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Using Passive Acoustic Monitoring to Determine Temporal Patters and Mixed Species Flocking Associations of Migrating North American Warblers in the Gulf of Maine

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PATTERNS AND MIXED-SPECIES FLOCKING ASSOCIATIONS OF MIGRATING

NORTH AMERICAN WARBLERS IN THE GULF OF MAINE

by

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ABSTRACT

Recent development of plans for offshore and land-based wind energy projects has created the need for a better understanding of migration in the Gulf of Maine region, an important flyway for countless migrant birds each year. To better understand migration in this region, the University of Maine's Lab of Avian Biology, working in collaboration with the U.S. Fish and Wildlife Service, deployed acoustic recording units at various sites throughout the Gulf of Maine to detect and quantify flight calls of nocturnally migrating songbirds. Using these data from selected nights, the detected flight call temporal patterns of American Redstarts (*Setophaga ruticilla*), Myrtle Warblers (*S. coronata coronata*), Black-and-white Warblers (*Mniotilta varia*), Common Yellowthroats (*Geothlypis trichas*), and Ovenbirds (*Seiurus aurocapilla*) were shown to be bunched non-uniformly throughout given nights. To show evidence of birds flying in aggregations or flocks a five second window of time was established around each selected warbler's detected flight calls and the presence of a corresponding flight call within that call window was treated as evidence of a possible flock or aggregation of birds. Approximately 50% of the detected flight calls of all five species showed evidence of potential conspecific and heterospecific flock associations with other songbirds during nocturnal migration.

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INTRODUCTION

Research in the Gulf of Maine has revealed that at least 80% of the more than 300 species of birds comprising all major taxa in its region are migrants (Holberton and Wright, 2013). The migration period poses the greatest risk of annual songbird mortality and events during this time play an important role in individual survival (Sillett and Holms, 2002). For many species, coastal areas provide an area for rest and a source of food, which can be especially vital for birds who have become displaced during nocturnal open-ocean flights (Baird and Nisbet, 1960; Able, 1977). Proposed development of offshore and coastal land-based wind energy projects throughout the Gulf of Maine region has created the need to better understand songbird migration throughout the region in order to better assess the potential impacts that turbines could have on the numerous species that depend on this flyway (Holberton and Wright, 2011; 2013). Turbines and other large towers present a high collision risk to migrating songbirds, especially in conditions of poor visibility (Hüppop *et al.,* 2006; Hüppop and Hilgerloh, 2012). Graber (1968) documented television tower collision-caused mortality of 478 birds comprising 32 species at one tower alone and Cochran and Graber (1958) provided evidence that migrants are attracted to bright lights, increasing potential collision risk with lighted structures.

In 2009 the U.S. Fish and Wildlife Service and the University of Maine's Lab of Avian Biology set up passive acoustic monitoring stations throughout much of the coastal Gulf of Maine region to document nocturnal passerine migration by detection of flight calls. Although nocturnal flight calls were first recorded decades ago, there is still much that remains a mystery in regards to their social context (Farnsworth, 2005). However, what is known is that these calls are the principal vocalizations given by many species of birds during migration, which for most songbirds occurs at night (Evans and O'Brien, 2002; Farnsworth, 2005; Farnsworth, 2007). Flight calls similar to those produced during the migration season are also made regularly in some species during non-migratory periods indicating their context could be situation specific (Mundinger, 1970; Farnsworth, 2007). A captive study done in the sixties suggested that flight calls are a means of communication between individuals in a flock and since then evidence shows that flight call frequency increases in conditions of poor visibility and collision risk (Hamilton, 1962; Evans and Mellinger, 1999; Hüppop and Hilgerloh, 2012). These findings suggest that if flight calls are used in maintaining flock cohesion then songbirds should be aggregating together in identifiable, cohesive conspecific or heterospecific groups during migration when flight calls are more frequently given (Farnsworth, 2007).

