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Research Paper

Morphometry, Feeding Ecology, Haematology, and Heavy Metal Bioaccumulation in House Crow (*Corvus splendens*) from Central Punjab, Pakistan

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Abstract

The house crow (*Corvus splendens*) is a highly adaptable urban bird widely distributed across Pakistan and serves as a potential bioindicator of environmental health. This study evaluated morphometry, feeding ecology, haematology, and tissue trace-metal burdens in house crows from cultivated and semi-urban landscapes of Okara District (Central Punjab, Pakistan) during March-June 2023. Sixty adults were captured, and a subset of 24 individuals (12 males and 12 females) was processed for detailed laboratory analyses. Standard morphometrics were recorded using a digital balance and digital calipers. Diet was assessed via gut-content examination and categorized into major food groups. Blood was collected from the brachial vein for routine haematology, and liver, kidney, and pectoral muscle tissues were digested ($HNO_3/HClO_4$) and analyzed by atomic absorption spectrophotometry for Zn, Cd, Ni, Fe, and Cr. Sexual dimorphism was limited, with males marginally heavier and slightly larger in wingspan. Gut contents indicated an opportunistic omnivorous diet with a high frequency of insects (83.3%), wheat grains (62.5%), and anthropogenic refuse (50%). Mean haematological indices were within expected avian ranges (e.g., RBC $2.93 \pm 0.45 \times 10^6/\mu L$; WBC $26.87 \pm 1.02 \times 10^3/\mu L$; PCV $37.97 \pm 2.00\%$). Trace metals were detected in all tissues, with Zn and Fe generally highest in liver and Cr relatively elevated in muscle. These findings provide baseline ecological and physiological information for *C. splendens* and support its utility as a sentinel species for monitoring anthropogenic food dependence and trace-metal exposure in agro-urban Punjab.

Introduction

The house crow (*Corvus splendens* Vieillot, 1817), also known as the Indian Grey-necked crow, is an intelligent bird that thrives in close association with humans (Singh et al., 2017). Belonging to the order Passeriformes and the family Corvidae (Patra & Chakrabarti, 2014), it is distributed in Pakistan, India, Bangladesh, Nepal, Burma, Myanmar, Nepal, Sri

Lanka and southern China (Madge & Burn, 1994; Ryall, 2002; Ali, 2008). In Pakistan, its distribution extends from the coastal regions of Baluchistan to Swat and Mansehra, but it is absent in the Murree hills (Robert, 1992). These crows are especially abundant in Central Punjab (Khan et al., 2007; Qureshi et al., 2010).

The house crows are omnivorous, consuming both plant material and invertebrates, with little visible distinction between sexes and age groups (Lockie, 1956). Morphologically, the house crow has a grey-brown neck and chest, black wings and legs, and a smoky-grey breast. Its body length ranges from 42–44 cm with a weight of 300–400 g, and males are slightly larger than females (Dhindsa et al., 1991). They are monogamous, maintaining pair bonds across breeding seasons (Archer, 1998). Although breeding occurs year-round (Akter et al., 1994), peak breeding takes place from June to August during the monsoon in Sindh and Punjab (Awais et al., 2015; Grimmett et al., 2016). Nests are typically built in tall, broad-crowned trees to minimize disturbance and maximize access to food (Goodwin, 1976).

In feeding the house crows include a variety of fruits and crops such as citrus (*Citrus reticulata*), sunflower (*Helianthus annuus*), unripe *Zizyphus jujuba*, guava (*Psidium guajava*), and jamun (*Jamun sambhar*). Among these, citrus and sunflower crops are the most heavily depredated, causing significant economic losses to farmers (Khan et al., 2007). From an ecological perspective, haematological and plasma biochemical parameters are widely used to assess the health and physiological condition of birds. These tools provide insights into nutritional status, parasite load, stress, and environmental adaptation (Cherel et al., 1988; Ots et al., 1998). Establishing baseline haematological data for the house crow is, therefore, important for understanding its ecology and interactions with the environment. At the same time, environmental pollution, particularly with heavy metals, is a growing concern. These elements, many of anthropogenic origin, contaminate soil and water systems, entering food chains and threatening biodiversity (Adams et al., 2004; Lee et al., 2006; Sheppard et al., 2009). Heavy metals bioaccumulate in vital organs such as the liver, kidney, brain, and heart, causing increased morbidity and mortality in wildlife (Godt et al., 2006). Through water and food consumption, these metals also accumulate in humans, leading to severe toxic effects (Bilandžić et al., 2010).

Given the house crow’s wide distribution, close association with human settlements, potential role in crop depredation, and exposure to environmental pollutants, this species can serve as an effective bioindicator for ecological and toxicological studies. Therefore, the present study was designed to analyse morphometric parameters of both sexes, record heavy metal concentrations in muscles, kidney, and liver, assess feeding preferences, and evaluate haematological parameters of the house crow to establish baseline values for future ecological and toxicological research.

Materials and Methods

Study area

The study was conducted in Okara District, Punjab, Pakistan (approx. 30°48′05″N, 73°26′54″E), a predominantly irrigated agro-urban landscape in the Sahiwal Division. Sampling sites represented cultivated fields, village peripheries, and semi-urban areas around Okara city. The region is characterized by extensive agriculture and expanding urban infrastructure, with plausible contaminant inputs from vehicular traffic corridors, agricultural inputs (fertilizers and pesticides), small-scale industries (including cotton-processing activities), and regional brick-kiln activity associated with air-quality concerns. Birds were handled following standard ethical practices to minimize stress and ensure accurate measurements.

Morphometric measurements

Morphometric data were recorded for both male and female house crows to assess sex-related differences. Measurements included body weight, body length, wingspan, single-wing length, primary wing length, tail length, tarsus length, metatarsus length, head length, bill length, and chest circumference. All measurements were taken by two trained observers; each trait was measured thrice per bird and the mean value was used for analysis. Body weight was measured using a calibrated digital balance, and linear dimensions were taken with a precision measuring scale/digital caliper following established ornithological procedures (e.g., Lockie, 1956).

Feeding preferences

Feeding ecology of house crows was studied through direct field observations in agricultural and semi-urban habitats. Particular attention was given to crops and fruits commonly visited by the birds. The diet included citrus (*Citrus reticulata*), sunflower (*Helianthus annuus*), unripe *Zizyphus jujuba*, guava (*Psidium guajava*), and jamun (*Jamun sambhar*). Among these food sources, citrus and sunflower were observed to be the most heavily depredated, leading to significant economic losses for farmers, which is consistent with earlier reports (Khan et al., 2007).

Haematological analysis

Blood samples were collected aseptically from the brachial vein of live captured individuals using sterile syringes. Fresh samples were analysed for the following parameters: red blood cell (RBC) count, white blood cell (WBC) count, haemoglobin (Hb) concentration, packed cell volume (PCV), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), and mean corpuscular haemoglobin concentration (MCHC). RBC and WBC counts were determined using a haemocytometer, haemoglobin concentration was measured by the cyanmethemoglobin method, and PCV was determined using microhaematocrit centrifugation. These haematological indices were selected as they are widely recognized tools for assessing physiological condition, nutritional status, parasite load, and environmental adaptation in avian ecological research (Cherel et al., 1988; Ots et al., 1998).

