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Unlocking avian adaptations: Morphometric study of preserved bird specimens at St. Xavier's College Zoology Museum

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ABSTRACT

This study presents a morphometric analysis of nine-decade-old avian specimens preserved in the Zoology Museum of St. Xavier's College, Palayamkottai, India. Due to the conservation of birds, legal restrictions, and logistical challenges preventing the collection of new bird specimens, these historical collections are invaluable for understanding avian morphology, diversity, and adaptations. However, due to the age and fragility of these specimens, there is a risk of irreversible data loss are not thoroughly documented, and preservation challenges make it difficult to maintain their condition indefinitely. Using morphometric measurements of Head, Beak, Body, Wing, and Leg structures (Head Length (HL), Head Width (HW), Head Height (HH), Body Length (BL), Body Width (BW) Eye Length (EL), Eye Width (EW), Beak Length (BeL), Upper Jaw (UJ), Lower Jaw (LJ), Upper Beak Nostril (UBN), Lower Beak Nostril (LBN), Start Beak Height (SBH), Middle Beak Height (MBH), Edge Beak Height (EBH),Wing Length (WL),Wing Width (WW), Neck Length (NL), Neck Throat (NT)). In this study, we analyzed (32) avian specimens including (25) families, and eleven male and eight female birds; other we couldn't identify the sex of museum specimens, due to the loss of feathers and body parts. By cataloguing these specimens now, this study preserves critical biological data, offering a lasting resource for future researchers, ornithologists, and conservationists.

Keywords: Avian Morphology, Museum Specimens Preservation, Morphometric Analysis, Zoology Museum Collections, Conservation Constraints

1. INTRODUCTION

Museums and their preserved specimens are invaluable assets for any taxonomist or ornithologist. These Avian specimens, often collected decades or even centuries ago, represent a crucial resource for studying avian morphology without needing to disturb current bird populations. Museum specimens are easy access to study the morphology. It's helping researchers understand the anatomy, physiology, and

evolutionary traits of birds across different regions (Remsen, 1995; Zarrin, 2023). Most of the specimens in SXC Zoology Museum are more than 80 years old. The museum specimens can degrade due to the long exposure to artificial light, dust particles, Insects damages the skins, feathers, and microbial decomposition of body, leading to possible decomposition or loss of morphological details if not carefully maintained.

The traditional preservation methods, such as conventional taxidermy, might not capture all anatomical details or may suffer from wear and tear, reducing their accuracy for modern studies. The museum specimens are also valuable for morphometric studies, as well as detailed measurements of bird anatomy that, can be used analyse size, shape, and proportions across species. To collect new avian specimens in the wild now is restricted. Researchers depend on museum specimens for this type of data, particularly patterns of morphology, inter and intra species variation (Remsen, 1995; Zarrin, 2023). Studying avian morphology faces challenges, primarily due to the conservation of birds. The Wildlife Protection Act enacts capturing of birds, especially rare or endangered species. The Wildlife Protection Act of 1972, India, which governs the protection of wildlife, restricts the capture, harm, or disturbance of any wild birds.

This Wildlife law restrict the researcher to collect live or newly dead specimens for research, especially for species that are threatened or endangered. Studied the morphological diversity of birds' beaks and their relationship to feeding behaviors, while explored the cranial adaptations associated with foraging behaviors in birds. Avian specimens in museums are essential and, often, the only practical resource for studying bird morphology today. The classification and preservation efforts, museums continue to serve as critical repositories for avian morphological research, ensuring that these specimens accessible to students, educators, and future researchers (Remsen 1995; Zarrin, 2023). St. Xavier's College, Zoology Museum has invertebrate and vertebrate specimens.

The bird specimens in the museum are nearly nine decades old. To prevent the loss of beaks, wings, legs, and morphological features due to aging, it is vital to thoroughly document these specimens now. This morphometric study of bird specimens from St. Xavier's College Zoology Museum aimed to document essential measurements across 32 bird specimens using various morphological parameters. We analyzed features like head dimensions, body proportions, beak measurements, and wing and leg lengths to assess the diversity of these birds. The data provide insights into species-specific adaptations that support feeding and movement.

2. MATERIALS AND METHODS

Study Area

This study focused on thirty-two avian specimens preserved in the Zoology Museum of St. Xavier's College, Palayamkottai. These bird specimens, which are on display at the museum, are almost nine decades old. The Jesuit Fathers of the Madurai Province established the college in 1923. The Department of Zoology and its museum was established in 1927. The college introduced a B.Sc. Zoology degree program in 1957, and M.Sc. Zoology program in 1979.

