Geographic Variation in the Extent of the Preformative Molt in American Goldfinches

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ABSTRACT

*The described extent of the preformative molt in American Goldfinches (*Spinus tristis*) varies depending on the reference from only including lesser coverts in some accounts to also including median and many to all greater coverts in other accounts. Resolving these discrepancies and understanding how to accurately age birds is a critical step toward pursuing additional questions about their ecology and evolution. I describe the extent of preformative molts in 150 HY/SY goldfinches caught in Louisiana between December and February over five winters. About 2/3 of individuals replaced all lesser coverts and at least a few median coverts, and 15.3% also replaced one to four inner greater coverts. Differences between my observations and published accounts appear to be explained by latitudinal (north-south) differences with wintering Louisiana birds found replacing fewer wing coverts than northern populations, and regional (east-west) differences with the nominate eastern subspecies (*S. t. tristis*) replacing fewer wing coverts than the western subspecies (*S. t. salicamans*). In Louisiana birds, males and females did not differ in their average preformative molt extent; however, I did find a suggestion of a difference in overall body molt intensity in HY/SY males with increased rates from December through February compared to other age/sex classes.*

INTRODUCTION

Sporting a golden yellow plumage with a black cap and wings, the male American Goldfinch (*Spinus tristis*) in breeding attire may be one of the most familiar birds in North America. It is well known that its striking yellow plumage is acquired before and worn during the breeding season, and that males become more olive-yellow, similar to females, in the winter (McGraw and Middleton 2009). Adult American Goldfinches accomplish this seasonal transition through two annual molts, following a Complex Alternate Strategy (*sensu* Howell et al. 2003), which is relatively unique among North American Fringillidae (Howell 2010). In its first year of life, each bird progresses through three molts starting with the prejuvenile (first prebasic), then the preformative (which leads to the formative plumage, *sensu* Howell et al. 2003), and then followed by the first prealternate (leading to the alternate plumage) (Pyle 1997a, Howell 2010). Despite this general understanding of the species' molt it is unclear which feathers are replaced during the bird's first year (prealternate and preformative molts), although it is accepted that all birds progress through feather molt in the same sequence leading to the concept of molt limits; i.e., the boundary between two generations of feathers resulting from less than complete molts (Mulvihill 1993, Pyle 1997a).

For American Goldfinches, only the annual prebasic molt (also known as prejuvenile molt in hatching-year birds) involves a complete replacement of all feathers; other molts inserted between annual prebasic molts, such as preformative and prealternate molts, do not involve flight feathers (i.e., remiges and rectrices; Dwight 1902, Middleton 1977, Mulvihill 1993, Pyle 1997a,b).

Protracted molts of body feathers lasting into and through the fall, winter, and spring (Pyle 1997a) have resulted in some confusion regarding which feathers are replaced during which molt (preformative vs. first prealternate for HY/SY birds, or definitive prebasic vs definitive prealternate for SY and older birds). In addition, individual differences in speed of replacement of body feathers adds another dimension to the question of molt timing. Previous reports agree that the preformative molt in American Goldfinches includes body feathers, but there are differences in their reporting of the occurrence of replacement of lesser coverts, median coverts, greater coverts, and tertials (in order of molt sequence; Dwight 1902; Middleton 1977; Mulvilhill 1993; Pyle 1997a, 1997b; McGraw and Middleton 2009). Identifying the timing and extent of the preformative molt of American Goldfinches could have important implications for aging birds accurately during the non-breeding season, could contribute toward our understanding of the evolution of molt (Wolfe et al. 2014) and plumage signaling through comparative, phylogenetic, and behavioral studies (Hill and McGraw 2006) and could be useful in isotope-based studies that depend on the ability to identify which feathers are grown where (Hobson and Wassenaar 1999). In this paper I describe observations of molt limits in formative-plumaged American Goldfinches in Louisiana and compare my results with existing published accounts (Dwight 1902; Middleton 1977; Mulvilhill 1993; Pyle 1997a,b; McGraw and Middleton 2009).