Heavy metal analysis

To evaluate bioaccumulation of heavy metals, tissue samples (liver, kidney, and muscle) were collected from dissected birds. Samples were digested using a wet acid digestion method with nitric acid (HNO_3) and perchloric acid ($HClO_4$), following the procedure described by Adams et al. (2004). The digested material was analyzed using Atomic Absorption Spectrophotometry (AAS), as recommended by Lee et al. (2006) and Sheppard et al. (2009).

The metals quantified included lead (Pb), cadmium (Cd), chromium (Cr), nickel (Ni), and zinc (Zn). These elements were chosen because of their common anthropogenic sources, environmental persistence, and toxicological significance. Organ-specific accumulation was compared to assess physiological impacts and possible ecological risks.

Data analysis

All morphometric and haematological parameters were expressed as mean ± standard error. Differences between sexes were assessed using Student's *t*-test. Heavy metal concentrations across tissues were analyzed using analysis of variance (ANOVA), and significant results were further explored using post-hoc tests. Statistical significance was determined at $p < 0.05$.

Results

Morphometric study

A total of 24 samples of house crow (*Corvus splendens*) were examined, comprising 12 males and 12 females. Morphometric parameters included body weight, body length, tail length, wingspan, single-wing length, primary wing length, head size, bill size, tarsal length, metatarsal length, and chest circumference. Ranges and mean values of morphometric characters for both sexes are presented in Table 1. The body weight of males ranged from 271–271.5 g (mean: 272.23 ± 0.92 g), while in females it ranged from 270–271.7 g (mean: 270.70 ± 0.67 g). The body length ranged from 40–41.5 cm (40.83 ± 0.62 cm) in males and 38.5–39.7 cm (39.40 ± 0.65 cm) in females. Tail length measured 15.5–16.4 cm (16.20 ± 0.51 cm) in males and 14.8–15.5 cm (15.20 ± 0.29 cm) in females.

Table 1: Morphometric Parameters in female and male adult 'house crow' sampled from cultivated lands of District Okara, Punjab, Pakistan.

Parameters	N	Range (Minimum-Maximum)	Mean	Std. Deviation
Male				
Body Weight (g)	12	271.271.5	272.23	0.92
Body Length (cm)	12	40-41.5	40.83	0.62
Tail Length (cm)	12	15.5-16.4	16.20	0.51
Wingspan (cm)	12	76.2-75.8	76.17	0.29
Single Wing Length (cm)	12	35-34.6	34.53	0.41
Primary Wing (cm)	12	23.7-24.3	24.03	0.25
Tarsal (cm)	12	4.2-4.1	4.27	0.17
Metatarsal (cm)	12	4-3.8	4.13	0.34
Head Length	12	5.2-5.5	5.23	0.21
Beak	12	4.6-5.2	4.93	0.25
Body Circumference (cm)	12	21.2-22.1	21.87	0.48
Female				
Body Weight (g)	12	27.0-271.7	270.70	0.67
Body Length (cm)	12	39.7-38.5	39.40	0.65
Tail Length (cm)	12	15.5-14.8	15.20	0.29
Wingspan (cm)	12	75.2-74.8	75.27	0.41
Single Wing Length (cm)	12	33.5-32.8	32.77	0.61
Primary Wing (cm)	12	23.2-24.2	23.60	0.43
Tarsal (cm)	12	3.9-3.5	3.83	0.25
Metatarsal (cm)	12	3.9-4.5	4.17	0.25
Head Length	12	4.2-3.9	4.27	0.33
Beak	12	4.8-4.5	4.80	0.24
Bill Length (cm)		22.1	21.83	0.21
Body Circumference (cm)	12	221.1-21.8	21.83	0.21

Similarly, wingspan ranged between 75.8–76.2 cm (76.17 ± 0.29 cm) in males and 74.8–75.2 cm (75.27 ± 0.41 cm) in females. Single-wing length ranged from 34.6–35 cm (34.53 ± 0.41 cm) in males and 32.8–33.5 cm (32.77 ± 0.61 cm) in females. Primary wing length was similar in both sexes (mean 24.03 ± 0.25 cm). Tarsal length was 4.1–4.2 cm in males (4.27 ± 0.17 cm) and 3.5–3.9 cm in females (3.83 ± 0.25 cm), while metatarsal length ranged from 3.8–4 cm (4.13 ± 0.34 cm) in males and 3.9–4.5 cm (4.17 ± 0.25 cm) in females. Head length ranged from 5.2–5.5 cm in males (5.23 ± 0.21 cm) and 3.9–4.2 cm in females (4.27 ± 0.33 cm). Beak length ranged from 4.6–5.2 cm (4.93 ± 0.25 cm) in males and 4.5–4.8 cm (4.80 ± 0.24 cm) in females. Chest circumference ranged from 21.2–22.1 cm (21.87 ± 0.48 cm) in males and 21.8–22.1 cm (21.83 ± 0.21 cm) in females.

Correlation analysis between morphometric parameters (Table 2) indicated that body weight, wingspan, wing length, primary wing length, tarsal length, metatarsal length, head length, and bill length were positively correlated between sexes, while body length and tail length showed negative correlation. Chest circumference showed a perfectly positive correlation between males and females.

Table 2: Comparison of morphometric characteristics between male and female 'house crow' from cultivated lands of District Okara, Punjab, Pakistan.

Characters	Gender	N	Mean	SD	SE	Coefficient (r)	t-value	p-value
Body Weight	Male	12	272.23	0.92	1.59	0.49	2.67	0.01
	Female	12	270.70	0.67	0.39			
Body Length	Male	12	40.83	0.62	1.08	0.33	1.62	0.12
	Female	12	39.40	0.65	0.37			
Tail Length	Male	12	16.20	0.51	0.88	0.00	0.00	1.00
	Female	12	15.20	0.29	0.17			
Wingspan	Male	12	76.17	0.29	0.50	0.98	23.47	0.00
	Female	12	75.27	0.41	0.24			
Single wing length	Male	12	34.53	0.41	0.71	1.00	61.20	0.00
	Female	12	32.77	0.61	0.35			
Primary wing Length	Male	12	24.03	0.25	0.43	0.87	8.12	0.00
	Female	12	23.60	0.43	0.25			
Tarsal	Male	12	4.27	0.17	0.29	0.95	14.89	0.00
	Female	12	3.83	0.25	0.14			
Metatarsal	Male	12	4.13	0.34	0.59	0.14	0.68	0.50546096
	Female	12	4.17	0.25	0.14			
Head Length	Male	12	5.23	0.21	0.36	0.40	2.03	0.054510168
	Female	12	4.27	0.33	0.19			
Beak Length	Male	12	4.93	0.25	0.43	0.96	16.25	0.350963937
	Female	12	4.80	0.24	0.14			
Circumference	Male	12	21.87	0.48	0.83	0.12	0.55	0.58660034
	Female	12	21.83	0.21	0.12			

NS = Non-significant (P>0.05); * = Significant (P<0.05); ** = highly significant (P<0.05) SD = Standard deviation; SE = Standard error

Figure 1 compares body length, chest circumference, and tail length, showing no significant sex-related differences. Figure 2 illustrates comparisons of wingspan, single-wing length, and primary wing length, indicating no significant variation. Figure 3 compares tarsal and metatarsal lengths, again showing no significant differences between sexes. Figure 4 demonstrates that head length and bill length were also statistically similar between male and female house crows.

