

Factors Influencing the Morphological Characteristics of Village Chickens' Genetic Resources in the Abu-Dhabi Emirate, UAE

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How to cite this paper: Tabbaa, M.J. and Hassanin, H.H. (2018) Factors Influencing the Morphological Characteristics of Village Chickens' Genetic Resources in the Abu-Dhabi Emirate, UAE. *Open Journal of Animal Sciences*, 8, 87-103.

<https://doi.org/10.4236/ojas.2018.81007>

Received: October 25, 2017

Accepted: January 9, 2018

Published: January 12, 2018

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Abstract

The study was accomplished to identify the characteristics of village chickens' (VCs) genetic resources in the Abu-Dhabi Emirate of United Arab Emirate (UAE) and to study factors affecting these characteristics. Each bird was individually observed, identified, measured and characterized of thirteen VCs pure breeds and crossbreds. The overall VCs had normal feather morphology (95.1%) and distribution (77%). Except for Fayomi chickens which were 100% mottled, no specific plumage pattern was found. Almost 52% of the VCs had white skins. Six different colors were reported for the shanks and maximized for white shanks (34.3%). Large breasts (46%) were more available. The predominant plumage color was mixed colors (37.5%). Face size tended to be small (42.8%) to medium (40.4%). More brown (48.9%) than orange (27.3%) eyes were found. Dark (49.7%) beaks were more available than white (28.6%) or yellow (21.7%) beaks. The distribution of wattle colors was similar to that of ear-lob colors with some variation. Small wattles (41.9%) were most available. Single comb (82.4%) is the most available; 11 other types and one with no comb were represented with low frequencies. In the whole sample, red and white combs (56.7%) were the most available; however, plain red (23.8%) and red and black (15.5%) were represented. Results of factors influence showed that body weight was high significantly ($P < 0.01$) influenced by the interaction between both breed and region and breed and sex. Significant ($P < 0.01$) influence of interaction was observed between breed and location on body length, wing span and shank length. The interaction between breed and sex only significantly ($P < 0.01$) influenced shank length. Though, all main effects of breed, sex and region significantly ($P < 0.01$) influenced continuous measures. Most morphological characteristics were significantly ($P < 0.01$) different

among breeds. This study reported the morphological characteristics of the different VCs breeds kept in Abu-Dhabi Emirate, which considered the scientific base for future implementing of conservation and/or genetic improvement programs.

Keywords

Body Weight, Breeds, Morphological Characteristics, UAE, Village Chickens

1. Introduction

Village chickens (VCs) are those kept under traditional raising system and used for multiple purposes with variable morphological characteristics [1] [2] [3]. In many regions of the world, VCs are kept for several goals which include local consumption, extra income, pest control and manure production [4] [5] [6] [7]. They are more adaptive to their climatic harsh conditions, resistant to local diseases and classified by small size and low egg production [8] [9]. In addition, VCs are used to utilize farm by-products and mostly resistant to diseases and parasites [10] [11] [12]. In general, even if local breeds have low production rate, they are more adapted to their environment and they may reserve an essential and special genes or traits that could meet the changeable preferences of consumers, alteration of production systems, and resistance to newly developing diseases [13]. Consequently, VCs are gene reservoirs for genetic future studies, improvement and conservation [3] [6].

The breed characteristics are considered as an important key for decision-making guide in livestock improvement, breeding programs and conservation [14] [15]. Characterization using molecular genetics provides trustworthy data though it is complex and expensive and should be always incorporated with phenotypic characteristics to be useful [13] [16]. In terms of morphological characteristics, the phenotypic traits of VCs may be considered to indicate the local chickens of the United Arab Emirates (UAE). Other characteristics like reproductive efficiency, egg production and body weight may be considered for specifying the VCs of the UAE. Most of these traits may have a direct or indirect influence on the marketability of chickens [17]. Qualitative and quantitative measurements can be determined by using FAO checklist for chickens' phenotypic characterization. There are many important traits like plumage color, feathers, skin color, shank color, ear lobe color, eye color, and comb type as examples of qualitative variables [1]. The morphological characteristics can clarify the correlation between the phenotypic traits and the production status of the VCs. Also, qualitative morphological characteristics assist in describing genetic variations, adaptive attributes, and have economic value in chickens [18]. The guidelines may also be useful to decision-makers who wish to obtain a better understanding about the potential contributions of phenotypic characterization studies to national policies and programs for animal genetic resources and of the practicali-

ties involved in implementing such studies [1]. No studies available in the UAE consider characterization of local breeds of chicken. Characterization of local breeds is the first step for future genetic improvement program in Abu-Dhabi. Therefore, the objectives of this study were to identify the characteristics of village chickens' genetic resources in the Abu-Dhabi Emirate of UAE and to study factors affecting these chicken's characteristics.

2. Materials and Methods

2.1. The Study Area

The study was accomplished between March 2015 and June 2016, in 18 randomly selected villages belong to Abu-Dhabi in UAE, located between 22°40' and 25°N and 51° and 56°E. The 18 randomly selected villages were located in each of the 3 Abu-Dhabi Emirate municipalities (Abu-Dhabi (6), Al-Ain (8) and Al-Dhafra (4)). The UAE's weather is characterized by hot desert climate, with mostly clear skies all-year-round and low rainfall. Average maximum temperature is above 39°C with high humidity during the period from June to September, while cool temperature reaches 19°C from November to March.

2.2. Sampling Procedures

Households within Abu-Dhabi Emirate who raise more than 10 VCs and willing to participate in the study were randomly selected. Chicken keepers who keep VCs under traditional system of raising for multiple purposes, regardless of the flock size were considered in the study. The sampling size of each farm was 5 - 10 adult hens and 2 - 5 adult cocks (>6-month-old) from each breed, with a total of 1208 chickens from a stratified random sampling procedure of 59 chicken keepers in the three municipal regions (Abu-Dhabi (20), Al-Ain (28) and Al-Dhafra (11)). The sample represents around 10% of the expected size of chicken keepers' population (Animal Wealth Division, Abu-Dhabi Food Control Authority, Personal communication).