Past studies reported that most songbirds depart at the beginning of the night and when aloft are flying singly, or at least in aggregates not easily identifiable as "flocks (Hebrard, 1971; Gauthreaux Jr., 1972), while Nisbet (1963) concluded that nocturnal migration in small groups, e.g. flocks, is widespread in wood-warblers (Parulidae), thrushes (Turdidae), and new-world sparrows (Emberizidae). Studies using ceilometer beams (Balcomb, 1977) and radar (Graber, 1962; Gauthreaux Jr., 1972; Larkin *et al.,* 2002; Farnsworth *et al.,* 2004; Larkin and Szafoni, 2008) have shown that migrating songbirds are not spatially nor temporally distributed uniformly aloft while more recent acoustical studies provide data showing that temporal patterns of flight calls occur in non-uniform clusters through the span of a given night (Farnsworth, 2005; Farnsworth and Russell, 2007; Hüppop and Hilgerloh, 2012). Therefore, there is still some gaps in understanding the degree of cohesiveness of birds aloft during nocturnal migration.

Recent development of automated and durable microphone-recording systems paired with the creation of an electronic identification guide of bird flight calls have made collecting and using flight-call data less laborious and more practical over large spatial scales. However, it is not possible to detect all species of songbirds even when they are present. New World Flycatchers (Tyrannidae) and Vireos (Vireondae) are two families of nocturnally migrating passerines that do not regularly give flight calls in any context. Swallows (Hirundinidae) and Finches (Fringilidae) give flight calls regularly but are diurnal migrants and thus cannot be monitored at the same time as nocturnal migrants (Evans and O'Brien, 2002; Farnsworth, 2005). Flight call data collected from Evening Grosbeaks (*Coccothraustes vesertinus*) provide evidence that acoustical monitoring could be used to identify finch subspecies (Sewall *et al.,* 2004) and the flight call of Pine Siskins (*Spinus pinus*) has been confirmed within the past few years (Watson *et al.,* 2011), indicating that acoustical monitoring is useful in observing diurnal songbird movements as well. Flight call data have even been used to support giving species recognition to groups formally considered "races". For example, Evans (1994) reported distinct differences between the flight calls of closely related Bicknell's Thrushes (*Catharus bicknelli*) and Gray-cheeked Thrushes (*C. minimus*), supporting the species-level separation of these two races in 1995.

Mixed-species flocks of migrant songbirds can be observed diurnally but it is not known if aggregation patterns seen for daytime migration are representative of how birds move at night (Wiedner *et al.,* 1992; Rodewald and Brittingham, 2002). The two main hypotheses as to why birds participate in flocks are that flocking behavior reduces predation and foraging in groups improves efficiency (Morse, 1977). Diurnal flocking behavior gives benefits through the dilution effect (Forster and Treherne, 1981), many-eyes effect (Pulliam, 1973), selfish herd effect (Hamilton, 1971), confusion effect (Neill and Cullen, 1974), and communal defense (Port *et al.,* 2011). However, inter-specific flocking with other species allows individuals to potentially benefit from individuals that have increased anti-predator detection (Diamond, 1981; Powell, 1985) and access to resources made available by other species (Peres, 1993). Bird species that join mixed-species flocks tend to be more insectivorous in their foraging habits and due to competition for similar prey sources the anti-predation benefits gained from forming such associations are most likely the driving factor behind mixed-species flocking (Sridhar *et al.,* 2009; Sridhar and Shanker, 2014). Harrison and Whitehouse (2011) suggested that mixed-species flocking behavior could even be a selecting force in niche construction in order to avoid competition between participants. However, all of these studies have been focused on diurnal flocking and not nocturnal. Little is known about flocking and flock composition during nocturnal migration of land birds.

For this thesis the detected flight calls of five selected wood-warbler species- American Redstarts (*Setophaga ruticilla*), Myrtle Warblers (*S. coronata coronata*), Common Yellowthroats (*Geothlypis trichas*), Ovenbirds (*Seiurus aurocapilla*), and Black-and-white Warblers (*Mniotilta varia*)- from the 2011 fall migration season in Hampden, Maine were collected and examined for the likelihood of the occurrence of conspecific or heterospecific flocking during nocturnal migration. Evidence for a temporally clumped distribution of calls would suggest spatio-temporal cohesion, perhaps even synchronized via calls. Data indicating songbirds flying together could suggest a potential increase in risks tied to localized hazards, such as turbine-collisions, but also provide important information on the migration biology and ecology of nocturnally migrating songbird species.

