

REMARKS ON A WORLD-WIDE INVENTORY OF AVIAN ANATOMICAL SPECIMENS

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ABSTRACT.—The Committee on Collections of the American Ornithologists' Union is preparing for publication three composite inventories of anatomical collections of the world. One will cover the 45 largest skeleton collections; another, the collections of spirit specimens; and the third, smaller skeleton collections. The inventories will be useful for managing collections and for planning research. Analysis of these inventories shows that some families and orders are well represented in collections but have not been extensively studied; by contrast, many are poorly represented at the generic and specific levels. About a third of the species of birds of the world are not available as skeletons, and the same is true for spirit specimens. Continued collecting is needed to replace specimens that are dissected, to enlarge the series available for most species, to fill gaps that now prevent comparative studies in some families, to build useful research collections in various parts of the world, and to salvage important species in advance of habitat destruction. *Received 12 July 1982, accepted 2 August 1982.*

THE Committee on Collections of the American Ornithologists' Union has been active since its inception in publishing information about avian museum collections. Two such reports provided general narrative descriptions of 283 North American collections (Banks et al. 1973, Clench et al. 1976), and a similar project, expanded to world-wide coverage, is now under way. In addition, the committee is now compiling a composite inventory of avian anatomical specimens in collections throughout the world. The purposes of this article are to describe the anatomical inventory, provide a brief history of its development and projected plans for the future, summarize some of its data, and discuss the inventory in relation to collection management and research.

HISTORY

The idea of a composite inventory of avian anatomical specimens in North American collections began in 1974 with Mary H. Clench, who then chaired the AOU Committee on Collections. Before the project could be initiated, her energies were diverted to a study of major museum collections and their users for the Panel

on Systematics Collections of an NSF-AOU Workshop on a National Plan for Ornithology (King and Bock 1978). Separately, but as part of that panel's report, Zusi distributed a questionnaire to 66 North American museums concerning the nature, uses, and curatorial problems of skeleton and spirit collections. From this questionnaire we learned that virtually all of the 44 museum curators who responded were willing to provide lists of their anatomical collections. One of the recommendations of the report was that the AOU should publish a composite inventory of anatomical collections (Zusi 1978), and this project then became Zusi's main responsibility as a member of the AOU Committee on Collections.

Beginning in 1979, Zusi requested inventories from 66 curators of North American collections. Scott Wood became a member of the committee in 1980 and joined him in the inventory project. As the new head of the committee, Marion Jenkinson continued support for the project and played an increasingly active role in its consummation. Wood urged that the inventories be computerized, and he designed the necessary algorithms. Gary D. Schnell at the University of Oklahoma generously offered access to computer facilities and contributed personnel for both programming and data entry. He will continue to maintain

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specimens, 1982; and Supplementary inventory of avian skeletal specimens, 1982. The format for the first two is described below; that for the third will differ and be as condensed as possible.

Figure 1 shows a sample page from the inventory of larger skeleton collections. Each of the 46 numbered columns contains a museum inventory (in decreasing order of size from left to right). In the published version, column 46 will hold the totals from all museums in the inventory of smaller skeleton collections. Because each column except the first is only one character wide, all entries greater than 9 are represented by the following codes: A = 10–15; B = 16–25; C = 26–50; D = 51–100; E = 101–500; F = (>500). The first column, however, will give the actual total number of specimens for each species.

The systematic species list follows the nomenclature and arrangement of Morony et al. (1975), with a few minor changes and the following major exceptions: volume 1 (Mayr and Cottrell 1979) and volume 8 (Traylor 1979) of Peters' "Check-list of birds of the world" are followed, and new names have been added from Bock and Farrand (1980) and from card files in the National Museum of Natural History.

The numbers presented in the inventories represent, to our knowledge, complete specimens. Because of lack of time or assistance, however, some curators did not separate partial from complete skeletons, carcasses from complete spirit specimens, or chicks from adults in their specimen counts. Persons using these inventories to locate specimens for study should verify with the curator the precise nature of the specimens in question.

We shall add new data and new inventories to the computer files as they are received. When the changes in a composite inventory become significant, a new edition will be published. Instructions for ordering the composite inventories will appear in *The Auk*, *The Condor*, *The Wilson Bulletin*, *The Ornithological News Letter*, and in major ornithological journals throughout the world.

SUMMARY OF DATA

In comparison with skin collections, anatomical holdings are very small. The largest skin collections are approximately 35 times the size