METHODS

In each of five consecutive winters starting in 2010-2011, I captured American Goldfinches between December and February, when goldfinches most frequently visit feeding stations in south Louisiana, using ATX-type mist-nets (12-m long, 36-mm mesh) primarily at one location, a residential yard with a feeding station near Milton, Lafayette Parish, LA (30.126 N, -92.077 W). I supplemented this dataset with captures from three other locations collected by Louisiana Bird Observatory volunteers: 1) Bluebonnet Swamp Nature Center, East Baton Rouge Parish (30.368° N, -91.107° W), a 101-acre (41-ha) urban forest reserve surrounded by residential properties; 2) a residential yard in Baton Rouge, East Baton Rouge Parish (30.441° N, -91.168° W); and 3) a private property in the town of Plaquemine, Iberville Parish (30.285 N, -91.245°N).

For each capture, I recorded sex, age, molt status, and in many formative-plumaged birds, when time allowed (i.e., when the extra time needed did not increase risk to captured birds), molt limit details. I determined each bird's sex by the intensity of black on the flight feathers; furthermore, AHY/ASY males were identified by their bright-yellow lesser coverts compared to HY/SY males possessing olive to yellowish olive lesser coverts (Pyle 1997a). Females were aged by looking for the presence or absence of a buff-tip on the carpal covert (Mulvilhill 1993), degree of skull ossification, rectrix shape, and plumage criteria as described in Pyle (1997a). I recorded the extent of body molt on a qualitative scale from absent, trace (a few feathers in one or two tracts), and light (several feathers on multiple tracts). No birds were considered to be in moderate molt (many feathers on multiple tracts) or heavy molt (obviously visibly molting without blowing along body feather tracts). Molt limits in the wing coverts were recorded by whether or not lesser coverts were all formative, or mixed juvenile and formative and by counting the number of alulas replaced, and the number of median and greater coverts replaced. I used chi-square tests to evaluate differences in amount of molt by sex-age class and by month, and to evaluate the extent of preformative molt between males and females.

RESULTS

I captured a total of 258 American Goldfinches (228 at Milton, 16 at Bluebonnet Swamp, 11 at the Baton Rouge residence, and three at the Plaquemine residence). Females outnumbered males and HY/SY outnumbered AHY/ASY: 18 AHY/ASY males, 34 AHY/ASY females, 83 HY/SY males, and 123 HY/SY females.

About one-third of all individuals captured were molting body feathers; 26.6% of individuals had trace amount of molt and 7.0% had light body molt. Adults of either sex did not significantly differ in the proportions of birds molting each month (AHY/ASY male: X^2_2 = 1.582, P = 0.812; AHY/ASY female: X^2_4 = 0.742, P = 0.690); however, HY/SY males were molting progressively more intensively from December to February (X^2_4 = 11.496, P = 0.022) and HY/SY females were molting more in January than December or February (X^2_4 = 12.504, P = 0.014; Fig. 2).

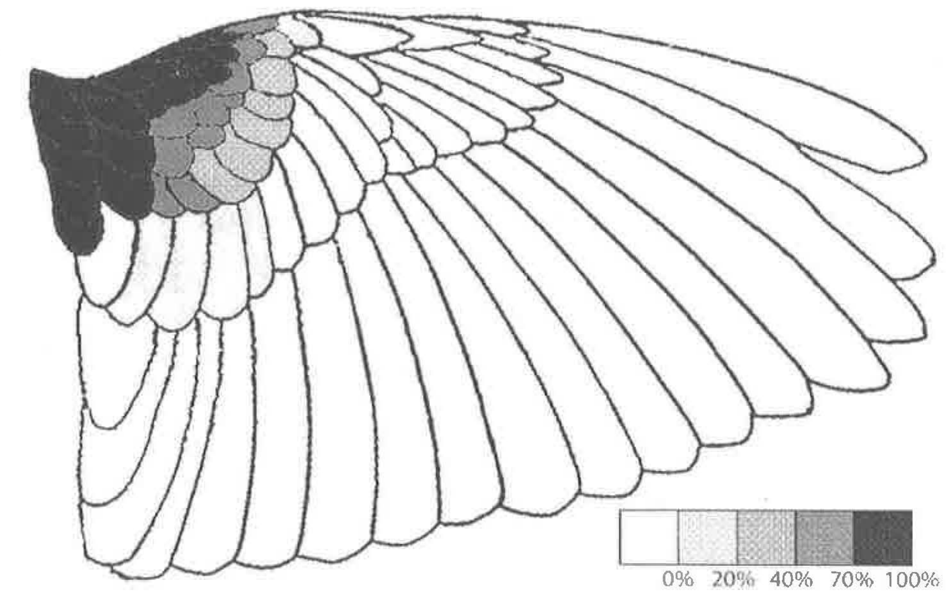

Fig. 1. The replacement pattern resulting from a variably partial preformative molt in American Goldfinches captured between December and February in Louisiana. Paler shading indicates a lower likelihood of a feather being replaced during the preformative molt.

