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FALL MIGRATION OF YELLOW WARBLERS (*Setophaga petechia*) IN WEST-CENTRAL FLORIDA

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Abstract.—A total of 5,993 Yellow Warblers (*Setophaga petechia*) were counted during fall migration at two study sites on and near the Gulf coast of Florida from 2006 through 2014. The total number of individuals counted per month for the nine years was 85 in July, 1,710 in August, 3,369 in September, and 829 in October. The migration pattern revealed three peaks in numbers: one in the middle of August, one at the end of the first week in September, and the highest peak in the third week of September. Photography was also used to classify 1,713 warblers by age and dorsal color. Of this sample, 807 warblers were “first-fall” birds and 906 were “after-hatch-year” adults. The high percentage of adult birds (53%) indicates that the west-central area of Florida is near the center of the main Yellow Warbler fall migration route, because first-fall birds are expected to predominate on the periphery. First-fall birds also appeared earliest in the migration and continued to be in the majority until the end of the second week in August. Birds with green and darker dorsal-plumage made up the majority of the migrants in the photo sample from September through October; this coloration, which is characteristic of more western and northern subspecies such as *S. p. amnicola*, suggests that the later arriving birds had relatively distant origins.

INTRODUCTION

Yellow Warblers (*Setophaga petechia*) are uncommon during spring migration in west-central Florida (Dunn and Garrett 1997), but are abundant during fall migration (Stevenson and Anderson 1994). A 10-year spring migration count at Green Key Peninsula, on the west-central coast of Florida, resulted in only six Yellow Warblers in a total of 12,885 warblers identified (Tracey and Greenlaw 2011), indicating that spring migration chiefly crosses the Gulf of Mexico west of Florida. Fall migration appears to begin along a broad front that corresponds to the width of the species’ breeding range in North

America (Lincoln et al. 1998), and continues across the lower United States with extralimital reports east to Bermuda (Lowther et al. 1999). Peak fall migration in Florida is believed to occur from mid-August to early September (Dunn and Garrett 1997, Floyd 2008). Some August migrants appear to be diurnal and use a circum-Gulf route (Duncan and Weber 1985). The Yellow Warbler has nine recognized subspecies (Browning 1994). The nesting areas for seven of these subspecies are in North America; the eighth is in Mexico, and the ninth is bisected by the border (Fig. 6). The fall migration routes of some subspecies have been confirmed by collected specimens. Confirmed fall subspecies passing through Florida include *S. p. aestiva*, which nests all over eastern/central U.S. and southern Canada; *S. p. amnicola*, which nests in northern Canada; and *S. p. rubiginosa*, which nests in the coastal areas of Alaska and British Columbia (Stevenson and Anderson 1994). Although western/Pacific subspecies generally migrate to Mexico and South America (Dunn and Garrett 1997), the fact that *S. p. rubiginosa* has been collected in eastern and southern states, ranging from Massachusetts to Louisiana (Chamberlin 1934, Griscom 1941, Mcatee et al. 1944, Parkes 1968), indicates that these subspecies can pass through Florida.

The chief goal of this study was to document the timing and nature of the Yellow Warblers' fall migration in west-central Florida. This goal was achieved through counting methods and through digital photography, which allowed me to assess characteristics of each bird. Characteristics included age, gender, and plumage color on the head and upperparts of adult males. These images were used to match colors and patterns of subspecies described in the literature (Browning 1994) known to pass through Florida (chiefly *S. p. aestiva* and *S. p. amnicola*), and to clarify the importance of the Florida gulf coast as a route of southward travel.