METHODS

Microphone and Recording Equipment Deployment:

Following the protocol outlined in Holberton and Wright (2011; 2013), recording equipment and a microphone were deployed in Hampden, Maine (-68.86 W, 44.73N). A H4n Zoom® (Zoom® Corporation) industrial-grade sound recorder was used by the Lab of Avian Biology in Hampden and the microphone was constructed using the “flowerpot” design developed by Bill Evans (Oldbird, Inc., http://oldbird.org/mike_home.htm) and was mounted approximately 3-4 meters above ground on a raised platform. Bungee cords were used to anchor the flowerpot to the platform and the recording equipment was powered by 120 AC current from a nearby building. Figure 1a shows the approximate location of the Hampden site in relation to the Gulf of Maine and Figure 1b displays the microphone and recording equipment setup used by the University of Maine’s Lab of Avian Biology and by U.S. Fish and Wildlife.

Species Identification:

The raw acoustical data from nightly recordings were uploaded and analyzed by the University of Maine’s Lab of Avian Biology using Cornell’s Raven 1.4® software. Flight calls were sorted out from the background noise and later identified down to species or a species group, such as the “zeep” complex which comprises several *Setophaga* warbler species, by their general shape, length (ms), and frequency (kHz) using the Cornell Laboratory of Ornithology library of flight calls and Evans and O’Brien (2002). Figures 2a-2e provide examples of the typical flight call made by the five focal warbler species and were recorded in Hampden, ME during the 2012 fall migration season.

Data Analysis:

The raw acoustical data for the nights of August 31st, September 1st, September 6th, September 9th, September 14th, September 23rd, and September 24th were first sorted through to identify flight calls from other noises (e.g., car horns) and detected calls were identified down to species or a species complex. Calls too unclear to identify down to species or of bad quality were labeled as "unclear" and calls of good quality that could not be identified using the available flight call references were labeled as "unknown". Temporal histograms were created for each of the nights by placing the relative frequency of detected flight calls of each species into hourly bins based on hours past sunset. The relative frequency of detected flight calls was chosen because total number of calls varied greatly between species and across nights. Temporal histograms depicting the relative frequency of detected flight calls across all seven nights and showing the combined distribution of all detected flight calls were generated as well. Chi-Squared Goodness-of-fit tests, with a Williams's correction when appropriate, were performed on the total number of detected flight calls for each species to determine if there was a non-uniform distribution of detected flight calls across the span of the hourly bins. The null hypothesis tested against was that there would be an even distribution of the detected flight calls across the hourly bins.

To look for evidence of birds flying in flocks or aggregations a five second window was placed around each detected flight call of the five chosen species. The five second call window was selected based on the highly variable volume of space that the microphone could pick up a flight call and the estimated time it would take a warbler flying at 40 km/h on average to fly through that space. Due to the many factors such as level of background noise and weather that could affect detectability of a flight call on a nightly bases it is difficult to establish a uniform call window that would be appropriate for each individual night. Therefore, for analysis purposes the presence of another call within an individual's five second window was treated as evidence of a spatio-temporal association between individuals (i.e., flocking). Assumptions that each individual bird had the same probability of calling and that each call represents a unique bird were made. The processed data were sorted through to determine the number of flight calls per night that contained at least one other flight call in their five second window and linear regressions showing the correlation between the total number of detected flight calls and the number of flight calls containing a corresponding flight call in their windows were generated for each of the five species. Afterwards, a second linear regression showing the number of detected conspecific calls plotted against the total number of identified calls within a species' window was created for each species. The detected calls within a species' call window were then identified down to the species or a species complex level and a series of pie charts were made showing the species composition of detected birds for each of the five focal species for each night and for all the detected calls across the seven nights combined. Calls that were identified as unclear or unknown were included in the initial presence or absence counts but were not included when determining species composition. The scientific names for detected species and the composition of each species complex are shown in Table 6.

