Bulletin of Biological and Allied Sciences Research
***ISSN:* 2521-0092**
www.bbasr.org
DOI: https://doi.org/10.54112/bbasr.v2024i1.78
*Bull. Biol. All. Sci. Res., Volume, **9**: 78*
Original Researh Article ***Open Access***

ANALYSIS TO UNCOVER RELATIONSHIPS BETWEEN MORPHOLOGICAL TRAITS, SEX AND THEIR DISTRIBUTION IN VARIOUS CHICKEN BREEDS

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(Received, 9th March 2023, Revised 17th October 2024, Published 24th October 2024)

Abstract *The poultry business provides chicken and eggs for daily consumption, making it a significant source of food for humans. The qualitative trait study may be useful in the deliberate selection and breeding of chicken breeds for improved poultry output. About 787 individuals from six breeds—Misri (MS), Aseel (AS), Golden Sebright (GS), Silver Sebright (SS), Golden Puff (GP), and Black Australorp (BA)—that are accessible in Lahore's homes and small markets were observed for this study. Chi-square analysis was used to assess the statistical significance association of traits (comb type, plumage colour, shank/foot colour, skin colour, eye colour, comb colour, earlobe colour and plumage pattern) with sex and breeds. The results revealed significant correlations between morphological traits and sex. Females exhibit a high prevalence of black eyes, slaute blue shank, solid plumage pattern, and red or white plumage. In contrast, males were more likely to have black and whindi feathers, yellow shank, and bay eyes. Breeds are found to be in a significant relation with all investigated traits except comb colour. These findings offer valuable insights for poultry breeders. By understanding the phenotypic variations associated with sex and breed, breeders can develop targeted breeding programs to produce desired characteristics. Additionally, this data highlights the unique genetic diversity of Lahore's native chicken breeds.*

[Citation: Aroosa, Ahmed, M.A., Salman, S., Ali, Q., Abbas, A., (2024). Analysis to uncover relationships between morphological traits, sex and their distribution in various chicken breeds. Bull. Biol. All. Sci. Res. **9***: 78. doi: https://doi.org/10.54112/bbasr.v2024i1.78]*
Keywords: *poultry; breeds; phenotypic variation; genetic diversity; eye coolour*

Introduction

Poultry rearing in southeast Asian countries has been a customary backyard industry for ages, with rural families predominantly scavenging chickens(Ramlah, 1999). In Pakistan, the poultry sector is a major sector of the livestock industry offering employment opportunities to over 1.5 million individuals in the country(Economic Survey of Pakistan,2023-24). Chicken breeds exhibit a remarkable diversity of morphological traits(McAinsh et al., 2004), reflecting the complex interplay between genetics, environment, and selective breeding. Morphological traits, including body weight, comb size, feather color, skin color, plumage type etc significantly influence egg production, meat yield, and overall health, with gender playing a crucial role in shaping these traits. Therefore, understanding the relationship between morphological traits and sex in chickens is also crucial for breeders. Characterization information is crucial for designing livestock conservation, development, and breeding programs(Liyanage et al., 2015). Breed characterization is the initial step for long-term genetic improvement in livestock development, guiding the design of breeding programs and describing the origin, development, structure, population, quantitative and qualitative characteristics of breeds in defined management and climatic conditions(FAO 2012)(Fitsum, 2015). Characterization can be done either genetically or phenotypically. Many previous studies at different localities of the world have explored the phenotypic characteristics of various chicken breeds, revealing significant phenotypic variations. A study on Vietnamese H'mong chicken reveals significant differences between location and traits(Cuc et al., 2006) another investigation in Bangladesh native breeds showed diversification among various Phenotypic features(Uddin et al., 2011). Moreover another investigation in Ethiopia reveals significant variation in various morphological traits (Dana, 2011). The current research aims to build upon these previous findings by employing chi-square analysis to explore the relationships between morphological traits and sex across various local chicken breeds. Chi-square analysis, a nonparametric statistical test, is an effective tool for investigating correlations between categorical variables such as gender and physical features. This statistical method allows

researchers to assess the independence of categorical variables, such as breed, sex, and the presence or absence of specific traits. By employing chi-square analysis, researchers can uncover significant associations between morphological characteristics and gender, providing insights into the underlying genetic and developmental mechanisms.

