EFFECTS OF BANDING ON THE TARSUS OF THE WHITE-CROWNED SPARROW

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Some of the markers or tags placed on birds may have at least minor effects. Even standard U.S. Fish and Wildlife Service bands can have a deleterious effect in special situations such as with species like the Turkey Vulture (*Cathartes aura*) that urinate on their legs (Henckel, 1976). I am unaware, however, of any reported effects of banding upon species that lack unusual behavioral attributes. I report here two physical effects of banding in the White-crowned Sparrow (*Zonotrichia leucophrys gambelii*), a frequently banded species in North America with no unusual attributes. The physical effects described here are probably not deleterious. Possibly, the physiological or other types of mechanisms responsible for these physical effects will prove to be of more interest than any minor consequences these effects have upon banded birds.

While banding White-crowns during the winter of 1975–1976, I noticed that the banded tarsus of recaptured birds had a grayish cast contrasting strongly with the light brown or tan of the unbanded tarsus. In some birds the gray seemed darkest around the edges of scutes and in some the overall grayish cast made the edges of the scutes less distinct than on the unbanded tarsus. Detailed records were not kept but the graying effect was detectable on at least the great majority (perhaps all) of the White-crowns I recaptured. It is also my impression that the graying becomes more extreme with time and that within one winter season it is darker in recaptured birds that were first banded in a prior season than in those banded earlier in the season. I know of no other reports relevant to the graying effect.

The second morphological effect of banding is an apparent slight swelling of the banded tarsus. The graying effect prompted me to inspect closely the tarsi of banded birds. These inspections led to the impression that the banded tarsus was wider than the unbanded one in some birds. To determine whether banded tarsi were consistently wider I measured the width of the tarsi. The remainder of this paper deals mostly with these tarsal measurements.

METHODS

Birds were captured during the winters of 1975–1976, 1976–1977 and 1977–1978 at a banding station in Goleta, California. Potter traps, a funnel trap, and a Havahart sparrow trap were used. I banded birds with size 1B bands, the size recommended in the North American Bird Banding Manual (U.S. Fish and Wildlife Serv. and Can. Wildlife Service, 1976) and used commercially available banding pliers. All birds were banded on the left tarsus in the 1975–1976 season, but in the two subsequent winters I usually alternated the tarsus on which I placed bands.

Measurements of the narrower diameter of the tarsus were taken at

the junction of the first and second long tarsal scutes above the toes. I used a Helios dial caliper and closed the arms of the caliper snugly around the tarsus while still allowing the tarsus to be moved back and forth. I took one measurement for each tarsus, measured both tarsi of every banded bird, and estimated readings to 0.01 mm.

During the 1976–1977 and 1977–1978 seasons I performed "control measurements" on unbanded birds to determine if my measurements were biased towards larger readings for the right or left tarsus and to determine whether in the absence of any banding effect birds show a consistent tendency for one tarsus to be wider than the other, i.e., bilateral asymmetry. In another attempt to uncover biases in my measurements and to determine the reproducibility of my data, eight birds were measured both by myself and by an associate, Gary N. Fugle, during two consecutive days in 1977–1978.

RESULTS

Fugle's measurements and mine were compared by computing a ratio for the diameter of the left to right tarsus of each bird. The correlation between the ratios derived from both series of measurements is significant at $P < .01$ ($\tau = .706$, n = 8, Kendall rank correlation. (This and all subsequent tests are from Siegel [1956]). Thus, my measurements of the differentials between the left and right tarsus of each bird are reproducible and appear to be free of biases.

Table 1 presents data that also test for biases in my measurements. At the time they were banded in the 1976–1977 season, 39 birds had the left tarsus wider than the right, whereas 29 had the right tarsus wider (row 1, Table 1). This comparison, 39:29, does not differ significantly from a 50:50 breakdown ($\chi^2 = 1.47$, d.f. = 1, $.1 < P < .5$). The comparable "control data" for 1977–1978—20:27 (row 3, Table 1)—also show no difference from 50:50 expectation ($\chi^2 = 1.04$, d.f. = 1, $.1 < P < .5$). Thus, there is no evidence that my measurements were biased towards one tarsus. Overall in both years, the left tarsus was wider in 59 birds, the right wider in 56; this almost certainly shows that unbanded birds do not have a consistent tendency for either the right or left tarsus to be the wider one.

