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Radiographic Cardiac Indices in Avian Orders: A Narrative Review

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ABSTRACT

Radiographic evaluation of cardiac size is a cornerstone of avian diagnostics, providing an accessible and objective approach for detecting cardiomegaly, congestive heart failure, and related conditions such as pulmonary hypertension syndrome (ascites). This narrative review synthesizes and critically evaluates published studies on radiographic cardiac indices across a broad range of avian taxa, including *Psittaciformes*, *Accipitriformes*, *Falconiformes*, *Galliformes*, *Columbiformes*, *Anseriformes*, *Sphenisciformes*, *Ciconiiformes*, *Piciformes*, and *Passeriformes*. Commonly reported indices include the cardiac width-to-thoracic width ratio, cardiac width-to-sternal width ratio, and ratios relating the cardiac silhouette to additional thoracic skeletal landmarks, including coracoid width and intercostal or clavicular distances. Data derived from studies on clinically healthy birds establish species-specific reference ranges, most frequently clustering between 0.50 and 0.60. In contrast, pathological reports consistently describe deviations from these ranges, including cardiac silhouette elongation and partial or complete loss of the cardiac waists in cases of cardiomegaly. Across avian orders, substantial interspecific anatomical variation, sensitivity to radiographic positioning and respiratory phase, and limited sample sizes, particularly in wild or non-companion species, represent major sources of variability. By consolidating radiographic cardiac indices across diverse avian groups, this review underscores the lack of universally applicable diagnostic thresholds. It emphasizes the necessity of species- and method-specific interpretation for accurate clinical decision-making. Furthermore, it highlights the need for future standardization of radiographic measurement protocols and their integration with complementary imaging modalities.

Keywords: *Birds, Cardiac index, Heart size, Radiography.*

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1 Introduction

Cardiovascular disorders represent an important and often underdiagnosed cause of morbidity and mortality in both captive and free-ranging birds (Krautwald-Junghanns et al., 2004). Conditions such as cardiomegaly, pericardial effusion, and Pulmonary Hypertension Syndrome (PHS; Ascites syndrome) may present with nonspecific clinical signs, making imaging a critical component of diagnostic evaluation (Krautwald-Junghanns et al., 2004; Wideman, 2000). On radiographs evaluation, cardiac disease commonly manifests as enlargement of the cardiac silhouette, blunting or loss of the cardiac waist, altered contact with the sternum, or silhouetting with adjacent coelomic organs and air sacs (Beregi et al., 1999; Naguib, 2017). Radiographic cardiac indices, quantitative ratios derived from standardized measurements on ventrodorsal (VD) and lateral projections, have therefore been developed to provide an objective assessment of heart size while minimizing the confounding effects of absolute body size (Geerinckx et al., 2019; Hanley et al., 1997; Mirshahi et al., 2016; Rettmer et al., 2011; Schnitzer et al., 2021; Straub, Pees, et al., 2002; Velayati et al., 2015). Early investigations primarily focused on companion birds, particularly *psittacines*, in which a high prevalence of cardiac pathology has been reported at necropsy (up to 36% macroscopic changes) (Krautwald-Junghanns et al., 2004). More recent studies have expanded this approach to raptors, production birds, and a variety of wild taxa (Barbon et al., 2010; Beaufrère et al., 2010; da Silva et al., 2020; Fischer et al., 2005; Gunay et al., 2022; Khaksar Bajestani et al., 2024; Lumeij et al., 2011; Norouzi et al., 2022; Straub, Valerius, et al., 2002; Woo et al., 2019; Yaygingul et al., 2025; Yunker et al., 2018). Despite this growing body of literature, interpretation of avian cardiac indices remains challenging because of substantial interspecific variation in thoracic anatomy, differences in respiratory mechanics, and methodological inconsistencies among studies (Naguib, 2017). This review aimed to synthesize available data on radiographic cardiac indices in birds, summarize species-specific reference values, evaluate methodological approaches, and discuss the clinical applicability and limitations of these indices in avian cardiology. To the authors' knowledge, this review provides the most comprehensive cross-order synthesis to date of radiographic cardiac indices in birds, integrating data from companion, production, and wild species to highlight both shared patterns and species-specific variability.

