Characteristics of Guinea Fowl Breeding in West Africa: A Review

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Summary

Guinea fowl production in sub-Saharan Africa (SSA) is generally practiced under family and traditional rearing systems mainly for consumption and income generation, but this species plays also a major socio-cultural role in specific ceremonies. Birds are kept in free range or in confinement with outdoor access and fed on grain cereals, vegetables, edible termites and kitchen residues found in nature or occasionally supplied by the farmers. Several Guinea fowl varieties are observed and all are characterized by slow growth, high mortality of young animals and a relatively wild instinct. Although this avian species is resistant to some poultry diseases (Newcastle disease, Marek disease, Gumboro disease, …), local guinea fowl are very sensitive to other poorly controlled diseases that require further study. These varieties differ greatly by their feather color, their morphological characteristics and growth performance, but further thorough and sustained research is needed to quantify these differences. Several researches established the nutritional requirements of local Guinea fowl but in terms of breeding, little works were done compared to chicken. Some recessive and dominant genes as well as genotypic differences were highlighted between varieties.

Résumé

Elevage de la pintade en Afrique de l'Ouest: une synthèse bibliographique

L'élevage de la pintade locale en Afrique subsaharienne se pratique généralement selon un système d'élevage familial. Dans ce système, les animaux sont en divagation stricte ou en semi-liberté et se nourrissent de grains de céréales, de végétaux, de termites non toxiques et de restes de cuisine trouvés dans la nature ou occasionnellement servis par les éleveurs. Plusieurs groupes à nuances spéciales appelés variétés sont rencontrés et sont caractérisés par une faible croissance, une forte mortalité des jeunes et un instinct sauvage. Semblables par leur forme, ces variétés diffèrent fortement par la couleur de leur plumage. En ce qui concerne les caractéristiques morphologiques et les performances de croissance, des différences ont été signalées par certains auteurs, mais méritent des recherches approfondies et soutenues pour mettre en évidence les dissemblances entre les variétés élevées. Des efforts de recherche ont été consentis dans le domaine de l'alimentation et ont permis d'avoir une idée sur les besoins nutritionnels de la pintade locale. Sur le plan de l'amélioration génétique, peu de travaux ont été effectués comparativement au poulet. Mais d'ores et déjà, des gènes récessifs et dominants de même que des différences génotypiques ont été soulignées entre les variétés. Sur le plan pathologique, bien que résistante à certaines maladies aviaires, les pintades locales restent sensibles à d'autres maladies très peu maîtrisées qui nécessitent des études plus approfondies.

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Introduction

In the tropics and specifically in West Africa, small poultry farming holds an important share in the agricultural economy which contributes up to 37% of the gross domestic product (GDP) and over 85% of export earnings of developing countries (19). Livestock production contributes up to 6% of national GDPs (42). In Benin, livestock estimates for 2014 for poultry reached 23,221,000 birds (13), while local breeds in species of poultry including chickens, ducks, Guinea fowls, turkeys, and pigeons, averaged 11.2 million birds and produced 10,560 tons of meat in 2004 (18). The importance of Guinea fowls (*Numida meleagris*) in national flocks varies according to the country. For example, with 6.5 million birds, it ranks 2nd after chicken in Burkina Faso (42), while in Benin, Guinea fowl is the 3rd most represented domestic bird species, after chicken and duck. Local guinea fowl populations in Benin represent 11% of the national poultry population, or 3.5 millions of birds, of which 79% are found in the north of Benin (9). Similar numbers are found in Burkina Faso with 6,117,826 heads in 2004 (38). The Ghana bird population in 2010 was about 36,271,000 heads including 7.1% of guinea fowl or approximately 2,575,000 heads (20). In Niger, according to Moussa Amadou et al. (33), the domestic poultry population in 2007 was 120,190,000 with in first rank the chicken (55%) followed by guinea fowl (26%). In the African tropics, Guinea fowls provide not only high quality dietary protein but these birds play also an important social and cultural role (14, 42). Guinea fowl is used to welcome important guests, as respectable social gifts, funerals, festivals, sacrifices and payment of dowries (10, 16). The motivations for the practice of small poultry farming are double: income generation through the sale of live poultry and sometimes eggs, and household consumption (31, 28). Guinea fowl meat is considered as a delicacy with demand being higher than supply and high price that make it a useful tool for poverty reduction (3). Dahouda (14) reported live guinea fowl and eggs prices of 1630 FCFA and 45 FCFA, respectively, when chicken is sold in Benin between the price of 800 and 1450 FCFA, and adult male between 1000 and 2000 FCFA while the chicken eggs are sold between 30 and 35 FCFA in 2002 (11). In Ghana, incomes derived by the guinea fowl breeders consists of 71% of the sale of live animals and 39% from eggs with an average profit of 8% (24).

