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SIZE COMPARISON OF RESIDENT AND WINTERING AMERICAN KESTRELS IN SOUTH-CENTRAL FLORIDA

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Abstract.—Body mass and six linear measurements of resident (*Falco sparverius paulus*) and wintering (*F. s. sparverius*) American Kestrels in south-central Florida were compared. Sex differences in size and variability (coefficient of variation) were somewhat greater in *sparverius* than *paulus*. Means of body mass of *paulus* males and females were 21.9% and 25.8% less than those of corresponding sexes of *sparverius*, and means of all linear measurements except culmen length were significantly ($P < 0.05$) smaller in one or both sexes of *paulus*. Although the smaller size of kestrels in the southeastern U.S. follows Bergmann's rule, the size difference might be related to smaller prey size as well as thermoregulatory factors. Measurements of presumed resident kestrels from Florida, Louisiana and Mississippi suggest a north–south trend of decreasing size, but the data are inadequate for detailed geographic comparison. The general similarity of coefficients of variation of measurements of *sparverius* and *paulus* is interpreted as evidence of no, or a low level of, interbreeding in the study area even though *paulus* is greatly outnumbered by wintering *sparverius* and individuals of the two subspecies may occur in close proximity during a major part of the *paulus* breeding season.

COMPARACIONES EN EL TAMAÑO DE INDIVIDUOS DE POBLACIONES RESIDENTES E INVERNALES DE *FALCO SPARVERIUS* EN LA PARTE SUR-CENTRAL DE FLORIDA

Sinopsis.—Se compararon la masa corporal y seis medidas lineares de individuos residentes (*Falco s. paulus*) e invernales (*F. s. sparverius*) del Cernícalo Americano. Diferencias entre el tamaño de los sexos y variabilidad (coeficiente de variación) resultaron algo mayores en *sparverius* que en *paulus*. La masa corporal promedio de los machos y hembras de *paulus* fueron 21.9% y 25.8% menos que las correspondientes a los sexos en *sparverius*. Las medianas de todas las medidas lineares, excepto el largo del culmen, resultaron significativamente menor ($P < 0.05$) en uno o ambos sexos de *paulus*. Aunque la reducción de tamaño en los sexos en el suroeste de los Estados Unidos, sigue la regla de Bergmann, la diferencia en tamaño entre los grupos estudiados podría estar relacionado al pequeño tamaño de sus presas y aspectos relacionados con la termoregulación. Medidas tomadas en cernícalos presumiblemente residentes de Florida, Luisiana y Mississippi, sugieren una tendencia en decrecimiento en tamaño de norte a sur, aunque los datos son inadecuados para establecer comparaciones geográficas detalladas. La similaridad general del coeficiente de variabilidad entre las medidas tomadas a ambos grupos, se interpreta como evidencia de que no existe o hay muy poca reproducción mixta en el área de estudio, aunque en el invierno *sparverius* se sobrepasa en números a *paulus* e individuos de ambas subespecies, pueden encontrarse muy cerca uno del otro durante la mayoría de la época de reproducción de *paulus*.

Few data on body size are available for the resident American Kestrel population (*Falco sparverius paulus*) of the southeastern United States. In addition to the linear measurements included in the original description by Howe (1902), Mearns (1892) and Friedmann (1950) listed measure-

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ments of presumed resident kestrels from Florida, Louisiana and Mississippi, and Storer (1966) and James (1970) gave wing lengths of small numbers of specimens from Florida and other gulf states. Willoughby and Cade (1964) reported body masses of kestrels captured in Florida during November–February, which they assumed included both *paulus* and *sparverius,* but they did not indicate to which subspecies individual values pertained.

Additional data on the size of known resident kestrels in different parts of the range of *paulus* would be useful for better defining the morphometric limits of this subspecies and as an aid in distinguishing individuals of *paulus* from those of *sparverius* in areas where the two subspecies are sympatric in winter. We recorded body mass and six linear measurements of resident and wintering northern kestrels in south-central peninsular Florida to assess the extent to which they differed in size and degree of sexual dimorphism. We also examined relative variability of the two populations for evidence of the occurrence of interbreeding, which has been demonstrated in captivity (Willoughby and Cade 1964). We assumed that if a significant amount of interbreeding was occurring, it was likely to be reflected in greater size variability in the low density *paulus* population than in the much more abundant wintering *sparverius* population.

METHODS

Measurements were obtained from kestrels live-trapped for banding within an area with a radius of about 20 km in Highlands and Glades counties. All resident birds ($n = 29$) were from the immediate vicinity of the Archbold Biological Station, 13 km S of the town of Lake Placid, Highlands County, near the southern end of the Lake Wales Ridge. Of the total of 37 *F. s. sparverius* measured, 29 were captured in the same area as the *paulus,* six were trapped a short distance from the east edge of the Lake Wales Ridge along county road 621 south and east of Lake Istokpoga (Highlands County), and two were from localities 6 and 10 km south of Brighton, Glades County.