Morphometric Analysis

The morphology of the bird's specimens using different morphological parameters. The body measurements are (Head Length (HL), Head Width (HW), Head Height (HH), Body Length (BL), Body Width (BW) Eye Length (EL), Eye Width (EW), Beak Length (BeL), Upper Jaw (UJ), Lower Jaw (LJ), Upper Beak Nostril (UBN), Lower Beak Nostril (LBN), Start Beak Height (SBH), Middle Beak Height (MBH), Edge Beak Height (EBH), Wing Length (WL), Wing Width (WW), Neck Length (NL), Neck Throat (NT)) of the birds in the museum were recorded. For length and width measurements, we used a Vernier Caliper (Model: AERO SPACE, Size: 200 x 0.02mm, 8" x 0.001in, Made in China).

Photographs captured with a Samsung Galaxy Camera 2 (Model: EK-GC200, 720 x 1280 pixels, 16.3 MP CMOS sensor, 21x Optical Zoom, 4.8" Touch Screen LCD, OS: Android 4.3, 1.6 GHz quad-core processor, Made in China). Additional measurements took using a thread method, a geometrical divider, a measuring tape, and a standard ruler. The sex and maturity of the specimens assessed based on features such as color patterns, color stripes, body shape, and the presence of bright or straightforward coloration. Each specimen identified and classified based on detailed morphological characteristics and categorized by family, IUCN conservation status, and other relevant criteria.

Preparation and Handling

Museum avian specimens are handled with care to preserve their integrity. Use of gloves for protection of both the handler and the specimens from damage or contamination.

Measurements

The feather color, body size, beak, legs, and wings measure vital morphometric traits. It's used for the correct identification of birds, which include beak length, wing length and width, tail length, body length and width. Repeating measurements to ensure accuracy and reliability. Photograph specimens for documentation and further analysis. They include Morphological Method and Identification of Sex. In Birds morphological method Bright et al., (2016), Gundemir et al., (2020) it is measured as:

Head: Head Length (HL), Head Width (HW), Head Height (HH), Head Index (HI): HW x 100/HL Head Maximum Dimension (HMD): HL x HW x HH

Body: Body Length (BL), Body Width (BW), Body Index (BI): BW x 100/BL

Eye: Eye Length (EL), Eye Width (EW), Eye Index (EI): EW x 100/EL

Beak: Beak Length (BeL), Upper Jaw (UJ), Lower Jaw (LJ), Upper Beak Nostril (UBN), Lower Beak Nostril (LBN), Start Beak Height (SBH), Middle Beak Height (MBH), Edge Beak Height (EBH)

Leg: Total Length of Leg (TL): Measuring without taking the part of Digits

Wing: Wing Length (WL), Wing Width (WW), Wing Index (WI): WW x 100/WL

Neck: Neck Length (NL), Neck Throat (NT), Neck Nape (NN)