2.3. Data Collection

A survey was conducted to study the VCs populations of Abu-Dhabi Emirate. Assigning names to breeds of chicken were accomplished based on keepers' perceptions and, explicit phenotypic differences among and consistencies within group and was partly based on the popular usage of particular name. The morphological characteristics of each bird were individually observed according to [1] checklist for phenotypic characterization of chickens as follow: Feather morphology (normal, frizzle, silky); feather distribution (normal, naked neck, feathered shanks and feet, muffs and beard, crest and vulture hocks (long stiff feathers protruding down and back from the hock joint)); plumage pattern (plain, barred, laced, mottled); plumage color (white, black, blue, red, wheaten. Skin color: not pigmented (white), yellow, blue-black); shank color (white, yellow, blue, green, black, brown); ear-lobe color (not pigmented (white), red,

white and red); comb type (single, pea, rose, walnut, cushion, strawberry, duplex, V-shaped, double); comb size (small, medium, large); eye color (pearl, brown, orange, red, black); body weight, body length (length between the tip of the rostrum maxillae (beak) and that of the cauda (tail, without feathers) with bird's body was completely drawn throughout its length); shank length (length in cm of the shank from the hock joint to the spur of either leg); and wing span (length in cm between tips of right and left wings after both were fully stretched out).

2.4. Statistical Analysis

Statistical analysis was performed on qualitative survey data using the Chi-square test of the FREQ procedure [19]. Least square analysis of variance was utilized to study the effect of region, sex and breed of chicken on quantitative data using GLM procedure [19]. All possible interactions were also tested though only their two-way interactions were left in the final statistical model. Means for significant effects were compared at $P < 0.05$ using t-test and standard errors calculated using GLM procedure [19] were presented in the Tables.

3. Results and Discussion

The UAE is an open country for animal genetic resources exchange throughout no restriction for people of Emirates to import animals and birds breeds from all over the world. Emirati people are interested in keeping robust birds that would rank high in exhibitions and competitions. These chickens are source of income for many Emirati families beside home consumption and reared for meat and egg production [7]. Therefore, 13 VCs breeds in addition to crossbreeds were found in this study (Table 1). The most available breed was the Emirati local chickens breed which sometimes called (Addar chickens) and was found in 71% of the properties. The population was observed to be highly diverse breed comes with many morphology and plumages, all given the same name. The direct consequences of the diversified phenotypic characteristics of the Emirati local VCs indicate high potential for genetic improvement. Therefore, this enormous gene pool should be conserved from extinction or inbreeding and genetic drift and be used for genetic improvement through individual selection with application of molecular technology, incorporating production objectives and preferred characteristics of the local Emirati people [3] [8] [20]. The extinction of the local breeds could happen due to arbitrary crossbreeding and breed replacement [3]. Since extinction is an irreversible process, precautions should be taken before permanent losses of the indigenous animal genetic resources [21]. Although, indigenous chickens (genotypes) were known as less productive, keepers prefer them, as they were more adapted to severe environmental conditions, have better maternal care, and produce leaner and tastier meat compared to exotic breeds [7] [22]. The second most available breed was Fancy or what is locally called French breed which was found in 36% of the properties. Though, the

Table 1. Body weight in grams (\pm standard error) of chicken as affected by the interactions of breed and region and of breed and sex of chicken.

Breed	Frequency		Breed * Region			Breed * Sex	
	%	Abu-Dhabi	Al-Ain	Al-Dhafra	Female	Male	
<i>P</i> -value			<0.0001			0.0007	
N	1208	417	587	204	831	377	
Local	71.19	1357 \pm 28i	1423 \pm 23i	1722 \pm 50cdef	1288 \pm 21f	1575 \pm 31de	
Fancy	35.59	2119 \pm 30b	2106 \pm 40b	1677 \pm 96efg	1819 \pm 28bc	2359 \pm 43a	
Crossbred	20.34	1551 \pm 54gh	1706 \pm 49def	1686 \pm 49defg	1431 \pm 37de	1876 \pm 51b	
Omani	11.86		1388 \pm 44i		1274 \pm 50f	1502 \pm 78de	
Pakistani	10.17		2210 \pm 280abcdef	1935 \pm 101bce	1596 \pm 112cde	2320 \pm 174a	
Brahman	8.47	1960 \pm 144bcdef	2547 \pm 186a	1116 \pm 99j	1528 \pm 86.83de	1514.29 \pm 147def	
Kuwaiti	6.78	981 \pm 132j	1173 \pm 77j		1050 \pm 87g	1200 \pm 112fg	
Fayomi	3.39			1635 \pm 101fg	1500 \pm 123def	1770 \pm 174bcd	
Kerala	3.39	1783 \pm 154cdefg	1305 \pm 117hij		1344 \pm 129efg	1614 \pm 147bcde	
Other breeds ¹	8.47		1676 \pm 65fg	1718 \pm 73cdefg	1514 \pm 58de	1874 \pm 89bc	

¹Other breeds: uncommon breeds that were named Holland, Australian, Japanese, Habhab and Abu-Dhabi. a,b,c,d Different superscripts within an interaction indicate significant differences ($P < 0.05$).

breed was not similar to any of the known French breeds, however, because fancy sound like French in Arabic most keepers called this breed as French. The Fancy breed was of two colors, one of which was very similar to New Hampshire Red, and the second was very similar to Delaware breed. Though, both had similar body conformation and body weight. They were preferred by local Emirati people because of their fast growth rate and final body weight. The third was the crossbred chickens (20%), which mainly crossed with Fancy breed, secondly with Pakistani and then with all other breeds. The fourth was the Omani chickens (12%) which were highly diverse group of chickens, very similar to the Emirati local breed, a little shorter, and found only in Al-Ain close to Oman boarder. The fifth breed was the Pakistani chickens (10%) which were originally from Pakistan and characterized by long body with divers colors and most shapes characteristics. Brahman chickens were mostly crested heads, brown and creamy in color with very diverse comb types. Other breeds were found in less than 10% of the visited sample farms. Kuwaiti chickens were originally from Kuwait had very small body size and weight, variable in colors and shapes characteristics. In Kuwait, it is traditionally called the Arabi chickens and it is important as a source of meat and eggs and used for entertainment [23]. Arabi chickens in Kuwait are highly resistant to the adverse environmental conditions and are characterized with medium body size, crested heads, V-shaped comb, short and dark shanks and multi-colored [23]. Fayomi chickens were a highly homogeneous group of chickens. All Fayomi chickens had normal feather morphology and distribution with mottled plumage pattern and single comb. Kerala chickens were characte-

rized with frizzle feather and mostly with single comb. Other breeds were each found in only one of the sampled farms. These were named as Holland, Australian, Japanese, Habhab and Abu-Dhabi chickens. They were grouped together because they have very similar characteristics, very little differences and very few in numbers. They are reported in this study because it is the first in the UAE.

