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Visual Characterization of the Cuban Fighting Cocks (*Gallus gallus domesticus*)

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Aim. To conduct a visual characterization of the Cuban fighting cocks (GLCC). **Materials and methods:** A total of 1 514 adult birds (1 227 females and 287 males) belonging to 158 farmers from the western, central, and eastern regions of Cuba were observed, according to five qualitative variables: plumage coloration, comb type, eye color, beak color, and tarsus color. The occurrence frequencies were determined for each variable using FREQ from SPSS 25®. The Chi Square test was used to evaluate the effect of sex on the eye color, comb type, and tarsus color based on the exact method and Bonferroni correction for pair comparison proportions; the binomial test method was used for the comb type. **Results and discussion:** The proportion of animals with a plain comb was higher (83.12%), having a predominant dark red color (54.28%); the birds with red eyes, yellow tarsus, and yellow-brownish beaks showed the highest percentages. **Conclusions:** The dark plumage colors were predominant as they were associated with each breeder's preference. The Cuban fighting cock has a defined morphological pattern similar to the Spanish fighting breeds that originated it.

Keywords: visual, fighting cocks, morphology (Source: *DeCS*)

INTRODUCTION

Fowl rearing does not require extensive investment and maintenance costs, so farmers take advantage of the soil-plant-water-mineral relation to keep them and have a source of protein from these animals (meat and eggs) for consumers, as well as income to support their families. These birds are commonly reared in rural areas, where the conditions are very favorable, as the animals are resistant to the local humidity and temperature conditions, after undergoing a natural selection process through many years. They feed from insects, mollusks, fruit, harvest stalks, food scraps, and other alternative foods. Fowls are more resistant to diseases than any other type of chicken (Andrade *et al*., 2018).

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The rearing of Cuban fighting cocks came along the formation of the Cuban nationality; it is an inseparable part of farm households across the island. The breeds have been kept for several hundred years, becoming a rooted cultural tradition to our days. Cock-related activities are a source of employment for quite a few people, and it has been the active support of many households due to the income generated by the animal sales. Additionally, the excess meat and eggs are consumed by the families, though it is not the main purpose (National Statutes and Rules, 2020).

Aviculture is a significant activity that provides foods for the Cuban rural households because of its contribution to the home economy and as an important national zoogenetic resource. Given the broad genetic variability of the Cuban hens, several studies have been done on this genetic library, which stem from the identification and characterization of Cuban varieties to determine the genetic potential linked to production and disease resistance (Villacís *et al*., 2016).

One of the most alarming issues in today's world is the extinction of species and breeds due to several different reasons, especially the natural ones caused by the loss or reduction of resistance to some diseases, and the incapacity to adapt to certain climate types. Other factors are the loss of genetic resources associated with intensive farming, genetic selection, foreign species introduced into a new habitat, and the costs of cryopreservation of the genetic material and for molecular analysis, which hinder preservation and the possibility of further studies of genetic characterization (Zinovieva *et al*., 2019; Roh *et al*., 2020).

Some animal populations have unique traits in specific environments, which undergo a genetic dilution or extinction, without being morphologically or genetically characterized. Hence, it is necessary to evaluate animals from a larger number of agroecological regions and production systems (Dhorne, 2020).

The conservation of genetic resources is essential due to its direct effect on the wellbeing and survival of the human species. In Cuba, research is being done on the characterization of several of these resources. The Cuban fighting cocks (GLCC) are an inseparable part of the local rural traditions; however, there are no reports of characterization studies regarding the rearing system, morphology, or genetic diversity of this zoogenetic resource, which are indispensable to design conservation and breeding programs. Accordingly, the purpose of this paper is to conduct a visual characterization of the Cuban fighting cocks (GLCC).

MATERIALS AND METHODS

The research was done in the western, central, and eastern regions of Cuba, between 23°17', 19°50' north latitude and 74°08', 84°58' longitude, in private rearing facilities of farmers affiliated to the National Company for the Protection of the Wildlife (ENPFF).

