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Counting Bird Strikes: Old Science or New Math?

Gary F. Searing
LGL Limited, Sidney, British Columbia, gfs@lgl.com

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Gary F. Searing
LGL Limited
9768 Second Street
Sidney, British Columbia V8L 3Y8
(250) 656-0127 gfs@lgl.com

Abstract

Airports use bird strike statistics to determine whether or not their bird control programs are necessary and effective. For example, each year Transport Canada publishes the number of bird strikes at Canadian airports and analyzes data from airports with the most strikes. While we often relate the number of strikes to the number of aircraft movements, we seldom relate the number of strikes to the hazardous species of birds. Richard Dolbeer and his co-authors (2000) ranked species according to their hazards to aviation based on the risk of damage or effect on flight they pose. I present a method for a cummulative measure of bird strikes that takes into account the level of hazard posed by each strike. The method is simple and allows comparison between years and among airports around the world. It also provides managers with a quantitative measure of the overall strike hazard and provides incentive for them to focus on hazardous species.

Introduction

Bird hazards and the success or failure of wildlife control programs at airports are usually gauged by the number of animals struck by planes each year. Sometimes those statistics are expressed as rates by dividing the number of strikes by the number of aircraft movements. But it has been well documented that the risk of damage to aircraft and/or effects on flight associated with bird strikes varies with each species (e.g., Dolbeer et al. 2000). Therefore, the number of strikes alone contains little information useful for strike management or comparisons between years or among airports. Furthermore, by focusing on the number of bird strikes, airport managers are prone to attempt to reduce the numbers of strikes regardless of individual strike hazards. As a result, much effort can be diverted from managing species that are known to be hazardous but only occasionally struck (e.g. great blue herons) to preventing strikes with more numerous small species that tend to increase strike numbers without posing a real hazard to aircraft (e.g., swallows). Nor is the solution to be found in reporting the numbers of each species or species group as recommended by Dolbeer et al. (2000). Not only would this type of reporting be difficult to compare between years and airports, managers would tend to total up the strikes and simply use the total figure in any event. Clearly a new method of assessing bird strike statistics is required, one which permits comparison between years and among airports, and that does not lead to a focus simply on reducing the number of strikes regardless of type, but on reducing the hazard associated with bird strikes.

After working with airport managers and wildlife controllers, and recognizing the failings of the simple "total number of strikes per year" statistics, I developed a method of assessing bird strike statistics at airports that retains the maximum information useful for managers and allows the data to be comparable between years and among airports around the world if desired. It provides an accurate measure of the total strike hazard present at an airport during the reporting period (e.g., calendar year) and of the mean strike hazard present. Hopefully, it will encourage managers to reduce strike hazards by focusing on reducing the number of hazardous species struck.

This paper describes a very simple method for assessing bird strike statistics and provides an example analysis using year 2000 data from Canadian Airports and 1995-2000 data from three Canadian airports. The requirements to make this method successful and universally applicable are discussed.

Description of Strike Data Assessment Methodology

Before describing the methodology proposed for bird strike assessment at airports, it is necessary to establish the premise upon which the system is based. Dolbeer et al. (2000) developed a hazard score for selected species and groups of wildlife by ranking various parameters such as percent of damaging strikes each species was involved in, percent of major damaging strikes, and percent of strikes that had an effect on flight. They found a strong relationship (R^2=0.79, 17 df, P<0.01) between their relative hazard score and mean body weight of birds. The nonlinear relationship (Figure 1) indicates that relative hazard increases slowly as the weight of the bird increases through low body weights then increases more rapidly at weights in excess of 1 kilogram. Given that a species' weight is related to the probability of damage to aircraft, it is appropriate to express a species' hazard by its weight alone.