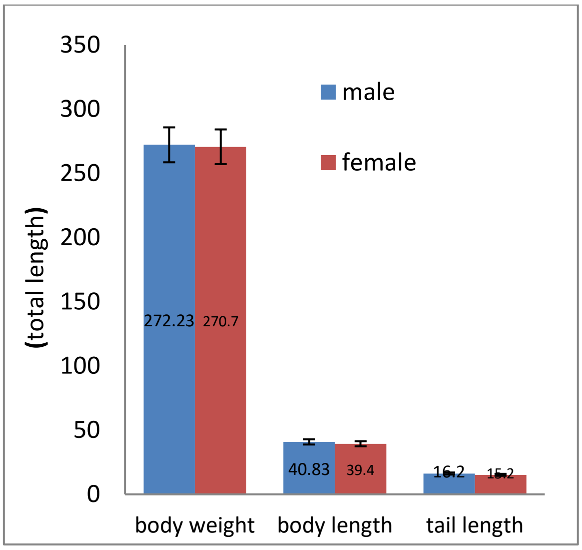

Figure 1: comparison between body weight, body length, tail length Male and Female house crow.

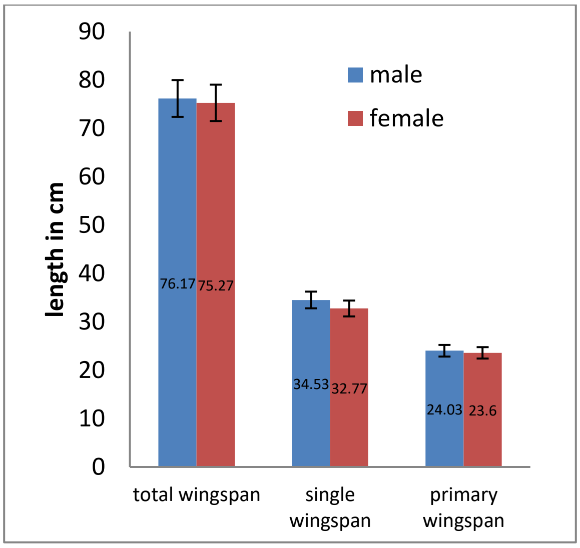

Figure 2. Comparison between total wingspan, single wingspan, primary wingspan of Male and Female house crow.

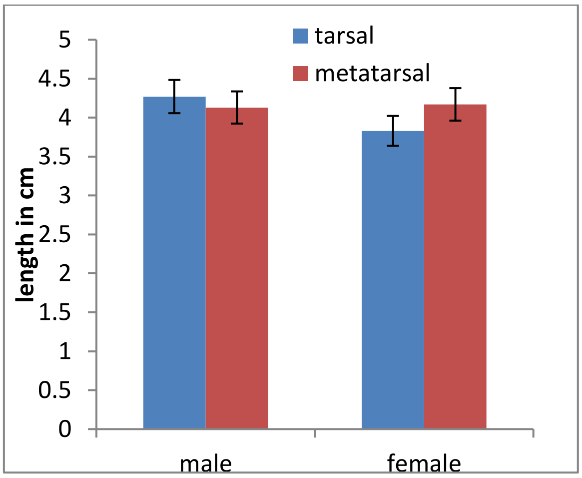

Figure 3. comparison between Tarsal and Met-tarsal of male and female house crow.

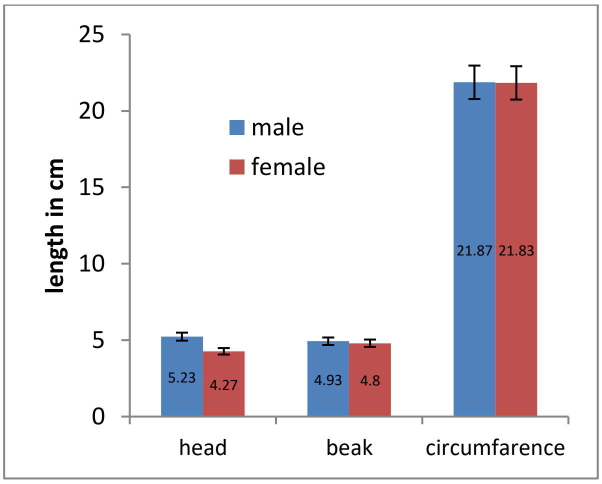

Figure 4: Comparison between head, beak, and circumference of Male and Female house crow

Correlation between morphometry and hematology

Male house crows

The correlation analysis between morphometric traits and haematological parameters in male house crows is presented in Table 3**.** Haemoglobin (Hb), white blood cells (WBC), total red blood cells (RBC), haemoglobin concentration (HBC), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration

(MCHC), packed cell volume (PCV), basophils, neutrophils, lymphocytes, monocytes, and eosinophils were found to be positively correlated with body weight, total wingspan, primary wing length, metatarsal length, head size, and chest circumference. Notably, HBC and eosinophils showed a perfect positive correlation with head size in male house crows.

Table 3: Correlation matrix between Mensural and Hematological parameters of Male house crow from Central Punjab

