WEIGHTS AND WING AREAS IN NORTH AMERICAN BIRDS

BY EARL L. POOLE

SEVERAL years ago the writer started to collect data on the relationship between weight and wing area of such species of our native birds as came into his hands. While considerable data on this subject have been collected in Europe, North Africa, and the Malay States, the aim has been in most cases to relate these data to aviation. The method employed has been to compute the entire 'bearing' area of the bird, as its shadow would be cast under a vertical ray of light, wings, tail, and body alike, being considered. On the other hand, my idea was chiefly to note the relationship of the factors of weight and wing area in different groups of birds, the variations within the species, the adjustability of the ratio to different types of flight in such species as habitually vary their method of flight, and to note what effect, if any, the ratio has on the flight characteristics of such species. By measuring only the area of the wing stretched to its full extent it seemed that any relative difference would be expressed more definitely than by considering the entire supporting area, body, tail and wings together. In other words, since the more usual method of flight among birds is by means of flapping, in which the motions of the wings form the supporting and propelling mechanism, it has seemed more logical to consider the wing areas only, rather than include the entire supporting area which functions in soaring flight. I have therefore included in the accompanying table, first, the weight of the bird in grams, taken as soon after death as possible; second, the area of both wings, fully outstretched, in square centimeters, which were closely traced for this purpose, and the resultant outlines measured accurately with a polar planimeter; finally, the ratio obtained by dividing the weight in grams into the area of both wings, as previously determined.

After weighing and measuring some hundreds of such species as came into my hands during the past few years, and arranging the results in a graph, it became evident that some rather interesting and unexpected conclusions could be drawn.

That there is a normal diminution in relative wing area with the heavier species, will be readily seen. It seems almost incredible that a Loon should have a wing ratio of only 0.56 square centimeters per gram weight, while a Black-chinned Hummingbird shows a ratio of 5.0 square centimeters per gram, almost ten times that of the Loon, and the Golden-crowned Kinglet has a ratio of 8.87 square centimeters per gram, well over fifteen times that of the Loon.

One possible explanation for this disparity in ratio may be that there is a constant ineffective marginal area, which may be actually or nearly the

same in both the large and the small species. Such an area would be ineffective through the tendency of the air, a flexible and compressible medium, to 'slip' around the margin of the wing rather than present a fairly secure purchase. As an illustration, a marginal area of slightly less than 7 millimeters in width, subtracted from the hummingbird's wing would reduce its wing ratio from 5.0 to 0.48, while a margin of the same width subtracted from the wings of the Loon would only reduce its ratio from 0.56 to 0.49, a negligible reduction. It is conceivable that such a factor would actually be somewhat variable, depending upon the rapidity of wing-beats, and possibly other considerations. Normally we would assume that a bird of soaring flight, such as the Turkey Vulture, or the Golden Eagle, would carry relatively more sail than a bird of rapid and direct flight, such as the Whistling Swan. As a matter of fact, the Golden Eagle has almost exactly twice the wing area of the Swan, the Red-tailed Hawk has more than twice the wing area of the Mallard and Ring-necked Pheasant, while the Turkey Vulture possesses well over three times the area of the Loon.

Generally speaking, among the larger birds, the owls and the herons possess the highest ratios, with the soaring hawks and the vulture close seconds. There is a decided gap between the latter and the rails. Then follow the freshwater ducks and geese, the gallinaceous birds, and finally the loons, grebes, and bay ducks. Among the smaller birds the comparative ratios are much closer, making it impossible to draw any deductions, except in the case of the Bob-white, which falls far below the others of comparable weight. As a rule the stronger fliers, such as the swallows and the Chimney Swift and Nighthawk, are very high, while the Leach's Petrel is apparently in a class by itself, with twice the ratio of most birds of its size. The ground-feeding birds, especially those species which ordinarily fly comparatively little—the Song Sparrow, Hermit Thrush, and Towhee—are all very low in ratio.

A rather notable exception to the rule that the birds of strong and protracted flight possess greater alar ratios is seen in the case of the hummingbirds, but their comparatively small wings are offset by the phenomenal speed with which they are used. I have recently seen a statement to the effect that the Rubythroat is capable of 75 wing-beats to the second (O. S. Pettingill, Jr., Bird-Lore, vol. 39, p. 194).