2 Materials and Methods

This narrative review uses peer-reviewed articles and selected case reports addressing radiographic assessment of cardiac size in birds. Literature was systematically searched using predefined keywords (e.g., "avian cardiac radiography," "radiographic heart size birds," "cardiac index avian," and "avian cardiomegaly") in major scientific databases, including PubMed and BioOne. Studies published between 1997 and 2025 were considered. Inclusion criteria comprised studies reporting quantitative radiographic measurements or ratios related to cardiac size in avian species. Studies based exclusively on echocardiography, computed tomography without radiographic comparison, or postmortem morphometry were excluded. A total of 23 publications met the inclusion criteria. From each study, data were extracted on species, sample size, radiographic projections, cardiac indices evaluated, reported reference ranges, and correlations with morphometric or demographic variables. Key findings are summarized descriptively and comparatively in Tables 1 and 2.

Table 1. Summary of Radiographic Cardiac Indices in Clinically Healthy Birds by Order

Avian Order	Species (examples)	n	Main Radiographic Indices	Normal Reference Values	Reference
Psittaciformes	African grey, Amazon, Senegal parrots	59	CW/TW, CW/SW, CW/CorW	CW/TW ≈ 0.51–0.61 (mean ≈0.55)	(Straub, Pees, et al., 2002)
	Budgerigar (*Melopsittacus undulatus*)	27	CW/TW, CW/CorW	CW/TW = 0.55–0.70 (0.62 ± 0.03)	(Velayati et al., 2015)
	Spix's macaw (*Cyanopsitta spixii*)	29	CW/TW, CW/Liver width	CW/TW = 0.46–0.60 (mean 0.53)	(Rettmer et al., 2011)
Accipitriformes / Falconiformes	Common kestrel (*Falco tinnunculus*)	14	CW/TW	CW/TW = 0.51–0.75 (mean 0.62± 0.05)	(Mirshahi et al., 2016)

	Peregrine falcon (*Falco peregrinus*)	100	CW/TW, CW/SW	0.59–0.71	(Lumeij et al., 2011)
	Osprey (*Pandion haliaetus*)	54	CW/TW, CW/SW	CW/TW = 0.60–0.76 (mean 0.68)	(Woo et al., 2019)
Galliformes	Texas A&M white quail (*Coturnix* sp.)	24	CW/TW	CW/TW = 0.42–0.63 (mean 0.55)	(Yaygingul et al., 2025)
	Broiler chicken (healthy)	150	CW/TW	≈0.50	(Wideman, 2000)
Columbiformes	Domestic pigeon (*Columba livia domestica*)	27	CW/TW, CW/SyW	CW/TW = 0.58- 0.63 (0.62 ± 0.03)	(Khaksar Bajestani et al., 2024)
Sphenisciformes	Humboldt penguin (*Spheniscus humboldti*)	10	VHS, CCWR, CKR	CCWR = 0.45–0.59 (mean 0.55); VHS = 7.4–10.4	(Yunker et al., 2018)
Ciconiiformes	White stork (*Ciconia ciconia*)	26	CW/TW, CW/CorW	CW/TW = 0.49–0.69 (mean 0.59)	(Gunay et al., 2022)
Piciformes	Toco toucan (*Ramphastos toco*)	15	CW/TW	≈0.53	(da Silva et al., 2020)
Passeriformes	Common mynah (*Acridotheres tristis*)	34	Absolute CW; correlations with TW	CW = 16.1 ± 0.9 mm	(Norouzi et al., 2022)

CW: Cardiac Width; TW: Thoracic Width; SW: Sternal Width; CorW: Coracoid Width; SyW: Synsacrum Width; CCWR: Cardiocoelomic Width Ratio; CKR: Cardiac Keel Ratio; VHS: Vertebral Heart Scale

Table 2. Radiographic Cardiac Indices in Pathological Conditions and Clinical Interpretation

Species / Group	Abnormal Index	Reported Value	Clinical Interpretation	Reference
Psittacines (e.g., PDD, dilated cardiomyopathy)	CW/TW	>0.65	Cardiomegaly; loss of cardiac waist	(Beregi et al., 1999; Krautwald-Junghanns et al., 2004)
Broiler chickens (pulmonary hypertension syndrome/ascites)	CW/TW	>0.70	Right ventricular hypertrophy; hepatic silhouetting	(Wideman, 2000)
Whooper swan (*Cygnus cygnus*)	Absolute CW	≈25% increase vs. expected normal	Severe cardiomegaly; coelomic silhouetting	(Fischer et al., 2005)
Raptors	CW/SW	Above species-specific reference range	Reduced flight performance; congestive heart failure	(Barbon et al., 2010; Lumeij et al., 2011; Woo et al., 2019)
Penguins	VHS, CCWR	Outside established reference intervals	Cardiomegaly or pericardial effusion	(Yunker et al., 2018)

