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WING LENGTH AS AN INDICATOR OF WEIGHT: A CONTRIBUTION

BY A. L. RAND

Wing length, measured from wrist to tip of longest primary, is often used as an indicator of weight when comparing bird populations and their adaptation to climate. Reasonable as this seems, actual data demonstrating the extent to which wing length is a reliable weight indicator, is scanty. It seems worthwhile to present some original data from Philippine song birds, and interpret it along with certain items from the literature, and to point out that bird banders can make additional use of the weights and measurements they take by interpreting them along these lines.

BACKGROUND

Despite the great individual and temporal variation in bird weights, they do seem to represent specific and even population characters. The wing length of course, when fresh, full grown wings of the same age and sex class are measured, is much less variable.

The intricacies of the question of bird weights has been discussed a number of times, especially by Nice, 1938 (biological significance); Poole, 1938 (wing loading); Amadon, 1943 (in taxonomy); Mayr, 1956 (and climatic adaptations); Saville, 1957 (adaptations wing-weight for flying); and Odum, 1958 (variation in migrants of different types).

The present paper is a contribution to only the narrow problem of the reliability of wing length as an indicator of weight in some song birds.

CORRELATIONS WITHIN SPECIES

In twenty-one Philippine species.—The collections made in recent years by Dr. D. S. Rabor of Silliman University, Dumaguete, Negros, P. I., from the three islands of Bohol, Samar, and Mindanao had the weights recorded on the labels of the specimens. For purposes of the following table only those song birds species of which at least three adult males were available from each of at least two of the islands were used. This curtailed sharply the number of species that could be used, to the twenty-one listed (Table 1).

For deciding whether or not differences existed, a difference of 3 millimeters in wing length, or 1 gram in weight between the populations of different islands was arbitrarily taken as the lowest acceptable difference. Using this, the following conclusions were arrived at. Of these 21 species, ten species showed no differences in wing or weight between populations of different islands. In ten species the populations

TABLE I.

Wing lengths and weights of different island populations of 21 species of Philippine Island songbirds, males only.

Species	Bohol				Mindanao				Samar			
	Wing		Weight		Wing		Weight		Wing		Weight	
	No.	Av.	No.	Av.	No.	Av.	No.	Av.	No.	Av.	No.	Av.
Coracina striata	(5)	162 mm.	(5)	109 grams	—	—	—	—	(3)	166	(3)	116
Hypsipetes philippinus	(9)	100.3	(9)	41.5	(4)	120	(3)	59	(15)	95.2	(15)	38.3
Pycnonotus goiavier	(6)	83	(5)	27.5	—	—	—	—	(14)	80.2	(14)	27.8
Irena cynogaster	(11)	134.1	(11)	79.6	—	—	—	—	(7)	132.6	(7)	86.2
Ptilocichla mindanensis	(9)	71.9	(9)	29.7	—	—	—	—	(3)	70.1	(3)	29.4
Macronus striaticeps	(10)	62.9	(8)	15.3	(5)	63.7	(4)	19	(10)	61.8	(10)	16.2
Stachyris nigrocapitata	(3)	70.8	(2)	14.8	—	—	—	—	(14)	69.3	(4)	14
Phylloscopus olivaceus	(11)	60.7	(10)	10	(4)	62	(4)	11.5	(12)	62.3	(12)	10.5
Cisticola exilis	(10)	44.9	(8)	7.1	—	—	—	—	(3)	44.2	(3)	6.8
Rhipidura superciliaris	(10)	78.9	(10)	13.7	(3)	83	(3)	15.6	(12)	79.6	(12)	13.5
Hypothymis azurea	(3)	69.6	(3)	11.5	—	—	—	—	(6)	65.6	(6)	11.1
Pachycephala philippinensis	(14)	82.7	(14)	21.5	(14)	84.2	(12)	23	(10)	82.6	(10)	22.3
Dicaeum trigonostigma	(4)	49.5	(3)	7.3	—	—	—	—	(12)	49.9	(12)	7.2
Dicaeum hypoleucum	(5)	53.6	(5)	8	(4)	53.8	(4)	8	(10)	51.5	(10)	7.9
Dicaeum australe	(6)	55.6	(4)	8.7	—	—	—	—	(10)	55	(10)	8.7
Arachnothera clarae	—	—	—	—	(5)	90	(5)	31	(6)	89.3	(6)	30.9
Aethopyga pulcherrima	(5)	49	(5)	5.4	—	—	—	—	(20)	49.3	(20)	6.6
Nectarinia jugularis	(19)	56.3	(18)	9.2	—	—	—	—	(4)	57.7	(4)	9.1
Nectarinia sperata	(3)	50.3	(3)	5.5	—	—	—	—	(23)	50.9	(23)	6.7
Zosterops everetti	(10)	54.8	(10)	10.2	(4)	57.5	(3)	10.8	(10)	55	(10)	9.7
Sarcops calvus	(6)	132.1	(6)	144.6	—	—	—	—	(10)	132.9	(10)	145

