Phenology and Length of Stay of Transient and Wintering Western Sandpipers at Estero Punta Banda, Mexico (Cronología Migratoria y Fidelidad de Calidris mauri Nómadas e Invernantes en Estero Punta Banda, Mexico)

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PHENOLOGY AND LENGTH OF STAY OF TRANSIENT AND WINTERING WESTERN SANDPIPERS AT ESTERO PUNTA BANDA, MEXICO

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Abstract.—The Western Sandpiper (*Calidris mauri*) is one of the most abundant shorebirds in northwestern Mexico; however, little is known about its winter ecology in this area. We studied residency patterns of male Western Sandpipers during the winters of 1995–1996 (1995) and 1996–1997 (1996) at Estero Punta Banda in Baja California, Mexico. We resighted 54 birds in 1995 and 56 birds in 1996. Birds arrived later in 1995 (median 1 December) than in 1996 (median 24 October). The median departure dates (6 March 1996 and 20 February 1997) did not differ between years. We observed two patterns of residency. Wintering birds in 1995 arrived on 17 November (median) and departed on 17 March (median), with length of stay of 120.0 ± 4.2 d; and in 1996 arrived on 12 October (median) and departed on 8 March (median), with length of stay of 146.9 ± 4.3 d. Transient birds in 1995 arrived on 7 December (median) and departed on 17 February (median), with stays of 33.7 ± 4.3 d; and in 1996 arrived on 23 October (median) and departed on 3 December (median), with stays of 33.7 ± 4.1 d. Residence time was independent of sighting effort. Both wintering birds and transients exhibited site fidelity between years. Both categories were independent with respect to age, trapping month, or year. The mid-season departures were not correlated with either age or the banding period. Older birds were more likely to depart earlier and switch their residency pattern from wintering to transient. While the ecological significance of variation in residency patterns remains unknown, evidence from this and previous studies suggest that such variation may be relatively common, with important implications for studies of shorebird populations and conservation strategies.

CRONOLOGÍA MIGRATORIA Y FIDELIDAD DE *CALIDRIS MAURI* NÓMADAS E INVERNANTES EN ESTERO PUNTA BANDA, MEXICO

Sinopsis.—*Calidris mauri* es uno de los playeros más abundantes en el noroeste de México, sin embargo, se conoce poco de su ecología durante el invierno en este país. Estudiamos los patrones de residencia de machos de *C. mauri* durante los inviernos de 1995–1996 (1995) y 1996–1997 (1996) en el estero Punta Banda, Baja California, México. Avistamos 54 aves en 1995 y 56 aves en 1996. Las aves llegaron más tarde en 1995 (21 nov.) que en 1996 (12 oct.). La fecha mediana de salida (6 mar. 1996 y 20 feb. 1997) no fue significativamente diferente entre temporadas. Observamos dos patrones de residencia. Las aves invernantes en 1995 llegaron el 17 de noviembre (mediana) y salieron el 17 de marzo (mediana), con una residencia de 120.0 ± 4.2 d; y en 1996 llegaron el 12 de octubre (mediana) y salieron el 8 de marzo (mediana), con una residencia de 146.9 ± 4.3 d. Las aves nómadas, en 1995 llegaron el 7 de diciembre (mediana) y salieron el 17 de febrero (mediana), con una estadía de y

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33.7 ± 4.3 d; en 1996 llegaron el 23 de octubre (mediana) y salieron el 3 de diciembre con una estadía de y 33.7 ± 4.1 d. Ambas categorías mostraron fidelidad al área entre años; la estadia fue independiente de la edad, mes o año de captura. Las salidas de mitad de temporada no estuvieron correlacionadas con la edad, ni con el período de anillamiento. Las aves más viejas es probable que salgan del estero antes y cambien de patrón de residencia de un año a otro, de invernante a nómada. El significado ecológico de ambas categorías de aves es desconocido. Éste estudio y otros previos muestran evidencia de que estos patrones pueden ser común y con implicaciones importantes en el estudio de las poblaciones de aves playeras y sus estrategias de conservación.

Many Nearctic shorebirds complete long distance migrations from arctic breeding grounds to tropical wintering areas (Burger and Olla 1984; Morrison 1984). Because migratory shorebirds may spend over 65% of the year at stopover areas and wintering grounds (Senner and Howe 1984), the conservation of many shorebird species depends on our ability to locate, describe, and protect these critical areas (Myers et al. 1987; Helmers 1992). However, outside the United States, our current knowledge of the most basic aspects of winter ecology of Nearctic shorebirds is meager (Smith and Stiles 1979; Delgado and Butler 1993; Naranjo et al. 1994; Rice 1995). The Western Sandpiper (*Calidris mauri*) is an example of a shorebird species where major gaps in winter information remain.

