

## Passage Dates, Energetic Condition, and Age Distribution of Irruptive Pine Siskins during Autumn Stopovers at a Reclaimed Landfill in the New Jersey Meadowlands

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**Abstract** - Little is known about the stopover biology of *Spinus pinus* (Pine Siskin) and other Fringillid birds during their irruptive movements into the US from boreal Canada. Here, we report on the passage timing, energetic condition, and age distribution of 402 Pine Siskins that we captured during autumn stopovers in New Jersey in the irruption year of 2012. Pine Siskins passed through our study site for ~3 weeks and peaked in abundance between 9 and 12 October. More birds were juveniles than adults (54% v. 46%), although the difference was not significant. Juveniles were heavier than adults, but fat scores did not differ by age. Neither age group appeared to gain significant mass during the stopover. We encourage migration banding stations like ours that experience irruptions to report the information they collect and help improve our understanding of the migration biology and behavior of irruptive species.

### Introduction

*Spinus pinus pinus* Wilson (Pine Siskin) and other Fringillid seed-eating birds that breed in boreal North America are known for their biennial irruptive movements to the south in response to synchronous, region-wide crashes in mast production that are caused by summer and winter climate patterns (Strong et al. 2015). In irruption years, massive numbers of Pine Siskins move through parts of the US where they are otherwise scant or absent, and they may travel as far south as the Gulf of Mexico (Dawson 2014). Despite these common and sometimes long-distance facultative migrations, the migratory behavior of Pine Siskins has not been well studied and their stopover ecology between migratory flights is poorly understood. Here, we describe the passage dates, energetic condition, diurnal mass-changes, and age distribution of 402 irruptive Pine Siskins captured at a reclaimed landfill in the New Jersey Meadowlands to contribute new information to what little is known about this species during migration stopovers.

### Methods

As part of a study of the value of a reclaimed landfill as stopover habitat for shrubland and grassland birds (Seewagen and Newhouse, in press), we passively mist-netted and banded autumn migrants at the former Erie Landfill in North

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Arlington, NJ (40°47'24.3"N, 74°06'57.0"W) 5 days per week (weather permitting) from 30 August to 20 November 2011 through 2013. The Erie Landfill is ~17.5-ha in extent; it was closed to operations in 2005 and capped in 2006. The site has since become colonized mostly by non-native plants, such as *Artemisia vulgaris* L. (Mugwort), *Robinia pseudoacacia* L. (Black Locust), and *Phragmites australis* Cav. (Common Reed). We operated 9 mist-nets at the landfill and an additional 7 mist-nets at an adjacent meadow (all nets were 36-mm mesh and 12 m long). We opened the nets at sunrise and checked them hourly for ~8 h, or for however long weather conditions allowed. All captured birds were banded with a US Geological Survey aluminum leg band, assigned to an age class of hatching year (juvenile) or after-hatching year (adult), identified as male or female when possible (Pyle 1997), measured (unflattened wing length to the nearest 1 mm), fat-scored on a 6-point scale (Helms and Drury 1960, Seewagen 2008), weighed to the nearest 0.1 g on a digital balance, and released.

During the irruption year of 2012, we captured 402 Pine Siskins over a 3-week period in October. To investigate whether these birds were refueling during their stopovers at the site, we tested the relationship between body mass and time of capture (e.g., Horton and Morris 2012, Seewagen et al. 2011) using a general linear model (GLM), with body mass as the dependent variable and time of capture, age, and their interaction as independent variables. We did not size-adjust body mass because the relationship between body mass and our measure of body size (wing length) was poor ( $r^2 = 0.01$ ), and we did not consider sex in our analyses because it cannot be determined reliably in Pine Siskins during autumn (Pyle 1997). The body mass–time-of-day regression technique is a common method of estimating mass-change rates of nocturnal migrants during stopovers and carries an assumption that all birds arrive at the site at or prior to dawn (Dunn 2000, Jones et al. 2002). Pine Siskins have traditionally been considered diurnal rather than nocturnal migrants based on observations of large flocks moving during the day (Dawson 2014). These movements, however, may represent so-called morning flights (Bingman 1980, Wiedner et al. 1992) or relocations within the same landscape (Taylor et al. 2011) rather than migratory flights, and night-flight call recordings have demonstrated that Pine Siskins sometimes migrate at night (Watson et al. 2011). The extent to which Pine Siskins migrate by day or night remains uncertain and so we cannot rule out the possibility that some or all of the Pine Siskins that we captured throughout the daytime hours in our study were newly arrived, diurnally migrating individuals. This situation would weaken or eliminate the ability of the body mass–time-of-day regression technique to determine mass-change rates, but analysis of recapture data was not a possible alternative because we recaptured only 1 individual. We note that the body mass–time-of-day regression technique has been applied to Pine Siskins before and yielded evidence of significant mass-change during stopover (Yong and Finch 2002).

