

INDIVIDUAL VARIATION IN THE FISH CROW,
CORVUS OSSIFRAGUS

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THE present study deals with quantitative variation in weight and in the integumentary and skeletal systems of *Corvus ossifragus*. The White-necked Raven (*Corvus cryptoleucus*) was similarly treated in a previous paper (Baumel, Condor, 55: 26-32, 1953).

Over a period of years I have had occasion to acquire and prepare a series of skeletons of *C. ossifragus*, most of which were collected in Florida. Weight, several external measurements, and age of each specimen were recorded prior to skeletonizing. The age classes, immature or adult, were determined from plumage characteristics following Emlen (Condor, 38: 99-102, 1936). Those birds which had not completed the first postnuptial molt were considered immature. Approximately half the series consists of immature specimens. Since the series is divisible into age classes, it was necessary to learn to what extent, if any, the classes differed in size and weight.

Throughout the paper the following abbreviations are used: N = number of specimens; R = observed range; M = mean; σ = standard deviation; V = coefficient of variability (per cent); CD = coefficient of divergence (per cent). Confidence limits equivalent to t -values of 3.00 are used as criteria of statistical significance.

Weight.—Emlen (*op. cit.*) states that first-year *Corvus brachyrhynchos* generally weigh 20 to 30 grams more than adults of their respective sexes as winter approaches. The specimens of *ossifragus* were collected throughout the year; thus, no direct comparison with *brachyrhynchos* along these lines can be undertaken. By calculating means and standard deviations for the four groups (adult males, immature males, adult females, and immature females) and applying statistical tests, it was learned that no significant differences between means of the age groups existed for either sex. Because of this, weights of immatures and adults were combined and recast as single distributions (Table 1).

TABLE 1
BODY WEIGHT (GRAMS) OF *Corvus ossifragus*

Sex	N	R	M	σ	V	CD
♂	20	260.4-332.0	299.94 ± 4.65	20.28 ± 3.21	6.76 ± 1.07	10.41
♀	19	194.7-304.2	270.25 ± 5.43	23.04 ± 3.74	8.52 ± 1.38	

From this table it is evident that the mean weight of males exceeds that of females, but the observed ranges overlap. The difference

between the means is significant ($t = 4.3$). The coefficients of variability suggest that females may be more variable than males. A t -test proved this difference was not real. The coefficient of divergence here conveys the information that male Fish Crows average 10.41 per cent heavier than females.

External Measurements (Table 2).—Culmen length was measured with dividers from the fronto-nasal angle to the tip of the bill. Wing

TABLE 2
EXTERNAL MEASUREMENTS (MM.) OF *Corvus ossifragus*

Measurement	Sex	N	R	M	σ	V	CD
Culmen length	♂	25	44.0-54.9	47.96±0.52	2.53±0.36	5.28±0.75	10.35
	♀	20	40.0-47.6	43.24±0.41	1.81±0.29	4.18±0.66	
Tarsus length	♂	25	42.8-49.5	46.40±0.35	1.72±0.24	3.71±0.53	4.16
	♀	20	41.7-46.2	44.51±0.32	1.41±0.22	3.17±0.50	
Middle toe without claw	♂	25	32.3-38.9	35.94±0.34	1.67±0.24	4.64±0.66	5.69
	♀	20	31.7-38.4	33.95±0.37	1.62±0.26	4.77±0.75	
Middle toe with claw	♂	25	42.5-52.1	47.99±0.62	3.04±0.43	6.33±0.90	7.21
	♀	20	41.5-50.2	44.65±0.53	2.29±0.36	5.12±0.81	
Wing length	♂	24	260-300	281.1 ±2.15	10.31±1.49	3.67±0.53	4.66
	♀	20	253-283	268.3 ±2.04	8.87±1.40	3.31±0.52	
Tail length	♂	24	147-174	159.7 ±1.38	6.60±0.95	4.14±0.60	6.40
	♀	20	135-160	149.8 ±1.40	6.12±0.97	4.09±0.65	

length was taken with the remiges flattened (arc). The other measurements are those in standard use among ornithologists and need no definition.

For the characters, culmen length, tarsus length, and lengths of middle toe with and without claw, the means of immatures and the means of adults very closely approximated one another. Age differences in neither sex were manifest.

In the case of the two remaining external characters, wing length and tail length, considerable differences between the means of adults and immatures were obtained. The means of adults were slightly larger in all instances. Statistical tests were applied, and it was observed that the age differences in wing length approached significance:

$$\begin{array}{ll} \text{Males } t = 1.9 & P < 0.10 \\ \text{Females } t = 1.6 & P < 0.20 \end{array}$$

Age differences between means for tail length are even more statistically valid than with the wing:

$$\begin{array}{ll} \text{Males } t = 3.4 & P < 0.01 \\ \text{Females } t = 2.2 & P < 0.05 \end{array}$$

It is felt that a larger sample might demonstrate all of these to be significant.