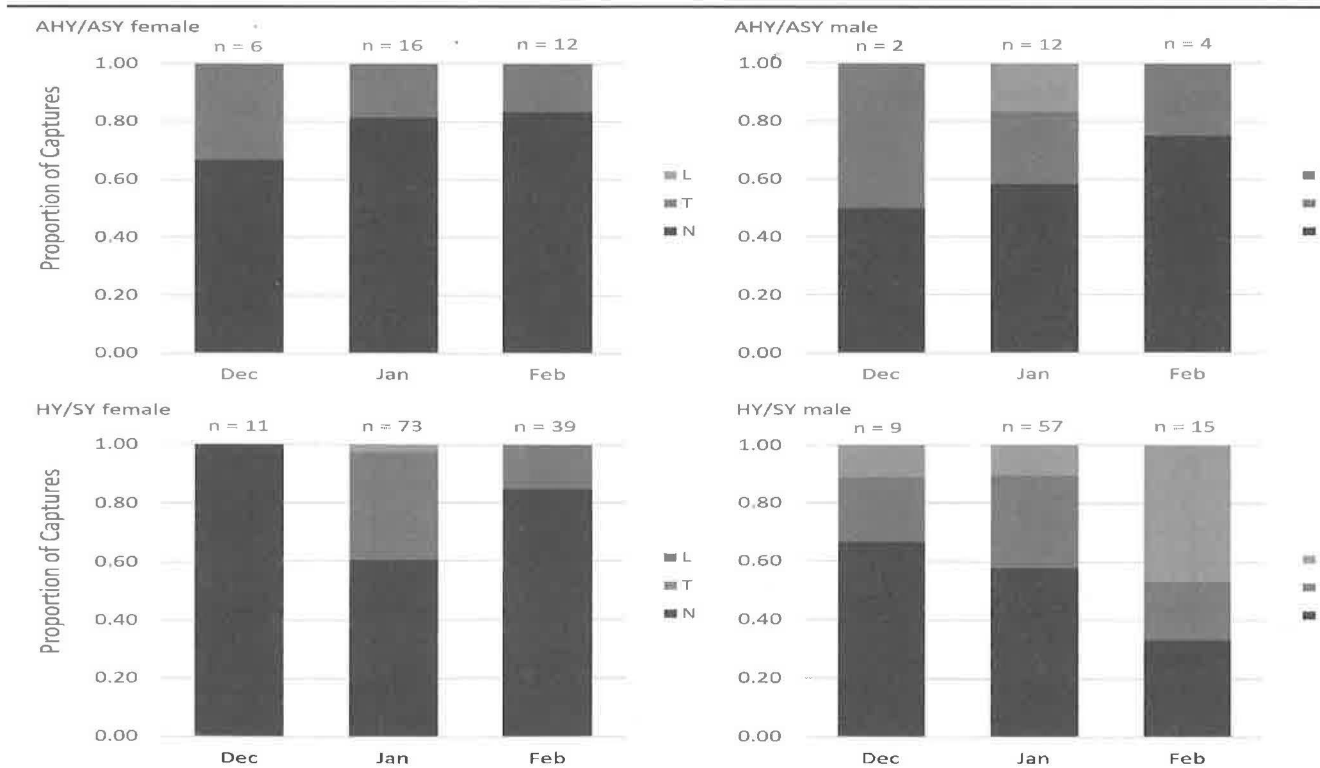

Fig. 2. The proportion of captures by age-sex class categorized by body molt intensity: N (none), T (trace), and L (light).