The Western Sandpiper is a monogamous, territorial shorebird that breeds in the western subarctic of Alaska and eastern Siberia, and winters primarily along the Pacific coast from California to Peru, and the Atlantic coast from New Jersey to Suriname (Wilson 1994), with males predominating at more northerly latitudes (Page et al. 1972; Naranjo et al. 1994; Buenrostro et al. 1999). The Western Sandpiper is one of the most abundant shorebirds in the Western Hemisphere, and the Pacific coast of Mexico, particularly the northwestern region, is one of its major wintering areas (Morrison et al. 1992, 1994; Engilis et al. 1998). The primary objectives of this study were to examine the phenology and residency periods of returning banded Western Sandpipers at Estero Punta Banda, in northwestern Baja California, Mexico. This study improves our basic understanding of the Western Sandpiper's winter ecology in a region where the lack of information may hamper efforts to conserve coastal wetlands for shorebird use.

STUDY AREA AND METHODS

We studied Western Sandpiper residency patterns in Baja California, Mexico at Estero Punta Banda (31°52′N, 116°37′W) from September to April 1995–1996 (1995) and 1996–1997 (1996). Punta Banda is located on the west coast of the Baja California peninsula, 13 km south the town of Ensenada, and comprises an area of approximately 20 km^2.

We captured Western Sandpipers with mist nets on high rising spring tides from October–March of 1994–1995 (1994) and 1995–1996. Immediately upon capture, we measured body mass (±0.5 g), exposed culmen (±0.1 mm), and wing length (flattened, ±1 mm). Each bird was sexed based on culmen measurements (female >24.8 mm, male <24.2 mm;

Page and Fearis 1971), and aged as an adult or first-year bird based on plumage and coloration (Page et al. 1972). Birds were banded with a USFWS band and individually color banded with Darvic color bands. We report results for males only because females represented less than 20% of birds captured.

Marked birds were resighted during 1–4 hr scanning surveys of Western Sandpiper flocks made on high-low spring tides throughout each year. Resightings in both seasons were done at capture sites and mudflats in the main channel of the estuary, when the tide was at 0 m height. Band combinations were read using spotting scopes. We resighted birds from 29 September to 2 April in 1995, and from 13 September to 6 April in 1996. We resighted Western Sandpipers on 42 days in 1995 ($\bar{x}$ = 5.2 d/mo, n = 8 mo), and on 63 days in 1996 ($\bar{x}$ = 7.8 d/mo, n = 8 mo).

To determine a minimum length of stay of previously marked birds, we used the first and last sighting of each color-banded bird as its arrival and departure dates, respectively. The difference between first and last sighting dates was considered the minimum duration of stay (MDS). This is a minimum because banded birds could have arrived prior to the day of first sighting and departed after the last day seen or our last date in the field. We calculated a "sighting proportion" as the number of sightings per bird divided by the number of visits made during the MDS of each bird. Calculated MDS depends on the actual time spent by the bird at the site, the sighting effort, i.e., number of days spent looking for marked birds, and the detection probability per day.

Although MDS is a continuous variable (Fig. 1), we classified birds with MDS fewer than 75 days as "transients," and those with MDS longer than 75 days as "wintering." Similar results were obtained with a range of classification variables (e.g., 60–100 days, Fig. 1). We used this classification to examine differences in the duration of site usage with respect to age, trapping month, time of the season, and year.

The arrival and departure distributions were compared between seasons with the chi-square median test. Spearman rank correlations were used to examine the relationship between MDS and sighting ratio. We compared MDS between bird categories using the t-test. Chi-square contingency tables were used to test for differences in bird categories by age, trapping month, year, or banding period. We report means ± SE unless otherwise noted. All tests were two-tailed with $\alpha = 0.05$. All statistical analyses were made using JMP (SAS Institute 1997).

RESULTS

Captures and resightings.—In 1994, 260 captured males were individually color banded; in 1995, 67; and in 1996, 133. We resighted 54 birds from 1994 in 1995, 31 adults (captured throughout the winter: 36% in November, 32% in December, 29% in January, and 3% in March) and 23 first-year birds (captured throughout the winter: 26% in November, 26% in December, and 48% in January). In 1996, we resighted 32 birds banded from 1994, 18 adults (captured throughout the winter of 1994: 28% in