Climatic characteristics

The climate in Cuba qualifies as humid subtropical, with two clearly defined seasons: dry (November to April) and rainy (May to October), with constant cooling breezes throughout the

year. The mean yearly temperature is 24 °C; in winter, the mean temperature is 20 °C, while in summer, it is 26-27 °C. The minimum temperatures vary between 1 °C and 8.5 °C in the west, whereas they are 3 °C-12.5°C in the east. The mean maximum temperatures vary between 27.7 °C and 32.8 °C, while the top recorded temperatures are between 36 °C and 38 °C. The historical average of the mean relative humidity is 78%. The annual rain totals are 1 450.3 mm, on average, with 1 003.5 mm in the rainy season, and 446.8 mm in the dry season (INSMET, 2015).

Animals and measurements

The visual characterization included a sample of 1 514 adult birds, 1 227 females and 287 males, belonging to Cuban fighting cocks from the western, central, and eastern regions of Cuba, all affiliated to ENPFF, which reported the national origin of the birds.

Visual traits evaluated: Feather color, tarsus color, eye color, beak color, and comb type.

Statistical analysis

The frequencies of feather color, eye color, comb type, beak color, and tarsus color were determined using FREQ from SPSS 25®. The Chi square test was used to evaluate the effect of eye color, comb type, and tarsus color, with the exact method and pair comparisons of proportions based on the Bonferroni correction, and the binomial technique for the comb type.

RESULTS AND DISCUSSION

Frequencies observed regarding the visual traits by sex (females/f and males/m)

Table 1 shows the color frequency values and percentages among the Cuban fighting cocks studied.

The feather colors of the GLCC are highly variable phenotypically, like most local birds, due to the display of different types of shades and countless color combinations derived from the presence of multi-allele genes (Toalombo *et al.*, 2019a). This is a visible quality acquired from their ancestor, the fighting Spanish cock, as reported by Méndez *el al*. (2010), which is a trait that tells them appart from the commercial lines and other breeds.

Table 1. Feather color frequencies observed

Color	Frequency		Percentage	
	F	M	F	M
Dark red	672	154	54.76	53.60
Ash gray	103	33	8.39	11.40
Yellow	26	6	2.11	2.09
Golden brown	118	22	9.61	7.66
Speckled yellow	133	28	10.85	9.85
White	63	14	5.15	4.90
Speckled	112	30	9.13	10.50

The predominant feather color of both sexes was dark red (54.76 % for the females, and 53.60% for the males), much higher than the other colors; the lowest values corresponded to the birds with white and yellow plumage. These results are similar to the ones described by Larrea (2012) upon a study of the population of local hens in Santiago de Cuba (88.33% of dark colors). The results observed in the GLCC matched the findings of Lázaro *et al*. (2012), in the state of Puebla, where in both the cocks and hens, red and black prevailed. It is significant for the animals reared in rural areas and semi-extensive systems due to the possibility of hiding behind their dark feathers from airborne and ground predators.

Valdés *et al*. (2010) used the observation method to estimate the frequency of appearance of some phenotypical traits in the locally originated hen (*Gallus Gallus*) in three areas of the San Andres Valley, La Palma municipality, Pinar del Rio province, Cuba. They reported similar results, where the dominant traits for plumage color were black (25%), black and red (22%), and speckled yellow (15%), while the gray and white were the least frequent (3%). The dark-feathered birds represented 75% of the sample.

The results of this research are similar to the findings of Méndez (2011), in his study of Jerezan and Sevilian fighting lines, which have a wide color variety, especially in dark colors, also coinciding with Marshall *et al*. (2021) in the reports of his research, in reference to the ample range of colors shown by the birds.

Various authors reported similar results in locally originated hens from Mexico, both Zaragoza *et al*. (2013), in Batsi Alak, Chiapas, and Hernández *et al.* (2017) in Veracruz. They observed a predominance of dark tones, like Revelo *et al*. (2017) in Colombia, and Toalombo *et al.* (2019a) in Ecuador. In pure game hens, the only study was done by Vázquez *et al*. (2015), who reported that in a population of pure game hens in Camaguey, Cuba, the predominant color was dark red.