It is well known that many birds are capable of varying their manner of flight to a considerable extent by adjusting the area to meet the air conditions. I have frequently noticed the adaptability of hawks in this respect, while they were migrating along the Kittatinny Ridge. On days of low wind velocity, the wings are usually extended to obtain the maximum bearing area, while on days of comparatively high wind velocity they are

flexed to a great degree. This reduction in wing ratio at such times may amount to 33 per cent of the maximum. There is also a considerable variation in ratio within each species; the Red-tailed Hawks have ranged from 1.63 to 2.73, the latter having been a rather emaciated male, while the former was a very fat female, but in the main there is a rather close conformity to the median.

Some closely related species show a wide disparity in wing ratio. It is interesting to note that the ratio of the Fish Crow (*Corvus ossifragus*) is 3.325, while that of the Eastern Crow (*Corvus b. brachyrhynchos*) is 2.43. This difference appears to be reflected in the flight of the two species; that of the former is ordinarily lighter and more buoyant than that of the latter.

It may be said, in general, that the ratio is reflected in the manner of flight of the species, as the large-winged herons and owls possess a peculiarly slow heavy flight, contrasting with the exceedingly rapid wing beats of the bay ducks, grebes, and loons, and inversely related to the speed at which the bird ordinarily flies. Such apparent exceptions as the case of the Chimney Swift, which is comparatively high in its weight group, may be due to the fact that the swift, like the swallows, is more completely aërial in its adaptation, spends long periods of time in the air, and has developed a method of flight that attains great speed at a minimum expenditure of effort.

The appended table, listing the weight in grams, area of both wings in square centimeters, and ratio of the two as obtained by dividing the former into the latter, is far from complete, but covers 143 North American species, arranged in order of their weight, from the Black-chinned Hummingbird, weighing 2.55 grams, to the Mute Swan, weighing 11,602 grams. In certain cases, as in the hawks and owls, where there is a considerable disparity in the weight of males and females, I have arranged the sexes separately in the table, according to their weight. In other cases where more than one specimen of a species was measured, I have taken an average for that species.

As might be expected, according to the law which appears to govern the reduction in wing ratio with the increase in weight, the heavier sex in each case, whether male or female, shows a lower ratio than the lighter one, demonstrating that this law functions within the species as well as among different species. Two female Mallards, for instance, with an average weight of 1233.5 grams show an average ratio of 0.769, while with two males of an average weight of 1408 grams, the ratio is but 0.73. A male Duck Hawk weighing 712 grams had a ratio of 1.61, while a female of the same species, weighing 1222.5 grams had a lower ratio of 1.10; and two male Screech Owls, with an average weight of 178 grams show a ratio of 2.94, while in two females with an average weight of 254 grams the ratio is reduced to

1.87. In such species as the Goshawk and Long-eared Owl, the same reduction is to be noted in the ratio of the heavier sex.

Weights and Wing-area Ratios (of 143 Species of North American Birds)