Pearson Correlation (2-tailed)		**HGB**	**WBCs**	**Total RBCs**	**HCT/PCV**	**MCV**	**MCH**	**MCHC**	**Basophils**	**Neutrophils**	**Lymphocytes**	**Monocytes**	**Eosinocytes**
Body Weight	**Pearson Correlation**	-0.33	-0.33	-0.26	-0.26	-0.25	-0.28	-0.29	-0.26	-0.37	-0.38	-0.38	-0.27
	Sig.	0.79	0.78	0.83	0.83	0.84	0.82	0.81	0.82	0.75	0.74	0.74	0.82
Total Body Length	**Pearson Correlation**	0.3	0.3	0.38	0.38	0.38	0.36	0.34	0.36	0.26	0.24	0.24	0.35
	Sig.	0.8	0.8	0.75	0.75	0.75	0.77	0.78	0.75	0.83	0.84	0.84	0.76
Tail Length	**Pearson Correlation**	-0.26	-0.26	-0.19	-0.18	-0.18	-0.21	-0.23	-0.19	-0.3	-0.31	-0.31	-0.2
	Sig.	0.83	0.83	0.88	0.88	0.88	0.87	0.85	0.87	0.8	0.79	0.79	0.86
Total Wingspan	**Pearson Correlation**	-0.99	-0.99	-1	-1	-1	-0.99	-0.99	-0.99	-0.98	-0.98	-0.98	-0.99
	Sig.	0.06	0.06	0.02	0.01	0.02	0.03	0.04	0.02	0.09	0.1	0.1	0.03
Single Wing Length	**Pearson Correlation**	0.61	0.61	0.55	0.55	0.55	0.57	0.59	0.56	0.65	0.66	0.66	0.56
	Sig.	0.58	58	0.62	0.63	0.63	0.61	0.6	0.62	0.54	0.54	0.54	0.61
Primary Wing Length	**Pearson Correlation**	0.35	0.35	0.28	0.27	0.27	0.29	0.32	0.28	0.39	0.4	0.4	0.29
	Sig.	0.77	0.77	0.82	0.83	0.83	0.81	0.79	0.81	0.74	0.73	0.73	0.8
Tarsal	**Pearson Correlation**	-0.97	-0.97	-0.95	-0.94	-0.94	-0.95	-0.96	-0.94	-0.97	-0.98	-0.98	-0.95
	Sig.	0.16	0.16	0.21	0.22	0.22	0.2	0.19	0.2	0.13	0.12	0.12	0.2
Metatarsal	**Pearson Correlation**	-0.97	-0.97	-0.95	-0.94	-0.94	-0.95	-0.96	-0.94	-0.97	-0.98	-0.98	-0.95
	Sig.	0.16	0.16	0.21	0.22	0.22	0.2	0.19	0.2	0.13	0.12	0.12	0.2
Head Size	**Pearson Correlation**	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.98	0.98	0.98	0.99
	Sig.	0.09	0.09	0.04	0.04	0.04	0.05	0.06	0.04	0.11	0.12	0.12	0.05
Bill Size	**Pearson Correlation**	0.31	0.31	0.38	0.38	0.38	0.36	0.34	0.36	0.26	0.24	0.24	0.35
	Sig.	0.8	0.8	0.75	0.75	0.75	0.77	0.78	0.75	0.83	0.84	0.84	0.76
Circumference	**Pearson Correlation**	-0.91	-0.91	-0.88	-0.87	-0.87	-0.88	-0.89	-0.88	-0.92	-0.93	-0.93	-0.88
	Sig.	0.27	0.27	0.32	0.32	0.32	0.31	0.29	0.31	0.24	0.23	0.23	0.3

Conversely, Hb, WBC, total RBC, HGB, MCV, MCH, MCHC, platelets, PCV, neutrophils, lymphocytes, monocytes, and eosinophils exhibited negative correlations with total body length, tail length, single-wing length, tarsal length, and beak size (Table 3).

Female house crows

The correlation between morphometric and haematological parameters in female house crows is shown in Table 4**.** Hb, WBC, total RBC, HBC, MCV, MCH, MCHC, basophils, PCV, neutrophils, lymphocytes, monocytes, and eosinophils were positively correlated with body weight, total body length, tail length, total wingspan, primary wing length, metatarsal length, head size, and chest circumference. A positive correlation was observed between haemoglobin concentration and primary wing length in females.

In contrast, Hb, WBC, total RBC, HBC, MCV, MCH, MCHC, PCV, basophils, neutrophils, lymphocytes, monocytes, and eosinophils were found to be negatively correlated with single-wing length, tarsal length, and beak size in female house crows (Table 4).

Table 3: Correlation matrix between Mensural and Hematological parameters of Female house crow.

Pearson Correlation (2-tailed)		HGB	WBCs	Total RBCs	HCT/PCV	MCV	MCH	MCHC	Basophils	Neutrophils	Lymphocytes	Monocytes	Eosinocytes
Body Weight	Pearson Correlation	0.55	0.65	0.71	0.71	0.69	0.69	0.68	0.7	0.16	0.6	0.6	0.69
	Sig.	0.63	0.55	0.49	0.49	0.5	0.51	0.52	0.5	0.57	0.58	0.58	0.5
Total Body Length	Pearson Correlation	-0.88	-0.94	-0.96	-0.96	-0.95	-0.96	-0.94	-0.95	-0.92	-0.91	-0.91	-0.95
	Sig.	0.31	0.23	0.18	0.18	0.19	0.19	0.2	0.18	0.25	0.26	0.26	0.19
Tail Length	Pearson Correlation	-0.57	-0.68	-0.73	-0.74	-0.71	-0.72	-0.7	-0.72	-0.64	-0.63	-0.63	-0.17
	Sig.	0.61	0.53	0.48	0.48	0.49	0.49	0.5	0.48	0.55	0.56	0.56	0.49
Total Wingspan	Pearson Correlation	-0.99	-0.99	-0.99	-0.99	-0.98	-0.99	-0.99	-0.98	-0.99	-0.99	-0.99	-0.98
	Sig.	0.03	0.06	0.11	0.11	0.09	0.09	0.08	0.1	0.02	0.02	0.02	0.05
Single Wing Length	Pearson Correlation	0.66	0.55	0.49	0.48	0.5	0.5	0.52	0.49	0.59	0.6	0.6	0.5
	Sig.	0.54	0.63	0.68	0.68	0.66	0.66	0.65	0.67	0.59	0.59	0.59	0.66
Primary Wing Length	Pearson Correlation	0.65	0.74	0.79	0.79	0.77	0.78	0.76	0.78	0.7	0.7	0.7	0.77
	Sig.	0.55	0.47	0.42	0.42	0.43	0.43	0.44	0.42	0.49	0.5	0.5	0.43
Tarsal	Pearson Correlation	-0.94	-0.98	-0.99	-0.99	-0.98	-0.99	-0.98	-0.98	-0.96	-0.96	-0.96	-0.98
	Sig.	0.22	0.14	0.08	0.08	0.09	0.09	0.11	0.09	0.16	0.17	0.17	0.09
Metatarsal	Pearson Correlation	0.53	0.64	0.69	0.69	0.68	0.68	0.66	0.68	0.6	0.59	0.59	0.68
	Sig.	0.65	0.56	0.51	0.51	0.52	0.52	0.53	0.51	0.59	0.59	0.59	0.52
Head Size	Pearson Correlation	-1	-0.99	-0.98	-0.98	-0.98	-0.98	-0.98	-0.98	-0.99	-0.99	-0.99	-0.98
	Sig.	0	0.07	0.13	0.13	0.11	0.11	0.09	0.12	0.04	0.03	0.03	0.11
Bill Size	Pearson Correlation	-0.99	-1	-0.99	-0.99	-0.99	-0.99	-1	-0.99	-0.99	-0.99	-0.99	-0.99
	Sig.	0.09	0.02	0.03	0.03	0,02	0.02	0	0.02	0.04	0.05	0.05	0.02
Circumference	Pearson Correlation	0.54	0.42	0.35	0.34	0.36	0.37	0.38	0.35	0.46	0.47	0.47	0.36
	Sig.	0.64	0.73	0.77	0.77	0.76	0.76	0.74	0.76	0.69	0.68	0.68	0.76

Haematological analysis

Blood samples were collected from 24 house crows (12 males and 12 females) in EDTA tubes for haematological analysis. The results of various haematological parameters are presented in Table 5. The total white blood cell (WBC) count ranged from 180.80–250.30 × 10^3/µL with a mean of 223.53 ± 30.54 × 10^3/µL. Red blood cell (RBC) concentration varied between 1.20–3.50 × 10^6/µL with a mean of 2.37 ± 0.94 × 10^6/µL. Haemoglobin levels ranged from 10.20–22.80 g/dL, while packed cell volume (PCV) ranged between 33–48.50% (mean: 37.97 ± 2.00%).

