

Methods for Sex Identification and Estimation of Wing Area in Semipalmated Sandpipers.—The initial purpose of this study was to explore whether wing-loading might differ between Semipalmated Sandpiper (*Calidris pusilla*) sexes inasmuch as females tend to have longer wings than males. The answer appears to be no (see below), but in exploring the question some useful ways of estimating wing-load indices and of determining sex in live birds were devised.

All measurements we have used are from fresh sandpiper specimens so as to minimize complications caused by shrinkage in museum specimens (Vepsäläinen 1968). Semipalmated Sandpipers were mist-netted at Plymouth, Massachusetts during autumn migrations from 1972 through 1977. Between 2 and 20 August 1976, we also collected and measured 18 male and 27 female adult Semipalmated Sandpipers, all of which were casualties of an unknown sickness. All birds, whether from banding operations or sickness casualties, were weighed to the nearest 0.1 g, culmen length (feathers to tip), and wing length (natural chord) were measured to the nearest 0.1 and 1.0 millimeter, respectively, and wing area (cm²), not including the spaces between feather tips, was estimated in dead birds by tracing the outline of what we judged to be naturally extended right wings, measuring the area with a planimeter, and doubling it. Sex of dead birds was determined by gonad examination. Statistical methods and abbreviations follow Sokal and Rohlf (1969), except where noted.

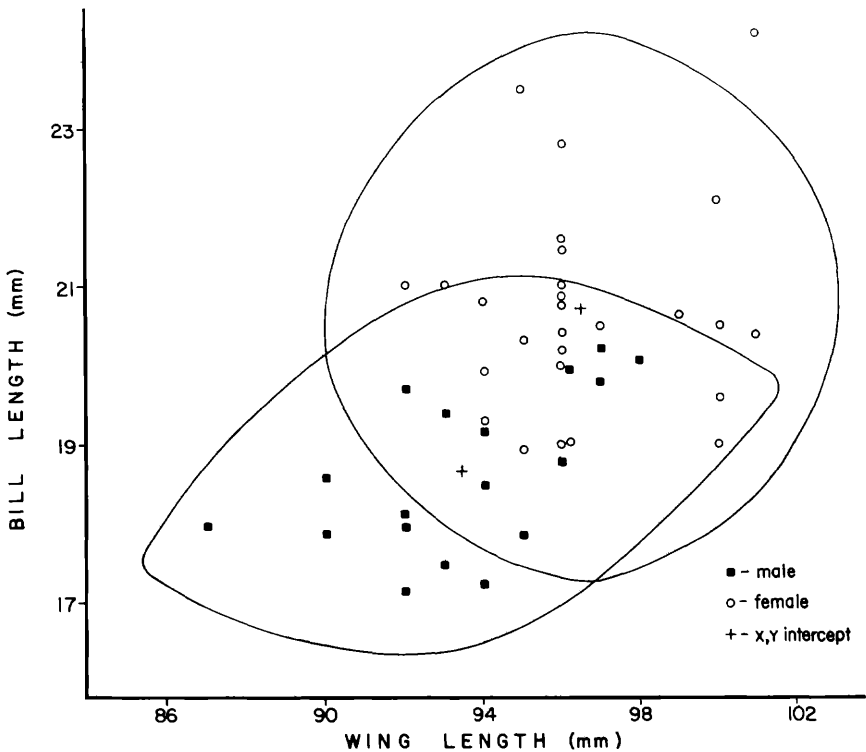


FIGURE 1. 95% confidence ellipses showing bivariate distribution of wing and bill lengths of known-sex, adult Semipalmated Sandpipers during autumn migration in Massachusetts.

