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Determining Sex of Pine Siskins Using Wing Stripe Morphology and Wing Chord Length

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ABSTRACT

Wing stripe width and brightness as well as wing chord length were assessed on known-age, known-sex Pine Siskins (*Carduelis pinus*) during the breeding season to determine usefulness of these criteria for determining sex outside the breeding season. Females tended to have narrower, paler wing stripes and shorter wing chords than males. Wing stripe width of both sexes tended to increase with increasing wing chord length, just as the percentage of more brightly colored wing stripes increased with increasing wing chord length. Despite these trends, wing stripe width and/or color used in isolation of any other criteria did not separate male from female reliably to any useful degree, because of the very substantial overlap of these criteria within the four possible age/sex classes of second-year/after-second-year males and females. Similarly, wing chord length alone was of limited utility in separating males from females. However, when wing chord criteria were combined with known age class and wing stripe color, it was possible to identify some of the males in the sample reliably, but not females due to too much male overlap in the female ranges. At best, birds with pale stripes and wing chords of 69 mm or less were only 90.9% female, failing to meet the 95% minimum set by the Bird Banding Laboratory, and these criteria identified only 22% of the females in that sample. When birds with bright wing stripes were considered, a wing chord of 74 mm or more (74-79 mm) was 96.7% reliable in identifying breeding males of both ages correctly and applied to 53% of the males in the sample. When applied to fully adult, after-second-year birds, these criteria were 96.2% reliable in recognizing 60% of the males in that age group, and for second-year birds with pale wing stripes was 95.2% reliable in identifying 24% of the males in that sample.

INTRODUCTION

Years ago, prompted by the suggestion in Roberts (1955) that female Pine Siskins have restricted yellow in the wings (implying that males had more yellow), and the questions posed by McEntee (1970) about how siskin wing stripes tended to fall into four classes: narrow-pale, narrow-bright, wide-pale, and wide-bright, and how these might relate to age-sex determination, I attempted to analyze data I had at the time on siskins I banded at Schenectady, NY, as well as measurement data taken on known-sex museum specimens (Yunick 1970, 1976). The results showed trends toward wider, brighter stripes suggesting males and narrower, paler stripes suggesting females, but this work was handicapped by a lack of sufficient birds of known sex, and (except for a few juveniles handled during late spring migration) enough birds of known age to be definitive in assessing sex determination.

In 1987 I began using rectrix shape to determine age of spring migrant siskins (Yunick 1995), and continued to note wing stripe coloration/width on migrants in breeding condition at Schenectady. During migratory irruptions in 1988, 1990, 1992 and 2001, Pine Siskins lingered to breed at my banding station at Jenny Lake near Corinth, NY, and I was able to expand greatly the collection of data on known-sex, known-age adults and on their hatching-year offspring, affording a more detailed analysis on the usefulness of wing stripe morphology to determine sex.

METHODS

Pine Siskins were captured at my yard in Schenectady, NY, where the species was an irruptive winter resident and spring migrant, and at

Jenny Lake at 380 m (1250 ft) elevation near Corinth, NY, in the Adirondack mountains where the species sometimes wintered, and passed as a spring migrant after winter irruption and on occasion lingered to breed. I measured the unflattened right wing chord (WC) to the nearest mm with a steel rule graduated to 1 mm, lacking an end stop, and the width of the dorsal yellow wing stripe (WS) extending beyond the wing coverts at primary 1-2 of the extended wing with the same rule to the nearest mm. I classified the color of the wing stripe as "bright" or "pale" where "bright" was approximated by a Munsell Soil Color of 5Y/8/8 or yellower, and "pale" was approximated by 5Y/8/6 or paler, in some instances an off-white with barely any yellow tint (Munsell 1971).