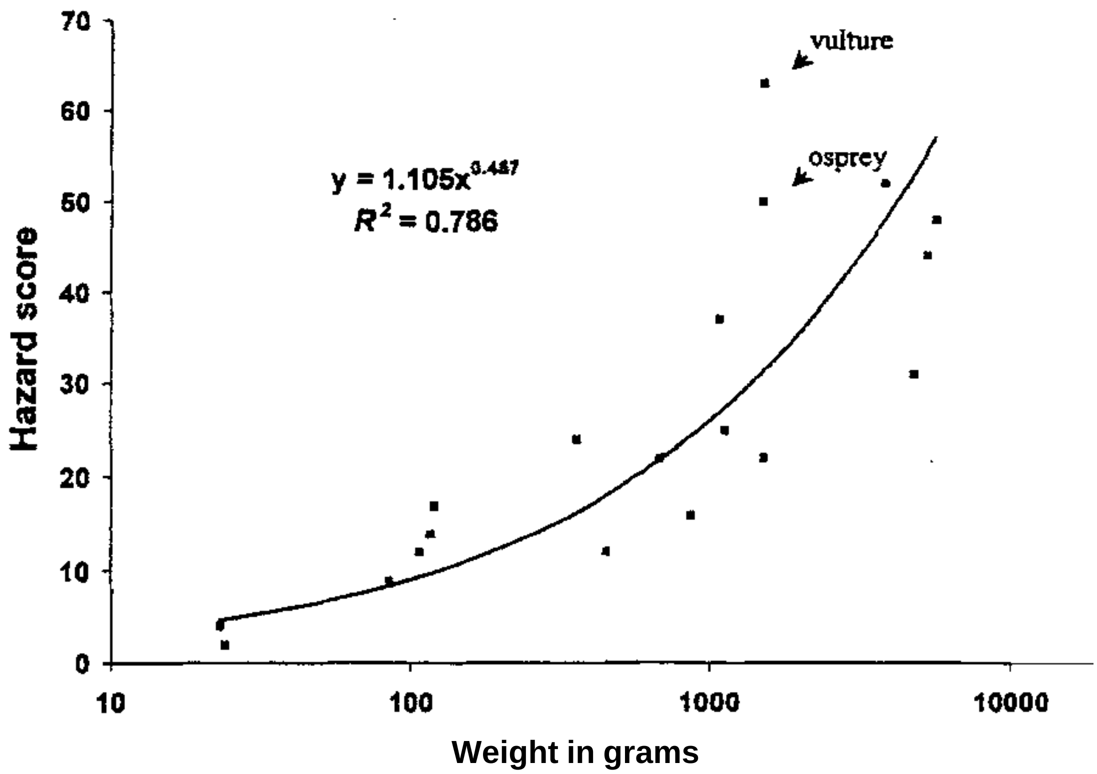

Figure 1. Relative hazard scores versus body weight of 19 bird species/groups (from Dolbeer et al. 2000).

The methodology proposed to assess bird strike data at airports is simple. Rather than merely summing the number of strikes in a calendar year, I propose that airports sum the weight in grams of birds struck in each strike event during the year. If two or more birds are struck during one strike event, then their total weight is used. I suggest that this number more accurately describes the total hazard present at the airport during the reporting period than a simple sum of strikes. The proposed method of assessing bird strike data at airports does not require any change in the current gathering of statistics on bird strikes except that the proposed methodology is more sensitive to lack of complete data than simple "number of strikes" reporting. The total weight statistic can also be averaged by the number of total aircraft movements (typically expressed as a rate: number of strikes per 10,000 aircraft movements).

In addition to reporting total weight of birds struck, a mean weight of strikes should also be calculated. This figure provides a mean hazard level of each strike. Since high total weights of birds struck could be caused by high numbers of small birds struck or lower numbers of large birds struck, the mean weight of strikes will distinguish where strikes at an airport lie along that spectrum. Not only should the objective of each airport manager be to reduce the total weight of birds struck, but also to reduce the mean weight of strikes. Finally, an extremely informative statistic to be calculated is the coefficient of variation (CV) which is simply the standard deviation expressed as a percentage of the mean. This figure provides a comparative measure of the variability in the weights of birds struck.