Immature and adult birds measured at the time of banding showed no differences in tarsal diameter (Table 2). This suggests that tarsal growth, at least in diameter, is completed before birds-of-the-year arrive on the wintering grounds. Both age classes are combined in subsequent analyses. In any event, age class differences or tarsal growth after banding would not bias the subsequent analyses because all these deal with ratios calculated from measurements, taken at the same time, of both tarsi of each bird.

Two types of analyses were done to investigate the possible swelling effect of banding: (1) I compared the ratios for birds recaptured in a winter subsequent to the one in which they were banded with the ratios

TABLE 1

Control data and ratios of width of wider/thinner tarsus.

Category	Season measurements taken	No. of birds measured	No. with one tarsus wider		Ratio of wider/thinner tarsus 1.01	1.02	1.03	1.04	1.05	1.06 to 1.11	Mean
1) Control data—ratios for birds before being banded[1]	1976–1977	83	left 39		10	15	6	2	2	4	1.026
			right 29		8	6	8	4	1	2	1.027
2) Ratios for birds banded in 1975–1976 and recaptured in 1976–1977, banded on left[2]	1976–1977	22	left 17		4	5	2	2	1	3	1.032
			right 3		1	1	1	0	0	0	1.020
3) Control data—ratios for birds before being banded[1]	1977–1978	56	left 20		5	9	1	3	0	2	1.026
			right 27		7	10	5	3	1	1	1.024
4) Ratios for birds banded in 1975–1976 plus 1976–1977 and recaptured in 1977–1978, banded on left[2]	1977–1978	23	left 16		0	2	2	4	2	6	1.048
			right 3		1	1	1	0	0	0	1.020
5) Ratios for birds banded in 1976–1977 and recaptured in 1977–1978, banded on right[2]	1977–1978	8	left 0		0	0	0	0	0	0	—
			right 8		2	2	1	1	0	2	1.033

[1] These rows represent one set of measurements for each bird, i.e., one measurement for each tarsus.
[2] These rows represent the average of the measurements taken each time the bird was recaptured during the season in question.

TABLE 2
Tarsal diameters of adult and immature White-crowned Sparrows.

Season	Age class	N	Tarsal diameters mm		SD
			Mean[1]	Range[1]	
1976–1977	adult	33	1.303	1.165–1.415	0.064
1977–1978	adult	24	1.287	1.18–1.38	0.062
1976–1977, 1977–1978	adult	57	1.297	1.165–1.415	0.063
1976–1977	im.	50	1.290	1.19–1.465	0.056
1977–1978	im.	32	1.296	1.175–1.405	0.061
1976–1977, 1977–1978	im.	82	1.292	1.175–1.465	0.058

[1] The datum used for each bird was the mean for the right and left tarsus, hence the reason some of the figures end in 0.001 mm even though readings were taken to 0.01 mm.

for unbanded birds. (2) I compared the ratios for birds at the time they were banded and before any possible banding effect, with ratios shown by the same birds later in the same winter.

Birds recaptured in a subsequent winter.—In 1976–1977, I recaptured 22 birds banded in 1975–1976; 17 of these had the banded or left tarsus wider, three had the right wider, and the tarsi were equal in two birds (row 2, Table 1). This breakdown, 17:3, differs significantly from the control data (row 1, Table 1) for 1976–1977 ($\chi^2 = 3.98$, d.f. = 1, $.01 < P < .025$ for 2×2 contingency table based on 17:3 versus 39:29). The breakdown of 17:3 is even more significant if compared against 50:50 expectation ($P = .001$, binomial proportion). Among birds banded on the left tarsus in 1975–1976 and 1976–1977 and recaptured in 1977–1978 (row 4, Table 1), 16 of 19 that showed a differential had the left tarsus wider. The comparison between these data and the control data for 1977–1978—row 4 versus row 3 (Table 1) or 16:3 versus 20:27—is significant at $P < .005$ ($\chi^2 = 9.32$, d.f. = 1). This comparison between rows 4 and 3 is not completely independent from that between rows 2 and 1 because some 1975–1976 birds recaptured in 1976–1977 were also recaptured in 1977–1978. If the comparison between rows 4 and 3 is done by deleting those birds that were recaptured in 1976–1977, the contrast becomes eight wider on the left and two wider on the right versus 20:27 and is significant at $.025 < P < .05$ ($\chi^2 = 3.25$, d.f. = 1). Thus, two independent tests show that birds banded on the left tarsus in one winter and recaptured in a subsequent winter have the left (banded) tarsus wider significantly more often than expected by chance.