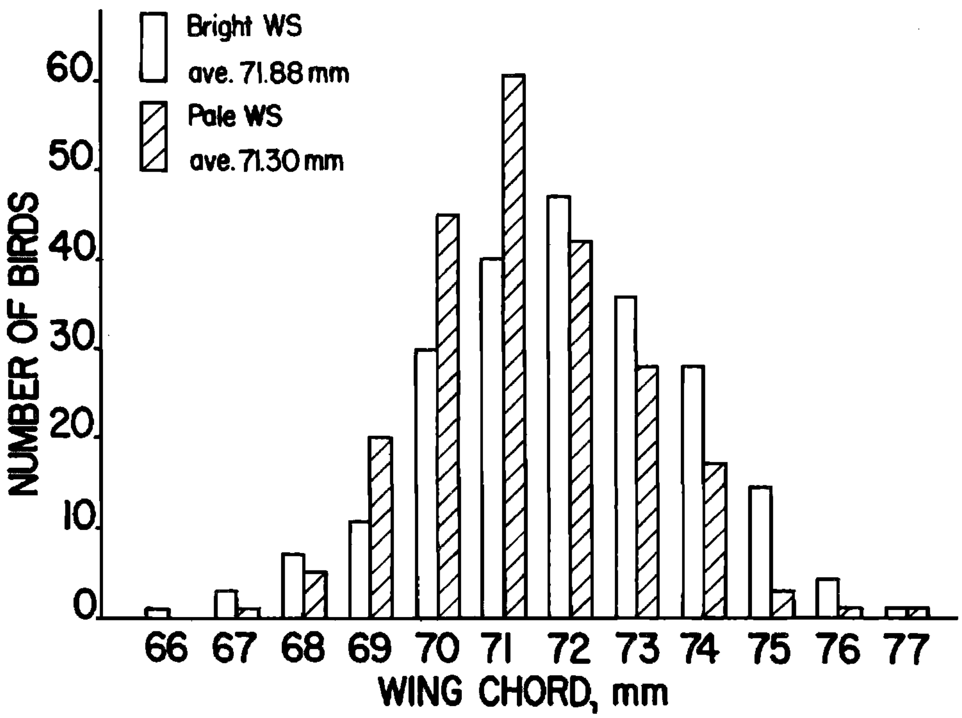
Prior to 1987, all siskins beyond hatching-year (HY) were classed as after-hatching-year (AHY), because I lacked the means to differentiate second-year (SY) from after-second-year (ASY) birds. As of 1987, I employed rectrix shape (Yunick 1995) to identify SY and ASY birds captured from January to July. Newly fledged HYs were recognized by their buffier, unworn juvenal plumage; and on one instance in 1986 when siskins appeared in the fall, HYs were then recognized by incomplete pneumatization of their skulls. Sex was determined on adults in breeding condition: males (M) with well formed cloacal protuberances, and females (F) with edematous brood patches (Pyle 1997).

RESULTS

The spring return flights following years of winter irruption were overwhelmingly made up of birds not yet in breeding condition, so it took years of sampling to extract the data on the annual minority of birds in breeding condition. Between 1976 and 1985, 154 siskins, mostly breeding adults and a few newly fledged young, were measured in five of those 10 years, mostly at Schenectady. From 15 Nov to 31 Dec 1986, measurements were taken on 190 HYs of unknown (U) sex at Schenectady; then, in eight of the next 15 years to 2001, data on another 1267 siskins were taken, the most on 725 birds in 1988. Age and sex of the 1988 adults and WS color were recorded on all of these, but not all were measured fully.

At Schenectady, over the 1976-2001 interval, adult birds in breeding condition appeared as early as 29 Mar to as late as 20 May and HY U birds appeared as early as 29 Apr to 20 May as the spring migration drew to a close. At Jenny Lake, adults in breeding condition appeared as early as 4 Apr, staying to as

Fig. 1. Distribution of wing chord lengths of hatching-year Pine Siskins with pale-colored wing stripes (dashed bars) and bright-colored wing stripes (clear bars). Data from Table 1.



late as 24 Jul, while HY U birds were captured between 12 May and 24 Jul when the local breeding season concluded and siskins departed the area. Major breeding appearances at Jenny Lake occurred in 1988, 1990, 1992 and 2001.

Table 1 summarizes the distribution of WC lengths of 446 HY U siskins segregated by bright and pale WS, and shows how average WS width varied according to WC length. The distribution of the WC data in this table is represented graphically in Figure 1. Table 2 is a similar summation on 178 females of mixed ages, while Table 3 summarizes the same data on 255 males of mixed ages.