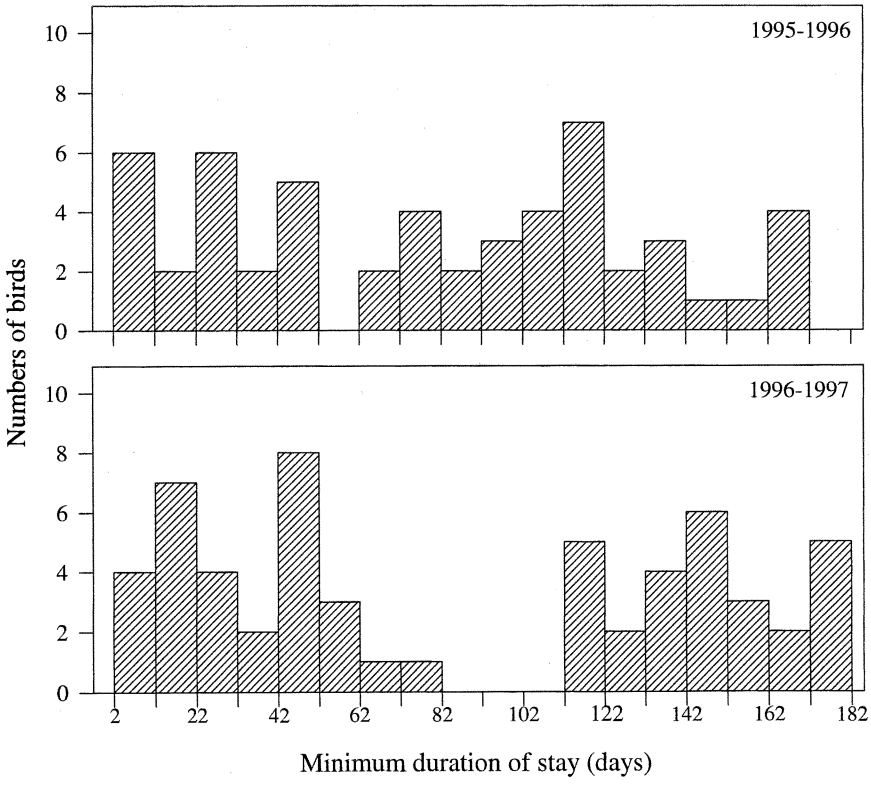

FIGURE 1. Minimum duration of stay in days of male Western Sandpipers at Estero Punta, Banda, Mexico, in the winters of 1995–1996 and 1996–1997.

November, 33% in December, and 39% in January) and 14 first-year birds (captured throughout the winter of 1994: 21% in November, 42% in December, 29% in January, and 8% in March); and 24 birds banded from 1995, 10 adults (captured throughout the winter of 1995: 40% in October, 30% in November, 10% in December, 10% in January, and 10% in March), and 14 first-year birds (captured throughout the winter of 1995: 7% in October, 14% in November, 7% in February, and 72% in March).

Arrival and departure patterns.—The arrival distributions of banded Western Sandpipers differed markedly between years (Fig. 2). In both years, birds arrived in the estuary by mid August, but the first previously banded Western Sandpipers arrived in late September. In 1995, the arrival distribution had peaked on 18 November, with seven birds. In 1996, the arrival peak of Western Sandpipers occurred one month earlier, with the highest number (15 birds) on 12 October. Marked Western Sandpipers arrived significantly earlier in 1996 (median = 12 October) than in 1995 (median = 21 November; median test $\chi^2_1 = 32.4$, $P < 0.05$).

