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MIGRATION CHRONOLOGY, SEX RATIO, AND BODY MASS OF LEAST SANDPIPERS IN BRITISH COLUMBIA

ROBERT W. BUTLER AND GARY W. KAISER[1]

ABSTRACT.—We banded, weighed, and measured 2147 Least Sandpipers (*Calidris minutilla*) migrating across the Fraser River delta in 1977–1987 and Sidney Island in 1990–1993. The adult migration from late June to early August overlapped the juvenile migration between late July and late September. The mean body mass of adult females on their northward migration was not significantly greater than on their southward migration. Samples sizes of northward migrating males were too small to draw similar comparisons. Adults were not significantly heavier than juveniles on the southward migration. Mean body masses were greatest in the third week of July among adults and in the third week of August among juveniles. The average length of stay during migration was estimated to be about five days in autumn. *Received 24 Aug. 1994, accepted 10 Feb. 1995.*

The Least Sandpiper (*Calidris minutilla*) is one of the most numerous shorebird species on the Pacific Coast of North America during migration (Jewett et al. 1953, Page et al. 1979, Butler and Campbell 1987, Butler 1994). Its breeding range extends across the boreal forests and southern tundra of North America (Miller 1986, Cooper 1994). Small numbers breed on the Queen Charlotte Islands and in northwestern British Columbia (Campbell et al. 1990, Cooper 1993), but the majority of western populations of Least Sandpipers breed farther north in Alaska and Yukon (Godfrey 1986, Hayman et al. 1986). During the winter, Least Sandpipers are found along the Pacific coast from southern Washington to southern Peru (Hayman et al. 1986, Paulson 1993). Information is available on the seasonal occurrence, habitat use, and body mass of Least Sandpipers migrating in Ontario and Venezuela and on the winter quarters in California (Page and Bradstreet 1968, Page and Salvadori 1969, Bradstreet et al. 1977, Page et al. 1979, Thomas 1987). However, this information is lacking during migration along the north Pacific Coast. This paper describes the timing of the southward migration, body mass of age and sex classes, and the length of stay of Least Sandpipers in southwestern British Columbia.

METHODS AND STUDY AREA

We studied migrant Least Sandpipers on the Fraser River delta (49°05′N, 123°00′W) and on Sidney Island (48°40′N, 123°20′W) in extreme southwestern British Columbia. The Fra-

[1] Pacific Wildlife Research Centre, Canadian Wildlife Service, 5421 Roberston Rd., RR 1, Delta, B.C. V4K 3N2, Canada.