Table 4 compares the distribution of bright and pale WS by age/sex class of 975 males and females of mixed ages, and 446 HY U birds. Table 5 illustrates the distribution of WS widths among bright and pale birds numbering 137 females and 207 males of SY and ASY age classes, and 446 HY U birds.

Table 1. Distribution of wing chord lengths and average wing stripe (WS) widths of hatching-year Pine Siskins sorted by bright and pale wing stripe color.

	Hatching-Year Wing Chord, mm												
WS Color	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**Total**
Bright, n	1	3	7	11	30	40	47	36	28	14	4	1	222
Pale, n		1	5	20	45	61	42	28	17	3	1	1	224
Bright, %				35.5	40.0	39.6	52.8	56.3	62.2				49.8
Pale, %				64.5	60.0	60.4	47.2	43.7	37.8				50.2
Bright, ave. WS width, mm			2.57	3.09	3.63	3.90	4.32	4.31	4.43	4.57			4.05
Pale, ave. WS width, mm			3.40	1.70	2.71	3.30	3.00	3.07	3.29				2.99

Table 2. Distribution of wing chord lengths and average wing stripe (WS) widths of female Pine Siskins beyond hatching year sorted by bright and pale wing strip color.

	Female Wing Chord, mm								
Age/WS Color	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**Total**
SY Bright, n			1	2	5	3	1			12
Pale, n	1	1	16	21	20	10	2	1		72
ASY Bright, n			2	4	9	12	6	2		35
Pale, n			2	4	4	5	2		1	18
AHY Bright, n			5	4	7	7	2			25
Pale, n	1	2	2	5	3	2	1			16
Total Bright, n			8	10	21	22	9	2		72
Pale, n	2	3	20	30	27	17	5	1	1	106
Total Bright, %			28.6	25.0	43.8	56.4	64.3			40.4
Pale, %			71.4	75.0	56.2	43.6	35.7			59.6
Bright ave. WS width, mm			3.88	3.80	5.62	5.09	6.11			5.03
Pale ave. WS width, mm		2.67	2.90	3.37	3.78	4.71	4.20			3.60

Table 3. Distribution of wing chord lengths and average wing stripe (WS) widths of male Pine Siskins beyond hatching year sorted by bright and pale wing stripe color.													
	Male Wing Chord, mm												
Age/WS Color	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**Total**
SY Bright, n		2	2	5	3	6	6	1		1			26
Pale, n	1	1	7	10	29	15	12	7	1				83
ASY Bright, n		1	2	5	9	17	22	16	5	7		1	85
Pale, n				2	2	8	1						13
AHY Bright, n			3	3	8	10	2	3		1			30
Pale, n			1	3	8	3	2	1					18
Total Bright, n		3	7	13	20	33	30	20	5	9		1	141
Pale, n	1	1	8	15	39	26	15	8	1				114
Total Bright, %			46.7	46.4	33.8	55.9	66.7	71.4	83.3	100.0			55.3
Pale, %			53.3	53.6	66.1	44.1	33.3	28.6	16.7	0.0			44.7
Bright ave. WS width, mm			4.86	3.31	4.40	4.85	5.77	6.05	5.40				5.12
Pale ave. WS width, mm			3.25	3.73	3.59	4.19	4.80	4.50					3.92

Table 4. Occurrence of bright and pale wing stripe colors of Pine Siskins sorted by age and sex class.					
Age/Sex Class	**Bright, n**	**Pale, n**	**Total, n**	**Bright, %**	**Pale, %**
SY Female	33	155	188	17.6	82.4
ASY Female	88	39	127	69.3	30.7
AHY Female	36	36	72	50.0	50.0
Total Female	157	230	387	40.6	59.4
SY Male	70	198	268	26.1	73.9
ASY Male	180	24	204	88.2	11.8
AHY Male	57	59	116	49.1	50.9
Total Male	307	281	588	52.2	47.8
Total All	464	511	975	47.6	52.4
Total ASY	278	63	341	81.5	18.5
Total SY	103	353	456	22.6	77.4
HY Unknown	222	224	446	49.8	50.2

Table 5. Distribution of wing stripe widths of Pine Siskins sorted by wing stripe (WS) brightness and age class.