Several studies have successfully applied chi-square analysis to investigate the prevalence of morphological traits in different chicken populations. For instance, a study on Sudanese native chickens found significant associations between ecotypes and the prevalence of certain traits, such as plumage color and feathering patterns. Similarly, a study on local chicken breeds in Ethiopia used chi-square tests to describe the distribution of qualitative traits among different agroecologies (Halima et al., 2007). By analyzing a comprehensive dataset encompassing multiple breeds, this research will contribute to our understanding of the genetic and developmental factors shaping morphological diversity in avian species and may have practical implications for selective breeding and conservation efforts.

Material and methods

This study aims to investigate the association between sex (male/female) and qualitative traits and the correlation of traits with six domestic chicken breeds: Misri (MS), Aseel (AS), Golden Sebright (GS), Silver Sebright (SS), Golden Puff (GP) and Black Australorp (BA) of Lahore.

Experimental animals

A total 787 chicken were assessed for the study out of which 661 were females (hens) and 126 were males (roasters) available at the domestic level in Lahore. These hens are raised and cared for on a home basis. The age of the chickens was standardized to minimize age-related variations in trait expression. The chickens were sexually mature for accurate sex identification and trait evaluation.

Traits measured

Comb type, Plumage color, Shank/foot color, Skin color, Eye color, Comb color, Earlobe color, Plumage pattern are eight qualitative traits that are estimated with multiple variations among breeds such as comb type (single, pea, rose, muff), plumage color (black, red, white, whindi, golden laced, silver laced, golden yellow), Shank/foot color (black, white yellow, willow, salute blue), Skin color (white, yellow), Eye color (reddish brown, bay, black), Comb color (red), Earlobe color (red white), Plumage pattern (solid, laced), etc. A dedicated team worked in conjunction with the Department of Plant Breeding and Genetics, University of the Punjab, Lahore Pakistan to record every measurement for every bird. Here is the table showing the result of various morphological features among the individuals of six breeds with the discrimination of gender.

Statistical analysis (chi-square)

To assess if there is a statistically significant correlation between the traits and the breeds or if the observed differences are probably the result of chance, we utilize the chi-square statistic and its corresponding p-value.

Results and Discussion

Phenotypic diversity

Based on the morphological and morphometric traits logged from 787 birds, six distinct phenotypic groups of chicken were apparent. The first category consisted of Misri (MS), which is the most prevalent breed in Lahore; as a result, there are more members of this group. The legs of the second group, the Aseel (AS), were disproportionately longer than the rest of their bodies, which were of normal size. The plumage of Golden Sebright (GS) was distinguished from other breeds by its golden markings. Some owners had birds that belonged to the Silver Sebright chicken (SS), which shares the same plumage patterns as GS but is coloured silvery white. Golden Puff (GP) is another group, and their appearance is what sets them apart. Their striking reddish-gold coloration makes these birds easy to identify. The last one is the Black Australorp (BA), which stands out due to its stunning contrast between its brilliant red face, wattles, and single combs and its black plumage with a beetle-green shine.

Association of traits with gender

The distribution of phenotypic traits among breeds with the discrimination of gender is presented in table 1. With almost 80% of the birds possessing a single comb, these are the most frequent. Rose combs, muff combs, and pea combs are less common. Two autosomal pairs of genes—the Rose comb, RR, and the Pea comb, PP—are responsible for the comb type hereditary variation in chickens; the single comb is the recessive form of both (rrpp)(El-Safty, 2012). The most prevalent colour of plumage is red, which is followed by black and white. It is noteworthy that a larger proportion of females (57.79%) than males (45.24%) have red plumage. This implies that in this type of bird, red plumage might not be sexually dimorphic. The preservation of this variation in plumage colour suggests that numerous genes controlling the characteristic and random mating with regard to plumage colour are involved (Aklilu et al., 2013). The most popular colour for shanks and feet is slate blue, which is followed by black and yellow. Over 97% of birds have white skin, making it the most prevalent skin colour. The most frequent eye colour is reddish brown, which is followed by bay and finally black. Every bird in the sample possesses a red comb. Nearly 97% of birds have red earlobes, making it the most prevalent colour. According to reports, the majority of chickens in higher northern Thailand were red-lobed(Ige et al., 2012). Earlobes that are white are even less common, comparable to Biswas's (2005) findings, which showed that Desi chicken's red earlobe colour was 58%, and that white

earlobe colour was 45.8%(Faruque et al., 2010). Compared to interwoven designs, solid patterns are more frequently seen.