Data Compilation Methods

In order to examine the implications of changing from a “total birds struck” assessment method to an assessment using total and mean weight of bird strikes, I used data in the Transport Canada bird strike database for 2000. It was necessary to attribute weights to each bird struck at Canadian airports during the year. Mean weights were obtained directly from Dunning (1984), or as the average of the male and female weights when there was sexual dimorphism and separate weights were provided. Where a species involved in a strike was identified, its mean weight was determined. Where the bird struck was identified only to a broader group (e.g., goose), the average weight of the identified species within that group that were struck at that airport during 2000 was used. Where insufficient data were available for an airport during 2000, data from 1996-1999 were used. Where those data were lacking, the mean weight for all species in the group struck at Canadian airports from 1996-2000 was used. Where the species of bird struck was recorded as “unknown”, often an additional descriptor for size (i.e., small, medium, large) was given. A similar process was used by averaging all known species within the size range at the airport for 2000, or 1996-1999 if data for 2000 were lacking, or all airports in Canada for 1996-2000 if data were still lacking. If no size range was provided, then the mean of all known species was used. While this method may not produce highly accurate data, the results are adequate for the purposes of this paper. Also, strike reporting is highly variable among airports, pilots and airlines. Clearly, lack of reporting has the greatest affect on bird-strike data and the analysis and interpretation of those data.

Results

Total numbers of strikes at each of 114 airports in Canada were calculated from the Transport Canada bird-strike database. The total weight of birds struck and mean weight of each strike was derived from the database and an average weight table developed from Dunning (1984). Average weights of each species and species grouping are presented in Appendix 1. The mean weights of birds struck at each airport during 2000 and at three airports during 1995-2000 and the coefficients of variation were calculated from the derived weight data. Airports were then ranked according to the traditional method of reporting strikes (i.e., total number of strikes), total weight of birds struck and mean weight of each strike. Those results are presented in Table 1.

There was a significant correlation between the number of strikes and the total weight of strikes ($r=0.901$, $F=524.77$, $df=1,122$, $P=0.0007$). Of those airports with 7 bird strikes or more (i.e., the top 26 airports by number of strikes), 19 of 26 (73%) remained in the top 26 when ranked by total weight of strikes. However only 5 of 26 airports (19%) were in the top 26 when ranked by mean weight of strikes. There was no statistically significant correlation between the number of strikes and the mean weight of each strike ($r=0.015$, $F=0.00026$, $df=1,122$,

Table 1. Bird strike data and ranking for the top 26 airports in Canada during 2000 by number of strikes.

Airport	Number of Strikes	Total Weight of Strikes (grams)	Mean Weight of Strikes (grams)	Coefficient of Variation	Rank by Number of Strikes	Rank by Total Weight of Strikes	Rank by Mean Weight of Strikes
TORONTO/LESTER B. PEARSON INT'L	79	67036	849	57	1	2	43
VANCOUVER INTERNATIONAL	74	74294	1004	80	2	1	15
CALGARY INTERNATIONAL	37	30621	828	95	3	4	46
EDMONTON INTERNATIONAL	36	24014	667	85	4	6	60
MONTREAL INTERNATIONAL (DORVAL)	35	14932	427	62	5	10	74
HAMILTON	34	20722	609	109	6	7	63
HALIFAX INTERNATIONAL	21	2461	117	161	7	49	94
OTTAWA/MACDONALD CARTIER INT'L	20	5161	258	98	8	20	89
VICTORIA INTERNATIONAL	20	24190	1210	93	8	5	13
WINNIPEG INTERNATIONAL	18	14818	823	29	10	11	47
TORONTO CITY CENTRE	17	44060	2592	61	11	3	7
MONCTON	14	5784	413	100	12	18	76
MONTREAL INTERNATIONAL (MIRABEL)	14	4514	322	70	12	24	86
SAINT JOHN	13	726	56	40	14	88	115
CHARLOTTETOWN	11	5936	540	76	15	17	66
PRINCE GEORGE	10	17605	1760	110	16	8	10
REGINA	10	6977	698	80	16	16	56
PRINCE ALBERT	9	3214	357	102	18	36	84
THUNDER BAY	9	7582	842	8	18	14	44
GREENWOOD	8	2053	257	134	20	52	90
KELOWNA	8	3272	409	200	20	35	77
SEPT-ILES	8	7335	917	0	20	15	18
TRENTON	8	4487	561	78	20	26	65
COLD LAKE	7	1395	199	118	24	62	92
LA RONGE	7	528	75	66	24	90	110
MOOSEJAW	7	3734	533	58	24	31	67