However, despite similar carcass dressing percentage, it is suspected that Guinea fowl has a higher production cost associated with a longer rearing period and a high feed conversion ratio estimated to 2.74 in comparison to 1.96 for chicken in intensive production systems (35). With 12 to 14 weeks, Guinea fowls take twice the time to reach a commercial live weight compared to the 7 to 8 weeks required for chicken.

Moreover, despite a strong market demand, rearing Guinea fowls in tropical Africa is undermined by several constraints such as feed quality and quantity and shelter that affect the health of the animals and the productivity of the whole system (42). Currently there is also only very limited work done on the genetic improvement of Guinea fowls under local conditions (38, 40, 7, 42). As stated before, in industrial systems, a production cycle for meat lasts between 82 and 94d (25). But in Benin and Burkina Faso, it may take 5 to 6 months (14, 42). In addition, most small poultry farmers raise birds from local breeds which performance potential are unknown. This manuscript reviews the characteristics of the traditional breeding system of local guinea fowls in West Africa focusing on the assets and constraints of this activity and the particularities of the varieties that are reared.

Origin and environmental requirements of Guinea fowls

Guinea fowls are part of the Galliformes order, lower order of the Alectoropodes, family of the *Phasianidae*, and subfamily of the Numididae including 4 genera (*Numida*, *Agelastes, Acryllium* and *Gutta*). Different species of *Numida* are found where *Numida meleagris* is the common ascendant strain of the domestic fowl that includes several varieties and improved strains (12, 29). Originating from hot and dry environments in tropical West Africa (7), the domestic Guinea fowl has generated different varieties that spread throughout the world with human migrations (12). First traces date back to the Antiquity with references in the Greek mythology stating that Guinea fowls were born from the transformation of the King Meleager's sisters in birds by the goddess Artemis. Guinea fowls were mainly used in ancient Rome and Greece as birds for sacrifice. Later, they left the altars for Greek and Roman tables and began to be raised in farmyards. Their trace was lost in Europe during the Dark Ages, reappearing in the late Middle Ages (1300 – 1500) (12, 29). Later, as for poultry in general, intensive rearing and breeding techniques were developed and the Guinea fowl industry is nowadays well-developed in some countries such as France or the US. Although, Guinea fowls originate from the tropics, the comfort zone of adult birds ranges from 10 to 25 °C (50) and feed intake strongly decreases between 20 and 30% when temperature reaches 32 °C. As for chicks during the first 30 days of life, the thermoneutrality zone is higher (31 to 33 °C) and thermoregulation is inefficient, inducing high death toll of young guinea fowls if T is too low (29).