METHODS

Study areas

This study covered nine fall seasons from 2006 through 2014 in Pasco County, Florida. Data was collected from 21 July to 29 October of each year. The majority of Yellow Warblers counted in this study were at Robert K. Rees Park (28.25449 N, -82.75383 W), which is on the Gulf of Mexico at the Green Key peninsula, and at Lake Lisa Park (28.28756 N, -82.69742 W), which is two miles inland from the Gulf in Port Richey, FL. A 2014 point count survey was done along Green Key Road 145 m east of the entrance gate at Robert K. Rees Park (28.254938 N, -82.749925 W). Because most migrants pass unseen overhead in both nocturnal and diurnal variations, I focused on two appealing habitats for stopover warblers: mangroves along the coast at Robert K. Rees Park, and Brazilian pepper (*Schinus terebinthifolius*) stands on the edge of an inland pond at Lake Lisa Park. These areas not only have suitable vegetation that provides food and shelter – they also resemble wooded and scrubby wetland areas that Yellow Warblers use for breeding (Lowther et al. 1999).

Counting methods

Of the 909 possible count days during these fall seasons, I completed morning counts on 469. Bad weather and other commitments were limiting factors on some mornings, but the successful sample of count days represents more than half of the available days. An additional 28 evening counts were performed in 2014. All counts lasted approximately one hour. Two counting methods were employed: standard count and point count. The standard count method was followed during each morning count. At Robert K. Rees Park, I walked the 0.58 km Green Key Road from the park gate to the beach searching for birds in the mangroves. Due to the very dense vegetation, I initially recognized the presence of warblers by the sound of their bills snapping on insects in the mangroves. I then played a Yellow Warbler recording to bring them into view. All identifiable warblers were counted.

At Lake Lisa Park, which is an old lime-rock quarry, I walked the 0.65 km pedestrian path along the east side of the quarry's edge. Migrating warblers frequented a narrow strip of Brazilian Peppers between this path and the quarry's edge. A Yellow Warbler recording was, again, used to lure the warblers out of the Brazilian peppers to photograph and count.

Migrating Prairie Warblers (*Setophaga discolor*) were also counted at Robert K. Rees Park as a control measure. This data gave me the opportunity to conduct a comparative analysis of fall migration patterns between the two species, in effort to look for potential environmental effects that are unique to this study area. The geography of the Green Key peninsula provides an excellent landmark for wind-displaced birds to find and reorient themselves (Tracey and Greenlaw 2011). If peaks in data are a result of wind-displaced birds finding their way back to land, those peaks would occur simultaneously for both species. The data obtained by the standard count method provided an index of the total number of warblers involved in early morning migration movements. Instead of comparing daily peaks during each of the nine seasons, I opted for three-day average counts. This approach smoothed the temporal pattern in the data by offering 34 data points in lieu of 101 one-day evaluations.

In 2014, I initiated a stationary point-count (Hostetler and Main 2008) survey of Yellow Warblers along Green Key Road, which is 145 meters east of the entrance gate at Robert K. Rees Park (28.254938 N, -82.749925 W). This count was utilized only during the last year to assist in validating the three possible migration peaks that appeared in the standard count data pattern. I chose this location after noticing a large evening flow of Yellow Warblers there in 2013. Although Yellow Warblers feed in the mangroves while moving south all day, I found that their numbers increased in the evening during their diurnal migration (Duncan and Weber 1985). I decided to count at that time to obtain a large sample size.

The point-count was conducted from 18:30 to 19:30 for 28 count days: one day in July, 10 days in August, 13 days in September, and four days in October. At this location, most warblers were noted flying in from the north, with a few coming in from the west off the Gulf. All identifiable warblers were counted using wide-field binoculars (8X 32) while standing at the point-count center. The mangroves at this location were approximately 100 meters wide and followed the coast in a north to south direction.

Photographic documentation

Along with recording the total number of Yellow Warblers seen each day, I attempted to photograph each bird for later analysis. Since Yellow Warblers are usually in constant motion as they flit from branch to branch, three cameras that focus rapidly were used in this study: the Kodak Z990 and Fuji S8200, which allow a 30 or 40 optical zoom, respectively, and the Canon Rebel XT, which has a 300 mm lens. Photographs captured

plumage characteristics not seen in most binocular views. Each photograph was dated and assigned a unique code for categorization purposes.