3 Radiographic Techniques in Avian Cardiac Assessment

Radiographic examination of birds requires careful adaptation to avian anatomy and physiology (Naguib, 2017). Extensive air sac systems provide natural contrast for the cardiac silhouette but also increase susceptibility to motion and positioning artifacts (Naguib, 2017). Standard projections include VD and lateral views, obtained under light anesthesia or controlled manual restraint to reduce motion and minimize rotational distortion (Naguib, 2017). Most cardiac indices are measured on VD projections, where the cardiohepatic silhouette typically assumes an hourglass shape (Straub, Pees, et al., 2002). Common measurements include maximum cardiac width (CW), thoracic width (TW) at a defined rib level, coracoid width (CorW), sternal width or length (SW), Synsacrum width (SyW), and, in some species, keel height or length (Barbon et al., 2010; da Silva et al., 2020; Fischer et al., 2005; Geerinckx et al., 2019; Gunay et al., 2022; Hanley et al., 1997; Khaksar Bajestani et al., 2024; Lumeij et al., 2011; Mirshahi et al., 2016; Norouzi et al., 2022; Rettmer et al., 2011; Schnitzer et al., 2021; Straub, Pees, et al., 2002; Velayati et al., 2015; Woo et al., 2019; Yaygingul et al., 2025; Yunker et al., 2018). Ratios such as CW/TW or CW/SW are used to normalize heart size relative to thoracic dimensions (Barbon et al., 2010; da Silva et al., 2020; Fischer et al., 2005; Geerinckx et al., 2019; Gunay et al., 2022; Hanley et al., 1997; Khaksar Bajestani et al., 2024; Lumeij et al., 2011; Mirshahi et al., 2016; Norouzi et al., 2022; Rettmer et al., 2011; Schnitzer et al., 2021; Straub, Pees, et al., 2002; Velayati et al., 2015; Woo et al., 2019; Yaygingul et al., 2025; Yunker et al., 2018). Lateral projections provide complementary information on cardiac height, shape, and sternal contact but are less frequently used for quantitative indices (Naguib, 2017). Adaptations of the vertebral heart scale (VHS), widely used in mammalian radiology, have been proposed for certain avian species by expressing cardiac dimensions in vertebral body units (Gunay et al., 2022) . Advanced modalities, particularly computed tomography, offer superior anatomic detail and facilitate three-dimensional assessment, although their routine clinical use remains limited by availability and cost (da Silva et al., 2020). Contrast-based vascular imaging can further enhance the assessment of hemodynamic abnormalities in selected cases (Beaufrère et al., 2010).

4 Species-Specific Studies on Radiographic Cardiac Indices

4.1 *Psittaciformes*

Psittacines represent the most extensively studied avian group in terms of radiographic cardiac morphometry, with multiple investigations focusing on companion species due to their high prevalence in clinical settings (Hanley et al., 1997; Rettmer et al., 2011; Schnitzer et al., 2021; Straub, Pees, et al., 2002; Velayati et al., 2015). Across multiple genera, normal CW/TW ratios in clinically healthy adult birds generally range from approximately 0.51 to 0.61 (with higher values up to 0.70 in smaller species like budgerigars), as synthesized in comprehensive reviews of internal organ measurements (Geerinckx et al., 2019). For example, in medium-sized psittacines such as African grey parrots, Senegal parrots, and orange-winged Amazon parrots, the mean cardiac silhouette width-to-thorax width ratio is 55% (0.55), and the mean cardiac silhouette width-to-coracoid width ratio is 600% (6.00). The mean cardiac silhouette width-to-sternum length ratio is 38% (0.38) (Straub, Pees, et al., 2002). These studies, involving 59 birds, demonstrate strong correlations between cardiac width and thoracic or sternal dimensions, supporting the use of ratio-based indices (e.g., r=0.92 with sternum length, r=0.85 with thoracic width, and r=0.84 with coracoid width), and no significant differences were found between species (Straub, Pees, et al., 2002). In budgerigars, based on 27 healthy adults, the cardiac width to thoracic width ratio ranges from 0.55 to 0.70 with a Mean ± SD of 0.62 ± 0.03, and the cardiac width to coracoid width ratio ranges from 5.62 to 8.61 with a Mean ± SD of 7.34 ± .68 (Velayati et al., 2015). These measurements showed moderate correlations with thoracic width ($R^2=0.28$) but no significant effects from sex or body weight (Velayati et al., 2015). Similarly, in Spix's macaws evaluated across 29 individuals, CW/TW averages 0.53 with a range of 0.46-0.60, and CW/liver width is 0.65-1.05 with a mean of 0.86, noting that juveniles exhibit larger heart width to thoracic width ratios compared to adults (Rettmer et al., 2011). In wild galahs, from a sample of 36 birds, CW/TW is 0.50-0.65 with a mean of 0.57, and CW/CorW is 570-743% with a mean of 656%, with significant correlations to body weight for both cardiac width and length, and measurements proving straightforward in both ventrodorsal and laterolateral views (Schnitzer et al., 2021). Reported deviations beyond these ranges, particularly CW/TW values exceeding 0.65, are commonly associated with cardiomegaly, dilated cardiomyopathy, or systemic diseases such as proventricular dilatation disease, where necropsy findings indicate macroscopic cardiac changes in up to 36% of cases and hypertrophic or dilatative cardiomyopathy in 15% (Krautwald-Junghanns et al., 2004). Several authors emphasize the importance of correlating radiographic findings with clinical signs and, where possible, echocardiographic evaluation to avoid misinterpretation related to positioning or respiratory phase, as the cardiac silhouette typically occupies 50-60% of the coelomic cavity width in ventrodorsal views, with pathological changes including silhouette elongation in wasting diseases (Hanley et al., 1997; Naguib, 2017).