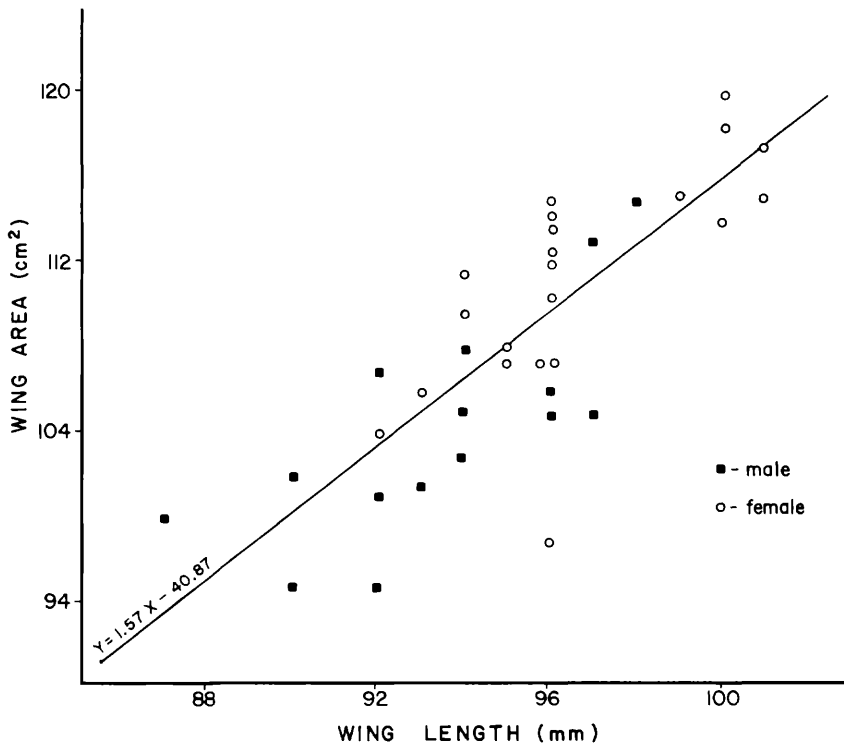


FIGURE 2. The relationship of wing area to wing length (chord) in adult Semipalmated Sandpipers during autumn migration in Massachusetts.

Sexual size differences.—We compared the wing and bill lengths of the 45 dead Semipalmated Sandpipers of known sex by constructing confidence ellipses (Sokal and Rohlf 1969, box 15.5) and found that about 40% (8/18 of the males and 11/27 of the females) can be identified as to sex on the basis of culmen and wing length, using a 95% confidence criterion (Fig. 1). Females averaged longer bills (this study, Forbush 1925) and wings (this study, Page and Middleton 1972) than males, but the amount of overlap between sexes is broader for wings than for culmen length. The regression formulas upon which the confidence ellipses are constructed are $10.58X - 122.36$ (female) and $7.38X - 44.42$ (male) where X is the bill length. These sexual size differences of adults probably do not have broad geographic or temporal application (*cf.* Harrington and Morrison 1979).

TABLE 1. Wing-loading indices of male and female Semipalmated Sandpipers based on estimated fat-free weights and (a) measured wing area or (b) estimated wing area.

	Males (a)	Males (b)	Females (a)	Females (b)
Number	15	15	21	21
Standard deviation	0.06	0.04	0.03	0.05
Average index	3.75	3.78	3.82	3.80

TABLE 2. Morphometrics and wing-loading indices of putative male and female Semipalmated Sandpipers, July–August 1976, Plymouth, Massachusetts.

	21–22 July		4–5 August		19 August	
	Males	Females	Males	Females	Males	Females
Number	15	22	15	15	13	15
Average wing length (mm)	92.0	96.1	92.2	94.1	91.2	94.1
Standard deviation	1.31	1.25	1.26	1.55	1.17	1.88
Average weight (g)	25.2	32.2	28.1	30.5	29.4	30.6
Standard deviation	2.88	4.54	4.85	3.25	4.58	3.57
Average WLI	2.43	2.35	2.35	2.33	2.28	2.33
Standard deviation	0.10	0.12	0.13	0.10	0.11	0.10

Wing length and wing area.—There is a positive correlation between wing length and wing area (Fig. 2) ($r = .82$, $P < .01$), but no significant sexual difference was found. At a 95% confidence level, wing length (X) can be used to estimate wing area (Y) to within 2% of the true mean value in Semipalmated Sandpipers using the linear regression formula $Y = 1.57X - 40.87$.

Wing-loading indices.—First we calculated wing-loading indices (WLI) for 36 dead sandpipers of known sex according to the formula

$$WLI = \frac{\sqrt[2]{\text{wing area}}}{\sqrt[3]{\text{ffw}}}$$

where ffw is the estimate of fat-free weight derived according to the methods of Page and Middleton (1972). Reasons for the suitability of this formula are described by Storer (1948). Next we recalculated the WLI for the same sample, but used an estimate of wing area derived by the method described above, instead of the measured wing area. The results (Table 1) are not statistically different from those where wing areas were measured, and so indicate that reasonable estimates of a fat-free, wing-loading index can be made on the basis of an estimated wing area and an estimated fat-free weight, each derived from the chord measurement of wing length. We found no statistically significant differences between sexes using this method. We have not determined the true WLI in this sample by using the known weights because all the birds had been incapacitated by sickness and were underweight—the result would be meaningless.

