited data on the performance of local Beldi chickens. ***Aim***: This study aims to characterize backyard poultry farming practices and assess the zootechnical performance of Beldi chickens in two contrasting regions: Khemisset, where backyard poultry farming is widespread; and Skhirate-Temara, known for intensive commercial poultry production, which exists alongside the traditional sector. ***Methods***: A field survey was conducted from November 2020 to March 2022, involving 320 randomly selected households (179 in Khemisset and 141 in Skhirate-Temara). Data were collected from face-to-face interviews using a semi-structured questionnaire. Further data were gathered from on-farm observations and direct measurements of poultry. A total of 240 hens and 134 roosters were weighed using digital scales. In addition, 200 eggs were weighed and measured for length and width using a vernier caliper. Descriptive statistics and Chi-square tests were applied to analyze flock composition, management practices and productivity. ***Results***: The results showed that 86% of poultry farms were managed by women, with a high illiteracy rate (76%) among farmers. Local chickens represented 84% of poultry flocks, with an average flock size of 25 birds per household. Feeding relied mainly on scavenging, supplemented with barley, stale bread and household wastes. Juvenile mortality was 64%, largely due to inadequate chick-rearing practices. Hens laid an average of 79 eggs per year, with a mean egg weight of 54.3 ± 5.4 g. Body weight averaged 1407 ± 291.9 g in hens and 1758 ± 335.2 g in roosters, with slight regional variations. Health management was poor, with 96% of farmers reporting frequent disease outbreaks. Only 5.4% of farmers had I access to veterinary practitioners. Biosecurity measures were minimal. Disease control was primarily based on traditional remedies or the use of antibiotics with no veterinary supervision. These findings highlight significant challenges for poultry production, including high mortality rates, poor housing, inadequate feeding and poor health management. ***Conclusions***: Addressing these issues by developing management strategies to improve biosecurity and veterinary access is essential to enhance the sustainability and productivity of backyard poultry farming in Morocco.

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■ INTRODUCTION

Poultry production is a cornerstone of global agriculture. It is vital for food security and economic stability worldwide (FAO, 2014). In 2020, global poultry meat production exceeded 137 million tons and egg production reached approximately 86.7 million tons, with 7.9 billion laying hens producing 1.6 trillion eggs (Poultry World, 2020). This tremendous level of production reflects the growing demand for poultry meat and eggs and highlights the sector's crucial role in terms of food security (Mottet *et al*., 2017). Although global poultry production

is dominated by the industrial sector, traditional poultry farming is important in many rural areas. This is particularly the case in developing countries, where it provides a livelihood for local populations (Jha & Chakrabarti, 2017). Africa's agricultural potential is phenomenal and represents numerous opportunities for poverty reduction. Poultry farming plays a strategic role when it comes to reducing poverty. Poultry meat production in Africa has seen significant growth, with production increasing from 598,000 tons in 1970 to 7.3 million tons in 2020 (Poultry World, 2020). Similarly, Africa's egg production accounted for 4.1% of the global total in 2020, with 3.5 million tons produced by 553 million laying hens. In North Africa, the poultry industry is complex due to the diverse production systems and economic structures. Traditional and backyard poultry farming is widespread in rural areas. It is an integral part of rural household economies and makes an important contribution to family nutrition (Kumar *et al*., 2021).

Straddling the line between Europe and Africa, Morocco has a unique poultry farming sector. Significant growth has been observed in both its industrial and traditional poultry sectors. However, the latter remains deeply embedded within the socio-economic fabric of rural communities (FAO, 2014). According to the poultry federation (FISA, 2023), Morocco's poultry meat production reached 655,000 tons in 2023. While the industrial sector dominates production, the traditional sector contributed approximately 50,000 tons. Following a similar pattern, egg production has surged, increasing from 278 million eggs in 1981 to 5.3 billion in 2023. The traditional sector produces approximately 800 million eggs. Backyard poultry farming is widespread in rural Morocco. Flocks tend to be small and mixed, including chickens, guinea fowl, pigeons and turkeys (Fagrach *et al*., 2023). These birds are commonly referred to as "Beldi" (which means "native" or "traditional" in Moroccan dialect). They not only provide a source of income (sale of meat and eggs), but also boost households' economic resilience. They constitute a form of savings, which families can fall back on in times of adversity.

Despite differences in production performance between indigenous and commercially bred birds, local breeds are celebrated for their resilience and adaptability. They thrive on low-input management systems, can subsist on foraged food and require minimal veterinary care (Minga *et al*., 2004). Thus, they are well-suited to the environmental and resource constraints of rural households. Additionally, meat from local breeds is often preferred for its distinct taste and texture. This quality, which is attributed to their natural diets and slower growth rates, enhances their appeal in local markets (Benabdeljelil & Arfaoui, 2001).

This paper investigates traditional poultry farming practices in Morocco's Khemisset province and Skhirate-Temara prefecture, by drawing on a combination of bibliographic research and extensive household surveys. The study aims to uncover detailed insights into the socio-economic conditions of poultry farmers, the characteristics of Beldi poultry flocks, and the various management practices employed. Our goal is to inform policy development and support sustainable growth initiatives that are tailored to the unique challenges and opportunities found in rural communities.

■ MATERIAL AND METHODS

Study area

Surveys were carried out in the province of Khemisset and the prefecture of Skhirate-Temara (Table I), two rural areas near the capital city, Rabat (Figure 1). The sites were selected for their distinct poultry farming practices. Khemisset is known for its widespread backyard poultry farming, while Skhirate-Temara has a high concentration of intensive poultry units. Thus, we were able to conduct an in-depth assessment of the prevalence of backyard poultry in a region with intensive commercial production. We conducted a comparative analysis of farming practices in the two areas and evaluated