All eight birds banded on the right tarsus in 1976–1977 and recaptured in 1977–1978 had the right tarsus wider than the left (row 5, Table 1). This result is significantly different from the control data for 1977–1978 ($P \leq .02$, Fisher exact test for row 5 versus row 3 or 0:8 versus 20:27).

If banding causes a tarsus to swell, then differentials between tarsi should be larger for banded than for unbanded birds. The ratios for

the control data (rows 1 and 3, Table 1) have means of 1.024 to 1.027. By contrast, for birds that had a banded tarsus wider than their unbanded tarsus the ratios have means of 1.032 (row 2), 1.033 (row 5) and 1.048 (row 4). The ratios in row 4 for birds with the left (banded) tarsus wider are in fact significantly larger than the comparable control ratios in row 3 ($P < .001$, $\chi^2 = 13.77$, d.f. = 1, Kolmogorov-Smirnov test. The comparable tests for rows 2 and 5 are not significant.). Also suggesting that banding causes the tarsus to swell is the fact that the few birds in rows 2 and 4 (Table 1) whose unbanded tarsus was wider than the banded one had relatively low ratios averaging 1.020.

Birds recaptured during the same winter in which they were banded.—Ratios for birds recaptured in 1976–1977 after they were banded earlier in the same winter show that tarsal swelling occurs soon after banding. To separate data into different time periods, the 1976–1977 season was divided into 10-day intervals starting with 21–30 Nov., then 1–10 Dec., etc. The "B" column in Figure 1 gives the ratio of banded:unbanded tarsus at the time birds were banded. Subsequent columns (1–13) refer to recaptures occurring in 10-day intervals that began after the interval in which the bird was banded. For example, a recapture is entered in the "1" column if it took place in the next fixed 10-day interval although the time elapsed could have ranged from 1–19 days. If a bird was recaptured more than once within a 10-day interval, its measurements were averaged to produce one ratio for the interval. Many of the birds were recaptured in two or more intervals.

At the time of initial capture, the tarsus that was to be banded was wider in 10 birds and narrower in 15 (column B, Fig. 1). Among birds recaptured in the next interval after being banded, the banded tarsus was wider in six and narrower in seven (column 1). By contrast, for recaptures after interval 1, the banded tarsus was wider in 37 cases and narrower in only seven. Figure 1 portrays all the available data and shows a clear trend, but it does not show the changes occurring with time in the measurements of specific individuals. Figure 2 shows changes in individual birds between the times they were banded and recaptured. Only intervals with a large number of recaptures are included (columns 1, 2, 3, and 5, Fig. 1). If the banded tarsus did not become wider relative to the unbanded one, the number of upward and downward sloping lines in Figure 2 should not differ significantly from equality. This is the case for birds recaptured after one interval, but for birds recaptured in the second interval, 11 showed an increased ratio and only one showed a decrease ($P = .003$, sign test). Similarly, birds recaptured after three or five intervals showed mostly increased ratios, although the samples are small and only the B-5 data are significant ($P = .02$). All of the birds recaptured after five intervals are different individuals from those recaptured after two intervals, so the two tests based on Figure 2 that are significant are independent. Furthermore, none of the birds recaptured after two intervals were recaptured in 1977–1978, so the test based on B-2 is completely independent of the tests on data in Table 1.

