SOME MORPHOLOGICAL FEATURES OF AVIAN KIDNEYS

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Knowledge of the external characteristics and weight of avian kidneys is fragmentary. Aside from generalized treatments (Stresemann, 1927–34; Benoit, 1950; Sperber, 1960), only limited information is available on external morphology (Kuroda, 1963) and kidney weight (Riboisiere, 1910; Crile and Quiring, 1940; Rensch, 1948; Quiring, 1962). Thus it seems appropriate to present the following data obtained as an adjunct to histological studies of the bird kidney.

Methods

Preserved materials and other data were obtained from representatives of 181 species from 20 orders. I collected most of these birds myself in various portions of the United States, primarily in Arizona, Colorado, Minnesota, and North Dakota. The specimens were weighed (to 0.1 g) in the field, and the synsacra (kidneys *in situ*) were fixed in AFA or formalin. Later in the laboratory, the kidneys were dissected free, weighed (to .001 g) in a sealed vial, and assigned to one of five categories (to be described later) representative of variations in external configuration. Prior to weighing, the kidneys were blotted lightly with absorbent paper. As used herein, kidney weight refers to the total of both organs in each individual. Where more than one specimen from a given species was available, mean kidney and body weight values were calculated.

Additional body and kidney weight data from the literature (Riboisiere, 1910; Crile and Quiring, 1940; Quiring, 1962) were added to the above information. The supplement included 175 species not represented in my collection, and 14 species that were. The overlapping data were considered separately when developing the curve (Figure 1). In all 356 species from 23 orders are represented in the study.

Results and Discussion

Weight.—The data are summarized in Table 1 and plotted logarithmically in Figure 1. The latter shows values ranging from hummingbirds to the ostrich (*Struthio camelus*). The data indicate a slight inverse relationship between kidney and body weight similar to those reported by Riboisiere (1910) and Rensch (1948). For the most part, the kidneys of relatively small birds (less than 100 g) exceed one per cent of body weight (latter level indicated by solid line in Figure 1). From 100 to about 1,000 g body weight, kidney weights are fairly evenly distributed around the one per cent line. In birds weighing more than 1,000 g, most kidney weights plot below the line. Because smaller birds metabolize more actively per unit body weight than do larger forms (King and Farner, 1961), the inverse kidney-body weight relationship probably reflects relative excretory demands. Also, most of the birds below 100 g

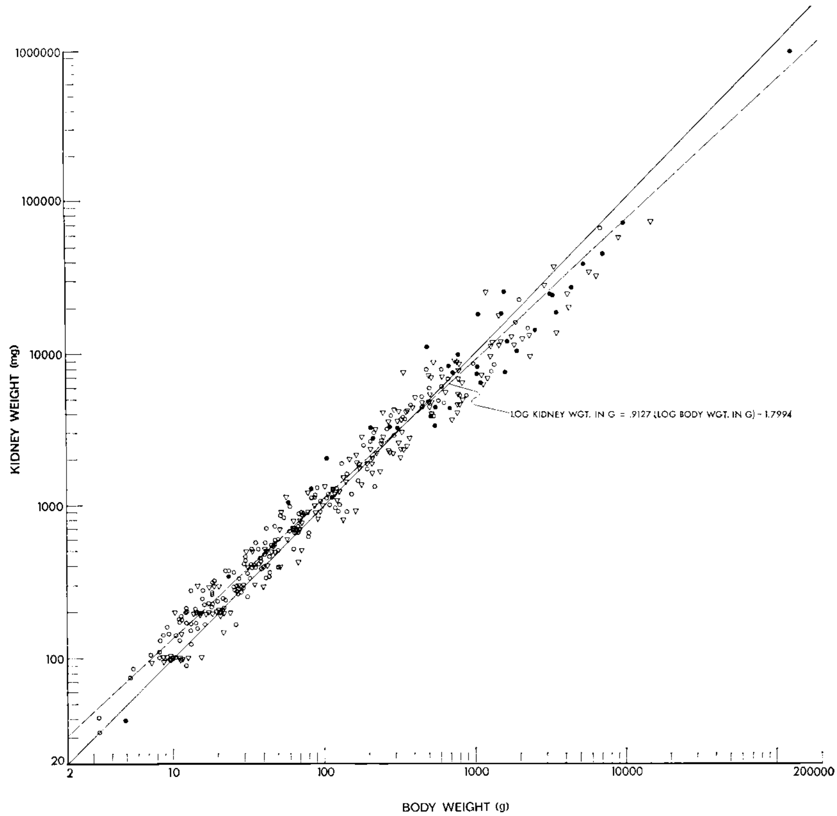

Figure 1. The relationship between body and kidney weight in 334 species of birds. Solid line indicates one per cent of body weight; regression shown by broken line. Unshaded circles represent present study; shaded circles represent data from Crile and Quiring (1940) and Quiring (1962); triangles represent data from Riboisiere (1910).

are passerines which, according to Lasiewski and Dawson (1967), have a higher weight specific metabolic rate than do nonpasserines. In this regard it is notable that the largest kidneys found among small (less than 100 g) nonpasserines were seen in the Charadriiformes (Table 1).

