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Performance of local breed hens (*Gallus gallus domesticus*) in two agro-ecological zones of Madagascar (High plateaus-south and south-east)

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Abstract

Traditional poultry farming in Madagascar occupies an important place in the household economy despite the challenges it faces. To have a better understanding of the production performance of poultry in Madagascar, a follow-up of 503 adult hens was carried out over 6 months in the High Plateaus - South and South-East agroecological zones. Data relating to egg and chick production were collected. It emerges from a total of 4728 eggs counted that 77.2% were white, and 89.6% were oval for the two study areas. The average weight of an egg was 43.75 ± 4.79 g for an average length of 4.92 ± 0.25 cm and an average width of 3.64 ± 0.19 cm. A significant difference was observed in the length and width between eggs from the two areas ($p < 0.001$). For a similar hatching rate (87%) for both zones, there appears a significant difference ($p < 0.001$) between the weights of the chicks from hatching to 6 weeks of age except for the second week of age in favor of the South-East zone.

Keywords: Phenotypic characterization, morpho biometric diversity, local hen, Madagascar

Introduction

Village poultry farming occupies an important place in the household economy in the world in general and in Africa in particular [1-3]. In Madagascar as in several African countries, it constitutes a financial and food security shield for vulnerable households and would constitute a significant part of domestic poultry [4-11]. The domestic poultry population would represent in size, a little more than 70% of the total livestock of livestock in Madagascar [12, 13].

Madagascar is experiencing a decline in performance among local breed chickens commonly called "Akoho Gasy", although they are recognized for their adaptability and hardiness [14]. This decline could be due to factors such as breeding management, pathologies, feeding and zoogenetic resources. Multiple voluntary and/or involuntary crosses are observed in traditional poultry farming practices aimed at improving poultry performance [8, 15, 16]. These constant and uncontrolled crosses over the years would manifest themselves by genetic erosions that could constitute a brake for this sector [17]. It is therefore important and as recommended by the FAO, to take stock of the phenotypic characteristics of local breed chickens in Madagascar. Indeed, the problem here is the lack of knowledge on the

zootechnical characteristics (production performance) of poultry in village poultry farming in Madagascar. Work on phenotypic characterization was carried out between September and November 2018, on 117 chickens from livestock households in two agroecological regions (Analamanga and Atsimo Andrefana). It allowed us to identify two ecotypes significantly different in their weight, wingspan and tarsi length. On the other hand, no significant difference in the morphological characters of poultry from the two regions despite the diversity was observed [18].

Given these diversities observed between poultry from Madagascar and those from the African continent on the one hand, between poultry from agro-ecological zones (Analamanga and Atsimo Andrefana) on the other hand, it is important to see if there are also diversities in the zootechnical performances of local breed poultry from Madagascar for secondary phenotypic characterization.

Materials and Methods

Study area and period

This study was conducted between May 2021 and October 2023 in the regions of Analamanga, Itasy, Vakinankaratra (Southern Highlands agro-ecological zone) and the Atsimo-

Atsinanana region (South-East agro-ecological zone).

Located in the High Plateaus, the population of the Analamanga region represents 12.7% of the total population of Madagascar. With a high agricultural potential, food crops are widely grown with crops such as cassava, corn, rice, sweet potatoes and potatoes to name a few. The practice of livestock farming, for the poultry, beekeeping, fish farming and dairy sectors, is a source of wealth ^[19].

Located almost in the center of the Big Island, the Itasy region has many lakes, hence its reputation in aquaculture, tourism and eco-tourism. More than 80% of the population of Itasy is involved in agriculture for a cultivable area of 84,3%. Rice cultivation is predominant there with an average yield of around 3.8 tons per hectare. Livestock farming is also practiced in the region with significant poultry and pig herds ^[20].

The Vakinankaratra region is distinguished by a higher

altitude and is dominated by volcanic soils. The cultivation of cereals, fruits, tubers and vegetables is equally important. In 2009, the number of livestock farmers in the region was estimated at around 78.000, with a pig herd estimated at 125.000 heads corresponding to just under 10% of the national herd. of the poultry herd currently represents 5.3% of the national herd ^[21].