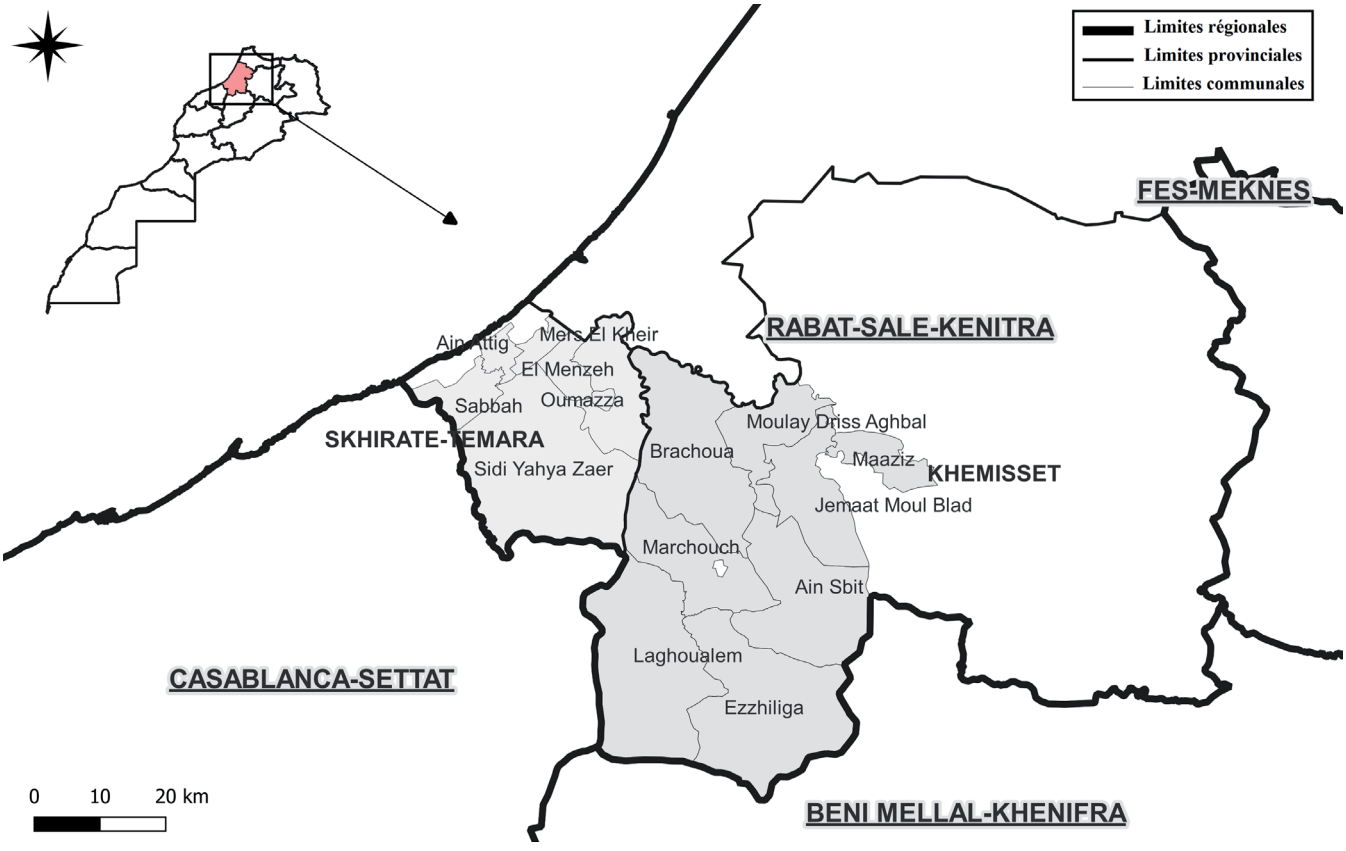

Figure 1

Table I: Socio-economic characteristics of interviewees /// *Caractéristiques socio-économiques des personnes interrogées*

Flock management (%)	
Women	86
Men	14
Level of education (%)	
Illiterate	76.2
Primary	15
Secondary	7.8
Average age (years)	
Women	48.4
Men	39.1
Years of experience in poultry farming	
Women	17
Men	6
Purpose of poultry products (%)	
Dual purpose	87
Self-consumption	10.3
Sale	2.7

the zootechnical performances of Beldi chickens in different farming contexts. Consumer demand for local poultry products is high in both regions. This has prompted many rural households to keep small backyard flocks. Rural households benefit from the increasing urban demand and the market preference for local breeds.

Sampling and data collection

Surveys were conducted following a multistage sampling technique, similar to those recommended for complex rural settings (Sennuga & Oyewole, 2020). This method generated a comprehensive representation of poultry farming practices across eight rural counties in Khemisset and six in Skhirate-Temara. A number of villages in these counties were strategically selected to cover a diverse cross-section of the poultry population. The selection of respondents, 320 households in total (179 in Khemisset and 141 in Skhirate-Temara), was proportional to the number of households recorded in the latest census (HCP, 2014). We used a randomized sampling approach to ensure data reliability.

The criteria for choosing specific counties included the abundance of backyard flocks and proximity to local weekly markets (souks), which are essential for the trade in poultry products. We visited larger weekly markets, where we were able to talk to commercial stakeholders and conduct practical assessments, such as weighing live birds. This was vital for understanding issues linked to market dynamics and farm incomes.

The semi-structured questionnaire covered a wide range of parameters to ensure robust data collection. It was initially prepared in French and then translated into the local dialect for reasons of clarity and accuracy. It was presented during face-to-face interviews, conducted by trained surveyors. The direct interaction with respondents helped minimize potential biases associated with self-reported data. The questionnaire included sections on: the socio-economic status of poultry farmers (including their experience in poultry farming, level of education and the destination of poultry products); poultry management (history of poultry farming, feeding practices, housing, health management, access to veterinary services, etc.); flock composition and performance (flock size, age distribution, productive and reproductive performance, life body weight, egg-laying rates, hatchability, etc.); as well as the various challenges and constraints (feed availability, disease outbreaks, predation, etc.).

The study's goals, scope and expected outcomes were clearly communicated to the participants during the initial interactions. This allowed us to secure their informed consent regarding their participation in the interviews and photographic documentation. By adopting this approach, we respected ethical standards and were able to foster trust and cooperation among the participants. In addition, we were able to observe the rearing conditions, inspect the shelters, take photographs, weigh birds, and conduct behavioral observations. This gave us a holistic understanding of the operational and environmental factors influencing poultry farming in the two regions. Data were collected by 12 trained surveyors, supervised by two coordinators to ensure standardized procedures and reliable data collection. Surveyors were assigned specific geographical areas. Random quality checks were conducted to ensure accuracy. In total, 14 personnel were mobilized, guaranteeing a comprehensive coverage of the study regions.

Measured Data

To assess poultry performance, data on key zootechnical parameters were collected. Live body weight was measured directly (roosters and chickens over 6 months old), using digital scales with an accuracy of 0.1 g. Productive and reproductive parameters, such as egg-laying capacity and mortality were recorded, based on farmers' reports. Hatchability rates were evaluated from reported data on the number of eggs per brood and the number of chicks hatched.