of the largest skeleton collections, and in many museums the number is much higher. Table 1 summarizes the specimen holdings of the 36 largest skeleton collections for which we received inventories as of 1 June 1982, and Table 2 provides specimen totals for all of the spirit collections inventoried as of that date. We have also received 28 skeleton inventories from collections that either contain fewer than 1,000 skeletons each or, if larger, were received too late to be included in Table 1. These museums are (in alphabetical order): Acad. Nat. Sci. Philadelphia, Arch.-zool. Arbeitsgruppe (Schleswig), Australian Mus., Barbados Mus., Bolton Mus. (England), British Columbia Provincial Mus., Bulgarian Acad. Sci., Charleston Mus., Czechoslovakian Acad. Sci., Cleveland Mus. Nat. Hist., Forschungsinstitut Senckenberg (Frankfurt), Glasgow Mus., Koninklijk Mus. Midden-Afrika (Tervuren), Merseyside County Mus. (Liverpool), Midwestern State University (El Paso), Mus. Dierkunde (Gent), Mus. Nac. Hist. Nat. (Santo Domingo), Nat. Mus. Bulawayo, Polish Acad. Sci., St. Bonaventure Univ., Univ. Connecticut, Univ. Helsinki Zool. Mus., Univ. Montana, Univ. New Mexico, Univ. Texas El Paso, Uppsala Univ. Zool. Mus., Virginia Commonwealth Univ., Washington State Univ., Wayne State Univ. (Detroit).

In Table 3 the anatomical data are summarized by family and subfamily. The number of these families or subfamilies in which all genera or species are represented by skeletons or spirit specimens is high (71% for both skeletons and spirit specimens), but most of these are very small families or subfamilies containing fewer than 4 genera or 5 species. Families with more than 10 genera, all of which are represented by skeletons, are the Procellariidae, Threskiornithidae, Anatidae, Scolopacidae, Alcidae, Hirundinidae, and Mimidae; for spirit specimens they are the Procellariidae, Scolopacidae, Hirundinidae, Laniidae, Mimidae, Estrildidae, Ploceidae, and Corvidae.

Based on the inventories we have received, skeletons are apparently lacking only for the Oxyruncidae, Neodrepanidinae, and Hypocoliinae, and spirit specimens for Atrichornithidae. Only 1–5 skeletons have been reported for each of the following families or subfamilies: Pedionomidae, Dromadidae, Micropsittinae, Phodilinae, Brachypteraciidae, Philepittinae, Atrichornithidae, Pseudochelidoninae, Salpor-

TABLE 1. Total numbers of specimens and species in the 36 largest skeleton collections for which inventories were received by 1 June 1982.

Museum	Specimens	Species
Royal Ontario Mus.	25,234	1,816
Univ. Kansas	22,533	1,633
Natl. Mus. Nat. Hist., Washington, D.C.	20,459	3,409
Univ. Michigan	16,646	3,145
Mus. Vert. Zool., Berkeley	10,704	1,752
Louisiana State Univ.	8,194	2,182
American Mus. Nat. Hist.	7,893	2,261
Peabody Mus., Yale	7,124	1,587
Florida State Mus.	7,077	598
Carnegie Mus. Nat. Hist.	6,133	864
British Mus. (Nat. Hist.), Tring	5,580	2,000
Washington State Mus.	4,489	535
Field Mus. Nat. Hist.	4,332	1,412
Univ. Oklahoma	3,987	502
Univ. South Florida	3,922	1,169
Los Angeles County Mus.	3,706	892
Delaware Mus. Nat. Hist.	3,423	717
Mus. Comp. Zool., Harvard	3,284	1,221
Rijksmus. Nat. Hist., Leiden ^a	3,228	1,510
Inst. Haustierkunde, Kiel	3,186	230
Univ. Miami, Florida	2,687	689
Cornell Univ.	2,663	459
Natl. Mus. Canada	2,619	283
Mus. Para. Emilio Goeldi, Belem	1,798	285
San Diego Mus. Nat. Hist.	1,796	638
Paleo. Inst., USSR Acad. Sci., Moscow	1,762	802
Mus. Nat. Hist., Göteborg	1,634	365
C.S.I.R.O., Canberra	1,607	520
Univ. Arizona	1,558	460
California Acad. Sci.	1,466	500
Natl. Mus. New Zealand, Wellington	1,382	231
Univ. California, Long Beach	1,336	401
Mus. Alexander Koenig, Bonn	1,255	467
Univ. California, Los Angeles	1,134	394
Moore Lab. Zool., Occidental College	1,069	456
Alberta Prov. Mus.	1,029	173

^a From van Oort (1907).

nithinae, Rhabdornithidae, Catamblyrhynchinae, and Cnemophilinae. Apparently only 1-5 spirit specimens exist for the Casuariidae, Anseranatinae, Pedionomidae, Aramidae, Ibisornithidae, Strigopinae, Phodilinae, Leptosomatidae, Oxyruncidae, Neodrepanidinae, Hypocoliinae, Tichodromadinae, Salpornithinae, and Cnemophilinae. Table 3 reveals that some families and subfamilies for which anatomical specimens are available in large numbers are, nonetheless, poorly represented at the generic and specific levels.

Table 4 lists the number of species represented by a given number of specimens. Roughly a third of the species of birds of the world are not available as skeletons nor a similar fraction as spirit specimens. Many more

species that are available in collections are represented by 10 or fewer specimens than by more than 10 for both skeletons and spirit specimens.