The mean corpuscular values were as follows: MCV ranged from 37.80–40.50 fL (mean: 37.97 ± 2.00 fL), MCH ranged from 35.00–61.00 pg (mean: 49.43 ± 4.78 pg), and MCHC ranged from 25.90–39.80 g/dL (mean: 31.63 ± 1.84 g/dL). Among leukocyte differentials, basophils ranged between 0.00–3.00 × 10^3/µL (mean: 1.93 ± 0.53 × 10^3/µL). Neutrophils ranged from 45.50–80.86% (mean: 1.93 ± 0.53%). Lymphocyte counts were between 14.00–50.50% (mean: 2.63 ± 0.57%), while monocytes ranged between 1.00–4.00% (mean: 2.43 ± 0.57%). Eosinophils were recorded in the range of 1.00–3.00% with a mean of 2.53 ± 0.60%.

Table 5. Overall, the haematological profile established in this study provides baseline values for house crows, which may be useful in future ecological and toxicological assessments.

Variable	(n= 20)	
	Mean ± SD	Range (Minimum-Maximum)
WBC (x10^3/µL)	26.87-1.02	16.00-37.95
RBC (x10^6/ µL)	2.93-0.45	2.30-3.95
Hbc g/dl	37.97-2.00	37.80-40.50
MCV	37.97-2.00	37.80-40.50
MCH (pg)	49.43-4.78	35.00-61.00
MCHC (g/dl)	31.63-1.84	25.90-39.80
PCV	37.97-2.00	33-48.50
Basophils	1.93-0.53	0.00-3.00
Neutrophils	1.93-0.53	45.50-80.86
Lymphocytes	2.63-0.57	14.00-50.50
Monocytes	2.43-0.57	1.00-4.00
Eosinophil	2.53-0.6	1.00-3.00

Food preference

For the assessment of feeding preferences, gut content analysis was carried out on 24 house crow (*Corvus splendens*) samples collected from the Okara District of Punjab, Pakistan. The procedure involved dissection of the gastrointestinal tract, measurement of gut weight, and microscopic examination of ingested material. Initially, the full gut weight was measured using a precision balance, followed by cleaning and measurement of the empty gut weight. The difference was recorded as the weight of food material consumed. Statistical analysis indicated that total gut weight, empty gut weight, and weight of food material showed no significant differences between male and female house crows (Table 6).

Table- 6: Comparison of Mensural Analysis of gut variables in male, female house crow sampled from Punjab.

Characters	Gender	N	Mean	SD	SE	F-value	P-value
Total weight of gut (g)	Male	24	1.18	0.74	0.43	6.46	0.082
	Female	24	1.65	0.49	0.28		
Weight of empty gut (g)	Male	24	1.23	0.81	0.47	0.35	0.731
	Female	24	2.38	0.89	0.52		
Weight of food material (g)	Male	24	1.17	0.82	0.48	1.85	0.299
	Female	24	1.24	0.06	0.04		

NS = Non-significant (P>0.05); * = Significant (P<0.05); ** = highly significant (P<0.01) SD = Standard deviation; SE = Standard error

The separated gut contents were collected in Petri dishes and examined under a microscope. A variety of food items were identified, including wheat grains, garbage, fish remains, nuts, insects, feathers, and other rubbish material**.** Among these, garbage, fish, grains, and insects constituted the most commonly consumed items. The percentage composition of food materials observed in the samples is presented in Table 7. Representative images of food content observed under the microscope are shown in the accompanying figures.

These findings confirm the omnivorous feeding behavior of house crows, highlighting their reliance on both natural and anthropogenic food sources, with a notable preference for human-derived waste materials.

Table-7: Food preference of 'house crow' sampled from Punjab Pakistan.

Type of Food	Samples	Positives Samples	Abundance (%)
Wheat grains	24	15	62.5
Feathers	24	10	41.6
Insects	24	20	83.3
Eating rubbish	24	12	50

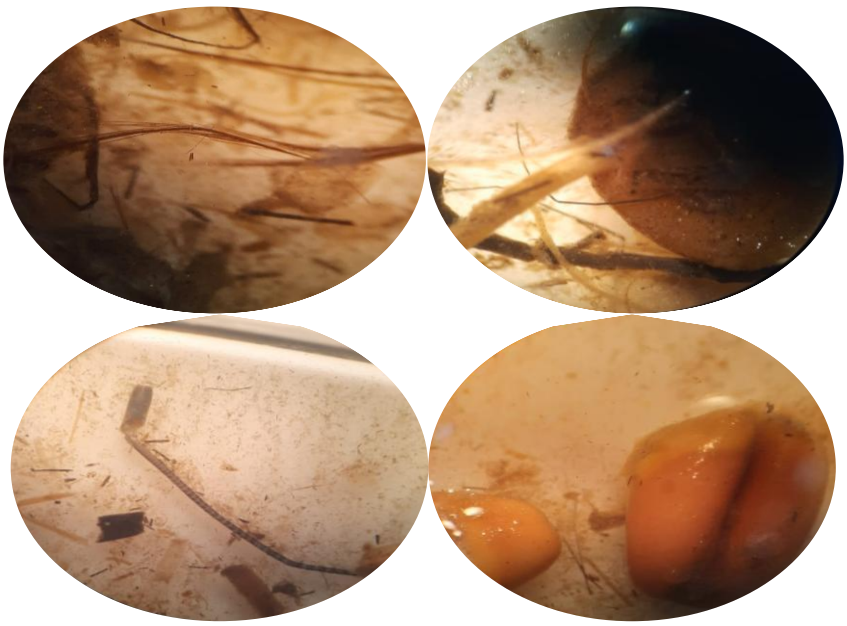

Figure 5. Different feeding contents recorded from gut of Male house crow.