Evaluations of photographs focused on identifications of age, gender, and dorsal body plumage (hereafter called the “dorsum”). Age was determined by apparent bill color: “first fall” or “hatch year” warblers have a tan lower mandible, while adults have black beaks (Mundy and McCracken 1997). Identifying age is important for determining overall migratory routes: first-fall wood warblers are more abundant along the geographic periphery of the mainstream adult migratory movement (Murray 1966, Dunn and Nol 1980, Ralph 1981). A high ratio of adult-to-young warblers thus indicates that a location is near the center of a migratory route. If a warbler’s bill was not clear enough for age determination, the photograph was not used in the analysis.

For adult birds, gender was determined by the presence (males) or absence (females) of chestnut streaking on the underparts. Dorsum color was recorded for most of the photographs and categorized by yellow, green, olive, dark-green, and brown coloring. These categories are consistent with descriptions of Yellow Warbler subspecies and give indication as to which region each bird originates from. Generally, lighter-colored dorsum birds breed in southern regions while darker-colored birds breed in northern regions (Dunn and Garrett 1997). The color categories were defined as: “yellow” birds with a yellow head, yellow or yellow-green dorsum; “green” birds with a yellow forehead, green crown, or green dorsum; “olive,” for the first fall *S. p. amnicola* birds from northeastern Canada that are olive overall; “dark-green” birds with a green forehead, green crown, green or dark green dorsum; and “brown” birds with a brown crown and brown dorsum.

RESULTS

A total of 5,993 Yellow Warblers were recorded during this study. The standard count method produced a record of 5,149 Yellow Warblers over 469 count days which average out to 11 warblers per day. Three distinct migration peaks emerged from this data (Fig. 1). These peaks occurred from 17 to 19 August, which averaged 14 warblers per day; 7 to 9 September, which averaged 18 per day; and 16 to 18 September, which averaged 25 per day. This last peak was the highest average recorded in this study.

During the point-count survey in 2014 (Fig. 2), 844 Yellow Warblers were counted on 28 evenings. Point counts with the largest number of birds closely matched the migration peaks discovered by the standard count method: 45 warblers were counted on 16 August; 63 warblers were counted on 12 September; and 132 warblers were counted on 18 September (Fig. 1). This last point-count, when combined with the standard count of warblers earlier that day, represents the highest count day ($n=179$) for this nine-year study. The monthly totals for the entire Yellow Warbler migration study were 85 in July, 1,710 in August, 3,369 in September, and 829 in October.

A total of 2,577 Prairie Warblers were also counted alongside the Yellow Warblers as a comparative measure (Fig. 3). Peak migration of Prairie Warblers was on 27 July (Fig. 3, “A”), which predates the first Yellow Warbler peak on 17 August by over two weeks (Fig. 3, “B”). After this peak, and in contrast to the pattern exhibited by Yellow Warblers,