Because of the above non-significant differences, all adult and immature external measurement values for each sex were lumped, and this aggregate data provides the basis for the statistics in Table 2.

Mean measurements of males are in all cases significantly larger than those of females (t 's 4.0–7.0); however, there is overlap. Comparison of the coefficients of variability shows neither sex significantly more variable than the other in any external character. Coefficients of variability of the six external measurements were averaged: ♂ $M = 4.63$, ♀ $M = 4.11$. Culmen length presents the most sexual divergence ($CD = 10.35$ per cent). The average sexual divergence (means of 6 CD 's) is 6.41 per cent. Comparison of skeletal data with the data on external measurements shows slightly more sexual dimorphism in size exhibited by the latter.

Skeletal Measurements.—Forty-one measurements of the skeleton were made on each of the 39 specimens unless elements were lacking or broken. Measurement methods for all but the few defined below were described in the previous paper on *Corvus cryptoleucus* (Baumel, *op. cit.*).

Maxillary width.—Greatest width of upper jaw, at level of bases of maxillo-palatine processes.

Interorbital width.—Least width across frontal bones between orbits.

Symphysis length.—Length of mandibular symphysis.

Articular width.—Transverse distance between tips of internal and external process of articular bone of lower jaw.

Sternum length.—Distance from ventral manubrial spine to posterior border of metasternum.

Anterior sternum width.—Transverse distance between lateral margins of sterno-coracoidal processes of sternum.

Epicleidium.—Antero-posterior length of dorsal, expanded end of clavicle.

Coracoid width.—Width of sternal end of coracoid; from internal distal angle to most lateral point on sterno-coracoidal process.

Pre-ilium width.—Least transverse width across pre-acetabular ilia.

Data on the skeleton are to be seen in Table 3. It should be explained that these data are based on samples comprised of both immature and adult specimens. Prior to combining the skeletal measurements of both groups, it was necessary to determine if adults and immatures differed to any appreciable extent. Significant differences were not found.