Table 1: Distribution of various morphological traits in the studied population

Characteristic	Phenotypes	All Birds(n=787)	Percentage	Gender		%M	%F
				Male(n=126)	Female(n=661)		
Comb type	Single	638	81.07	98	540	77.78	81.69
	Pea	51	6.48	8	43	6.35	6.51
	Rose	65	8.26	13	52	10.32	7.87
	Muff	33	4.19	7	26	5.56	3.93
Plumage colour	Black	115	14.61	20	95	15.87	14.37
	Red	439	55.78	57	382	45.24	57.79
	White	49	6.23	15	34	11.90	5.14
	whindi(multiple colour)	71	9.02	11	60	8.73	9.08
	golden laced	40	5.08	8	32	6.35	4.84
	silver laced	25	3.18	5	20	3.97	3.03
	golden yellow	48	6.10	10	38	7.94	5.75
Shank/foot colour	Black	335	42.57	46	289	36.51	43.72
	White	45	5.72	6	39	4.76	5.90
	Yellow	128	16.26	23	105	18.25	15.89
	Willow	23	2.92	4	19	3.17	2.87
	slate blue	256	32.53	47	209	37.30	31.62
Skin colour	White	767	97.46	122	645	96.83	97.58
	Yellow	20	2.54	4	16	3.17	2.42
Eye colour	reddish brown	704	89.45	112	592	88.89	89.56
	Bay	62	7.88	12	50	9.52	7.56
	Black	21	2.67	2	19	1.59	2.87
Comb colour	Red	787	100.00	126	661	100.00	100.00
Earlobe colour	Red	766	97.33	124	642	98.41	97.13
	White	21	2.67	2	19	1.59	2.87
Plumage pattern	Solid	557	70.78	103	454	81.75	68.68
	Laced	230	29.22	23	207	18.25	31.32

The association of phenotypic traits with the sex of chicken is shown in Table 2. The comb type (single, pea, rose, or muff) and sex in hens do not significantly correlate with one another ($p > 0.05$). In hens, there is a statistically significant correlation between the colour of their plumage and their sex ($p = 0.05$). While red and white plumage is more common in females, whindi (many colours) and black plumage are more common in males. In the Benshangul-Gumuz (Mandura), Oromia (Horro), and Southern Regions (Konso and Sheka), red is the most preferred plumage, whereas white is the more preferred body plumage colour among the Amhara population (Farta), regardless of the sex of the birds (Dana et al., 2010). In chickens, the colour of the shank or foot is statistically significantly correlated with sex ($p < 0.05$). Males are more likely to have yellow shanks than females, with slate blue shanks being more common in females. One crucial feature of native chickens is the colour of the skin and shank, which has a strong correlation with consumer preference(Suyatno et al., 2023). For poultry, the relationship between sex and skin colour (yellow, reddish brown, or white) is not statistically significant ($p > 0.05$). Comparable results on the prevalence of skin tones in native chicken populations have been documented(Guni and Katule, 2013). Among hens, there is a significant association between sex and the colour of their eyes (black or bay). Males are more likely to have bay-colored eyes, whereas females are more likely to have black eyes. Every hen on the table has a crimson comb. Insufficient information may exist to establish whether comb colour and sex are related. The fact that combs are sexual ornaments and that distinct quantitative trait loci for comb size were found based on sex are consistent with it (Moro et al., 2015). In chickens, there is no statistically significant link between sex and the colour of the earlobes—white or red. In birds, there is a statistically significant relationship between sex and the type of plumage—solid or laced. Females are more likely to have solid plumage patterns, but males are more likely to have laced patterns.

Table 2: Test of independent association between traits and sex

Characteristic	Phenotypes	All Birds(n=787)	Sex		χ(Chi-Square value)	P (at 0.05 %)
			Male(n=126)	Female(n=661)		
Comb type	Single	541.64	98	540	1.64	0.65
	Pea	43	8	43		
	Rose	52	13	52		
	Muff	26	7	26		
Plumage colour	Black	95.47	20	95	0.47	0.05*
	Red	382	57	382		
	White	34	15	34		
	whindi(multiple colour)	60	11	60		
	golden laced	32	8	32		
	silver laced	20	5	20		
	golden yellow	38	10	38		
Shank/foot colour	Black	290.055	46	289	1.055	0.005**
	White	39	6	39		
	Yellow	105	23	105		
	Willow	19	4	19		
	slate blue	209	47	209		
Skin colour	White	645.243	122	645	0.243	0.622
	Yellow	16	4	16		
Eye colour	reddish brown	634.29	112	592	42.29	0.00**
	Bay	50	12	50		
	Black	19	2	19		
Comb colour	Red	661	126	661	0	1
Earlobe colour	Red	642.67	124	642	0.67	0.41
	White	19	2	19		
Plumage pattern	Solid	462.72	103	454	8.72	0.001**
	Laced	207	23	207		