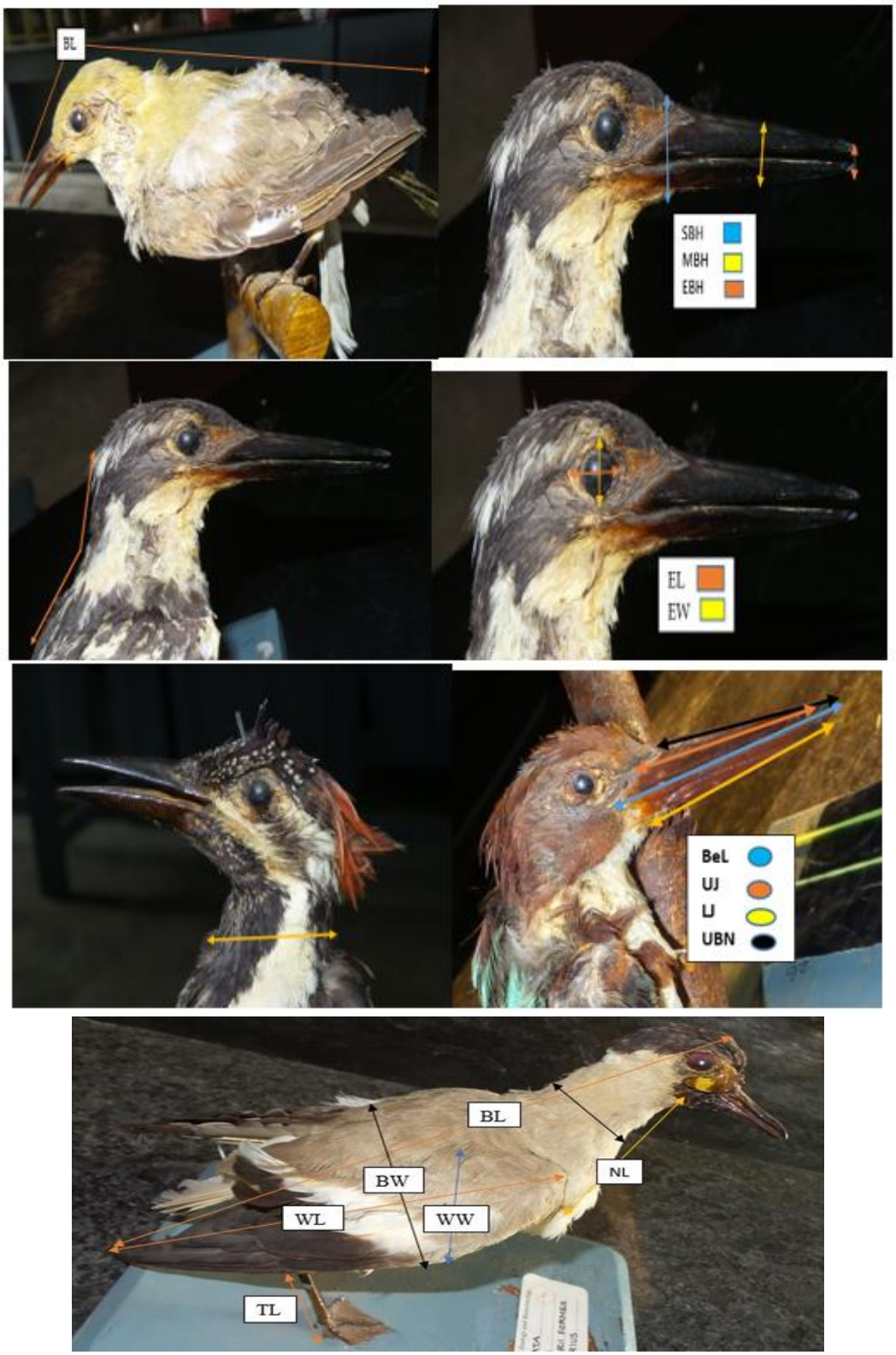


Figure 1 Morphometric measurements of museum birds (Head Length (HL), Head Width (HW), Head Height (HH), Body Length (BL), Body Width (BW), Eye Length (EL), Eye Width (EW), Beak Length (BeL), Upper Jaw (UJ), Lower Jaw (LJ), Upper Beak Nostril (UBN), Lower Beak Nostril (LBN), Start Beak Height (SBH), Middle Beak Height (MBH), Edge Beak Height (EBH), Wing Length (WL), Wing Width (WW), Neck Length (NL), and Neck Throat (NT)).

3. RESULTS AND DISCUSSION

This morphometric study of avian specimens from St. Xavier's College Zoology Museum was recorded using various morphological parameters (Figure 1). We have analyzed features like head dimensions, body proportions, beak measurements, and wing and leg lengths to assess the diversity and morphological adaptations of these birds. The morphometric analysis of thirty-two avian specimens in the zoology museum results shows significant information about the diversity, condition, and categorization of these specimens (Table 1). Various monographs and checklists identified the bird specimens. The bird species documented by common and scientific name, family, and IUCN status. The specimens represent a diverse collection of avian families, and this study categorizes and interprets these specimens based on their family classification, condition, and morphological characteristics.

Table 1 List of observed and analysed bird specimens in SXC Zoology Museum

S. No.	Name of the Birds	Scientific Name	Family	IUCN	Gender
SXCDZMA01	Shikra	*Accipiter badius*	Accipitridae	LC	Female
SXCDZMA02	Common Kingfisher (or)Eurasian Kingfisher	*Alcedo atthis*	Alcedinidae	LC	Male
SXCDZMA03	Pied Kingfisher	*Ceryle rudis*	Alcedinidae	LC	Male
SXCDZMA04	White Throated Kingfisher	*Halcyon smyrnensis*	Alcedinidae	LC	Male
SXCDZMA05	Lesser Whistling Teal (or) Lesser Whistling Duck	*Dendrocygnajavanica*	Anatidae	LC	Juv
SXCDZMA06	Pond Heron	*Ardeola grayii*	Ardeidae	LC	Juv
SXCDZMA07	Senegal Wattled Plover	*Vanellus sene gallus*	Charadriidae	LC	-
SXCDZMA08	Indian Roller	*Coracias benghalensis*	Coraciidae	LC	Male
SXCDZMA09	Rufous Treepie	*Dendrocittavagabunda*	Corvidae	LC	-
SXCDZMA10	Asian Koel	*Eudynams scolopaces*	Cuculidae	LC	Female
SXCDZMA11	Southern Coucal (or) Greater Coucal (or) Crow Pheasant	*Centropus sinensis*	Cuculidae	LC	-
SXCDZMA12	Black Drongo	*Dicrurus macrocercus*	Dicruridae	LC	-
SXCDZMA13	Barn Swallow	*Hirundo rustica*	Hirundinidae	LC	-
SXCDZMA14	Bronze Winged Jacana	*Metopidius indicus*	Jacanidae	LC	-
SXCDZMA15	Pheasant Tailed Jacana	*Hydrophasianus chirurgus*	Jacanidae	LC	Female
SXCDZMA16	Brown Headed Gull	*Chroicocephalus brunnicephalus*	Laridae	LC	Male
SXCDZMA17	Whiskered Tern	*Chlidonias hybrida*	Laridae	LC	-
SXCDZMA18	Coppersmith Barbet	*Psilopogon haemaceph lus*	Megalaimidae	LC	Male
SXCDZMA19	Indian Paradise Flycatcher	*Terpsiphone paradisi*	Monarchidae	LC	Male
SXCDZMA20	Oriental Magpie Robin	*Copsychus saularis*	Muscicapidae	LC	Female
SXCDZMA21	Sunbird	*Cinnyris asiaticus*	Nectariniidae	LC	-
SXCDZMA22	Indian GoldenOriole	*Oriolus kundoo*	Oriolidae	LC	Male
SXCDZMA23	Indian GoldenOriole	*Oriolus kundoo*	Oriolidae	LC	Female
SXCDZMA24	Indian Cormorant	*Phalacrocoraxfuscicollis*	Phalacrocoracidae	LC	-
SXCDZMA25	Grey Francolin(or) Grey Patridge	*Ortygornis pondicerianus*	Phasianidae	LC	Female
SXCDZMA26	Black RumpedFlame Back Wood Pecker	*Dinopium benghalense*	Picidae	LC	Female
SXCDZMA27	Indian Pitta	*Pitta brachyura*	Pittidae	LC	Male
SXCDZMA28	Indian Pitta	*Pitta brachyura*	Pittidae	LC	Male
SXCDZMA29	Plum HeadedParakeet	*Psittacula cyanocephala*	Psittaculidae	LC	Male
SXCDZMA30	Grey HeadedSwamphen	*Porphyrio poliocephalus*	Rallidae	LC	-
SXCDZMA31	Black WingedStilt	*Himantopshimantops*	Recurvirostridae	LC	Female
SXCDZMA32	MalabarTrogon	*Harpactes fasciatus*	Trogonidae	LC	-