P=0.987) and no significant difference between the mean weight of strikes at the airports listed in Table 1 versus all other Canadian airports in the Transport Canada database (t=0.596, df=122). The coefficient of variation for airports with more than one bird strike during 2000 ranged from 0 to 200 (i.e., twice the mean). There was no correlation between the mean and the CV (r=0.177, F=2.456, df=1,76, P=0.121), but the "Top 26" airports had a significantly higher CV at 83.5 than other airports at 52.4 (t=0.018, df=76).

Annual comparisons of bird-strike statistics for three Canadian airports are presented in Figure 2. Although the number of strikes and the total weight of strikes have essentially the same patterns of annual changes, and even the weight of strikes per 10,000 aircraft movement data show a similar pattern, there are some subtle differences that are important to note. The graphs for Calgary International Airport depict a situation where the mean weight of birds struck remained relatively constant and as a result the total weight of strikes was very similar in pattern to the total number of strikes. At Lester B. Pearson International Airport the mean weight of strikes has been increasing and as a result the pattern of total weight of birds struck per year is trending higher than the "number of strikes" pattern. Finally, at Vancouver International Airport, the mean weight of birds struck increased until 1998, then decreased substantially followed by another increase in 2000.

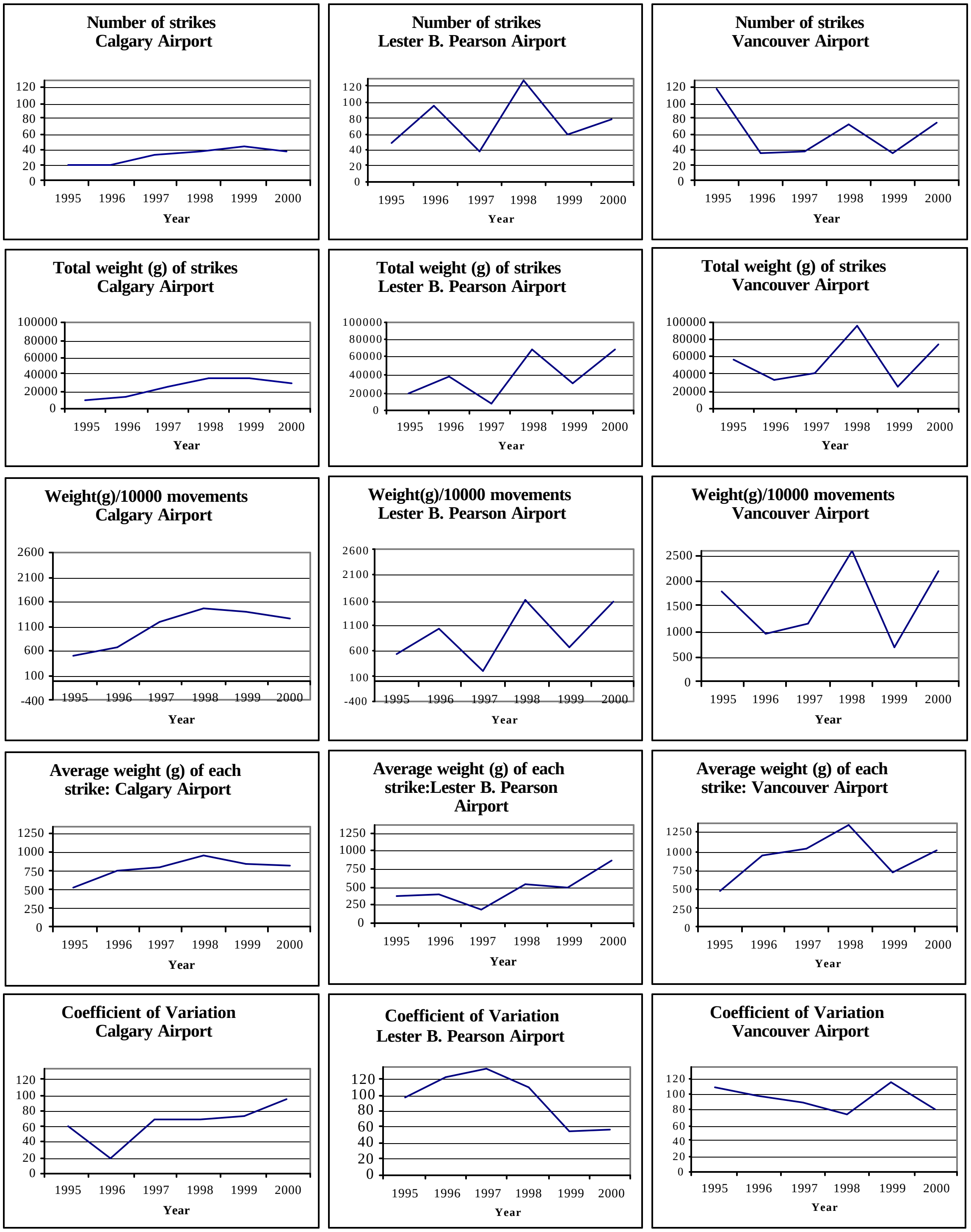

Figure 2. Annual comparisons of bird-strike data for three major airports in Canada.

The fluctuations in the mean weight of birds struck has caused the "total weight of strikes" graph to have a similar, but more exaggerated pattern than the number of strikes graph in Figure 2. Finally, the coefficient of variation at Calgary International Airport has been increasing, decreasing at Toronto's airport and remaining somewhat constant in Vancouver (see Figure 2).

Discussion