	Weight grams	Wing area sq. cm.	Wing area per gram
Black-chinned Hummingbird, *Archilochus alexandri*, male	2.55	12.75	5.00
Ruby-throated Hummingbird, *Archilochus colubris*, male	2.98	12.40	4.16
Eastern Golden-crowned Kinglet, *Regulus s. satrapa*	5.75	51.	8.87
Eastern Ruby-crowned Kinglet, *Corthylio c. calendula* (av. 2)	6.73	58.25	8.66
American Redstart, *Setophaga ruticilla*	8.	62.5	7.61
Brown Creeper, *Certhia familiaris americana* (av. 2)	8.	66.5	8.31
Magnolia Warbler, *Dendroica magnolia*	9.20	69.	7.50
Black-throated Green Warbler, *Dendroica v. virens*	9.20	58.50	6.36
Black-throated Blue Warbler, *Dendroica c. caerulescens*	9.25	67.	7.34
Eastern Winter Wren, *Nannus h. hiemalis*	9.4	41.	4.36
Northern Yellow-throat, *Geothlypis trichas brachidactyla*	9.5	58.53	6.26
Black and White Warbler, *Mniotilta varia*	10.5	71.	6.19
Eastern House Wren, *Troglodytes a. aëdon*	11.	48.40	4.40
Chestnut-sided Warbler, *Dendroica pensylvanica*	11.1	60.5	5.45
Northern Parula Warbler, *Compsothlypis americana pusilla*	11.85	56.	4.73
Eastern Field Sparrow, *Spizella p. pusilla*	12.1	62.	5.12
Black-capped Chickadee, *Penthestes a. atricapillus*	12.5	76.	6.08
Indigo Bunting, *Passerina cyanea*	13.	82.	6.31
Eastern Chipping Sparrow, *Spizella p. passerina*	13.5	91.	6.74
Eastern Goldfinch, *Spinus t. tristis* (av. 2)	14.	83.	5.92
Northern Water-Thrush, *Seiurus n. noveboracensis*	14.5	86.	5.93
Myrtle Warbler, *Dendroica coronata*	15.5	91.	5.87
Rough-winged Swallow, *Stelgidopteryx ruficollis serripennis* (av. 2)	15.75	107.	6.79
Blue-headed Vireo, *Vireo s. solitarius*	16.75	88.	5.25
Barn Swallow, *Hirundo erythrogaster* (av. 2)	17.	118.5	6.96
Swamp Sparrow, *Melospiza georgiana* (av. 3)	17.	73.	4.30
Chimney Swift, *Chaetura pelagica*	17.3	104.	6.00
Lincoln's Sparrow, *Melospiza l. lincolni*	17.8	72.5	4.07
Eastern Tree Sparrow, *Spizella a. arborea* (av. 2)	18.	90.	4.99
Eastern Grasshopper Sparrow, *Ammodramus savannarum australis*	18.5	89.	5.23
American Pipit, *Anthus spinoletta rubescens*, female	19.	109.	5.74
Phoebe, *Sayornis phoebe*, female (av. 2)	20.	134.5	6.73
Tree Swallow, *Iridoprocne bicolor*, male	20.1	125.	6.22
Slate-colored Junco, *Junco h. hyemalis* (av. 2)	21.5	99.	4.42

	Weight grams	Wing area sq. cm.	Wing area per gram
Eastern Song Sparrow, *Melospiza m. melodia* (av. 2)	22.	86.5	3.94
Tufted Titmouse, *Baeolophus bicolor* (av. 2)	22.5	117.8	5.21
Orchard Oriole, *Icterus spurius*	23.	100.5	4.37
English Sparrow, *Passer d. domesticus* (av. 2)	24.5	92.5	3.78
Eastern Purple Finch, *Carpodacus p. purpureus*	24.5	104.	4.24
Downy Woodpecker, *Dryobates pubescens medianus* (av. 3)	24.8	136.	5.54
Cedar Waxwing, *Bombycilla cedrorum*	25.	130.	5.65
Leach's Petrel, *Oceanodroma l. leucorhoa*	26.5	251.	9.47
White-throated Sparrow, *Zonotrichia albicollis*	26.5	108.	4.07
Eastern Vesper Sparrow, *Pooecetes g. gramineus*	27.	108.	4.00
Eastern Hermit Thrush, *Hylocichla guttata faxoni*	29.5	116.	3.89
Veery, *Hylocichla f. fuscescens* (av. 2)	32.3	147.	4.59
Eastern Bluebird, *Sialia s. sialis*	32.7	148.	4.53
Gray-cheeked Thrush, *Hylocichla minima aliciae*	34.	150.	4.41
Hepatic Tanager, *Piranga flava hepatica*	35.8	153.	4.26
Catbird, *Dumetella carolinensis*	39.	150.	3.84
Rose-breasted Grosbeak, *Hedymeles ludovicianus*, male	40.	166.5	4.16
Eastern Fox Sparrow, *Passerella i. iliaca*	40.5	116.	2.85
Red-eyed Towhee, *Pipilo e. erythrophthalmus* (av. 2)	41.7	145.	3.49
Purple Martin, *Progne s. subis* (av. 2)	43.	185.5	4.32
Black-headed Grosbeak, *Hedymeles m. melanocephalus*	44.7	200.	4.47
Eastern Solitary Sandpiper, *Tringa s. solitaria*	47.	192.	4.08
Spotted Sandpiper, *Actitis macularia*	47.5	146.	3.07
Canadian Pine Grosbeak, *Pinicola enucleator leucura*	50.	189.	3.78
Eastern Cowbird, *Molothrus a. ater*	50.5	179.	3.54
Yellow-billed Cuckoo, *Coccyzus a. americanus*	61.	266.	4.36
Virginia Rail, *Rallus l. limicola*	65.	221.	3.40
Eastern Red-wing, *Agelaius p. phoeniceus*	70.	245.	3.50
Ant-eating Woodpecker, *Balanosphyra f. formicivora*	74.5	306.	4.11
Sora, *Porzana carolina*	75.	176.	2.34
Eastern Nighthawk, *Chordeiles m. minor* (av. 2)	75.25	349.5	4.64
Eastern Robin, *Turdus m. migratorius*	82.	244.	2.97
Starling, *Sturnus v. vulgaris* (av. 3)	84.	190.3	2.25
Killdeer, *Oxyechus v. vociferus*	85.	275.	3.23
Red-bellied Woodpecker, *Centurus carolinus*	87.	262.	3.00
Northern Blue Jay, *Cyanocitta c. cristata*	89.	236.	2.65
Dovekie, *Alle alle*	96.	146.	1.52
Sharp-shinned Hawk, *Accipiter v. velox*, male (av. 2)	97.5	439.	4.50
Northern Flicker, *Colaptes auratus luteus*, male	100.	324.	3.24
Pectoral Sandpiper, *Pisobia melanotos*	101.	199.	1.97