The broken line and its equation (Figure 1) show the regression that best fits the data. The equation is tentative and no doubt will be modified when additional values are obtained.

As an indication of relative kidney size, the ratio of kidney weight to body weight (expressed as mg of kidney per g of body weight) was calculated for most specimens (Table 1). A high degree of intraspecific constancy was notable with minor variations. The latter are probably due to variables such as the relative amount of body fat, the quantity of residual blood in the kidneys when fixed, and the content of the digestive organs. A few cases of rather marked intraspecific variation (wherein the only variable appeared to be kidney size itself) were found. For example, two adult male Black-billed Magpies (*Pica pica*) of similar weight (199 and 210 g, respectively) contained kidneys weighing 1.8 and 3.2 g, respectively. Comparable differences were noted in the Spotted Sandpiper (*Actitis macularia*), Franklin's Gull (*Larus pipixcan*), Black Tern (*Chlidonias niger*), Mourning Dove (*Zenaidura macroura*), and Cliff Swallow (*Petrochelidon pyrrhonota*). Rensch (1948) mentions a tendency for intraspecific kidney weight to be highest in the fall and winter seasons. The possibility of such a cycle should be studied further. My samples are too small and too restricted seasonally (most birds were taken during the breeding period) to allow any comparisons.

Kidney to body weight ratios (Table 1) ranged from 6 to 21 mg/g. The upper value represents the Long-billed Marsh Wren (*Telmatodytes palustris*) which, in relative terms, displays the largest kidneys found thus far. Benoit (1950) states that avian kidneys range from 1 to 2.6 per cent of body weight (10 to 26 mg/g) according to species. Obviously, the lower end of this range is modified by present findings. Benoit (1950) further indicates that the largest kidneys (in relative terms) are to be found in birds of aquatic habitats, a generality not confirmed by the present study (Table 1). The range in kidney to body weight ratios from the literature (Riboisiere, 1910; Crile and Quiring, 1940; Quiring, 1962) is comparable to my data, except that Riboisiere notes generally small kidneys in raptors (as low as 3.4 mg/g in *Aquila chrysaëtos*, for example). Although in general agreement, kidney to body weight ratios for the 14 species represented jointly in the literature and the present study showed some disparity. The most striking difference (Quiring, 1962) involved a female Pintail (*Anas acuta*) in which the kidney to body weight ratio was approximately twice that of a male in my collection. This disagreement plus the intraspecific variation mentioned above stress the need for additional data.

Among bird species of comparable body weight, both Riboisiere (1910) and Rensch (1948) note a tendency for insectivores to have larger kidneys than herbivores. No such trend was manifest in the present study, and indeed would be difficult to support amid other variables. For example, the kidneys of swallows are larger than those of comparably sized sparrows (Table 1), but this may relate to the intense activity of swallows rather than to their food habits.

No trend was apparent with respect to weight asymmetry between the left and right kidneys. Also, no significant intraspecific differences were noted in the relative size (mg/g) of kidneys from males and females. In