Bird weighing

Digital scales with an accuracy of 10 g were used to measure the body weight of roosters and chickens over 6 months old. The sexual size dimorphism index (SSDI) was calculated using the following formula (Weidinger & van Franeker, 1998):

SSDI (%) =
[(mean male body weight / mean female body weight) - 1] × 100 (equation 1)

Eggs measurements

A total of 200 eggs (100 from each location) were collected from farmers and measured using a vernier caliper with a precision of 0.02 mm. We recorded egg width (EW) and egg length (EL). The eggs were classified according to the egg shape index (ESI), as follows: sharp (SI < 72); normal (standard) (SI = 72–76); and round (SI > 76) (Sarica *et al*., 2024). The ESI was calculated using the formula (Romanoff & Romanoff, 1949):

ESI = (EW / EL) x 100 = (equation 2)

Data processing and analysis

For data collection, descriptive statistics and graph design, we used Excel® software (2016 version). To determine if there were any significant differences between variables in the calculated frequencies and proportions, we used the Khi2 test in IBM SPSS Statistics 26 (SPSS Inc., Chicago, IL, USA). Additionally, a Khi2 test of independence was conducted to examine possible associations between variables. All statistical tests were subjected to a significance threshold of 5%.

Bibliographic sources

The literature review focused on studies related to traditional poultry farming practices and the zootechnical performance of indigenous chickens. We gave priority to peer-reviewed articles and research conducted in contexts similar to Morocco. Selection criteria included thematic relevance, methodological rigor, and recent publication. By

drawing on the selected sources, we were able to contextualize our findings, identify comparative trends, and discuss potential discrepancies with existing data.

■ RESULTS

Respondents' socio-economic profiles

Of the 320 poultry farms surveyed, an overwhelming 86% (276 farms) are managed by women (Table II). Most of the women farmers stated that poultry farming is not just an occupation, but their primary source of income. Indeed, it as the sole source of income for 74% of the respondents. The level of education among farmers is low, with 76% illiteracy. Experience in poultry farming varies widely among respondents, ranging from 2 to 50 years. Over half of the farmers (51%) have more than 20 years of experience, while only 12% have been in the sector for less than 5 years.

Regarding the use of poultry products, a small proportion of the farmers (10.3%) reported using their flocks solely for self-consumption. A smaller fraction (2.7%) stated that their poultry products were exclusively for generating income. However, the majority (87%) indicated that their poultry products are dual purpose—both for sale and household consumption ($p < 0.001$). Poultry dishes are often served to guests during religious and cultural ceremonies. This reflects the integral role of poultry farming in rural Moroccan communities and its socio-economic and cultural importance.

The characteristics of poultry flocks

In the study region, all the households surveyed were involved in traditional poultry breeding. Additionally, 64% of households reared small ruminants, particularly sheep. This highlights the importance of mixed farming in the region.

Distribution of Backyard Flock Species

The structure and size of poultry flocks in the study area are shown in Table III. A total of 10,227 birds were recorded across all surveyed households during the study. Local chickens were ubiquitous. A significant proportion of farmers (31%) manage a mixed-species flock, with chickens and other poultry species.

Chicken farming is the predominant type of poultry production, accounting for over 84% of the rural poultry population. This is followed by guinea fowl, which constitute 6.8% of the poultry population. Pigeons and turkeys represent 5.9% and 2.4% of the total flock, respectively.

Local chicken flock

The average chicken flock size is 25, ranging from 1 to 200 birds/flock. The average sex ratio is one rooster to four hens. Approximately two thirds of the farmers (65%) had flocks ranging from 1 to 20 chickens, and only 16% had flocks with more than 40 birds ($p < 0.05$). Thus, an average flock of 25 local birds consists of approximately 14 hens, five chickens, three roosters and three chicks.

The majority of local chickens in the study were hatched on-farm (81.6%) ($p < 0.001$). However, 87.5% of poultry farmers declared that they had previously purchased new birds from local markets, while 13.5% stated that their flocks were comprised of home-hatched birds alone. Almost one-fifth of farmers (19.3%) reported that they frequently purchased mating roosters from weekly souks. A few farmers (5.4%) stated that they occasionally borrowed roosters from their neighbors.

Phenotypic variability

The local chicken flocks exhibited notable phenotypic variation, which was clearly evident in plumage and shank colors. The plumage ranged from black, brown, and golden to combinations of gray and white. The brown/red plumage was the most prevalent, indicating a possible selection preference or an adaptive advantage in the local environment. There was also a wide spectrum of shank colors, including light yellow, white, black, green, and gray, with no dominant single color.

The majority of chickens displayed simple feather types. A small portion of the population exhibited the naked neck phenotype, which is often associated with better heat tolerance. We did not observe any frizzy or silky plumage types among the local flocks. In terms of patterns, barred and marbled plumage were the most common. This may be due to some adaptive advantages or simply a matter of preference with regard to local breeding practices.

Simple comb forms were prevalent across both genders, while other comb forms were less common. This could suggest a stronger genetic drift towards simpler comb types in the local population or selective breeding practices that favor this trait. Eggshell color varied widely from white to dark brown, providing insights into flock genetic diversity.

Adaptation and preference for local breeds

Despite the availability of commercial or crossbred strains, only three male farmers stated that they bred these types. The general preference for local breeds is primarily due to their superior hardiness and

Table II: Bioclimatic and demographic features of the study area /// *Caractéristiques bioclimatiques et démographiques de la zone d'étude*

Location	Skhirat-Temara	Khemisset
Geographic location	Coastal, near Rabat, 40–60 km inland	Inland, ~70–120 km from Rabat
Climate (1)	Mediterranean, oceanic influence	Continental Mediterranean
Annual rainfall (1)	450–600 mm	300–500 mm
Temperature (1)	Avg: 18°C Range: 10–30°C	Avg: 21°C Range: 0–40°C
Population density (2)	~700 inhabitants/km²	~150 inhabitants/km²
Total population (2)	~500,000	~230,000
Percentage of people involved in agriculture (3)	35%	65%
Market access (3)	Weekly markets, proximity to Rabat	Limited access, reliance on small local markets
Literacy rate (2)	~75%	~45%

(1): Direction de la Météorologie Nationale (2021); (2): HCP (2014); (3): Ministère de l'Agriculture, de la Pêche Maritime du Développement Rural et des Eaux et Forêts (2020)

Table III: Backyard flock species distribution and average flock size in the study area /// *Répartition des espèces de troupeaux de basse-cour et taille moyenne des troupeaux dans la zone d'étude*

	Khemisset	Skhirat-Temara	Overall (%)	Range	p-Value
No. of flocks	179	141	320		
Average flock size	31.7 ± 5.7	27.5 ± 4.5	29.6 ± 5.1	1 - 352	> 0.05
Average size of chicken flock	22.4 ± 4.4	27.2 ± 5.4	24.8 ± 4.9	1 - 200	< 0.05
Domesticated birds (%)	5 716 (55.9%)	4 511 (44.1%)	10 227		< 0.05
Chickens (%)	4 661 (54.3%)	3 930 (45.7%)	8 591 (84.0%)	1 - 200	< 0.05
Guinea fowl	457	228	695 (6.8%)	0 - 100	< 0.05
Pigeons	438	165	603 (5.9%)	0 - 80	< 0.05
Turkeys	191	56	247 (2.4%)	0 - 20	> 0.05
Geese	41	10	51 (0.5%)	0 - 14	< 0.05
Ducks	18	12	30 (0.3%)	0 - 12	> 0.05
Peacocks	8	2	10 (0.1%)	0 - 8	> 0.05

adaptability to the environmental challenges in the region. The local breeds were described as highly self-sustaining (81.4%), low cost compared to commercial strains (77%) and relatively disease resistant (38.2%).