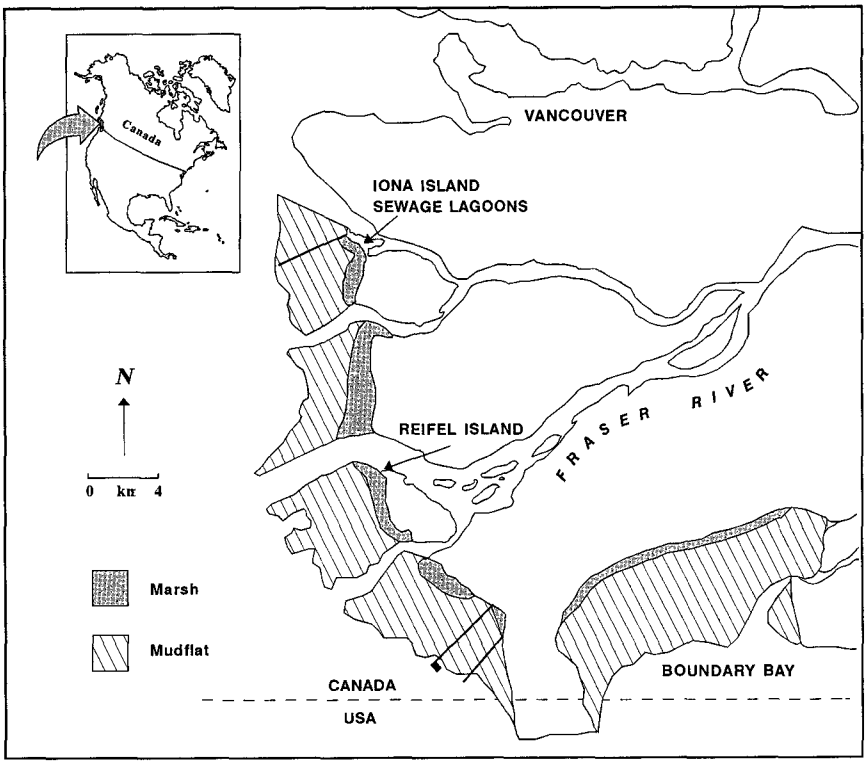

FIG. 1. Distribution of foraging habitats for Least Sandpipers in the Fraser River delta, British Columbia.

ser River delta has over 250 km^2 of mud and sandflat and about 0.4 km^2 of marsh is exposed during the lowest tide (Fig. 1, Butler and Campbell 1987). Marshes at the mouth of the Fraser River are dominated by plant species that can tolerate brackish and freshwater conditions. Boundary Bay marshes are dominated by saltmarsh plant species. Two sewage lagoons on Iona Island (Fig. 1) were used as a roost by large numbers of shorebirds during high tides. The lagoons were built behind 2 m-high dykes within 250 m of the marsh (Fig. 1). The study site on Sidney Island was a lagoon containing about 96 ha of mudflat, eelgrass beds, and saltmarsh (Butler et al. 1987).

On the Fraser River delta, sandpipers were caught during the periods of 10 May–10 June 1977, 7 June–15 November 1978, 4 May–9 September 1979, 7 July–9 September 1980, 5 July–28 August 1981, 9 July–1 September 1982, 5 July–10 September 1983, 7–16 August 1984, 4–24 July 1985, 27 July–23 August 1986, and 15 July–22 August 1987. On Sidney Island, Least Sandpipers were caught in the periods 1 July–31 August 1990–1993. Sandpipers were caught in mist nets strung across the beach and marshes for about 1–2 h on either side of high tides. On the Fraser River delta, we caught sandpipers at a sewage lagoon near brackish marshes on Iona Island, in brackish marshes on Reifel Island, and in salt marshes in Boundary Bay (Fig. 1).

TABLE 1

PROPORTION OF ADULT AND JUVENILE LEAST SANDPIPERS IN NET CATCHES ON THE FRASER RIVER DELTA DURING SOUTHWARD MIGRATION

Period	Number		Adult proportion
	Adult	Juvenile	
June 21–30	6	0	1.000
July 1–7	37	0	1.000
July 8–14	354	0	1.000
July 15–21	135	7	0.951
July 22–31	66	138	0.324
August 1–7	14	367	0.037
August 8–14	1	502	0.020
August 15–21	0	257	0.000
August 22–15 Sept.	3	235	0.013
Total	616	1506	0.290

Each bird was weighed within 0.5 h of capture with a Pesola spring balance, and its culmen was measured with a ruler. We used plumage characteristics to classify each bird as either adult (AHY) or juvenile (HY) (Prater et al. 1977). Least Sandpipers, can be sexed from measurements of their culmen lengths (Page 1974, Prater et al. 1977). Page (1974) derived his measurements of culmen lengths from 89 museum specimens of known sex collected on the Pacific Coast. Cooper's (1993) culmen measurements from 148 males and 135 females caught on nests on the Queen Charlotte Islands were nearly identical to Page's (1974) measurements from museum specimens (Page: mean = 17.9, SD = 0.7, 15.8–20.2 mm; Cooper; mean = 17.9, SD = 1.0, 15.5–20.4 mm). Therefore, we used Page's (1974) measurements of culmen lengths to assign sex of males (<17.5 mm) and females (>18.7 mm).

Individual differences in body mass were standardized as a proportion of body structural size by the expression $WT/C^{0.497}$, where WT is the body mass, C is the culmen length, and 0.497 is the slope of the fitted least-squares regression line between the logarithm of the culmen length and the logarithm of body mass (Summers 1988).