Eye color has been little described in the literature, though it can be useful to infer the influence of exotic fighting breeds on the Cuban animals. The results of that research show that red eye was the highest percentage in hens (56.20%), followed by the orange and black eyes (26.5% and 17.3%, respectively) (Table 2). These values were higher than the ones reported by Revelo *et al*. (2017), who described frequencies of 26.70 % (black eyes); 32.90% (red eyes); and 40.5% (pearled eyes). The cocks in this research had red, orange, and green eyes with the following percentual values: 69, 70%, 24, 70%, and 5, 60%, respectively. No black-eyed animals were identified.

Table 2. Eye color frequencies observed

Color	Frequency		Percentage	
	F	M	F	M
Red	689	200	56.2	69.7
Orange	326	71	26.5	24.7
Black	212	0	17.3	0
Yellow	0	16	0	5.6

The results show that the highest percentage was related to red-eyed animals in both sexes, a trait observed in their ancestor, the Spanish fighting cock, as reported by Méndez (2010) in research done on this breed, where the iris color was red or orange.

Hernández *et al.* (2017) described different results as to eye color; the predominant color was orange in females and males, upon an evaluation of local hens in Veracruz, Mexico. Although this color was observed in the Cuban birds in the two sexes as well, the values were lower.

The literature consulted showed no reports of any relation between the eye color and feather color. Seemingly, eye color is nor related to the feather color.

Only animals with a rose comb with serrations, having the highest percentages in the two sexes for the former. The combs with serrations was 81.10% in the females and 76.30% in the males, whereas the rose comb was observed in 18.90% of the females and 23.70% of the males (Table 3). These results coincided with Revelo *et al*. (2017) and Galíndez (2020), who found the largest percentages of occurrence in the animals with serrations or single combs, upon evaluating the single, pea-like, rose, and nut-like combs. The findings showed 86.4%, 5.5%, 4.5%, and 3.6% in the cocks, whereas the hens showed 83.3 %, 8.8%, 1.0%, and 6.9%, respectively. The rose combed animals showed a lower percentage of occurrence in the two sexes than the Cuban animals.

Table 3. Comb type color frequencies observed

Comb	Frequency		Percentage	
	F	M	F	M
Serrations	995	219	81.1	76.3
Rose	232	68	18.9	23.7

Valdés *et al*. (2010) described similar results to ours, the highest percentages for the single comb (82%), rose (11%), and also referred to the nut-like comb (5%), and the pea-like comb (2%), the last two were not present in the animals evaluated in this paper. Several papers linked the rose comb to low fertility, especially in the homozygotic males (RR), which was attributable to a drop in sperm viability compared to other phenotypes. It is significant, as it is a way for birds to lose heat in the birds, so the larger the size, the more efficient way of heat loss (Toalombo *et al*., 2019b).

Likewise, the results of this paper coincided with Tovar *et al*. (2014), who noted that the most frequent comb shape in the two sexes was the single, which was present in 100% of the red-brown hens, 90% of white hens, and 78% of black and barred hens used in the research. Besides, Toalombo *et al.* (2019a) said that the most frequent comb shape was the single (76.74%); they did not observe the rose comb, but did observe the nut-like comb (8.20%), which was not present in the sampled animals. Both the nut-like and pea-like combs are distinctive traits of Asian birds.

In a study of the morphological traits and variations of Mediterranean hens, Parés and Berenger (2020), referred to the highest frequency of single comb occurrence above all the others, coinciding with the results of this paper.

In the current paper, the findings in terms of beak color in the two sexes reported yellow-brown as the most frequent color (51.10%) in the hens, and the cocks (44.90%) (Table 4), unlike Valdés *et al*. (2010) who reported that in 78 % of males it was yellow, whereas 54% was observed in the females. White was the lowest (8%), similar to the results found in this paper, where the white beaks showed 10.10% in the females, and 10.20% in the males. Black was not observed in the sample birds.

Table 4. Beak color frequencies observed

Color	Frequency		Percentage	
	F	M	F	M
Yellow-brown	627	129	51.1	44.9
White	126	29	10.3	10.1
White-brown	121	6	9.9	2.1
Yellow	353	113	28.7	39.4
Brown	0	10	0	3.5

In the Mediterranean birds, the predominant beak colors were white, black, yellow, blue-grayish, and white-pinkish, in a descending order (Parés and Berenger, 2020). Only yeloow coincided with the findings in the current work, which shows the diversity of beak colors in European animals.