in which the individuals averaged longer wing also averaged heavier. In one species only did the populations with longer wing length weigh less *(Irena)*. The observed differences in wing length were considerably less than the differences ordinarily used to give subspecific rank to a population, except in one species *(Hypsipetes)*.

From this data it appears that within these species wing length correlates closely with weight within 20 out of 21 species.

TABLE II.

Wing length and weight of nine populations of Pigmy Nuthatch, *Sitta pygmaea melanotis*, males only (data from Norris, 1958).

Locality	Wing		Weight	
	No.	Av.	No.	Av.
Idaho, etc.	(15)	62 mm.	(1)	9.6 grams
Napa Co., California	(77)	62	(8)	9.9
Brit. Columbia-Oregon	(33)	63	(10)	10.0
No. Sierra, California	(23)	63	(16)	10.3
W. Nevada	(13)	63	(9)	10.7
New Mexico	(35)	64	(5)	10.2
E. Nevada	(48)	64	(7)	10.3
N. Coahuila	(9)	64	(9)	10.4
So. Sierra, California	(41)	65	(20)	10.6

Pigmy Nuthatch, *Sitta pygmaea.*—The data in Table 2 shows the correlation between wing-length and weight in nine populations within the subspecies *S. p. melanotis.* Considering that the total difference in wing length is only four millimeters and that in weight is only just over one gram, the close though not absolute correlation within the series is more than one would expect. Yet the size of the samples used makes one think that the correlation is probably real.

The data for the rest of the subspecies, Table 3, does not show as close a correlation, though the longest winged subspecies is also the heaviest. However, the shortest winged birds are not the lightest, and the next to the longest winged are next to the lightest.

Scrub jays, genus *Aphelocoma.—A. coerulescens,* from the data in Table 4, also shows a general correlation of increased weight with increased wing length. There are particularly striking exceptions: the subspecies *nevadae* and the subspecies *sumichristi* and part of *superciliosa* are much lighter than the wing length would lead one to expect. It should be noted that two of these exceptions are subspecies in different subspecies groups that could be considered as representing two separate species, judging by standards other than those Pitelka (1951, p. 376) accepts. He also comments on the habitat relation of the populations with relatively different wing length and weight.

In another scrub jay, *A. ultramarina,* Table 5, which is longer winged than *A. coerulescens,* only some of the populations are heavier, and the correlation of wing-weight within the series has many exceptions. These

TABLE III.

Wing length and weight of seven subspecies of pygmy nuthatch, *Sitta pygmaea,* except *melanotis;* males only (data from Norris, 1958).

Subspecies	Locality	Wing		Weight	
		No.	Av.	No.	Av.
pygmaea (pt.)	Marin Co., California	(33)	59 mm.	(18)	10.4 grams
pygmaea (pt.)	Monterey Co. (1), California	(42)	62	(10)	10.9
chihuahuae (pt.)	Durango, etc.	(20)	63	(3)	9.3
pygmaea (pt.)	Monterey Co. (2), California	(14)	64	(14)	10.9
chihuahuae (pt.)	W. Chihuahua	(24)	65	(8)	10.4
flavinucha	W. Puebla	(20)	65	(2)	10.4
brunnescens	Jalisco, etc.	(11)	66	(1)	10
leuconucha	Lower California	(55)	68	(33)	11.4

TABLE IV.

Wing length and weight of nineteen subspecies and populations of the scrub jay, *Aphelocoma coerulescens,* males only (data from Pitelka, 1951).