Among the HY/SY, I recorded details of molt limits resulting from preformative molts in 150 individuals (Fig. 1). In general, and like other passerines and near-passerines (Pyle 1997a), the sequence of American Goldfinch molt appeared to have progressed from the lesser coverts, to the median coverts, to the greater coverts and alulas. However, the timing of molt among these various feather tracts regularly overlap as molt limits were usually found within multiple tracts (e.g., lesser and median coverts). I never saw, for example, molt limits among the greater coverts, without at least some or all of the lesser and median coverts having also been replaced. Overall, 33.3% (n = 50) of individuals had molt limits in the lesser coverts with the remaining 66.7% (n = 100) replacing all lesser coverts. Again among all birds examined, 90% (n = 135) also showed molt limits among the within-the-median coverts with 8% (n = 12) replacing no median coverts, and 2% (n = 3) replacing all median coverts. A total of 15.3% (n = 23) also replaced at least some greater coverts, and all of these had replaced at least some median coverts. The inner-most greater covert was never replaced; the second inner-most greater covert was replaced in all individuals with greater covert limits, the next outer covert was replaced in 4.7% (n = 7) of individuals, and the subsequent two outer greater coverts were each replaced in 0.7% (n = 1) of individuals. The alula covert was also replaced in 1.3% (n = 2) of individuals. No individuals replaced all greater coverts, the carpal covert, the greater or lesser alula, secondaries (including tertials), primaries, primary coverts, or rectrices. The extent of preformative molt replacement did not differ between males and females (X^2_3 = 1.856, P = 0.603; Fig. 4) and did not differ from December to February (X^2_6 = 10.791, P = 0.095; Fig. 3).

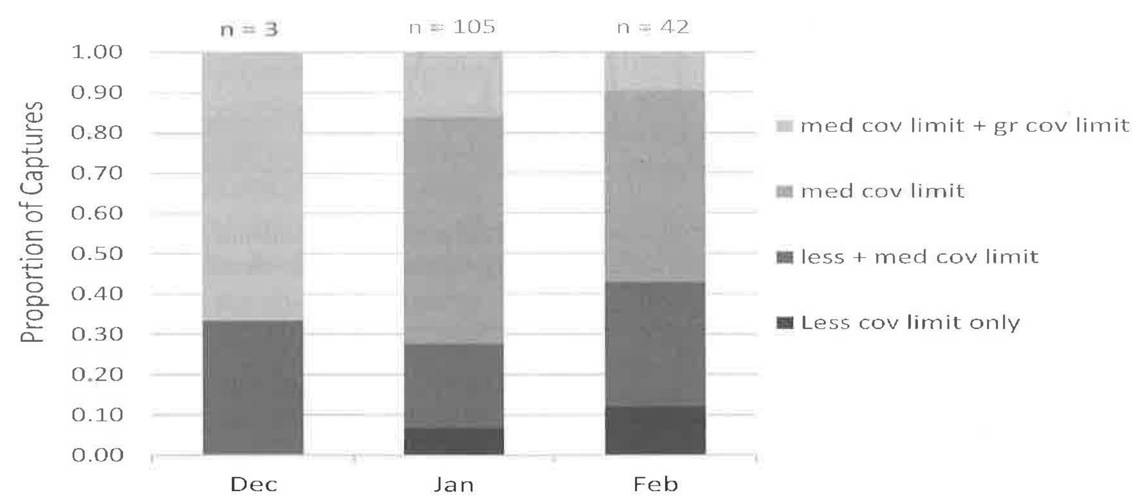

Fig. 3. The percent of HY/SY by month that had replaced various wing covert tracts during the preformative molt.

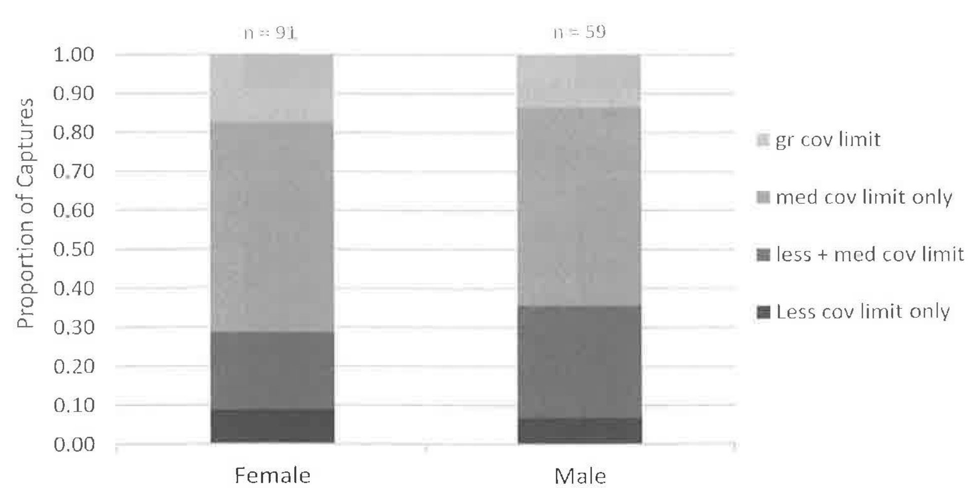

Fig. 4. The percent of HY/SY by sex that had replaced various wing covert tracts during the preformative molt.