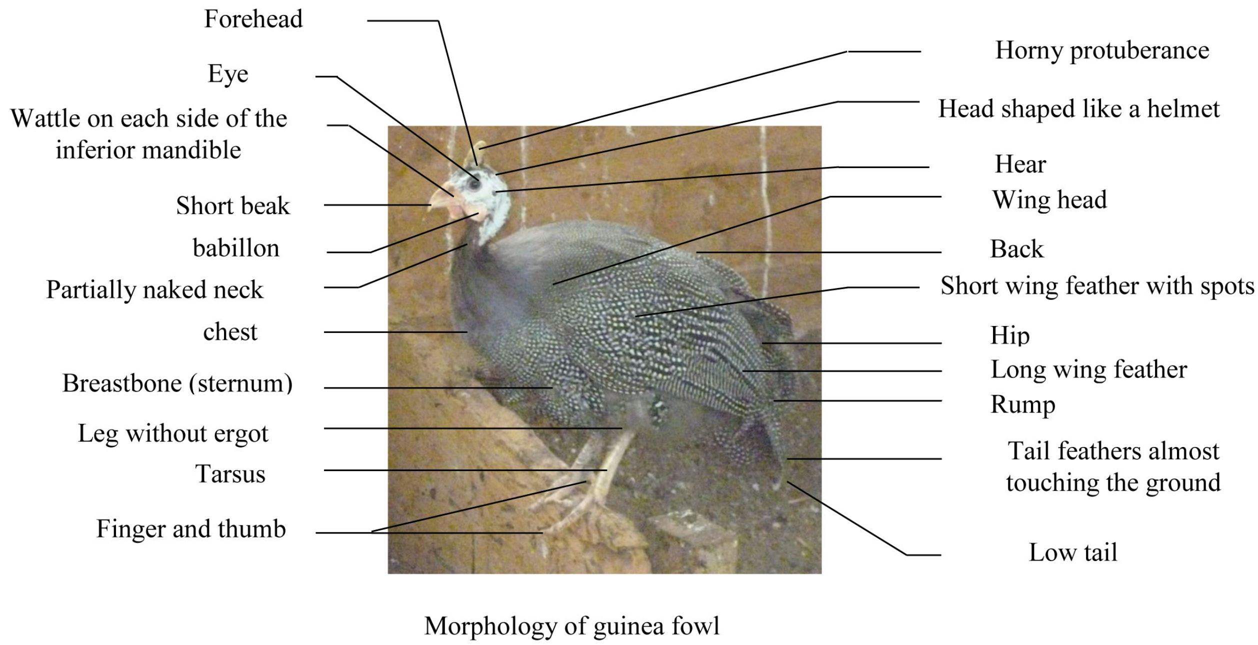

Figure 1: Morphology of a guinea fowl.

Table 1
Morphological differences between guinea fowl varieties.

The morphological part	Morphological characteristics betw een varieties
Body length	Varying from 43 to 75 cm according to the variety (21, 45).
Sternum length	9.03 cm for Common, 8.85 cm for Ash and 8.93 cm for Black at 28 w eeks (17)
Tarsus length, drumstick length, body length, w ings length and the chest circumferences	Similar betw een varieties (17)
Main characters (15)	
White Guinea fow l or albino guinea fow l: w hich is rare and the feathers are completely w hite w ithout beads (chicks and adults) and their skin is not pigmented	
Chamois guinea fow l: Feathers are yellow ish-slightly ocher and is sometimes w rongly referred to as White guinea fow ls	
Lilac guinea fow l: w ith bright blue gray feather and dark chest and neck	
Isabella guinea fow l: Feathers are beige w ith	
Purple guinea fow l: Feather are uniformly dark	
Bonaparte guinea fow l: Considered as a crossed breed betw een Gray, Lilac, Purple, and White varieties. It presents w hite-albino feathers on the chest and secondary flight feathers on the w ings, but never at the top nor on the tail. They also give birth to very heterogeneous groups, concerning the plumage	

Surprisingly, there is also a strong sensitivity to day-length in the development of reproductive organs and the fattening of females resulting in a well-marked laying season (40), possibly resulting in a synchrony between resources availability and egg production. The best performances are reported to be found in the rainy season; when it was observed in West Africa that feed intake was highest (28). Furthermore, the birds lay in cycles of up to 40 weeks which coincide with the rainy season and last until several weeks after the onset of the dry season (3, 28). Finally, Bougon *et al.* (8) reported that under continuous lighting conditions, fat deposition was reduced by 12 and 23% for males and females, respectively.

Morphology and genotype of Guinea fowls

The birds of the subfamily *Numidae*, including guinea fowl (Figure 1), have the form of vultures and were well described by various authors (4, 5, 7, 12, 21, 21). Unlike most avian species, sexual dimorphism in Guinea fowls is characterized by heavier females than males (29). The weight development of both sexes is the same until 12 weeks of age, but beyond, females display higher weight gains with a difference of about 20% as a consequence of sexual maturity resulting in higher fat deposition and development of the genitalia (6). Cloaca examination is the surest assessment concerning sexing at 8 weeks of age (2). The cry is also an element of sexing used by farmers; according to them it is composed of double syllables and monosyllable for females and males, respectively (9).