Subspecies	Locality	Wing		Weight	
		No.	Av.	No.	Av.
coerulescens	Fla.	(16)	115 mm.	(2)	78 grams
cactophila	Central Lower Calif.	(25)	118	(10)	79
obscura	No. Lower Calif.	(56)	121	(51)	78
obscura	San Diego Co., Calif.	(30)	121	(6)	79
hypoleuca	Cape area, Lower Calif.	(36)	121	(10)	85
californica (pt.)	Central coastal Calif.	(22)	123	(14)	95
caurina	No. coastal Calif. and Oreg.	(38)	123	(29)	98
californica (pt.)	Inner coast range, etc., central Calif.	(16)	125	(15)	93
superciliosa (pt.)	Calaveras, Calif.	(39)	124	(39)	93
superciliosa (pt.)	Sacramento Valley, etc., Calif.	(42)	124	(16)	97
superciliosa (pt.)	San Joaquin Valley, Calif.	(34)	126	(27)	97
oocleptica	Marin Co., Calif.	(16)	127	(7)	100
oocleptica	Contra Costa, Calif.	(21)	126	(7)	106
superciliosa (pt.)	No. Calif., Oreg.	(38)	128	(27)	93
nevadae	Calif.—Nevada line	(33)	130	(33)	81
nevadae	Arizona	(39)	131	(6)	77
nevadae	Nevada	(17)	131	(17)	81
insularis	Santa Cruz Isl.	(45)	139	(20)	125
sumichrasti	S. E. Mexico	(8)	143	(5)	100

exceptions do not all accord with the subspecies groups outlined by Pitelka (1951, p. 376).

CORRELATIONS BETWEEN SPECIES

The data presented above shows that the correlations between change in wing length and weight may be rather precise in many cases within species. However, this is not always true.

Such discrepancies could be the sort of material which selection could use in establishing species. Hence, we could expect to find deviation from the increase in wing and weight postulate better established at the species level and the factors with which they are correlated to be more easily seen when distantly related birds are compared With this in mind the following are pertinent.

TABLE V.

Wing lengths and weights in nine subspecies and populations of the scrub jay *Aphelocoma ultramarina,* males only (data from Pitelka, 1951).

Subspecies	Locality	Wing		Weight	
		No.	Av.	No.	Av.
couchii	Texas	(35)	153.8 mm.	(3)	102 grams
couchii	So. Coahuila, etc.	(18)	156.9	(4)	125.7
couchii	So. Nuevo Leon, etc.	(21)	158.8	(2)	104.3
wollweberi	Durango, etc.	(28)	160.9	(4)	86
arizonae (pt.)	No. Sonora	(16)	163	(9)	120
sordida	E. central Mexico	(7)	164.3	(2)	133
arizonae (pt.)	S. E. Arizona	(14)	170	(8)	135
ultramarina (pt.)	Michoacan	(16)	175.9	(8)	140.6
ultramarina (pt.)	Vera Cruz, etc.	(17)	180.6	(4)	130.5

TABLE VI.

Wing lengths and weights of eight species of flowerpeckers, of the genus *Dicaeum* of the Philippines, males only.

Species	No.	Wing Av.	Weight Av.
pygmaeum	(3)	45 mm.	5 grams
trigonostigma	(12)	50	7
bicolor	(4)	51	8
hypoleucum	(10)	51	8
ignipectus	(3)	55	9
australe	(10)	55	9
anthonyi	(2)	57	12
nigrilore	(10)	58	11

SPECIES WITHIN A GENUS

By definition, the members of a genus are closely related, and the same general type of bird. The eight species of the genus *Dicaeum* of the Philippines, Table 6, show a remarkably close wing length-weight correlation. The seven species of woodwarblers of the genus *Dendroica,* Table 7, show a general correlation and the two exceptions are not greater than found in subspecies of the pygmy nuthatch. There are also exceptions in populations of the two species of scrub jay, Table 4 and 5, as mentioned earlier.

TABLE VII.

Wing length and weight of seven species of *Dendroica,* males only (data from Woodford and Lovesy, 1958).

Species	No.	Wing Av.	Weight Av.
magnolia	(51)	59 mm.	9.6 grams
virens	(4)	61	10.4
pennsylvanica	(8)	62	10.0
palmarum	(2)	62	11.2
petechia	(6)	63	10.7
fusca	(4)	66	11.2
coronata	(9)	72	12

SPECIES IN DIFFERENT GENERA IN A FAMILY

Here we deal with species with less close relationships, and which may be rather different types of birds.

The three species of Philippine babblers, family Timaliidae of which we have data, Table 8, do not show correlation of wing and weight. Here for the first time another correlation is plainly evident. The first species, *P. mindanensis* with the heavy weight, is a bird of the forest floor that presumably flies little. The second species, *M. striaticeps* with a lighter weight for its wing length, is a bird that hops in the shrubbery in the forest. The third, *S. nigrocapitata* with lightest weight for its wing length, is a bird that feeds among the twigs and branches of the trees, not unlike a wood warbler, and its wing-weight relation approaches that of *Dendroica coronata* of Table 7.

TABLE VIII.

Wing length and weight of three Philippine babblers, Family Timaliidae, males only.