We compared the ratio of juveniles to adults using a chi-square test, and we examined age differences in energetic condition by using a two-tailed *t*-test and Mann-Whitney *U*-test to compare body masses and fat scores, respectively,

between age groups. All continuous variables met the normality assumptions of a GLM and *t*-test. All tests were performed in SYSTAT 12 (Systat Software, San Jose, CA), and significance was accepted when  $P < 0.05$ .

Published information on Pine Siskin migration that could provide context within which to interpret our data is limited; thus, we acquired banding records from the US Geological Survey Bird Banding Lab (BBL) for all Pine Siskins banded between 1 September and 1 December 2005 through 2016, in the states of New Jersey, New York, and Pennsylvania. We truncated the dataset to exclude Pine Siskins banded anywhere in New York State north of the lower Hudson Valley because those portions of New York State are within the species' breeding range (Dawson 2014). We focused on data from the 2 most apparent and substantial irruption years within this date range: 2012 and 2014. Unfortunately, banding records submitted to the BBL lack information about sampling effort and period (hours of the day as well as days of the year), and usually energetic condition (e.g., body mass, fat score). It was not possible to determine passage timing from these data because we could not standardize numbers of captures to effort and we could not determine if capture effort in a given location spanned the entire fall migration period. Therefore, we further limited our analyses of passage dates to Pine Siskins that were banded at the Powdermill Nature Reserve in Rector, PA, approximately 440 km west of our study site, where a constant-effort banding station is operated each year from April through November. This station alone accounted for 66% of the Pine Siskin banding records from New York, New Jersey, and Pennsylvania provided by the BBL. We also used the data from Powdermill Nature Reserve to calculate the ratio of juvenile to adult Pine Siskins banded there in 2012 and 2014 for comparison to the age distribution that we observed at our study site.

## Results and Discussion

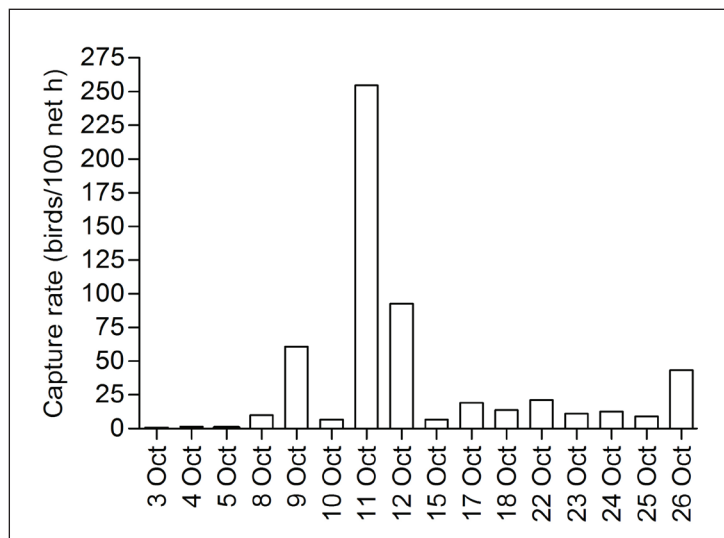
We captured all 402 Pine Siskins during the fall 2012 season between 3 and 26 October. By comparison, we captured only 20 Pine Siskins at our station during 2010, 2011, and 2013 combined (all of which occurred in 2010). Peak passage during the irruption was during 9–12 October, when we caught 253 (63%) of the 402 Pine Siskins. Capture rate was highest on 12 October (255 birds/100 net h) and substantially greater than on any other day (Fig. 1). Approximately 70 km east of our site, Ausubel (2013) noted that peak passage of Pine Siskins through Robert Moses State Park on Long Island, NY, in 2012 also occurred in mid-October, and a record number of individuals were counted on the 21<sup>st</sup> of that month. Pine Siskins peaked in abundance in Kiptopeke, VA, approximately 435 km south of our study site, 1 to 2 weeks later between late October and early November that year (Kolbe and Brinkley 2013). At the Powdermill Nature Reserve, Pine Siskins were first captured on 6 October and last captured on 14 November during the 2012 irruption. The peak there occurred on 2 November, ~3 weeks later than the peak at our study site, when 58% of the 326 Pine Siskins banded that season were captured. No more than 10% of the total number of Pine Siskins banded for the season was captured on any other single day. Peak passage at the Powdermill Nature Reserve