We found no differences in Western Sandpiper departure dates be-

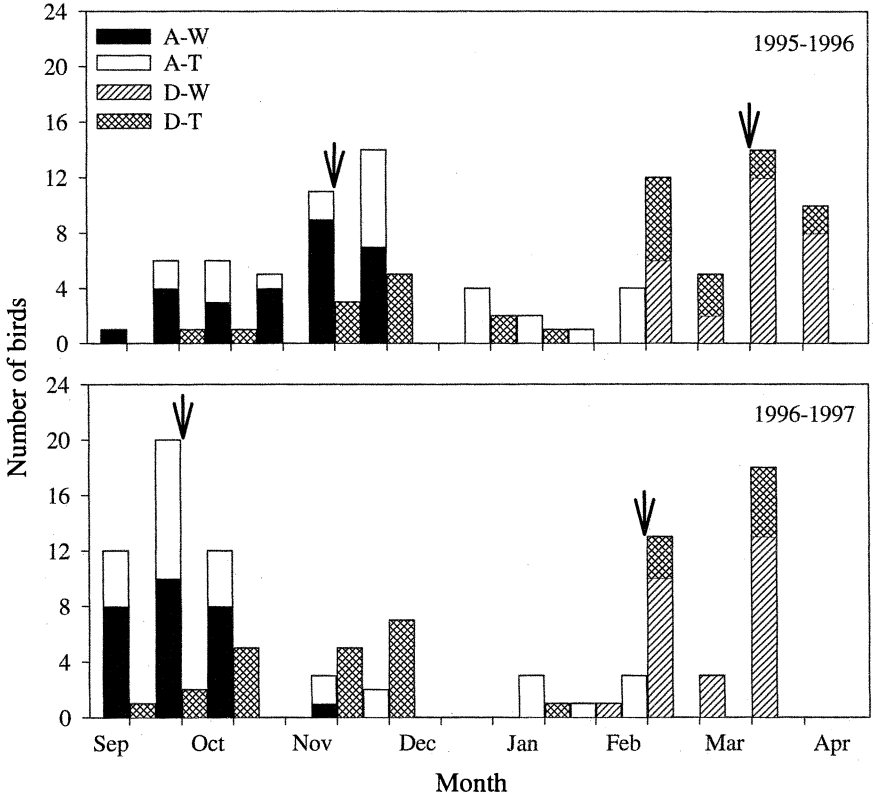

FIGURE 2. Distribution of arrival and departures dates of male Western Sandpiper by residency pattern at Estero Punta Banda, Mexico, in the winters of 1995–1996 and 1996–1997. Arrows show the median arrival and departure dates of all birds each winter. A–W: arrivals of wintering birds; A–T: arrivals of transient birds; D–W: departures of wintering birds; and D–T: departures of transient birds.

tween years (Fig. 2). In 1995, 76% (41/54) of marked birds departed from Punta Banda between February and March, while in 1996, 62% (35/56) departed in this period. There was also no differences between years in the proportion of birds departing in February–March ($\chi^2_1 = 2.3$, $P = 0.12$). The median departure dates 6 March and 20 February, did not differ between years (median test $\chi^2_1 = 0.6$, $P = 0.45$).

We detected differences between residency categories in arrival and departure dates. In 1995, wintering birds arrived (median = 17 November) significantly earlier than transient birds (median = 7 December; median test $\chi^2_1 = 7.2$, $P < 0.05$); and wintering birds departed later (median = 17 March) than transient birds (median = 17 February; median test $\chi^2_1 = 16.4$, $P < 0.05$). In 1996, the median arrival date did not differ between wintering (median = 12 October) and transient birds (median = 23 October; median test $\chi^2_1 = 1.7$, $P = 0.18$); but wintering birds

departed later (median = 8 March) than transients birds (median = 3 December; median test $\chi^2_1 = 17.9$, $P < 0.05$).

Wintering birds arrived almost one month earlier in 1996 than in 1995 (median test $\chi^2_1 = 19.4$, $P < 0.05$); but the median departure date did not differ between years (median test $\chi^2_1 = 2.1$, $P = 0.14$). On the other hand, transient birds arrived later in 1995 than in 1996 (median test $\chi^2_1 = 7.8$, $P < 0.05$), and they departed almost two months later in 1995 than in 1996 (median test $\chi^2_1 = 5.9$, $P = 0.02$).

In 1996, we tested for a possible age effect in the median arrival and departure of wintering birds banded in 1994 and 1995. In 1996, we resighted 18 wintering birds banded in 1994 (44% adult birds), and 9 wintering birds banded in 1995 (33% adult birds). There was not a significant difference in age compositions of birds present each year (Fisher's exact test, $P = 0.44$). We found no differences of wintering birds' arrivals between 1994 (median 12 October) and 1995 (median 12 October; median test $\chi^2_1 = 1.8$, $P = 0.17$). However, we detected differences in the median departure dates. The birds banded in 1994 departed significantly earlier than those banded in 1995 (median 23 February vs. median 20 March, respectively; median test $\chi^2_1 = 4.5$, $P = 0.03$).

Length of stay.—The banded birds' lengths of stay were similar in both years. In 1995, the first sighting of a banded bird was 29 September; the last one was 2 April. In 1996, the first banded bird was sighted 25 September; the last one was 23 March. No banded birds were observed outside this period in either season, although in both cases Western Sandpipers were present. The MDS ranged from 2–170 d in 1995 and from 2–179 d in 1996 (Fig. 1). Our estimate of MDS was not correlated with sighting proportion in either year ($r_s = -0.2$, $P = 0.10$, $n = 54$ for 1995; $r_s = -0.2$, $P = 0.13$, $n = 56$ for 1996; Fig. 3).

In 1995, the MDS of transient birds was 33.7 ± 4.3 d ($n = 26$), while that of wintering birds was 120.0 ± 4.2 d. For 1996, the MDS of transient birds was 33.7 ± 4.1 d ($n = 29$), while that of wintering birds was 146.9 ± 4.3 d ($n = 27$). The average MDS of transient Western Sandpipers did not differ between years ($t_{53} = 0.001$, $P = 0.91$). However, the wintering birds stayed longer in 1996 than in 1995 ($t_{53} = -4.4$, $P < 0.05$).

