WEIGHTS AND WING LENGTHS OF WILD SONORAN MASKED BOBWHITES DURING FALL AND WINTER

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Bobwhite (*Colinus virginianus*) populations extend from Minnesota south to the Mexican state of Chiapas (approximately 3500 km) and from the far eastern United States west to central Colorado (approximately 2800 km) (Aldrich and Duvall 1955). The species has a complex and definable pattern of morphological variation which is clinal throughout most of its range (Aldrich 1946). The Masked Bobwhite (*C. v. ridgwayi*), a geographically isolated form, inhabits mesquite-grasslands at elevations of 120–730 m in the state of Sonora, Mexico. This population once extended into southern Arizona but was extirpated there by overgrazing of suitable habitat before 1900 (Tomlinson 1973a). Its current status in Sonora is critical as a result of continued land abuse, and the bird has been listed as "endangered" since 1966 (Bureau of Sport Fisheries and Wildlife 1966, 1968, 1973). I conducted an ecological study of this endangered population during 1968–72 (Tomlinson 1973b), and efforts to reestablish the Masked Bobwhite in the historical range of Arizona are currently underway (Tomlinson 1973c).

This paper presents weight and wing measurement information obtained from wild-captured Sonoran birds, compares weights with those of other Bobwhite populations in the U.S. and Mexico, and discusses Bergmann's Rule as it pertains to the Bobwhite.

METHODS

During the three fall-winter seasons between 1968 and 1971, 187 Masked Bobwhites were captured near Benjamin Hill, Sonora as part of a life history study (Table 1). At the time of capture, I examined each bird and recorded sex and age, stage of primary molt, wing length, and total body weight. A standard U.S. Fish and Wildlife Service band was attached to one leg.

Weights were obtained in the field on a 500-g Hanson Dietetic scale, accurate to 1 g. A special millimeter board was used to measure one wing of each bird from the bend of the wing to the tip of the longest primary when the primaries were fully extended. Wing lengths obtained by this method are known to be slightly longer and therefore not directly comparable with standard museum wing (chord) measurements (Aldrich 1946—103–111 mm chord length for 7 specimens of Masked Bobwhite vs. 107–120 mm for 52 adult specimens in this study). Molt category was determined by noting the most recent primary to fall, but measurements of emerging primaries were not attempted; exact aging of immatures (Petrides and Nestler 1952) was therefore not possible and approximate figures are used for comparative purposes. I distinguished adults from immatures by differences in coloration of primary coverts (Leopold 1939, Haugen 1957). Separation of subadults from older adults was not practicable during the trapping periods because most birds had molted through their eighth and ninth primaries and distinguishing char-

TABLE 1

SUMMARY OF MASKED BOBWHITE TRAPPING NEAR BENJAMIN HILL, SONORA, MEXICO, WINTERS 1968–1970

	Adults		Immatures			
Fate of Trapped Birds	Male	Female	Male	Female	Unknown	Total
Saved for propagation stock	10	8	16	23	0	57
Banded and released	18	10	25	15	1	69
Recaptured and released	8	2	25	13	2	50
Died in traps	1	4	1	5	0	11
Total	37	24	67	56	3	187

acteristics were usually lacking. Accordingly, subadults were grouped with adults. Weights of recaptured adults (repeats) were not included in the summaries of adult weight data (Table 2) to avoid introducing biases in the small sample. Data from recaptured immatures, however, were included in the summaries of weights of immatures (Table 3), as weight gains between trappings represented new information.

RESULTS

Adult Weights and Wing Lengths—The average weight for 26 adult males was 168.6 g, and for 19 adult females, 162.8 g. Weights for males generally followed a normal frequency distribution, but those for females tended to be clustered at both ends of the distribution. Examination of the data by month revealed that the lowest weights for females were generally obtained in October. Pooled t-tests (Dixon and Massey 1951:103) indicated that October females (156.3 g) were significantly lighter than females caught later (168.7 g) ($t = 2.25$, $P < 0.05$, 17 d.f.), that male weights were not significantly different between October (166.1 g) and later samples (170.8 g) ($t = 1.59$, $P > 0.10$, 24 d.f.), and that there were no significant differences between all males (168.6 g) and those females caught after October (168.7 g) ($t = 0.03$, $P > 0.10$, 34 d.f.). Females probably reach their lowest annual weight in October because this population nests later than U.S. Bobwhite populations and sometimes does not bring off broods until late October or early November (Tomlinson 1973b:305). After October, average weights for the sexes are not significantly different (170.7 g for males and 168.7 g for females; $t = 0.47$, $P > 0.10$, 22 d.f.). This conclusion was also reached for Bobwhites in the Midwest (Hamilton 1957, Roseberry and Klimstra 1971).