Poultry Flock Management

Housing

The majority of farms visited (91.3%) use a semi free-range system, where birds roam freely during the day and are housed at night ($p < 0.001$). Most farmers (87.8%) provided shelter for their birds, with cheap locally available materials. Generally, the constructions had bare earth floors with no litter (78.1%), and walls made from large tree branches (64.7%), chipboard panels (34.2%), reeds (30.4%), or rammed earth (12.7%). These materials are often combined with mesh nets and plastic for ventilation to keep the birds cool during the hottest hours of the day in the summer months. Plastic is the most common roofing material (82%). Only 27.4% of shelters had bedding, made from straw-based material in most cases (81%), and dried grass or wood shavings in 15% and 4% of cases, respectively. These traditional shelters fall short of meeting basic hygiene criteria and construction norms. They are often badly designed with inadequate ventilation or, on the contrary, are very drafty. They have leaky roofs, no separation between different poultry species and poor waste disposal. These factors create favorable conditions for the development of pathogens and parasites, which can have a negative impact on flock productivity.

In general, these cheap home-made constructions are flimsy and cannot withstand adverse weather conditions, such as rain, wind, snow, etc. Consequently, they fail to provide adequate protection for the birds, which are frequently attacked by nocturnal predators (e.g. rats, hedgehogs, foxes, owls, etc.), and diurnal predators (e.g. raptors, stray dogs, etc.). This predation sometimes causes high mortality, especially among young birds (15%). The size of shelters is rarely proportional to flock size.

Only half of the shelters in our study are equipped with nests (54%). Typically, the nests are made from plastic or wooden crates filled with straw to provide a space for hens to lay eggs and brood. Given the limited number of nests, only a few hens can lay simultaneously (less than 1/3 of the laying hens in the flock). As a result, the hens choose their own nest site, often a long way from the hen houses, for example, in sheepfolds, barns, under bushes and cactus plants around the house. This can be problematic, leading to the loss of a large number of eggs, either due to predation or simply because they are hard to find.

Poultry equipment

The surveyed farms lack specialized breeding equipment, such as feeders or drinkers. Instead, 97.4% utilize recycled material containers (utensils and plastic containers) to provide water to their poultry, while only 2.6% use commercial drinkers ($p < 0.001$). Feed distribution practices vary, with 27.1% of farmers using recycled plastic or metal utensils and covers. On most farms (72.9%), feed is thrown directly on the ground ($p < 0.001$). This practice increases the likelihood of birds being contaminated with pathogens.

In general, feed hygiene recommendations are not followed. The recycled feeders are seldom washed (on 14.7% of farms only). Water containers are washed more regularly (on 82.4% of farms), but not enough (only once a week in 66.2% of cases). The equipment is rarely kept separate from other animals, which may cause waste (both food and water), and favor disease transmission and spread. In some cases, not enough drinkers and feeders are provided, which means the whole flock may not be properly fed and watered.

Feeding

Most of the local poultry in the study area forage for food in the farm vicinity. Foraging provides a wide range of resources, depending on the area available and the diversity of flora and entomological fauna. At sunrise, the birds leave their shelter to go in search of food around the house, on nearby wasteland, as well as fallow and stubble fields. Birds feed on insects, worms, snails, and cereal grains that fall from ruminants' feeders.

Nearly all farmers (98.1%) provide supplementary feed to their flock throughout the year ($p < 0.001$), composed of cereal grains, in particular, barley, wheat, bran and to a lesser extent corn. This feed is generally purchased, with only a small proportion produced on farm (mainly barley). Barley (95.9%), stale bread (82.5%), household leftovers (food waste and vegetable peelings) (67.82%) constitute the main supplementary feed for flocks. Wheat bran is fed exclusively to chicks. The adult birds are also fed wheat grain and bran. The supplementary food is distributed to the whole flock, with no separation between the different species and age groups. Only 1.9% farmers do not provide any supplementary food to their flocks. In contrast, 9% feed their birds with cereal grains, 13.7% add stale bread, 54.7% introduce household waste, and 16.5% use compound feed as a chick starter. Some farmers do not use cereal grains to supplement their

poultry's diet, instead they provide a mixture of stale bread and household leftovers (2.2%). Two farmers just use the compound feed (Figure 2).

The number of feeds per day varies from one (18% of farmers) to three (19%). The majority of farmers (63%) feed their flocks twice a day, early in the morning and then around noon, and/or in the evening to encourage the birds to roost in their shelter.

Watering

A total of 95.4% of farms provided water *ad libitum* to their birds throughout the year. The water generally comes from wells or public drinking water networks, although 5.6% of flocks depended on sources of water in their environment. The same drinkers are used for the entire flock, with no separation between species or age groups. As a result, the youngest birds are at risk from drowning in containers that are too wide and/or deep for them.

Management of reproduction

Brooding and hatching

Brooding occurs on average 3 to 4 times a year (Table IV). However, according to some farmers (17%), it can be as much as five times a year. In general, hens choose a quiet dark place, in nests when they are provided, or elsewhere on the farm, in straw bales, sheepfolds, near the home and even between xerophytic plants (cactus). The limited availability of nests on the farms surveyed results in high egg losses, which affects productivity. The main reported causes of hatching failure were egg infertility (65%), embryonic mortality (38%) and accidents (16%) ($p < 0.05$). Breeders reported a clear decrease in the hatching rate during the summer, due to the high temperatures, which cause the eggs to rot.

The main selection criteria for a broody hen include good conformation (79.7%), good brooding traits (61.3%), adult over one year old (57.5%), and good layer (32.2%) (Table V). Some farmers (28.75%) with small flocks do not select hens for brooding. Instead, they use any hen that goes broody.

"Unbrooding" is a very common practice in our study area (84%) ($p < 0.001$). It is used to increase the number of eggs laid per cycle and maximize chick survival. This is an issue, especially when the hen is too young and the environmental conditions are unfavorable for chick survival. Several techniques are used by farmers to prevent brooding in hens. These include: tying the hen's shanks for three to four days (64.6%), the time it takes to inhibit the broodiness instinct; soaking the hen in cold water (23.4%); destroying nests (11.9%). Other techniques are also used, such as putting feathers in the broody hen's nostrils (3.5%), but their effectiveness has not been proven. With a sex ratio of one rooster to four hens (0.25), fertility is not a criterion for selecting eggs for hatching. Instead, farmers are interested in two major selection criteria, which they consider will affect chick vigor: egg size (79.1%) and origin (laying hen) (66.5%).