Although the total number of bird strikes is significantly correlated with total weight of birds struck, by using total number of strikes *versus* total weight of strikes one arrives at considerably different interpretations of bird hazards. This difference is crucial, considering that the total number of birds struck is largely insensitive to the nature of the hazards posed. The mean rank of the 26 airports with the most strikes is 13. However, by total weight of birds struck and average weight of birds struck, mean ranks of those same airports fall to 25 and 62, respectively. These substantial drops in rankings indicate that strikes at some airports involve proportionately greater numbers of smaller, less hazardous species. Interestingly, only 20% of the 26 airports with the most strikes remained in the top 26 when ranked by mean weight.

The annual comparisons of three airports highlight the importance of bird weight statistics for the analysis and interpretation of bird hazards to aircraft. While the number of strikes at Calgary International Airport remained constant during 1995 and 1996, total strike numbers masked the likelihood that hazards actually increased owing to greater mean and total weights of those strikes in 1996. Data from Lester B. Pearson International Airport in Toronto show an odd pattern of greatly changing numbers and weights of strikes each year. The mean weight of birds struck there rose from 185 g (in 1997) to 849 g (in 2000). This dramatic increase in average weight resulted in Pearson Airport's 2000 total weight of birds struck being 535 g (0.8%) below the maximum total weight ever recorded in a year despite the number of strikes being only 61% of the same peak year. At Vancouver International Airport, rapidly increasing average weights of strikes between 1995 and 1998 resulted in peak total weight of strikes in 1998 despite total strike numbers being only 61% of those at the numerical peak in 1995. A subsequent reduction in the mean weight of strikes in 1999 and 2000 resulted in a 22% decrease in the total weight of birds struck in 2000 compared to 1998 despite very similar strike totals during those periods.