The species best represented by skeletal specimens is the House Sparrow (*Passer domesticus*), with approximately 9,000. A few other species number between 1,000 and 3,000: Savannah Sparrow (*Passerculus sandwichensis*), Horned Lark (*Eremophila alpestris*), European Starling (*Sturnus vulgaris*), Dark-eyed Junco (*Junco hyemalis*), Ovenbird (*Seiurus aurocapillus*), Red-eyed Vireo (*Vireo olivaceus*), Yellow-rumped Warbler (*Dendroica coronata*), Brown-headed Cowbird (*Molothrus ater*), and Northern Fulmar (*Fulmarus glacialis*). No species is represented by as many as 1,000 spirit speci-

TABLE 2. Total numbers of specimens and species in collections of spirit specimens for which inventories were received by 1 June 1982.

Museum	Specimens	Species
Natl. Mus. Nat. Hist., Washington, D.C.	14,362	2,438
Koninklijk Mus. Midden-Afrika, Tervuren	14,352	735
British Mus. (Nat. Hist.), Tring	12,395	2,909
Peabody Mus., Yale Univ.	9,192	1,997
American Mus. Nat. Hist.	8,949	2,372
Royal Ontario Mus.	3,672	957
Delaware Mus. Nat. Hist.	3,602	665
Univ. Kansas	3,453	698
Field Mus. Nat. Hist.	3,121	990
Louisiana State Univ.	2,945	1,114
Carnegie Mus. Nat. Hist.	2,666	840
Mus. Vert. Zool., Berkeley	2,497	658
Los Angeles County Mus.	2,130	480
Mus. Alexander Koenig, Bonn	1,294	474
Univ. Michigan	1,266	503
Washington State Univ.	993	504
Natl. Mus. Canada	955	161
C.S.I.R.O., Canberra	717	253
Australian Mus., Sydney	634	289
Univ. Connecticut	549	150
South Australian Mus., Adelaide	353	128
Natl. Mus. New Zealand, Wellington	288	85
Texas A&M Univ.	229	113
Moore Lab. Zool., Occidental College	206	143
California Acad. Sci.	189	83
Univ. Uppsala	92	76
Mus. Nacional, Santo Domingo	82	48

mens. The five species most numerous in collections are: Red-headed Quelea (*Quelea erythrops*), Village Weaver (*Ploceus cucullatus*), Common Bulbul (*Pycnonotus barbatus*), *Vireo olivaceus*, and *Passer domesticus*. Some species have been collected in large numbers for studies of skeletal variation (e.g. *Passer domesticus*, Johnston 1969, Johnston and Selander 1971; *Passerculus sandwichensis*, Rising, in progress; *Eremophila alpestris*, Niles 1973). Others are received in large numbers by museums because of TV-tower kills (e.g. *Seiurus aurocapillus*, *Vireo olivaceus*, *Dendroica coronata*).

MANAGEMENT OF ANATOMICAL COLLECTIONS

The inventories prepared by curators for this project will undoubtedly prove useful to them in reviewing the adequacy of their collections with respect to their particular goals and in judging the strengths and weaknesses of their collections in relation to regional and worldwide resources. Focusing attention on anatomical collections will, we hope, lead to improvements in their care and management. We also

hope that the deficiencies exposed by the composite inventory will provide a stimulus for the collecting of new material.

The publication of synoptic inventories will certainly stimulate exchanges among museums and provide more even coverage of material in various parts of the world. Arranging exchanges can be very time-consuming, but the inventories can be used to maximize the benefits of this work. It is far more useful for a curator of a North American museum, for example, to add a representative of a genus not found in any other North American collection than simply to add one new to his or her museum.

The inventories will allow curators of large collections that traditionally receive the major burden of loan requests to suggest additional sources to borrowers and allow a more equitable distribution of loans. This will clearly benefit the borrower and the large museum. Also, the small collection will thereby become more useful to the research community, which may be an important criterion for its continuing support.

TABLE 3. Summary data for anatomical inventories by family or subfamily. An asterisk (*) = 100%.

Inclusive taxon	Skeletons				Spirit specimens			
	Total genera	Total species	Total specimens	Percentage of taxa represented		Total specimens	Percentage of taxa represented	
				Genera	Species		Genera	Species
Struthioniformes								
Struthionidae	1	1	118	*	*	11	*	*
Rheidae	2	2	75	*	*	48	*	*
Casuariidae	1	3	37	*	*	2	33	0
Dromaiidae	1	2	66	*	50	12	50	50
Apterygidae	1	3	92	*	*	31	*	33
Tinamiformes								
Tinamidae	9	46	329	*	60	39	77	50
Procellariiformes								
Diomedidae	2	13	335	*	*	70	*	76
Procellariidae	12	60	3,156	*	91	78	*	81
Hydrobatidae	8	21	581	*	90	80	*	85
Pelecanoididae	1	4	105	*	*	75	*	75
Sphenisciformes								
Spheniscidae	6	16	503	*	93	93	*	*
Gaviiformes								
Gaviidae	1	4	650	*	*	35	*	75
Podicipediformes								
Podicipedidae	6	20	1,278	*	*	197	*	95
Pelecaniformes								
Phaethontidae	1	3	84	*	*	62	*	*
Fregatidae	1	5	161	*	80	44	*	80
Phalacrocoracidae								
Phalacrocoracinae	1	29	1,127	*	93	79	*	75
Anhinginae	1	2	145	*	*	36	*	*
Sulidae	1	9	382	*	*	82	*	77
Pelecanidae	1	6	502	*	*	33	*	66

TABLE 3. Continued.