Family Categorization

The bird specimens belong to twenty families, as detailed in Table 2 & Figure 2**,** with each family having a various representative. The highest number of bird's specimens is found in the Alcedinidae family (kingfishers), with three specimens, accounting for 9% of the collection. Moderate representation (two specimens per family) is seen in Cuculidae, Jacanidae, Laridae, Oriolidae, and Pittidae, each making up 6% of the total. The remaining 19 families are represented by a single specimen each, contributing 3% to the overall collection.

Accipiter badius SXCDZMA01

Alcedo atthis SXCDZMA02

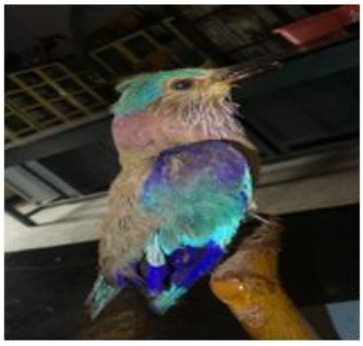
Ceryle rudis SXCDZMA03

Halcyon smyrnensis SXCDZMA04

Dendrocygna javanica SXCDZMA05

Ardeola grayii SXCDZMA06

Vanellus senegallus SXCDZMA07



Coracias benghalensis SXCDZMA08

Dendrocitta vagabunda SXCDZMA09

Eudynams scolopaces SXCDZMA10

Centropus sinensis SXCDZMA11

Dicrurus macrocercus SXCDZMA12

Hirundo rustica SXCDZMA13

Metopidius indicus SXCDZMA14

Hydrophasianus chirurgus|SXCDZMA15

Chroicocephalus brunnicephalus SXCDZMA16

Chlidonias hybrida SXCDZMA17

Psilopogon haemacephalus SXCDZMA18

Terpsiphone paradisi SXCDZMA19

Copsychus saularis SXCDZMA20

Cinnyris asiaticus SXCDZMA20

Oriolus kundoo SXCDZMA21

Oriolus kundoo SXCDZMA22

Phalacrocorax fuscicollis SXCDZMA23

Figure 2 Observed and analyzed bird specimens in SXC Zoology Museum.

Table 2 Family wise details bird specimen in the SXC Zoology Museum.

S. No.	Family	No. of Counts	S. No.	Family	No. of Counts
A	Accipitridae	1	N	Monarchidae	1
B	Alcedinidae	3	O	Muscicapidae	1
C	Anatidae	1	P	Nectariniidae	1
D	Ardeidae	1	Q	Oriolidae	2
E	Charadriidae	1	R	Phalacrocoracidae	1
F	Coraciidae	1	S	Phasianidae	1
G	Corvidae	1	T	Picidae	1
H	Cuculidae	2	U	Pittidae	2
I	Dicruridae	1	V	Psittaculidae	1
J	Hirundinidae	1	W	Rallidae	1
K	Jacanidae	2	X	Recurvirostridae	1
L	Laridae	2	Y	Trogonidae	1
M	Megalaimidae	1			

Specimen Condition and Documentation

The bird's specimens, collected over several decades starting in 1927, are preserved in varying conditions. Some specimens show signs of degradation, making gender identification and detailed morphological analysis challenging. Despite these limitations, in this study, the morphological characteristics such as beak structure, feather coloration, body shape and size, and sex identification (where possible) were documented for each bird.

