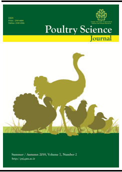

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Indigenous Race of Hen: Egg Physical Characteristics and Laying Performance - Case of a Family Poultry Farm in Madagascar

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Abstract
The purpose of the present study is to get a better knowledge of the Malagasy indigenous race of hen through its egg physical characteristics and its laying performance in order to promote villager poultry production. This study was undertaken within a local family farm, of the rural Township of Ambalamahasoa, Haute Matsiatra Region, Madagascar, with 25 hens and 4 roosters in age to reproduce. From 180 collected eggs and 4 incubation tests with three repetitions, the results showed that: 1 – Eggs were light weighted (average weight=45.49±4.63g), of small calibers (average length=4.82±0.22cm; average diameter = 3.61±0.15cm) but of normal format (average IF=0.75±0.03) 2 – they were presenting a good fertility rate (73.94%) with a high hatching percentage (90.16%) and a low embryonic death rate (9.84%). The mother-hen is both a good brooder and a good local reproducer. Egg physical variability reflects a broad genetic diversity within the indigenous race among the poultry population; which could constitute an asset for villager poultry production promotion and poultry biodiversity conservation in Madagascar.

Introduction

Due to its rusticity and its greater ability to adjust to the environment, the indigenous race chicken is often raised in low input villager systems and, therefore, with low production rate. Moreover, the animals are not spared by illnesses such as the avian cholera or the Newcastle disease because of lack of periodic immunizations (Bonfoh *et al.*, 1997; Devine, 2003; Ocean-Consultant, 2004; FOFIFA, 2006; MAEP, 2013a). Besides, they are raised within a non-organized, informal system which potentially could be able to offer a non-negligible opportunity for the improvement of rural farmer standard of living. More, the raising of indigenous race hen is oriented toward fertilized egg production in order to increase flock size in order to cover the daily needs of the households. Natural incubation is the most convenient reproduction method used due to lack of electricity but also because indigenous race hens are excellent brooders. However, some incubation losses have been recorded within some poultry farmer households (Ocean Consultant, 2004; FOFIFA, 2006; MAEP, 2013a). Thus, this study was initiated to improve the knowledge about poultry indigenous race egg physical characteristics as well as its hatching performance in natural incubation.

Materials and Methods

This study was undertaken in a family poultry farm raising indigenous race chicken, located in the rural Commune of Ambalamahasoa, Haute Matsiatra Region (ex-province of Fianarantsoa), for a duration of 7 months, from November 2016 up until June 2017. A total of 25 females and 4 males having reached maturity (aged 7 months to 3 years), of indigenous race were used. The birds were raised outside in liberty while benefitting from staple food residues and losses from rice harvesting. A total of 180 eggs were collected and incubated in lots of 15 eggs each, by 4 mother hen chosen at random among the 25 initial laying females in order to get 4 incubation tests and 3 repetitions by each mother-hen. Each hatching material is constituted of a basket filled with a straw litter. The normal length of an incubation period is 21 days. The mother hen itself

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would take care of the good progress of the incubation process while feeding itself appropriately.

In order to appreciate egg quality, only one single criterion was kept, the shell integrity state. Each egg was weighed (weight) with an electronic scale of 1g precision, and its length (Lω) and its diameter (Dω) were determined using a Vernier caliper of 0.01mm precision (Figure 1) (Ayorinde and Ayeni, 1986; Sanou, 2005).

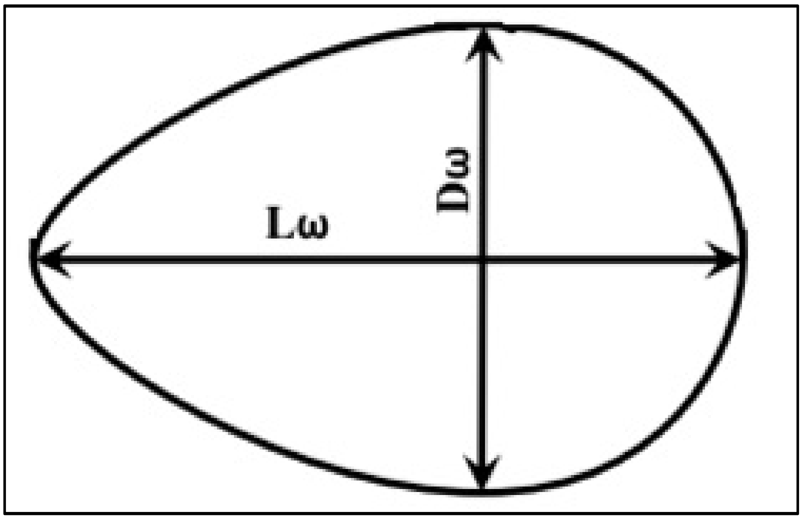

Figure 1. **Egg measurements**
Lω : Egg length (cm) ; Dω : Egg diameter (cm)