was slightly earlier during the 2014 irruption year, when 53% of the 163 Pine Siskin captures occurred from 20 to 26 October and another 25% occurred 4 days later on 30 October. From these observations throughout the region, it appears to take waves of irruptive Pine Siskins ~3 weeks to move from the latitude of southern New York State and northern Pennsylvania into the northern mid-Atlantic area and Allegheny Mountains. It also appears that coastal migrants might move ahead of or faster than inland migrants, given that peak passage at the Powdermill Nature Reserve in western Pennsylvania during the 2012 irruption occurred around the same time as it did ~435 km to the southeast, in Kiptopeke, VA.

At our site, the relationship between Pine Siskin body mass and capture time was not dependent on age (age\*time:  $F_{1,391} = 0.45$ ,  $P = 0.50$ ) and was not statistically significant after dropping the interaction term and pooling age groups ( $r^2 = 0.01$ ,  $P = 0.09$ ), which indicated that birds were not gaining significant mass during the morning hours. We caution that some or all of the Pine Siskins that we captured could have been migrating diurnally rather than nocturnally and arriving at different times throughout the day, in which case the relationship between body mass and capture time would fail to indicate true mass-changes of birds at the site.

We recaptured only 1 Pine Siskin before the end of the study period on 20 November, which suggests that length of stay at the site was extremely short regardless of whether birds were migrating diurnally or nocturnally. Pine Siskins stopping at the landfill may have been using the site for rest, energy maintenance, and/or predator avoidance more so than substantial fuel deposition (Alerstam and Lindström 1990), or they may have departed shortly after arrival in search of alternative habitat if conditions at the site were poor. Along the Rio Grande in New Mexico, Yong and Finch (2002) also found that Pine Siskin stopover durations during autumn were brief (mean = 1 day), but regressions of body mass and capture time indicated that birds there gained an average of 6.5% of their body mass per day.

Figure 1. Capture rates of Pine Siskins at a New Jersey stopover site during autumn of the irruption year of 2012. Dates not shown within the 3–26 October range are dates on which there was no capture effort.



Pine Siskin body masses in our study ranged widely from 9.6 g to 17.6 g. Average body mass was 12.9 g ( $\pm 1.0$  SD) and the 25<sup>th</sup> percentile was 12.2 g, which is more representative of Pine Siskin body masses usually observed during spring and summer (mean = 12.91 g  $\pm 1.15$  SD; range = 11.0–15.5 g;  $n = 20$ ) than during fall and winter (mean = 16.3 g  $\pm 1.03$  SD; range = 14.3–18.1 g;  $n = 32$ ) (Dawson 2014). Yong and Finch (2002) reported a lower average body mass of 12.3 g ( $n = 1687$ ) among Pine Siskins during autumn stopovers in New Mexico.