We used the method described by Butler et al. (1987) to estimate the length of stay of 155 Least Sandpipers. The Fraser River delta was too large to search for marked sandpipers each day, so we focused this work on the small study area on Sidney Island. Butler et al's (1987) length of stay method involves banding sandpipers with unique combinations of colored bands and searching for them each day through the migration period. The number of days lapsed between the banding date and the date of the last sighting is used as a minimum estimate of the length-of-stay.

RESULTS

Timing of age and sex classes during southward migration.—The earliest adult Least Sandpiper was caught on 26 June, and most had left by the end of July, although a small number were caught as late as 15 September (Table 1). The first juvenile was caught on 16 July, and most juveniles had departed by the middle of September. Small numbers of

TABLE 2

FREQUENCY DISTRIBUTION OF LEAST SANDPIPER CULMEN LENGTHS IN SOUTHWESTERN BRITISH COLUMBIA[a]

Culmen length (mm)	Number
<14.0	1
14.0–14.9	0
15.0–15.9	13
16.0–16.9	184
17.0–17.9	603
18.0–18.9	675
19.0–19.9	479
20.0–20.9	154
21.0–21.9	22
22.0–22.9	14
23.0–23.9	2
Total	2147

[a] Mean = 18.4, SD = 1.2, SE = 0.03, Range = 13.3–23.5.

juveniles were caught up to 11 November, when our study ended (Table 1). A small number of Least Sandpipers spend the winter on the Fraser River delta and elsewhere in southwestern British Columbia (Campbell et al. 1990).

Page's (1974) culmen measurements for males and females allowed us to sex 1280 (59.6%) of the 2147 sandpipers (474 males and 806 females, Table 2). The apparently skewed sex ratio probably was an artifact of the method of using culmen lengths to sex our sample. The mean culmen length in our sample of 2147 birds was 18.4 mm compared to 17.9 mm calculated by Page (1974) and Cooper (1993) from samples of 89 and 283 birds, respectively. This artifact might also explain the apparent decline we found in the weekly proportion of females captured during the migration of adults ($t = -21.7$, $r^2 = 0.97$, $P = 0.002$) and juveniles ($t = -14.6$, $r^2 = 0.99$, $P = 0.005$) (Table 3). The change in proportions of females in captures between the beginning and end of the migration period of adults and juveniles was about 10% (Table 3). Therefore, a small percentage of females incorrectly classified as males would explain these results.

Seventy-three of the 2147 Least Sandpipers captured on the Fraser River delta had longer culmens than the maximum length (20.4 mm) reported by Cooper (1993), and 100 were longer than the 20.2 mm maximum length reported by Page (1974). One bird had a culmen shorter than the minimum length (15.5 mm) reported by Cooper (1993), and 14

TABLE 3
PROPORTION OF ASSIGNED MALE AND FEMALE LEAST SANDPIPERS IN NET CATCHES ON THE FRASER RIVER DELTA DURING SOUTHWARD MIGRATION

Period	Number		Female proportion
	Male	Female	
June 21–30	1	4	0.800
July 1–7	7	16	0.696
July 8–14	82	139	0.629
July 15–21	33	41	0.554
July 22–31	48	80	0.625
August 1–7	79	162	0.672
August 8–14	118	215	0.646
August 15–21	64	98	0.605
August 22–15 Sept.	42	51	0.548
Total	474	806	0.630

were shorter then Page's (1974) minimum measurement of 15.8 mm. The respective probabilities that Page (1974) and Cooper (1993) would have missed a long billed Least Sandpiper if it occurred in the same proportion as in our sample (73 out of 2147) is very low and significant (Page: $P = (1 - (73/2147)^{89} = 0.05$; Cooper: $P = 1 - (73/2147)^{283} = 0.00006$). However, in our study, long billed birds were caught in each of the nine yrs that more than 50 Least Sandpipers were caught on the Fraser River delta and in the three years we sampled on Sidney Island. Moreover, the frequency of capture was similar on Sidney Island and the Fraser River delta; 3.4% (73 out of 2147) of the sandpipers caught on the Fraser River delta had long bills compared to three out of 154 sandpipers (2.3%) on Sidney Island. Lastly, the proportion of long billed sandpipers was nearly identical among adult (24/689 adults = 0.035) and juvenile age classes (49/1427 juveniles = 0.034). We conclude that a small number of Least Sandpipers on the Fraser River delta have longer bills than those reported by Page (1974) and Cooper (1993).