Besides the descriptive and comparative statistical analyses used during fertilized egg characterization (Dagnelie, 1986; Vessereau, 1988), a. two other metric variables were calculated in order to fully appreciate the egg physical characteristics (Bonnet and Mongin, 1965; Sanou, 2005):

1 - egg volume (Vω) (Bonnet and Mongin, 1965) according to the equation (1)

$$V\omega = \frac{\pi}{6}(L\omega)(D\omega)^2 \ (1)$$

with π = 3,14 : $L\omega$: egg length(cm) ; $D\omega$: egg diameter (cm) ; $V\omega$: egg volume (cm^3)

2 – a. egg shape index (IF) (Gendron and Blentz, 1970; Panda, 1996) according to the equation (2)

$$IF = \frac{D\omega}{L\omega} \ (2)$$

with $L\omega$: egg length(cm); $D\omega$: egg diameter (cm); $V\omega$: egg volume (cm^3)

and- b. five incubation variables were considered for natural incubation performance assessment (Ayorinde and Ayeni, 1987):

1 - the clear egg rate, equation (3)

$$Clear\ egg\ rate = \frac{Clear\ egg\ number}{Incubated\ egg\ number} \text{ X } 100 \ (3)$$

2 - the fertilized egg rate, equation (4)

$$Fertilized\ egg\ rate = \frac{Fertilized\ egg\ number}{Incubated\ egg\ number} \text{ X } 100 \ (4)$$

3 - the embryonic death rate, equation (5)

$$Embryonic\ deathrate = \frac{Egg\ with\ dead\ embryo\ number}{Fertilized\ egg\ number} \text{ X } 100 \ (5)$$

4 – the apparent hatching rate, equation (6)

$$Apparent\ hatching\ rate = \frac{Hatched\ chicklet\ number}{Incubated\ egg\ number} \text{ X } 100 \ (6)$$

and 5 - the actual hatching rate, equation (7)

$$Actual\ hatching\ rate = \frac{Hatched\ chicklet\ number}{Fertilized\ egg\ number} \text{ X } 100 \ (7)$$

The JMP/SAS 5.0.1.2 software as well as the Tukey multiple comparison test at 5% level were used during the collected data statistical treatments.

Results and Discussion

Egg physical characteristics

The whole set of collected and studied eggs shows a one-mode weight structure spread toward the left with a modal class comprised between 44g and 48g (thus 36% of the population) (Figure 2).

A wide weight distribution (32g to 55g) of the indigenous race chicken eggs was noted during this study in relation to the proposed typology by Kenneth (1981) as well as for those met in West and Central Africa for an egg weight comprised between 37.95g and 44.90g (Fotsa, 2008). Moreover, eggs were of small calibers (average Length = 4.82±0.22cm; average Diameter = 3.61±0.15cm) and light in weight (average Weight = 45.49±4.63g) (Table 1).

The average weight of this study indigenous race chicken eggs (45.49±4.63g) (Table 1) were significantly lower than those of improved races such as the Arbor Acres broiler strain in Madagascar which showed an average egg weight in the order of 59.73±0.24g (Raharimanana, 2017), the Isa Brown layer strain, with an average egg weight varying from 62.90±0.25g to 63.43±0.33g (Ratsarasataharitera, 2016; Hantanirina *et al.*, 2018), the Hy-line strain (average egg weight varying from 57.92g to 59.34g)

(Rabenirina, 2006) or the Lohman layer strain (average egg weight = 64.5g) (Schmutz, 2013). Yet, the results of this study showed a value similar to that found in Cameroon (weight = 44.89g) (Keambou *et al.*, 2009); Madagascar indigenous race chicken egg is heavier compared to that of Fayoum local race in Egypt (weight = 42g) (Zaza, 1992; Akouango *et al.*, 2010) or to that of Center Burkina Faso local guinea fowl (29.2±1.7g to 37.8±3.5g) (Sanfo *et al.*, 2012); or also of Western Burkina Faso local guinea fowl(35.7±2.Bg) (Hien, 2002); of Central Mali (37.3g) (Kuit *et al.*, 1986) or of Nigeria (35.8g to 44.6g) (Ayorinde, 1991). Otherwise, egg recommended minimum size among layer strains (weight = 50g) (Marcelo, 2014) is included within this study weight interval (egg weight varying from 32g to 55g) (Table 1). This allows to conclude that Madagascar indigenous race chicken could be classified as one of the local egg producers, in spite of noted differences in performance compared to that of improved races.