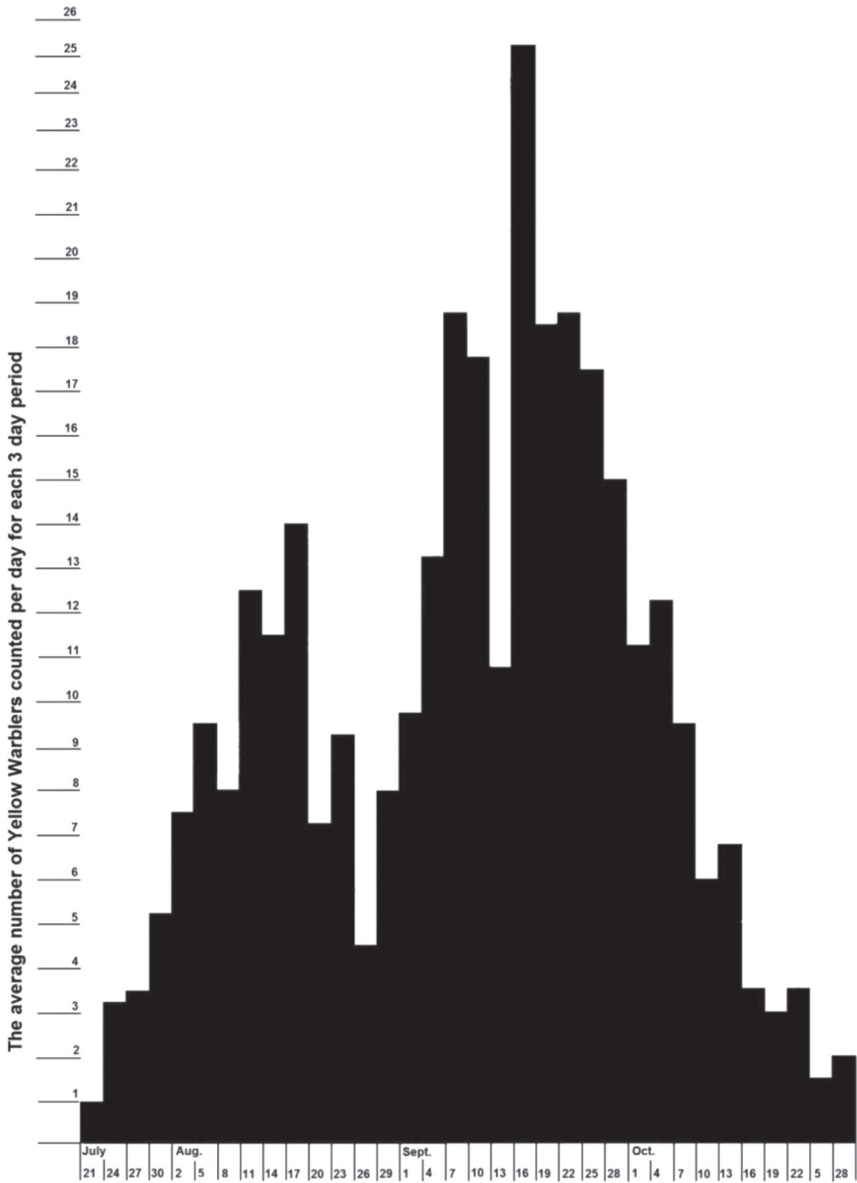


Figure 1. Frequency distribution of standard counts summarized; as daily averages over 3-day survey periods for the 5,149 Yellow Warblers counted for 9 years from 2006 to 2014.

the Prairie Warbler numbers steadily decrease until the final count period of 28 October. In September, the two migration peaks of Yellow

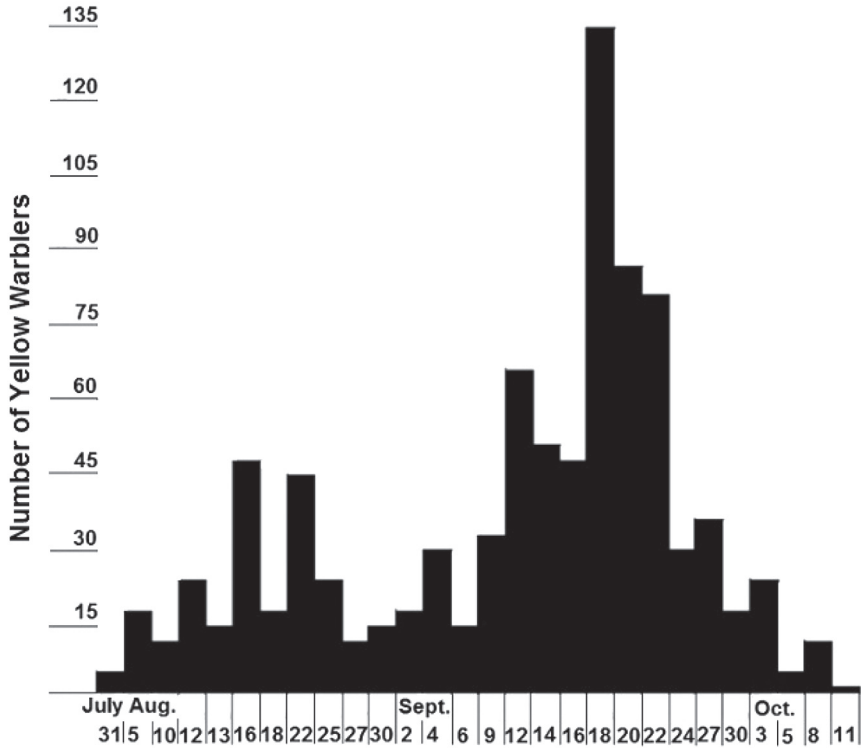


Figure 2. Frequency distribution of the 2014 point-count data collected along Green Key Road.