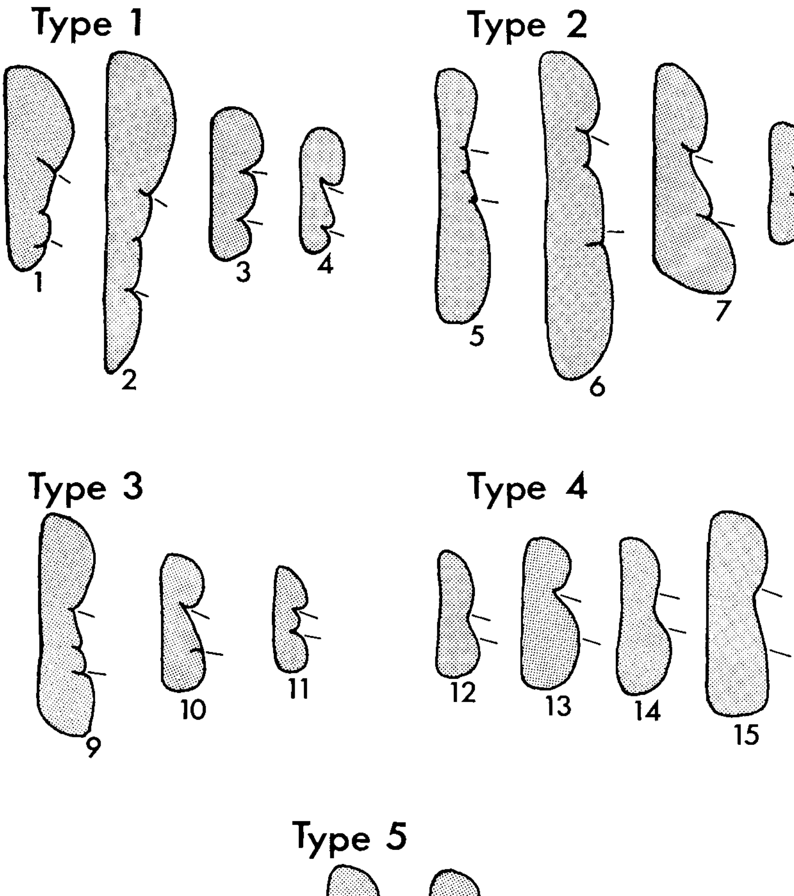

Figure 2. Diagrams of kidneys representing each shape category. Drawings show ventral views. The short lines mark locations of major blood vessels that traverse the kidney (see text). Diagrams 1 through 11 are ⅔ actual size; 12 through 17 are 1⅓ actual size. Kidneys shown represent these species: 1. *Botaurus lentiginosus,* 2. *Fulica americana,* 3. *Geococcyx californianus,* 4. *Otus asio,* 5. *Anas discors,* 6. *Aythya americana,* 7. *Lagopus lagopus,* 8. *Chlidonias niger,* 9. *Perdix perdix,* 10. *Charadrius vociferus,* 11. *Pitangus sulphuratus,* 12. *Eremophila alpestris,* 13. *Petrochelidon pyrrhonota,* 14. *Campylorhynchus brunneicapillum,* 15. *Toxostoma curvirostre,* 16. *Passer domesticus,* 17. *Passerculus sandwichensis.*

contrast, Rensch (1948) reports an intraspecific trend for larger kidneys in female birds.

External characteristics.—The avian kidney is usually described as a trilobate organ composed of cranial, middle, and caudal lobes (Stresemann, 1927–34; Benoit, 1950; Sperber, 1960). The middle lobe is always the smallest.

The kidneys examined defined five categories with respect to external configuration (Figure 2). These variations of the basic trilobate pattern can be described as follows:

Type 1—Three lobes present, middle lobe well developed and separated from the caudal lobe by a distinct indentation or obvious connective tissue-filled septum, cranial lobe largest.

Type 2—As above, except caudal lobe largest.

Type 3—As above, except caudal and cranial lobes approximately equal in size.

Type 4—Middle lobe not well defined as it is apparently fused closely to the other lobes (especially to the caudal), the latter combination exceeding the size of the cranial portion.

Type 5—As above, except cranial portion larger than or approximately equal to the caudal portion.

It is obvious that kidney shape varies considerably depending upon the relative development and contours of the three lobes. It is important to note that the five categories were developed from kidneys that had been removed from their synsacral fossae so that all surfaces could be examined. In many cases viewing only one surface would have been misleading.

All the representatives (except for the Adélie penguin *Pygoscelis adeliae,* and some Procellariiformes and Piciformes) of the 19 nonpasserine orders shown in Table 1 had obviously trilobate kidneys. The kidneys of most Passeriformes, on the other hand, had no well developed middle lobe, and thus appeared superficially bilobate. While the latter condition might represent loss or reduction of the middle lobe, it seems instead to be the result of close association between the lobes which renders their junctions obscure. Several lines of evidence favor this interpretation: (1) As described by Sperber (1960), four major blood vessels pass through the kidney at or near the junctions between lobes. Thus the femoral artery