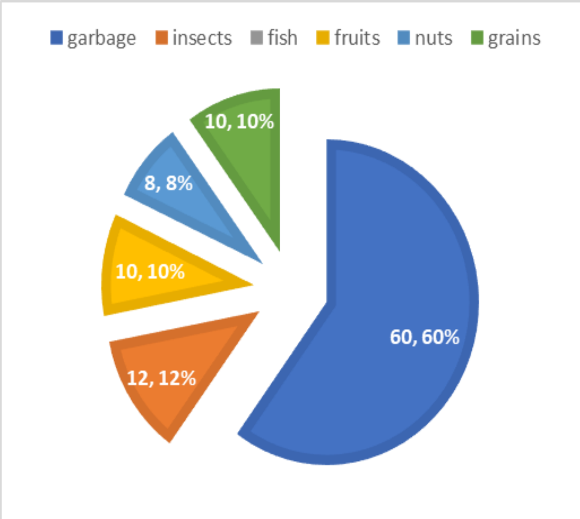

Figure 6: Percentage of different feeding contents recorded from gut of Female house crow

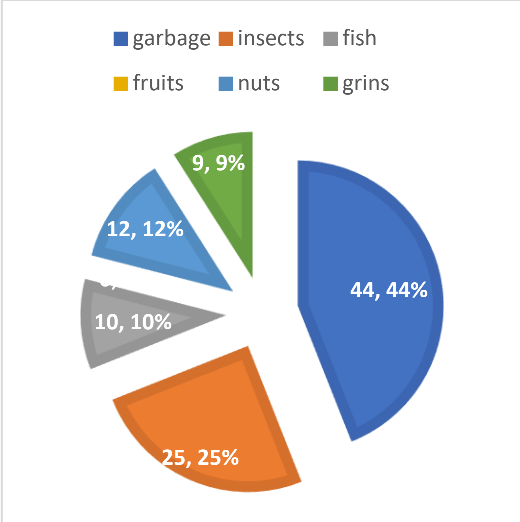

Figure 7: Percentage of different feeding contents recorded from gut of Male house crow

Heavy metals concentration

Five heavy metals zinc (Zn), cadmium (Cd), nickel (Ni), iron (Fe), and chromium (Cr) were detected in the liver, muscle, and kidney tissues of house crows (*Corvus splendens*). The concentrations (µg/kg) of these metals varied significantly among tissues and are summarized in Table 8.

Table 8: Heavy metals concentration in the liver, muscle, and kidney of house crow

Metal	Organs	N	Range (Minimum-Maximum)	Mean	Std. Deviation
	Liver	24	12.22-15.31	14.62	1.75
Zn	Muscle	24	11.12-13.56	13.18	1.55
	Kidney	24	10.33 -11.34	11.41	0.92
	Liver	24	1.12-3.22	1.70	1.08
Cd	Muscle	24	1.01-2.11	1.25	0.63
	Kidney	24	0.2-1.221	0.66	0.42
	Liver	24	2.50-2.80	2.87	0.33
Ni	Muscle	24	1.33-2.48	2.08	0.53
	Kidney	24	1.66-2.58	2.34	0.49
	Liver	24	9.21-12.15	11.16	1.38
Fe	Muscle	24	8.12-10.12	9.45	0.94
	Kidney	24	7.66-9.88	9.16	1.06
	Liver	24	1.23-2.44	1.46	0.72
Cr	Muscle	24	2.34-2.55	1.84	0.86
	Kidney	24	1.17-2.21	1.27	0.73

Zinc (Zn) was found in the range of 12.22–15.31 µg/kg in the liver (mean: 14.62 ± 1.75), 11.12–13.56 µg/kg in muscle (mean: 13.18 ± 1.55), and 10.33–11.34 µg/kg in the kidney (mean: 11.40 ± 0.92). Cadmium (Cd) concentrations were comparatively lower, ranging 1.12–3.22 µg/kg in the liver (mean: 1.70 ± 1.08), 1.01–2.11 µg/kg in muscle (mean: 1.25 ± 0.63), and 0.20–1.22 µg/kg in kidney (mean: 0.66 ± 0.42).

Nickel (Ni) levels ranged 2.50–2.80 µg/kg in liver (mean: 2.87 ± 0.33), 1.33–2.48 µg/kg in muscle (mean: 2.08 ± 0.53), and 1.66–2.58 µg/kg in kidney (mean: 2.34 ± 0.49). Iron (Fe) was relatively abundant, with concentrations of 9.21–12.15 µg/kg in liver (mean: 11.16 ± 1.38), 8.12–10.12 µg/kg in muscle (mean: 9.45 ± 0.94), and 7.66–9.88 µg/kg in kidney (mean: 9.16 ± 1.06). Chromium (Cr) levels were recorded at 1.23–2.44 µg/kg in liver (mean: 1.46 ± 0.72), 2.34–2.55 µg/kg in muscle (mean: 1.84 ± 0.86), and 1.17–2.21 µg/kg in kidney (mean: 1.27 ± 0.73).

Statistical analysis revealed that concentrations of Cr, Cd, Ni, and Fe differed highly significantly among tissues ($p < 0.01$), as shown in Table 9.

Table 9: Comparison of different heavy metals (ug/kg) in muscle, liver, and kidney of house crow

Metal	Organs	N	Mean	SD	SE	F-value	P-value
Zn	Liver	24	14.62	1.75	1.01	2.45	0.166
	Muscle	24	13.18	1.55	0.90		
	Kidney	24	11.41	0.92	0.53		
Cd	Liver	24	1.70	1.08	0.63	0.94	0.44
	Muscle	24	1.25	0.63	0.36		
	Kidney	24	0.66	0.42	0.24		
Ni	Liver	24	2.87	0.33	0.19	1.51	0.29
	Muscle	24	2.08	0.53	0.31		
	Kidney	24	2.34	0.49	0.28		
Fe	Liver	24	11.16	1.38	0.80	1.80	0.24
	Muscle	24	9.45	0.94	0.54		
	Kidney	24	9.16	1.06	0.61		
Cr	Liver	24	1.46	0.72	0.42		
	Muscle	24	1.84	0.86	0.50	0.14	0.87
	Kidney	24	1.27	0.73	0.42		

** = Highly significant (P<0.01) NS = Non-significant (P>0.05); * = Significant (P<0.05) SE = Standard error

Correlation matrix of metals in muscles, liver, and kidneys

Table 10 shows the correlation matrix between different heavy metal concentrations in muscle of house crow.Cr had non-significant and highly negative correlation wih Zn. A non-significant and positive correlation with Cd, a non- significant and negative correlation with Ni and a non-significant and negative correlation with Fe.Cd had non significant and high positive correlated with Ni and Fe.Ni had non-significant and positve corelation with Fe.

Table 11 shows the correlation matrix between different heavy metal concentrations in liver of house crow.Cr had a higly non-signficant positive correlation with Cd and Fe. Fe had a significant and perfect negative correlation wih Zn. Cr had non-significant and negative correlation with Ni.Cd had a non-significant and negative correlation with Ni and positve correlation with Fe.Ni had a significant and highly positve correlation with Fe.