Species	No.	Wing Av.	Weight Av.
Ptilocichla mindanensis	(3)	70 mm.	29 grams
Macronus striaticeps	(10)	62	16
Stachyris nigrocapitata	(2)	70	14

TABLE IX.

Wing length and weight of various woodwarblers, Family Parulidae, males only (data from Woodford and Lovesy, 1958).

Species	*No.*	*Wing Av.*	*Weight Av.*
Geothlypis trichas	(16)	55 mm.	11 grams
Setophaga ruticilla	(6)	63	8.2
Wilsonia canadensis	(20)	64	10.4
Wilsonia pusilla	(21)	54	8.1
Vermivora peregrina	(3)	64	11.3
Vermivora ruficapilla	(4)	56	11.4
Mniotilta varia	(2)	68	11.4
Icteria virens	(5)	72	23.1
Dendroica coronata (large species)	(9)	72	12
Dendroica magnolia (small species)	(51)	59	9.6

In the wood warblers data from seven genera in Table 9, various discrepancies emerge in regard to the wing-weight correlations. The chat *(Icteria)* and the yellowthroat *(Geothlypis)* both have much heavier weight, and the redstart *(Setophaga)* has a lighter weight than a comparison, on wing length alone, with the species of *Dendroica* would lead one to expect. However, in these cases it is plainly correlated with habits: the chat and yellowthroat are more skulking birds of the shrubbery than the *Dendroica* species, and the redstart is more aerial. However, there is another discrepancy, the heavy weight of the Nashville warbler, *V. ruficapilla*, compared with that of the Tennessee warbler, *V. perigrinus*, despite both having similar habits.

NORTH AMERICAN SONG BIRDS OF VARIOUS FAMILIES

A selection of North American song birds given in Table 10 illustrates how birds with longer wings tend to have heavier weights, comparing birds of quite different sizes, but that the correlation of wing-weight is greatly influenced by habits. Birds of the ground and

TABLE X.

Wing lengths and weights of selected North American songbirds from various sources.

Species	*Wing Av.*	*Weight Av.*
House Wren, *Troglodytes aedon*	51 mm.	11 grams
Golden-crowned Kinglet, *Regulus satrapa*	56	5.7
Swamp Sparrow, *Melospiza georgiana*	62	17
Chestnut-sided Warbler, *Dendroica pensylvanica*	62	11.1
Solitary Vireo, *Vireo solitarius*	75	16.5
White-crowned Sparrow, *Zonotrichia leucophrys*	75	26.5
Catbird, *Dumetella carolinensis*	88	39
Cedar Waxwing, *Bombycilla cedrorum*	95	25
Rose-breasted Grosbeak, *Pheucticus ludovicianus*	101	40
Scrub Jay (Florida), *Aphelocoma c. coerulescens*	115	78
Barn Swallow, *Hirundo rustica*	118	17
Eastern Meadowlark, *Sturnella magna*	122.4	145
Blue Jay, *Cyanocitta cristata*	134	89
Purple Martin, *Progne subis*	142	43
Common Grackle, *Quiscalus quiscula*	144	122
Common Crow, *Corvus brachyrhynchos*	321	552.5

TABLE XI.

Wing lengths and weights of seven selected non-passerine birds; data from various sources.

Species	*Wing*	*Weight*
Virginia Rail *Rallus limicola*	106 mm.	119.0 grams
Chimney Swift *Chaetura pelagica*	111	17.3
Bobwhite *Colinus virginianus*	111	191.0
Pied-billed Grebe *Podilymbus podiceps*	130	343.0
Yellow-billed Cuckoo *Coccyzus americanus*	143	61.0
Leach's Petrel *Oceanodroma leucorhoa*	157	26.5
Common Nighthawk *Chordeiles minor*	197	75.0

shrubbery, such as wren, sparrows, catbird, Florida jay, meadowlark, have much heavier weights than do birds of somewhat similar wing length that live in the trees, as kinglets, warblers, vireo and waxwing, or catch their food on the wing, as do swallows and martins.

A FEW SELECTED NON-PASSERINE BIRDS

Though the data presented so far has been restricted to passerine birds, it seems advisable to present a selected few examples of non-passerines from within the common wing length range of song birds to illustrate how great can be the range of weight within birds of somewhat similar wing length, but of very different habits and distant relationships, Table 11.

Evidently the very different manner of life has influenced the wing-weight relationship. Birds that depend on their wings a great deal, like swifts, nighthawks and Leach's petrels, have long wings and light weight; those that depend on their legs for locomotion, like rails, grebes, and quail, have heavier bodies and shorter wings.

