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GEOGRAPHIC VARIATION IN SIZE OF FEMALE WILD ROCK DOVES[1]

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The Rock Dove (*Columba livia*) was domesticated around 5,000 years ago in the eastern Mediterranean region generally called the Near East (Levi 1974). Escapes of domestics from confinement for thousands of years have provided stocks that developed into feral populations. Feral pigeons now have characteristics of both wild and domestic ancestry, frequently live essentially as though they are wholly wild, and are capable of broadscale genetic introgression in wild colonies (Johnston et al. 1988, Johnston and Janiga 1995).

In western Europe, wild colonies are known to exist in the Outer Hebrides of Scotland and perhaps on the coastline of northern and western Ireland; in the Mediterranean basin, wild colonies are known from coastal Sardinia, northwestern Egypt, and perhaps Libya and montane sectors of the former Yugoslavia. Interior montane North Africa, the Near East, Afghanistan, Pakistan, northwestern montane India, southwestern China, Uzbekistan, and Russia probably have Rock Dove populations that are still isolated from feral pigeons, but recent information is fragmentary. No information exists on the degree to which wild Rock Doves are killed for food by humans living under high densities in politically and economically unstable regions, but the birds can be subjected to overharvesting when their nesting cliffs are discovered by people short of dietary protein.

For these reasons, as well as of the difficulties in travelling to some of the regions just noted, specimen samples of wild Rock Doves are not likely to be significantly augmented in the near future. An earlier report (Johnston 1992) on size variation was restricted to samples of male specimens, although a display of sexual size dimorphism over the characters employed was provided. Here I provide comparable data for females.

MATERIALS AND METHODS

Museum specimens of wild *C. livia* represent the following regions of Europe, Africa, and Asia: the Faeroes, Shetland, Orkney, Hebrides, Ireland, Italy, Crete, Turkey, north coastal Africa, Chad, Sudan, Egypt, the Near East, Iran, Afghanistan, Pakistan, and northwestern India (Table 1). As is true for males, no specimens from Russia, lowland India, and northwestern coastal Africa were examined. Most specimens were taken in the last half of the 19th century and the first two decades of the 20th, but a few came from the 1940s. Specimen localities were aggregated into 17 regional samples (Table 1). The specimens examined were from the British Museum of Natural History, Tring, England; Museum für Naturkunde der Humboldt-Universität zu Berlin, Germany; and the National Museum of Natural History, Washington, D.C.

The size variables (Table 1) were wing length as maximum chord (using a metal ruler with an end stop), tarsus length, from the heel transversely to the last undivided frontal scute, bill length, from the tip to ceral-base feather growth, and bill width at the anterior edge of the external nares (using dial calipers for the last three).

Data were log-transformed and processed using the

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TABLE 1. Localities, sample sizes, means, and standard deviations (mm) for four size variables of female *Columba livia.*

Localities	n	Wing		Tarsus		Bill l		Bill w	
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
British Isles	19	217.3	5.49	30.6	1.14	18.0	0.68	3.1	0.16
N. Mediterranean	3	211.3	7.51	29.5	0.55	18.0	0.45	3.0	0.15
S. Mediterranean	10	212.8	4.10	28.8	0.86	18.2	0.64	3.0	0.16
E. Mediterranean	15	213.5	6.64	27.8	1.38	18.6	0.70	3.0	0.19
Iraq	3	218.0	2.65	30.4	1.25	18.2	1.48	2.9	0.15
Iran	2	218.5	2.12	29.6	0.78	18.1	0.21	3.0	0.14
Baluchistan	3	221.3	6.43	30.4	1.00	19.2	1.31	2.8	0.12
Afghanistan	3	224.0	10.82	29.8	0.27	19.1	0.80	2.9	0.06
Kashmir	8	221.3	9.13	28.8	1.06	18.7	0.71	3.1	0.02
Punjab	10	214.9	8.69	29.5	0.99	18.7	0.77	2.9	0.15
Sind	7	222.4	6.78	29.2	1.39	19.6	0.67	2.9	0.11
Saudi Arabia	5	204.2	5.63	28.0	0.97	19.0	1.08	2.8	0.13
Yemen	8	214.8	5.06	28.9	1.14	19.1	0.79	3.1	0.18
E. Sudan	4	201.0	3.92	27.1	0.64	19.0	0.58	3.0	0.15
W. Sudan	12	200.9	7.27	27.7	1.28	18.4	0.74	3.1	0.15
S. Algeria	5	204.4	2.97	26.8	1.27	18.5	0.53	3.0	0.16
Dakhla Oasis	6	202.0	5.33	27.4	1.95	18.2	0.59	2.9	0.15

BMDP suite of statistical programs (Dixon, 1990). General or overall size of individuals was obtained as principal component 1 (PC-1) scores, and of localities as the mean of the PC-1 scores of individuals included within each pooled sample. The variance-covariance matrix was used in the PC analysis. Interlocality variation of original variables and of PC scores was examined by ANOVA; the Student-Newman-Keuls (SNK) multiple-range test of means of the PC scores, provided *a posteriori* estimates of interlocality statistical homogeneities.

RESULTS AND DISCUSSION

Interlocality variation in the original size variables was evident (Tables 1 and 2), paralleling the variation found earlier in male specimens (Johnston 1992). Variation in each character was relatively complex, and except for bill length, tended toward small sizes in northern Africa and the Near East, and larger sizes clinally northwesterly through Europe and easterly and southeasterly through the Middle East to the southwestern sectors of the central Asian high country.