Assignment of individuals to subspecies was based on known breeding status, molt, habitat and season. Behavior also provided a clue, as *paulus* individuals tend to be tamer than *sparverius* and less likely to flush when approached on foot or by a vehicle. Bond (1980) also noted that wintering North American kestrels in the Bahamas were shyer than the resident subspecies (*F. s. sparveroides*). Seven of 15 male *paulus* were known members of breeding pairs. One of these had been originally banded as a nestling. Of the remaining eight males, one had been banded locally as a nestling, two were closely associated with females and engaging in courtship behavior, two were in heavy adult molt when captured in late summer prior to arrival of migrants, and three were trapped during winter in typical *paulus* nesting habitat, which long-term observations indicated was avoided by wintering kestrels. Eleven of 14 females were known breeders, one was captured in midsummer and two were trapped in typical *paulus* habitat in midwinter. Of presumed *sparverius,* the individuals from

near Lake Istokpoga and Glades County were from areas where no kestrels were observed during 7 yr of roadside surveys in July and extensive observations from late spring to late summer over a 20-yr period. The remainder of the wintering birds, although captured in the same general area as *paulus,* were in places rarely or never occupied by known or suspected residents. Band recoveries indicate that wintering kestrels in south-central peninsular Florida come mainly from the Atlantic seaboard north to Nova Scotia (Layne 1982).

Body mass was taken to the nearest 1 g with a 300-g Pesola scale or a platform balance, and linear measurements were made with dial calipers or a steel rule and dividers. Culmen, middle toe and middle claw lengths were recorded to the nearest 0.1 mm, and wing, tail and tarsus to the nearest 1 mm. Not all measurements were made on every individual handled, and sample sizes for different measurements ranged from 8 to 20 for each sex and subspecies. Measurements made on live individuals may not be directly comparable to those obtained from museum skins because of drying in the skin and muscle tension and movement in the living bird.

Differences between means and coefficients of variation (CV) were tested by the *t*-test and variance ratio test, respectively (Zar 1984), with $\alpha < 0.05$ (two-tailed).

RESULTS

Male *sparverius* were significantly smaller than females in mass, wing, tail and tarsus, whereas male *paulus* were significantly smaller than females in mass, culmen and middle toe (Table 1). Percentage differences (=dimorphism index of Storer 1966) between mean measurements of male and female *sparverius* and *paulus* were, respectively: mass 16.6, 13.0; culmen 2.4, 5.7; wing 5.8, 2.2; tail 7.4, 0.8 (longer in female); tarsus 3.3, 0.3; middle toe 0.4, 7.3; middle claw 1.0, 2.2. CVs of mass and linear measurements ranged from 2.5 to 6.5 (mean = 5.1) in male *sparverius* and from 2.6 to 11.2 (mean = 5.6) in females. CVs for *paulus* ranged from 2.4 to 7.3 (mean = 5.1) in males and from 3.6 to 8.8 (mean = 5.8) in females. Females of *sparverius* had significantly larger CVs than males for mass (11.2 vs. 5.7) and middle claw (9.8 vs. 4.4), while males were significantly more variable in tail (6.5 vs. 3.0) and middle toe (6.4 vs. 3.5). The only significant sex difference in variability in *paulus* was in wing length (males 2.4, females 4.4).

Comparing subspecies, means of mass, wing, toe and claw were significantly smaller in both sexes of *paulus,* and the tarsus of male and tails of female *paulus* were significantly shorter than the corresponding sexes of *sparverius* (Table 1). Differences in mean culmen length were slight and not significant. The mean of the percentage differences of mass and linear measurements between the two subspecies was 8.3 for males and 9.0 for females. The maximum difference between subspecies was in mass, which was 21.9% less in male *paulus* and 25.8% less in females. Percentage differences between linear measurements of respective sexes

TABLE 1. Means, standard errors and ranges (in parentheses) of body mass (g) and length measurements (mm) of wintering *Falco s. sparverius* and resident *F. s. paulus* in south-central Florida.