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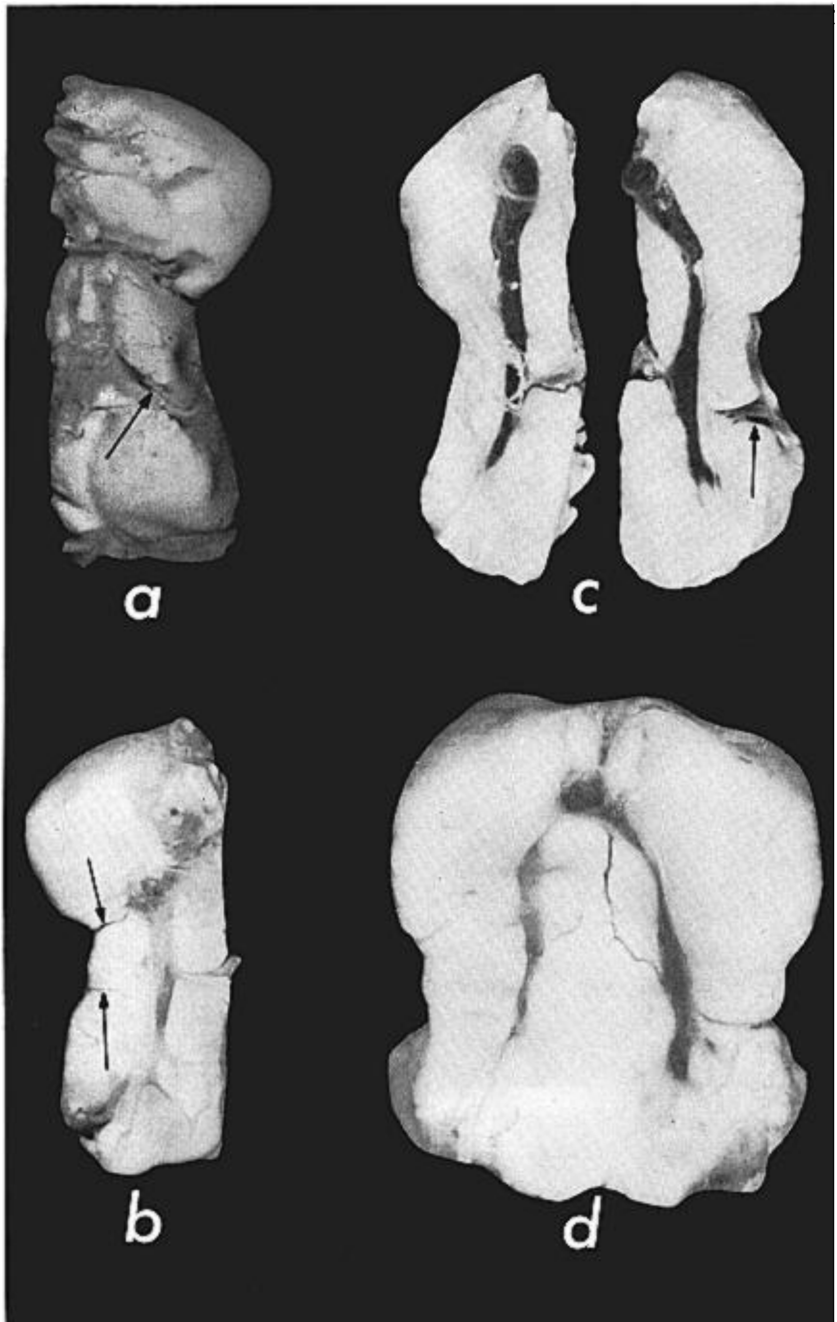
Figure 3. a. Dorsal surface of right kidney from *Sialia mexicana.* Arrow points to shallow groove at level of ischiadic blood vessels. (4×). b. Ventral surface of right kidney from *Sialia mexicana.* Arrows show delicate septa at apparent boundaries of the middle lobe. (4×). c. Ventral view of the kidneys from *Molothrus ater.* Arrow points to cleft at middle-caudal lobe junction. Note the absence of this separation in the other kidney. (4×). d. Ventral view of the kidneys from *Parus wollweberi* showing caudal fusion. (7.5×).


a
c
b
d

and external iliac vein mark the boundary between the cranial and middle lobes, and the ischiadic artery and vein lie at the junction of the middle and caudal lobes. As indicated in Figure 2, the obviously trilobate kidneys (types 1, 2, and 3) showed vessels in the positions described. In type 4 and 5 kidneys (where the middle lobe is not apparent), the vessels continue to bound an area that logically represents the middle lobe. (2) In a number of instances, a shallow groove (Figure 3a) was observed on the dorsal surface of the kidney at the level of the ischiadic vessels. This break in the contours of the organ suggests a boundary between the middle and caudal lobes. In addition, obscure septa (Figure 3b) were noted commonly along the lateral edge of the ventral surface at the level of the iliac or ischiadic vessels or both. Such discontinuity appears to represent further evidence of middle lobe boundaries. (3) In several instances an individual contained one kidney that displayed an obvious cleft at the middle-caudal lobe junction while the other did not (Figure 3c). This demonstrates variability in the degree of association between these two lobes within the same individual.