Fifty percent of the birds we captured had a body mass that was below the average fat-free body mass of Pine Siskins reported by Dawson and Marsh (1985; 12.89 g), which should not be possible, but this fat-free body-mass value was based on a small sample of birds collected during winter when hypertrophy of pectoralis muscles and the heart for increased thermogenic capacity increases fat-free body mass above what it is during warmer seasons (Dawson and Carey 1976, Liknes and Swanson 2011). Mulvihill et al. (2004) reported an average fat-free body mass of 12.5 g for Pine Siskins, but it is not clear during what season(s) the data were collected and the value was based on the average body mass of birds with no visible subcutaneous fat (i.e., 0 fat score) rather than destructive body-composition analysis. Birds with no visible subcutaneous fat can have substantial unseen and metabolically available fat stores, and this approach is therefore likely to overestimate true fat-free body mass (Seewagen 2008). The Pine Siskins we captured that had body masses below both of these reported fat-free body mass values of 12.89 g and 12.5 g had a median fat score of 1, and many had fat scores of 2 or 3. The overall median fat score of all of the Pine Siskins we captured was 2 (Table 1); thus, we do not consider the majority of the birds to have been in poor energetic condition.

Juvenile pine siskins were significantly heavier than adults (Table 1). Among obligate passerine migrants, juveniles have been found to be heavier than adults in some species and lighter than adults in others (Woodrey 2000, Moore et al. 2003, Woodrey 2000, Woodrey and Moore 1997). The reasons for this are not clear, but the degrees to which there are age differences in social dominance, access to food resources, physiological constraints, and migratory route within different species are expected to be primary factors (Woodrey 2000). Fat scores of the Pine Siskins did not differ between age groups (Table 1), suggesting that differences in total body mass were driven by differences in lean mass more than fat mass. As in some other bird species (Guglielmo and Williams 2003, McCabe 2015), it is possible that juvenile Pine Siskins maintain heavier digestive organs than adults as a means

Table 1. Body masses and fat scores of Pine Siskins during autumn stopovers in New Jersey during the 2012 irruption year. Body-mass values are means  $\pm$  SD and fat score values are medians. Juvenile and adult body masses and fat scores compared with a *t*-test and Mann-Whitney *U* test, respectively.

	All birds	Juveniles	Adults	<i>t</i> or <i>z</i>	<i>P</i>
Body mass	12.9 $\pm$ 1.0	13.1 $\pm$ 1.1	12.8 $\pm$ 0.9	3.5	0.001
<i>n</i>	395	216	179		
Fat score	2	2	2	-1.25	0.21
<i>n</i>	401	216	185		

to compensate for poorer foraging and/or nutrient-assimilation efficiency, and this may have accounted for their greater average body mass.

We captured more juveniles than adults (54% v. 46%), but the difference was not significant ( $\chi^2 = 2.6$ ,  $P = 0.11$ ). However, Pine Siskin age distribution at Powdermill Nature Reserve was significantly skewed towards juveniles during the 2012 ( $\chi^2 = 22.6$ ,  $P < 0.0001$ ) and 2014 ( $\chi^2 = 77.3$ ,  $P < 0.0001$ ) irruptions. This result could be the result of adults tending to follow coastal routes and/or juveniles tending to follow inland routes, but the opposite pattern is usually observed among passerine migrants (e.g., Morris et al. 1996, Murray 1966, Ralph 1981; but see Mills 2016). Age differences in the irruptive migratory behavior of Pine Siskins have not been studied, to our knowledge, and are an interesting topic for future investigation.

The winter ecology and proximate and ultimate drivers of irruptive movements of Pine Siskins and other Fringillid birds have received a lot of attention, but much remains to be learned about the biology of these species during their facultative migrations. Their stopover biology in particular, including refueling physiology, lean-mass dynamics, stopover durations, departure decisions, and overall strategy (e.g., time minimization v. energy minimization), has yet to be well-studied, and we encourage migration banding stations like ours that experience irruptions of these species to help fill in these knowledge gaps.

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