	F. s. sparverius							
	Males				Females			
	n	x̄	SE	Range	*n*	x̄	SE	Range
Mass	20	110.7[a,b]	1.4	(96–121)	17	129.1[a,b]	3.5	(108–149)
Culmen	17	12.6	0.2	(11.0–13.5)	16	12.9	0.1	(12.0–13.8)
Wing	20	181.7[a,b]	1.0	(176–192)	17	192.9[a,b]	1.2	(184–204)
Tail	16	114.0[a]	2.0	(101–129)	14	122.4[a,b]	1.0	(115–129)
Tarsus	15	36.5[a,b]	0.4	(34–39)	16	35.3[a]	0.4	(32–39)
Middle toe	16	23.3[b]	0.4	(20.7–25.7)	15	23.4[b]	0.2	(21.4–24.6)
Middle claw	16	9.9[b]	0.1	(9.2–11.0)	13	10.0[b]	0.3	(8.9–12.5)
	F. s. paulus							
	Males				Females			
	n	x̄	SE	Range	*n*	x̄	SE	Range
Mass	15	90.8[a,b]	1.7	(84–109)	14	102.6[a,b]	2.4	(88–119)
Culmen	12	12.3[a]	0.1	(11.5–13.4)	14	13.0[a]	0.2	(11.5–14.0)
Wing	14	174.5[b]	1.1	(170–184)	14	178.4[b]	2.1	(163–190)
Tail	11	109.4	1.3	(100–117)	14	110.3[b]	1.7	(95–122)
Tarsus	9	34.0[b]	0.6	(31–37)	8	34.1	0.4	(31–35)
Middle toe	11	20.6[a,b]	0.4	(18.4–23.1)	10	22.1[a,b]	0.4	(21.0–24.5)
Middle claw	12	9.4[b]	0.2	(8.4–10.5)	12	9.2[b]	0.2	(7.8–10.2)

[a] Significant difference ($P < 0.05$) between sexes within subspecies.
[b] Significant difference ($P < 0.05$) between subspecies within sexes.

of the two subspecies ranked as follows; males: middle toe (13.1) > tarsus (7.4) > middle claw (5.3) > tail (4.2) > wing (4.1) > culmen (2.4); females: tail (11.0) > middle claw (8.7) > wing (8.1) > middle toe (5.9) > tarsus (3.5) > culmen (0.8, *paulus* females larger). The only significant subspecific difference in CVs was in tail length of females, which was almost twice as variable in *paulus* (5.6%) as in *sparverius* (3.0%).

DISCUSSION

As noted by Amadon (1975) for raptors in general, the greatest difference in size of the sexes of both kestrel populations was in body mass. The degree and pattern of sexual size dimorphism was somewhat different in the two subspecies. *F. s. sparverius* was more dimorphic than *paulus*. In addition to mass, males and females of *sparverius* differed significantly in wing, tail and tarsus, which reflect general body size, whereas *paulus* sexes differed significantly only in culmen and middle toe, which are not as closely related to overall body size. The relative differences between sexes of *sparverius* in mass, wing, tail and tarsus were 3–6% greater than in *paulus*. *F. s. sparverius* also was relatively more variable in mass and linear measurements than *paulus*, having significantly larger CVs than *paulus* for four measurements compared with a significantly larger CV

for only one measurement in *paulus*. These differences support Storer's (1966) conclusion based on wing length that smaller subspecies of *F. sparverius* are less sexually size dimorphic than larger races. His dimorphism index (DI) for wing length was 4.9 for *sparverius* and 4.4 for *paulus*, compared with 5.8 and 2.2, respectively, in this study. DIs calculated from wing lengths reported for *sparverius* and *paulus* by other authors (Table 2) include (value for *sparverius* listed first): 6.6, 4.3 (Friedmann 1950); 1.0, 2.2 (Howe 1902); and 4.1, 5.8 (Mearns 1892). Bowman (1987) gave DIs for the cube root of body mass (8.4) and tarsus length (4.3) of *sparverius* from southwestern Quebec. DIs for cube root of mass of *sparverius* and *paulus* from Florida were less, 5.2 and 3.9, respectively, and in contrast to Bowman's data, mean tarsus length of *sparverius* was greater in males than females and only slightly and nonsignificantly larger in female than male *paulus*. Other tarsus measurements for *paulus* (Table 2) indicate either little or no sex difference or larger size in males. We have the impression from our observations of the two subspecies that the less dimorphic *paulus* is not as aggressive as *sparverius* in such things as nest defense and tendency to attack larger prey. This suggests that Amadon's (1975) hypothesis that the degree of sexual size dimorphism in birds of prey is related to general level of aggressiveness may apply to intraspecific populations in some cases.

The most pronounced difference between the two kestrel populations in south-central Florida was in mass, with means for *paulus* being about 22% (males) and 26% (females) less than those of *sparverius*. A mass of 100 g separates about 85% of the males and 114 g about 75% of the females. Seasonal differences in amount of fat in males or females of either or both subspecies could potentially account for some of the observed differences in mass. Based on small sample sizes, there was no significant difference in mean mass of either sex of *paulus* or *sparverius* between time periods when differences in fat condition might be expected. For *paulus* these included the nonbreeding (August–January) and breeding period (February–July) and for *sparverius* the winter (November–January) and premigratory period (February–March). Bloom (1973) also found no significant seasonal variation in mass of kestrels in California. One or both sexes of *paulus* were significantly smaller than *sparverius* in all linear measurements except culmen. The similarity in culmen length in the two subspecies indicates that the smaller *paulus* has a relatively larger bill, as noted by Howe (1902). Howe (1902) also regarded short wings and tail as diagnostic of *paulus*, which is supported by the present data, although the difference in tail length was significant only for females.