Table 3 shows that in every instance, except that of *interorbital*

TABLE 3
SKELETAL MEASUREMENTS (MM.) OF *Corvus ossifragus*

Measurement	Sex	N	R	M	σ	V	CD
Skull length	♂	20	73.6-81.3	77.90±0.45	2.01±0.32	2.58±0.41	6.67
	♀	19	70.5-76.4	72.87±0.35	1.53±0.25	2.10±0.34	
Cranial length	♂	20	35.7-37.8	36.56±0.14	0.61±0.10	1.66±0.26	3.71
	♀	18	33.7-36.4	35.23±0.18	0.75±0.12	2.12±0.35	
Cranial depth	♂	19	20.6-23.0	21.51±0.15	0.64±0.10	2.98±0.48	0.47
	♀	19	19.7-22.6	21.41±0.16	0.71±0.12	3.33±0.54	
Culmen length	♂	20	39.5-45.7	42.85±0.38	1.72±0.27	4.01±0.63	9.45
	♀	18	36.3-41.0	38.89±0.29	1.21±0.20	3.12±0.52	
Frontonasal width	♂	20	18.3-20.5	19.10±0.12	0.54±0.09	2.81±0.45	4.99
	♀	18	16.4-19.6	18.17±0.18	0.76±0.13	4.16±0.69	
Maxillary width	♂	20	16.8-18.9	17.83±0.13	0.58±0.09	3.26±0.52	7.69
	♀	19	16.0-17.8	16.51±0.12	0.51±0.08	3.07±0.50	
Interorbital width	♂	20	12.2-14.6	13.37±0.16	0.71±0.11	5.32±0.84	*1.12
	♀	17	11.6-16.3	13.52±0.23	0.95±0.16	7.06±1.21	
Postorbital width	♂	20	31.1-33.2	31.97±0.13	0.60±0.10	1.88±0.30	3.44
	♀	19	29.9-31.7	30.89±0.11	0.49±0.08	1.58±0.26	
Ramus length	♂	19	60.3-66.7	63.38±0.40	1.73±0.28	2.73±0.44	7.45
	♀	18	56.8-62.1	58.83±0.36	1.53±0.26	2.60±0.43	
Ramus height	♂	20	6.1-6.9	6.53±0.05	0.23±0.04	3.55±0.56	3.90
	♀	19	5.8-6.6	6.28±0.05	0.24±0.04	3.77±0.61	
Symphysis length	♂	19	13.8-16.9	15.31±0.20	0.85±0.14	5.57±0.90	10.66
	♀	18	12.3-15.2	13.76±0.18	0.74±0.12	5.40±0.90	
Articular width	♂	20	9.5-10.9	10.45±0.07	0.33±0.05	3.15±0.50	7.24
	♀	19	9.3-10.2	9.72±0.06	0.26±0.04	2.65±0.43	
Basihyal length	♂	20	11.5-14.6	13.15±0.20	0.88±0.14	6.68±1.06	7.25
	♀	19	10.4-13.8	12.23±0.21	0.91±0.15	7.44±1.21	
Sternum length	♂	20	46.0-49.5	47.68±0.22	0.98±0.16	2.05±0.32	6.21
	♀	19	41.4-47.2	44.81±0.36	1.58±0.26	3.52±0.57	
Keel length	♂	20	42.6-46.8	44.95±0.27	1.21±0.19	2.69±0.43	6.90
	♀	18	38.7-45.0	41.95±0.42	1.76±0.29	4.21±0.70	
Keel depth	♂	20	13.8-16.5	15.15±0.13	0.56±0.09	3.69±0.58	5.49
	♀	19	13.5-15.3	14.34±0.14	0.63±0.10	4.37±0.71	
Anterior sternum width	♂	20	24.9-29.4	27.07±0.25	1.13±0.18	4.17±0.66	4.96
	♀	18	23.6-28.1	25.76±0.29	1.21±0.20	4.71±0.78	
Mid-sternum width	♂	20	21.7-26.0	23.35±0.24	1.06±0.17	4.55±0.72	2.56
	♀	18	21.8-24.3	22.76±0.18	0.76±0.13	3.34±0.56	
Clavicle length	♂	19	36.6-40.1	37.90±0.24	1.04±0.17	2.74±0.45	4.73
	♀	19	34.2-38.1	36.15±0.23	1.00±0.16	2.76±0.45	
Epicleidium	♂	20	9.3-11.0	10.14±0.09	0.40±0.06	3.96±0.63	7.89
	♀	19	8.8-9.9	9.37±0.06	0.28±0.05	2.96±0.48	
Coracoid width	♂	20	9.9-11.9	11.03±0.11	0.50±0.08	4.54±0.72	4.07
	♀	19	9.7-11.7	10.59±0.11	0.46±0.07	4.33±0.70	
Coracoid length	♂	20	37.9-40.8	39.36±0.15	0.68±0.11	1.73±0.27	7.90
	♀	19	35.2-40.2	37.33±0.22	0.97±0.16	2.60±0.42	
Scapula length	♂	20	42.2-47.5	45.30±0.31	1.39±0.22	3.08±0.49	6.26
	♀	19	39.8-44.9	42.55±0.24	1.04±0.17	2.44±0.40	
Humerus length	♂	20	55.7-60.0	58.05±0.26	1.15±0.18	1.98±0.31	4.74
	♀	19	52.5-59.0	55.36±0.35	1.52±0.25	2.74±0.44	
Ulna length	♂	20	70.3-79.2	74.45±0.44	1.98±0.31	2.65±0.42	4.59
	♀	19	67.3-76.2	71.11±0.46	2.02±0.33	2.84±0.46	
Radius length	♂	20	63.6-72.0	67.65±0.40	1.79±0.28	2.65±0.42	4.15
	♀	19	61.2-69.8	64.90±0.47	2.04±0.33	3.14±0.51	
Metacarpus II	♂	20	37.4-42.0	39.82±0.26	1.16±0.18	2.91±0.46	4.31
	♀	19	35.8-39.6	38.14±0.22	0.96±0.16	2.52±0.41	
Metacarpus III	♂	20	40.9-45.6	43.25±0.26	1.15±0.18	2.66±0.42	4.88
	♀	19	39.2-42.6	41.19±0.21	0.93±0.15	2.25±0.37	

* Mean for female greater than that for male.