4.2 *Accipitriformes and Falconiformes*

Raptors exhibit marked interspecific variation in thoracic conformation related to flight style and athletic conditioning, with studies highlighting differences between smaller and larger species (Barbon et al., 2010; Lumeij et al., 2011; Mirshahi et al., 2016; Woo et al., 2019). In kestrels and other small falcons, relatively narrow cardiac silhouettes have been reported, with CW/TW ratios often around 0.50–0.55; for instance, in 14 healthy common kestrels, CW/TW is 0.62 ± 0.05, showing strong positive correlations with thoracic parameters (r>0.80) but no differences based on sex (Mirshahi et al., 2016). In contrast, larger raptors such as peregrine falcons, hawks, and ospreys demonstrate higher CW/TW ratios, frequently 0.58–0.71 (Barbon et al., 2010; Lumeij et al., 2011; Woo et al., 2019). In four falconiform species, including Harris' hawks, peregrine falcons, saker falcons, and lanner falcons across 115 birds, heart length to carina is 56-58%, CW/TW ranges from 0.58-0.69, and CW/CorW from 706-900%, with significant differences between hawks and falcons but no intra-falcon species variations (Barbon et al., 2010). In peregrine falcons, from a sample of 100 birds, CW/TW is 0.59-0.71, with sternal width proving a superior predictor ($CW = 0.83SW + 0.37 \pm 0.16$) over thoracic width due to respiratory influences (Lumeij et al., 2011). Similarly, in ospreys evaluated in 54 birds (22 adults, 19 juveniles, 13 undetermined), CW/SW is 82.83-98.51% with a mean of 91.32%, and CW/TW is 59.89-75.85% with a mean of 68.13%, supported by a predictive model ($CW = 1.14 + 0.64SW + 0.17TW + 0.84\times age$) and strong correlations with sternal width ($r=0.76$) (Woo et al., 2019). Several studies suggest that sternal width or length may serve as a more reliable scaling parameter than thoracic width in raptors, as thoracic dimensions can be influenced by respiratory dynamics (Lumeij et al., 2011; Woo et al., 2019). Regression models incorporating multiple thoracic measurements and age have been proposed to improve predictive accuracy in these species, and narrower silhouettes (CW/TW <0.50) are noted in athletic builds like kestrels (Mirshahi et al., 2016).

4.3 *Galliformes*

In galliform birds, particularly broiler chickens, radiographic cardiac indices have been used to investigate the pathophysiology of pulmonary hypertension syndrome, with baselines established in healthy individuals (Wideman, 2000; Yaygingul et al., 2025). Healthy quail and other galliforms typically exhibit CW/TW ratios below 0.42–0.63; for example, in 24 healthy Texas A&M white quail, CW/TW averages 0.55 ± 0.03, with regression models showing significant correlations to thoracic width ($\beta=0.65$, $p<0.01$) and including measurements like coracoid and synsacrum widths (Yaygingul et al., 2025). In broiler chickens, healthy controls show CW/TW around 0.50. In contrast, birds affected by ascites show marked enlargement of the cardiac silhouette, often exceeding 0.70, with right ventricular hypertrophy and silhouetting of the liver due to pulmonary hypertension linked to fast growth and genetic susceptibility (Wideman, 2000). These findings support the utility of radiography for early detection of cardiopulmonary compromise in production settings.