Successful airport wildlife management programs rely on proactive and adaptive management strategies rather than reactive ones. Therefore, the focus of airport management should not be on tallying bird strikes or deriving methods of presenting bird-strike information so as not to reflect badly upon the airport (including non-reporting). However, every airport should have a method of evaluating the hazard caused by birds in order to assess whether greater or different control measures are required. The number of birds struck does not necessarily relate to the overall bird hazard at an airport because often small species are a large component of the strikes yet a negligible hazard because they do not contribute significantly to damage or effect on flight statistics. .

However, bird-strike data can be used to assess the relative and absolute hazard level in order to determine if the hazard posed by birds is changing at an airport over time or whether hazards present at an airport appear to be “acceptable” in comparison with other airports. The use of bird weights for gauging the absolute and relative hazard of birds rather than the number of strikes keeps the focus on reducing the potential for strikes by hazardous species (i.e., heavy birds or flocks of lighter birds) rather than simply reducing the number of strikes (many of which may be caused by species that seldom cause damage).

Strike reporting using the total weight of birds struck, the weight of birds struck per 10,000 aircraft movements, the average weight of strikes and the coefficient of variation will inform airport managers, airlines and pilots of the hazard level present at the airport, the relative hazard of each strike and the amount of variability in the relative hazard figure. These statistics are truly comparable between years and among airports.

The utility of the statistics is a function of data quality. If all strikes are not reported or logged into a database, under-reporting could result in serious bias. However, the mean weight of strikes and the CV is less prone to such bias. To the extent possible, each strike needs to be reported as to the species of bird involved, and the weight of intact birds should be measured accurately to develop a local database of bird weights. Where bird remains are collected but are not identifiable by field examination, comparison with a reference collection or lab analysis including electrophoresis or DNA analysis is warranted.

Dolbeer et al. (2000) anticipated that their hazard ranking would prioritize management actions to reduce strike hazards. Yet as long as we sum bird strikes at year end, managers will be tempted to focus their actions on reducing the total number of bird strikes rather than on reducing the hazards associated with bird strikes. By bringing about a change in the way we analyse bird strike data, we can better maintain a focus on managing strikes by hazardous species and tracking the success of airport wildlife management programs at managing the total and relative hazards to aircraft associated with bird strikes.

Acknowledgements

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Appendix 1. Average weights of birds struck at Canadian airports (from Dunning 1984)