Average wing length for 31 adult males was 113.5 mm, and for 21 adult females, 112.9 mm (Table 2). Mean wing lengths for each sex were not significantly different ($t = 0.88$, $P > 0.10$, 50 d.f.), although females again tended to have more individuals at each extreme of the frequency distribution.

TABLE 2

AVERAGE WEIGHT (G) AND WING LENGTH (MM) BY MONTH OF ADULT WILD SONORAN MASKED BOBWHITES

	WEIGHT			
	MEAN		RANGE	
Month	Male	Female	Male	Female
Oct.	166.1 (12)[1]	156.3 (9)	149–179	147–170
Nov.	173.8 (5)	175.0 (3)	165–181	157–195
Dec.	167.0 (6)	167.0 (3)	162–173	146–179
Jan.	173.0 (3)	165.2 (4)	173–173	150–176
Overall	168.6 (26)	162.8 (19)	149–181	146–195
± t.05 S.E	± 3.04	± 6.10		

	WING LENGTH			
	MEAN		RANGE	
Month	Male	Female	Male	Female
Aug.	111.5 (2)	–	110–113	–
Oct.	113.2 (14)	112.5 (11)	110–117	110–116
Nov.	115.8 (5)	115.3 (3)	115–118	112–120
Dec.	113.4 (7)	114.6 (3)	112–115	110–117
Jan.	112.8 (3)	110.5 (4)	111–114	107–112
Overall	113.5 (31)	112.9 (21)	110–118	107–120
± t.05 S.E.	± 0.72	± 1.28		

[1] Sample size in parentheses—Discrepancies in sample sizes from Table 1 due to summer trapping and/or measurement of dead birds. No trap repeats included.

Immature Weights and Wing Lengths—Immature weights and wing lengths (Table 3) were grouped according to the stage of their primary wing molt rather than by month as with adults. This grouping allows comparison of young birds at various ages. The actual ages of these birds are unknown although an estimate can be made if one assumes that Masked Bobwhites molt at the same rate as their midwestern counterparts (Petrides and Nestler 1952). Birds molting the second primary could not be accurately sexed because of incomplete plumage development.

Weights of immature Masked Bobwhites increased from about 75 to 158.0 g for females and to 169.9 g for males between their second and eighth primary molt stages, for an average weight gain of approximately 85 to 95 g in about 3 months. Simultaneously, the average wing length of Masked Bobwhites increased from 98 to 112.6 mm for females and to 112.2 mm for males. This growth rate compares well with that of immature Illinois birds, which gained from 78 to 174 g during the same physiological period (Roseberry and

TABLE 3

AVERAGE WEIGHT (G) AND WING LENGTH (MM) BY PRIMARY MOLT CATEGORY FOR IMMATURE SONORAN MASKED BOBWHITES[1]

		WEIGHT			
		MEAN		RANGE	
Primary Molt Category	Approx. Age in Days	Male	Female	Male	Female
2	37	75.0 (2)[2]		75–75[2]	
4	50	91.0 (3)	88.5 (2)	78–100	81–96
5	65	126.7 (3)	132.0 (3)	114–136	130–134
6	80	140.1 (14)	128.3 (6)	122–158	118–137
7	99	160.3 (28)	146.9 (33)	138–192	124–172
8	126	169.9 (9)	158.9 (8)	159–180	146–179

		WING LENGTH			
		MEAN		RANGE	
Primary Molt Category	Approx. Age in Days	Male	Female	Male	Female
2	37	98.0 (2)[2]		97–99[2]	
4	50	103.0 (2)	102.0 (2)	103–103	102–102
5	65	111.0 (7)	109.0 (3)	108–114	105–111
6	80	109.0 (9)	107.5 (4)	107–110	106–109
7	99	111.8 (27)	110.1 (35)	107–117	105–115
8	126	112.2 (9)	112.6 (8)	110–115	110–114

[1] Sample size in parentheses. Samples include trap repeats for both weight and wing length and dead birds for wing length.
[2] Incomplete plumage development for these two birds did not allow accurate judgement of sex.

Klimstra 1971). Wing length data from the Midwest are not available for comparison.

Young Masked Bobwhites had essentially reached adult size and weight by the time they molted their eighth primaries. The older immature males averaged slightly heavier than adult males (169.9–168.6 g, $t = 0.45$, $P > 0.10$, 33 d.f.) but had slightly shorter wings (112.2–113.5 mm, $t = 1.74$, $P > 0.05$, 38 d.f.). Immature females weighed less than adult females (158.9–162.8 g, $t = 0.76$, $P > 0.10$, 25 d.f.) and had completed growth of wing feathers (112.6–112.9 mm, $t = 0.28$, $P > 0.10$, 27 d.f.). Although not statistically significant in this study, a relatively lighter weight of immature females in comparison to other age and sex classes was also observed in the Illinois study.