The Atsimo Atsinanana region, found in the South-East of the big island, is made up of a coastal area of hills and plains, an area of medium and small hills and an area of cliffs and forests. Cash crops such as coffee, cloves and pepper are widely grown there as well as rice and cassava. Livestock farming, although practiced, is complementary to agriculture for sectors such as poultry farming, pig farming and cattle breeding. Fishing is widely practiced, both in the sea or river ^[22].

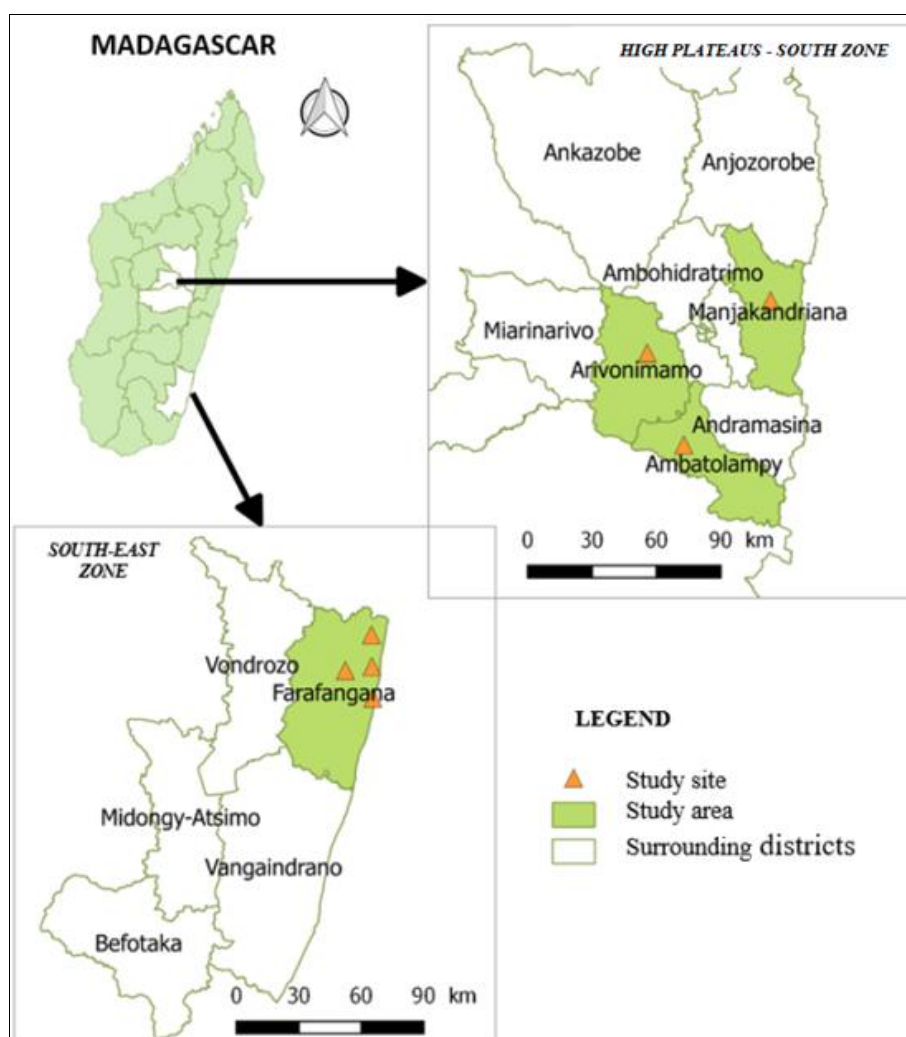


Fig 1: High Plateaus - South and South-East study areas

Data collection and sampling

Surveys were conducted periodically (every 4 weeks, for 6 months) in:

- The commune of Ambohitseheho, in the district of Manjakandriana, region of Analamanga;
- The commune of Imerintsiatosika, in the district of Arivonimamo, region of Itasy;
- The commune of Ambatolampy, in the district of

Ambatolampy, region of Vakinankaratra;

- The communes of Anosy Tsararafa, Amporofo, Mahavelo and Farafangana, in Farafangana District, Atsimo Atsinanana Region.

It should be noted that the municipalities of the same district are at least 20 km apart. A total of 136 poultry households were surveyed using snowball sampling, with inclusion

criteria being the household's acceptance to take part in the study, a flock size in the farm of at least 4 hens and one adult rooster, morphologically well-formed. After the survey of farmers on the practice of village poultry farming, at least 4 adult hens per farm were selected per farmer for evaluation of their reproductive performance over 6 months.