We saw no evidence that the classification of a Western Sandpipers as a transient or wintering bird was influenced by age (1995: $\chi^2_1 = 2.4$, $P = 0.09$; 1996: $\chi^2_1 = 0.04$, $P = 0.83$; Table 1); or by trapping month (1995: adults, $\chi^2_3 = 0.8$, $P = 0.84$, first-year birds: $\chi^2_2 = 5.3$, $P = 0.07$, pooled, $\chi^2_3 = 4.0$, $P = 0.25$; 1996: adults, $\chi^2_4 = 2.6$, $P = 0.62$, first-year birds: $\chi^2_5 = 4.5$, $P = 0.48$, pooled, $\chi^2_5 = 3.2$, $P = 0.66$; Table 2).

Among transients, there was no significant difference between the age composition of birds present in the first and second parts of the season (1995: Fisher's exact test, $n = 9$ adults, 5 first-year birds, early; 4 and 8 respectively, late, $P = 0.24$; 1996: $n = 12$ adults, 4 first-year birds, early; 5 and 8, respectively, late, Fisher's exact test, $P = 1.00$). Birds were commonly sighted in the part of the season when they were banded. Seventy-eight percent of the transient Western Sandpipers banded between Oc-

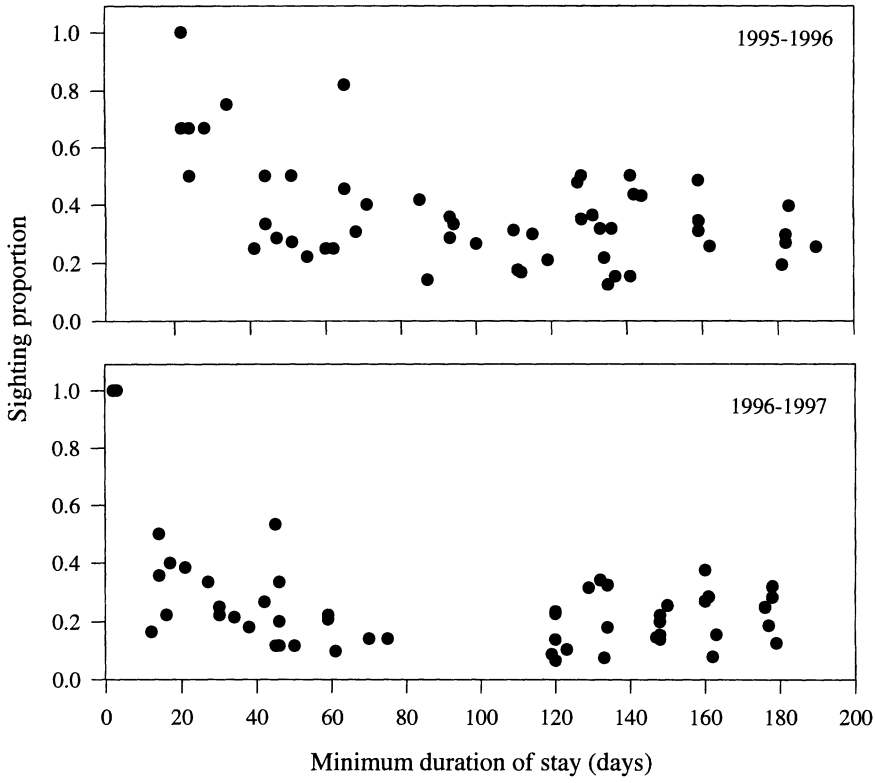

FIGURE 3. Sighting proportions (number of sightings per bird divided by the number of visits made during the minimum duration of stay of each bird) and minimum duration of stay of male Western Sandpipers at Estero Punta Banda, Mexico, in the winters of 1995–1996 and 1996–1997.

tober and December were observed in 1995 when southward migration was in progress, and 66% of the transient birds banded between January and March were observed during the period of northward migration. In 1996, transient birds banded between October and December (n = 16)

TABLE 1. The number of transient and wintering Western Sandpipers by age class (first-year and adult males) for the 1995 and 1996 winters at Estero Punta Banda, Mexico.

		Adult birds	First-year birds	Total
1995	Transient	13	13	26
	Wintering	18	10	28
	Total	31	23	54
1996	Transient	17	12	29
	Wintering	11	16	27
	Total	28	28	56

TABLE 2. The number of transient and wintering Western Sandpipers by age class (A: adult, and F: first-year bird) and trapping month for the 1995 and 1996 winters at Estero Punta Banda, Mexico.