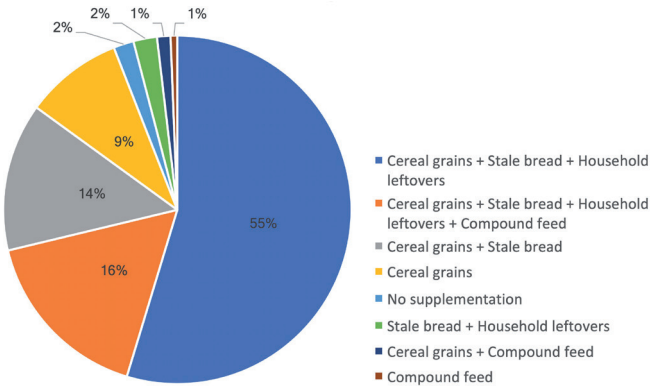

Figure 2

Table IV: Laying parameters of backyard chickens /// *Paramètres de ponte des poules de basse-cour*

Reproduction parameters	Minimum	Maximum	Mean	SD
Age at point of lay (months)	3	9	6.6	± 2.3
Clutch length (days)	14	40	23.8	± 10.2
Inter-clutch period (days)	7	60	22.6	± 13.7
Clutch size	6	23	15.9	± 3.2
Number of eggs laid per year	40	150	79.4	± 15.3

Table V: Criteria for choosing broody hens /// *Critères de sélection des poules couveuses*

Selection criteria	Number of households	Frequency	95% confidence interval
Large size	255	79.7 %	[237, 273]
Good brooder	196	61.3 %	[176, 216]
Age	184	57.5 %	[164, 204]
Good layer	103	32.2 %	[86, 120]
No criterion	92	28.8 %	[75, 109]

Raising Chicks

During the first two weeks after hatching, 36% of farmers confine chicks with the mother hen away from the rest of the flock. This facilitates their supplementary feeding. The chicks' diet tends to differ from that of adult birds. It is composed of semolina, wheat bran, bread crumbs, and for a minority of farmers, starter feed for commercial broilers. A small container with water is provided to ensure that the young birds have enough water to drink.

Later, the young birds are usually released to join the rest of the flock. Their mothers teach them how to peck and forage outside. This period is a transitional stage before the chicks are naturally weaned from their mother. Weaning occurs at 76 days old (±28) in our study area. Many chicks disappear before they reach 2 months of age. The juvenile mortality rate is above 64%. The main causes are disease (55%), predation (17%), and accidents (8%).

Production performance

Laying

In the region studied, the average age at point of lay is around 6.6 months (Table IV). The average laying cycle (clutch length) lasts 23.8 days, during which the hen lays 15.95 eggs on average (ranging from 6–23 eggs per clutch). Average hatchability is 72.9% (±24.8), i.e., farmers usually obtain 12 chicks from a clutch of 16 eggs. At the end of each laying cycle, the hen exhibits brooding behavior or the "desire" to brood. If the conditions for brooding are unfavorable or in the case of controlled "unbrooding", the hen generally resumes laying after 22.6 days. On average, the total number of eggs laid per year is 79, ranging from 50 to 130.

Egg measurements

Our field measurements showed that hens in the region of Skhirate–Temara produced larger eggs (Table VI), with an average weight, length and width of 54.5 g, 56.1 mm and 41.5 mm, respectively. In comparison, the weight, length and width of eggs collected in the region of Khemisset were 54.1 g, 56.6 mm and 41.4 mm, respectively. The average ESI was 73.7% (± 3.6), with the higher value recorded in Skhirate–Temara (74.1% ± 4.3). This shows that most eggs in our study are of standard shape.

Poultry weight

Birds (age > 6 months) in the study area had an average live weight of 1407 ± 291.9 g (hens) and 1758 ± 335.2 g (roosters), with an average sexual size dimorphism index (SSDI) of 23.9% (Table VII). Average live body weights were higher for roosters (1886.6 g) and hens (1428.9 g) in the Skhirate–Temara region, compared to the Khemisset region (1671.1 g and 1383.2 g, respectively). SSDI was higher in the Skhirate–Temara region, where roosters were 26.7% heavier than hens.

Health management

Disease incidence and diagnosis

The study revealed a significant disease burden in the poultry flocks. This was identified as the primary cause of mortality by 89% of farmers ($p < 0.001$). Farmers stated that they lacked formal training in disease recognition and treatment. Instead, they rely predominantly on personal experience and share knowledge on diagnosing ailments with family and neighbors. Almost all farmers (97.1%) reported that respiratory infections were the most prevalent. Other common conditions include greenish diarrhea (38.3%), nodules on the head and legs (32.6%), and locomotor disorders (27.1%). Prostration and anorexia were also reported by 24.6% of respondents, while neurological symptoms, such as torticollis and paralysis were less common (6.5%). The ubiquity of ectoparasite and endoparasite infestations was reported on all the surveyed farms.

Treatment and veterinary care

Very few farmers (3.7%) used vaccination programs and professional veterinary care. Self-medication with inappropriate antibiotics was common, reported by nearly half of the respondents (48.6%) ($p < 0.05$). Almost a third of farmers (31.2%) relied on traditional ethnomedicine. It is interesting to note that a significant portion of farmers (29.2%) did not administer any treatment to unhealthy birds. Management of ectoparasite control was more common. For example, pesticides were directly applied to birds on 20.2% of farms. However, this practice raises concerns about the adequacy of pesticide applications and potential implications for bird health and food safety. In the studied region, the biosecurity measures were grossly inadequate. For example, in the free-range housing systems (76.5%) of farms, the frequent contact with wild birds heightens the risk of disease transmission. The disinfection protocols for visitors were non-existent, and quarantine measures for newly introduced birds were rarely implemented (26.8%). Most farmers (83.4%) remove dead birds from the farm premises, and some (38.6%) dispose of carcasses near commercial poultry units. These practices may facilitate disease spread within a flock and between local poultry farms.

