

## MORPHOMETRIC VARIATION AND HABITAT USE OF SEMIPALMATED SANDPIPERS DURING A MIGRATORY STOPOVER

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The bill length of Semipalmated Sandpipers (*Calidris pusilla*) in arctic nesting zones varies in relation to geographic location and sex (Ridgway 1919, Manning et al. 1956, Harrington and Morrison 1979). Harrington and Morrison (1979) have shown that migrants captured in Massachusetts during southward migration apparently include short-billed individuals from westernmost parts of the species' range, as well as some of the longest-billed forms from eastern parts of the range. The purpose of this study was to explore whether the very high degree of variation in bill lengths of Semipalmated Sandpipers in Massachusetts is related to foraging habits at a marine stopover area during south migration. Smith and Evans (1973), studying sexually dimorphic godwits wintering in England, found evidence of habitat and possibly resource partitioning between males and females. The results of the present study suggest that longer-billed Semipalmated Sandpipers tend to use muddier habitats than shorter-billed individuals, but only when hunting by tactile cues. Whether this habitat partitioning is related primarily or secondarily to sex and/or bill length is not resolved.

### AREA DESCRIPTION AND METHODS

Plymouth Bay, on the west side of Cape Cod Bay, Massachusetts, has a water surface area of about 4000 ha at mean high tide, and about 2200 ha at mean low tide. Mean tidal amplitude is 2.9 m, and the exposed intertidal area is about 1860 ha (Iwanowicz et al. 1974).

Substrates of the intertidal zone of Plymouth Bay range from sand with little silt or mud, to mudflats in more sheltered areas. Mudflats have a high content of silt and clay, and generally do not dry out during exposure at low tide. The combination of large acreage and variety of tidal habitats, and nearby beaches suitable for resting at high tides, apparently makes the Plymouth area attractive to shorebirds during migration, especially in autumn.

In 1973 and 1974, 1929 adult Semipalmated Sandpipers were captured and color-banded at Plymouth during autumn migration. Most birds were caught on Plymouth Beach with mist nets at night; a single sample of 27 birds was entrapped by a rocket net at Manomet Beach during daylight on 16 August 1974. Manomet Beach is a rocky and sandy coastal beach 12 km ESE of Plymouth Beach.

Captured sandpipers were marked with an aluminum U.S. Fish and Wildlife Service band and a unique combination of colored, plastic leg bands. Measurements taken included the exposed culmen length with

dial calipers to the nearest 0.1 mm. All birds were released 3 to 8 h after being caught.

Daylight surveys of tidal flats were made to count shorebirds in Plymouth Bay and at Manomet Beach in 1974. In the course of these censuses all color-banded individuals and their feeding method (probing or pecking) were noted; bill lengths were later determined from banding records.

Censuses of tidal flats also were made at irregular intervals. On most days too few color-banded birds were found to allow reasonable comparisons of bill lengths from different areas on the same dates. Therefore samples from similar areas on nearby dates are grouped together for comparison.

Sex determinations were made following methods of Harrington and Taylor (in press). Unless otherwise noted, our statistical procedures and terminology are from Sokal and Rohlf (1969). All means of measurements are given with  $\pm 1$  standard deviation.

#### RESULTS

*Morphometric variation.*—Culmen lengths of the adult Semipalmated Sandpipers captured in July, August, and September between 1973 and 1974 averaged  $20.2 \pm 1.6$  mm (range = 16.4–25.0 mm;  $n = 1929$ ). In other words, the variation of bill lengths exceeds 50%. The average bill length of males collected in Plymouth ( $18.68 \pm 1.0$  mm,  $n = 18$ ) is statistically shorter ( $F = 30.3$ ,  $P < .001$ ) than of females ( $20.7 \pm 1.3$  mm,  $n = 27$ ).

*Habitat use, beachfronts.*—Semipalmated Sandpipers in the Plymouth region forage in a wide variety of littoral zone habitats. As Burger et al. (1977) found in New Jersey, foraging cycles are regulated by tidal rather than by diel rhythms. Our observations were made only during daylight.

In Plymouth the Semipalmated Sandpiper foraging cycle begins on bay and ocean beaches 1–1.5 h after the tide starts to fall. Foraging at this tide tends to differ in several ways from foraging at lower tides when flats become exposed, principally because: (1) overt aggressive behavior is more frequent (Dowd 1977), (2) most birds hunt using visual rather than tactual cues (cf. Recher and Recher 1969), and (3) many birds remain in resting flocks and do not begin to hunt until flats become exposed 2–3 h after high tide. Prey capture, observable when birds are hunting visually, is infrequent and occurs mostly around bits or patches of weed stranded by receding tides.

I have not found significant bill length differences of Semipalmated Sandpipers feeding in different beachfront habitats. This was found in comparisons made from several days, but is best exemplified by data collected within 2 h after high tide on 5 August 1974. Fifty-two color-banded sandpipers that had been measured in the preceding 20 days were watched foraging in 3 habitats; 8 were on a sandy/muddy bayside beach, 21 on the sandy oceanside beach, and 23 on a sandy oceanside beach strewn with small rocks. According to an analysis of variance, the

TABLE 1. Sex ratios and bill lengths of Semipalmated Sandpipers caught at 2 nearby sites in Massachusetts.