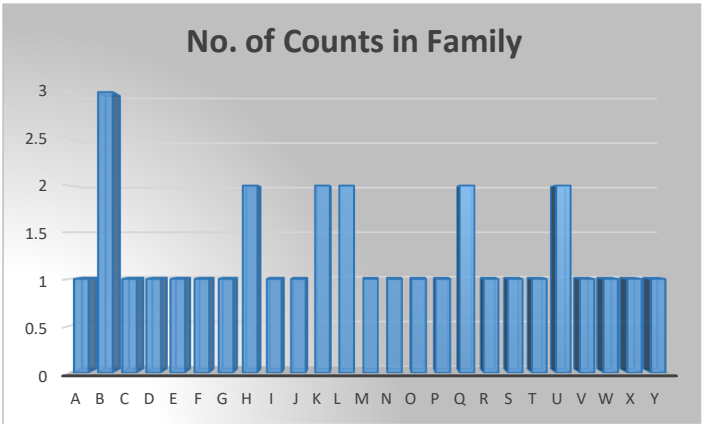


Figure 3 Number of Bird Families at SXC Zoology Museum

This bar chart (Figure 3). Illustrates the total count of bird specimens by family. The Alcedinidae family (kingfishers) has the highest representation, followed by families with two specimens, including Cuculidae, Jacanidae, Laridae, Oriolidae, and Pittidae. This pie chart (Figure 4) breaks down the specimen collection by family as a percentage of the whole, showing that Alcedinidae holds the highest percentage at 9%. The following highest percentage categories include the moderately represented families (Cuculidae, Jacanidae, Laridae, Oriolidae, and Pittidae) at 6% each, while all other families contribute 3% each.