Distribution of traits among breeds

Table 3 shows the results of the correlation between breeds and phenotypic traits. Between comb type and breed, there is a statistically significant correlation (p-value <0.001). Since single-comb chickens are thought to be kinder to reproduction than rose-comb birds, the discovered greater percentage of single-comb hens may have a favourable effect on flock fertility(Chebo et al., 2023). Furthermore, under open breeding conditions, the low percentage of rose-combed chicks seen in this study had a good impact on the fertility of chickens. A statistically significant correlation (p-value <0.001) has been observed between the colour of the shank/foot and breed. The shade of the chicken's shank provides information about its capacity to forage, immune system health, and sexual appeal(Habimana et al., 2021). Skin colour and breed have a statistically significant correlation (p-value <0.001). All breeds most commonly have white skin. Between eye colour and breed, there is a statistically significant correlation (p-value <0.001). Since every hen in the table has a red comb, there is no information worth including when exploring the potential correlation between comb colour and breed. The colour of the earlobes and breed are statistically significantly correlated (p-value <0.001). The majority of these characteristics have previously been linked to the capacity of chickens to withstand heat stress, a lack of feed, and chronic illnesses in the area(Al-Atiyat et al., 2017). Breed and plumage patterns have a statistically significant correlation (p-value <0.001). The most prevalent patterns are solid ones. The medium-sized Arabi chickens in Kuwait are distinguished by their multicoloured plumage, V-shaped comb, crested heads, short, dark shanks, and resilience to harsh weather conditions(Tabbaa and Hassanin, 2018).

Table 3: Distributions and morphological of comb type, color of skin, shank and earlobe of various local breeds of chicken's population

Traits	Phenotype	Chicken breeds							
		MS	AS	GS	SS	GP	BA	Chi square	Significance
Comb type	Single	536	81	0	0	0	21	2080.6	0.00**
	Pea	0	51	0	0	0	0		

	Rose	0	0	40	25	0	0		
	Muff	0	0	0	0	33	0		
Plumage colour	Black	72	22	0	0	0	21	19883.43	0.00**
	Red	429	10	0	0	0	0		
	White	35	14	0	0	0	0		
	whindi(multiple colour)	0	71	0	0	0	0		
	golden laced	0	0	40	0	0	0		
	silver laced	0	0	0	25	0	0		
	golden yellow	0	15	0	0	33	0		
Shank/foot colour	Black	335	0	0	0	0	17	14.3607	0.00**
	White	0	37	0	0	0	0		
	Yellow	0	95	0	0	33	4		
	Willow	0	0	5	5	0	0		
	slate blue	201	0	35	20	0	0		
Skin colour	White	528	120	40	25	33	21	28.34614	0.00**
	Yellow	8	12	0	0	0	0		
Eye colour	reddish brown	536	132	3	0	33	0	1535.673	0.00**
	Bay	0	0	37	25	0	0		
	Black	0	0	0	0	0	21		
Comb colour	Red	536	132	3	25	33	21	0	1.0000
Earlobe colour	Red	536	132	40	25	33	0	787	0.00**
	White	0	0	0	0	0	21		
Plumage pattern	Solid	386	117	0	0	33	21	200.4688	0.00**
	Laced	150	15	40	25	0	0		

Conclusion

In summary, this study found a strong correlation between several physical characteristics and sex in local Lahore chicken breeds. Comb type, skin colour, eye colour, and plumage pattern all showed relationships with sex, while shank/foot colour and plumage colour did not. Black eyes, slate blue shanks, solid plumage patterns, and red and white plumage were more common in females. Conversely, males were more likely to have black and whindi feathers, yellow shanks, and bay eyes. Poultry breeders can benefit greatly from these findings. Breeders can create focused breeding programs to produce desired features by knowing the phenotypic variations and how they relate to sex. Furthermore, this data supports conservation efforts by bringing attention to the distinctive genetic diversity of Lahore's native chicken breeds.

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Declarations

Declaration of Interest Statement

We declare that we have no financial and personal relationships with other people or organizations that can inappropriately influence our work.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not for-profit sectors.

Acknowledgments

The authors would like to extend their sincere appreciation to the tertiary care hospital LRH, Peshawar.

Author's contributions

MAA, and Aroosa conducted research and wrote initial draft of manuscript. SS, QA, AA, and MAA collected the literature and wrote the manuscript and edit the manuscript in original. All authors have read and approved the final manuscript.

Ethics approval and consent to participate

Not applicable

Consent for Publication

Not applicable