The yellow tarsi had the highest percentage of occurrence in the females (77.10%), and males (88.20%), followed by the white tarsi in the females (18.80%) and the males (11.80%). The green tarsi showed a lower proportion in the females (4.10%), but it was not observed in the males (Table 5), Tovar *et al.* (2014), when evaluating Colombian hens, found that the yellow tarsi showed the highest occurrence (49.80%), whereas white was lower (16.00%), while black and brown were not present in this research.

Table 5. Tarsus color frequencies observed

Color	Frequency		Percentage	
	F	M	F	M
Yellow	946	253	77.1	88.2
White	231	34	18.8	11.8
Green	50	0	4.1	0

Revelo *et al*. (2017) reported that the yellow tarsi showed the highest occurrence in the two sexes, through the values were below the findings of this research (80.60% and 1.90 %, respectively), whereas the hens underwent frequencies of 41.40% and 2.0%, respectively, also lower than the values identified in this paper. The hens did not show green tarsi, while the animals included in the current paper sowed 4.10% occurrence.

Visual traits by sex

The predominant eye color both for females and males, was red, followed by orange (Table 6), unlike the reports of Hernández *et al.* (2017) who observed that the predominant eye color was orange in the two sexes. The GLCC study did not show significant differences between these two colors in the two sexes, through there were significant differences in the black color of eyes in the hens and green in the cocks (Table 6). The females had no occurrence of yellow, while the males did not show black eyes.

Table 6. Relation between sex and eye color

		Red				
		Red	**Orange**	**Black**	**Yellow**	**Total**
Females	Count	689[a]	326[a]	212[b]	0[c]	1 227
	Expected count	720.5	264.2	229.4	13.0	1 227.0
	Sex %	56.2%	26.6%	17.3%	0.0%	100.0%
	Red %	77.5%	74.9%	100.0%	0.0%	81.0%
Males	Count	200[a]	71[a]	0[b]	16[c]	287
	Expected count	168.5	53.6	61.8	3.0	287.0
	Sex %	69.7%	24.7%	0.0%	5.6%	100.0%
	Red %	22.5%	25.1%	0.0%	100.0%	19.0%
Total	Count	889	283	326	16	1 514
	Expected count	889.0	283.0	326.0	16.0	1 514.0
	Sex %	58.7%	18.7%	21.5%	1.1%	100.0%
	Red %	100.0%	100.0%	100.0%	100.0%	100.0%

Each superscript denotes an eye color subset whose proportions on the column differ significantly at 0.05.

The results of this research indicate a significant predominance ($P < 0.001$) of the single or serrated comb in the females (Figure 1) and males (Figure 2), followed by the animals with the rose comb (Table 7). These findings coincide with the reports of Revelo *et al*. (2017) and Toalombo (2019a), who identified animals having combs with serrastions with the highest occurrence percentage.

