Yellow birds stand out in a crowd

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Highly visible auxiliary markers, such as neck collars, nasal saddles, patagial tags, and leg streamers, are used regularly and effectively with banding in studying migration and distribution of large birds (e.g. waterfowl, birds of prey, wading birds). Simply stated, a large bird can accommodate a marker that is large enough to be seen readily by an observer but still small enough not to alter behavior or impair flight (see Marion and Shamis 1977 for review). Such is not true with smaller birds, and consequently information on their migration routes and distribution is usually poorer than for larger birds. The use of colored leg bands increases the frequency of detection of small birds that have been banded; however, a large percentage of such marked birds is usually still overlooked. Only by using highly visible techniques, such as plumage dyes and bleaches in conjunction with leg bands, can one obtain significant numbers of sightings of small birds. Here we present information from sightings of large numbers of marked Dunlins *(Calidris alpina)* and Western Sandpipers *(C. mauri)* that dramatically demonstrates this.

Methods

Between 1977 and 1981 we captured postbreeding Dunlins and Western Sandpipers with mist nets and a rocket net at roosting sites on the Alaska Peninsula (56°00'N, 161°10'W) and on the Yukon-Kuskokwim River Delta (61°15'N, 165°35'W), Alaska. Ninety-four per cent of the birds captured were banded with a U.S. Fish and Wildlife Service aluminum band and one or more colored plastic leg bands, and 91% of birds were dyed (Table 1). To dye birds, we painted all white feathers on the breast, abdomen, and flanks yellow with a saturated aqueous solution of picric acid; we mixed 3-5 drops of mild dishwashing detergent with each pint of dye to cut the oil on the feathers and allow the dye to "take." The sandpipers were caged until they were dry and had preened their feathers, a period lasting usually no longer than 1-2 hours. We found that this procedure prevented the plumage of the birds from becoming waterlogged when they bathed and that it thereby increased the sandpipers' chances of survival. Before each field season we notified numerous individuals, universities, and agencies of our study and explained our color-marking program and reporting procedures. By the end of the second year of the study, one or more principal contacts had been established at most major estuaries and at other sites where these sandpipers congregate along the Pacific Coast from Alaska to southern California.

Table 1. Summary of color-marking schemes.

Scheme	Number marked (%)	
	Dunlins	Western Sandpipers
No dye or colored bands	7 (<1)	0 (0)
Colored bands only	485 (16)	53 (2)
Dye only	1 (<1)	346 (12)
Dye and colored bands	2,629 (84)	2,405 (86)
Total	3,122 (100)	2,804 (100)

In conjunction with our analysis of the distribution of recoveries, which will be reported in another paper, we made two comparisons to test the premise that observers would see and report a significantly greater proportion of sandpipers that were dyed and color-banded than of those that were only color-banded. First we compared the number of birds on which both dye and colored bands were seen with the number of birds on which only dye was seen. Those marked birds on which only dye could be seen constituted a group which would otherwise have gone undetected; what proportion of sightings fell into this category would be an important although minimal indication of the added effectiveness of dyeing.

Second, we compared the number of sightings reported during the period when birds still retained dye with the number of sightings of birds after they had lost their dyed feathers through molt. Some but not all Western Sandpipers begin prebasic molt before they leave the breeding grounds, but none complete molt until after they have departed (Holmes 1972; Gill and Handel, unpublished data). The first individuals with completed molt have been recorded in mid-October along the Pacific Coast (Holmes 1972); at Bolinas Lagoon, California, Page (1974) found that the height of first prebasic molt (hatching-year birds) occurs between September and early November. Consequently, most of the Western Sandpipers banded on the two staging areas in Alaska would have retained their dye until they had reached wintering areas and completed prebasic molt. In contrast, Dunlins complete prebasic molt of flight feathers and most body feathers before fall migration (Holmes 1971; Page 1974; Gill and Handel, unpublished data). Since we captured and dyed Dunlins in various stages of molt, some would have lost the dye before departure, some would have lost it when completing prebasic molt on the wintering grounds, and others would have retained it until prealternate molt.