■ DISCUSSION

Backyard poultry farming is a widespread practice in rural areas in developing countries. It is viewed as a viable means to guarantee food security, increase farm incomes, and empower women (FAO, 2014). Despite its importance in rural areas in Morocco, there is little available data on backyard flocks regarding population structure,

Table VI: Local Beldi hen egg measurements in the study area /// *Mesures locales des œufs de poule Beldi dans la zone d'étude*

Location	n	Weight (g)		Length (cm)		Width (cm)		ESI (%)	
		Mean (SD)	Range	Mean	Range	Mean	Range	Mean (SD)	Range
Khemisset	100	54.1 (± 5.8)	44.8 - 70.5	5.7	4.4 - 6.3	4.1	3.8 - 4.5	73.3 (± 3.64)	64.0 – 91.0
Skhirate-Temara	100	54.5 (± 5.1)	45.4 - 66.6	5.6	6.5 - 6.3	4.1	3.9 - 4.4	74.1 (± 4.33)	63.5 – 91.8
Overall	200	54.3 (± 5.4)	44.7 - 70.5	5.6	4.4 - 6.3	4.1	3.8 - 4.5	73.7 (± 4.01)	63.5 – 91.8

Table VII: Live body weight (g) of local chickens in the study area /// *Poids vif (g) des poulets locaux dans la zone d'étude*

Location	Gender	Live Body Weight (g)			SD	Counts
		Min	Max	Mean		
Khemisset	Roosters	1 045	2 856	1 671	± 346.3	63
	Hens	825	2 079	1 383	± 269.8	115
	SDI			20.8 %		
Skhirate-Temara	Roosters	1 385	2 751	1 810	± 324.8	71
	Hens	730	1 647	1 429	± 310.3	125
	SDI			26.7 %		
Overall	Roosters	1 045	2 856	1745	± 335.2	134
	Hens	730	2 079	1407	± 291.9	240
	SDI			23.9 %		

production and reproductive performance, and management practices. The purpose of our research was to examine the local "Beldi" flocks, by focusing on the farming systems and practices used, in addition to production and reproductive performance.

Traditional poultry farming in Morocco is a female-dominated activity. Women manage most of the day-to-day poultry operations, including feeding, egg collection, and healthcare. They are often assisted by their children and other younger family members. In contrast, men tend to be involved in other agricultural activities, such as rearing ruminants. However, they occasionally help sell poultry products at local markets. This gender distribution reflects the poultry sector's secondary status, compared to other agricultural activities. This perception may also be linked to its lower income generating potential. The observed gender-based division of labor is consistent with findings from a preliminary investigation in the same study area (Fagrach *et al*., 2023). It aligns with surveys carried out by Benabdeljelil and Arfaoui (2001) in the region of Khenifra in Morocco. Similar findings have been reported in other developing countries where women play a central role in poultry rearing (Halima *et al*., 2007; Mahammi *et al*., 2014; Ould Ahmed & N'Daw, 2015). In our study, most poultry products were intended for sale and self-consumption during cultural and religious ceremonies. Our findings highlight the crucial role of backyard poultry keeping. By contributing to food security and poverty alleviation (Kumar, *et al*., 2021), it improves the livelihood of rural populations, especially women.

In this study, the prevalence of the local breed, "Beldi", aligns with the general trend observed in many developing countries, where there is a preference for indigenous chicken breeds. This is largely due to their hardiness and adaptability to local environmental conditions (Siddiky, 2017; Assefa, 2019). The phenotypic diversity observed within the local type in the study areas is consistent with the findings of Boujenane (2023) in the Draa-Tafilalet in Morocco. It suggests the potential existence of subpopulations, which should be characterized before implementing a selective breeding program.

The average chicken flock size (25 birds), can be qualified as small to medium, which is consistent with findings from previous investigations in Morocco (Benabdeljelil & Arfaoui, 2001; Fagrach *et al*., 2023). However, when comparing different regions worldwide, the variation in flock size can be substantial. For instance, in Africa, higher average flock sizes (43 birds/flock) were reported in Niger (Amadou *et al*., 2011), while Ethiopia registered a smaller average flock size of 7 (Halima *et al*., 2007). The difference in flock sizes may be due to various factors, such as cultural preferences and resource availability. It also reflects the diversity of poultry farming practices globally. Understanding these variations is crucial for developing appropriate management strategies and sustainable poultry production practices in each specific context.

Our analysis of flock composition revealed that there were few older birds, particularly males. This dynamic is influenced by several factors, including high chick mortality during the brooding period (Pym & Alders, 2012; Kumar *et al*., 2021), and the sale of roosters. Conversely, females are kept for egg production and rarely sold, except for culling. As a result, there are more laying hens (> 6 months) compared to other age categories.

Semi free-range farming systems, where birds roam freely during the day and are housed at night, is a typical feature of traditional poultry farming systems, as observed in similar contexts (Tarus *et al*., 2016; Rajkumar, 2021). The poor housing design and infrastructure are also common in backyard poultry farming systems in different regions (Halima, 2007; Amadou *et al*., 2011; Kumar *et al*., 2021). This has a negative impact on flock health and productivity. Our findings underline the need for context-specific action to improve housing, with the use of appropriate construction materials. In addition, better hygiene practices could enhance backyard poultry welfare and productivity. The reliance on foraged food and household leftovers observed in Morocco is common in developing countries (Halima, 2007; Amadou *et al*., 2011; Kumar *et al*., 2021; Rajkumar *et al*., 2021). Although most farmers provide supplementary feed to their birds, the distribution of cereal grains and household scraps is limited in terms of quantity and frequency. This issue is a concern and may lead to nutritional deficiencies. Although the lack of protein, mineral and vitamin supplements during the birds' different developmental stages is open to debate, it could potentially impact poultry health and productivity (Applegate & Fowler, 2021). This situation highlights the economic constraints facing small-scale farmers worldwide. Research on affordable, locally available feed supplements is essential to improve the birds' diet in developing countries.

Selection criteria for broody hens prioritized brooding behavior and overall body conformation. This differs from the findings in Northern Ethiopia (Fitsum, 2017), where farmers gave priority to egg size and plumage color, with broodiness ranking third, followed by disease resistance and hatchability. In our study, fertility-related traits tend to be overlooked, instead egg size was favored for its perceived association with chick vigor. Despite special chick care during the first two weeks, with confinement and feeding on more than 1/3 of farms, the persistent high juvenile mortality rate before the age of two months remains a serious problem.

The average age of pullets at first laying (6.6 ± 2.2 months) and hatchability (72.86% ± 24.83) were lower compared to the Drâa-Tafilalet region in Morocco (6.89 ± 3.22 and 82.9% ± 26.8, respectively) (Boujenane, 2023), while clutch size (15.95 ± 3.17 eggs vs 13.9 ± 1.89 eggs) and duration (23.8 ± 10.1 days vs 18 ± 9.3 days) were higher. In comparison, the age at first laying was reported to be 5.8 months and hatchability was 78% in the region of Khenifra (Benabdeljelil & Arfaoui, 2001). The number of eggs laid per year and per hen were similar to reports by Benabdeljelil and Arfaoui (2001) (78 eggs/year), and higher than reports by Boujenane (2023) (62.4 eggs/year). We observed greater variation between hens in our study area (±15.31 vs ±7.56). Therefore, improved management practices and genetic selection programs could potentially homogenize laying performance and maximize productivity.