DISCUSSION

American Goldfinches captured in south Louisiana showed considerable individual variation in their intensity of body molt with about 1/3 of birds molting body feathers between December and February. Surprisingly, the proportion of individuals molting did not change during this period, suggesting I was observing the final stages of a protracted preformative molt, the early onset of a prealternate molt, or both. Only HY/SY males became more likely to show body molt in February (66.7%) compared to December and January (41.9%), suggesting they were entering a prealternate molt before other age and sex classes. Regardless, the December to February body molt did not appear to include wing coverts, as the extent of apparent molt limits did not advance through the winter,suggesting this important criterion for aging goldfinches is static at least between December and February.

The extent of American Goldfinch preformative molts that I observed between December and February was variable, but generally considered to be partial (*sensu* Pyle 1997a) and ranged from having some lesser coverts replaced to having included all lesser and median coverts plus up to four greater coverts. This is more advanced (with higher frequencies of molt limit occurring within median coverts) than has been described by Dwight (1902), Middleton (1977, 1993), and Mulvihill (1993), but less extensive than Pyle (1997a,b; Table 1). Several possible explanations for these discrepancies are suggested.

First, it may be that preformative molts are protracted through the winter, ultimately appearing less extensive earlier in fall and more extensive by early spring. As described above, however, about 1/3 of captures had at least a trace amount of body molt detected, which may indicate a slow progression of molt. However, it appeared that the trace to light molts I observed generally only involved contour feathers and not wing coverts, such that the molt limits I observed were apparently in stasis and did not progress from December to February.

Second, prealternate molts may begin in early winter (Pyle 1997a) and I may have confused limits assumed to be associated with preformative molts. Again, molt limits appeared to be in stasis from December to February, which is inconsistent with this notion. In addition, first prealternate molts, like definitive prealternate molts, are apparently more extensive than preformative molts as suggested by various authors, "erasing" most or all evidence of the preformative molt and include most or all lesser, median, and typically multiple greater coverts (Mulvilhill 1993, Pyle 1997a,b). In no birds did I observe three generations of feathers in the wing coverts to indicate the replacement patterns I observed were caused by an early prealternate molt.

Table 1. Extent of the preformative molt in American Goldfinch as described by various authors.

Author	Location	Body	Less Cov	Med Cov	Gr Cov	Terts	Flight Feathers
Dwight (1902)	New York	Yes	Yes	Rarely	No	No	No
Middleton (1977)	Ontario	Yes	Maybe?[a]	No	No	No	No
Mulvihill (1993)	Pennsylvania	Yes	Some	No	No	No	No
Pyle (1997a,b)	California	Yes	Yes	Most or all	4-10	s8 (9%)	No
McGraw and Middleton (2009)	Compilation	Yes	Maybe?[a]	Sometimes ?[a]	No	No	No
This Study	Louisiana	Yes	Some (33%) to all 67%)	Some (90%) to all (2%)	1-4 (15%)	No	No

[a] The terminology in Middleton (1977) specifically states no wing coverts are replaced, but the author may have considered these as part of the body plumage given their general agreement with the description by Dwight (1902). The terminology is also ambiguous in McGraw and Middleton (2009).

Third, and the most likely explanation for the discrepancy of preformative molt extents among several authors, is that there appears to be regional variation in the extent of preformative molts. Northeastern wintering populations apparently experience less extensive preformative molts (e.g., New York, Dwight 1902; Ontario, Middleton 1977; Pennsylvania, Mulvihill 1993) than birds in Louisiana. Louisiana's wintering population is almost entirely dominated by eastern *S. t. tristis* (Oberholser 1938, Lowery 1974), and may originate from more southerly populations on average than *S. t. tristis* wintering in Pennsylvania, New York, or Ontario. A latitudinal gradient in preformative molt extent, with more extensive molts experienced by southern populations, is suggested by Pyle (1997a) in many of his species accounts (e.g., Carolina Wren [*Thryothorus ludovicianus*], White-eyed Vireo [*Vireo griseus*], and Northern Cardinal [*Cardinalis cardinalis*]), and we have found evidence of this in at least one other songbird species in Louisiana, Eastern Towhee (*Pipilo erythophthalmus*; Johnson et al. 2013). The more extensive preformative molt described by Pyle (1997a) in which multiple greater coverts and sometimes tertials are replaced is apparently based on the western subspecies *S. t. salicamans* (P. Pyle, pers. com.). In a recent examination of 17 HY/SY *S. t. salicamans*, between 1 and 10 greater coverts (mean = 4.6) and 0 to all 3 (mean = 0.2) tertials were replaced (P. Pyle, unpublished data).