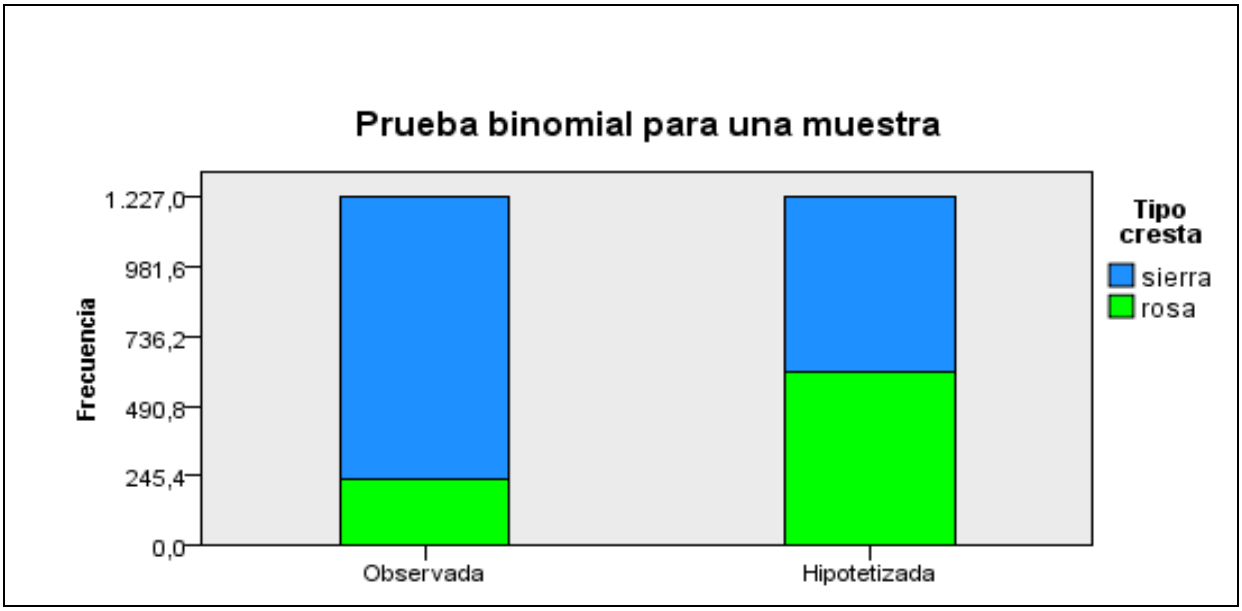

Figure 1. Comb type (females)
(N= 1227; Contrast statistics= 995.000; Standard error= 17.514; Standardized contrast statistics= 21.754; Asymptotic Sig. (two-sided test= 0.000)

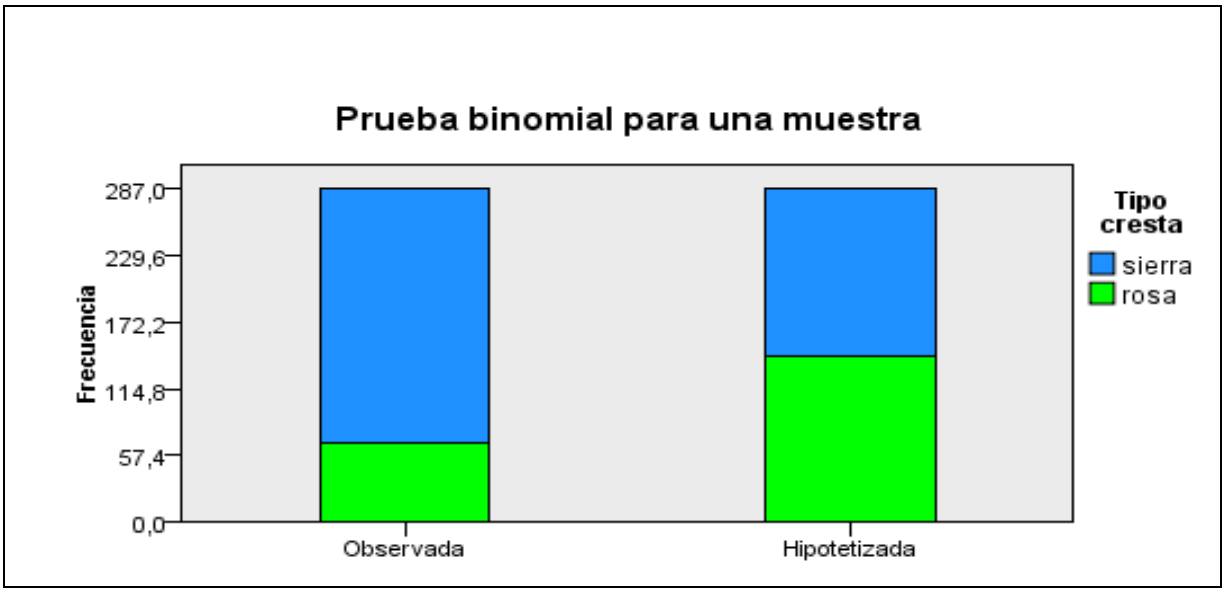

Figure 2. Comb type (males)
(N= 287; Contrast statistics= 219.000; Standard error= 8.471; Standardized contrast statistics= 8.854; Asymptotic Sig. (two-sided test= 0.000)