Numida meleagris var. *galeata* commonly called the pearl gray helmeted Guinea fowl is the most widespread variety in Africa (Table 1). The cephalic protuberance is brown-colored; the cheeks take on lilac, dark brown eyes, bright red wattles, and pink beak at basis with ash-like color at the other end. The legs are slate gray; the feathers are blue-gray with many bead-shaped white spots (21, 45). The neck and the upper breast are black-blue uniform. Newly hatched pearl gray helmeted Guinea fowl chicks are red-brown with five black longitudinal stripes on the head. Their back is striped and dotted with black spots and stripes and the belly is yellowish. Their legs and beak are red (21, 45). The first feather of chicks after hatching is brown edged with red and yellow brown color (29). From the fifth to the tenth week, tiny white spots appear in a gray-brown feather. From the tenth week, the guinea fowl take their adult morphology (29). Despite morphological common features, some differences not only in plumage color but also in body part sizes allows to differentiate 5 additional varieties which presence varies with the location between and within countries such as Benin, Niger or Nigeria (4, 9, 45). Table 1 shows some morphological differences between some varieties. According to Dams (15), the different colors of guinea fowl are characterized by different genes (Table 1). The lilac color is represented by an autosomal recessive gene 'l', a dilution of gray with a background blue azure color, chicks having light ash-colored stripes with dark ash. Chamois guinea fowls have an autosomal recessive gene ‘c’ and a pigmented skin with yellow stripes slightly reddish. The gray color is observed in individuals carrying at least one dominant allele, the Lilac 'L', the chamois 'c' or isabelle 'Is'; thus, the pearl gray guinea fowl are generally heterozygous and frequently obtained from crossing between the 'violet' and 'lilac' ones. Finally, the Dun color, is present on a sex-related gene with 'is is' for the male and 'is-' for females. Conversely to mammals, male birds have two identical sex chromosomes while female birds have two different sex chromosomes (15). Likewise, it is difficult to obtain double recessive males from Isabella individuals regarding a gene linked to the sex. However, auto sexing crossings are possible. Possible genetic formulas of different colors according to Dams (15) are described in Table 2. Notwithstanding plumage differences, genetic variations seem to affect birds performances as different varieties differ also in terms of productive straits (17) and resistance under traditional farming conditions (42): e.g. number of eggs laid per season, egg, quality such as shell thickness and viability of young guinea fowls. Ayorinde et al. (4) showed significant difference between consumption and feed conversion between white, gray, black and ash varieties; while the growth performance did not vary significantly.

The challenge in Guinea fowl reproductive improvement in traditional farming systems of West Africa lies in the enhancement of the laying performance, including egg weight, conformation of the shell, eggs hatchability rates, in females and the ability to harvest the semen volume and fertility in males. The complexity of guinea fowl improvement is related to the fact that laying and weight performances on one hand and levels of abdominal fat and meat yield on the other are antagonist criteria (5) while both are important for increased productivity in dual purpose traditional systems. The genetic variability of local guinea fowl already illustrated by the differences in variety has also been highlighted by microsatellites studies (27). Singh et al. (46) showed by a multivariate test of cluster that there is a low (weak) genetic distance between the guinea fowl of variety lavender and the varieties of hens and quails (0.211-0.215) but a genetic great distance with the duck and the turkey (goose) (0.343-0.350). This genetic variability opens a huge opportunity to improve local varieties of guinea fowl in sub-Saharan Africa.

Table 2
Genetic formulas of different colors (15).