Species or Species Group		Unidentified		Range		Male		Range		Female		Range	
	Mean Weight	Mean Weight	N	min	max	Mean Weight	N	min	max	Mean Weight	N	min	max
Loons	2896.5												
Pacific Loon	1659.0	1659	17	990	2450								
Common Loon	4134.0	4134	3	3600	4480								
Western Grebe	1477.0	1477	13	795	1818								
American White Pelican	6000.0	6000		4500	13600								
Double-crested Cormorant	1674.0					1808	33			1540	32		
Great Blue Heron	2390.0					2576	17			2204	15		
Cattle Egret	338.0	338	9										
Waterfowl	4361.3												
Swans	8750.0												
Tundra Swan	6650.0					7100	76	4700	9600	6200	86	4300	8200
Trumpeter Swan	10850.0					11400	27			10300	47		
Geese	3511.5												
Canada Goose	4392.5					4741	99			4044	104		
Snow Goose	2630.5					2744	467			2517	422		
Ducks	822.3												
Mallard	1082.0	1082	5847	720	1580								
American Black Duck	1250.0					1400	376	900	1800	1100	176	900	1500
Gadwall	919.5					990	16			849	14		
Northern Pintail	1010.5					1035	232			986	60		
Green-winged Teal	341.0					364	194		454	318	81		409
Blue-winged Teal	386.0					409	105		590	363	101		545
American Wigeon	755.5					792	65	635	1036	719	68	512	872
Northern Shoveler	613.0					636	90		908	590	71		726
Redhead	1045.0					1100	1157			990	485		
Lesser Scaup	820.0					850	112	620	1050	790	118	540	960
Turkey Vulture	1467.0	1467	20										
Osprey	1485.5					1403	10	1220	1600	1568	14	1250	1900
Eagles	4467.5												
Golden Eagle	4195.0					3477	31			4913	18		
Bald Eagle	4740.0					4130	35	3637	4919	5350	37	3631	6400
Hawks	693.6												
Sharp-shinned Hawk	138.5					103	435	82	125	174	487	144	208
Cooper's Hawk	439.0					349	51	297	380	529	57	460	588
Buteos	871.6												
Red-tailed Hawk	1126.0					1028	108			1224	100		
Red-shouldered Hawk	559.0					475	10			643	14		
Broad-winged Hawk	455.0					420	14			490	13		
Swainson's Hawk	988.5					908	5			1069	7		
Rough-legged Hawk	956.0					847	152	600	1128	1065	119	783	1660
Ferruginous Hawk	1145.0					1059	15			1231	4		
Northern Harrier	435.5					358	186	301	472	513	174	375	661
Falcons	362.5												
Peregrine Falcon	781.5					611	12			952	19		
Merlin	190.5					163	145	134	223	218	189	134	281
American Kestrel	115.5					111	69			120	111		
Partridges	483.8												
Grey Partridge	389.5					398	87			381	57		
Hungarian Partridge	578.0					619	22			537	24		
Ring-necked Pheasant	1135.0					1317	6378		1861	953	759		1453
Grouse	610.5												
Ruffed Grouse	576.5					621	180			532	214		
Sharp-tailed Grouse	885.0					953	236		1090	817	247		999
Ptarmigan	490.3												
Willow Ptarmigan	558.5					601	498			516	326		
Rock Ptarmigan	422.0	422	139	359	482								
American Coot	642.0					724	27	576	848	560	20	427	628

Appendix 1. (continued).