3.1. Quantitative Morphological Characteristics

Body weight was highly significantly ($P < 0.01$) influenced by the interaction between both breed and region and breed and sex (**Table 1**). All main effects were also highly significant ($P < 0.01$), however, the three-way interaction was not significant ($P > 0.1$). Body weight differences are due to differences in body size and condition score of the bird [12]. Al-Dhafra region has the heaviest Emirati local breed, while Fancy breed was heavier in both Abu-Dhabi and Al-Ain than that of Al-Dhafra. Brahman was the heaviest breed in Al-Ain and was the least in Al-Dhafra, while Kuwaiti breed had the lightest body weight. Similarly, many researchers reported significant differences in body weight due to location for the same and different breeds in different countries [2] [12] [13] [20]. Although, Kuwaiti chickens were very small, many people prefer them as game birds. Small body size is a promising character because it decreases feed requirements for maintenance and increase feed efficiency [15].

Males were always heavier than females, differences were not consistent among breeds; male-female differences within some breeds were not significant ($P > 0.05$, **Table 1**). Similarly, influence of sex of chickens on body weight favoring males was reported by many [3] [12] [18]. Body weight advantage of males over that of females particularly at birth is due to fetal hormones which sustain higher skeletal growth in males, in addition to longer gestation period in males [12]. Although were significantly different, the average body weights reported for males' and females' Kuwaiti chickens in Kuwait were much smaller than that in this study [23].

The significant ($P < 0.01$) influence of interaction between breed and location on body length, wing span and shank length were presented in **Table 2**, while the interaction between breed and sex was only significantly ($P < 0.01$) influenced shank length (**Table 3**). Though, all main effects of breed, sex and region significantly ($P < 0.01$) influenced body length, wing span and shank length. Comparably, [2] reported that shank length, body length and wing span were different among different sub-populations of chickens of different breeds and regions. Region influence was reported to have effect on body length [12], while breed-location interaction was reported to have influence on shank length [2] [18] [20]. Males had mostly higher values than that for females (**Table 3**). Similarly, [12] and [18] have shown that males have larger values for body length and shank length. However, [3] reported that although males have larger values of wing and shank lengths, differences were not significant. Fayomi had similar body length for both sexes while Brahman has similar wing span for both sexes.

Table 2. Body length, wing span and shank length (\pm standard error) of chicken as affected by the interaction of breed and region.

Breed	Body length			Wing span			Shank length		
	Abu-Dhabi	Al-Ain	Al-Dhafra	Abu-Dhabi	Al-Ain	Al-Dhafra	Abu-Dhabi	Al-Ain	Al-Dhafra
<i>P</i> -value	<0.0001			<0.0001			0.0005		
Local	39.61 \pm 0.23gh	39.7 \pm 0.2gh	41.8 \pm 0.4de	41.4 \pm 0.3h	42.8 \pm 0.2fg	45.0 \pm 0.5c	5.6 \pm 0.1g	5.7 \pm 0.1fg	6.1 \pm 0.1bde
Fancy	44.68 \pm 0.24b	44.6 \pm 0.3b	44.6 \pm 0.8b	47.4 \pm 0.3a	48.1 \pm 0.4a	38.1 \pm 1.0jk	6.8 \pm 0.1ac	6.6 \pm 0.1bc	7.1 \pm 0.2a
Crossbred	42.73 \pm 0.43cd	42.8 \pm 0.4cd	44.2 \pm 0.4b	44.1 \pm 0.6cde	46.9 \pm 0.5ab	43.5 \pm 0.5defg	6.7 \pm 0.1abc	6.3 \pm 0.1bd	6.4 \pm 0.1bd
Omani	40.3 \pm 0.4fg			42.3 \pm 0.5fgh			5.4 \pm 0.1h		
Pakistani	49.6 \pm 2.3a		44.8 \pm 0.8b	51.0 \pm 2.9ab		41.4 \pm 1.0ghi	7.1 \pm 0.6abc		6.3 \pm 0.2bd
Brahman	44.44 \pm 1.16bc	44.9 \pm 1.5abc	38.1 \pm 0.8h	48.4 \pm 1.5ab	49.8 \pm 1.9a	33.1 \pm 1.0l	6.2 \pm 0.3bdefg	5.7 \pm 0.4defgh	6.4 \pm 0.2bcd
Kuwaiti	34.77 \pm 1.06i	35.4 \pm 0.6i		38.5 \pm 1.4ijk	37.8 \pm 0.8k		4.5 \pm 0.3i	4.3 \pm 0.2i	
Fayomi	40.4 \pm 0.8efgh			42.1 \pm 1.0efgh			7.0 \pm 0.2ac		
Kerala	42.53 \pm 1.24bcdef	38.3 \pm 0.9h		46.1 \pm 1.6abcd	40.7 \pm 1.2ghij		6.5 \pm 0.3abcd	5.4 \pm 0.3gh	
Other breeds ¹	41.2 \pm 0.5ef		41.1 \pm 0.6ef	43.0 \pm 0.7defg		45.3 \pm 0.8bc		5.3 \pm 0.1h	5.8 \pm 0.2efg

¹Other breeds: uncommon breeds that were named Holland, Australian, Japanese, Habhab and Abu-Dhabi. a,b,c,d Different superscripts within an interaction indicate significant differences ($P < 0.05$).

Table 3. Body length, wing span and shank length (\pm standard error) of chicken as affected by the interaction of breed and sex of chicken.