	Weight grams	Wing area sq. cm.	Wing area per gram
Pinyon Jay, *Cyanocephalus cyanocephalus*	108.	390.	3.70
Saw-whet Owl, *Cryptoglaux a. acadica*	108.	420.	3.88
Wilson's Snipe, *Capella delicata*	112.	250.	2.22
Purple Grackle, *Quiscalus q. quiscula* (av. 3)	122.3	324.	2.65
Eastern Mourning Dove, *Zenaidura macroura carolinensis* (av. 2)	130.	357.5	2.36
Eastern Sparrow Hawk, *Falco s. sparverius*, female (av. 2)	137.	372.	2.74
Eastern Meadowlark, *Sturnella m. magna*	145.	265.	1.83
Eastern Belted Kingfisher, *Megaceryle a. alcyon*, male (av. 2)	155.	376.	2.45
Greater Yellow-legs, *Totanus melanoleucus*, male	170.	412.	2.42
Sharp-shinned Hawk, *Accipiter v. velox*, female	171.	607.	3.55
Eastern Pigeon Hawk, *Falco c. columbarius*, male	173.	410.	2.37
Eastern Screech Owl, *Otus asio naevius*, male (av. 2)	178.	523.	2.94
American Woodcock, *Philohela minor* (av. 3)	198.5	354.66	1.65
Eastern Bob-white, *Colinus v. virginianus* (av. 5)	198.64	216.8	1.09
King Rail, *Rallus e. elegans*	227.	536.	2.36
Eastern Green Heron, *Butorides v. virescens*	230.	660.	2.87
Long-eared Owl, *Asio wilsonianus*, male	230.	1182.	5.13
Screech Owl, *Otus asio naevius*, female	254.	476.	1.87
Fish Crow, *Corvus ossifragus*, female (av. 2)	273.5	912.5	3.325
Long-eared Owl, *Asio wilsonianus*, female (av. 2)	288.	1198.	4.22
Fish Crow, *Corvus ossifragus*, male	309.	1072.	3.46
Rock Dove (Domestic Pigeon), *Columba l. livia* (av. 2)	314.	567.	1.66
Green-winged Teal, *Nettion carolinense*, female	321.	374.	1.16
Blue-winged Teal, *Querquedula discors*	332.	370.	1.10
Florida Gallinule, *Gallinula chloropus cachinnans* (av. 2)	332.	479.5	1.45
Pied-billed Grebe, *Podilymbus p. podiceps*. (av. 2)	343.5	291.	.81
Horned Grebe, *Colymbus auritus* (av. 2)	369.5	350.	.95
Broad-winged Hawk, *Buteo p. platypterus*	376.	1012.	2.69
Buffle-head, *Charitonetta albeola*, male (imm.)	377.	412.	1.09
Marsh Hawk, *Circus hudsonius*, male	414.	1382.	3.34
Cooper's Hawk, *Accipiter cooperi* (av. 2)	428.5	898.	2.07
American Coot, *Fulica a. americana*	435.	596.	1.37
Little Blue Heron, *Florida c. caerulea* (av. 2, imm.)	449.	1246.5	2.77
Barn Owl, *Tyto alba pratincola* (av. 2)	505.	1683.	3.37
Northern Barred Owl, *Strix v. varia*	510.	1830.	3.59
Eastern Ruffed Grouse, *Bonasa u. umbellus*	516.5	527.	1.02
Eastern Crow, *Corvus b. brachyrhynchos* (av. 2)	552.5	1344.	2.43
Shoveller, *Spatula clypeata* (av. 2)	570.	570.	1.00
Wood Duck, *Aix sponsa*, male	589.	660.	1.12
Marsh Hawk, *Circus hudsonius*, female	615.	1696.	2.75
American Bittern, *Botaurus lentiginosus*, female	625.	1258.	2.01
Ruddy Duck, *Erismatura jamaicensis rubida*	635.	394.	.62