The overall smaller size of *paulus* compared with the more northern *sparverius* follows Bergmann's rule, although, as suggested by McNab (1971) for carnivorous and granivorous mammals, the smaller size of kestrels in the southeast also might be related to smaller prey size (more arthropods and fewer vertebrates, particularly mammals) as well as thermoregulatory factors. Assuming wing length is proportional to wing area, male and female *sparverius* have heavier wing loading (mm/g) than *paulus*

(males 1.64 vs. 1.92, females 1.42 vs. 1.74), which is the reverse of what would be predicted on the basis of *sparverius* being migratory and *paulus* sedentary. The heavier wing loading in *sparverius* might be an adaptation for taking larger vertebrate prey, particularly voles (*Microtus*). In contrast, the similarity in relative size of the middle toe (64 and 66% of tarsus length in male and female *sparverius* vs. 61 and 65% in *paulus*) and middle claw (43% of middle toe length in both male and female *sparverius* vs. 46 and 42% in *paulus*) suggests that there is no difference in relative size of the feet in the two subspecies associated with different prey size.

Linear measurements of *paulus* in this study were generally comparable to those reported for this subspecies by other authors (Table 2). Of these sources, only Howe's (1902) sample (*n* not given) came from a relatively restricted region, "southern Florida," and was stated to consist of "breeding birds." Mearns's (1892) sample (10 males, 10 females) and Friedmann's (1950) series (15 males, 13 females) included specimens from throughout Florida as well as coastal Louisana and Mississippi. Mearns's specimens were all collected in winter, and he did not state how resident individuals were distinguished from wintering northern kestrels, which suggests the possibility that his series may have included both subspecies. Friedmann did not indicate dates of collection of specimens. Although the data presently available do not permit critical comparison of sizes of kestrels in different parts of the southeast, they are broadly suggestive of a north–south trend of decreasing size.

Means of linear measurements of wintering *F. s. sparverius* in south-central Florida agree with those given for this subspecies by Mearns (1892) and Friedmann (1950), and means of body mass of males and females were comparable to those of corresponding sexes of captive-reared birds of Canadian and northeastern U.S. stock (Bird and Clark 1983, Porter and Wiemeyer 1970) and other specimens trapped in Florida in winter (Porter and Wiemeyer 1970).

As a result of a marked decline of the *paulus* population in Florida (Hoffman and Collopy 1988, Robertson and Kushlan 1974, Wiley 1978) and the massive influx of wintering *sparverius,* resident kestrels are usually greatly outnumbered by northern birds in winter. Individuals of both subspecies may coexist in the same local area and habitats. For example, resident pairs or individuals in the vicinity of the Archbold Biological Station usually have from one to three, occasionally more, wintering kestrels within or adjacent to their home range (pers. obs.). Aggressive encounters between the two subspecies are infrequent, and they often hunt, and occasionally roost, in close proximity. Residents commence courtship by mid-January, and the breeding season is well advanced before the northern birds depart in late March or early April. Given these conditions, there would seem to be some possibility that single residents coming into breeding condition in an area with potential *paulus* mates in short supply might attract a nearby wintering *sparverius* of the opposite sex, particularly one close to the time of migration and somewhat advanced in its own reproductive cycle. Considering the marked difference in body

TABLE 2. Comparison of mean length measurements (mm) of presumed *F. s. paulus* from four sources.

Measurement	Friedmann 1950		Howe 1902		Mearns 1892		Present study	
	M	F	M	F	M	F	M	F
Culmen	11.7	12.3	12.1	12.0	12.1	12.3	12.3	13.0
Wing	171.3	179.0	173	177	179	190	174.5	178.4
Tail	115.8	117.1	105	102	118	126	109.4	110.3
Tarsus	35.4	34.4	33	33	34.1	34.3	34	34.1
Middle toe	20.9	21.2	—	—	22.7	22.2	20.6	22.1

size of *paulus* and *sparverius* and the low density of residents relative to wintering northern birds, a significant frequency of interbreeding would be expected to result in increased variability of *paulus*. Therefore, the generally lower variability of *paulus* compared with *sparverius* found in this study suggests that interbreeding in south-central Florida does not occur or is rare. Field observations support this conclusion. We have intensively monitored single male and female *paulus* living in close proximity to wintering *sparverius* of the opposite sex and have not observed any sexual interaction between the two subspecies.

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