Breed	Body length		Wing span		Shank length	
	Female	Male	Female	Male	Female	Male
<i>P</i> -value	0.1027		0.3371		0.0005	
Local	38.0 \pm 0.2hi	41.8 \pm 0.2d	40.1 \pm 0.2fghi	45.0 \pm 0.3cd	5.2 \pm 0.1h	6.2 \pm 0.1de
Fancy	42.1 \pm 0.2cd	47.2 \pm 0.3a	44.3 \pm 0.3d	49.9 \pm 0.5a	6.2 \pm 0.1de	7.3 \pm 0.1a
Crossbred	40.8 \pm 0.3ef	45.7 \pm 0.4b	41.8 \pm 0.4efg	47.9 \pm 0.6b	6.0 \pm 0.1e	6.9 \pm 0.1bc
Omani	37.88 \pm 0.4hi	42.8 \pm 0.6cd	40.4 \pm 0.5fghi	44.2 \pm 0.8cd	5.1 \pm 0.1h	5.6 \pm 0.2fg
Pakistani	43.0 \pm 0.9cd	47.4 \pm 1.4ab	40.1 \pm 1.2fghi	44.2 \pm 1.9bcdef	6.0 \pm 0.2ef	6.8 \pm 0.4abcd
Brahman	39.1 \pm 0.7gh	42.2 \pm 1.2cdef	39.1 \pm 0.9i	39.5 \pm 1.6fghij	6.3 \pm 0.2de	6.2 \pm 0.3def
Kuwaiti	33.8 \pm 0.7j	36.7 \pm 0.9i	36.4 \pm 0.9j	39.6 \pm 1.2fghi	4.2 \pm 0.2j	4.5 \pm 0.2ij
Fayomi	39.4 \pm 1.0fgh	41.3 \pm 1.4cdefg	39.1 \pm 1.3ghij	45.0 \pm 1.9bcde	7.0 \pm 0.3abc	7.0 \pm 0.4abcd
Kerala	36.9 \pm 1.0hi	42.7 \pm 1.2cde	39.5 \pm 1.4ghij	45.8 \pm 1.6bcd	5.2 \pm 0.3ghi	6.4 \pm 0.3cde
Other breeds ¹	38.8 \pm 0.5gh	43.5 \pm 0.7c	41.4 \pm 0.6efgh	46.6 \pm 1.0bc	5.1 \pm 0.1h	5.9 \pm 0.2ef

¹Other breeds: uncommon breeds that were named Holland, Australian, Japanese, Habhab and Abu-Dhabi. a,b,c,d Different superscripts within an interaction indicate significant differences ($P < 0.05$).

Shank length was not different between sexes for each of Brahman, Kuwaiti and Fayomi. Pakistani breed in Al-Ain had the longest body and wing span, with long shanks. Body length was consistently second for Fancy in all locations while Brahman body length was similar in Abu-Dhabi and Alain and was lower in Al-Dhafra. Kuwaiti as usual had consistently the shortest body. Wing span of Brahman and Fancy in Abu-Dhabi and Alain were similar to that of Pakistani in

Al-Ain, however, these breeds had lower values in Al-Dhafra. Similarly, [3] reported that wing span was a major discriminant among different genetic groups. Shank length was not consistent for almost all breeds in different locations.

3.2. Qualitative Morphological Characteristics

Emirati local chickens and the overall VCs in the Emirate had normal feather morphology (95.1%), with other morphology types were represented, however, differences among breeds were highly significant ($P < 0.01$, Figure 1). Village chickens in Philippines had normal feather morphology [13], while that of VCs feathers in Ethiopia was silky [18] and that in Sri Lanka was variety of morphologies [3]. Morphological variations are maybe due to variations in single qualitative genes in the VCs gene pool [3] [8]. Pakistani, Fayomi and rare chicken breeds were all with 100% normal feather morphology, while Kuwaiti chickens had only 87.5% of normal feather morphology and the other 12.5% had silky feather. 100% of Kerala chickens had frizzle feather.

In general, 77% of all chicken breeds had normal feather distribution, while feathered shanks and feet and crested head each represent 10% of the sampled