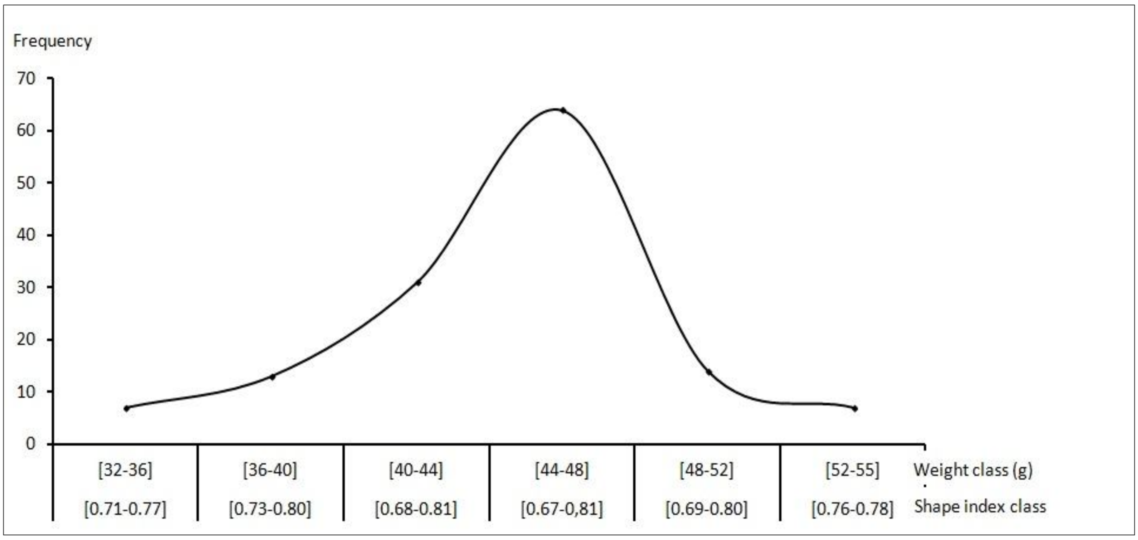

Figure 2. Indigenous race chicken egg weight structure

Table 1. Indigenous race chicken egg physical characteristics (mean±SE)

	Overall (n = 180)	Test 1 (n = 45)	Test 2 (n = 45)	Test 3 (n = 45)	Test 4 (n = 45)
Weight (g)	45.49 ± 4.63 32 – 55	44.96 ± 4.49 32 – 53	43.87 ± 5.76 32 – 52	47.20 ± 3.22 38 – 54	45.96 ± 3.98 43 – 55
Length (cm)	4.82 ± 0.22 4.30 – 5.20	4.82 ± 0.22 4.30 – 5.20	4.71 ± 0.26 4.30 – 5.20	4.95 ± 0.15 4.50 – 5.20	4.79 ± 0.17 4.40 – 5.10
Diameter (cm)	3.61 ± 0.15 3.20 – 4.00	3.57 ± 0.12 3.30 – 3.90	3.59 ± 0.18 3.20 – 3.80	3.69 ± 0.12 3.40 – 4.00	3.62 ± 0.12 3.40 – 3.90
Volume (cm^3)	33.10 ± 3.76 23.58 – 43.54	32.27 ± 3.22 24.51 – 39.00	31.97 ± 4.64 23.58 – 37.78	35.29 ± 3.00 27.22 – 43.54	32.88 ± 3.09 27.83 – 39.80
Shape Index (IF)	0.75 ± 0.03 0.67 – 0.81	0.74 ± 0.03 0.67 – 0.80	0.76 ± 0.03 0.71 – 0.81	0.74 ± 0.02 0.67 – 0.81	0.76 ± 0.03 0.69 – 0.80