Table 10. Correlation matrix of heavy metals in Muscle of house crow'

Pearson Correlation (2-tailed)		**Zn**	**Cr**	**Cd**	**Ni**	**Fe**
Cr	Pearson Correlation	-0.700				
	Sig.	0.506				
	N	24				
Cd	Pearson Correlation	-0.083	0.769			
	Sig.	0.947	0.441			
	N	24				
Ni	Pearson Correlation	0.928	-0.384	0.295		
	Sig.	0.243	0.749	0.810		
	N	24				
Fe	Pearson Correlation	0.937	-0.408	0.269	1.000	
	Sig.	0.226	0.733	0.826	0.017	
	N	24				

Upper values indicated Pearson's correlation coefficient; Lower values indicated level of significance at 5% probability.
* = Significant (P<0.05); ** = Highly significant (P<0.01)
*. Correlation is significant at the 0.05 level.

Table 11: Correlation matrix of heavy metals in liver of house crow

Pearson Correlation (2-tailed)		**Zn**	**Cr**	**Cd**	**Ni**	**Fe**
Cr	Pearson Correlation	-0.010				
	Sig.	0.994				
	N	24				
Cd	Pearson Correlation	0.147	0.988			
	Sig.	0.906	0.100			
	N	24				
Ni	Pearson Correlation	0.910	-0.422	-0.276		
	Sig.	0.271	0.722	0.822		
	N	24				
Fe	Pearson Correlation	0.969	0.237	0.386	0.780	
	Sig.	0.159	0.847	0.748	0.430	
	N	24				

Upper values indicated Pearson's correlation coefficient; Lower values indicated level of significance at 5% probability. * = Significant (P<0.05); ** = Highly significant (P<0.01) *. Correlation is significant at the 0.05 level (2-tailed).

Table 12 shows the correlation matrix between different heavy metal concentration in kidney of house crow. Zn had a non-significant and highly positve correlation ion with with Cd,Ni,andFe. And a highly non-significant and negative correlation Cr. Cr had a non significant and positive corelation with Cd. Cr had a significant and negative correlation with Fe. Cd had a non-significant and highly positive correlation with Ni and Fe. Fe had a non significant and highly positive correlation with Ni.

Table 12: Correlation matrix of heavy metals in Kidney of 'house crow'

Pearson Correlation (2-tailed)		Zn	Cr	Cd	Ni	Fe
Cr	Pearson Correlation	-0.465				
	Sig.	0.692				
	N	24				
Cd	Pearson Correlation	0.266	0.730			
	Sig.	0.828	0.479			
	N	24				
Ni	Pearson Correlation	0.919	-0.079	0.624		
	Sig.	0.258	0.950	0.571		
	N	24				
Fe	Pearson Correlation	0.857	0.078	0.738	0.988	
	Sig.	0.357	0.951	0.471	0.100	
	N	24				

Upper values indicated Pearson's correlation coefficient; Lower values indicated level of significance at 5% probability. * = Significant ($P<0.05$); ** = Highly significant ($P<0.01$)*. Correlation is significant at the 0.05 level (2-tailed).

Correlation analysis further demonstrated that in muscle tissue, all five metals (Zn, Cr, Cd, Ni, and Fe) were positively correlated. In both liver and kidney tissues, positive correlations were observed among Cr, Cd, Ni, and Fe. These findings highlight that house crows accumulate varying levels of heavy metals across different organs, with significant correlations indicating possible co-accumulation pathways.

Zn concentration is higher in Liver (concentration liken) followed by muscle (concentration) and kidney (concentration). It means that the trend of bioaccumulation of Zn in the vital organs of house crow is as Liver> Muscle> kidney (Fig. 9).

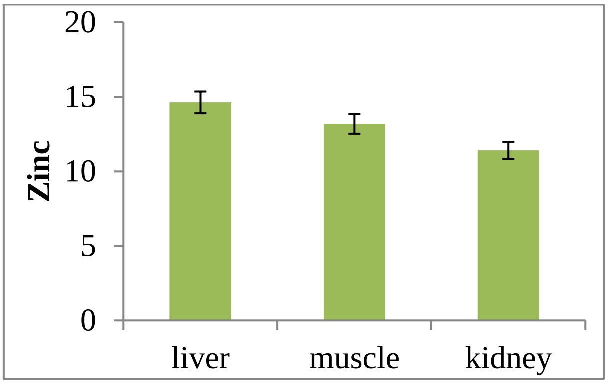

Figure 9: Concentration of Zn in liver, muscle and kidney of house crow

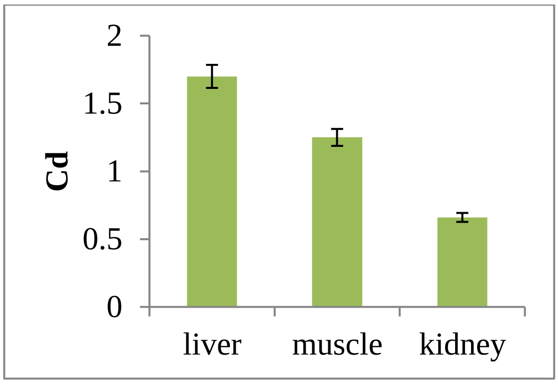

Figure 10: Comparison in concentration of Cd in muscle, liver, and kidney of house crow

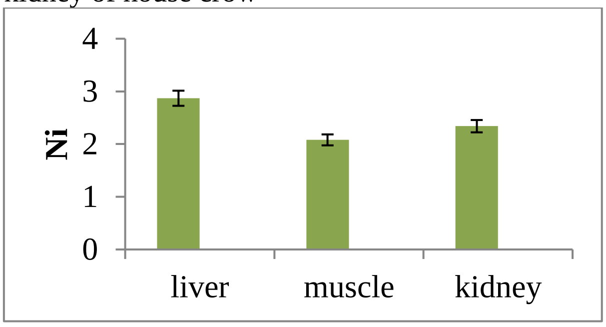

Figure 11: Comparative concentration of Ni in muscle, liver, and kidney of house crow.

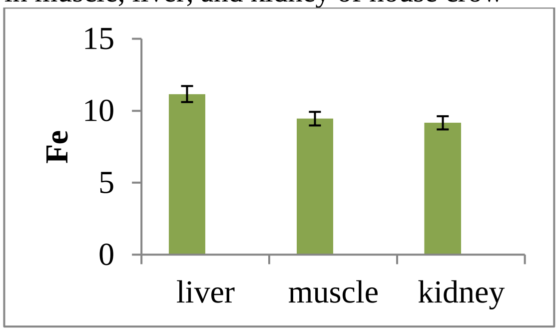

Figure 12: Concentration of Fe in muscle, liver, and kidney of house crow.

Cd concentration is higher in Liver (concentration liken) followed by muscle (concentration) and kidney (concentration). It means that the trend of bioaccumulation of Cd in the vital organs of house crow is as Liver> Muscle> kidney (Fig. 10).

Ni concentration is higher in Liver (concentration liken) followed by kidney (concentration) and muscle (concentration). It means that the trend of bioaccumulation of Ni in the vital organs of house crow is as Liver> kidney> muscle (Fig. 11).