Quantitative and qualitative variables

During the 6 months, the birds were monitored by collecting data on the number, color, shape, length, width, and weight of eggs laid. Data on hatchability, chick weight, and chick mortality rate were collected. Several equipment were used, including a 1g precision portable electronic scale (Wei Heng) with a capacity of 10 kg, a 5g precision scale for eggs and chicks, and an aluminum caliper with a 1/10 dial and 15 cm long.

All statistical analyses were performed using R 4.3.2 software and following FAO guidelines.

Results

The study involved 503 adult hens distributed in 136 livestock households. Table 1 shows a distribution of

poultry monitored in the two agroecological zones.

Table 1: Agroecological zone and poultry monitored

Agroecological zone (Region)	Poultry (Chickens)	
	Number (N)	Percentage (%)
Analamanga	19	26
Itasy	983	24
Vakinankaratra	79	18
High Plateaus - South	341	68
South - East (Atsimo Atsinanana)	162	32
Grand total	503	100

Morpho-biometric characteristics of eggs

Egg color and shape

During the six months of monitoring the hens, a total of 4728 eggs were counted. Among these eggs, 77.2% had a brown shell and 22.8% had a white shell (Table 2). A predominance of white eggs was observed in the Itasy region (84.1%). On the other hand, a predominance of brown eggs was observed in the Atsimo Atsinanana region (41.6%).

Table 2: Agroecological zone and egg color

Egg characters: Color	White (N)	Brunette (N)	Grand total
Analamanga	19	1056	1075
Itasy	908	248	1156
Vakinankaratra	62	828	890
High Plateaus - South	989	2132	3121
South - East (Atsimo Atsinanana)	90	1517	1607
Grand total	1079	3649	4728

N = number of eggs

Furthermore, regarding the shape of the eggs counted, 89.6% had an oval shape and only 10.4% had a rounded shape. Of the 4238 oval-shaped eggs observed, 36.5% came from farms in the Atsimo Atsinanana region. Similarly, among the 490 round-shaped eggs inspected, 55.1% came from farms in the Vakinankaratra region. No round-shaped eggs were recorded in the Analamanga region. The table below shows the distribution of eggs according to their shape in the two agroecological zones.

Table 3: Agroecological zone and egg shape

Egg characters: Shape	Rounded (N)	Oval (N)	Grand total
Analamanga	-	1075	1075
Itasy	162	994	1156
Vakinankaratra	270	620	890
High Plateaus - South	432	2689	3121
South - East (Atsimo Atsinanana)	58	1549	1607
Grand total	490	4238	4728

N = number of eggs

Egg measurements

Of the eggs counted, the average weight in grams of an egg was 43.77 ± 4.79 for an average length in centimeters of 4.92 ± 0.25 and an average width in centimeters of 3.64 ± 0.19 .

Eggs from the Vakinankaratra region showed a higher average length than eggs from the Itasy region and the Atsimo Atsinanana region. Eggs from the Itasy region showed an average width of $3.69 \pm$ greater than those from the Analamanga, Vakinankaratra and Atsimo Atsinanana regions respectively. Bivariate analysis of egg length and width showed significant differences ($p < 0.001$) between agroecological zones (Southern Highlands and South-East). Analyses by region of origin showed that there were significant differences in egg length and width from the Analamanga and Atsimo Atsinanana regions on the one hand, and only for the length of eggs from the regions of Vakinankaratra and Atsimo Atsinanana on the other hand, as presented in Table 4.

Table 4: Agroecological zone and egg measurements

Egg characteristics: measurements	High Plateaus - South				South - East	Total Average -
	Analamanga (n=1075) (M $\pm$ σ)	Itasy (n=1156) (M $\pm$ σ)	Vakinankaratra (n=890) (M $\pm$ σ)	Average	Atsimo Atsinanana (n=1607) (M $\pm$ σ)	
Average egg length	4.84 ± 0.11^a	4.92 ± 0.34^{ab}	5.06 ± 0.24^a	4.93 ± 0.23	4.9 ± 0.21^a	4.92 ± 0.25
Average egg width	3.48 ± 0.12^a	3.69 ± 0.23^{ab}	3.68 ± 0.15^{ab}	4.62 ± 0.16	3.67 ± 0.17^b	3.64 ± 0.19
Average egg weight	43.35 ± 3.05^a	44.57 ± 5.23^{ab}	43.37 ± 4.07^a	43.81 ± 4.12	43.68 ± 5.64^a	43.77 ± 4.79