Variation in preformative molt extent across American Goldfinch populations and subspecies may be best explained by the timing of breeding and length of the growing season. Among eastern *S. t. trisis*, northern populations breed later and may be constrained in the number of feathers they can replace before winter compared to southern populations. The western subspecies *S. t. salicamans* breeds notably earlier (late Apr to early Jul, peaking in May) than *S. t. tristis* (late May to early Sep, peaking in Jul; Tyler 1968, McGraw and Middleton 2009), which again corresponds to an increased amount of time available before fall and winter to replace feathers during the preformative molt. The extent of preformative molt has similarly been shown to increase with earlier hatch date in at least one other species, Wrentits (*Chamaea fasciata*; Elrod et al. 2011).

SUMMARY

It appeared that observed molt limits between December and Febuary in Louisiana American Goldfinches resulted from variably partial preformative molts, which included some lesser coverts and no other wing coverts in some (33.3%) individuals, but in others (15.3%) at the more advanced extreme, the preformative molt included all lesser, median, and up to four greater coverts, but not flight feathers. The most frequent molt limits occurred within the median covert category (90% of birds). Regardless of the extent of molt limits, which I caution can be subtle to detect, aging birds can be effectively accomplished by examining the carpal covert for a buffy tip in HY/SY birds, although beware of this tip being worn off even by mid-winter (Mulvilhill 1993). Especially given the emerging pattern of variation in preformative molt extent across various populations and subspecies, I would urge banders to carefully examine and document the extent of molt limits in American Goldfinches and other widespread species to collectively better understand regional and latitudinal variations in the extent of the preformative molt. This will create new opportunities to ask interesting ecological and evolutionary questions about what drives variation in the extent of preformative molts.

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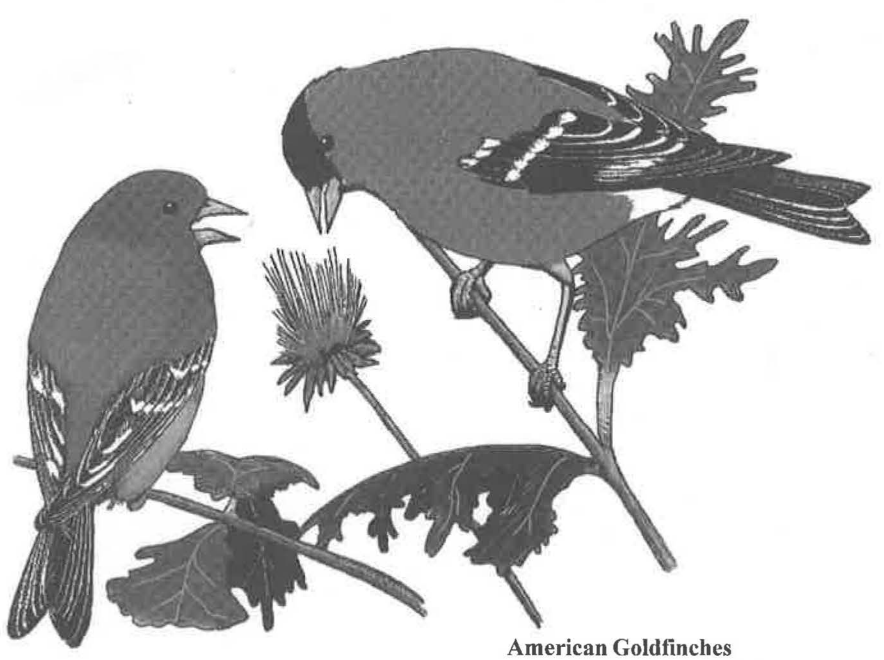

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