Warblers are evident at “C” on 7 September and at “D” on 16 September, with no corresponding peaks in Prairie Warblers (Fig. 3).

A total of 1,713 Yellow Warbler photographs were used in this study. These photographs confirmed that 906 birds (53%) were adult warblers as indicated by all black beaks and 807 birds (47%) were “first fall” or “hatch year” warblers as indicated by tan lower mandibles (Mundy and McCracken 1997). This yields an overall adult-to-young ratio of 0.53. However, between 17 August to 7 October, the number of adult warblers grew to 61% (Fig. 4), yielding an adult-to-young ratio of 0.61 for all migration peaks. On the other hand, “hatch year” birds were the first to arrive as migration season began, comprising of 76% of warblers before 17 August, and made up the majority of migrants at the end of the season, comprising of 58% after 6 October (Fig. 4).

Another significant trend was discovered by evaluating the plumage color of each photographed warbler. Birds with yellow dorsum comprised of 89% of the July/August migration, while birds

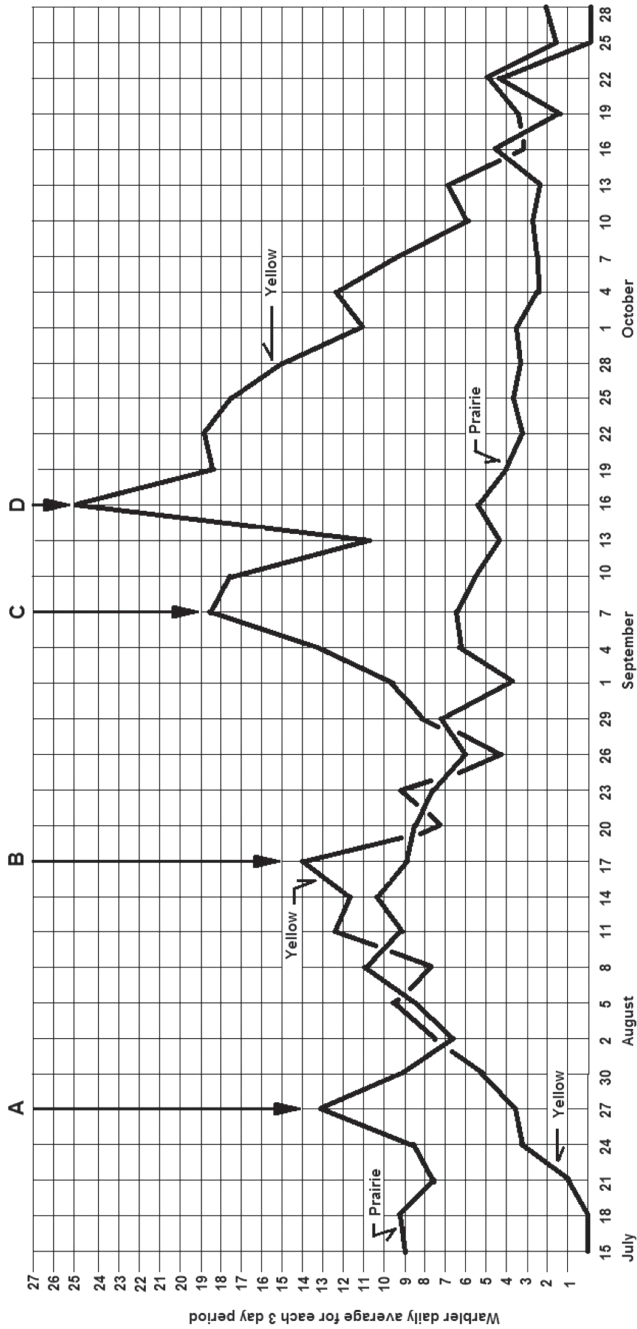


Figure 3. The migration timing of Prairie Warblers (N=2,577) compared to the migration timing of Yellow Warblers (N=5,149).