		Oct.		Nov.		Dec.		Jan.		Feb.		Mar.	
		A	F	A	F	A	F	A	F	A	F	A	F
1995	Transient	—	—	5	4	4	1	4	8	—	—	—	—
	Wintering	—	—	6	2	6	5	5	3	—	—	1	—
1996	Transient	3	1	4	1	5	1	5	2	—		—	6
	Wintering	1	—	4	3	2	5	3	2	—	1	1	5

were observed only during southward migration and 53% of the transient birds banded between January and March ($n = 13$) were observed during the period of northward migration. However, the transient category was influenced by the banding period only in 1996 (Fisher's exact test, $P < 0.05$), but not in 1995 (Fisher's exact test, $P = 0.67$).

For 21 males banded in 1994 and sighted in 1995 and 1996, 11 (52%) were wintering in both years, of which 6 were adults; 2 (9.5%) first-year birds were transients in both years; 6 (29%) adult males were wintering birds in 1995 and transient birds in 1996; and 2 (9.5%) first-year birds showed the reverse pattern. Older males may have more flexibility in their residency pattern from year to year. However, the likelihood of switching residency pattern from year to year was not significantly different between adults and first-year birds (Fisher's exact test, $P = 0.37$).

DISCUSSION

The migration strategy of Western Sandpipers differs by age and sex (Morrison 1984). In British Columbia, during fall migration, peak numbers of adults occur by mid August, followed by peak numbers of first-year birds from late August to mid September (Butler et al. 1987). At Punta Banda, and further south in Mexico (Fernández et al. 1998), Western Sandpipers arrived at the estuary in mid August, but the first returning banded birds were not observed until late September in both years. A similar pattern was observed in Puerto Rico, where Western Sandpipers used the area as a stopover site between August and September, and wintering area between October and December, when the mean length of stay increased (Rice 1995).

Many of the Western Sandpipers returning to Punta Banda in late September exhibited site fidelity and remained at the site throughout the season, as found at other sites (Smith and Stiles 1979; Rice 1995; Warnock and Takekawa 1996). However, some individuals, which we called transient birds, had short lengths of stay because they arrived later and/or departed earlier than wintering birds. Even though these birds had shorter lengths of stay, they demonstrated similar rates of site fidelity between years, a finding that has not been reported for wintering Western Sandpipers at other locations (Smith and Stiles 1979; Rice 1995). Some of

these transient birds may be migratory birds for which Punta Banda is a regular stopover site, a strategy used by other North American shorebirds (Smith and Houghton 1984).

One possible explanation of the detection of transient birds is resighting bias. However, Punta Banda is a small estuary, and under certain tidal conditions, most of the sandpipers concentrate to feed at the main channel. Most of our resighting effort was carried out during these periods when birds were most concentrated. Our resighting rate was relatively high (ca. 70%; Fernández 1996) during the study period, and we detected most of the banded birds each year. The length of stay estimates were independent of resighting effort.

During spring migration, the median departure dates of wintering Western Sandpipers at Punta Banda were between two and three weeks earlier than the main migration period in the Pacific Flyway in North America. In California, spring migration begins in late March and ends in mid May, with the peak in the third week of April (Page et al. 1979; Shuford et al. 1989). In British Columbia, migration extends from mid April to mid May (Butler et al. 1987). Delgado and Butler (1993) suggest that spring migration could begin earlier in southerly sites. In both years, we observed a specific Western Sandpiper abundance pattern in March and early April. The number of birds declined during March, but in early April we detected a spring migration peak. These birds were probably migrants from farther south. Support for this idea comes from our observations of flagged Western Sandpipers from Panama in early April, which were not present during the winter.

The arrival pattern and the length of stays observed at Punta Banda were variable between years, with birds arriving earlier and staying for longer periods in 1996 than in 1995. The transient birds also arrived earlier in 1996. This variability could reflect how birds responded to different conditions during migration along the Pacific Flyway (Iverson et al. 1996). On the other hand, during spring migration birds departed from Punta Banda quite synchronously in both 1995 and 1996. Spring migrants are probably being "time-selected" because the cost of being late may be greater in the spring than in the fall (Lyons and Haig 1995). At Punta Banda, older birds were more likely to depart earlier. Consistent with this finding, older adults arrive at the breeding grounds earlier (Sandercock 1997).

We did not find age, body size, or timing correlates of the length of stay. It has been suggested that that body size is an important factor for influencing settlement patterns because smaller individuals are more susceptible to being displaced by competition (Evans and Townshend 1986). We did not detect any differences in body size (e.g., wing cord corrected by body size) or body mass between transient and wintering birds (G. Fernandez et al., unpubl. data).

At Punta Banda, older birds were more likely to switch residency patterns from wintering to transient. It is possible that older birds might change wintering sites because they have sufficient experience to evaluate

sites and the current site does not have enough resources to assure survivorship. In Dunlin (*Calidris alpina*), most first-year birds seem to become attached to a wintering site during November (Baccetti et al. 1999). We did not detect that the residency pattern was related to the month of capture in either adult or first-year birds, and transient category seems not influenced by banding period.