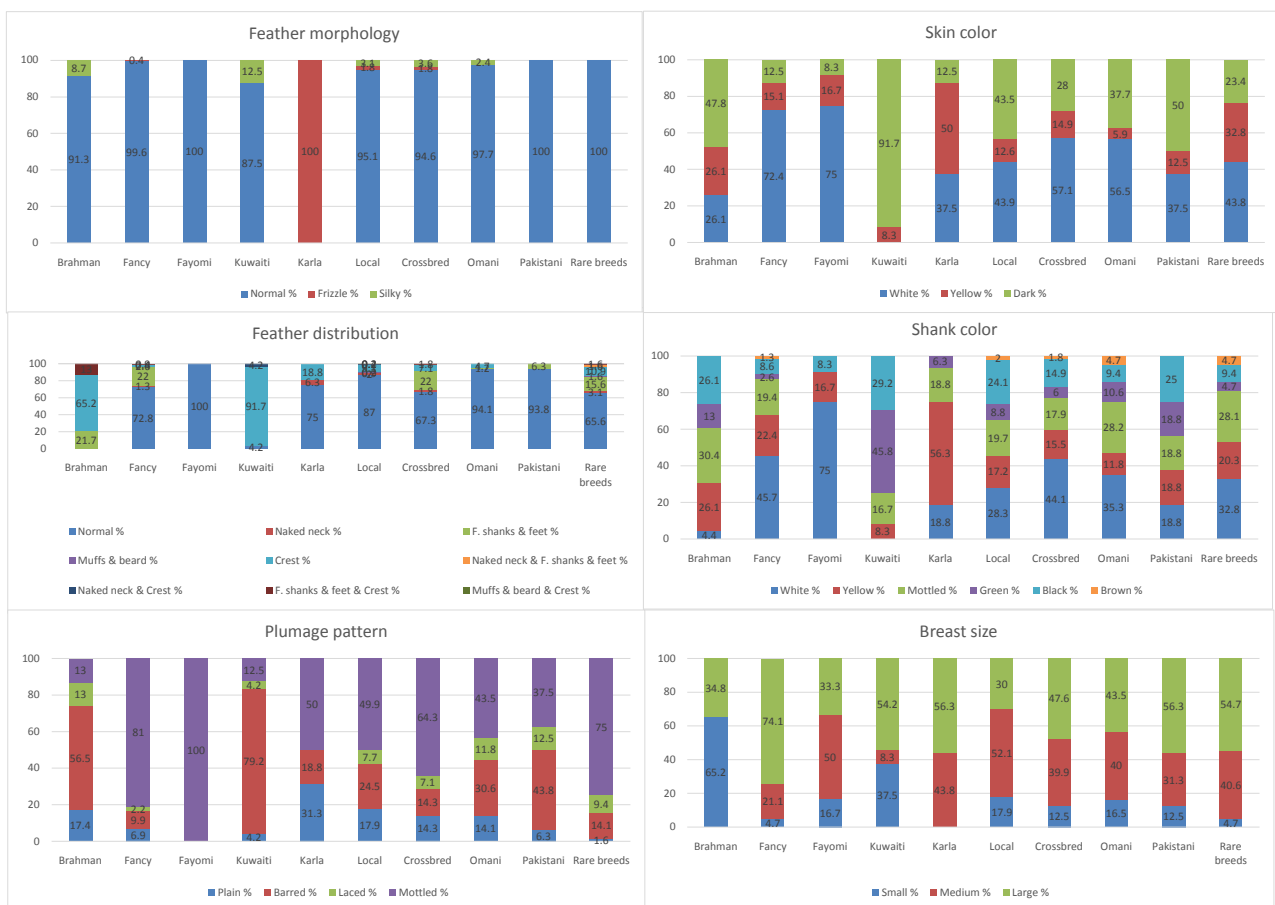


Figure 1. Feather morphology and distribution, plumage pattern breast size, skin and shank color as affected by breed of chicken. P-value for the chi-square test ($P < 0.001$). Other breeds: uncommon breeds that were named Holland, Australian, Japanese, Habhab and Abu-Dhabi.

chicken population. Contrary to this result, [9] observed absence of feather on shanks in Bhutan VCs. However, each breed had significantly different values ($P < 0.01$). For instance, 87% of Emirati local chickens had normal feather distribution with 9% of crested heads, while 100% of Fayomi had normal distribution. On the other hand, around 92% and 65% of each of Kuwaiti and Brahman, respectively, had crested heads. High diversity of feather distributions in VCs within and among different countries [3] [8] [9] [18] [20]. Although, naked neck gene is a dominant gene and is responsible for loss of feather in neck region [24], naked neck distribution of feather in this study was very low (2.3% in the overall VCs). Similar result was observed by [18] in Ethiopia. Furthermore, naked neck gene may increase feed efficiency, growth rate, disease resistance and has desirable effects on heat tolerance and adult fitness [18] [25]. However, farmers maybe did not favor the naked neck chickens and select against this gene, which make it at risk of extinction unless actions are made to genetically conserve it [18].

Except for Fayomi chickens which were 100% mottled, no specific plumage pattern was found for the whole population. Though, the mottled pattern was main pattern with 58.5% of the population, followed by barred (21.5%), plain (13.3%) and laced (6.8%) patterns, however, different breeds had different distribution of plumage patterns ($P < 0.01$). The Local breed had mottled pattern represented by almost 50%, with the presence of other patterns. Fancy, Omani, Kerala and rare breeds had mainly mottled pattern of 81%, 43.5%, 50% and 75%, respectively. On the other hand, Pakistani, Brahman and Kuwaiti had mainly barred pattern with 43.8%, 56.5% and 79.2%, respectively. On the other hand, researcher in different parts of the world reported that no specific plumage pattern found for the majority of their sampled VCs [3] [15].

Almost 52% of the overall sampled population of VCs had white or not pigmented skins; dark skinned chickens represent one third (33.3%) of the population and the rest had yellow skin (15%), though, differences among breeds were significant ($P < 0.01$). Emirati local chickens skin color was ranging from white (44.9%) to yellow (12.6%) to dark skin (43.5%). Fancy and Fayomi skins were mostly white (72.4%, 75%, respectively), while Kuwaiti chicken skins were mostly dark (91.7%). However, different regions of Ethiopia had differences in the majority of skin color either white or yellow [2] [18]. Presence of carotenoid pigments causes the yellow skin color, which is due to homozygous recessive alleles causing the inhibition of expression of the beta-carotene dioxygenase-2 enzyme while white birds are carrying the dominant allele [2]. Cabarles [13] reported low diversity of skin colors within genetic groups in Philippines. Kosbal *et al.* [20] observed differences of VCs skin colors influenced by region of the country.

Six different colors were found for the chicken shanks, with 34.3% of the sampled population had white or not pigmented shanks; in addition to 18.4% had yellow shanks (Figure 1). Researchers in other parts of the world reported diversity of shank colors for VCs [3] [9] [12] [15] [20]. Differences in shank color were highly significant ($P < 0.01$) among different breeds of VCs. All shank col-

ors were represented in the Local chicken breed. Fayomi had 75% white shanks, while Kuwaiti had no white shanks. Cabarles [13] observed high diversity of shank color ranged among groups of VCs but not within groups. Genes responsible for shank color also affect plumage color [9].

Breast size relative to body was tended to be large (46%) to medium (39.5%, **Figure 1**). Distribution of breast size was significantly ($P < 0.01$) different among different breeds. Breast size in the Emirati local chickens was ranging from small to large with highest percentage for the medium size (52.1%). Fancy breed had the highest large breast frequency (74.1%) among all breeds, while Brahman had the highest small breast frequency (65.2%). In Sri Lanka breast size measured by circumference had low variability within groups and can be used to characterize different phenotypic groups with males always having larger values for body circumference [3]. Breast size and skin color are two economically important traits, since breast meat is more expensive and preferable by many people and they do not like the dark-skinned chickens. However, some people consider chicken with dark skins as more natural.

Feather color

The color variations among and within local breeds of VCs in UAE were attracting poultry fanciers that were interested in selection of showy and colorful birds. Feather color of various body parts of the sampled chickens were highly significant ($P < 0.01$) among different breeds (**Figure 2**). The predominant plumage color for the overall sampled population of VCs was mixed colors (37.5%), the same ratio was found in Emirati local chickens, also in Fancy (42.7%), Omani (40%), Fayomi (66.7%) and rare breeds (45.3%) chickens were dominated with mixed colors plumage. The next color was the brown and cream color (24.3%), which was predominant in Pakistani (43.8%), Brahman (73.9%), Kuwaiti (50%) and Kerala (25%) chickens. The third overall wide spread color was black and brown (15.9%). Other colors were found with low frequencies on the overall. Researchers observed high variability in plumage color among and within breeds of VCs in some countries worldwide [3] [8] [12] [15]. This might be due to that several genes interact to determine plumage colors and VCs were not selected for these traits [2] [12]. However, other researchers reported the predominance of certain colors in plumage in each genetic group VCs, which could be due to selection preferences of keepers [9] [13] [18]. Hackle or neck feather color was highly variable within and among breeds with reddish-brown having the highest frequency of less than 22% in the overall. Emirati local, Fancy, Omani, Kerala and Kuwaiti chickens' breeds had all range of colors for the hackle feathers (**Figure 2**). On the other hand, 75% Fayomi had reddish brown hackle feathers, while other breeds had medium variability. Breast feather also had high variability, however, in the overall, brown and cream color had the highest frequency (31.6%), with all other colors were represented by less than 15% (**Figure 2**). Though, lower variability was observed within breed. Brahman had 65.2% brown and cream breast and Fayomi had 75% light brown. Similarly, wing coverts feathers were brown and cream (26.9%), with all other colors were