M $\pm$ σ : Mean $\pm$ Standard deviation; a and b = indicate the existence of statistically significant differences; *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

Performance of hens in reproduction

A total of 503 adult hens were monitored in four regions including 130 in Analamanga (period), 122 in Itasy (period), 89 in Vakinankaratra and 162 in Atsimo Atsinanana (period). The average number of eggs laid per hen per cycle was higher in the Vakinankaratra region (10 eggs) than in Analamanga (8.26 eggs), Itasy (9.47 eggs) and Atsimo Atsinanana (9.91 eggs) over the same period (Table 5). However, no significant difference in the average number of eggs laid was observed between the regions except that between Analamanga and Atsimo Atsinanana ($p < 0.001$). The average per agroecological zone is 9.14 eggs for the Southern Highlands zone, and 9.91 eggs for the South-East zone, and this difference is significant ($p < 0.001$). Similarly,

the hatching rate for the 4 regions is respectively 82.61% for Vakinankaratra, 95.07% for Analamanga and 84.27% for Itasy and 87.25% for Atsimo Atsinanana. This rate is 87.94% for the Southern Highlands zone and 87.25% for the South-East zone, and the difference is not significant ($p = 0.6$).

It appears that poultry from the Vakinankaratra and Atsimo Atsinanana regions are better layers than those of the Itasy and Analamanga regions (Table 5). On the other hand, although poultry from the Vakinankaratra regions are better for laying than others, they are less so for brooding. Poultry from the Analamanga region appear to be better brooders than those from other regions.

Table 5: Agroecological zone and reproduction performance

Hens' performances	High Plateaus - South				South-East	Total general
	Analamanga	Itasy	Vakinankaratra	Average	Atsimo Atsinanana	-
Number of hens followed	130	122	89	341	162	503
Number of eggs laid	1075	1156	890	3127	1607	4728
Average number of eggs laid/hen/cycle	8.26±2.45	9.47±2.64	9.95±2.21	9.14±1.5	9.91±2.53	9.39±2.57
Number of eggs hatched	1014 ^a	950 ^a	732 ^{ab}	2696	1390 ^b	4092
Average number of eggs hatched/hen/cycle	7.80±2.32	7.78±2.39	8.20±2.03	7.90±0.5	8.58±2.15	8.11±2.25
Hatching rate / chicken (%)	95.07	84.27	82.61	87.31	87.25	87.3

Driving chicks

Evolution of the average weight of chicks

Student t-test, the mean weight of the chicks evolves with a significant difference during the 6 weeks of growth except for the second week ($p = 0.790$). The mean weight of the

chicks in the South-East agroecological zone is significantly higher than that of the Southern Highlands zone ($p \leq 0.001$). This difference in mean weight intensifies more and more from the 4th week of age (figure 2).