Inclusive taxon	Skeletons					Spirit specimens							
	Total genera	Total species	Total specimens	Percentage of taxa represented		Total specimens	Percentage of taxa represented		Total specimens				
				Genera	Species		Genera	Species					
Ciconiiformes													
Ardeidae	6	36	1,957	*	83	58	330	83	69	41			
Nycticoracinae	3	8	397	*	75	50	76	*	50	50			
Tigrisomatinae	3	5	59	66	60	40	6	33	40	0			
Botaurinae	3	13	321	*	*	53	73	66	76	46			
Scopidae	1	1	35	*	*	*	15	*	*	*			
Balaenicipitidae	6	17	425	*	*	94	46	*	76	11			
Threskiornithidae	1	1	15	*	*	*	11	*	*	*			
Balaenicipitidae	12	23	425	*	91	43	75	50	47	26			
Threskiornithinae	1	5	148	*	*	60	17	*	40	40			
Plataleinae													
Phoenicopteriformes	3	5	264	*	*	80	63	*	*	60			
Phoenicopteridae													
Falconiformes													
Cathartidae	5	7	356	*	*	85	28	*	71	42			
Accipitridae													
Pandioninae	1	1	152	*	*	*	16	*	*	*			
Accipitrinae	59	217	4,212	89	69	40	585	69	43	11			
Sagittariidae	1	1	67	*	*	*	13	*	*	*			
Falconidae													
Polyborinae	6	13	196	*	84	69	46	*	76	23			
Falconinae	4	46	1,162	*	80	41	295	75	63	21			
Anseriformes													
Anatidae													
Anseranatinae	1	1	22	*	*	*	3	*	*	0			
Dendrocygninae	2	9	217	*	*	77	61	*	*	55			
Anserinae	6	24	2,069	*	*	*	160	*	91	45			
Tadorninae	6	19	546	*	94	94	105	*	89	52			
Anatinae	17	70	4,168	*	94	84	634	*	90	54			

TABLE 3. Continued.

Inclusive taxon	Skeletons					Spirit specimens							
	Total genera	Total species	Total specimens	Percentage of taxa represented		Total specimens	Genera	Percentage of taxa represented		Total specimens	Genera	Species	
				At least one specimen	More than five specimens			At least one specimen	More than five specimens			At least one specimen	More than five specimens
Merginae	7	20	2,816	*	95	80	268	85	90	55			
Oxyurinae	3	8	259	*	75	50	55	*	75	25			
Anhimidae	2	3	90	*	*	*	6	*	66	0			
Galliformes													
Megapodiidae	7	12	65	71	58	25	54	57	50	16			
Cracidae	8	44	357	*	75	38	51	87	52	4			
Phasianidae													
Meleagridinae	2	2	258	*	*	*	25	*	*	*			
Tetraoninae	6	16	974	*	87	75	166	*	81	68			
Odontophorinae	10	33	932	*	63	36	145	90	57	21			
Phasianinae	40	154	1,964	90	69	38	631	77	53	15			
Numidinae	5	7	166	*	*	71	75	*	*	57			
Opisthocomidae	1	1	37	*	*	*	60	*	*	*			
Gruiformes													
Mesitornithidae	2	3	11	*	*	33	10	*	*	0			
Turnicidae	2	14	79	*	64	28	17	*	71	42			
Pedionomidae	1	1	4	*	*	0	2	*	*	0			
Gruidae													
Gruinae	3	13	451	*	92	84	39	*	53	15			
Balearcinae	1	2	95	*	*	*	22	*	*	*			
Aramidae	1	1	44	*	*	*	5	*	*	0			
Psophiidae	1	3	57	*	*	*	8	*	*	0			
Rallidae													
Rallinae	52	133	1,654	65	59	27	770	69	55	24			
Fulicinae	1	9	685	*	*	44	121	*	55	33			
Helmithidae	3	3	21	66	66	33	31	*	*	66			
Rhynchoetidae	1	1	16	*	*	*	8	*	*	*			
Eurypygidae	1	1	46	*	*	*	15	*	*	*			
Cariamidae	2	2	40	*	*	*	6	*	*	0			
Otididae	11	24	111	90	66	29	34	72	37	12			

TABLE 3. Continued.