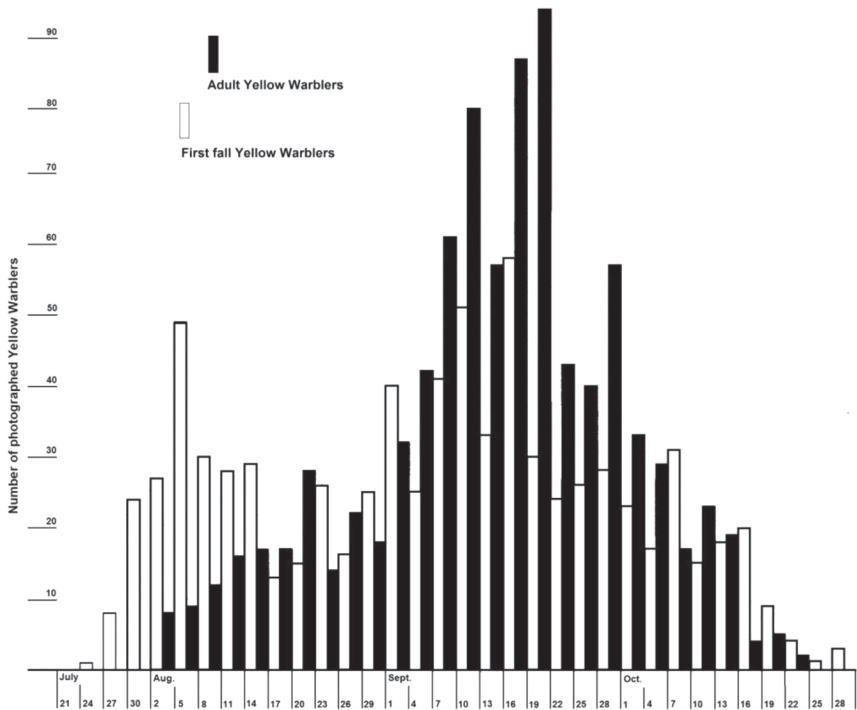


Figure 4. The migration timing of all 1,713 photographed Yellow Warblers, showing “first fall” (N=807) and adult (N=906) age groups.

with green, olive, dark-green, or brown dorsum accounted for 59% of those photographed in September/October. Of the 1,713 total warblers photographed, 917 had a yellow dorsum (259 adult males); 571 had a green dorsum (192 adult males); 32 had an olive dorsum (0 adult males); 137 had a dark green dorsum (26 adult males); 49 had a brown dorsum (15 adult males); and 7 were indeterminate.

DISCUSSION

The timing of Yellow Warblers’ fall migration through Florida has been described by several authors as occurring from mid-August to early September (Dunn and Garrett 1997), with the highest passage expected in August (Floyd 2008). However, I found that the September numbers in west-central Florida nearly doubled those of August, with the highest passage occurring in mid-September (Fig. 1). There were also three migration peaks, which were defined as three-day periods averaging more than 11 birds per day: the first occurred 17 to 19 August (n=14 birds per day), the second occurred 7 to 9 September (n=18 birds per day), and the final occurred from 16 to 18 September (n=25 birds

per day). These three-day average peaks were confirmed by the 2014 point-count survey, in which 45 warblers were counted on 16 August, 63 warblers on 12 September, and 132 warblers on 18 September.

This triple-peak pattern appears to have biological meaning rather than being a result of environmental factors, such as the wind displacement of birds (Tracey and Greenlaw 2011), that are unique to the Green Key peninsula. The Prairie Warbler migration data also collected in this study supports this argument: the highest passage of Prairie Warblers occurred more than two weeks before the Yellow Warblers' first peak, and the number of migrant Prairie Warblers decreased as the season continued. Moreover, the two species did not share any overlapping peaks. This finding aligns with the more complex temporal distribution of different Yellow Warbler populations in North America relative to the simple distribution of Prairie Warblers.