TABLE 3—Continued

Measurement	Sex	N	R	M	σ	V	CD
<i>Index, Phalanx 1</i>	♂	20	19.4-21.9	20.81±0.12	0.55±0.09	2.66±0.42	6.81
	♀	19	17.8-20.8	19.44±0.16	0.70±0.11	3.62±0.59	
<i>Index, Phalanx 2</i>	♂	20	11.7-13.1	12.54±0.11	0.47±0.07	3.76±0.59	4.48
	♀	19	11.2-12.6	11.99±0.10	0.43±0.07	3.56±0.58	
<i>Synsacrum length</i>	♂	18	36.1-40.2	38.20±0.25	1.05±0.18	2.76±0.46	4.17
	♀	18	33.7-38.7	36.64±0.27	1.14±0.19	3.11±0.52	
<i>Pre-ilium width</i>	♂	20	14.8-17.9	16.60±0.16	0.70±0.11	4.22±0.67	4.37
	♀	19	15.3-17.1	15.89±0.11	0.47±0.08	2.94±0.48	
<i>Mid-synsacrum width</i>	♂	20	27.3-30.1	28.35±0.16	0.70±0.11	2.46±0.39	3.48
	♀	19	26.0-28.7	27.38±0.15	0.67±0.11	2.46±0.40	
<i>Post-ilium width</i>	♂	19	24.9-28.3	27.01±0.21	0.90±0.15	3.34±0.54	2.06
	♀	19	25.2-28.5	26.46±0.21	0.89±0.15	3.38±0.55	
<i>Pelvic width</i>	♂	19	20.8-23.8	21.78±0.16	0.71±0.12	3.26±0.53	4.22
	♀	19	19.2-22.7	20.88±0.21	0.91±0.15	4.35±0.71	
<i>Femur length</i>	♂	19	42.3-46.7	44.54±0.26	1.11±0.18	2.50±0.41	4.50
	♀	19	39.3-45.7	42.58±0.27	1.18±0.19	2.77±0.45	
<i>Tibia length</i>	♂	20	70.6-79.4	75.50±0.43	1.91±0.30	2.53±0.40	4.51
	♀	18	67.7-77.5	72.17±0.50	2.10±0.35	2.91±0.49	
<i>Tarsus length</i>	♂	20	43.8-49.7	47.65±0.33	1.49±0.24	3.12±0.49	4.24
	♀	18	42.4-48.2	45.67±0.30	1.27±0.21	2.79±0.46	
<i>Pygostyle length</i>	♂	18	16.4-19.2	17.53±0.19	0.82±0.14	4.66±0.78	6.30
	♀	19	14.7-18.4	16.46±0.19	0.83±0.14	5.06±0.82	
<i>Hallux, Phalanx 1</i>	♂	20	17.4-20.2	18.90±0.16	0.71±0.11	3.74±0.59	7.01
	♀	19	16.3-18.4	17.62±0.11	0.47±0.08	2.68±0.44	
<i>Hallux, Ungual Phalanx</i>	♂	20	13.9-15.9	15.03±0.13	0.57±0.09	3.78±0.60	6.95
	♀	19	13.2-14.9	14.02±0.09	0.41±0.07	2.90±0.45	

width, the means of males are greater than those of females, but the observed ranges overlap. Only four characters [*cranial depth* ($t = 0.46$), *interorbital width* ($t = 0.55$), *mid-sternum width* ($t = 1.95$), and *post-ilium width* ($t = 1.89$)], failed to demonstrate a significant difference between the means of males and those of females.

Coefficients of divergence, expressing the percentage of size dimorphism between the sexes, range from 0.47 to 10.66, and average 5.39 per cent (*interorbital width* excluded). The modal class of coefficients of divergence falls between 4 and 5 per cent; thus, it can be stated that the skeletons of male *ossifragus* are about 5 per cent larger than those of females.

Coefficients of variability range from 1.58 to 7.44 per cent for males and from 1.66 to 6.68 per cent for females. In no instance was either sex significantly more variable than the other. Means and modes were calculated on the coefficients of variability for the entire group of 41 measurements:

	Mean	Mode
♂	3.29	2.66
♀	3.41	2.39

An idea of the degree of variation in size of the "composite" skeleton of *ossifragus* may be gained from the summation above.

Discussion.—Wing length and tail length are the only characters considered which demonstrate any appreciable mean size differences between immatures and adults. Inasmuch as these are plumage characters, such differences are not unexpected in view of the other qualitative or morphological differences in plumage exhibited between birds of the year and adults.

The other external measurements are in reality measurements of the skeleton. Significant differences between the age groups are lacking for these as well as for the skeletal measurements *per se*, which indicates that definitive skeletal size in *ossifragus* is probably attained soon after fledging.

Corvus ossifragus displays essentially the same magnitude of variation as does *C. cryptoleucus*; however, greater average size differences between the sexes are found for *ossifragus* than for *cryptoleucus*. The following figures will illustrate this:

<i>Average of CD's (per cent)</i>	<i>C. ossifragus</i>	<i>C. cryptoleucus</i>
Weight	10.41	8.23
External measurements	6.41	3.07
Skeletal measurements	5.39	3.18

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