Body mass of age and sex classes.—Body masses of Least Sandpipers in our study ranged from 17 to 36 g. The mean mass of adult females was not significantly greater on their northward migration in May than during their southward migration in July, and adults were not significantly heavier than juveniles (Table 4). Larger samples are required to draw conclusions about body masses of adult males on the northward and southward migrations. Body masses of adults were significantly greater in the saltmarsh than in the riverine marsh and sewage lagoon (Table 5). Juveniles had significantly greater mass in the saltmarsh and riverine

TABLE 4
BODY MASS OF LEAST SANDPIPERS ON THE FRASER RIVER DELTA

	Adult				Juvenile			
Period	Mean	SE	N	Range	Mean	SE	N	Range
Spring								
Male	22.3	2.3	3	18–26		Not applicable		
Female	25.2	0.9	13	21–33		Not applicable		
Autumn								
Male	22.6	0.3	122	17–33	21.9	0.2	304	15–33
Female	24.3	0.2	196	20–33	23.8	0.2	529	15–36

marsh when compared to the sewage lagoon (Table 5). The mean body mass of adults was significantly greater than juveniles in the saltmarsh (Table 5).

The body mass of samples of Least Sandpipers increased significantly through the migration period of adults ($t = 2.1$, $P = 0.04$, $r^2 = 0.007$) and juveniles ($t = 4.0$, $P < 0.0001$, $r^2 = 0.011$; Fig. 2). The greatest mean mass occured in samples taken in the week of 15–21 July for adults and 22–31 August for juveniles (Fig. 2). The daily change in mass among eight Least Sandpipers that were recaptured was highly variable. Three birds lost body mass, one showed no change, and four birds increased in body mass between captures. The average change in mass of the eight recaptured Least Sandpipers was 0.22 g/d (SE = 0.15). In comparison, four Western Sandpipers (*C. mauri*) recaptured in the same period gained body mass at an average rate of 0.34 g/d (SE = 0.08).

Length of stay.—Of 155 color-marked Least Sandpipers on Sidney Island, 51 (32.9%) disappeared following banding, and the remaining 104

TABLE 5
STANDARDIZED BODY MASS INDICES (SEE METHODS) OF ADULT AND JUVENILE LEAST SANDPIPERS AT THREE LOCATIONS ON THE FRASER RIVER DELTA

	Adults			Juveniles		
Habitat	$\bar{x}$	SE	N	$\bar{x}$	SE	N
Sewage lagoon	5.308[a]	0.077	71	5.260[c]	0.042	320
Riverine marsh	5.459[b]	0.039	266	5.398[c]	0.034	469
Saltmarsh	5.619[b]	0.041	262	5.455[a]	0.032	569

[a] t-test $P < 0.001$.
[b] t-test $P < 0.01$.
[c] t-test $P < 0.02$.