The process by which shorebirds select a nonbreeding site is largely unknown (Myers et al. 1986). Local and regional winter movements of shorebirds are known to occur to take advantage of changing feeding opportunities at nearby estuaries (Ruiz et al. 1989) or in response to weather conditions (Warnock et al. 1995). The presence of transient birds at Punta Banda may be due to two factors: habitat quality and opportunistic behavior of individuals. Habitat quality is a major factor influencing movements of Western Sandpipers (Warnock and Takekawa 1995, 1996). Moreover, in Dunlins there are opportunistic individuals that exploit different sites, and these mobile birds appear to be in better condition than resident birds (Ruiz et al. 1989). Flexibility in wintering site attachment may be needed to maximize overwinter survivorship under changing habitat conditions (Warnock and Takekawa 1996).

We have demonstrated that some Western Sandpipers have different, but consistent, residency patterns between years, similar to Dunlins wintering in California (Warnock et al. 1995). We have also shown that many Western Sandpipers are site-faithful to Punta Banda. However, site fixation may be more variable in Western Sandpipers than in other shorebirds species (Baccetti et al. 1999), as older birds at Punta Banda may not settle until after their second wintering season (Fernández 1996, unpubl. data). The proximate mechanisms controlling why some sandpipers remain at the estuary throughout a season need more research. Our study establishes the functional importance of Punta Banda in the annual cycle of the Western Sandpiper. Effective conservation of shorebird populations must include an understanding of the different alternative wintering strategies and the reasons for these alternative strategies. If density-dependent processes occur at all for this species in the nonbreeding season (Goss-Custard 1980), the effect of these processes could be different for wintering and transient birds, according to their susceptibility to interference and/or competition for food, and because of permanent habitat modifications on the wintering areas. Individual decisions play a central role in determining local population size, not just for the current year, but for the lifetime of an individual (Townshend 1985; Myers et al. 1986).

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LITERATURE CITED

BACCETTI, N., L. SERRA, G. CHERUBINI, AND A. MAGNANI. 1999. Timing to attachment to wintering site as revealed by experimental displacements of Dunlins (*Calidris alpina*). J. Ornithol. 140:309–317.

BUENOROSTRO, M. A., N. WARNOCK, AND H. DE LA CUEVA. 1999. Wintering Western Sandpipers *Calidris mauri* at Estero de Punta Banda, Baja California, México. Wader Study Group Bull. 88:59–63.

BUTLER, R. W., G. W. KAISER, AND G. E. J. SMITH. 1987. Migration chronology, length of stay, sex ratio, and weight of Western Sandpipers, (*Calidris mauri*) on the south coast of British Columbia. J. Field Ornithol. 58:103–111.

BURGER, J., AND B. L. OLLA, Eds. 1984. Behavior of marine animals, vol. 6. Shorebirds: migration and foraging. Plenum Press, New York.

DELGADO, F., AND R. W. BUTLER. 1993. Shorebirds in Parita Bay, Panama. Wader Study Group Bull. 67:50–53.

ENGILIS, A., JR., L. W. ORING, E. CARRERA, J. W. NELSON, AND A. MARTINEZ LOPEZ. 1998. Shorebirds surveys in Ensenada Pabellones and Bahia Santa Maria, Sinaloa, Mexico: critical winter habitats for Pacific Flyway shorebirds. Wilson Bull. 110:332–341.

EVANS, P. R., AND D. J. TOWNSHEND. 1986. Site faithfulness of waders away from the breeding grounds: how individuals migration patterns are established. Proc. Int. Ornithol. Congr. 19:599–603.

FERNÁNDEZ, G. J. 1996. Tasas de retorno y residencia de *Calidris mauri* (Charadriiformes: Scolopacidae) en el estero Punta Banda (B. C., México) en la temporada invernal de 1995–1996. M.S. thesis, CICESE, Ensenada, Mexico.

———, R. CARMONA, AND H. DE LA CUEVA. 1998. Abundance and seasonal variation of Western Sandpipers (*Calidris mauri*) in Baja California Sur, Mexico. Southwest. Nat. 43:57–61.

GOSS-CUSTARD, J. D. 1980. Competition for food and interference among waders. Andea 68: 31–52.

HELMERS, D. L. 1992. Shorebird management manual. Western Hemisphere Shorebird Reserve Network, Manomet, Massachusetts.

IVERSON, G. C., S. E. WARNOCK, R. W. BUTLER, M. A. BISHOP, AND N. WARNOCK. 1996. Spring migration of Western Sandpipers along the Pacific coast of North America: a telemetry study. Condor 98:10–21.

LYONS, J. E., AND S. M. HAIG. 1995. Fat content and stopover ecology of spring migrant Semipalmated Sandpipers in South Carolina. Condor 97:427–437.