Thus all the kidneys examined in this study were basically trilobate, with an obscure middle lobe in many cases. Bilobate kidneys would necessarily involve the complete loss of one of the lobes. Such a condition may be characteristic of the hornbills (Van Tyne and Berger, 1959). Feinstein (1962) mentions several species wherein the kidney lobes were nearly or entirely separated from one another. In these cases, the middle lobe appeared to be joined to either the cranial or caudal lobe. As shown in Figure 2 (nos. 1, 2, 5, 6, and 9) several birds displayed a variation in the shape of the middle lobe, which a slight lateral indentation subdivided into two parts.

Although samples are not extensive, kidney shape appears to be relatively consistent among the members of certain groups (Table 1). Very elongate type 1 kidneys were present in the podicipediform and gruiform birds examined. Type 2 kidneys were characteristic in all of the anseriform and columbiform birds examined, and in most of the Galliformes. Among the Passeriformes, type 4 kidneys were found in all representatives of the families Mimidae and Turdidae, and type 5 kidneys were seen in all Parulids examined. Except for the flycatchers, swallows, and jays, all Passeriformes contained either type 4 or 5 kidneys. Considerable intra-order variation was noted in the Charadriiformes, which had kidney types 1, 2, and 3. In several cases (Table 1) intraspecific variation necessitated the use of two types to describe the representative kidneys. For example, individual cliff swallows displayed either type 3 or 4 kidneys. The major variations in kidney shape described above appear to have relatively little systematic importance. Rather they seem to be gross reflections of dif-

TABLE 1

MORPHOLOGIC FEATURES OF KIDNEYS FROM 181 SPECIES OF BIRDS

Species	*Mean body weight (g)*	*Mean kidney weight (mg)*	*Kidney-body weight ratio (mg/g)*	*Kidney shape*[1]
Sphenisciformes				
Pygoscelis adeliae (1♂)	–	–	–	5
Podicipediformes				
Podiceps caspicus (2♂)	330.0	3,711	11	1(1)
Podilymbus podiceps (2♂)	496.0	5,864	12	1(2)
Procellariiformes				
Diomedea nigripes (1♂, 1♀)	–	–	–	4
Diomedea immutabilis (1♀)	–	–	–	4
Fulmarus glacialis (1♂)	–	–	–	4
Puffinus griseus (1♂)	–	–	–	1
Puffinus tenuirostris (1♀)	–	–	–	1
Pterodroma hypoleuca (1♀)	–	–	–	1
Oceanodroma leucorhoa (2♂)	–	–	–	1
Pelicaniformes				
Phaëthon rubricauda (1♂)	–	–	–	3(1)
Pelecanus erythrorhynchos (2♂)	6,777.0	65,950	10	2
Fregata minor (1♀)	–	–	–	3
Ciconiiformes				
Ardea herodias (1♀)	1,840.0	15,804	9	3(1)
Nycticorax nycticorax (1♂, 1♀)	657.2	6,721	10	1
Botaurus lentiginosus (2♀)	625.0	4,694	7	1
Anseriformes				
Olor columbianus (1♀)	–	–	–	2
Branta canadensis (1♀)	–	–	–	2
Chen caerulescens (2♂, 2♀)	2,155.0	13,753	6	2
Anas platyrhynchos (1♂)	1,143.0	11,124	10	2
Anas acuta (1♂)	862.0	5,073	6	2
Anas discors (1♂, 1♀)	448.5	4,323	10	2
Anas cyanoptera (1♂)	368.5	4,490	12	2
Mareca americana (1♂)	–	–	–	2
Aythya americana (1♂, 1♀)	1,055.0	8,373	8	2
Oxyura jamaicensis (1♂, 1♀)	438.6	5,070	12	2
Falconiformes				
Buteo jamaicensis (1♀)	1,225.0	7,636	6	1
Falco sparverius (1♂, 1♀)	106.7	1,179	11	1
Galliformes				
Bonasa umbellus (2♂)	577.0	4,857	8	2
Lagopus lagopus (3♂, 2♀)	602.4	5,970	10	2
Pedioecetes phasianellus (1♀)	791.0	5,138	6	2
Centrocercus urophasianus (1♂, 1♀)	2,013.0	22,325	11	2
Callipepla squamata (2♂)	167.5	1,420	8	2
Lophortyx gambelii (2♂, 1♀)	150.4	1,161	8	2
Cyrtonyx montezumae (1♂, 1♀)	211.6	1,296	6	2
Phasianus colchicus (4♂)	1,283.0	8,232	6	2
Perdix perdix (1♂, 1♀)	521.0	3,810	7	3

[1] See text for a description of the shape categories. Numbers in parentheses in the last column denote occurrences of fusion in each sample (see text for further explanation).