In the present study, the average egg measurements for the local "Beldi" hens were 54.3 ± 5.4 g (weight), 56.32 mm (length) and 41.43 mm (width). These values are higher than those reported by Boujenane (2023) (53.0 ± 4.82 g, 53.8 ± 2.37 mm and 39.5 ± 2.02 mm, respectfully), and by Guni and Katule (2013) (43.9 g, 50.4 mm and 36.0 mm, respectfully). The mean egg weight was higher than the value reported by Mwalusanya *et al*. (2002) (44.1 g) and Badubi *et al*. (2006) (48.5 ± 5.7 g). Commercially produced chicken eggs are typically categorized by size, using the USDA (United States Department of Agriculture) grading system. This system considers both weight and minimum diameter (USDA, 2022). Based on these standards, the average egg weight (54.3 g), and length (56.3 mm) in our study area are close to the medium category, while average width (41.43 mm) is slightly narrower than the minimum diameter requirement for medium eggs. Therefore, the eggs in our study would be categorized as small. The average egg shape index (ESI) in our study was 73.72%, which is higher than that recorded in Tanzania (71.6%) (Guni & Katule, 2013), but similar to that reported by Boujenane (2023) (73,4%). The ESI serves as an objective measure of external egg quality. It correlates with efficient egg packaging for transport to minimize potential damage. It is also a significant factor in consumer preference. Studies conducted by Narushin and Romanov (2002) have established a link between egg shape and hatchability. Sarica *et al*. (2024), classify egg shape as sharp (ESI < 72%), normal (ESI = 72% – 76%) or round (ESI > 76%). The eggs in our study area predominantly fall within the average range in the "normal" category. Hence, they are more likely to appeal to

consumers, be less easily damaged during transport and have a higher rate of hatchability when incubated.

The average body weight was 1407 ± 291.9 g for hens and 1758 ± 335.2 g for roosters. These values are higher than those reported by Benabdeljelil and Arfaoui, (2001) in the Khenifra region in Morocco (1200–1400 g), (Fotsa *et al*., 2010), and in Cameroun (1160–1259 g for hens and 1400–1665 g for roosters). Interestingly, we found that birds in the Skhirate-Temara region had slightly higher live weights than those in Khemisset. Similar findings were made by Fotsa *et al*. (2010). The variations could be attributed to management practices and environmental factors, as well as to genetic differences between local chicken populations. Further research is required to explore the potential influence of these factors on live weight in the "Beldi" chicken populations. A better understanding of these factors could help improve breeding strategies and management practices, leading to higher live weights and more productive local chicken farming systems.

The current study identified the significant prevalence of disease in local Moroccan poultry farms. Indeed, farmers reported it as the main cause of mortality. This aligns with previous research in developing countries (Halima, 2007; Kumar *et al*., 2021). The farmers in our study lack formal training in disease recognition. This situation appears widespread, with similar reports from Bangladesh, where traditional knowledge was the primary source of disease identification for small-scale poultry farmers (Rimi *et al*., 2018). This highlights a critical knowledge gap, which could be resolved through educational programs to teach farmers how to recognize common poultry diseases and their symptoms. The common occurrence of respiratory infections, greenish diarrhea, and lameness suggests that respiratory coccidiosis, and Newcastle disease may be prevalent. Almost half of the farmers self-medicate with antibiotics, which may be inappropriate. This practice is a genuine concern and can lead to antibiotic resistance in poultry pathogens. This could reduce the effectiveness of veterinary treatments in the future (Okeke *et al*., 2009). The use of ethnomedicine warrants further investigation. Although some traditional remedies may have beneficial properties, their efficacy and safety require scientific evaluation. The inadequate biosecurity measures observed in this study, including free-range housing, lack of disinfection for visitors, and unsatisfactory confinement procedures, have also been reported in other low- and middle-income countries (Hamilton *et al*., 2012; Di Pillo *et al*., 2019). This could contribute to the high mortality rates observed. As yet, no studies have examined the feasibility of implementing biosecurity protocols in backyard poultry systems (Conan *et al*., 2012). However, educational programs have improved farmer knowledge in the Khemisset region (Fagrach *et al*., 2024). The adoption of better hygiene practices in the field remains limited, primarily due to resource constraints, linked to higher costs, labor demands, and time. Social stigma is also significant. To overcome these barriers, educational outreach programs should be complemented with state support, such as the provision of poultry equipment (feeders, drinkers, or fencing materials), financial incentives or subsidies, access to affordable veterinary services, and community-based training programs tailored to local contexts. Practical interventions, such as isolating feeders and waterers to minimize contact with wild birds, the safe disposal of contaminated carcasses, and respecting strict hygiene measures, can effectively reduce disease transmission. These measures are essential, not only for improving flock health and animal welfare, but also for ensuring the sustainability of small-scale poultry production systems in resource-limited settings.

■ CONCLUSION

This work underscores the vital role traditional poultry farming plays in supporting rural livelihoods in Morocco. The indigenous Beldi chicken flocks are remarkably resilient and productive under harsh environmental conditions. They provide a valuable source of income for many rural households, particularly for women. In addition, they are culturally important, and represent a significant genetic resource for sustainable agriculture and biodiversity conservation. Future strategies should include selective breeding programs to enhance egg production and growth rates in order to improve flock resilience and overall productivity. Comprehensive morpho-biometric characterizations and genomic studies are planned to explore the genetic diversity, adaptability, and production capabilities of Beldi chickens. This type of research will provide insights into the genotype-environment interactions, underpinning the birds' valuable traits and could pave the way for optimized breeding strategies.

In essence, while immediate improvements to management practices are crucial, the long-term focus should be to optimize the unique characteristics of traditional poultry farming in order to improve the livelihoods of rural communities. This approach aligns with sustainable development goals, which emphasize resilience, biodiversity preservation, and sustainable agricultural practices. In this way, Beldi chickens will continue to make an important contribution to Morocco's rural economy.

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Conflict of interest

The study was carried without any conflict of interest.

Author contributions

MKC: Conceptualization, methodology, supervision; investigation; formal analysis and interpretation; writing - original draft. AF: Investigation, formal analysis and interpretation. SEA: Formal analysis and interpretation. MB, BB, XL, AA: Conceptualization, methodology, supervision. SF: Conceptualization, methodology, supervision. All of the authors read and approved the manuscript for submission.