The Yellow Warbler peaks can be envisioned as “waves” of migrants (Fig. 6), and the approximate distances from the study area of west-central Florida to the potential origin of the birds may account for these three peaks. The first wave of *S. p. aestiva*, which nest approximately 1,000 km from the study area in the eastern United States, was observed in mid-August in Florida; the second wave of *S. p. aestiva* and *S. p. amnicola*, which are centered approximately 2,000 km from the study area in northeastern Canada, passed through Florida at the end of the first week of September; and the final wave of *S. p. aestiva*, *S. p. amnicola*, and possibly other western and northern subspecies arrived in Florida during the third week in September from locations approximately 4,000 km from the study area in northwestern Canada. The third wave may be typical of subspecies identified in two tower kills. The Westport Minnesota tower kill occurred on 9-10 September 1962 and had *S. p. aestiva*, *S. p. amnicola*, and Mackenzie Delta (*S. p. parkesi*) subspecies identified as traveling the same nights (Raveling and Warner 1990). The Warner Robbins Georgia tower kill occurred on 7-8 October 1954 and had *S. p. amnicola* and *S. p. rubiginosa* identified (Johnston and Haines 1957). These towers appear to be on a direct flight line to the study area in Florida (Fig. 4).

Although photographs are not a generally accepted standard for definitively identifying subspecies, in some cases, determinations can be made from well-lit photographs. In this study, the combination of counting methods, appropriate timing, and photography skills resulted in a number of subspecies identifications. Categorizing Yellow Warblers by their dorsum colors provided evidence that *S. p. aestiva* (259 males with a yellow dorsum) and *S. p. amnicola* (193 males with a green dorsum) are migrating through Pasco County, FL. Olive-colored first-fall birds were most likely *S. p. amnicola* from northeast Canada – this population is known to exhibit this plumage color in first fall (Dunn

and Alderfer 2011). The dark-green and brown dorsum assignments are more subjective, and could represent *S. p. amnicola*, *S. p. parkesi*, *S. p. banksi*, *S. p. morcomi*, or *S. p. rubiginosa*.

A review of specimens in the Florida Museum of Natural History's collection (n=40) shows that while *S. p. aestiva* were collected throughout the entire Yellow Warbler migration period, *S. p. amnicola* and *S. p. rubiginosa* were only collected in September and October (Fig. 5). This migration timeline closely matches this study's findings of 59% green, dark-green, and brown dorsum birds in September and October. There is also evidence that *S. p. rubiginosa*'s dorsum color fluctuates between dark-green in the spring/summer and brown in prebasic fall molt, which may cloud efforts to identify subspecies that were originally defined by spring male or breeding plumages (Browning 1994). Similarly, my photographs of brown dorsum first fall warblers were a good match to the drawing of a brownish Yellow Warbler that appears in Dunn and Alderfer (2011) and is identified as *S. p. rubiginosa*.

Several authors have suggested that some *S. p. rubiginosa* specimens collected along the east coast of the U.S. could be *S. p. parkesi*, as the latter subspecies was not named until recently (Browning 1994). However, an inspection of three "first fall" *S. p. rubiginosa* specimens at the Florida Museum of Natural History revealed bill lengths between 8.08–8.24 mm, which is, indeed, consistent with *S. p. rubiginosa* and outside the accepted range of 6.90–7.90 mm for *S. p. parkesi* (Browning 1994). Aside from this difference in bill length, *S. p. rubiginosa* and *S. p. parkesi* are hard to differentiate because both subspecies share a dark-green dorsum color. Despite this, my photographs of 41 males with dark-green and brown dorsum suggest that other northern and