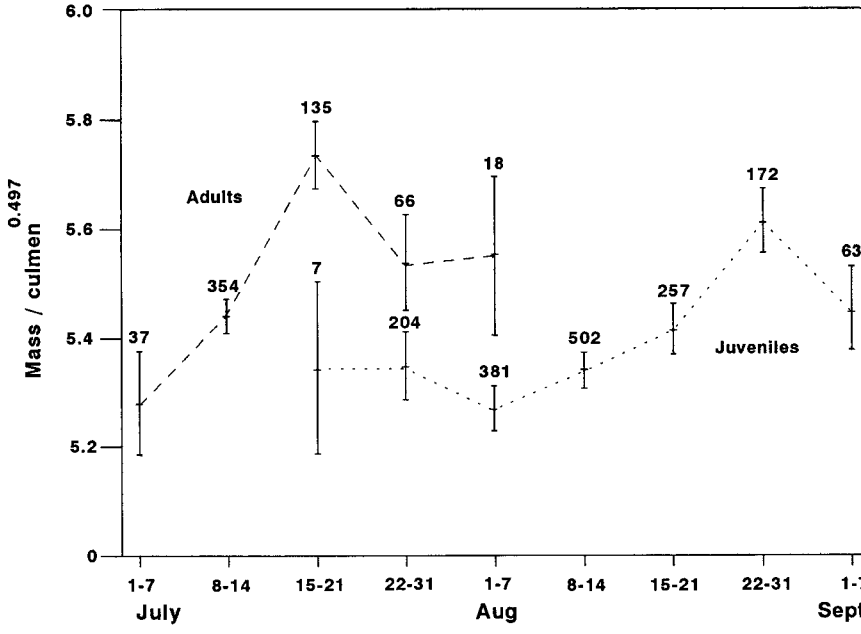

FIG. 2. Average standardized body mass of adult and juvenile Least Sandpipers during each week of the southward migration. Body size was standardized by dividing the mass by culmen raised to the power of 0.497. See Methods for details. Standard errors are represented by vertical bars and sample sizes appear above each sample.

were seen between one and 17 days later (Table 6). Using the methods described by Butler et al. (1987), we estimated P, the probability that a bird present the current day was present the next, and L, the expected length of stay. Our results are $P = 0.798$ and $L = 4.96$ (Table 6). This method provides a minimum estimate, because it includes birds that had already been present on the island for a few days before being caught and birds that fled as a result of capture.

DISCUSSION

The timing of southward migrations of age classes and sex classes of the Least Sandpiper through southwestern British Columbia was essentially the same as that of the Western Sandpiper. Adults of both species migrated mostly between the last week of June and the end of July, followed by juveniles from end of July to mid-September (this study, Butler et al. 1987). Our results concur with findings from migration studies of other calidridines in which the sexes generally migrate at slightly different times (Myers 1981, Butler et al. 1987). We found that females preceded

TABLE 6

NUMBER OF DAYS THAT MARKED LEAST SANDPIPERS WERE SEEN ON SIDNEY ISLAND[a]

Number of days	Number of individuals
1	155
2	104
3	90
4	75
5	66
6	59
7	46
8	42
9	39
10	27
11	23
12	15
13	13
14	7
15	3
16	3
17	1

[a] $S_k = 613$, $X_0 = 155$, $X_k = 0$, $\hat{P} = 0.7982$, var $(\hat{P}) = 0.0002$, SE$(\hat{P}) = 0.0145$, $\hat{L} = 5.0$; confidence intervals for $\hat{P}$ [0.7692, 0.8271]; confidence intervals for $\hat{L}$ [4.3, 5.9].

males during the adult and juvenile migrations. However, the accuracy of sexing Least Sandpipers using culmen lengths needs to be examined.

We showed that extremes in culmen lengths occurred regularly at low frequency among Least Sandpipers caught on migration in southwestern British Columbia. The origin of these Least Sandpipers is unknown. However, the scattered dates of occurrence in our catches, the presence among adult and juvenile cohorts, and their occurrence on the Fraser River delta and Sidney Island indicate that these individuals are widespread in Pacific Coast populations.

Least Sandpipers netted on their northward migration on the Fraser River delta were not significantly heavier than adults caught during the southward migration. This contrasts with the Western Sandpiper that migrates through the same habitats on the Fraser River delta at the same time of year. Adult Western Sandpipers were significantly heavier in spring than in fall (Butler et al. 1987). Many calidridines that breed in arctic environments carry large amounts of lipid and protein in spring to make the migration and survive inclement weather on the breeding grounds (e.g., Davidson and Evans 1988, Harrington et al. 1991). The Least Sandpiper breeds at the most southerly latitude of any North American calidridine (AOU 1983). We hypothesize that the Least Sandpiper

carries proportionately smaller nutrient reserves because it migrates shorter distances and does not need to contend with periodic food shortages that confront arctic breeding species.

The southward migration of individual Least Sandpipers was more protracted than that of the Western Sandpiper on Sidney Island. The average Least Sandpiper stayed about five days compared to about three days for the Western Sandpiper (Butler et al. 1987). Moreover, Least Sandpipers gained body mass at about two-thirds the rate of Western Sandpipers. We hypothesize that Least Sandpipers needed more time to increase their body mass and therefore remained on Sidney Island longer than Western Sandpipers.

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