Statistical covariation of the original variables was close to that found earlier in males. In the multivariate summary, PC-1 fairly represented general or overall size (Table 3), containing 42% of the total variation and receiving significant positive loadings from wing and tarsus lengths, and bill width. The pattern of variation (Table 4) shows small sizes in northern Africa and the Near East, with PC-1 size increasing easterly into the western sectors of the central Asiatic montane uplift, as well as westerly to the British Isles. Three statistically homogeneous subsets are recognized by SNK analysis (Table 4). The seven African locality samples are statistically separable from all of the remaining ten samples; but if those from Britain and Kashmir are dropped, the remaining 15 are statistically homogeneous.

PC-2 concerned shape—a contrast between wing + tarsus lengths and bill width—and contained 29% of the variation. Birds from the high montane localities of Asia had short wings and legs relative to bill widths and those from the desert localities of Africa had long wings and legs relative to bill widths; these shape differences may be related to differences in the temperature and humidity environments of these distinct bioclimatic regions. SNK analysis showed three broad statistical differentiates that support these generalizations reasonably well.

TABLE 2. Summaries of analyses of variance of interlocality variation in wing, tarsus, and bill lengths, bill width, PC-1, PC-2, and PC-3 in wild female *Columba livia.*

Variable	df	F	P
Wing length	16	9.18	<0.0001
Tarsus length	16	7.34	<0.0001
Bill length	16	1.63	0.0005
Bill width	16	0.07	0.0019
PC-1	16	5.25	<0.0001
PC-2	16	5.89	<0.0001
PC-3	16	3.48	0.0001

TABLE 3. Loadings[a] of the original variables onto the three principal components of variation in size characters of wild *Columba livia* females.

Variable	PC-1	PC-2	PC-3
Wing length	0.613	−0.443	−0.068
Tarsus length	0.834	−0.440	−0.121
Bill length	0.123	−0.055	0.986
Bill width	0.622	0.782	0.001
Eigenvalues	1.472	1.005	0.991

[a] Correlations of the original variables to PCs 1–3.

TABLE 4. Locality[a] means and standard deviations of scores on PC-1 and PC-2 from a matrix of four skin variables of female *Columba livia,* with an estimate of the minimum number of statistically homogeneous locality subsets.[b]

PC-1				PC-2			
Locality	Mean	SD	SNK	Locality	Mean	SD	SNK
Dakh	−1.14	1.22		Balu	−1.51	0.53	
Sara	−1.14	0.68		Afgh	−1.23	0.17	
Salg	−1.02	0.66		Sind	−1.11	0.43	
Esud	−0.88	0.51		Iraq	−0.86	0.34	
Wsud	−0.50	0.86		Punj	−0.67	0.60	
Emed	−0.38	0.87		Sara	−0.64	0.53	
Smed	−0.14	0.79		Iran	−0.31	0.96	
Punj	0.09	0.87		Smed	−0.21	0.65	
Sind	0.12	0.94		Brit	−0.12	0.85	
Nmed	0.30	0.65		Nmed	0.08	0.80	
Yemn	0.32	1.02		Yemn	0.24	0.58	
Afgh	0.38	0.55		Emed	0.26	1.01	
Balu	0.44	0.59		Kash	0.31	1.25	
Iran	0.45	0.07		Dakh	0.37	0.60	
Iraq	0.55	1.05		Salg	0.86	0.97	
Kash	0.58	0.57		Esud	0.97	0.74	
Brit	1.02	0.58		Wsud	1.20	0.63	

[a] Locality abbreviations can be translated by comparison to entries in Table 1.
[b] SNK convention, using the 95% confidence level.

PC-3 concerned bill length and summarized 28% of the variation. Bill lengths do not run parallel to the general picture of size variation as summarized in PC-1. Statistical differentiation is not well developed, but short bills are found in western Europe and the Near East, and longer bills in northern Africa, the middle east, and the Asian high country.

The male and female analyses may be considered to be statistical replicates of one another—the females are a second specimen set drawn from the same locality pools as the males; females differ from males by having one Z chromosome, with attendant morphologic, endocrinologic, and behavioral consequences. These differences, incidentally, account for the fact that fewer female pigeons than males are collected: collectors are up and about early each day, and in the prolonged breeding season of pigeons females are still on the nest at those hours. Males take over incubation and brooding at perhaps 09:00 and sit until around 16:00 to 17:00; males are thus maximally exposed to both early morning and early evening hunting by bird collectors.

Comparing mean locality scores of PC-1 for both sexes, locality rank-orders of the scores were strongly correlated ($r_s = 0.834$, $P < 0.01$). For PC-2, the rank-order correlation for locality scores was $r_s = 0.748$ ($P < 0.01$). The geographic configurations of the scores are complex, as noted above. Replication in females of the patterns first found in males is unlikely to have occurred by chance ($P < 0.0001$). Since male and female Rock Doves share a common genetics, one expects to find not only a shared morphometrics (Lande 1980), but also a shared pattern of geographic morphometric variation. Indeed, absence of shared patterns probably would have indicated some kind of inadequacy in the study.

Concerning infraspecific taxonomy (e.g., Vaurie 1965 and Cramp 1985), size variation in the female specimens supports what was learned from the males (Johnston 1992). Thus, the earlier conclusion is still tenable, namely that the pervasively clinal and geographically complex size variation in *C. livia* makes the application of size characters to the definition of subspecies arbitrary and dependent on gaps in collection localities.

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