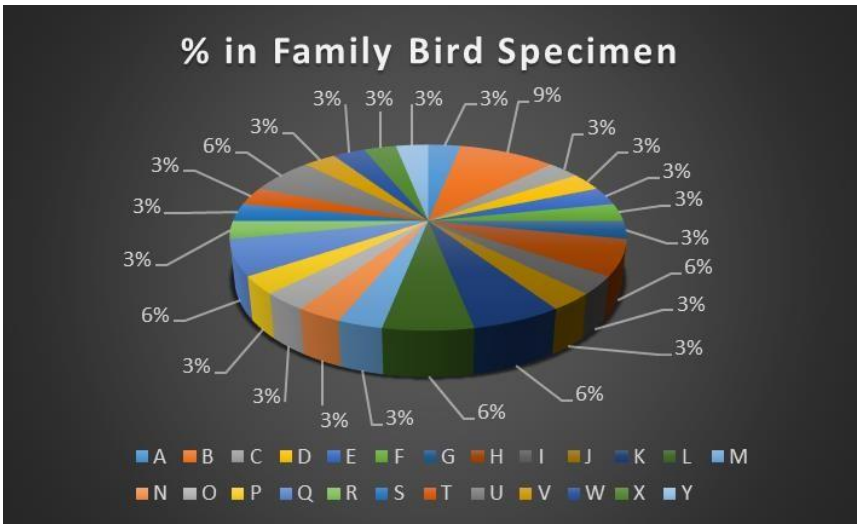


Figure 4 Percentage in Family of Bird Specimen at SXC Zoology Museum

Table 3 Morphometrical Analysis of Birds in SXC using Museum Specimen

Specimen No.	Common Name	Head			Body		Eye		Beak								Leg	Wing			Neck	
		HL	HW	HH	BL	BW	EL	EW	BeL	UJ	UL	UBN	LBN	SBH	MBH	EBH	TL	WL	WW	NL	NT	NN
SXCDZMA01	Shikra	3	2	2.2	34	10.6	1.9	1.15	2.4	1.9	1.6	1	0.6	0.45	0.3	0.2	10.4	27.8	6.8	2.2	1.55	1.35
SXCDZMA02	Common Kingfisher	2	1.52	1.8	16.1	3.51	0.7	0.6	4.4	4.2	4.3	3.6	3.5	0.93	0.52	0.3	5.8	5.5	2.13	1.51	1.5	1.3
SXCDZMA03	Pied Kingfisher	2.34	3.23	3.8	27.2	2.7	0.9	1	7.2	6.6	6.8	5.2	4.5	1.5	1.13	0	3.9	13.3	4.15	2.9	1.8	1.2
SXCDZMA04	White Throated Kingfisher	2.6	2.2	2.5	17.9	5	0.8	0.9	6.9	6.6	3.5	6	5.9	1.7	1.4	0.8	4.7	4.9	2.8	2.8	1.7	1.9
SXCDZMA05	Lesser Whistling Teal	4.9	2.1	2.8	38.4	12.8	1	1.1	2.9	2.6	2.5	1.9	1.5	1.5	0.9	0.5	5.1	16.9	6.1	6.5	1.1	1
SXCDZMA06	Pond Heron	5.8	1.81	3	28.7	6.04	1.36	0.92	3.05	2.6	2.6	2	1.1	0.9	0.6	0.45	7.3	9.6	3.2	7.9	0.82	1.1
SXCDZMA07	Senegal Wattled Plover	2.5	1.7	1.95	31.4	4.52	1.2	0.9	3.2	2.65	3	2	2.2	0.75	0.55	0.3	9.8	19.6	3.6	3.9	1	1.15
SXCDZMA08	Indian Roller	3.6	3.5	4.4	29	6.7	0.85	0.9	3.8	4	3.4	3.1	2.8	1.56	1.48	0.98	5.3	9.6	6.6	5.4	1.65	2.5
SXCDZMA09	Rufous Treepie	2.85	1.85	1.8	33	5.6	0.95	0.95	3	2.25	2.35	2.1	1.65	1.54	0.5	0.3	6	22.2	5	2.1	1.6	1.35
SXCDZMA10	Asian Koel	2.3	2.2	3	41.4	3.8	1.2	1.05	3.2	2.6	2.35	2	2.45	1.15	0.85	0.35	5.8	22	14.8	3.4	1.4	0
SXCDZMA11	Southern Coucal	4.3	2.5	3.4	47	13.2	1.1	1	4.8	3.5	3.3	2.5	2.4	1.9	1.7	0.7	8.7	19.2	6.4	3.4	2.7	2.2
SXCDZMA12	Black Drongo	2.55	2.4	1.6	26.3	4.5	0.85	0.9	3.1	2.7	2.45	1.85	1.95	1	0.7	0.2	8.5	16.1	5.2	1.85	1.35	1.75
SXCDZMA13	Barn Swallow	3	2.9	1.5	15.8	9.9	0.6	0.8	2.2	2.5	1.9	1.6	1.8	1.1	0.83	0.4	3	12.6	3.4	1.8	1	1.6
SXCDZMA14	Bronze Winged Jacana	4.4	1.9	2.4	27.9	10.1	0.9	0.8	0	0	0	0	0	0	0	0	11.2	16.5	5.1	4.9	1.1	1.3
SXCDZMA15	Pheasant Tailed Jacana	3.6	1.6	2.4	27.9	10.1	0.9	0.7	3.1	2.9	2.7	0.7	1.4	1	0.8	0.5	9.6	17.6	4.7	3.5	0.21	1.1
SXCDZMA16	Brown Headed Gull	6.7	2.7	4.8	41.2	31.2	0.8	0.7	6.2	4.9	4.1	2	1.8	1.7	1.7	0.9	7.4	30	11.1	8.5	1.7	2.1
SXCDZMA17	Whiskered Tern	3.95	1.8	2.4	3.2	5.7	1.15	0.75	4.8	4.2	4.25	3	4	1.05	0.6	0.25	7	24.6	10	2.9	11	1.2
SXCDZMA18	Coppersmit	2.8	4	2.2	14.2	5.2	0.55	0.6	2.1	2	1.5	1.4	1.2	1	0.9	0.5	4.1	7.7	1.2	1.4	1.5	1.6