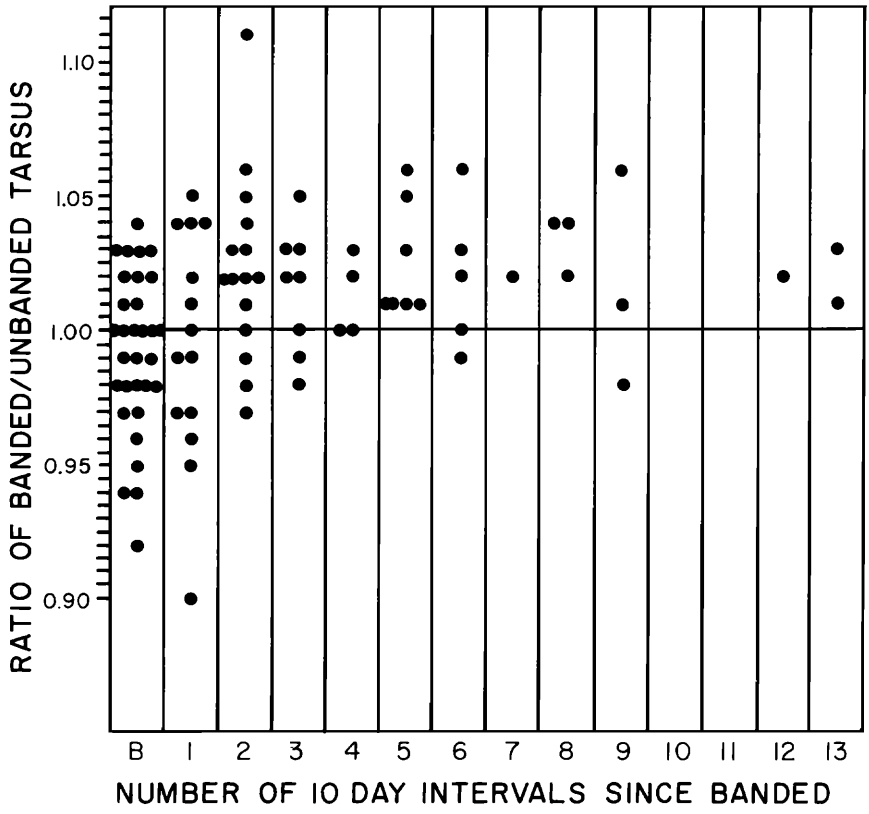

FIGURE 1. Ratios of diameter of banded:unbanded tarsus for 37 birds banded in the winter of 1976–1977 and recaptured at least once in the same winter. The "B" column gives the ratio for each bird at the time it was banded. Numbered columns after B refer to ratios when birds were recaptured during a fixed series of 10-day intervals set up for the entire 1976–1977 season (see text). Although the graph contains data on 37 birds, only 31 ratios are in the B column because six birds were not measured at the time of their initial capture.

I have not presented data for the 1975–1976 and 1977–1978 seasons in the same manner as I have for 1976–1977 (Figs. 1, 2) because in 1975–1976 I did not measure tarsi at the time of initial capture and in 1977–1978 I ceased measuring tarsi on 15 Dec. at which time only nine 1977–1978 birds had been recaptured. Of these nine, six had increased ratios for the diameter of the banded to unbanded tarsus, one had a decreased ratio, and two were unchanged ($P = .06$).

Rapidity and intensity of tarsal enlargement.—The total amount of swelling and the period over which it occurs are difficult to calculate accurately. Figure 2 indicates that swelling is not detectable after 1–19 days (one interval), but that it has occurred after 11–29 days (2 intervals). As