4.4 *Columbiformes*

Radiographic cardiac indices in domestic pigeons have been investigated to establish species-specific reference values and evaluate their relationship with skeletal parameters. In a study of 27 clinically healthy adult pigeons, the cardiac width–to–thoracic width (CW/TW) ratio was reported as 0.62 ± 0.03 (95% CI: 0.58–0.63), representing one of the most consistent indices with the lowest coefficient of variation (Khaksar Bajestani et al., 2024). Regression analyses demonstrated significant positive associations between cardiac width and thoracic width as well as synsacrum width, independent of sex and body weight (Khaksar Bajestani et al., 2024). In contrast, correlations between cardiac width and both clavicle distance and inter-femoral head distance were influenced by sex, necessitating the inclusion of sex as a variable in those regression models. Coracoid width and the distance between the third and fourth ribs did not show significant associations with cardiac width. Collectively, these findings indicate that thoracic- and synsacrum-based indices provide more robust and reliable reference measures for radiographic cardiac assessment in pigeons compared with alternative skeletal landmarks (Khaksar Bajestani et al., 2024).

4.5 *Anseriformes*

Radiographic reference data for cardiac size in anseriform birds remain scarce and are largely confined to isolated case reports rather than population-based studies. The most detailed description concerns a whooper swan (*Cygnus cygnus*) diagnosed with severe cardiomegaly, in which radiography revealed a marked enlargement of the cardiac silhouette. Cardiac width measured approximately 15 cm on ventrodorsal projections and 17 cm on lateral views, corresponding to an increase of about 25% compared with expected normal dimensions (Fischer et al., 2005). These quantitative changes were accompanied by classic qualitative radiographic features of cardiomegaly, including silhouetting with adjacent coelomic structures and partial loss of the normal cardiac waists (Fischer et al., 2005). The condition was associated with an underlying infectious process, highlighting the clinical relevance of radiography for detecting advanced cardiac pathology even in large-bodied aquatic birds. Collectively, available evidence underscores both the diagnostic value of radiographic assessment in Anseriformes and the current lack of standardized reference indices for this order, emphasizing the need for systematic studies in clinically healthy individuals (Fischer et al., 2005).

4.6 *Sphenisciformes*

In penguins, adaptations of the vertebral heart scale and additional indices such as cardiac keel ratios have been reported (Yunker et al., 2018). In 10 clinically healthy

Humboldt penguins, VHS ranges from 7.4-10.4 with a mean of 9.13, cardiac silhouette-to-keel ratio (CKR) from 3.5-4.5 with a mean of 3.94, and cardiocoelomic width ratio (CCWR) from 0.45-0.59 with a mean of 0.55 (Yunker et al., 2018). Available data indicate relatively consistent reference ranges in clinically healthy individuals, although sample sizes remain small and species coverage is limited.

4.7 Ciconiiformes

Radiographic studies in white storks demonstrate CW/TW ratios broadly comparable to those reported in other large avian species, with significant correlations between cardiac and thoracic dimensions (r=0.556) (Gunay et al., 2022). In 26 storks, CW/TW ranges from 0.49-0.69 with a mean of 0.59 ± 0.05, heart length to carina from 0.31-0.53 with a mean of 0.44 ± 0.05, and CW/CorW from 399-647 with a mean of 508% (Gunay et al., 2022). Considerable individual variation underscores the need for cautious interpretation.

4.8 Piciformes

Combined radiographic and computed tomographic evaluation in toucans has shown CW/TW ratios close to 0.53, with CT providing superior delineation of cardiac margins and adjacent air sacs (da Silva et al., 2020). In 15 healthy toco toucans (10 females, 5 males, average 650g), heart length is 23.76 ± 2.1 mm, CW is 25.94 ± 1.8 mm, and thoracic cavity width is 48.87 ± 3.2 mm, yielding CW/TW ≈0.53 (da Silva et al., 2020). These findings highlight the complementary role of cross-sectional imaging in anatomically complex species, where the lung shows a honeycomb-like pattern and air sacs appear as dark, air-filled spaces.

4.9 Passeriformes

In passerines such as common mynahs, reference intervals for absolute cardiac width and ratio-based indices have been established, demonstrating moderate correlations with thoracic measurements (e.g., $R^2=0.37$ with TW, $R^2=0.25$ with CorW, $R^2=0.34$ with rib distance) (Norouzi et al., 2022). In 34 healthy mynahs, CW is 16.1 ± 0.9 mm with a 95% CI: 14.1-18 mm (Norouzi et al., 2022). These data provide a foundation for clinical assessment in small-bodied birds, although further studies across diverse passerine taxa are needed.