SUGGESTIONS

One of the difficulties in interpreting wing-weight relationships is that weights and measurements of the same birds are not available for good sized samples. Here bird banders and those collecting birds from major disasters such as those at radio towers can make a contribution.

"General size" of a bird is a meaningless term, except by definition; total length, wing length, weight, or whatever unit is used should replace it.

The use of formulae and derived ratios are tempting complications, such as using the cube root of weight to compare with the lineal wing length (since mass increases as the cube of a lineal measurement). However, wing loading would seem a better next step in correlating wing-weight relations. Though there is a general relation between wing loading and weight, as heaviest wing loading occurs only in longer-winged flying birds, lightest only in shorter-winged flying birds (Poole, 1938), this general tendency seems often upset by the birds' adaptation to a way of life. For instance, the wing loading of the grebe (wing, 130 mm.) is about ten times that of the Leach's petrel (wing, 157) of Table 11. Many facets of the bird as a flying machine are discussed by Saville (1957).

As a bird bander at one station can work best with one or at most a few populations of a species, cooperative use of data from a series of stations where populations of a species are known to differ in size, as in different subspecies, might be productive. The analysis of the data could be directed toward attempting to see if differences in the wing-weight relationships were correlated with local habits, with migration, and fat deposition, or with some aspect of the habitat.

DISCUSSION AND SUMMARY

In closely related bird populations, comparison of size as determined by wing length may be a fairly delicate indicator of comparative weights. However, even at the subspecies level or below it, wing length may fail as a weight indicator.

With species in a genus, species in different genera in a family, and species in different families and orders, the "increase in weight with increase in wing length" correlation becomes increasingly disrupted.

The most obvious factor correlating with these conspicuous disruptions in quite different birds is the manner of life, as is seen by comparing an aerial feeding swallow and an arboreal jay (Table 10), or a Leach's petrel that feeds in fluttering flight, with a grebe that feeds on or in the water or a quail that feeds on the ground (Table 11).

Probably some of the minor discrepancies seen in comparing the wing-weight relations of closely related populations may be due to minor adaptations to slightly different ways of life. If these were adaptations to different types of habitat, themselves due to different types of climate in different areas, the differences might mistakenly be ascribed directly to climatic factors and correlated physiology. A tentative generalization is that birds which fly more have larger wings, relative to their weight.

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FURTHER STUDIES ON NESTING OF THE COMMON NIGHTHAWK

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The Common Nighthawk *(Chordeiles minor minor)* has nested on the campus of Kent State University at Kent, Ohio, since 1948, and reports have been published through the season of 1956 (Dexter, 1952; 1956). In 1957, Nighthawks returned to the campus on May 12. They had also been found five days earlier on the roof of the Akron City Hospital, where they had been studied in 1953, but the writer was unable to continue his studies in the season of 1957.

In 1958 the Nighthawks again returned to the Kent campus on May 12. A pair was located on the roof of Wills Gymnasium incubating two eggs on June 1. For the first time in seven years of nesting on the campus, the eggs were placed on the open roof at some distance from the protection of a wall. Previously, the eggs had always been deposited in a corner where the walls of the roof formed a right-angle bend. This new situation presented an opportunity to study the orientation of the incubating and brooding female in relationship to the direction of sun-rays and prevailing wind. Weller (1958) published a detailed study on the orientation of this species to sunlight. His observations are compared with the present study, and additional relations are noted here.

On June 5, 1958, the incubation behavior was observed continuously from sundown until total darkness. Just at sundown, the male came to the roof of Wills Gymnasium, flew over the roof-top several times in power dives, and then landed about one foot away from the female incubating the eggs. After several minutes, he left. At twilight he returned and again circled the roof, giving his characteristic call, and landed on the roof some distance south of the female. He called to the female several times, then flew to a position near her. After several minutes, he again left the roof. At dusk, when he was barely visible, he returned to the roof, but this time flew in silently and replaced the female at the nest. He continued incubating the eggs until it was too dark to see further. This is the first time the writer has observed the male taking part in the incubation of the eggs.

On June 6, at 10:30 P.M., the writer flushed the adult bird on the nest and listened to peeping sounds coming from one of the two eggs. The next day this egg was hatched. That evening the male joined the female on the roof at 9:15 P.M. On June 8, the female was captured in a drop trap and proved to be No. 42-232611, which has nested on our campus since 1950. The nestling was banded with No. 512-45998. The male circled overhead, while the female was being captured and the nestling was banded, but he did not land on the roof at any time the writer was in sight.