Table 7. Relation between sex and comb type

		Comb type		Total
		Serrations	Rose	
Females	Count	995[a]	232[b]	1 227
	Expected count	983.9	243.1	1 227.0
	Sex %	81.1%	18.9%	100.0%
	Comb type %	82.0%	77.3%	81.0%
Males	Count	219[a]	68[b]	287
	Expected count	230.1	56.9	287.0
	Sex %	76.3%	23.7%	100.0%
	Comb type %	18.0%	22.7%	19.0%
Total	Count	1 214	300	1 514
	Expected count	1 214.0	300.0	1 514.0
	Sex %	80.2%	19.8%	100.0%
	Comb type %	100.0%	100.0%	100.0%

Each superscript denotes a comb type subset whose proportions on the column do not differ significantly at 0.05.

The predominant beak color was the yellow-brown combination for males and females, with significant differences from the other colors described (Table 8). It did not coincide with Valdés *et al*. (2010) who reported that 78 % of the males' beaks was yellow, whereas 54% of the females' beaks was black. In this paper, the white beaks occurred in a lower proportion than the yellow and brown in the two sexes.

Table 8. Relation between sex and beak color

		Beak color					Total
		Yellow-brown	White	White-brown	Yellow	Brown	
Females	Count	627[a]	126[b]	121[c]	353[ab]	0[d]	1 227
	Expected count	612.7	125.6	102.9	377.7	8.1	1 227.0
	Sex %	51.1%	10.3%	9.9%	28.8%	0.0%	100.0%
	Beak color %	82.9%	81.3%	95.3%	75.8%	0.0%	81.0%
Males	Count	129[a]	29 [b]	6[c]	113[ab]	10[d]	287
	Expected count	143.3	29.4	24.1	88.3	1.9	287.0
	Sex %	44.9%	10.1%	2.1%	39.4%	3.5%	100.0%
	Beak color %	17.1%	18.7%	4.7%	24.2%	100.0%	19.0%
Total	Count	756	155	127	466	10	1 514
	Expected count	756.0	155.0	127.0	466.0	10.0	1 514.0
	Sex %	49.9%	10.2%	8.4%	30.8%	0.7%	100.0%
	Beak color %	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Each superscript denotes a beak color subset whose proportions on the column differ significantly at 0.05.

The predominant tarsus color in the females and males was yellow, followed by white (Table 9), similar to the findings of Tovar *et al.* (2014) who evaluated local hens and identified yellow tarsi as the most frequent. In this paper, significant differences were observed between this color and the colors described for the two sexes; the males did not show green tarsi.

Table 9. Relation between sex and tarsus color

		Tarsus color			Total
		Yellow	White	Green	
Females	Count	946[a]	231[b]	50[c]	1 227
	Expected count	971.7	214.8	40.5	1 227.0
	Sex %	77.1%	18.8%	4.1%	100.0%
	Tarsus color %	78.9%	87.2%	100.0%	81.0%
Males	Count	253[a]	34[b]	0[c]	287
	Expected count	227.3	50.2	9.5	287.0
	Sex %	88.2%	11.8%	0.0%	100.0%
	Tarsus color %	21.1%	12.8%	0.0%	19.0%
Total	Count	1 199	265	50	1 514
	Expected count	1 199.0	265.0	50.0	1 514.0
	Sex %	79.2%	17.5%	3.3%	100.0%
	Tarsus color %	100.0%	100.0%	100.0%	100.0%

Each superscript denotes a tarsus color subset whose proportions on the column differ significantly at 0.05.

CONCLUSIONS

The predominant visual features of the Cuban fighting cocks found were the dark red feather, combs with serrations, red eyes, yellow-brown beaks, and yellow tarsi, though other phenotypical varieties co-exist. The dark colors result from each breeder's preference, and adjustment to the environment, which permit the birds to camouflage easily.

This research has provided a broad set of data that, when analyzed methodically, show a clearly true and authentic Cuban fighting cock phenotype, which is very similar to the Spanish breeds that originated it.

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AUTHOR CONTRIBUTION

Research conception and design: AVG, JABV, RVM; data analysis and interpretation: AVG, JABV, RVMO, LMFB; redaction of the manuscript: AVG, JABV, RVMO, LMFB; DPC, LDGC.

CONFLICT OF INTERESTS

The authors of this paper confirm the absence of conflict of interests.