5 Discussion

Radiographic cardiac indices represent a foundational element in avian veterinary diagnostics, offering a non-invasive means to quantify heart size and detect deviations indicative of cardiovascular pathology (Barbon et al., 2010; Beaufrère et al., 2010; da Silva et al., 2020; Fischer et al., 2005; Geerinckx et al., 2019; Gunay et al., 2022; Hanley et al., 1997; Khaksar Bajestani et al., 2024; Lumeij et al., 2011; Mirshahi et al., 2016; Norouzi et al., 2022; Rettmer et al., 2011; Schnitzer et al., 2021; Straub, Pees, et al., 2002; Straub, Valerius, et al., 2002; Velayati et al., 2015; Woo et al., 2019; Yaygingul et al., 2025; Yunker et al., 2018). Across the diverse avian taxa examined in this review, spanning Psittaciformes, Accipitriformes, Falconiformes, Galliformes, Columbiformes, Anseriformes, Sphenisciformes, Ciconiiformes, Piciformes, and Passeriformes, these indices consistently reveal species-specific reference ranges rather than a singular, universally applicable threshold (Barbon et al., 2010; Beaufrère et al., 2010; da Silva et al., 2020; Fischer et al., 2005; Geerinckx et al., 2019; Gunay et al., 2022; Hanley et al., 1997; Khaksar Bajestani et al., 2024; Lumeij et al., 2011; Mirshahi et al., 2016; Norouzi et al., 2022; Rettmer et al., 2011; Schnitzer et al., 2021; Straub, Pees, et al., 2002; Straub, Valerius, et al., 2002; Velayati et al., 2015; Woo et al., 2019; Yaygingul et al., 2025; Yunker et al., 2018) (Figure. 1). This taxonomic variability underscores the influence of evolutionary adaptations in thoracic anatomy, such as differences in air sac volume, sternal morphology, and flight-related cardiovascular demands (Naguib, 2017). For instance, athletic raptors like kestrels exhibit narrower cardiac silhouettes (CW/TW ≈0.62) compared to more sedentary galliforms such as quail (CW/TW ≈0.55), highlighting how lifestyle and phylogeny shape baseline metrics (Mirshahi et al., 2016; Yaygingul et al., 2025).