	h Barbet																				
SXCDZMA19	Indian Paradise Flycatcher	1.7	1.5	2	19.8	5.5	0.7	0.5	3	2.5	0	1.4	0	0.6	0	0	2.6	9.5	5	2	1.1	1.4
SXCDZMA20	Oriental Magpie Robin	2.3	1.55	1.75	19.2	7.6	0.7	0.75	2.5	1.56	1.85	1.35	1.1	0.45	0.3	0.1	5.4	13.4	3	1	0.8	0.9
SXCDZMA21	Sunbird	1.1	0.7	0.75	9.6	3.2	0.4	0.3	1.45	1.4	1.55	1.1	1.05	0.35	0.25	0.05	2.8	5.6	1.4	1	0.5	0.8
SXCDZMA22	Indian Golden Oriole	3.2	1.6	2.1	16.6	6.7	1.1	0.8	3.5	2.7	2.7	2.1	2	1	0.9	0.4	6.2	12.4	2.8	1.5	1.3	0.9
SXCDZMA23	Indian Golden Oriole	3.6	1.5	2.5	21.6	4.6	1	0.9	3	3	2	2.1	2	0.8	0.6	0.5	5.5	14	3.7	1.35	1.4	1.3
SXCDZMA24	Indian Cormorant	7.5	2.7	3.8	66.5	26	1.2	1	7.9	5.9	7.4	5.9	4.6	2.7	1.3	1.1	3.9	25.6	9	15.5	2.9	5
SXCDZMA25	Grey Francolin	2.5	2	2.2	24.55	10.2	0	0	2.1	1.6	1.5	1.2	0.9	1.2	0.9	0.5	5.9	12.9	4.9	4.5	2.1	1.4
SXCDZMA26	Black Rumped Flame Back Wood Pecker	4.9	2	2.6	24.2	5	0.7	0.82	3.6	3.9	3.5	3.8	3	1.4	1	0.6	4.8	12.2	3.2	2.1	1.4	1.3
SXCDZMA27	Indian Pitta	3.4	1.7	2.1	13.7	8.5	1.1	1.7	2.5	1.9	1.8	1.4	1.4	1	0.7	0.5	6.2	11	4	1.5	1.4	1.9
SXCDZMA28	Indian Pitta	5.9	1.9	2.1	9.6	8.9	0.9	0.7	2.5	2.1	0	1.5	0	0	0	0	7.1	10.3	3.7	0	0	0
SXCDZMA29	Plum Headed Parakeet	3.3	2.15	3.5	21.5	5.54	0.5	0.4	2.3	2.3	1.1	2.1	1	2.1	1.6	0	1.3	14.2	42	1.9	1.9	2.3
SXCDZMA30	Grey Headed Swamphen	3.25	2	2.85	42	11.6	1.3	1.05	4.3	3.4	3.8	2.7	3	1.15	0.75	0.5	17.8	24.6	7.2	2.1	1.45	1
SXCDZMA31	Black Winged Stilt	2.4	1.5	3.6	39.6	16.2	1.35	1.3	0	0	0	0	0	0	0	0	3.6	24	8.2	7.8	1.9	1
SXCDZMA32	Malabar Trogon	3.9	1.6	2.3	28.4	6	1.4	0.9	3.5	2.8	2.6	1.8	1.4	1.2	1.1	0.6	0	12.4	3.4	1.7	1.7	1.3

Morphometric Characteristics

Head Morphology: Beak Length (BeL), Upper Jaw (UJ), Lower Jaw (LJ), Upper Beak Nostril (UBN), Lower Beak Nostril (LBN), Start Beak Height (SBH), Middle Beak Height (MBH), Edge Beak Height (EBH), Wing Length (WL), Wing Width (WW), Neck Length (NL), Neck Throat (NT).

Head measurements: Head Length (HL), Head Width (HW), and Head Height (HH) reveal substantial variation. The Brown Headed Gull (SXCDZMA16) exhibited the largest head dimensions (HL = 6.7, HW = 2.7, HH = 4.8), which may correlate with its feeding habits and ecological niche. Small sized species, like the Sunbird (SXCDZMA21), had smaller heads suitable for nectar feeding.

Body Proportions: Body Length (BL) and Body Width (BW) measurements showed that larger-bodied birds, like the Indian Cormorant (SXCDZMA24), had proportionally longer bodies (BL = 66.5, BW = 26), while smaller-sized species, like the Common Kingfisher (SXCDZMA02), had compact bodies (BL = 16.1, BW = 3.51), enhanced for swift flight (Table 3).

Eye Measurements: Eye Length (EL) and Eye Width (EW). Eye dimensions indicate that bigger species like the Malabar Trogon (SXCDZMA32) have comparably large eyes, which likely enhance vision. Equally, the small sized birds like the Barn Swallow (SXCDZMA13) showed smaller eye dimensions.

Beak Structure: Beak lengths and nostril sizes varied significantly among species. The Pied Kingfisher (SXCDZMA03) had a remarkably long beak (BeL = 7.2), reflecting adaptations for fish catching. Similarly, the Sunbird (SXCDZMA21) showed a short, thin beak (BeL = 1.45) suitable for nectar feeding.

Wing and Leg Morphology: Birds with longer wings, like the Whiskered Tern (SXCDZMA17) and Indian Cormorant (SXCDZMA24), reflect adaptations for excellent flight, while shorter-winged species, the Common Kingfisher (SXCDZMA02) exhibit wings optimized for short, fast movements (Table 3).

Specific adaptations

Predators and Fish-eaters: Birds like the Shikra (SXCDZMA01) and Pied Kingfisher (SXCDZMA03) have longer legs and more developed beaks, aiding in prey capture. Their head dimensions also support rapid head movements, which are vital for hunting. Nectar Feeders: The Sunbird (SXCDZMA21) shows slender, elongated features, with a narrow beak and a compact body, ideal for hovering and accessing flowers.

Ground Dwellers: Ground-dwelling birds like the Grey Francolin (SXCDZMA25) have comparably longer legs and broader bodies, facilitating walking and foraging in the ground.

Correlation Analysis

The correlation analysis of avian museum species is to determine any consistent relationships exist between Head Height (HH), Body Length (BL), Body Width (BW), Wing Length (WL), and Wing Width (WW) among the birds. The Head Height (HH) and Body Length (BL) the correlation coefficient value is 0.5879; Head Height and Body Length (BW) value is 0.5608. These positive correlations suggest that, in general, birds with taller heads tend to have longer and broader bodies. However, since these specimens represent different species, these trends may reflect evolutionary patterns rather than specific relationships within each species. Head Height (HH) and Wing Length (WL) coefficient value is 0.4134. The positive correlations with wing dimensions suggest that birds with taller heads may have more enormous wings overall, though this relationship is weaker than with body measurements.