Inclusive taxon	Skeletons				Spirit specimens			
	Total genera	Total species	Percentage of taxa represented		Total specimens	Genera	Species	
			At least one spec-imen	More than five specimens			At least one spec-imen	More than five specimens
Charadriiformes								
Jacaniidae	6	8	201	*	75	83	75	75
Rostratulidae	2	2	34	*	50	*	*	50
Dromadidae	1	1	5	*	0	*	*	*
Haematopodidae	1	7	510	*	85	*	71	57
Ibidorhynchidae	1	1	6	*	*	*	*	0
Recurvirostridae	3	10	388	*	60	*	70	60
Burhinidae	2	9	*	*	88	*	88	33
Glareolidae								
Cursoriinae	3	8	48	*	50	*	87	50
Clareoliniae	2	8	64	*	37	*	75	37
Charadriidae	8	64	1,905	*	87	*	84	43
Scolopacidae								
Tringinae	9	31	1,894	*	90	*	87	70
Arenariinae	1	2	253	*	*	*	*	*
Phalaropodinae	1	3	582	*	*	*	*	*
Scolopacinae	1	6	298	*	50	*	50	33
Gallinagoninae	4	20	749	*	75	*	55	35
Calidridinae	7	24	3,368	*	*	*	*	83
Thinocoridae	2	4	82	*	50	*	*	50
Chionidae	1	2	46	*	50	*	*	*
Stercorariidae	1	5	294	*	*	*	*	*
Laridae								
Larinae	1	46	3,884	*	93	*	73	45
Sterninae	3	43	1,943	*	86	*	72	55
Rynchopidae	1	3	202	*	66	*	*	33
Alcidae	13	23	3,115	*	*	92	86	73
Columbiformes								
Pteroclididae	2	16	107	*	75	*	62	18
Raphidae	2	3	2	50	33	0	0	0
Columbidae	42	303	3,919	90	67	83	57	24

TABLE 3. Continued.

Inclusive taxon	Skeletons					Spirit specimens					
	Total genera	Total species	Total specimens	Percentage of taxa represented		Total specimens	Genera	Percentage of taxa represented		Total specimens	
				At least one spec-imen	More than five specimens			At least one spec-imen	More than five specimens		
Psittaciformes											
Loriidae	11	54	435	90	72	27	202	*	59	18	
Cacatuidae											
Cacatuinae	5	17	408	*	94	76	85	*	82	35	
Nymphicinae	1	1	108	*	*	*	80	*	*	*	
Psittacidae											
Nestorinae	1	3	38	*	66	66	10	*	66	33	
Micropsittinae	1	6	5	*	50	0	25	*	66	33	
Psittacinae	61	258	3,914	88	79	48	1,144	85	67	24	
Strigopinae	1	1	19	*	*	*	2	*	*	0	
Cuculiformes											
Musophagidae	5	18	209	*	88	66	106	*	88	38	
Cuculidae											
Cuculinae	16	47	372	75	65	36	287	75	61	29	
Phaenicophaeinae	12	28	813	75	67	46	228	83	71	28	
Crotophaginae	2	4	359	*	*	*	138	*	*	*	
Neomorphaeinae	6	13	256	*	61	30	31	*	61	15	
Couinae	1	10	10	*	50	0	14	*	40	10	
Centropodinae	1	27	85	*	44	18	110	*	55	29	
Strigiformes											
Tytonidae	1	9	439	*	55	33	99	*	44	11	
Tytoninae	1	2	2	*	50	0	4	*	50	0	
Phodilinae											
Strigidae	21	111	2,242	76	59	28	561	57	45	20	
Buboninae	6	25	1,111	83	80	44	148	66	56	28	
Caprimulgiformes											
Steatornithidae	1	1	15	*	*	*	39	*	*	*	
Podargidae	2	13	54	*	30	7	38	*	61	15	
Nyctibiidae	1	6	27	*	50	16	14	*	50	16	

TABLE 3. Continued.

Inclusive taxon	Skeletons					Spirit specimens				
	Total genera	Total species	Total specimens	Percentage of taxa represented		Total specimens	Genera	At least one specimen	Percentage of taxa represented	
				Genera	Species				Genera	Species
Aegothelidae	1	8	26	*	37	12	19	*	50	25
Caprimulgidae	4	7	429	*	85	42	156	*	*	57
Chordelinae	15	70	592	66	54	20	422	73	55	21
Caprimulginae										
Apodiformes										
Apodidae	4	12	93	*	58	33	76	*	41	33
Cypseloidinae	14	71	731	78	59	30	780	92	59	29
Apodinae	1	4	25	*	75	50	23	*	75	25
Hemiprocniidae	116	343	2,748	86	65	30	2,481	79	63	32
Trochilidae										
Coliiformes										
Coliidae	1	6	124	*	83	66	171	*	*	66
Trogoniformes										
Trogonidae	8	37	500	*	86	48	208	*	78	37
Coraciiformes										
Alcedinidae	2	9	569	*	*	88	256	*	88	77
Cerylinae	4	23	211	*	69	30	469	*	78	52
Alcedininae	8	60	372	87	55	28	558	87	56	30
Daceloninae	1	5	89	*	*	*	64	*	*	80
Todidae	6	9	218	*	*	66	107	*	88	55
Momotidae	3	24	273	*	87	58	654	66	83	58
Meropidae	2	11	162	*	90	45	149	*	81	63
Coraciidae	3	5	5	66	60	0	8	*	80	0
Brachypteraciidae	1	1	6	*	*	*	5	*	*	0
Leptosomatidae	1	1	139	*	*	*	53	*	*	*
Upupidae	1	1	8	*	62	37	46	*	62	37
Phoeniculidae	1	1	53	*	82	53	189	*	60	20
Bucerotidae	12	45	417	91	82	53	189	83	60	20
Piciformes										
Galbulidae	5	17	96	*	64	23	59	*	64	23

TABLE 3. Continued.