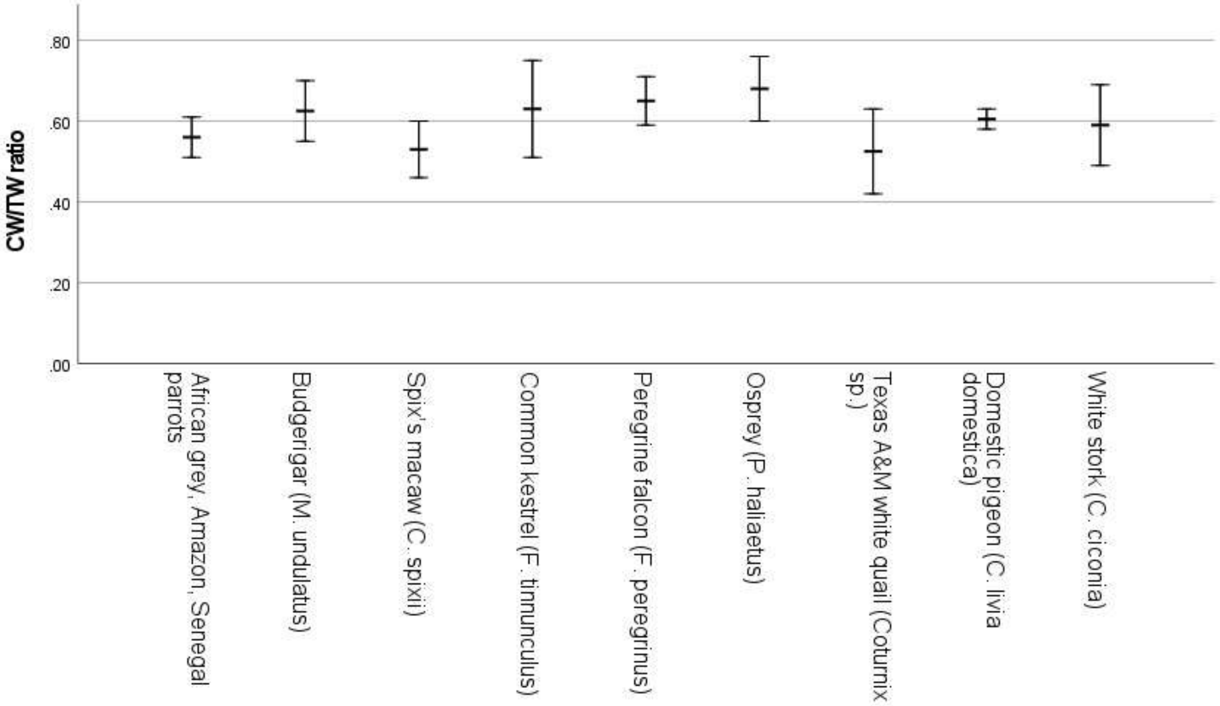

Figure 1. Mean and range of the CW/TW ratio across selected avian species based on published data.

In clinically healthy birds, CW/TW ratios most frequently cluster between approximately 0.50 and 0.60, providing a practical benchmark for initial assessments (Barbon et al., 2010; Beaufrère et al., 2010; da Silva et al., 2020; Fischer et al., 2005; Geerinckx et al., 2019; Gunay et al., 2022; Hanley et al., 1997; Khaksar Bajestani et al., 2024; Lumeij et al., 2011; Mirshahi et al., 2016; Norouzi et al., 2022; Rettmer et al., 2011; Schnitzer et al., 2021; Straub, Pees, et al., 2002; Straub, Valerius, et al., 2002; Velayati et al., 2015; Woo et al., 2019; Yaygingul et al., 2025; Yunker et al., 2018). This convergence is evident in psittacines (approximately 0.50–0.60 in most medium-sized psittacines, with higher values reported in smaller species such as budgerigars (up to 0.70)), columbiformes (0.58 in pigeons) (Khaksar Bajestani et al., 2024; Straub, Pees, et al., 2002). Deviations from these norms, particularly values exceeding 0.65, are strongly associated with cardiomegaly or cardiopulmonary disease (Krautwald-Junghanns et al., 2004; Wideman, 2000). In psittacines, such enlargements often correlate with dilated cardiomyopathy or secondary conditions like proventricular dilatation disease, where necropsy studies report macroscopic cardiac changes in up to 36% of cases (Krautwald-Junghanns et al., 2004). Similarly, in broilers, CW/TW >0.70 signals Pulmonary Hypertension Syndrome (Ascites), a condition exacerbated by rapid growth and genetic factors, leading to right ventricular hypertrophy and hepatic silhouetting on radiographs (Wideman, 2000). These patterns are not merely descriptive; they facilitate early intervention, as seen in production settings where radiographic screening can identify at-risk individuals before clinical decompensation (Wideman, 2000).

The robustness of these indices is further supported by strong correlations between cardiac dimensions and thoracic parameters, which mitigate the confounding effects of body size variation (Barbon et al., 2010; Beaufrère et al., 2010; da Silva et al., 2020; Fischer et al., 2005; Geerinckx et al., 2019; Gunay et al., 2022; Hanley et al., 1997; Khaksar Bajestani et al., 2024; Lumeij et al., 2011; Mirshahi et al., 2016; Norouzi et al., 2022; Rettmer et al., 2011; Schnitzer et al., 2021; Straub, Pees, et al., 2002; Straub, Valerius, et al., 2002; Velayati et al., 2015; Woo et al., 2019; Yaygingul et al., 2025; Yunker et al., 2018). Correlation coefficients often exceed 0.80 (e.g., CW with thoracic width in kestrels, r>0.80; CW with sternum length in psittacines, r=0.92), enabling the development of predictive regression models (Mirshahi et al., 2016; Straub, Pees, et al., 2002). In peregrine falcons, for example, CW = 0.83SW + 0.37 ± 0.16 accounts for respiratory influences on thoracic width, making sternal measurements a superior predictor (Lumeij et al., 2011). Such models enhance diagnostic precision, particularly in wild or variable-sized populations like ospreys, where combined predictors (CW = 1.14 + 0.64W + 0.17TW + 0.84 age) incorporate demographic factors (Woo et al., 2019). However, these correlations are not infallible; they assume standardized radiographic techniques, and inconsistencies in projection angles or restraint can inflate variability (Naguib, 2017).