TABLE 1 (*Continued*)

Species	*Mean body weight (g)*	*Mean kidney weight (mg)*	*Kidney-body weight ratio (mg/g)*	*Kidney shape*[1]
Gruiformes				
Porzana carolina (1♂)	67.0	878	13	1
Fulica americana (3♂, 1♀)	591.5	7,672	13	1
Charadriiformes				
Charadrius vociferus (1♂, 2♀)	88.2	1,313	15	3
Bartramia longicauda (1♂)	141.0	1,585	11	1
Actitis macularia (2♀)	41.2	703	17	3
Catoptrophorus semipalmatus (1♂)	259.5	3,154	12	3
Totanus melanoleucus (2♂)	212.3	2,923	14	1
Erolia melanotos (2♀)	85.1	1,140	13	3
Limnodromus scolopaceus (2♂)	129.8	1,788	14	3
Ereunetes pusillus (2♂)	23.4	381	16	3
Limosa fedoa (1♂)	322.0	3,610	11	2
Steganopus tricolor (2♂, 1♀)	46.9	727	15	3
Larus delawarensis (1♂, 3♀)	488.0	7,202	15	2
Larus pipixcan (2♀)	274.9	3,891	14	3
Chlidonias niger (2♂, 1♀)	59.5	978	16	2
Columbiformes				
Columba livia (1♂)	285.5	2,800	10	2
Zenaida asiatica (2♂, 1♀)	141.1	899	6	2
Zenaidura macroura (3♂, 1♀)	124.2	843	7	2
Scardafella inca (2♂)	43.3	342	8	2
Psittaciformes				
Aratinga astec (1♂)	–	–	–	2
Amazona finschi (1♀)	–	–	–	2
Melopsittacus undulatus (6♂)	39.1	285	7	2
Cuculiformes				
Geococcyx californianus (2♀)	189.9	1,701	9	1
Strigiformes				
Otus asio (1♂)	109.2	1,010	9	1
Micrathene whitneyi (1♂, 1♀)	37.0	417	11	1
Speotyto cunicularia (1♂)	–	–	–	1
Caprimulgiformes				
Chordeiles minor (1♂, 2♀)	79.6	632	8	2
Apodiformes				
Selasphorus platycercus (2♂)	3.2	33	10	1
Selasphorus rufus (1♂)	3.7	42	11	1
Trogoniformes				
Trogon citroleus (2♂)	–	–	–	2,3
Coraciiformes				
Megaceryle alcyon (2♀)	172.9	2,169	12	2
Momotus mexicanus (1♂)	–	–	–	3
Eumomota superciliosa (1♀)	–	–	–	3
Piciformes				
Ramphastrus sulfuratus (1♂)	–	–	–	2
Colaptes auratus (1♂)	125.6	982	8	–
Colaptes cafer (2♂)	124.5	910	7	2
Colaptes chrysoides (2♂)	115.6	952	8	2
Centurus uropygialis (2♂, 1♀)	67.5	729	11	2,4

TABLE 1 (*Continued*)