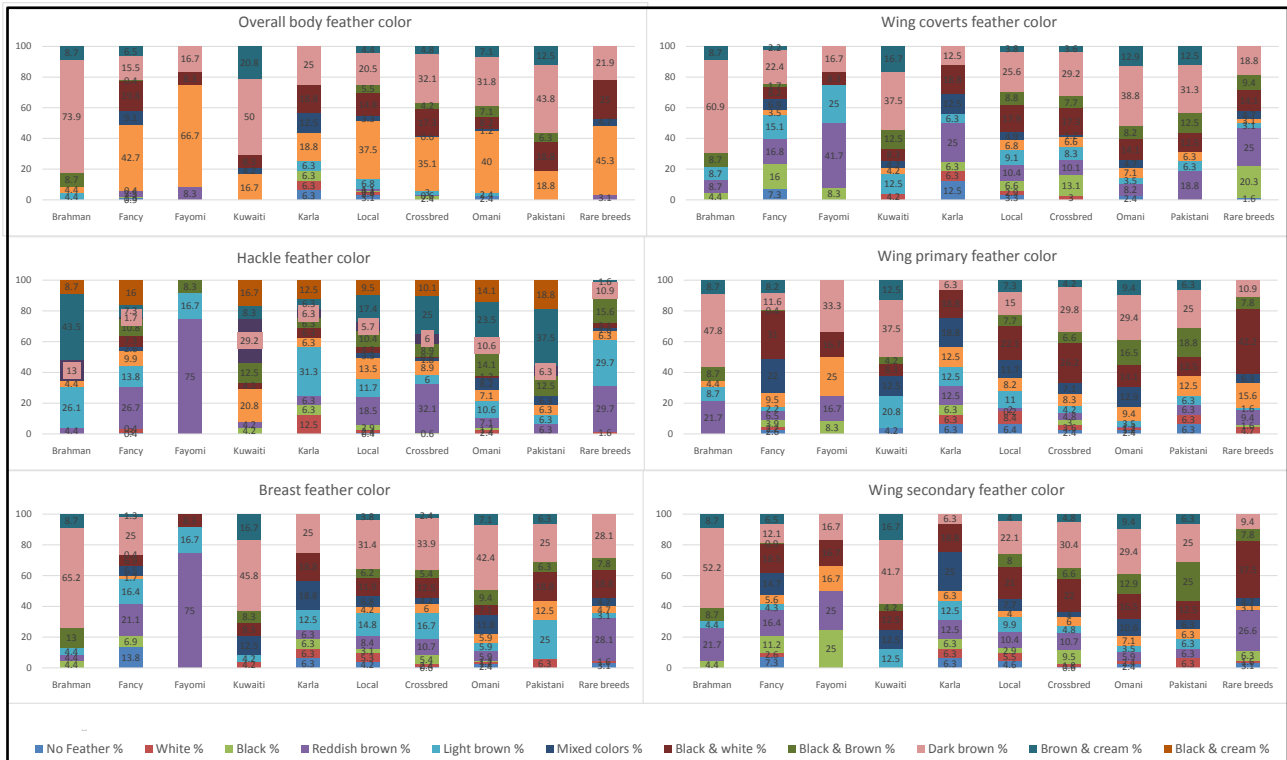


Figure 2. Feather color of various body parts of the sampled chickens. P-value for the chi-square test ($P < 0.001$). Other breeds: uncommon breeds that were named Holland, Australian, Japanese, Habhab and Abu-Dhabi.

represented by less than 15% in the overall (Figure 2). Brahman had 60.9% brown and cream breast while Fayomi had only 41.7% light brown wing coverts feathers. Wing primary and secondary feathers were more of brown and black, or brown and cream colors (Figure 2). However, each breed had its own more frequent color represented, with high variability in almost all VCs breeds. This was also true for the Emirati local breed, which was more variable in various body parts feathers, even more than other breeds.

Head characteristics

Figure 3 shows various head characteristics which were all highly significantly ($P < 0.01$) different for the different breeds of VCs. In the overall, face size tended to be small (42.8%) to medium (40.4%). Emirati local, Fancy and Omani breeds, in addition to, the crossbreds had similar values for the frequency of the different face size classes. However, other breeds had different frequencies; Pakistani (50%) and Kerala (75%) chickens tended to have medium face sizes, while Brahman (73.9%) and Kuwaiti (83.3%) tended to have small face sizes. Fayomi had only small (41.7%) or medium (58.3%) size faces (Figure 3).

The overall eye color was more of brown (48.9%) or orange (27.3%). Other colors frequencies such as pearl, red and black were less than 10%. Emirati local, Fancy, Omani, Kerala, crossbreds and rare breeds had similar values for the frequency of the different eye colors. However, 62.5% of Pakistani chickens had orange eyes, 82.6% of Brahman and 83.3% of Fayomi had brown eyes, and 75% of Kuwaiti chickens had black eyes (Figure 3). Different eye colors were the