Ethics approval

This study was conducted in agreement with the Hassan II University, the Agronomy and Veterinary Institute of Rabat and the Moroccan Ministry of Agriculture recommendations, which are in accordance with international ethical standards (European Union Directive 2010/63/EU) legislation and ARRIVE (Animal Research Reporting of In Vivo Experiments) guidelines.

Data availability

The data were not deposited in an official repository. The data that support the study findings are available from the authors upon request.

Declaration of Generative AI in the writing process

The authors did not use any artificial intelligence-assisted technologies in the writing process.

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Résumé

Challioui M.K., Fagrach A., Bouslikhane M., Fellahi S., El Aayadi S., Badaoui B., Liu, X., Araba A. Aviculture traditionnelle au Maroc : Pratiques d'élevage et performances des troupeaux à Khémisset et Skhirate-Témara

Contexte : L'aviculture traditionnelle occupe une place importante dans les zones rurales du Maroc. Cependant, sa gestion demeure informelle et les données relatives aux performances du poulet local Beldi soient limitées. ***Objectif*** : La présente étude se propose de caractériser les pratiques d'élevage en milieu familial et d'évaluer les performances zootechniques des poulets Beldi dans deux régions contrastées : Khémisset, où l'aviculture traditionnelle est prédominante, et Skhirate-Témara, région à forte intensification avicole coexistant avec le secteur traditionnel. ***Méthodes*** : Une enquête de terrain a été menée de novembre 2020 à mars 2022 auprès de 320 ménages sélectionnés aléatoirement (179 à Khémisset et 141 à Skhirate-Témara). Les données ont été recueillies via des entretiens directs à l'aide d'un questionnaire semi-structuré, complétés par des observations sur le terrain et des mesures zootechniques. Au total, 240 poules et 134 coqs ont été pesés à l'aide de balances électroniques, et 200 œufs ont été mesurés (poids, longueur, largeur) à l'aide d'un pied à coulisse. Les données ont été analysées à l'aide de statistiques descriptives et de tests du Khi-deux, et ont porté sur la composition des troupeaux, les pratiques de conduite et les performances de production. ***Résultats*** : Il en ressort que 86 % des élevages sont gérés par des femmes, avec un taux d'analphabétisme atteignant 76 %. Les poules locales constituent 84 % des effectifs, avec une taille moyenne de 25 sujets par exploitation. L'alimentation repose principalement sur la divagation, complétée par l'orge, du pain rassis et des restes ménagers. La mortalité juvénile atteint 64 %, en lien avec des pratiques inadaptées d'élevage des poussins. La ponte moyenne est de 79 œufs/an/poule, pour un poids moyen de 54,3 ± 5,4 g. Le poids vif moyen est de 1407 ± 291,9 g chez les poules et de 1758 ± 335,2 g chez les coqs, avec de légères variations régionales. La gestion sanitaire reste précaire, avec 96 % des éleveurs signalent des épisodes fréquents de maladies, tandis que seuls 5,4 % ont recours à des services vétérinaires. Les mesures de biosécurité sont faibles, avec un recours dominant aux remèdes traditionnels ou à l'automédication sans encadrement professionnel. Ces résultats mettent en évidence les contraintes majeures liées à la mortalité élevée, aux carences alimentaires, à l'insuffisance des infrastructures et à la faiblesse de l'encadrement vétérinaire. ***Conclusions*** : Des actions ciblées en matière de conduite d'élevage, de biosécurité et d'appui vétérinaire s'avèrent nécessaires pour améliorer la durabilité et la productivité de l'aviculture familiale au Maroc.

Mots-clé : Aviculture, race indigène, élevage d'arrière-cour, performance animale, gestion de l'exploitation agricole, Maroc

Resumen

Challioui M.K., Fagrach A., Bouslikhane M., Fellahi S., El Aayadi S., Badaoui B., Liu, X., Araba A. Avicultura tradicional en Marruecos: prácticas de cría y rendimiento de los corrales en Jemisset y Sjirat-Temara

Contexto: La avicultura tradicional ocupa un lugar importante en las zonas rurales de Marruecos. Sin embargo, su gestión todavía es informal y los datos relativos al rendimiento del pollo local Beldi son limitados. ***Objetivo***: Este estudio pretende caracterizar las prácticas ganaderas en medio familiar y evaluar el rendimiento zootécnico de los pollos Beldi en dos regiones contrastadas: Jemisset, donde la avicultura tradicional es predominante, y Sjirat-Temara, región con una fuerte intensificación avícola que coexiste con el sector tradicional. ***Métodos***: De noviembre de 2020 a marzo de 2022 se llevó a cabo una encuesta sobre el terreno a 320 hogares seleccionados aleatoriamente (179 en Jemisset y 141 en Sjirat-Temara). Los datos se recopilaron mediante entrevistas directas utilizando un cuestionario semiestructurado, y se completaron con observaciones sobre el terreno y medidas zootécnicas. En total, se pesaron 240 gallinas y 134 gallos utilizando balanzas electrónicas, y se midieron 200 huevos (peso, longitud y anchura) mediante un pie de rey. Se analizaron los datos mediante estadísticas descriptivas y pruebas chi-cuadrado, que informaron sobre la composición de los corrales, las prácticas de manejo y los rendimientos productivos. ***Resultados***: Se obtuvo que el 86 % de los corrales están gestionados por mujeres, con una tasa de analfabetismo que alcanza el 76 %. Las gallinas locales constituyen el 84 % de los efectivos, con una media de 25 sujetos por explotación. La alimentación se basa principalmente en la divagación, y se completa con cebada, pan duro y restos domésticos. La mortalidad juvenil alcanza el 64 %, en relación con las prácticas inadaptadas de cría de polluelos. La puesta media es de 79 huevos/año/gallina, con un peso medio de 54,3 ± 5,4 g. El peso vivo medio es de 1407 ± 291,9 g en las gallinas y de 1758 ± 335,2 g en los gallos, con ligeras variaciones regionales. La gestión sanitaria todavía es precaria: el 96 % de los granjeros señalaron episodios frecuentes de enfermedades, mientras que solo el 5,4 % había recorrido a servicios veterinarios. Las medidas de bioseguridad son pocas, se recurre predominantemente a los remedios tradicionales o a la automedicación sin un marco profesional. Estos resultados ponen en evidencia las importantes limitaciones relacionadas con la mortalidad elevada, las carencias alimentarias, la insuficiencia de las infraestructuras y el poco seguimiento veterinario. ***Conclusiones***: Son necesarias acciones en materia de manejo de los corrales, de bioseguridad y de soporte veterinario para mejorar la durabilidad y la productividad de la avicultura familiar de Marruecos.

Palabras clave: Avicultura, raza indígena, cría doméstica, desempeño animal, manejo de fincas, Marruecos