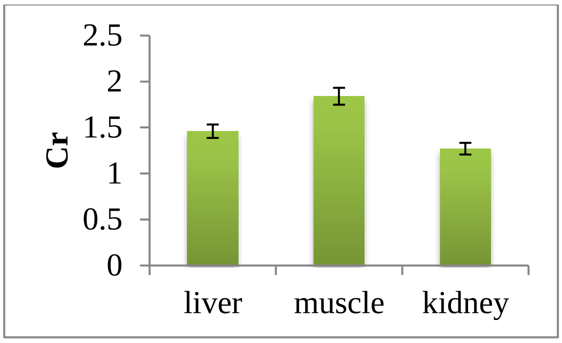

Figure 13: Comparison in concentration of Cr in muscle, liver, and kidney of house crow

Fe concentration is higher in Liver (concentration liken) followed by muscle (concentration) and kidney (concentration). It means that the trend of bioaccumulation of Zn in the vital organs of house crow is as Liver> Muscle> kidney (Fig. 12).

Cr concentration is higher in muscle (concentration liken) followed by liver (concentration) and kidney (concentration). It means that the trend of bioaccumulation of Zn in the vital organs of house crow is as Muscle> Liver> kidney (Fig. 13).

Discussion

The house crow (*Corvus splendens*), also known as the Indian Grey-necked Crow, is an intelligent, invasive, and omnivorous bird belonging to the family Corvidae. It is among the most invasive avian species, having spread across more than 25 nations throughout the Indian Ocean, Arabian Peninsula, and Southeast Asia, where it thrives even under unfavorable conditions (Suliman et al., 2011). The present study was conducted to record the morphometric parameters of males and females, identify gastrointestinal food contents, analyze haematological parameters, and detect heavy metal concentrations in the liver, muscle, and kidney of crows collected from District Okara.

Morphometric analysis

The morphometric traits studied included body weight, body length, tail length, wingspan, wing length, primary wing length, tarsal length, metatarsal length, head length, beak length, and chest circumference. Our findings recorded male crows averaging 250 g and females 240 g. The wingspan averaged 76 cm in males and 75 cm in females, confirming earlier reports (Dhindsa, 1991). There is very little species-specific morphometric data published for the house crow; however, most detailed datasets exist for other corvids (e.g., jungle crow, hooded/grey crow, rook, jackdaw, magpie). Several other morphometric traits were documented for the first time in this research, thus contributing novel baseline information for *C. splendens*.

Feeding preferences

The dietary analysis revealed that house crows consumed a wide variety of food items including garbage, insects, wheat grains, fish, and feathers. Quantitatively, gut analysis showed the following abundances: wheat (62.5%), feathers (41.6%), insects (83.3%), and rubbish/garbage (50%). These findings confirm the opportunistic feeding behavior of house crows. Earlier reports noted that crows engage in kleptoparasitism, mobbing ospreys to steal fish, though with low success rates (Yosef et al., 2012). The reliance on agricultural crops such as wheat also highlights their role as significant agricultural pests. For instance, Ahmad et al. (2016) demonstrated that anthraquinone-treated wheat seeds were significantly more effective than methylanthranilate in deterring crows, indicating the need for developing practical crop protection strategies.

Haematological parameters

The haematological assessment provided baseline values for house crows in District Okara. WBC counts ranged from 180.80–250.30 × 10^3/µL (223.53 ± 30.54), RBC counts from 1.20–3.50 × 10^6/µL (2.37 ± 0.94), and haemoglobin from 10.20–22.80 g/dl. PCV values ranged from 33–48.50 (37.97 ± 2.00), while MCV, MCH, and MCHC ranged from 37.80–40.50 fL (37.97 ± 2.00), 35.00–61.00 pg (49.43 ± 4.78), and 25.90–39.80 g/dl (31.63 ± 1.84), respectively. Differential leukocyte counts showed basophils (0.00–3.00 × 10^3/µL), neutrophils (45.50–80.86), lymphocytes (14.00–50.50), monocytes (1.00–4.00), and eosinophils (1.00–3.00). These values not only reflect the physiological condition of the sampled population but also provide important reference data for ecological and toxicological studies on *C. splendens*.

Heavy metal accumulation

The study detected five heavy metals Zn, Cd, Ni, Fe, and Cr in the liver, muscle, and kidney. Mean Zn concentrations were highest in the liver (14.62 ± 1.75 µg/kg) compared to muscle (13.18 ± 1.55 µg/kg) and kidney (11.40 ± 0.92 µg/kg). Cadmium was highest in the liver (1.70 ± 1.08 µg/kg), while Ni concentrations peaked in the liver (2.87 ± 0.33 µg/kg) and kidney (2.34 ± 0.49 µg/kg). Iron levels were consistently high across organs, with the liver averaging 11.16 ± 1.38 µg/kg. Chromium concentrations varied between 1.23–2.44 µg/kg in liver, 2.34–2.55 µg/kg in muscle, and 1.17–2.21 µg/kg in kidney.

Heavy metals are known to cause toxic effects on avian physiology, impairing enzymatic activity and damaging vital organs. Bioaccumulation in birds not only affects their survival but also serves as a bioindicator of environmental pollution. Previous studies from India and Pakistan confirm similar findings, with *C. splendens* shown to accumulate heavy metals in feathers and tissues, particularly Cr, Ni, and Cd (Sanchari et al., 2016; Kaur & Khera, 2018). The current findings emphasize the ecological role of crows as effective bio indicators of environmental contamination, especially in agro-ecosystems.

Conclusion

This study provides the first comprehensive assessment of morphometry, feeding ecology, haematological health, and heavy metal bioaccumulation in wild populations of C. splendens from central Punjab, Pakistan. The findings reveal that house crows exhibit marked morphological uniformity between sexes, a highly omnivorous diet dominated by anthropogenic food sources, and mild physiological stress reflected in haematological indices. Importantly, detectable concentrations of toxic heavy metals (Pb, Cd, Cr) in liver and kidney tissues highlight continuous environmental exposure and potential ecological risks. Given their abundance, urban association, and wide-ranging feeding behavior, C. splendens can serve as a useful bioindicator species for monitoring environmental contamination and ecosystem health in urban landscapes. These baseline data will support future ecotoxicological surveillance, public health risk assessments, and wildlife conservation planning in Pakistan and other South Asian regions.

Declarations

Use of generative AI and AI-assisted technologies

The author(s) used ChatGPT (OpenAI) to assist in language editing, and subsequently reviewed and revised the content, taking full responsibility for the final version of the manuscript.

Ethical approval

The Animal Ethical Committee of the University of Veterinary and Animal Sciences, Lahore, Pakistan (UVAS-135) approved the study. All procedures complied with institutional and national guidelines for the ethical treatment of wildlife.

Data availability

All data generated or analyzed during this study are included in this published article.

Conflict of interest

The authors declared no competing interests.

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