Guinea fow l w ith pearls	Guinea fow l w ithout pearls
Pure Gray: PP LL CC Is (Is Is for male)	Purple: pp LL CC Is (Is Is for male)
Lilac: Pp ll CC is (Is Is for male)	Azure: ppll CC is- (Is Is for male)
Isabelle: PP LL CC is- (is is for male)	Rachel: pp LL CC is- (is is for male)
Buff: PP LL cc Is- (Is Is for male)	Fulva: pp LL cc Is- (Is Is for male)

According to our knowledge only France is operating an organized guinea fowl genetic improvement system (43). This system is based on the breeding and improvement of closed complementary female and male lines and their crossing to obtain final production (30). The current system is based on traditional phenotypic and genealogical information. Genomic selection is not expected to be used until five or ten years because, the genome of the guinea fowl has not yet been sequenced and genomic selection remains costly (30). For the same author, profitability of guinea fowl genomic selection is much less obvious than in cattle where the generation interval is longer.

Traditional rearing system in West Africa

The traditional free-range rearing system for Guinea fowls in West Africa is well documented (40, 7). It is integrated in the family poultry rearing system where birds scavenge in groups of at least twelve birds together with birds of different age and species such as chicken, Muscovy ducks or turkeys (38). In Benin, family rearing of guinea fowls is mostly met in in the north of the country. Housing for poultry includes traditional circular mud huts (the “Tatas Somba”), henhouse or barns built with mud walls or straw (9). The door of the barn is always oriented westwards opposite of prevailing winds (9). The roof is usually made of stubble found around the villages. Stubble acts as a good insulator against direct sunlight, but is also a nest for various parasites (47).

Feeding

Smallholders feeding systems are based on grain, herbaceous plants and insects scavenged in the field and in the areas around the villages. The birds fed themselves around concessions, by gleaning here and there and received occasionally from the traditional breeder some grain supplement. Although qualitative assessments have been performed, the quantity of raw matter ingested in the wild during scavenging has not been correctly measured yet. According to Dahouda (14) and Boko (7), the diet of the scavenging bird is generally made of energy (kitchen waste, bran, corn, millet, sorghum, soybeans and rice), vitamins (green fodder, sprouted grains and fruits), minerals (salt, pounded shells) and protein-rich (termites, legumes, and soybean draff) ingredients. The composition of the supplements distributed by the farmers varies with the availability of the feed ingredients and the age of the birds: young chicks with down feathers are often supplemented ad libitum with crushed cereals and termites; feathered chicks and adults receive only cereal grains as complement (corn, millet and sorghum) in the morning and/or the evening (10). Besides its nutritive function, the feeding of birds encourages them to return to the chicken house in the evening (14, 7).

Animal performances in traditional systems of West-Africa

Growth

Ayorinde *et al.* (4) observed three phases of growth for birds reared in West-Africa: from 0 to 6 weeks corresponding to a rapid growth and 7 to 16 weeks corresponding to a slower growth with an inflection point found around 16 weeks. Local guinea fowls are known for having lower growth rates than improved breeds such as strain Galor (17). Moreover, the growth performance in avian species depends on the farming system (49, 48) and the energy and protein levels in the diet. In traditional breeding system in Benin, guinea fowl weight at 12 weeks of age 417 g and 334 g for males and females, respectively while at six months, the average live weight was 1121±100 g (14). In improved rearing, i.e. where animals were bred in chicken houses, received complete diet, were separated by sex and received veterinary care, the mean weights at the same age were 1151±108 g for males versus 1085 ± 74 g for females (14). These values are similar to those reported by Sanfo *et al.* (41) in a similar system. In Algeria, Halbouche *et al.* (22), reported 1.008 kg live weight for 90 days old guinea fowls fed a well-balanced 2800 kcal ME/kg and 22% CP diet.

This performance of local guinea fowl is far lower than those displayed by improved birds in Europe who reach 1.8 kg bodyweight under 3000 kcal/kg diet (29) and raises the question of the assessment of the feed requirements for local varieties of Guinea fowls.
Those performances a much higher than the ones obtained by Dahouda (14) in local guinea fowls reared in confinement in Benin which varies from 687 g to 695 g at 12 weeks of age with the respective levels of energy for starting, growing and finishing of 2902, 2914 and 2910 kcal ME /kg, and 23.3, 20.3, 16.3% for protein. Under similar rearing conditions, the average weight of grey (510 g) differs from that of the Black (478 g) and Ash (467 g) at 12 weeks. This difference is low at 28 weeks with 980.1 g for grey guinea fowl, 970.4 g for ash and 950.8 g for black (17).