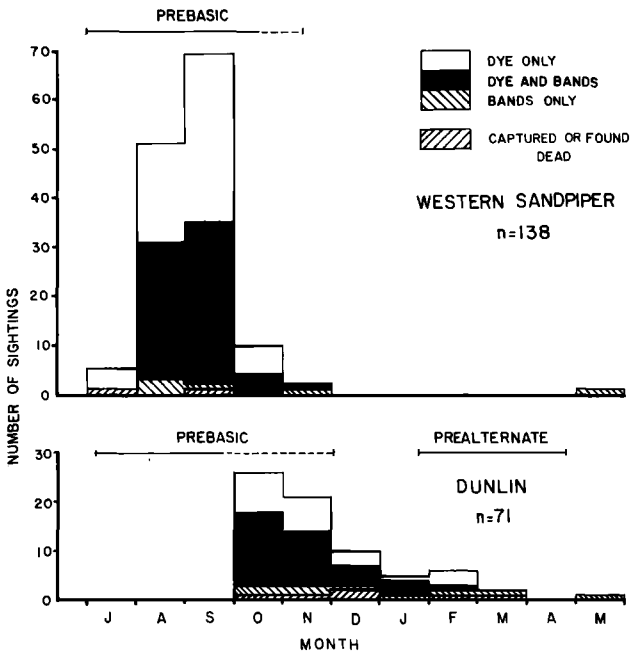

Figure 1. Number of banded Western Sandpipers and Dunlins captured again, found dead, or sighted with various color-markings. Bracketed lines above each histogram delineate periods of molt; dashed portion of each line indicates period during which most birds complete body molt (from Holmes 1971, 1972; Page 1974; Gill and Handel, unpublished data).

Results and discussion

From the 5,926 birds captured and marked, we received 209 reports of sightings or captures away from the banding sites (Figure 1). With the exception of one Dunlin and one Western Sandpiper that were recaptured, all observations of marked birds occurred within a year of their banding. Only 1% of the Western Sandpipers and 8% of the Dunlins that were reported were birds that were captured again or found dead. These represent the maximum numbers that would have definitely been reported had we used no auxiliary markings of any kind.

Only 4% of the 136 marked Western Sandpipers observed were birds that were seen with colored bands only. Observers reported seeing both dye and colored bands in 66 (49%) of the sightings, but did not see any colored bands for an almost equal number: 64 (47%). Because 87.4% of the 2,751 Westerns that we dyed were also color-banded (Table 1), by chance we would have expected 114 of the 130 birds seen with dye to have also been color-banded, instead of the 66 reported. The discrepancy between the number of birds observed and the number expected to be seen only with dye was highly significant ($X^2 = 164.21$, df = 1, $P<0.001$). Thus we estimate that 48 of the 64 birds reported only with dye (Figure 1) probably also had colored bands that observers simply did not see. Including the two birds that were captured again, we thus received 138 reports of marked birds (Figure 1), for a reporting rate of 4.9% (of 2,804 birds banded); if no birds had been dyed, none of those birds on which bands were not seen would have been noted and the reporting rate would have been at most 2.6% (74 sightings). Since many observers reported seeing the dye first and then searching hard for bands, it is likely that the reporting rate would have been much lower than 2.6% if no birds had been dyed.

This point is supported by comparison of total number of sightings of banded Western Sandpipers before and after prebasic molt was completed. A marked drop in the number of sightings corresponded precisely with the period during which molt was completed, and only 2% of the sightings occurred afterward (Figure 1). Although some banded Westerns may have moved farther south to winter (cf. Page et al. 1972), it is unlikely that the decline in their sightings during October was due to their movement south since numbers of Western Sandpipers peak along the coast between San Francisco Bay and San Diego during October and November (Storer 1951; Jurek 1973; Gill, unpublished data). Probably only a minor part of the decline in sightings of either species was due to mortality. The annual survival rate of Dunlins in Europe has been estimated at 61.1% for adults and 38% for juveniles (Boyd 1962). The rate of mortality is probably lower during winter than during migration; however, if we conservatively assume that it is fairly constant throughout the year, the monthly survival rate averages about 96% for adults and 92% for juveniles. These figures are probably good estimates of the survival rates of Western Sandpipers, too, since the 2 species are similar in size and habits and have almost identical longevity records, slightly over 9 years each (Clapp et al. 1982). When the number of marked Western Sandpipers encountered in September (before molt was completed) is compared with the numbers encountered in October and November (after most had completed molt but before they may have moved farther south), the difference is highly significant, even after adjusting for the added factor of mortality, estimated at about 6% per month ($X^2 = 88.83$, df = 2, $P<0.001$). One could argue that the number of sightings of banded birds dropped during subsequent winter months because the sandpipers moved to wintering areas farther south where reporting rates were lower, but the rates would still have been expected to increase when the birds returned north during spring migration. Such an increase did not occur. It is likely that many moved along the Pacific Coast states and provinces but their colored bands were simply not seen.

Observations of color-marked Dunlins followed a similar pattern. The number of sightings of marked birds gradually declined as prebasic molt was completed (Figure 1). Dunlins observed with dye during subsequent winter months were birds that had been banded after they had partially acquired basic plumage. Once prealternate molt began in spring, these birds too lost their dye and the number of sightings again dropped. The steady decline in encounters of marked Dunlins as the season progressed was significantly different from that expected to occur from mortality alone ($X^2 = 51.95$, df = 7, $P<0.001$), if a rate of mortality of 6% per month is again assumed. To match closely the observed decline in encounters of marked birds, the monthly survival rate would have to have been about 63%; this then would have resulted in an annual survival rate of only 0.4%, which contrasts sharply with the 38-61% annual survival rates found for this species (Boyd 1962). Thus it is extremely unlikely that the decrease in the number of sightings was due to mortality alone. In addition, the number of sightings of marked birds declined steadily from October through May (Figure 1) even though numbers of Dunlins usually peak in November or December and large numbers continue to reside throughout winter along the coast from Washington to California (Storer 1951; Holmes 1966; Recher 1966; Jurek 1973; Page 1974; Widrig 1979; Gill, unpublished data). Thus it is unlikely that the steady decline in encounters of marked Dunlins through winter was due to movement of birds to an area of lower reporting rates. It appears, then, that the steady decline in reports of marked birds can be attributed primarily to the birds' loss of dye as winter progressed.