Species	*Mean body weight (g)*	*Mean kidney weight (mg)*	*Kidney-body weight ratio (mg/g)*	*Kidney shape*[1]
Piciformes (continued)				
Melanerpes formicivorus (1♂, 1♀)	63.1	517	8	4
Sphyrapicus varius (2♀)	44.8	545	12	2
Sphyrapicus thyroideus (2♂, 1♀)	43.1	459	11	2
Dendrocopos arizonae (2♀)	43.2	375	9	4
Passeriformes				
Platypsaris aglaiae (1♂)	29.0	295	10	–
Tyrannus tyrannus (2♂, 1♀)	49.0	604	12	2(1)
Tyrannus verticalis (2♂)	38.8	388	10	2
Tyrannus vociferans (2♀)	46.4	557	12	3(1)
Pitangus sulphuratus (1♂)	79.0	657	8	3
Myiarchus cinerascens (2♂, 2♀)	26.3	299	11	3
Empidonax oberholseri (1♀)	12.1	204	17	–
Contopus sordidulus (2♂, 1♀)	14.3	157	11	3
Nuttallornis borealis (1♂)	36.5	515	14	3
Pyrocephalus rubinus (2♂)	13.9	211	15	3
Eremophila alpestris (4♂)	27.5	284	10	4
Tachycineta thalassina (1♂, 1♀)	15.7	282	18	4
Iridoprocne bicolor (2♂, 1♀)	18.0	315	17	4
Hirundo rustica (2♂, 1♀)	18.6	325	17	3,4
Petrochelidon pyrrhonota (4♂, 1♀)	22.2	374	17	3,4
Progne subis (1♂, 1♀)	46.6	544	12	4
Cyanocitta stelleri (2♂)	103.7	1,101	11	1
Aphelocoma ultramarina (2♀)	120.2	1,274	11	4
Pica pica (3♂, 1♀)	198.2	2,556	13	3,4(1)
Parus wollweberi (3♂, 1♀)	10.4	144	14	5(3)
Auriparus flaviceps (3♂, 1♀)	7.0	107	15	4(4)
Psaltriparus minimus (1♀)	8.0	102	13	5(1)
Sitta carolinensis (1♀)	15.8	225	14	4
Certhia familiaris (1♂, 1♀)	8.4	145	17	5(1)
Troglodytes aedon (2♂, 1♀)	11.0	175	16	5(2)
Thryomanes bewickii (1♂)	12.2	212	17	5(1)
Campylorhynchus brunneicapillum (3♂, 2♀)	38.4	424	11	4(5)
Telmatodytes palustris (1♂, 1♀)	13.0	278	21	5(2)
Catherpes mexicanus (1♀)	11.2	180	16	–(1)
Salpinctes obsoletus (1♂, 1♀)	15.5	249	16	5(2)
Mimus polyglottos (3♂)	49.1	508	10	4
Dumetella carolinensis (1♂)	36.8	452	12	4
Toxostoma bendirei (1♂)	63.6	660	10	4(1)
Toxostoma curvirostre (1♂, 2♀)	72.4	875	12	4
Toxostoma dorsale (1♂, 1♀)	58.8	677	11	4
Oreoscoptes montanus (3♂)	40.0	570	14	4(1)
Turdus migratorius (2♂, 1♀)	86.6	1,172	13	4
Hylocichla guttata (1♂)	31.0	359	12	4
Hylocichla ustulata (1♀)	29.8	461	15	4
Hylocichla minima (1♂)	33.2	396	12	4
Catharus occidentalis (1♂)	31.2	252	8	4
Catharus aurantiirostris (1♀)	33.8	405	12	4
Sialia mexicana (2♂, 2♀)	29.3	408	14	4(1)
Polioptila caerula (2♂)	5.1	75	15	5(1)
Polioptila melanura (3♂)	5.4	86	16	5(2)
Bombycilla cedrorum (3♂, 1♀)	40.1	471	12	4
Phainopepla nitens (2♂, 1♀)	25.3	368	15	4(1)
Sturnus vulgaris (2♂, 2♀)	82.2	1,133	14	4

TABLE 1 (*Continued*)