Reproduction performance

Reproductive performances are strongly affected by the strain, the climate and the quality of the feed. Sexual maturity in females can theoretically be reached at 24 weeks (38), but in traditional systems it takes between 32, 36 and 37 weeks in Nigeria (4), Benin (14) and Algeria (22) respectively. Guinea fowl are seasonal breeders (31). Economically, the short laying season coinciding with the rainy season is a limiting factor to the activity (9). Nonetheless, Moreki and Seobo (32) reported that Guinea fowl hens start laying in spring with increasing daylight and are able to lay during 9 months in a row. The egg-laying period can be extended and early fertility improved by using artificial lighting. In Ghana, Konlan *et al.* (28) argued that female Guinea fowl with pearls (Common breed) are capable of laying fertile eggs throughout the year with a daily laying rate of 40% (28) when given adequate supplementary feeds and if provided water ad libitum. In the same study, hatchability was 69% and 66% in October and November, respectively (28). This result is similar to the 68% hatchability reported by Karbo *et al.* (26) and the 70% observed by Avornyo *et al.* (3) but lower than the hatchability of 88% reported by Saina *et al.* (36). However Konlan *et al.* (28) found that the hatchability sharply decreased to 18% in December at the peak of the Harmattan hot and dry season. Therefore, besides the seasonal impact of feed availability on female laying performances, the environmental changes associated with the hot dry season seem to be detrimental either to eggs hatchability because of problems during brooding or males semen quality and sexual activity. Indeed, sperm quantity and quality depend on the weight of the testicles which are affected by environmental factors such as lighting, temperature and feeding (29). Males' activity and fertility might be especially problematic in Guinea fowls since the monogamous character requires a higher sex ratio to get a good fertility as compared to other poultry species.

The number of eggs laid each year per female in Nigeria reached 97 (4) and higher than values of 72 and 68 reported under Benin controlled environment by Chrysostome (9) and Dahouda (14). In Burkina Faso, Sanfo *et al.* (38) indicated 103.8±9.6 eggs/female/year in accordance with the findings of (22) who pointed out 107 eggs/female/year. The duration of the laying season is 7 month (14). For Sanfo *et al.* (42), the duration of laying season in improved system is to 5 month for the first year and 7.5 months for the second laying year.
Eggs of Guinea fowl are smaller but more resistant to breakage than those of hens (24, 23). They are on average 47 mm long and 36.5 mm large for the largest diameter and they weight between 25 and 50 g (42). For example, Ikani and Dafwang (24) in Nigeria showed that eggs of Guinea fowl weight between 35 and 40 g against 45 to 55 g for chicken. External and internal characteristics of guinea fowl eggs varies also from a local variety to another (23). According to Narushin and Romanov (34), both thick egg shells and firm interiors, which are accepted as being higher than average, lead to an increase in egg weight, which results in the more successful hatching of embryos from heavier eggs. For example, investigations in the central region of Burkina Faso showed that eggs weight ranged between 25 to 50 g (39) and their fertility rate averaged 84.4% but varied with the egg weight. The embryonic death varied between 11.2% and 17.3%. Hatching rate was reported to be positively correlated ($r= 0.85$, $p<0.05$) to the egg weight (39). The one-day chicks weighed 25.2±1.9 g on average and their weight was positively correlated ($r= 0.96$, $p<0.05$) to egg weight (39). Furthermore, Sanfo *et al*. (38) showed that eggs from guinea fowl reflect the basic tendency for low hatchability to be a feature of eggs with shapes that are not within the normal range. In addition, these authors showed that more rounded eggs were less successful in hatching than those with sharp ends. Similar observations have been reported for quail eggs by Sezer (44). Therefore, the external and internal quality of eggs could be used as criteria to improve egg weight and fertility and used as selection criteria between varieties (1). Incubation condition may also influence hatchability. In Northern Benin, eggs are brooded by hens, guinea fowl or duck (7). In traditional free range breeding system of West Africa, the incubation period of guinea fowl eggs lasts between 26 and 28 days (9, 38, 14) and hatching rates are usually higher than and 80%: 79.9% in Benin (14), and between 81 and 93 in Nigeria (4). In Burkina Faso, the production cycle of local Guinea fowl females was estimated to 3.2±1 year with a productivity of 5.3±1.2 adult guinea fowls per female each year (38).