Despite these strengths, several limitations constrain the broader interpretation and application of radiographic cardiac indices. Sample sizes in many studies are notably small, especially for wild or non-companion species—such as Humboldt penguins (n=10), white storks (n=26), or toco toucans (n=15)—which limits statistical power and generalizability (da Silva et al., 2020; Gunay et al., 2022; Yunker et al., 2018). The underrepresentation of age-related changes compounds this. At the same time, some reports note larger relative heart sizes in juveniles (e.g., higher HW/TW in young macaws), longitudinal data are scarce, potentially leading to misdiagnosis in growing birds (Rettmer et al., 2011). Technical factors further exacerbate challenges: positioning artifacts can distort silhouettes, respiratory phase influences thoracic width (e.g., narrower during expiration), and anesthetic effects may alter cardiac output and air sac distension, as emphasized in raptor and psittacine protocols (Mirshahi et al., 2016; Naguib, 2017). These variables introduce measurement error, necessitating orthogonal views (VD and lateral) and correlation with clinical history to avoid false positives (Naguib, 2017).

Advanced imaging modalities address some of these shortcomings by providing superior anatomic and functional resolution (Beaufrère et al., 2010; da Silva et al., 2020). Computed tomography (CT), for instance, excels in delineating cardiac margins and air sacs in complex species like toucans, where CW/TW ≈0.53 is more accurately measured without superimposition artifacts (da Silva et al., 2020). Contrast-based vascular imaging reveals hemodynamic details, such as shunts or effusions, that radiography alone may miss (Beaufrère et al., 2010). However, these techniques are not universally accessible due to cost, equipment requirements, and the need for prolonged anesthesia, limiting their routine use in field or general practice settings (da Silva et al., 2020). Integration with echocardiography could bridge this gap, offering real-time functional assessment alongside static radiographic indices (Krautwald-Junghanns et al., 2004).

In applied contexts, radiographic indices have demonstrated practical value, particularly in production birds (Wideman, 2000). Selective breeding programs in broilers, informed by CW/TW monitoring, have reduced ascites susceptibility by targeting genetic lines with lower pulmonary hypertension risk (Wideman, 2000). Yet, this raises ethical considerations: intensive selection for growth traits may inadvertently exacerbate welfare issues, such as skeletal deformities or chronic stress, warranting balanced evaluation under animal welfare frameworks (Wideman, 2000). Similarly, in wildlife rehabilitation, indices aid in assessing trauma-related cardiomegaly in raptors or swans, but ethical dilemmas arise when interventions prolong suffering in non-releasable individuals (Fischer et al., 2005).

Overall, radiographic cardiac indices should be regarded as decision-support tools rather than absolute diagnostic criteria, always interpreted within the broader clinical context—including history, physical examination, and ancillary tests (Naguib, 2017). Their value lies in accessibility and objectivity, but realizing full potential requires addressing gaps through larger, multicenter studies and methodological standardization. Future research should prioritize underrepresented taxa, age-stratified cohorts, and multimodal protocols to refine these indices and advance avian cardiology.

6 Conclusion

Radiographic cardiac indices constitute a valuable, widely accessible component of avian cardiovascular assessment (Barbon et al., 2010; da Silva et al., 2020; Fischer et al., 2005; Geerinckx et al., 2019; Gunay et al., 2022; Hanley et al., 1997; Khaksar Bajestani et al., 2024; Lumeij et al., 2011; Mirshahi et al., 2016; Norouzi et al., 2022; Rettmer et al., 2011; Schnitzer et al., 2021; Straub, Pees, et al., 2002; Velayati et al., 2015; Woo et al., 2019; Yaygingul et al., 2025; Yunker et al., 2018). The literature demonstrates clear species-specific norms and reproducible patterns of deviation in pathological states, supporting their use in both clinical practice and research (Krautwald-Junghanns et al., 2004; Wideman, 2000). Nonetheless, the absence of standardized methodologies and universally applicable thresholds limits direct comparison across taxa (Naguib, 2017). Future studies should prioritize methodological standardization, expanded species coverage, and integration of radiography with complementary imaging techniques to refine diagnostic accuracy in avian cardiology (da Silva et al., 2020; Straub, Valerius, et al., 2002).

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AI Use Statement

This work employed an AI-assisted tool (ChatGPT, Grammarly) exclusively for linguistic refinement, including grammar correction and enhancement of text fluency. All scholarly content, critical analysis, interpretations, and final conclusions remain solely attributable to the authors.

Conflict of Interest

The authors declare that no ethical approval is required for this review article, as it relies entirely on previously published research.

Author Contributions

Authors contributed equally to this article.

Data Availability Statement

Data are available from the corresponding author upon reasonable request.

Ethical Considerations

This study is a narrative review based solely on previously published data and did not involve any new animal experiments or sample collection. Therefore, ethical approval was not required.

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