On the other hand, large egg format variability may be noted with a shape index ranging from 0.67 to 0.81 (Table 1). this indicates that indigenous race chicken eggs may take either a stretched out format (IF = 0.67) or a rounded one (IF = 0.81), going through the normal value interval (IF = 0.70 to 0.75); thus, eggs are able to reach an index of 0.65 for a very stretched out one or an index of 0.82, for a very rounded egg (Sauveur, 1988); that includes standard formatted eggs (0.72 to 0.75) (Gendron and Blentz, 1970). However, on average, eggs in this study could be assumed to present a normal format (average IF = 0.75±0.03) (Table 1). Thus, the shape index values found in this study are similar to those obtained with the Hy-line Brown layer strain (IF = 0.76) (Rabenirina, 2006) and (IF ranging from 0.76 to 0.77) (Er *et al.*, 2007) as well as with those of Vietnamese layer races (IF = 0.76 to 0.78) (Moula *et al.*, 2011) or those of Rugao layer strain (IF = 0.76 to 0.78) (Shi *et al*., 2012). The indigenous race chicken egg shape index of this study also presents similarities to that of Benin local guinea fowl (IF = 0.75) (Houndonougbo *et al*., 2014) or that of Center Burkina Faso guinea fowl (0.76±0.02 to 0.79±0.05) (Sanfo *et al*., 2012). Moreover, this shape index is similar to that of the Isa Brown strain (IF = 0.72 to 0.75) (Ratsarasataharitera, 2016; Hantanirina *et al*., 2018), to that of the Japanese quail (IF = 0.77 to 0.78) (Zita *et al*., 2013) as well as to that of Japanese quail raised in Algeria (IF = 0.79) (Smaï *et al*., 2018).

Indeed, egg physical characteristics (weight, volume and the shape) are not only affected by the mother hen age - noting that egg laid at the beginning of the laying period are more stretched out, meaning that the egg shape index value decreases with mother hen age (Moula *et al*., 2014) - but also by the mother hen ingested feed quantity and quality (Ratsimbarison, 2004; Ayssiwede *et al*., 2011; Gueye and Bessei, 2013; Juin *et al*., 2015). On the other hand, egg volume increases with egg weight (Akram *et al*., 2014). Moreover, shape index (IF) affects hatching rate as much as egg resistance is important for the success of the laying and the hatching process (Moula *et al*., 2014; Smaï *et al*., 2018). However, it should be noted that shell solidity decreases with the mother hen age (Nau *et al*., 2010a; Nau *et al*., 2010b) and egg tends to be rounder as the mother hen age increases (Moula *et al*., 2014). This last variability is also related to animal strain, climate, daylight length, age of hen at first laying, laying period and feed protein level (Lacassagne and Jacquet, 1963; Pagot *et al*., 1983; Galea *et al*., 2003; Narushin, 2005; Sanou, 2005; Thiele, 2009; Nau *et al*., 2010a; Nau *et al*., 2010b; King'Ori, 2012; Soltani *et al*., 2014; Yavuz and Kalinowsk, 2014).

Natural incubation

On the whole, the indigenous race hen is a good brooder for an actual hatching rate of about 90%; it is also a good reproducer with an egg fertility rate of about 74% combined with a low embryonic death rate (about 10%) (Table 2).

Table 2. Natural incubation performance

Rate (%)	Whole (n = 165)	Test 1 (n = 41)	Test 2 (n = 43)	Test 3 (n = 42)	Test 4 (n = 39)
Clear egg	26.06	14.63	39.53	14.29	35.90
Fertilized egg	73.94	85.37	60.47	85.71	64.10
Embryonic death	9.84	8.57	15.38	5.56	12.00
Apparent hatching	66.67	78.05	51.16	80.95	56.41
Actual hatching	90.16	91.43	84.62	94.44	88.00

This study natural incubation hatching rate in the order of 90.16% (Table 2) may be compared to and is similar to the indigenous race hatching rate found in former study (70% to 80%) (Raharison, 2004) as well as to that of artificial incubation observed with Arbor acres (a broiler strain) in the order of 90.10% (Raharimanana, 2017). Otherwise, this study fertility rate (about 74%) (Table 2) is noticeably lower than that of the broiler strain Arbor acres, about 96%; clear (non fertilized) egg rate is also lower (26% *vs* 4%) as well as the death rate (about 10% *vs* 5%) (Raharimanana, 2017).