	Weight grams	Wing area sq. cm.	Wing area per gram
Duck Hawk, *Falco peregrinus anatum*, male	712.	1146.	1.61
Gadwall, *Chaulelasmus streperus*	723.	718.	.993
Ring-necked Duck, *Nyroca collaris* (av. 3)	757.31	460.	.61
Lesser Scaup Duck, *Nyroca affinis*, female	763.	472.	.62
Black-crowned Night Heron, *Nycticorax nycticorax hoactli* (av. 3)	804.	1773.	2.21
Northern Red-shouldered Hawk, *Buteo l. lineatus* (av. 3)	804.	1656.	2.11
Eastern Goshawk, *Astur a. atricapillus*, male	848.6	1480.	1.74
Herring Gull, *Larus argentatus smithsonianus*	850.	2006.	2.40
Eastern Red-tailed Hawk, *Buteo b. borealis*, male	875.	1878.	2.14
American Egret, *Casmerodius albus egretta*	899.	2528.	2.81
American Pintail, *Dafila acuta tzitzihoa* (av. 2)	970.	761.	.784
American Brant, *Branta bernicla hrota*, female	1024.	1264.	1.23
Old-squaw, *Clangula hyemalis*, male	1038.	550.48	.53
American Rough-legged Hawk, *Buteo lagopus s. johannis*	1110.	2592.	2.33
Common Black Duck, *Anas rubripes tristis*, female	1142.	1007.	.882
Duck Hawk, *Falco peregrinus anatum*, female	1222.5	1342.	1.10
Common Mallard, *Anas p. platyrhynchos*, female (av. 2)	1233.5	952.	.769
Ring-necked Pheasant, *Phasianus colchicus torquatus* (av. 3)	1304.	917.	.701
Eastern Red-tailed Hawk, *Buteo b. borealis*, female (av. 2)	1307.	2294.	1.75
Eastern Goshawk, *Astur a. atricapillus*, female	1370.	2004.	1.45
Snowy Owl, *Nyctea nyctea*, male	1404.	2576.	1.835
Common Mallard, *Anas p. platyrhynchos*, male (av. 2)	1408.	1029.	.73
Great Horned Owl, *Bubo v. virginianus*, female (av. 2)	1446.5	2534.	1.765
Pacific Horned Owl, *Bubo virginianus pacificus*	1480.	2426.	1.64
Osprey, *Pandion haliaëtus carolinensis* (av. 2)	1797.5	3211.	1.79
Great Blue Heron, *Ardea h. herodias*	1905.	4436.	2.33
Turkey Vulture, *Cathartes aura septentrionalis*	2409.	4356.	1.81
Common Loon, *Gavia i. immer*, female	2425.	1358.	.56
Eastern Turkey, *Meleagris gallopavo silvestris* (small) female	3897.	3752.	.962
Golden Eagle, *Aquila chrysaëtos canadensis*, female	4664.	6520.	1.397
Common Canada Goose, *Branta c. canadensis* (fat)	5662.	2820.	.498
Whistling Swan, *Cygnus columbianus*	5943.	4156.	.699
Mute Swan, *Sthenelides olor*, female	11,602.	6808.	.59

Reading Public Museum and Art Gallery
Reading, Pennsylvania