DISCUSSION

Weight data for certain Bobwhite populations in the U.S. have been presented by several authors. Hamilton (1957) gave an excellent review of

Bobwhite winter weights in relation to geographical location in the U.S. Roseberry and Klimstra (1971) presented voluminous weight data for Bobwhites taken in southern Illinois during all seasons of the year. These authors, as well as Ripley (1960) and Robel and Linderman (1966), discussed Bergmann's Rule as it pertains to this species, i.e., that body size, and therefore weight, increases from south to north in the U.S. A positive correlation between latitude and weight was observed by each writer.

Bergmann's ecogeographical rule was defined by Mayr (1963) as follows: "Races from cooler climates tend to be larger in species of warm-blooded vertebrates than races of the same species living in warmer climates." James (1970) and McNab (1971) recently reviewed this rule as applied to birds and mammals, respectively. McNab (1971) concluded that mammals generally do not follow the rule. James (1970), however, presented strong evidence that, "Intraspecific size variation in homeotherms [12 species of birds] is related to a combination of climatic variables that includes temperature and moisture." And that, "Small size is associated with hot, humid conditions, larger size with cooler or drier conditions." She further describes the clinal aspects of size changes in relation to topography and latitude.

A modification of Hamilton's (1957) summary, with additional data on Bobwhite populations from Mexico provided by Leopold (1959) and by my study, is presented in Table 4. These data suggest that the varied populations in Mexico also increase in weight from south to north. The correlation coefficient for the mean weights and respective latitudes in Table 4 is 0.95. The discrepancies (in Morelos and the uplands of south-central Mexico) possibly occur because the birds were collected at higher elevations and this factor probably affects weight as does latitude (James 1970:375 and 387–388).

The area in Sonora where the Masked Bobwhites were trapped during my study is almost exactly at 30°N latitude, which corresponds to north Florida and southern Georgia where Stoddard (1931) reported an average weight of 165 g for all age and sex Eastern Bobwhites encountered during the fall and winter. I obtained an almost identical figure (165.7 g) when weights for all immatures in the eighth primary molt category and all adults were averaged. Thus, weights of Bobwhites, at the same latitude but of different populations and separated by over 2600 km longitudinally, are astonishingly alike. James (1970) found that the bird species she examined tended to be larger in dry climates than in moist climates with approximately equal average temperatures. Although Sonora has a drier climate than Florida, the high temperature and humidity during the July–September rainy season in Sonora (the breeding season of the Masked Bobwhite, Tomlinson 1973b) may be the selective force affecting weights similar to those of the Florida population.

Bergmann's Rule, as defined by Mayr (1963), appears to hold true for

TABLE 4

AVERAGE WEIGHTS OF BOBWHITES DURING FALL AND WINTER AS RELATED TO LATITUDE (MODIFIED FROM HAMILTON 1957 AND LEOPOLD 1959)

Location of Study	Approx. Latitude, °N	Average Wt. (g)	N	Authority
Chiapas, Mexico	16	129	?	Leopold (1959)
Morelos, Mexico	19	149	?	"
Vera Cruz, San Luis Potosi, Mexico (coastal)	21	133	?	"
San Luis Potosi, Jalisco. Queretaro, Mexico (uplands)	22	159	?	"
Tamaulipas, Nuevo Leon, Mexico	24	152	?	"
Florida	25–30	161.6	?	Nelson and Martin (1953)
Sonora, Mexico	30	165.7	65	Tomlinson (this study)
N. Florida and S. Georgia	30–31	165.0	188	Stoddard (1931)
South Carolina	32	176.3	244	Stoddard (1931)
S. Illinois	37	178.2	847	Roseberry and Klimstra (1971)
S. Missouri	37	186.0	166	Leopold (1945)
Central Missouri	39	176.3	215	Hamilton (1957)
Leetonia, Ohio	41	186.8	108	Stewart (1937)
Dunn Co., Wisconsin	45	203.0	845	Buss, et al. (1947)

Bobwhites from Chiapas, Mexico, to the northern distributional limits of the species in the U.S. Hamilton's (1957) suggestion that the quality of soils at different latitudes might be the causative factor for weight differences in Bobwhites has some merit but it should be pointed out that soil quality also varies greatly from place to place at the same latitude. The explanation that the birds' weights have become adjusted through the evolutionary process to more easily regulate body temperature in relation to air temperature and humidity (James 1970) seems to be more plausible.

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