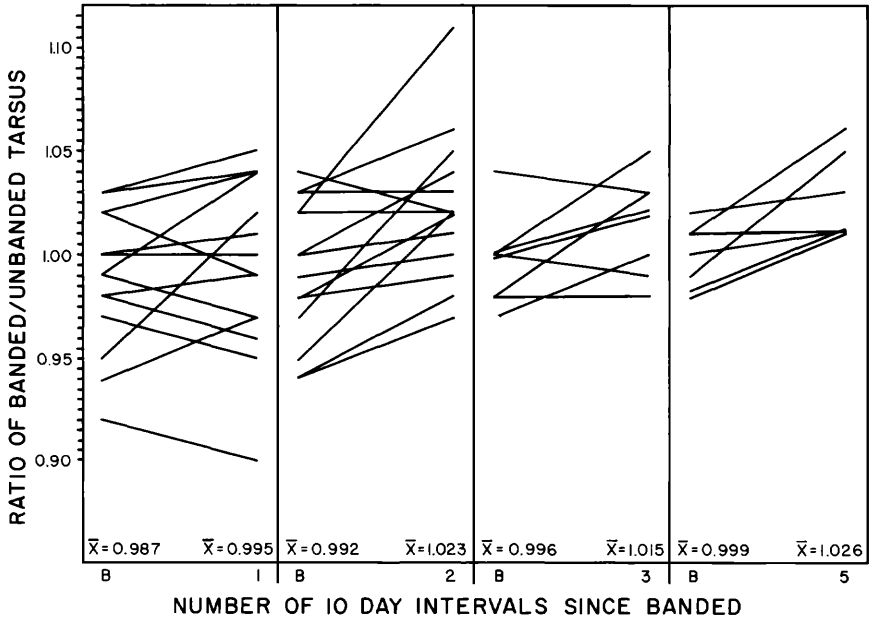

FIGURE 2. Ratios of diameter of banded:unbanded tarsus for birds banded in the winter of 1976–1977 and recaptured in an interval in Figure 1 when a relatively large number of recaptures occurred. The start of each line is the ratio for a bird at the time it was banded; the end of each line is the ratio that existed during the interval in which the recapture occurred. Upward sloping lines indicate an increase in the diameter of the banded tarsus.

the average ratio changed from 0.992 to 1.023 within two intervals after banding (Fig. 2), it appears that banded tarsi swelled by about 3% within 11 to 29 days. Data in Table 1 indicate that no further swelling occurs even after the birds have been banded for 1–2 years. Birds recaptured in the first winter after being banded had their banded tarsus wider than their unbanded one by the following percentages: row 2 (Table 1), 2.2% (n = 22); row 5, 3.3% (n = 8); row 4 (counting only birds banded in 1976–1977), 3.0% (n = 6). Similarly, in the second winter after being banded, the banded tarsus was 3.1% wider (as calculated by counting only the row 4 (Table 1) data that are based on birds banded in 1975–1976, n = 17).

Tarsal swelling versus tarsal narrowing.—Because my analyses deal with ratios they cannot exclude the unlikely possibility that banding, rather than causing the banded tarsus to swell, actually causes the unbanded one to become narrower. However, measurements of tarsal diameter at the time of each bird's last recapture in 1976–1977 averaged 1.310 mm for the banded tarsus and 1.295 mm for the unbanded one (n = 31). For birds first captured in 1976–1977, tarsal diameter averaged 1.295 mm at the time each bird was banded (n = 83). This analysis indicates

that the banded tarsus swells and that the unbanded one remains unchanged.

DISCUSSION

The graying effect described at the beginning of this paper is presumably due to a build-up of an oxide of the metal used to make the bands. The cause of the swelling can only be speculated upon. There are two major possibilities: (1) The increased diameters of banded tarsi are due to the deposition of the material that causes the graying effect. (2) The increased diameter is due to a swelling or thickening of the skin, of the underlying muscles and tendons, or of the bone itself.

As stated above, there is no evidence that either of the two effects of banding reported here is deleterious. Considering the slight degree of swelling that occurs, it is unlikely that any consequences could be great. The swelling was never great enough to keep a band from freely rotating around a bird's tarsus.

SUMMARY

Banding with U.S. Fish and Wildlife Service bands induces two morphological effects upon White-crowned Sparrows. The banded tarsus acquires a grayish cast due presumably to an oxide given off by the band. Secondly, the banded tarsus increases in diameter whereas the unbanded one remains unchanged. Most birds banded in one winter and recaptured in a subsequent winter have the banded tarsus wider than their unbanded one. By contrast, unbanded birds show no consistent trends in differentials between the diameters of their two tarsi. Repeated measurements of birds banded in one season and recaptured in the same season indicate that tarsal swelling reaches about 3% within one month and that it probably shows no further increase thereafter. There is no evidence that either the tarsal discoloration or swelling are deleterious.

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