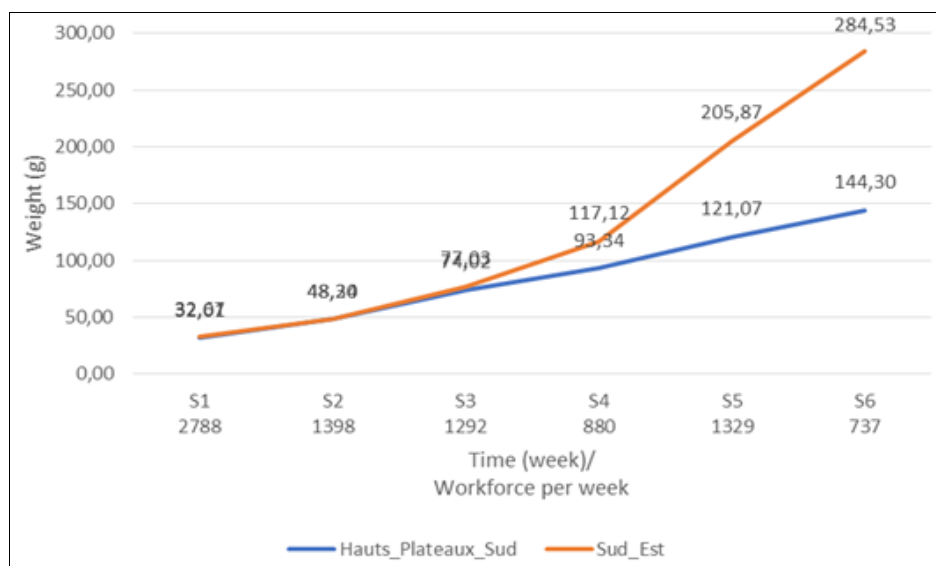


Fig 2: Agroecological zone and evolution of average chick weight

Chick mortality rate

Chi2 test showed that the mortality rate of chicks is significantly different between the two agroecological zones during the first 3 weeks of growth ($p < 0.001$). It peaks in the

3rd week for the South-East zone and decreases significantly until the 6th week. Mortality rates are not significantly different from the 4th to the 6th week. The p values are 0.008 (S4), 0.692 (S5) and 0.003 (S6), respectively.

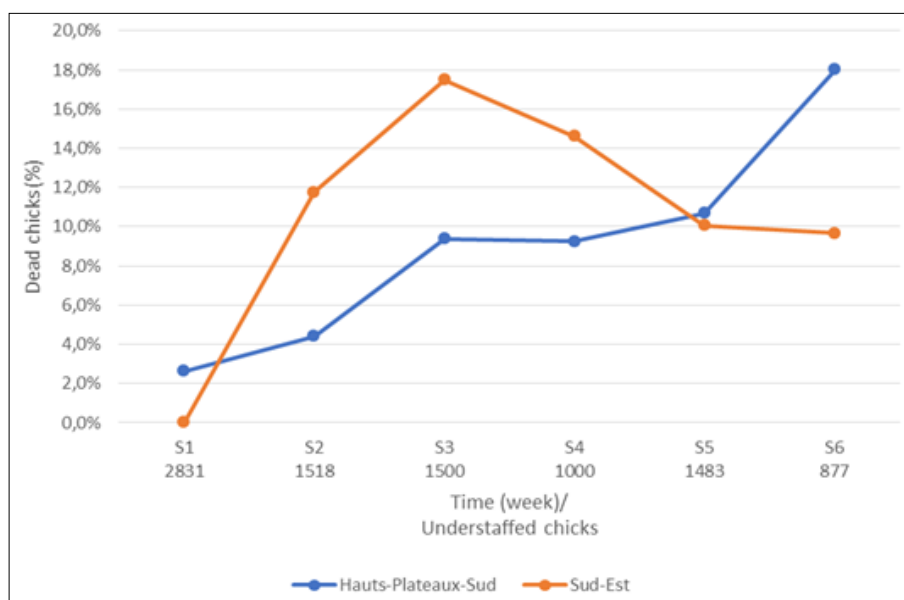


Fig 3: Agroecological zone and chick mortality rate

Discussion

Sample size

This study involved a total of 503 adult poultry, distributed in 136 farms and monitored for 6 months. The farms were found in two agroecological zones of Madagascar, namely the Southern Highlands zone and the South-East zone. The size of our flock, the number of farms and the period of monitoring of the hens differ from that of Nahimana *et al.* in Senegal who worked on 45 farms and monitored 90 hens specifically for one year. The minimum radius between our 7 study communes was 20 km. This distance is less than that announced in the study of Moussa *et al.* in Niger (25 km). On the other hand, in the same study, the number of villages was 4. The work of Keambou *et al.* in Cameroon had involved a total of 640 poultry [10, 23, 24].

Shell color and shape

A total of 4728 eggs were counted and identified during our study. This number is respectively 7.3 and 1.6 times higher than the numbers reported respectively in the Keambou study *and al.* in the West Cameroon region and the Koko *and al.* study in the Ambohimangakely and Moramanga areas of Madagascar. Regardless of our agroecological zones, brown and white shell eggs were recorded. However, a predominance of brown shell eggs was observed at 77.2% in our study with 41.6% in the Atsimo Atsinanana region. This brown color of the egg shell was also predominant in the West Cameroon region with a higher proportion than ours (84.84%) and more precisely in the rural area of their study. On the other hand, our results differ from those obtained by Missohou *and al.* who observed in the local chicken of Senegal a predominance of white eggs (73%) [25]. Indeed, it should be noted that egg colors and the thickness of the white are linked to genetic characteristics in poultry [26]. It is thus possible that there are genes linked to the color of the shell, which is different between poultry from Madagascar and Senegal, yet similar between poultry from Madagascar and Cameroon [2, 24].