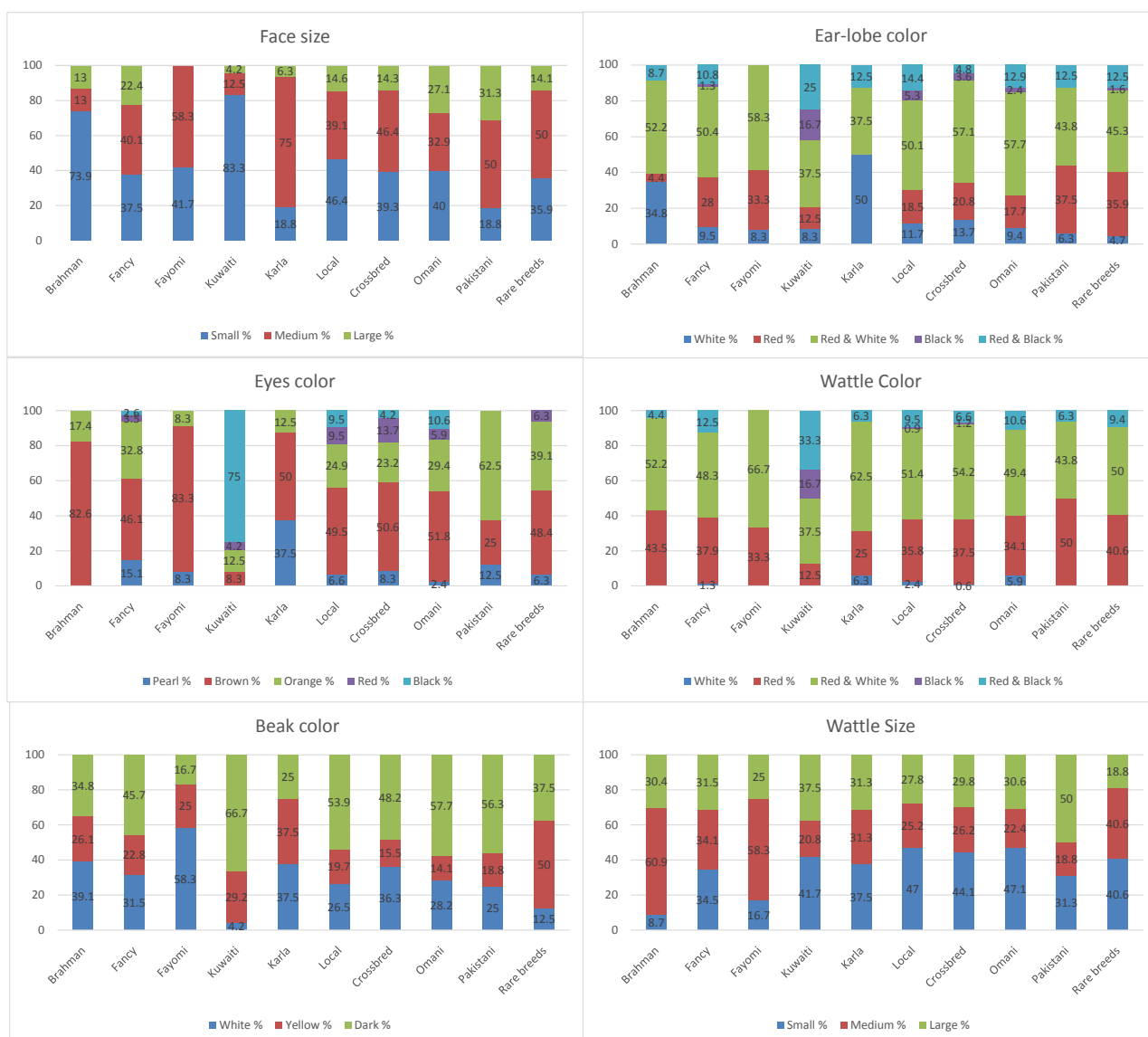


Figure 3. Face size, eye, beak color and ear-lobe color and wattle color and size as affected by breed of chicken. P-value for the chi-square test ($P < 0.001$). Other breeds: uncommon Rare breeds that were named Holland, Australian, Japanese, Habhab and Abu-Dhabi.

most prominent in different parts of the worlds; this include dark brown, orange, light brown, black and red; with high diversity [2] [3] [12] [20]. This diversity in eye color is dependent on carotenoid pigments and blood supply within the eye [26], which in consequence is related to intake and efficiency of utilization of carotenoids, genetic makeup and crossbreeding among different genotypes [13] [20].

In all VCs breeds, dark (49.7%) beaks were more available than white (28.6%) or yellow (21.7%) beaks. More white beaks were available than other colors for Brahman (39.1%) and Fayomi (58.3%), while 66.7% of beak color for Kuwaiti were dark (Figure 3). Red and white (51.1%) ear-lobes were more found than other ear-lobe colors in all VCs breeds, though wide variation were found among different VCs breeds (Figure 3). However, black ear-lobes had the lowest fre-

quency (3.7%) in the whole population of VCs, except for Kuwaiti chickens which had 16.7% of black ear-lob. Kerala chickens, on the other hand, had 50% white, 37.5% red and white, and 12.5% black and white ear-lob colors. Tashi and Dorji [9] reported different prominent earlobe colors for different genotypic groups of VCs among which were red, white, and white and red in Bhutan, while in Sri Lanka, [3] reported red ear-lob for the majority of VCs except for the crossbred chickens. However, [2] reported only 4 ear-lob colors in VCs of Ethiopia. The amount of variation in earlobe colors is related to different genetic groups [13].

The distribution of wattle colors was similar to that of ear-lob colors with some variation. Red and white (50.9%) wattles were more available than other colors, secondly the red (36.3%) wattles then red and black (10%) wattles with black wattles being the least (0.9%) in the overall VCs breeds. Local, Fancy, Omani, Kerala and crossbred chickens were not very different. Fayomi chickens had either red and white (66.7%) or red (33.3%) wattles, while Kuwaiti chickens had relatively high frequency of black (16.7%) and black and white (33.3%) wattles (Figure 3).

Small wattles (41.9%) were more available than medium (28.9%) and large (29.2%) ones in the overall VCs sampled breeds. However, more frequency of large (50%) wattles was found in the Pakistani chickens than other sizes and more medium (60.9%) wattles were found for Brahman chickens than other sizes (Figure 3). Aklilu *et al.* [2] reported significant differences in wattles size among different genotypic groups of VCs. Large wattles allow for better heat loss especially in countries with hot environment and are related to gonad development and amount of sex hormones secretion [2] [15].

Comb characteristics

Most of the sampled VCs in the Emirate had single comb (82.4%), with 11 other types and one with no comb were represented with low to very low frequencies, with significant ($P < 0.01$) differences among breeds (Figure 4). 85.2% of Emirati local breed had single comb with all other 11 and the no comb types were represented with less frequency than 4% for each of the types, while all Fayomi had single comb. Higher frequency of the single comb type which was also the largest in size is suggesting a natural selection advantage due to greater adaptability to hot environment conditions [12]. Pakistani chickens had either single (75%), rose 18.8% or pea (6.2%) comb types, also Kerala had 87.4% single 6.3% walnut and 6.3% buttercup comb types. On the other hand, Kuwaiti had 41.7% buttercup and only 29.2% single comb in addition to 16.7% V-shape with spike comb and Brahman had 30.4% V-shape, 26.1% single, 17.4% spike and 8.7% no comb. However, fewer comb types were reported by other researchers. Wani *et al.* [15] in Sudan and [2] in Ethiopia reported only 4 comb types in VCs with differences in frequencies among different genetic groups, while [9] reported only 3 comb types in VCs of Bhutan. Although, single comb is predominant comb type in many parts of the world, significant differences among genetic groups were reported [3] [9] [12]. However, other researchers reported different predominant comb types [8] [18].