Last, using measured weights, we calculated WLI for Semipalmated Sandpipers captured on different dates whose sex and wing areas were estimated following the procedures described above. The results (Table 2) suggest that the average wing-loading indices of males are higher than for females in a day-by-day comparison, but that the season averages are statistically the same for both sexes, and that, as expected, the wing-loading indices vary by as much as 20%. Weights vary by as much as 50%.

Summary.—A study of Semipalmated Sandpipers (*Calidris pusilla*) shows that sex for 42% of the adults caught in Massachusetts during autumn can be determined with 95% confidence using wing and bill length. A method is described for estimating wing-loading indices from weight and wing length measurements. Wing-load values from a large sample varied by 20–25%, mostly due to weight variation.

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LITERATURE CITED

- FORBUSH, E. H. 1925. Birds of Massachusetts and other New England states, Vol. 1, Mass. Dept. of Agric.
- HARRINGTON, B. A., AND R. I. G. MORRISON. 1979. Semipalmated Sandpiper migration in North America. *Studies in Avian Biology* 2:83-100.
- PAGE, G., AND A. L. A. MIDDLETON. 1972. Fat deposition during autumn migration in the Semipalmated Sandpiper. *Bird-Banding* 43:85-96.
- SOKAL, R. R., AND R. J. ROHLF. 1969. *Biometry*. W. H. Freeman and Co., San Francisco.
- STORER, J. H. 1948. The flight of birds. *Cranbrook Inst. Sci., Bull.* 28.
- VEPSÄLAINEN, K. 1968. Winglength of Lapwing before and after skinning. *Ornis Fennica* 45:124-126.
- BRIAN A. HARRINGTON AND AVERY L. TAYLOR. *Manomet Bird Observatory, Manomet, Massachusetts 02345*. Received 13 July 1981; accepted 21 Jan. 1982.

Do Birds Use Color Bands in Recognition of Individuals?—The use of color bands by researchers to recognize individual birds in behavioral studies has posed the criticism: if researchers use unique color combinations to recognize individual birds, the birds could be using these clues in a similar way. Usually, such recognition would not present a serious problem in studies where recognition abilities are not being tested (however, see Burley, *Science* 211:721-722, 1981). In contrast, several of my studies test individual recognition among sparrows (Harris' Sparrows, *Zonotrichia querula*; White-crowned Sparrows, *Z. leucophrys*; White-throated Sparrows, *Z. albicollis*; and Dark-eyed Juncos, *Junco hyemalis*), and the possibility that birds could facilitate individual recognition by using color bands required testing. I was particularly concerned with respect to the White-crowned Sparrows, since this species has little inter-individual plumage variation and, as adults, individuals of the same subspecies are essentially monomorphic. Thus, I designed the current study to evaluate the effect, if any, of color bands on individual recognition in a group of captive White-crowned Sparrows.

Adult White-crowned Sparrows were captured during spring migration (April 1980) in Norman, Oklahoma, and banded with colored plastic leg bands. They were maintained together in an indoor aviary until October 1980, when this study was conducted. Birds were fed a mixture of ground dogfood and seeds and were provided with water for drinking and bathing. Dominance relationships were determined from analysis of supplanting and avoidance encounters of birds at a food dish on 3 October and again the morning of 10 October. Total observation time these 2 days was 135 min. The dominance matrix shown in Figure 1 (constructed following Brown, *The Evolution of Behavior*, W. W. Norton & Co., New York, 1975:86) shows that the hierarchy is essentially linear (only 2 dominant relationships occur beneath the diagonal) and that few reversals (attacks of subordinates on dominants) occur. At noon on 10 October, color bands on all birds were removed and switched to other individuals in the group. In this manner, each bird's identity, based on color bands, had been switched with another bird's identity. Table 1, which lists birds in order of dominance rank, indicates the color band combinations of the 10 birds before and after the switching of their bands. Each bird is referred to by a number which corresponds to its original rank. My choice of identities to be switched included those with similar and those with very different color combinations as well as those close in rank and those with large differences in rank. If confusion over identity had occurred for some birds and not others, the importance of similarity in rank and/or color of bands could have been investigated further.

Immediately after the bands were switched, all birds were released into the aviary, and subsequent dominance encounters were scored (numbers in parentheses to the right in Figure 1). Birds were observed 125 min. It was critical to observe the possible mistakes in individual recognition immediately after reintroduction of birds with switched bands since, otherwise, the birds could learn the new identities from band combinations over a period of time through social interactions.