The present study revealed that 89.6% of the eggs had an oval shape and only 10.4% had a rounded shape. These

results are similar to those obtained by Keambou *and al.* in the study titled "Comparison of egg quality and growth performance of local chicks from urban and rural areas of West Cameroon" [24].

Egg measurements

It was shown in our study that the average weight in grams of an egg was 43.75 ± 4.79 with no significance between the egg weights of the two agroecological zones. These results are similar to those found in poultry by Keambou *and al.* in the West Cameroon region which were respectively 44.89 ± 04.99 in rural areas and 45.94 ± 05.73 in urban areas. On the other hand, this weight average is higher than that obtained in the work of Missohou *and al.* carried out in Dakar where the average weight was 31.7 ± 3.9 [24, 25].

The results obtained by Keambou *and al.* in the same study were superior to ours in terms of egg length and width. Indeed, they reported an egg length of 5.42 ± 0.26 cm in rural areas and 5.43 ± 0.26 cm in urban areas, respectively, that is superior to ours which are respectively 4.93 ± 0.27 cm in the Southern Highlands and 4.90 ± 0.21 cm in the Southeast. Similarly, the egg width in their studies is respectively 3.94 ± 0.15 cm in the rural area and 3.96 ± 0.232 cm in the urban area and is superior to ours which is respectively 3.62 ± 0.20 cm in the Southern Highlands and 3.67 ± 0.17 cm in the Southeast [24]. These similarities and differences in weight, length and width of the measurements of eggs of local breed poultry observed in Madagascar and Cameroon could be explained by the difference in breed and agro-ecological zone.

Performance of hens in reproduction

Number of eggs laid and hatching rate

Our study involved 503 poultry from 4 districts located in two agroecological zones of Madagascar. We obtained an average of 9.14 eggs laid per hen and per cycle in the Southern Highlands. This value is lower than that of hens in the South-East, which was 9.91 eggs. These averages are lower than those found in the work of Koko *and al.* (11.7 eggs per hen and per clutch) in other ecological zones of

Madagascar. In Niger, Moussa *and al.* had found an average of 12.5 eggs per hen and per cycle ^[23], similar (12.4 eggs) to that of Missohou in Senegal ^[25]. Our averages are also lower than those found in the work of Akouango *and al.* in Congo Brazzaville, which were respectively 17 and 14 eggs in black and negro subjects and ermine tawny subjects ^[3]. These variations in the number of eggs laid per hen and per cycle could be explained on the one hand by the genetic variability of poultry and on the other hand by their ecosystem including the climate.

Our work also showed a hatching rate in the Southern Highlands of 87.31% and in the South-East of 87.25%. This difference is not significant and is interpreted as meaning that poultry from both agroecological zones would have the same performances in terms of incubation and egg hatching. However, our percentages are slightly lower than those found in Niger (higher than 87.98% for poultry aged over 25 weeks) and similar to those found by Nahimana ^[10, 23]. However, they are higher than the 78.6% found by Koko and his colleagues in 2006.). The climate as well as the breeding conditions could influence the assiduity of the mother hen during incubation, and thus influence the hatching rate ^[3]. This lack of significance could also be explained by the strong presence of laying hen farming (table egg production) in the High Plateaus - South agroecological zone, resulting in a low consumption of eggs from local breeds of poultry, unlike in the South-East agroecological zone. Indeed, a better laying rate should result in a better hatching rate, which is not the case for the South-East agroecological zone.

It is also important to note that there is a correlation between the fertility rate and the hatching rate in birds. This correlation considers the male/female ratio in the farm. In this study, we only considered the presence of at least one rooster capable of breeding in the farm. In addition, in village poultry farming, the poultry are stray and the rooster/hen ratio varies from one farm to another and also, the presence of roosters in the neighborhood not included in the study and which can influence the fertility rate and therefore the hatching rate ^[27].