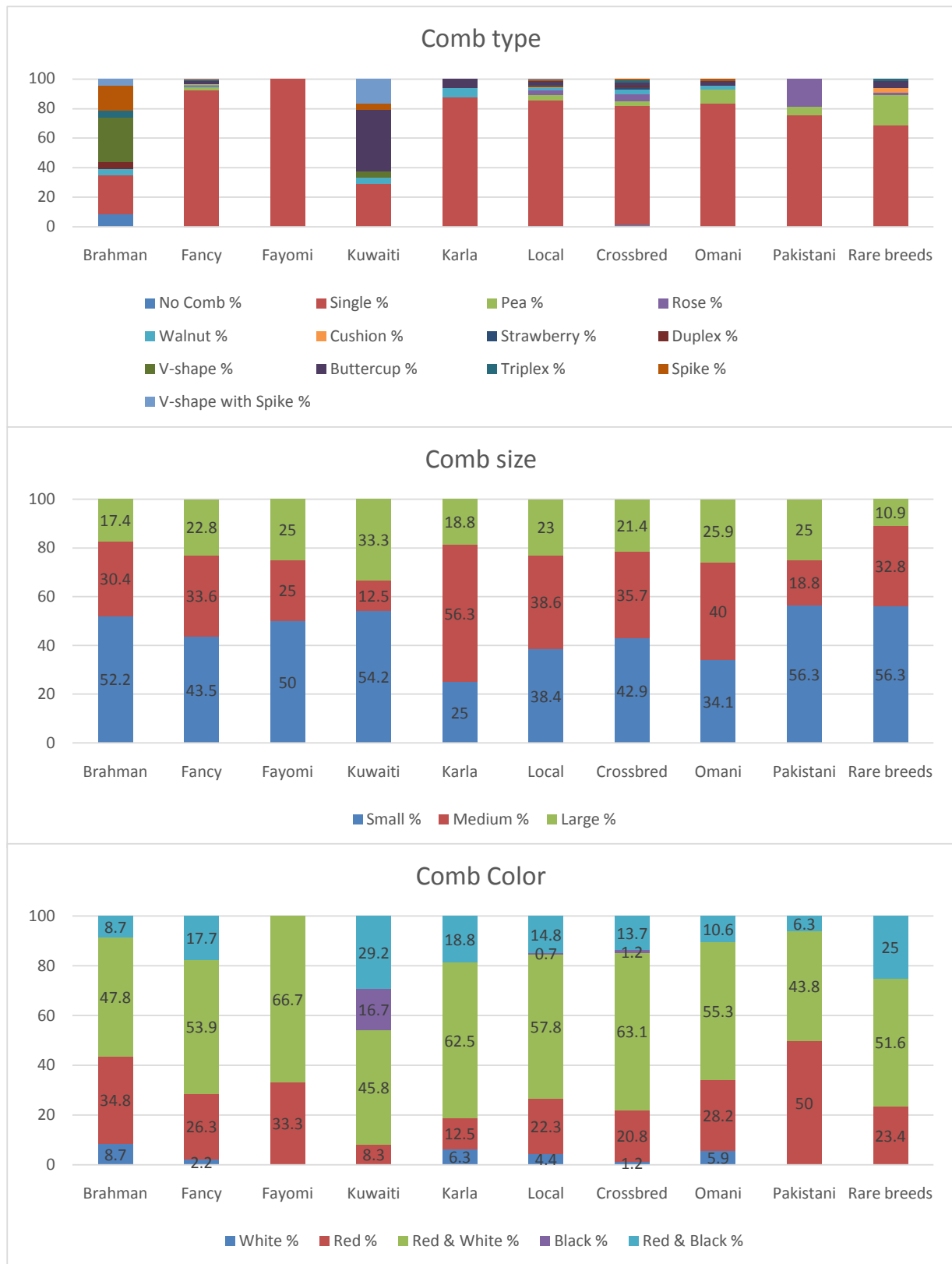


Figure 4. Comb type, size and color as affected by breed of chicken. P-value for the chi-square test ($P < 0.001$) except for comb size was not significant among breeds ($P > 0.1$). Other breeds: uncommon breeds that were named Holland, Australian, Japanese, Habhab and Abu-Dhabi.

Small combs (41.7%) were more available than either medium (36%) or large (22.3%) combs in the overall sampled population. Despite that, combs allow for better heat loss in the tropical climate of UAE [9] [12]. However, classification of comb sizes is regardless of their types, where single comb had the highest frequency. In other hot climate countries, large combs were more frequent [2] [12]. However, also in hot climate country like Ethiopia the small combs were the most frequent [18]. Although, numerical differences in frequencies of comb sizes were found among different breeds, no significant ($P > 0.1$) difference was found.

In the whole sample, red and white combs (56.7%) were the most available, however, plain red (23.8%) and red and black (15.5%) were represented by high percentages, with high significant ($P < 0.01$) differences among VCs breeds (Figure 4). In Pakistani chickens, the red combs were the most available (50%), though, red and white (43.7%) and red and black (6.3%) were also available. Fayomi combs were either red and white (66.7%) or plain red (33.3%). High percentage of black (16.7%) and red and black (29.2%) combs were found for Kuwaiti chickens. Wani *et al.* [15] reported high diversity in combs colors among and within Sudanese VCs of different genotypes.

4. Conclusion

In Abu-Dhabi Emirate, many VCs breeds existed (13 breeds and crossbreds), which exhibited wide phenotypic variation. This phenotypic variation reflected by the morphological characteristics of the different breeds raised in Abu-Dhabi Emirate, which considered the scientific base for future implementing of conservation and/or genetic improvement programs. Estimates of production performance and molecular based characterization of the different breeds of VCs reported in UAE under relatively improved management conditions are important before executing any genetic improvement program.

Acknowledgements

The authors are grateful to Abu-Dhabi Food Control Authority (ADFCA), Abu-Dhabi, UAE, for the financial support and to all persons who helped in achieving this study.

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