Species	*Mean body weight (g)*	*Mean kidney weight (mg)*	*Kidney-body weight ratio (mg/g)*	*Kidney shape*[1]
Passeriformes (continued)				
Vireo solitarius (1 ♀)	16.0	169	11	4
Parula pitiayumi (1 ♂)	8.0	112	14	5
Dendroica petechia (2 ♂, 1 ♀)	9.3	148	16	5
Dendroica auduboni (1 ♂)	12.2	202	16	5
Dendroica nigrescens (3 ♂, 2 ♀)	8.2	132	16	5(1)
Dendroica occidentalis (1 ♂, 1 ♀)	10.9	127	12	5
Dendroica palmarum (2 ♂)	11.3	190	17	5
Setophaga ruticilla (1 ♂)	9.5	100	10	5
Setophaga picta (1 ♂)	9.1	163	18	5
Myioborus miniatus (1 ♂)	9.5	97	10	5(1)
Passer domesticus (4 ♂, 1 ♀)	29.3	301	10	5
Taeniopygia castanotis (2 ♂)	11.9	90	8	4(2)
Dolichonyx oryzivorus (3 ♂)	35.2	396	11	4
Sturnella neglecta (2 ♂)	113.4	1,247	11	4
Agelaius phoeniceus (4 ♂)	67.5	668	10	4
Icterus cucullatus (2 ♂)	25.2	294	12	5
Icterus bullockii (2 ♂, 1 ♀)	33.1	410	12	5
Euphagus carolinus (1 ♂)	66.2	687	10	4(1)
Euphagus cyanocephalus (3 ♂)	70.9	863	12	4
Quiscalus quiscula (1 ♂, 2 ♀)	94.3	1,037	11	4
Molothrus ater (2 ♂)	49.7	398	8	4
Piranga ludoviciana (2 ♀)	33.2	514	15	4(1)
Richmondena cardinalis (1 ♂, 2 ♀)	47.0	590	13	4(2)
Pyrrhuloxia sinuata (1 ♀)	35.1	574	16	4
Guiraca caerulea (1 ♂)	28.1	273	10	4
Hesperiphona vespertina (1 ♂)	52.3	860	16	4
Carpodacus mexicanus (3 ♂, 2 ♀)	19.5	239	12	4
Pinicola enucleator (1 ♀)	53.5	833	16	4
Spinus pinus (1 ♂)	12.4	172	14	5
Spinus psaltria (1 ♂)	10.3	102	10	5(1)
Chlorura chlorura (1 ♂, 1 ♀)	29.6	436	15	4
Pipilo erythrophthalmus (1 ♂)	39.6	397	10	4
Pipilo fuscus (1 ♂, 1 ♀)	41.3	333	8	4(1)
Calamospiza melanocorys (1 ♂)	–	–	–	4
Passerculus sandwichensis (1 ♂, 2 ♀)	17.7	261	15	5(1)
Ammodramus savannarum (1 ♂)	–	–	–	5(1)
Pooecetes gramineus (2 ♂)	26.3	285	11	4
Chondestes grammacus (1 ♀)	26.2	166	6	5(1)
Aimophila carpalis (3 ♂)	14.0	171	12	5(3)
Aimophila ruficeps (1 ♀)	17.9	264	15	5(1)
Aimophila cassinii (1 ♀)	17.0	234	14	5(1)
Amphispiza bilineata (4 ♂, 2 ♀)	12.9	154	12	5(5)
Junco hyemalis (4 ♀)	21.7	216	10	4(1)
Junco caniceps (2 ♂)	22.4	241	11	4
Spizella arborea (2 ♂, 2 ♀)	17.8	219	12	4
Spizella passerina (1 ♂)	13.3	125	9	–
Spizella pallida (1 ♂)	13.0	170	13	4
Spizella breweri (1 ♂, 3 ♀)	10.6	178	17	4(1)
Zonotrichia leucophrys (1 ♂, 1 ♀)	27.2	331	12	4
Zonotrichia albicollis (2 ♂, 1 ♀)	26.5	279	10	4
Melospiza lincolnii (5 ♂)	18.1	228	13	5(2)
Melospiza melodia (2 ♂)	21.1	247	12	4
Calcarius lapponicus (2 ♂)	26.7	261	10	4
Plectrophenax nivalis (1 ♂)	31.1	337	11	4

ferences in synsacral shape and in the amount of synsacral area available for lobe development.

A union or fusion between the mesial surfaces of the kidneys (continuous cortex) was noted in a number of individuals (Figure 3d). This anatomical peculiarity (mentioned briefly by Stresemann, 1927–34; and by Benoit, 1950) appears to be a relatively common feature of avian kidneys. In all, representatives of 41 species showed kidney fusion (Table 1).

Except for the Eared Grebe (*Podiceps caspicus*), Pied-billed Grebe (*Podilymbus podiceps*), Red-tailed Tropic-bird (*Phaëthon rubricauda*), and Great Blue Heron (*Ardea herodias*), all the fusion observed was in passeriform birds. Although much larger samples would be required to assess the extent of this phenomenon, fusion is apparently a characteristic (or at least very common) trait in some birds. For example, note the Verdin (*Auriparus flaviceps*), wrens, Rufous-winged Sparrow (*Aimophila carpalis*), and Desert Sparrow (*Amphispiza bilineata*) in Table 1.

The site of fusion was found to be almost exclusively the caudal lobes. The only exception was one Pied-billed Grebe wherein fusion also included the middle lobes.

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Summary

Morphologic data pertaining to the kidneys of a wide variety of birds are presented. An inverse relationship was found between kidney and body weight. Kidneys from relatively small birds generally exceeded one per cent of body weight; the reverse was true in larger birds.

Kidney to body weight ratios varied over a range from 6 to 21 mg/g, and were generally consistent intraspecifically. No difference was detected in relative kidney size between the two sexes.

The kidneys studied were divided into five categories descriptive of variations in external configuration. Obscurity of the middle lobe (especially marked in Passeriformes) appears to result from its close association with the other lobes, particularly the caudal.

Direct mesial continuity (fusion) of the kidneys was relatively common, and typically involved the caudal lobes.

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