MORRISON, R. I. G. 1984. Migration systems of some new world shorebirds. Pp. 125–202, *in* Burger, J. and B. L. Olla, eds. Behavior of marine animals, vol. 6. Plenum Press, New York.

———, R. K. ROSS, AND J. P. GUZMÁN. 1994. Aerial surveys of Nearctic shorebirds wintering in Mexico: preliminary results of surveys of the southern half of the Pacific coast, states of Chiapas to Sinaloa. Canadian Wildlife Service Progress Notes 209. Ottawa, Canada.

———, ———, AND M. S. TORRES. 1992. Aerial surveys of Nearctic shorebirds wintering in Mexico: some preliminary results. Canadian Wildlife Service Progress Notes 201. Ottawa, Canada.

MYERS, J. P., C. T. SCHICK, AND G. CASTRO. 1986. Structure in Sanderling (*Calidris alba*) populations: the magnitude of intra- and interyear dispersal during the nonbreeding season. Proc. Int. Ornithol. Congr. 19:604–615.

———, R. I. G. MORRISON, P. Z. ANTAS, B. A. HARRINGTON, T. E. LOVEJOY, M. SALLABERRY, S. E. SENNER, AND A. TARAK. 1987. Conservation strategy for migratory species. Am. Sci. 75:19–26.

NARANJO, L. G., R. FRANKE, AND W. BELTRÁN. 1994. Migration and wintering of Western Sandpipers on the Pacific coast of Colombia. J. Field Ornithol. 65:194–200.

PAGE, G., AND B. FEARIS. 1971. Sexing Western Sandpipers by bill length. Bird-Banding 42: 297–298.

———, ———, AND R. M. JUREK. 1972. Age and sex composition of Western Sandpipers on Bolinas Lagoon. Calif. Birds 3:79–86.

———, L. E. STENZEL, AND C. M. WOLFE. 1979. Aspects of the occurrence of shorebirds on a central California estuary. Stud. Avian Biol. 2:15–32.

RICE, S. M. 1995. Residency rates, annual return rates and population estimates of Semipalmated and Western Sandpipers at the Cabo Rojo Salt flats, Puerto Rico. M.S. thesis, Univ. Puerto Rico, Puerto Rico.

RUIZ, G. M., P. G. CONNORS, S. E. GRIFFIN, AND F. A. PITELKA. 1989. Structure of a wintering Dunlin population. Condor 91:562–570.

SAS INSTITUTE. 1997. JMP. Version 3.2.1. [IBM OS]. SAS Institute, Cary, North Carolina.

SANDERCOCK, B. K. 1997. Factors affecting the breeding demography of Western Sandpipers (*Calidris mauri*) and Semipalmated Sandpipers (*C. pusilla*) at Nome, Alaska. Ph.D. diss., Simon Fraser University, Burnaby, Canada.

SENNER, S. E., AND M. A. HOWE. 1984. Conservation of Nearctic shorebirds. Pp. 379–422, *in* Burger, J. and B. L. Olla, eds. Behavior of marine animals, vol. 6. Plenum Press, New York.

SMITH, P. W., AND N. T. HOUGHTON. 1984. Fidelity of Semipalmated Plovers to a migration stopover area. J. Field Ornithol. 55:247–249.

SMITH, S. M., AND G. F. STILES. 1979. Banding studies of migrating shorebirds in northwestern Costa Rica. Stud. Avian Biol. 2:41–47.

SHUFORD, W. D., G. W. PAGE, J. G. EVENS, AND L. E. STENZEL. 1989. Seasonal abundance of waterbirds at Point Reyes: a coastal California perspective. Western Birds 20:137–541.

TOWNSHEND, D. J. 1985. Decisions for a lifetime: establishment of spatial defence and movement patterns by juvenile Grey Plovers (*Pluvialis squatarola*). J. Anim. Ecol. 54:267–274.

WARNOCK, N., G. W. PAGE, AND L. E. STENZEL. 1995. Non-migratory movements of Dunlins on their California wintering grounds. Wilson Bull. 107:131–139.

WARNOCK, S. E., AND J. Y. TAKEKAWA. 1995. Habitat preferences of wintering shorebirds in a temporally changing environment: Western Sandpipers in the San Francisco Bay estuary. Auk 112:920–930.

———, AND ———. 1996. Wintering site fidelity and movement patterns of Western Sandpipers *Calidris mauri* in the San Francisco Bay estuary. Ibis 138:160–167.

WILSON, W. H. 1994. Western Sandpiper, *Calidris mauri*. No. 90, *in* A. Poole and F. Gill, eds. The birds of North America. The Academy of Natural Sciences, Philadelphia and American Ornithologists' Union, Washington, DC.

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