Date (1974) Location	13 August Plymouth Beach	16 August Manomet Beach	26 August Plymouth Beach
No. males <sup>a</sup>	47	17	25
No. females	49	2	16
No. unknown	59	8	14
Mean bill length (mm)	19.9	18.9	19.7
S.D. (mm)	1.33	1.12	1.36

<sup>a</sup> Sexes determined by mensural characters (Harrington and Taylor, in press.)

average bill lengths (range of 17.1–23.5 mm) of each of these groups ( $20.4 \pm 1.4$  mm,  $20.3 \pm 1.6$  mm, and  $20.6 \pm 1.6$  mm, respectively) were not statistically different ( $F = .82$ ,  $P > .10$ ) from each other, nor from the average length in a larger sample captured on the same beach 4 days earlier ( $20.1 \pm 1.6$  mm,  $n = 143$ ). Thus variation of bill lengths is not related to use of beachfront habitats by visually hunting Semipalmated Sandpipers at Plymouth.

*Habitat use, tidal flats.*—Beginning about 2½ h after high tide, Semipalmated Sandpipers in Plymouth begin to leave the ocean and bayfront beaches to forage on tidal flats. Unlike the visual foraging methods described above, birds foraging on the flats hunt principally by tactile means. In these circumstances bill length is related to habitat use. I first suspected this from measurements of 3 catches (Table 1) of sandpipers at high-tide resting areas in Manomet and Plymouth, about 12 km apart. Each of these areas was used by birds from different feeding grounds. The sample from Manomet was mostly of short-billed birds, predominantly males and birds of undetermined sex; the average bill length was substantially and significantly ( $P < .01$ ) shorter than the average from samples caught at Plymouth Beach 3 days earlier and 10 days later (Table 1). Later observations showed that most of the birds color-banded at Manomet foraged nearby in sandy, oceanfront habitats, and were preferentially hunting tactually for benthic amphipods (Dowd 1977). The birds that were color-banded at Plymouth Beach were subsequently found foraging on tidal flats in Plymouth Bay that were sandy or muddy.

Habitat partitioning that is related to bill length occurs in Semipalmated Sandpipers probing for prey on tidal flats, but not among birds hunting visually on flats. A comparison of the bill lengths during 1973 (Table 2) shows that the color-banded birds probing in muddy-sand at White Flat had a significantly shorter mean bill length than others probing in soft, mucky mud at the Nook ( $F = 7.60$ ,  $P < .01$ ). Similarly, in 1974 the average bill length of birds probing in the muddiest part of White Flat ( $n = 12$ ) was  $21.1 \pm 1.9$  mm, significantly longer ( $F = 7.51$ ,  $P < .01$ ) than averages from 3 other, sandier regions of the same flat [ $19.6 \pm 1.5$  mm ( $n = 33$ ),  $19.6 \pm 1.5$  mm ( $n = 12$ ), and  $19.8 \pm 1.8$  mm

TABLE 2. Average culmen lengths of Semipalmated Sandpipers foraging in 3 different habitats.

Date (1973) Location (Substrate)	1-5 September White Flat (Muddy sand)	20-31 August Ichabods Flat (Mud w/mussels)	1 September Nook (Mud)
No. males <sup>a</sup>	11	12	5
No. females	2	3	5
No. unknown	9	5	2
Mean culmen length (mm)	18.9	19.2	20.3
S.D. (mm)	1.3	1.6	1.7

<sup>a</sup> Sexes determined by mensural characters (Harrington and Taylor, in press.)

( $n = 27$ )]. On the other hand, sandpipers that were hunting on the flats by visual means (pecking) in patches of algae on a mussel bed (Ichabods Flat, Table 2) did not have bill lengths significantly different from others probing at similar tides on nearby flats (The Nook and White Flat, Table 2).

#### DISCUSSION

The conclusions of this study are: (1) that Semipalmated Sandpipers have highly variable bill lengths, (2) that bill length is sex-related, and (3) that Semipalmated Sandpipers with different bill lengths tend to use different habitats at a migratory stopover area, but only during the lowest tidal phases. As it happens, these phases are the most important foraging period for Semipalmated Sandpipers at marine migration stopover areas (Burger et al. 1977, and pers. observ.). Dowd (1977), working in Manomet where parts of this study were made, showed that both tactile and visual foraging methods are employed on sandy flats. However, probing is used in preference to visual modes. Furthermore, the prey captured by the 2 foraging methods are different, which with results given here suggests the possibility of resource partitioning related to bill length. Dowd also shows that overt aggression occurs less frequently among sandpipers foraging on flats than in sandpipers foraging on beachfronts, or in other words, at times when resource partitioning may occur. Further study of individual birds foraging in different habitats is needed to clarify this possibility.

The results presented here show that understanding Semipalmated Sandpiper habitat requirements at stopover and wintering areas is complex. Page et al. (1972), studying the sexually dimorphic Western Sandpiper (*Calidris mauri*), found that males and females have somewhat different wintering areas. Results given here indicate that Semipalmated Sandpipers have different habitat use which is related to bill length, and that bill length is sex-related as in the Western Sandpiper. Semipalmated Sandpipers from various parts of the breeding range also have different average bill lengths and so may have somewhat different habitat requirements during migration and winter.

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