Inclusive taxon	Skeletons						Spirit specimens				
	Total genera	Total species	Total specimens	Percentage of taxa represented			Total specimens	Percentage of taxa represented			
				Genera	At least one specimen	More than five specimens		Genera	At least one specimen	More than five specimens	
Bucconidae	7	32	171	*	81	31	*	109	*	78	18
Capitonidae	13	81	481		71	37		536		92	30
Indicatoridae	4	16	46		50	18		124		75	31
Ramphastidae	6	33	641		84	63		119		*	24
Picidae											
Jyninae	1	2	31	*	*	50	*	46	*	*	50
Picumninae	3	31	77	*	48	19	*	120	*	51	32
Picinae	23	171	4,015	95	81	44		1,426	95	76	32
Passeriformes											
Eurylaimidae											
Eurylaiminae	7	11	59	*	90	36		85	71	72	36
Calyptomeninae	1	3	34	*	*	33		18	*	66	33
Dendrocolaptidae	13	52	815	84	73	55		588	84	75	40
Furnariidae											
Furnariinae	5	37	255	*	70	27		165	80	64	24
Synallaxinae	17	116	464	82	60	25		370	94	58	17
Philydorinae	12	66	539	83	75	40		388	91	74	36
Formicariidae	52	239	1,736	90	61	29		1,151	82	56	23
Rhinocryptidae	12	30	47	58	36	10		55	75	63	10
Tyrannidae											
Elaeniinae	37	180	1,455	97	70	31		1,024	97	63	28
Fluvicolinae	34	122	2,394	97	81	52		1,168	97	84	41
Tyranninae	17	72	2,038	94	86	47		830	*	70	37
Tityrinae	2	20	196	*	85	40		87	*	60	30
Pipridae	17	51	931	88	74	43		814	94	74	49
Cotingidae	25	61	251	64	54	21		123	72	52	13
Oxyruncidae	1	1	0	0	0	0		2	*	*	0
Phytotomidae	1	3	40	*	*	66		25	*	*	66
Pittidae	1	26	91	*	50	19		122	*	53	30
Philepittidae											
Philepittinae	1	2	3	*	50	0		11	*	*	50
Neodrepanidinae	1	2	0	0	0	0		3	*	*	0

TABLE 3. Continued.

Inclusive taxon	Skeletons					Spirit specimens				
	Total genera	Total species	Total specimens	Percentage of taxa represented		Total specimens	Genera	Percentage of taxa represented		Total specimens
				At least one spec-imen	More than five specimens			At least one spec-imen	More than five specimens	
Acanthisittidae	2	4	9	*	50	22	*	75	50	
Menuridae	1	2	9	*	50	7	*	50	50	
Atrichornithidae	1	2	1	*	50	0	0	0	0	
Alaudidae	15	78	2,511	73	47	491	86	50	20	
Hirundinidae										
Pseudochelidoninae	1	2	1	*	50	18	*	*	*	
Hirundininae	19	78	1,931	*	74	1,593	*	79	50	
Motacillidae	5	54	705	*	61	737	*	68	33	
Campephagidae	9	70	300	77	68	370	88	64	20	
Pycnonotidae	15	123	1,011	86	66	2,429	93	75	47	
Irenidae	3	14	177	*	71	109	*	78	42	
Laniidae										
Prionopinae	2	9	71	*	77	101	*	66	55	
Malaconotinae	7	39	232	85	79	324	*	69	35	
Laniinae	2	25	532	*	80	380	*	84	48	
Pityriasiinae	1	1	8	*	*	10	*	*	*	
Vangidae	9	13	27	66	53	51	*	84	23	
Bombycillidae										
Ptilogenatinae	3	4	172	*	*	52	*	*	25	
Bombycillinae	1	3	700	*	*	145	*	66	66	
Hypocoliinae	1	1	0	0	0	4	*	*	0	
Dulidae	1	1	75	*	*	38	*	*	*	
Cinclidae	1	5	70	*	60	63	*	80	80	
Troglodytidae	14	60	1,914	78	73	859	78	85	56	
Mimidae	13	31	1,984	*	96	610	*	87	51	
Prunellidae	1	12	73	*	75	30	*	50	8	
Muscicapidae										
Turdinae	48	309	6,553	79	66	3,507	91	68	38	
Orthonychinae	9	19	26	66	47	50	77	73	21	
Timalinae	49	255	1,103	73	52	1,607	75	59	26	
Panurinae	3	19	62	*	42	67	*	52	26	
Picathartinae	1	2	14	*	*	26	*	*	*	
Polioptilinae	3	12	326	*	75	209	*	75	58	

TABLE 3. Continued.