WS Color, Age/Sex		Wing Stripe Width, mm 0	1	2	3	4	5	6	7	8	9	10	11	12	Total
Bright	SY Female	2	1	2		1	3	1	2						12
	ASY Female		2	4	7	1	11	2	2	3	2	1			35
	Total Female	2	3	6	7	2	14	3	4	3	2	1			47
Pale	SY Female	5	3	14	14	17	13	4	2						72
	ASY Female		1	2	2	4	3	1	1	2	2				18
	Total Female	5	4	16	16	21	16	5	3	2	2				90
All Female		7	7	22	23	23	30	8	7	5	4	1			137
Bright, %				27.3	30.4	8.7	46.7	37.5							34.3
Pale, %				72.7	69.6	91.3	53.3	62.5							65.7
Bright	SY Male	1	2	6	3	4	7	3							26
	ASY Male		3	8	9	10	9	8	12	12	5	4	3	2	85
	Total Male	1	5	14	12	14	16	11	12	12	5	4	3	2	111
Pale	SY Male	4	7	15	8	11	13	13	9	3					83
	ASY Male			2	2	2	3	1	2	1					13
	Total Male	4	7	17	10	13	16	14	11	4					96
All Male		5	12	31	22	27	32	25	23	16	5	4	3	2	207
Bright, %			41.7	45.2	54.5	51.9	50.0	44.0	52.2	75.0					53.6
Pale, %			58.3	54.8	45.5	48.1	50.0	56.0	47.8	25.0					46.4
Bright HY Unknown		22	21	22	22	30	36	35	21	8	4	1			222
Pale HY Unknown		27	39	39	38	27	23	14	8	4	4	1			224
All HY Unknown		49	60	61	60	57	59	49	29	12	8	2			446
Bright, %		44.9	35.0	36.1	36.7	52.6	61.0	71.4	72.4	66.7					49.8
Pale, %		55.1	65.0	63.9	63.3	47.4	39.0	28.6	27.6	33.3					50.2

Table 6. Pine Siskin sex-determining criteria based on age, wing stripe (WS) color, and wing chord (WC) length.

Age/WS Color	WC Criterion, mm	Reliability, %	Applicability, %	Identifies
SY Pale	≤ 69	90.0	25.0	SY Female
SY/ASY Pale	≤ 69	90.9	22.2	SY/ASY Female
	≤ 70	83.3	50.0	SY/ASY Female
SY Pale	≥ 74	95.2	24.1	SY Male
SY Bright	≥ 73	93.3	53.8	SY Male
	≥ 74	100.0	30.8	SY Male
ASY Bright	≥ 74	96.2	60.0	ASY Male
SY/ASY Bright	≥ 74	96.7	53.1	SY/ASY Male
	≥ 75	100.0	27.9	SY/ASY Male

DISCUSSION

WC/WS Color Distribution of HY Birds - The data in Table 1 and Figure 1 show a nearly complete overlap in distribution of pale and bright wing stripes over the entire WC range. Overall, WS color distribution is nearly equal at 49.8:50.2 for bright:pale birds, though pale stripes predominate at WCs of 71 mm or less and bright stripes at WCs of 72 mm or more. Birds with bright stripes show a trend toward widening of the stripe width with increased WC length, while such a trend in pale stripe width is not as apparent; and bright stripes average wider than pale stripes. WS color/width and WC offer no clear means of assigning sex to these immatures.

WC/WS Color Distribution of Breeding Birds - Table 2 breeding females and Table 3 breeding males show some of the same trends as do HYs in Table 1. Overlap in distribution of bright and pale stripes is apparent; stripe widths for both bright and pale birds increase with increasing WC; bright stripes average wider than pale; but now the occurrence of bright and pale stripes among the sexes deviate from the nearly 50:50 distribution found in HYs. Males appear brighter by about 55:45, bright:pale; females by about 40:60.