Similarly, the availability of ranges or breeding areas, as well as their surface area and feed richness, would play an important role in poultry feeding. There is a correlation between range, feed and laying rate. In our study, these aspects were not addressed ^[28].

Driving chicks

Our study showed a significant difference between the weight of chicks in the South-East agroecological zone and that of the Southern Highlands. The evolution of the average weight of chicks from the first week to hatching is similar to that of Moussa *et al.* in Niger (2010) and Keambou *et al.* in Cameroon (2009). On the other hand, the average weight of chicks from hatching to the 4th week obtained in the work of Nahimana *et al.* in Senegal are lower than ours ^[10, 23].

The chick mortality rates observed in our study in the two areas showed a significant difference from the first to the third week. These rates were, however, lower than those found by Akouango *et al.* in Congo Brazzaville (4.24 ± 0.20%). This difference could be explained by the breed of poultry, but also by food availability, livestock management and the characteristics of the areas regarding poultry

diseases which should not be neglected.

Limitations of the study

This study involved 503 adult poultry of local breed. An increase in the number of chickens monitored could have improved the quality of our results. In addition, the duration of the poultry monitoring was 6 months, which is less than that found in the literature (which can go beyond a year and allow a better evaluation of the average number of eggs laid per cycle, and per hen (greater than or equal to 12 eggs in several studies), and the breeding management (weight of the chicks).

Conclusion

At the end of our study, which aimed to compare the zootechnical performances of local poultry from the agroecological zones of the Southern Highlands with those of the South-East in Madagascar, we can note that:

- With a production of about 10 eggs per cycle, poultry from the South-East Zone are better layers than those from the Southern Highlands Zone. The brown color and oval shape of the eggs are observed in both zones and are the most widespread.
- Although there is no significant difference between the egg weights of the two zones, it appears that the eggs of the South-East zone are of better caliber than those of the Southern Highlands. This observation could suggest the existence of a correlation between the weights of the eggs and that of the hen on the one hand, and between those of the eggs and the chicks at hatching.
- A significant difference was observed for the hatching and mortality rate between local poultry in the two zones. Thus, local poultry in the Southern Highlands zone would be less good at brooding and would have lower capacity in managing chicks than those in the South-East zone.

Although the genetic factor certainly plays an important role in the differences observed during the present study between the poultry of the two zones, like the breeding management, it would be interesting to conduct this study on a larger flock in order to improve the quality of the results on the one hand and to carry out molecular analyses to highlight the genetic diversities existing between the poultry of the two zones on the other hand.

Thanks

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References

1. Fotsa J, *et al.* Phenotypic characterization of local chicken (*Gallus gallus*) populations from the dense humid forest zone with bimodal rainfall in Cameroon.