Inclusive taxon	Skeletons				Spirit specimens				
	Total genera	Total species	Total specimens	Percentage of taxa represented		Total specimens	Genera	Percentage of taxa represented	
				At least one specimen	More than five specimens			At least one specimen	More than five specimens
Sylviinae	63	349	2,371	66	52	2,895	73	52	25
Malurinae	26	106	498	80	66	952	84	79	40
Muscicapinae	24	153	577	91	58	860	95	65	26
Platyteirinae	4	26	92	*	57	189	*	53	34
Monarchinae	17	91	280	76	50	556	88	63	34
Rhipidurinae	2	40	218	50	57	371	*	65	32
Pachycephalinae	10	46	287	90	69	430	70	65	30
Aegithalidae	3	7	217	*	71	126	66	57	42
Remizidae	4	10	144	75	50	92	*	70	30
Paridae	3	47	1,826	*	74	656	*	61	44
Sittidae									
Sittinae	1	22	659	*	50	214	*	59	36
Daphoenosittinae	2	3	12	50	33	25	*	66	33
Tichodromadinae	1	1	8	*	*	3	*	*	0
Certhiidae									
Certhiinae	1	5	317	*	80	108	*	60	20
Salpornithinae	1	1	4	*	*	5	*	*	0
Rhabdomithidae	1	2	2	*	50	13	*	50	50
Climacteridae	1	6	37	*	83	66	*	*	66
Dicaeidae	7	58	285	85	58	473	*	75	44
Nectariniidae	5	117	674	*	58	26	*	76	47
Zosteropidae	11	83	271	54	39	614	63	49	25
Meliphagidae	39	172	1,059	82	57	1,333	92	69	36
Emberizidae									
Emberizinae	65	279	17,022	89	79	5,007	92	75	49
Catamblyrhynchinae	1	1	2	*	*	9	*	*	*
Cardinalinae	9	39	2,708	*	84	724	77	82	56
Thraupinae	58	240	3,215	82	73	2,218	94	73	39
Tersininae	1	1	33	*	*	16	*	*	*
Parulidae	28	126	13,403	92	78	5,575	96	80	57
Drepanididae									
Psittirostrinae	5	17	153	80	70	138	80	70	29
Drepanidinae	5	6	86	60	50	67	60	50	33

TABLE 3. Continued.

Inclusive taxon	Skeletons					Spirit specimens					
	Total genera	Total species	Total specimens	Percentage of taxa represented		Total specimens	Percentage of taxa represented		Genera	At least one spec-imen	More than five specimens
				Genera	Species		Genera	Species			
Vireonidae	1	2	77	*	50	53	*	50	*	50	50
Cyclarhinae	1	3	26	*	66	7	*	*	*	0	0
Vireolaniinae	2	38	2,758	*	84	1,104	*	84	*	55	55
Icteridae	22	94	7,543	86	78	1,330	81	76	81	48	48
Dolichonychiinae	1	1	298	*	*	45	*	*	*	*	*
Fringillidae	1	3	206	*	*	111	*	*	*	66	66
Fringillinae	19	120	5,017	68	65	1,415	78	61	78	35	35
Carduelinae	28	127	2,486	92	81	3,231	*	73	*	55	55
Estrildidae	2	2	31	*	*	63	*	*	*	*	*
Ploceidae	8	37	10,008	*	72	45	*	75	*	40	40
Bubalornithinae	7	95	1,068	*	63	36	*	69	*	41	41
Passerinae	1	10	184	*	90	60	*	80	*	60	60
Sturnidae	25	109	3,564	88	66	890	80	65	80	24	24
Buphaginae	1	2	10	*	*	20	*	*	*	*	*
Oriolidae	2	25	135	*	64	24	*	64	*	36	36
Dicruridae	2	20	212	*	70	45	*	75	*	45	45
Callaeidae	3	3	28	*	*	21	*	*	*	66	66
Grallinidae	1	2	46	*	*	38	*	*	*	50	50
Corcoracinae	2	2	49	*	*	41	*	*	*	*	*
Artamidae	1	10	125	*	80	80	*	90	*	60	60
Cracticidae	3	10	145	*	90	70	*	70	*	40	40
Ptilonorhynchidae	8	18	83	62	61	62	62	62	62	22	22
Paradisaeidae	3	3	2	66	66	0	66	66	66	0	0
Cnemophilinae	17	39	273	76	66	33	88	76	88	28	28
Paradisaeinae	26	106	4,738	96	86	58	*	74	*	31	31
Corvidae	2,005	9,005	203,948								
Totals						91,175					

TABLE 4. Numbers of species represented by various amounts of anatomical material.

Numbers of specimens	Preparation	
	Skeletons	Spirit specimens
0	2,706	2,957
1	919	1,027
2-5	1,757	1,949
6-10	1,026	1,086
11-25	1,216	1,128
26-50	614	501
51-100	364	237
101-200	214	89
>200	189	31

Finally, we hope that presentation of these composite inventories, incomplete as they are, will stimulate those in charge of unreported collections to submit their inventories to one of us for inclusion in a future printing.