Of the 65 sight records of Dunlins, 52% were of birds on which both dye and colored bands were seen, and an additional 34% were of birds on which only dye was detected (Figure 1). Only 14% of the sightings were of birds which had no dye even though, judging from the Dunlins' state of molt when we banded them, we estimated that 60-80% of those we dyed should have lost all their dye by December. Including the 6 birds that were captured again or found dead, we obtained 71 sightings, or a reporting rate of 2.3% (Figure 1). If no Dunlins had been dyed, the 22 birds whose colored bands were not seen would not have been detected and the reporting rate would have been at most 1.6% (49 reports). The number of sightings of Dunlins with colored bands only did not increase as the birds molted their dyed plumage, suggesting again that few of the dyed birds would have been seen had they been marked only with colored bands.

For the two species combined, excluding the 8 found dead or recaptured and the 16 Western Sandpipers seen that were dyed but probably not color-banded, 70 of the 185 reports were of birds whose dye but no colored bands were seen. Thus, at a minimum, dyeing the sandpipers increased the effectiveness of color-marking 61% above the level of color-banding alone. However, from reports of observers we know that many of the color-banded birds would not have been detected if there had been no dye. By comparing the relative proportions of dyed and undyed color-banded Dunlins that were observed, we can get a better estimate of how effective dyeing was as an auxiliary marker. After an analysis of the stages of prebasic molt the Dunlins were in when we banded and dyed them, we concluded that about 50% (1,315) of them would have lost their dye through molt before they left the staging areas in Alaska. If we assume that 12% of the birds had died before reaching wintering grounds, then almost 2% (23 birds, Figure 1) of the Dunlins that still survived and still retained dye (estimated 1,157 of the original 2,630 dyed, see Table 1) were observed during the month of October. By comparison, only 2 birds that had colored bands but no dye were observed that same month. During October there would have been approximately 1,584 Dunlins surviving that were marked only with colored bands. These would have included the 88% (427 birds) surviving of the 485 originally marked just with colored bands (Table 1) as well as an additional 1,157 Dunlins estimated to have lost their dye and survived migration. Thus the 2 Dunlins seen that month with only colored bands represented about 0.13% of the birds so marked at that time. The difference in the proportions of dyed and undyed Dunlins observed was highly significant ($X^2 = 25.64$, df = 1, $P < 0.001$). By comparison, then, Dunlins with dye are estimated to have been seen about 16 times as often as those with colored leg bands only (reporting rates of 2% vs. 0.13%).

In view of these findings, it is very probable that only a small percentage of the birds on which dye and bands were both seen would have been detected if the birds had not been dyed. Considering the low recovery rates obtained even when such auxiliary markings are used, the information gained by substantially increasing the number of recoveries illustrates the value of using dye on certain small birds, such as sandpipers, to determine seasonal patterns of movement over large geographic areas.

Summary

Between 1977 and 1981 we captured and banded 5,926 postbreeding Dunlins and Western Sandpipers in southwestern Alaska. 94% were color-banded and 91% were dyed yellow with picric acid. When analyzing the distribution of the 209 sightings and recoveries of these birds during migration and on the wintering grounds, we also tested the hypothesis that observers would have seen and reported a significantly greater proportion of sand-

pipers that had been dyed and color-banded than of those that had only been color-banded. Only 1% of the Western Sandpipers and 8% of the Dunlins that were reported were birds that were recaptured or found dead, and thus were the maximum numbers that would have definitely been reported had we used no auxiliary markings of any kind. Of the 185 birds sighted that were estimated to have been marked with both dye and colored leg bands, 70 (38%) were reported to have only dye, and thus represented a group of birds that would have gone undetected if they had not been dyed. Many observers also reported that they first saw dye on the sandpipers and only detected the colored bands after a long search. To estimate what proportion of the dyed and color-banded birds would never have been seen if they had not been dyed, we compared the relative proportions of dyed and undyed color-banded Dunlins that were observed. Taking into account the effect of mortality and the proportion of birds that would have already molted their dyed plumage, we concluded that a sandpiper dyed yellow was about 16 times more likely to be seen than one that was only color-banded. This conclusion was supported by the abrupt decline in reports of marked birds as molt was completed and the birds lost their dye.

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