Body Length (BL) and Wing Length (WL), the correlation coefficient value is 0.6392: A strong positive relationship between body length and wing length suggests that birds with longer bodies tend to have longer wings, possibly to support the larger body size for flight. Body Length (BL) and Wing Width (WW) correlation coefficient value is 0.1608. The weak correlation between body length and wing width may indicate that wing width does not scale as directly with body length across species, likely due to species-specific adaptations for flight. Wing Length (WL) and Wing Width (WW) the correlation coefficient value is 0.2804: The weak positive correlation indicates a slight tendency for longer wings also to be more expansive, but this relationship is not strong, suggesting that wing length and width may vary independently depending on each species' flight and ecological requirements.

The correlation results suggest some relationships (larger birds needing more enormous wings) between body size and wing dimensions across these bird species, likely due to shared evolutionary pressures. The age old, museum specimens may undergo shrinkage, distortion, or degradation, particularly avian species (Remsen, 1995; Zarrin, 2023). This type of shrinkage, and distortion can affect dimensions like Body Length (BL), Body Width (BW), Wing Length (WL) and Wing Width (WW). It's possibly altering the factual correlations between measurements. Species-specific anatomical changes could affect the relationships between head, body, legs, eyes, and wing measurements. The present study, correlation analysis indicates, all the museum avian species will show common trends in morphological characters, but may not represent species-specific relationships (Prum and Brush, 2002; Bird Life International, 2021).

However, the age and brittleness of these specimens pose challenges, as they are vulnerable to worsening. In this study, bird head, beak, body, wing, and leg structures, were analyzed to investigate their morphological variations. These characters are vital for understanding how birds have evolved in response to ecological pressures, and our study bring into line with previous research that highlights the role of morphology in avian adaptation (Prum and Brush, 2002; Bright et al., 2016; Claramunt et al., 2012). This investigation gives to existing knowledge by cataloging specific morphometric data, providing a lasting resource that can be used by researchers, ornithologists, and conservationists to assess morphological variations. This study highlighted the value of museum collections as repositories of biodiversity knowledge. The morphometric data collected from these avian specimens offer insights into evolutionary adaptations, replicating each species' shows exclusive morphology and specialized features.

The body sizes associated with wing adaptions (flight efficiency) and specialized beaks for feeding provide clues to the functional roles; these characters help to identify of bird species. This preserved data also acts as a critical baseline for examining morphological changes over time, offering valuable comparative data for future studies on avian taxonomy, evolution, and conservation (Rahbek et al., 2019). Specified the restrictions on studying live wild birds, under the Wildlife Protection Act of 1972, India. Preserved specimens offer an essential resource for understanding avian bio-diversity, adaptations, and evolutionary relationships (Mayr, 2017). This study, keen to the documentation, detailed morphometric data, is valuable biological data (Gundemir et al., 2020).

4. CONCLUSION

In this study, the morphometric data of avian specimens documented here will continue to serve as a reference for students, researchers, and ornithologists. The comparative analyses of avian morphometric characteristics data, to supporting ecological and evolutionary studies in the future. By preserving avian specimens, the museum preserves historical biodiversity data but also enhances future research opportunities, ensuring that these collections remain valuable for generations.

Abbreviations

Head Length (HL), Head Width (HW), Head Height (HH), Body Length (BL), Body Width (BW), Eye Length (EL), Eye Width (EW), Beak Length (BeL), Upper Jaw (UJ), Lower Jaw (LJ), Upper Beak Nostril (UBN), Lower Beak Nostril (LBN), Start Beak Height (SBH), Middle Beak Height (MBH), Edge Beak Height (EBH), Wing Length (WL), Wing Width (WW), Neck Length (NL), Neck Throat (NT).

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Author Contributions

All authors contributed to the study conception and design**.** Joshua AR, conducted the investigation and curated the data, Sahana, Maria Jerlin Nancy and Pon Ranjini performed the formal analysis, validated the results, Azhagu Raj conceptualized the study, designed the methodology, supervised the project, reviewed, and edited the manuscript.

Ethical approval & declaration

In this article, as per the animal regulations & specimen ethics followed in the Zoology Museum of St. Xavier's College, Palayamkottai, India, the authors present a morphometric analysis of nine-decade-old avian specimens. The ethical guidelines for species samples, specimens, or fossils are followed in the study for observation & identification. Meantime, the animal ethical guidelines are also followed in the study for species observation, identification & experimentation.

Informed consent

Not applicable.

Conflicts of interests:

The authors declare that there are no conflicts of interests.

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Data and materials availability

All data associated with this study are present in the paper.

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