RESEARCH

Undoubtedly, the inventories will foster anatomical research by facilitating the finding of specimens and the design of feasible research projects and by encouraging the collecting of new material. They clearly demonstrate that, while a few species are represented by large numbers, most are represented by few specimens or are lacking. This prompts us to ask whether or not we need large series of anatomical specimens (>100 per species), and whether or not existing collections meet the research needs of the present and immediate future.

The answer to the first question is "yes" for the following reasons.

1. Analyses of infraspecific variation in the avian skeleton are rare for lack of large samples of most species. Series of the same age, sex, season, physiological state, or geographical origin may be required. Such series may be impossible to assemble, even from large numbers of skeletons or spirit specimens. It is not reasonable to expect museums always to have the necessary specimens on hand, but they should have enough to indicate the potential of a proposed project.

2. Skeletal specimens are often poorly cleaned, incomplete, or damaged; simple totals do not reflect the number of *useful* specimens. Furthermore, skeletons are either articulated or disarticulated. Paleontologists, archaeologists,

and those analyzing hawk and owl pellets need disarticulated, well-cleaned specimens; systematists and functional anatomists often need articulated skeletons as well. Spirit specimens are sometimes poorly fixed or stored, and many were in substandard condition before they were fixed and are thus too hard, soft, or deteriorated for proper dissection. Difficult dissections may have to be done repeatedly to establish an anatomical relationship and to reveal a range of variation.

3. Skeletal specimens are relatively durable, but delicate ones may be broken with use, and small bones can be lost in packing and unpacking. Some spirit specimens are kept more or less intact as distributional records or documentation for published statements, but in general they achieve usefulness only in proportion to the degree to which they are dissected. Study of one anatomical system may ruin that specimen for other studies. Apart from such legitimate destruction, Burton (1980) has emphasized the hazard of loss of spirit specimens from drying. Thus, we see that both skeletons and spirit specimens should continue to be collected as replacements, even if augmentation of the collection is not an objective.

4. Several circumstances suggest a need to develop strong collections throughout the world. The collections useful for broad systematic research are mostly concentrated in North America and Europe. Laws, designed to protect populations of birds from over-exploitation by commercial trade, have inadvertently imposed burdens on museums by requiring permits or excessive documentation for routine international loans. Specimens are lost or damaged by postal and other systems with increasing frequency. Some museums prohibit loan of specimens represented by only one or a few individuals in their collections, and their curators have a responsibility to maintain collections for resident scientists and visitors. All of these facts point to the need for a higher degree of regional independence in satisfying the need for specimens.

Do existing collections meet the needs for present and future research? The answer is "only in part" for the following reasons.

1. The emphasis of systematic studies based on comparative anatomy in recent decades has changed from broad surveys of a few species or genera per family to detailed comparisons of many species and genera within families or

orders. Many of the "characters" such as palatal types, leg muscle formulae, and toe arrangements used by earlier systematists are not necessarily homologous throughout birds. Furthermore, the states of such characters are less diagnostic of orders and families than was previously thought. It is important to survey as many species and genera as possible in any higher taxon to determine the variation and evolutionary trends in such features. Some orders and families that need further study are well represented in anatomical collections (e.g. Procellariiformes, Podicipediformes, Pelecaniformes, Anseriformes, Gruiformes, Charadriiformes, Tyrannidae, and many oscine families). Reference to Table 3, however, will show that other groups are not well enough represented in spirit or skeletal collections to permit extensively comparative studies in systematics, functional morphology and adaptation, ecomorphology, and other fields.

Stresemann (1959) thought that studies based on anatomical evidence have solved relatively few phylogenetic problems and that they are usually incapable of doing so. We think, however, that anatomical studies sufficiently comparative to support phylogenetic arguments are only beginning to be made and that comparative anatomy will become increasingly important in the elucidation of avian phylogeny.

2. Limitations of museum collections for studies on infraspecific variation, or even for pilot projects on such studies, have already been mentioned.

CONCLUSIONS

For broadly comparative studies or analysis of variation within species, the world's anatomical collections are often inadequate. Further selective collecting is needed on a broad scale. The forthcoming composite inventories are intended to maximize the efficiency of this endeavor. In the course of collecting new specimens it is essential to keep in mind that full data with each skeleton and spirit specimen are as important as they are with a skin. Field collectors, if not thoroughly familiar with the scientific uses of specimens, should become acquainted with the principles and practices presented in such papers as Miller (1940), Van Tyne (1952), Parkes (1963), Zusi (1969), and Burton (1980). We also remind collectors and curators that, when they obtain a rare or little

known species as a fresh specimen, it may make a more significant contribution to knowledge as a spirit specimen or skeleton (and partial skin) than as a traditional skin.

We must emphasize that loss of habitat, declining avian populations, restrictions on collecting, and political hostilities are all obstacles to the development of collections. It is vitally important that ornithologists in all parts of the world build strong anatomical collections of their local avifaunas and of other avifaunas readily accessible to them, before the habitats and birds are gone. Otherwise, many ornithological questions of great significance will remain unanswerable for lack of material.

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