Causes of mortality

In the Borgou department of Benin, a survey carried out on Guinea fowl breeding system showed that 28% of the mortalities were due to various illnesses, 19% to straying in the bush, 17% to various accidents, 7% to drowning in run-off water during heavy rain, 5% to predators, 5% to food poisoning and 18% to other causes (14). In Niger the causes of high mortality observed according to Moussa *et al*. (33) were undiagnosed diseases (72%), poor housing (13%), predation (8%) and lack of feed (6%). According to Sanfo et al. (39), causes of chicks mortality can be related to the weight of the incubated eggs where mortality is higher among guinea fowl obtained from eggs of 25 g to 35 g (46%) than eggs of 45 g to 50 g (6%). The major pathology in free range system is due to parasitic infestation such as ascariasis, capillariasis and syngamose. These parasites are responsible of major retardation in growth of birds reared in free range, weight loss and diarrhea, although Guinea fowls are the birds performing the best under poor hygienic conditions (7). The traditional free range and multi-species systems induces high infestation rate (7, 10).

Comparatively to Niger, the prevalence trichomoniasis infection is low in Benin (10), whereas the coccidia prevalence is very high, reaching about 71% in Benin (10). Five categories of ectoparasites with a dominance of Argas sp were identified by Salifou *et al.* (37) in Benin. However, the impact of ectoparasites on the mortality of Guinea fowls has not been clearly established. Guinea fowls are not immune to outbreaks of pasteurellosis, Salmonella pullorum and Newcastle virus although it is said by the farmers to be more resistant than chickens to viral diseases (10). According to Singh *et al.* (45) young subjects under two months are the most vulnerable in Burkina Faso, Sanfo e*t al.* (38) indicated that the highest mortality rates ranging from 33.1 to 68.9% according to the villages is observed between the hatching to the fourth week of age. Similarly, Boko (7) indicates that global chick mortality varies between 65 and 68% in Benin.

Conclusion

Family poultry breeding occupies a significant place in the activities of rural households and peri-urban Africa and Guinea fowl plays an important part, along with other species such as chickens, Muscovy ducks, and turkeys. In terms of preference of producers and consumers, guinea fowl ranks first because of its dual abilities: producing meat and laying eggs. Despite the fact that Guinea fowl is more interesting compared to the other avian species, it often remain less available for the consumer because of its low productivity in the current traditional breeding system in sub-Saharan Africa. The low annual production of eggs, low-weight performance and high mortality especially of the young, determine the low productivity of guinea fowl. The lack of suitable follow-up in its breeding system is characterized by the lack of control of the habitat, diet and disease especially in chicks younger than two months old. Several experiments to improve farming conditions have shown that egg production can be increased, as well as weight and mortality can be decreased without achieving the performance of exotic strains. Similarly, the significant difference in growth performances among the local guinea fowl population has to be studied, also to enable any genetic improvement programs. Finally, contrary to chicken, typically local guinea fowl of Benin has not yet benefited from any health follow-up or prophylactic standard leading to the improvement of their survival and their productivity. Hence, to develop and increase productivity, family poultry in general and Guinea fowl in particular could be dynamized thourgh conservation and improvement programs of local birds populations whose zootechnical characteristics and genetics are presently overlooked. Specifically, we should:

- identify and characterize the performance local varieties in their natural environment ;
- evaluate the influence of the diet on the expression of the produciton potential of those varieties, with a specific focus on growth, body composition, reproduction and physical and chemical qualities of the products (eggs and meat).

Such a set of information would serve as reliable basis to initiate conservation programs and sustainable genetic improvement through selection or cross-breeding based on the use of local genetic resources and/or commercial strains.

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