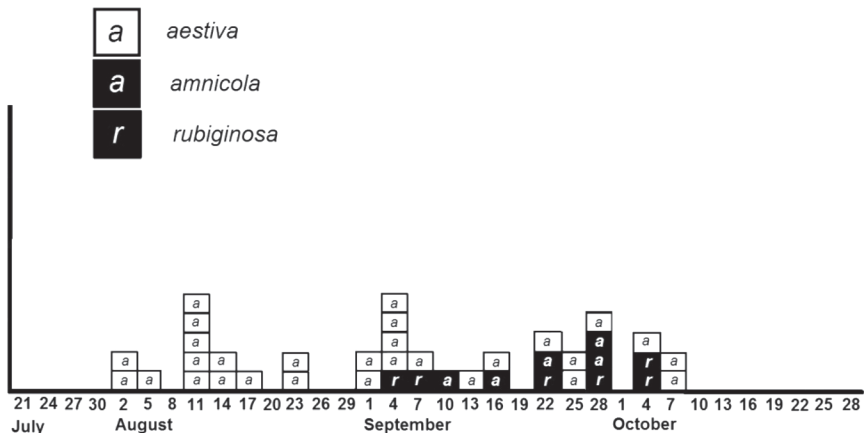


Figure 5. The timing of fall migration represented by Florida museum specimens (N=40) of Yellow Warblers that were identified to subspecies.

western subspecies, aside from *S. p. rubiginosa*, may also be migrating through Florida. Fig. 6 shows the nesting area of *S. p. rubiginosa*, which is the most western and northern subspecies after *S. p. banksi*. It is hypothetical that northern *S. p. morcomi* and *S. p. parkesi*, which are nesting east of *S. p. rubiginosa*, may also be Florida migrants. To date, *S. p. parkesi* specimens have only been collected on the east coast in Massachusetts (Parkes 1968).

The overall adult-to-young ratio of 0.53 for the photographed sample – which increased to 0.61 during the three peak periods – suggests that the



Figure 6. Map of study area showing nesting regions of currently recognized subspecies and general wintering grounds of northeastern birds. Boundaries of breeding areas of subspecies are from Browning (1994) with updates by Dunn and Garrett (1997). Westport Minnesota and Warner Robbins Georgia, tower kill locations are shown (Raveling and Warner 1978, Johnston and Haines 1957). Possible “migration waves” as interpreted by the author are indicated from collected data. Study area inserts show the locations of Lake Lisa Park and Robert K. Rees Park, and the point-count location at the latter site.

Gulf coast of central Florida is near the center of the Yellow Warblers' fall migration route. A similar ratio of 0.56 adults was found in Ralph's (1981) review of 234 Blackpoll Warbler (*Setophaga striata*) specimens in Bermuda, which is located in the center of their migration route (Stephenson and Whittle 2013). However, this Yellow Warbler study also revealed a fluctuating percentage of "first fall" warblers throughout the migration season. Before 17 August, first fall constituted 76% of migrants; after this, their numbers dropped to 39% until 6 October. This initial youth-majority ratio, which appears to contradict my assertion that this study area lies near the center of the migration path, may be explained by the prebasic molt of adult warblers. Prebasic molt occurs on the breeding grounds just before fall migration: while adults lose all of their feathers, first fall birds retain their flight feathers (Dunn and Garrett 1997, Pyle 1997). Consequently, first-falls can begin their journeys sooner than their adult counterparts.

Although 1,713 photographs aided in identifying the age and probable subspecies of passerby warblers, there are limitations to using this method alone for a study. To begin with, Yellow Warbler subspecies in North America are relatively weakly differentiated and evidently clinal (Pyle 1997), so a categorical classification of predominant plumage hues will likely result in some erroneous assignments of photographed birds to named populations. Also, the dorsal plumage categories used in this study were subjective and dependent upon the quality of each individual photograph. It is also important to remember that the position of the bird in relation to the sun and the camera's orientation can lead to differences in color absorption.

Nevertheless, the value in using photographs that capture plumage characteristics of hue and pattern may be particularly useful for subspecies that are reasonably well-marked. Digital photographs of geographically variable species – taken under well-lit conditions and associated with time and location data – can provide evidence of possible origins of migrating birds. Plumage characteristics of well-marked subspecies can be better understood if photography archives that document variations within known populations are created. For Yellow Warblers, the result of such effort could provide an invaluable tool for assessing likely regions of origin using the plumage markers of migrating or wintering populations that do vary geographically on their breeding grounds.

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