Concerning the death rate, this study shows a very low rate (10%) compared to what was found in Burkina Faso with this country indigenous race chicken (death rate up to 40.9%) (Seydou, 2011) or with the Center of Burkina Faso local guinea fowl, with death rate in the order of 25.7% (Sanfo *et al*., 2012); but it is higher than that of Azeroul (2006) which shows a rate in the order of 7.3%.

Nevertheless, this study results might be classified as one of the best results obtained with the Malagasy indigenous race chicken since here the hatching rate found seems to be higher in a rural environment setting (50% to 79.62%) than in research station (70% to 76%) (Wageningen *et al*., 1998; Wageningen *et al*., 2004; Ayssiwede *et al*., 2011) or considering the actual hatching rate (74.3%) obtained with Center Burkina Faso local guinea fowl (Sanfo *et al*., 2012); however, those rates are similar to that of Niger guinea fowl (55% to 100%) (Assoumane and Gouro, 1997). Thus, it can be implied that the Malagasy indigenous race chicken in a natural brooding system, in this study, is more effective than West Africa guinea fowl (hatching rate of 85.2% in artificial incubation and 82.9% in natural incubation) (Sonaiya, 1992). Yet, Center Burkina Faso local guinea fowl eggs are more fertile (82.7%) (Sanfo *et al*., 2012) than that of indigenous race chicken in this study (73.94%) (Table 2); this egg fertility rate (73.94%) is higher than the rate mentioned by Sauveur (1988).

Therefore, natural incubation success would be based mostly on the mother hen incubation performance, on sex-ratio (Sauveur, 1988), on strain

(Assoumane and Gouro, 1997), but also on animal raising management method as, among others, fertilized egg collection frequency and egg physical characteristics (Sauveur, 1988; Smaï *et al*., 2018).

Indeed, a regular daily fertilized egg collection is necessary to avoid the phenomenon of egg pre-incubation during the laying period. This pre-incubation (warming up of non collected laid egg) has a negative effect on fertilized egg hatching rate (Wageningen *et al*., 1998; Fasenko *et al*., 2002; Wageningen *et al*., 2004; Fasenko, 2007; Fasenko *et al*., 2009; Uddin and Hamidu, 2014). Moreover, probabilities to get low embryonic mortality rates are higher with shorter fertilized egg conservation duration (Ayorinde, 2004; Sanou, 2005; Fasenko, 2007).

Besides, temperature and humidity (relative humidity) are incubation success two major and determining factors. For low temperature (lower than 35°C), there is a delay in hatching, while with high temperature (higher than 40°C) embryonic mortality would increase. Thus, optimal incubation temperature would be between 37°C and 38°C for a good embryonic development allowing thereafter to get more vigorous chicks (Decuypere *et al*., 1979; Pagot *et al*., 1983; Decuypere and Michels, 1992; Wageningen *et al*., 1998; Decuypere *et al*., 2001; Wageningen *et al*., 2004; Lourens *et al*., 2005; Cobb-Vantress, 2013b). Humidity, more or less, acts in the same way since, with too low a relative humidity, the eggs would dry up while, with too high a relative humidity, the egg air chamber would shrink. The optimal incubation relative humidity would be comprised between 50% and 60% during all the incubation period, to rise up to 65% for the last three days of this period (Wageningen *et al*., 1998; Sauveur and Picard, 1990; Baggott, 2001; Wageningen *et al*., 2004). Thus, in natural incubation, obtaining optimal incubation temperature is instinctively insured by the mother hen along with the appropriate heat distribution among the brooded eggs in order to allow a good embryo development inside the egg itself. The same way is valid for relative humidity regulation during incubation; egg ventilation would take place during the period when the mother hen leaves the nest to feed itself (Sauveur, 1988; Wageningen *et al*., 1998; Wageningen *et al*., 2004; Orr, 2012). Nevertheless, it should be noted that much stretched out or very rounded eggs would have low hatching rates (Sauveur, 1988).

Conclusion

This study allowed to describe Madagascar indigenous race chicken incubation performance as well as its egg outer physical characteristics. The results showed that indigenous race chicken eggs are of small calibers, light weighted but, of various shapes (from rounded to stretched out) and that the indigenous race hen is a good brooder, enabling it to be qualified as the local reproducer. Egg physical variability met during this study reflects a broad genetic diversity within the indigenous race chicken population of Madagascar. This later fact deserves to be exploited in order to promote rural villager poultry production through technical supports and production network organization for economic development and poultry biodiversity conservation.

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