Species or Species Group		Unidentified				Male				Female			
				Range				Range				Range	
	Mean Weight	Mean Weight	N	min	max	Mean Weight	N	min	max	Mean Weight	N	min	max
Sandhill Crane	5571.0					5797	61	5040	6700	5345	28	4900	6030
Plovers	158.3												
Black-bellied Plover	220.0	220	31	181	263								
Kildeer	96.6					92.1	10	83.9	109	101	6	87.7	121
Large Shorebirds	483.0												
Whimbrel	379.5					355	29	310	403	404	36	345	459
Long-billed Curlew	586.5					531	12	493	597	642	24	570	689
Sandpipers	40.0												
Baird's Sandpiper	41.1					38.6	46			43.5	16		
Dunlin	46.9					44.2	92			49.6	92		
Solitary Sandpiuper	48.4	48.4	104	31.1	65.1								
Western Sandpiper	23.3	23.3	42	18	30								
Spotted Sandpiper	40.4	40.4	56	29.4	59.8								
Common Snipe	122.0					128	15		156	116	14		156
American Woodcock	197.5					176	390		222	219	313		278
Gulls	916.9												
Franklin's Gull	280.0	280	40	220	335								
Mew Gull	403.5					432	96	340	552	375	72	290	530
Ring-billed Gull	518.5					566	48			471	51		
Herring Gull	1135.0					1226	220	755	1495	1044	139	717	1385
Glaucous-winged Gull	1010.0	1010	110	730	1400								
Glaucous Gull	1412.5					1576	39	1280	1820	1249	26	1070	1430
Great Black-backed Gull	1658.5					1829	116	1380	2272	1488	93	1033	2085
Terns	115.0												
Common Tern	120.0	120	265	103	145								
Arctic Tern	110.0	110	261	86	127								
Dove	236.8												
Rock Dove	354.5					369	41			340	37		
Mourning Dove	119.0					123	140			115	95		
Owls	955.5												
Common Barn Owl	523.5					479	33			568	41		
Great Horned Owl	1543.0					1318	22	985	1588	1768	29	1417	2503
Short-eared Owl	346.5					315	20	206	368	378	27	284	475
Snowy Owl	2042.5					1806	23	1606	2043	2279	21	1838	2951
Northern Hawk Owl	322.0					299	16	273	326	345	14	306	392
Common Nighthawk	61.5	61.5	13										
Hummingbirds	3.3												
Ruby-throated Hummingbird	3.2					3	202	2.4	4.1	3.3	489	2.7	4.8
Rufous Hummingbird	3.5	3.5	112	2.8	4.5								
Northern Flicker	132.0					135	94	114	160	129	65	106	164
Passerines	85.7												
Horned Lark	31.4					31.9	207			30.8	93		
Skylark	40.0					42.7	102	32	51	37.2	286	29	47
Swallows	24.3												
Purple Martin	49.4	49.4	22										
Cliff Swallow	21.6	21.6	88	17.5	26.7								
Tree Swallow	20.1	20.1	82	15.6	25.4								
Barn Swallow	16.0					16.2	1337	12.1	28.2	15.8	994	11	24.8
Violet-green Swallow	14.2					14.4	16	13	16.3	13.9	15	12.5	15.2
Black-billed Magpie	177.5					189	81	159	209	166	39	135	197
Crows	419.8												
Northwestern Crow	391.5					415	19	389	486	368	8	315	421
American Crow	448.0					458	6			438	6		
Common Raven	1199.0					1240	5	1100	1400	1158	3	1050	1300
Chickadees	10.3												
Black-capped Chickadee	10.8	10.8	1880	8.2	13.6								
Boreal Chickadee	9.8	84	7	12.4									
Tufted Titmouse	21.6	21.6	668	17.5	26.1								
Wrens	9.9												
Winter Wren	8.9	8.9	54	7.5	10.5								
House Wren	10.9	346	8.9	14.2									
Snow Bunting	42.2	42.2	35	34	56								
Bobolink	42.1					47	22	28.5	56.3	37.1	5	26.5	44.3

Appendix 1. (continued).

Species or Species Group		Unidentified				Male				Female			
				Range				Range				Range	
	Mean Weight	Mean Weight	N	min	max	Mean Weight	N	min	max	Mean Weight	N	min	max
Western Meadowlark	100.7					112	51			89.4	32		
Blackbirds	68.2												
Red-winged Blackbird	52.6					63.6	290	52.9	81.1	41.5	249	29	55
Brewer's Blackbird	62.7					67.2	19	60	73	58.1	15	50.6	67
Common Grackle	113.5					127	197			100	135		
Brown-headed Cowbird	43.9					49	757	32.4	58	38.8	692	30.5	51.2
Northern Oriole	33.8					34.3	57	22.3	41.5	33.2	59	28.1	41.3
American Robin	77.3	77.3	401	63.5	103								
American Pipit	23.9	23.9	100	19.5	24								
European Starling	82.3					84.7	1942			79.9	915		
Warblers	11.0												
Common Yellowthroat	10.1					10.3	965	7.6	15.5	9.9	644	7.6	15.3
Pine Warbler	11.9	11.9	21	9.4	15.1								
Sparrows	22.1												
Brewer's Sparrow	10.9	10.9	83										
House Sparrow	27.7					28	538	20	34	27.4	469	20.1	34.5
Savannah Sparrow	20.1					20.6	71			19.5	35		
Vesper Sparrow	25.7					26.5	28			24.9	15		
White-throated Sparrow	25.9	25.9	1884	19	35.4								
Dark-eyed Junco	19.6					20.4	2819	14.3	26.7	18.8	1316	14.3	25.1
Finches	19.7												
Purple Finch	24.9	24.9	316	18.1	35.3								
House Finch	21.4	21.4	220	19	25.5								
American Goldfinch	12.9					13.2	2178	8.6	20.7	12.6	1547	10	17.1