- Animal Genetic Resources / Ressources scientifiques / Recursos genéticos animales. 2010;46:49-59.
2. Keambou T, *et al.* Morphobiometric characterization of genetic resources of local chickens from the western highlands of Cameroon. *Livestock Research for Rural Development*. 2007;19(8):1-15.
 3. Parisse A. Overview of some qualitative parameters in the morpho-biometric characterization of local chickens (*Gallus gallus*) or 'Batéké' in the northern and southern peripheries of Brazzaville in the Republic of Congo. *Animal Genetic Resources/Recursos Genéticos Animales*; 2019:12-18.
 4. Ayssiwede SB, *et al.* Traditional or indigenous chicken farming in Senegal and Sub-Saharan Africa: status report and constraints. In: *Annals of Veterinary Medicine*. Liège, Belgium: ULg-University of Liège; 2013. p. 312-325.
 5. Buldgen A, *et al.* Study of the demographic and zootechnical parameters of the local chicken of the Senegalese peanut basin. *Journal of Breeding and Veterinary Medicine of Tropical Countries*. 1992;45(3-4):341-347.
 6. Guèye E. Preserving poultry genetic resources. *International Network for Family Poultry Development*. 2001;11(1):2-11.
 7. Issa Y, Mopate L, Missohou A. Marketing and consumption of traditional poultry in sub-Saharan Africa. *Journal of Animal & Plant Sciences*. 2012;14(3):1985-1995.
 8. Joint FAO/IAEA. Improving farmyard poultry production in Africa: Interventions and their economic assessment. Proceedings of a final research coordination meeting. Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture; c2006. p. 42-59.
 9. Koko M, *et al.* Village poultry farming in Madagascar: productivity and growth performance. *Improving Farmyard Poultry Production in Africa: Interventions and Their Economic Assessment*. 2006:137-143.
 10. Nahimana G, *et al.* Improving chick survival and zootechnical performance of local hens in village conditions in Senegal. *Journal of Livestock and Veterinary Medicine in Tropical Countries*. 2017;70(1):3-8.
 11. Sarkar K, Bell J. Potential of indigenous chicken and its role in poverty alleviation and food security for rural households. *International Family Poultry Development Network*. 2006;16(2):16-28.
 12. MAEP. Agricultural Census (AR), 2004-2005 agricultural campaign, Volume IV. Ministry of Agriculture, Livestock and Fisheries; 2007. p. 110-113.
 13. MAEP. Rapid assessment of agricultural production, food security and the impacts of COVID-19 in Madagascar: 2019-2020 agricultural campaign. Ministry of Agriculture, Livestock and Fisheries of Madagascar; Food and Agriculture Organization; World Food Programme, Antananarivo; c2021. p. 68.
 14. Mraidi R. Modeling and control of Newcastle disease virus transmission in family poultry farms in Madagascar. University of Reunion; c2014. p. 41-54.
 15. Maminiana O, *et al.* Epidemiology of Newcastle disease in village poultry farming in Madagascar. *Rev Sci Tech Off Int Epi*. 2007;26:691-700.
 16. Ouedraogo B, *et al.* Characteristics of village poultry farming and influence of improvement techniques on its zootechnical performances in the Sourou province, North-West region of Burkina Faso. *International Journal of Biological and Chemical Sciences*. 2015;9(3):1528-1543.
 17. AnGR, BAHPA. Phenotypic characterization of local populations of chickens (*Gallus gallus domesticus*) in Togo. *Animal Health and Production*. 2015;15:15-22.
 18. Andriamaroarison A, *et al.* Identification of different ecotypes of village *akoho gasy* (*Gallus gallus domesticus*) in the regions of Analamanga and Atsimo Andrefana, Madagascar. *International Journal of Agriculture Extension and Social Development*. 2021;4(2):29-39.
 19. CREAM. Monograph Analamanga Region. Center for Research, Studies and Support for Economic Analysis in Madagascar; 2013. p. 1-296.
 20. CREAM. Itasy Region Monograph. Center for Research, Studies and Support for Economic Analysis in Madagascar; c2013. p. 1-174.
 21. CREAM. Monograph on the Vakinankaratra Region. Center for Research, Studies and Support for Economic Analysis in Madagascar; 2013. p. 1-169.
 22. CREAM. Monograph Region Atsimo Atsinanana. Center for Research, Studies and Support for Economic Analysis in Madagascar; c2013. p. 1-222.
 23. Amadou BM, Idi A, Benabdeljelil K. Rural family poultry farming in Niger: feeding and zootechnical performance. *Family Poultry Communications*. 2010;2(1):47-62.
 24. Keambou T, *et al.* Comparison of egg quality and growth performance of local chicks from urban and rural areas of West Cameroon. *International Journal of Biological and Chemical Sciences*. 2009;3(3):548-562.
 25. Missohou A, Sow R, Ngwe-Assoumou C. Morphobiometric characteristics of the Senegalese chicken. *Animal Genetic Resources/Recursos Genéticos Animales*. 1998;24:63-69.
 26. Mérat P, *et al.* Genes with visible effect and coloration or thickness of eggshells. In: *Annals of Genetics and Animal Selection*. EDP Sciences; c1970. p. 11-32.
 27. Sanfo R, *et al.* Effect of guinea fowl (*Numida meleagris*) egg weight on guinea fowl reproduction and growth parameters in Burkina Faso. *Journal of Livestock and Veterinary Medicine in Tropical Countries*. 2017;70(4):121-125.
 28. Mourad M, Bah A, Gbanamou G. Evaluation of the productivity and mortality of local chickens on the Sankaran plateau, Faranah, Guinea, in 1993-1994. *Journal of Livestock and Veterinary Medicine of Tropical Countries*. 1997;50(4):343-349.