This same distribution was examined in Table 4 on a larger sample of birds segregated and analyzed by age class. Overall, females showed the approximately same 40:60 distribution and male color distribution changed slightly to 52:48 compared to 55:45 in Table 3. However, SY birds now markedly differed from ASY birds by favoring a preponderance of pale stripes. SY females were 17.6:82.4, bright:pale, while SY males were 26.1:73.9, posing the question why they diverge from the nearly 50:50 distribution found in HYs?

These SY birds are anywhere from only six months older than the Nov-Dec 1986 HYs in the sample to 10-13 months older than the Apr-Jul HYs that made up the rest of the HY sample. No intervening flight feather molt occurred in this interval to cause change in this color distribution. Furthermore, molting into adult plumage favors increased brightness not a decline thereof. Selective mortality or differences in geographical or seasonal distribution may be possible factors, but are not deemed likely causes. A more likely, though unproven, explanation for this observation is feather fading. Possibly the pigmentation in these originally bright juvenal feathers is more subject to oxidative and photolytic degradation causing fading from bright to pale, causing the observed shift in color distribution.

The data for ASY birds in Table 4 show that stripe brightness is generally, but not totally, an adult attribute with females averaging 69.3:30.7, bright to pale; and males 88.2:11.8. Nevertheless, this color criterion fails to separate male from female or immature from adult reliably.

WS Width/Color Distribution - Table 5 compares WS width over the 0-12 mm range for bright and pale WSs of all ages of females and males as well as HYs of unknown sex. Among all, there is a trend for the percentage of bright stripes to increase with increasing stripe width, more so among males than females. Pale stripes prevail at all WS widths in females, while in males pale stripes prevail at WS

widths of 0-2 mm, then vary but tend to be brighter at and beyond 3 mm. Pale stripes prevail at 0-3 mm width in HYs, then bright stripes dominate thereafter. But here again overlap in stripe width is so considerable that stripe width and color do not afford a means of separation of sex and age.

WC/WS Color Compared by Age Class - I found that if I re-sorted the data in Tables 2 and 3 for breeding adults first by age class (SY vs. ASY), then by WC length and WS color, the following criteria emerged in Table 6. The sorting was prompted by previous trends showing females tending to be paler striped and shorter in WC than males, and SY birds paler than ASY birds. By segregating SY birds with pale stripes at WCs of 69 mm or less, I found these criteria were 90.0% reliable in identifying a SY female. This reliability fails to meet the 95% minimum required by the U. S. Bird Banding Laboratory and, furthermore, identified only 25% of the females in the sample.

By expanding the criteria to both SY and ASY pale birds at 69 mm or less, the reliability edged up to 90.9%, still failing to meet 95%. Expanding it further to a WC of 70 mm or less doubled the number of females found to 50%, but further dropped the reliability to an unacceptable 83%. Visual inspection of the data in Tables 2 and 3 shows that too many males are distributed in these female ranges to allow reliable recognition of a female of any age by these criteria.

Applying the same kind of sorting of known-age birds with longer WCs gave the following. Pale SY birds with WCs of 74 mm or more were 95.2% male, but only 24% of males in the sample were so identified. By then switching to birds with bright stripes, the same 74 mm WC criterion was 100.0% reliable in identifying SY males, but still at a low applicability of only 31% of the males in the sample. Lowering the WC criterion to 73 mm or more caused the number of recognized SY males to rise sharply to 54%, but failed the 95% reliability requirement at 93.3%.

The ASY age group with bright stripes offered the best possibility for identifying males. At a WC of 74 mm or greater, these criteria were 96.2% reliable in recognizing 60% of the ASY males in the sample. When ASY and SY age classes were combined, a WC of 75 mm or more was 100.0% reliable in identifying 28% of the males.

Among the Pine Siskins examined, I observed age- and sex-related trends in wing stripe brightness, stripe width, and wing chord length. But there was extensive overlap of bright and pale wing stripe distribution and measurements. That overlap prevented reliable sexing of both HY birds and also females of all ages. However, (following their age determination based on rectrix shape) it did identify nearly one-quarter of the males.

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