RESULTS

American Redstart:

Figure 3 shows the relative frequency of detected American Redstart flight calls for each of the seven analyzed nights. September 6th had the highest number of calls with a total of 104 detections over the course of the night while September 14th had the lowest with only 10 calls detected. The nights of August 31st, September 1st, September 9th, September 23rd, and September 24th had 13 to 51 flight calls detected. Peaks of detected flight calls varied throughout the seven nights with August 31st through September 9th all having their peaks of detected relative flight call frequencies in the 3rd through the 5th hourly bins. September 14th and September 24th had their peak in detected call frequency in the 2nd hourly bin whereas September 23rd had its peak in the 1st. Figure 4 shows the relative frequency of detected American Redstart flight call across all seven nights and Figure 5 shows the relative frequency of all the detected American Redstart flight calls from all seven nights combined. There was a total of 233 detected American Redstart flight calls detected in the seven nights (Figure 5) and the peak of all the detected flight calls occurred in the 5th hourly bin. The nights of August 31st, September 1st, September 6th, September 14th, September 23rd, as well as the combined distribution all had statistically significant pattern showing that there was a non-uniform temporal distribution of detected flight calls.

Table 1 shows the total number of calls detected in the five second call window of American Redstart flight calls which ranged from a low of five calls detected out of 18 total calls (28%) found on August 31st to a high of 16 calls out of 24 total calls (67%) found on September 23rd. There was an overall total of 115 flight calls out of 233 (49%)

detected American Redstart flight calls that were found to have another corresponding flight call occur in their five second window and a R^2 value of 0.96 was calculated when a simple linear regression was made plotting the number of detected calls within a call window against the number of detected calls throughout the night (Figure 6a). The total number of conspecific calls detected ranged from 0% of the total identified calls which occurred on August 31st and September 24th to 80% of the total identified calls found on September 14th. Out of the 104 identified calls within American Redstart call windows only 37 (36%) were conspecific. A R^2 value of 0.94 was calculated from a linear regression created by plotting the number of identified conspecific calls against the total number of identified calls within an American Redstart call window (Figure 6b).

Figure 7 shows the composition of identified species within American Redstart five second call windows across the seven nights. September 6th had the most number of incidences with a total of 51 identified calls comprised of nine species and two species complexes while September 9th had fewest with only four identified flight calls comprised of one species and one species complex. August 31st had five identified calls comprised of two species and two species complexes, September 1st with 10 identified calls from three species and one species complex, September 14th with five identified calls made from one species and one species complex, September 23rd with 23 identified calls from four species and three species complexes, and September 24th with five identified calls comprised of two species and one species complex. Figure 8 shows the diversity of calls found in the five second American Redstart call window from all the nights combined. There was a total of 104 identified calls and 13 identified species or species complexes and American Redstart calls were the most frequent of the detected species making up 38% of the total detected calls. The “Zeep” complex followed with 18%, Ovenbirds with 10%, and the Northern Parula (*S. americana*) with 9% of the total identified calls. The other nine species or species complexes comprised 5% or less of the total species composition and a checklist of identified species in the American Redstart call window and the list of species which make up the “Zeep” complex are listed in Table 6.

Myrtle Warbler:

Figure 8 shows the relative frequency of detected Myrtle Warbler flight calls over the course of the seven analyzed nights. September 24th had the highest number of flight calls in a given night with total of 55 detections while August 31st and September 14th had the fewest with a total of nine detected calls. The nights of September 1st, September 6th, September 9th, and September 23rd ranged from 12 to 39 total detected calls. Peaks of detected flight calls varied greatly across the nights with September 14th having its peak in the 1st hourly bin, September 23rd during the 2nd, September 9th during the 4th, September 24th in the 5th, and August 31st in the 6th. September 1st and September 6th were both found to have bimodal distributions with their peaks in the 2nd and 3rd hourly bins and 4th and 7th respectively. Figure 10 shows the relative frequency of detected Myrtle Warbler flight calls across all seven nights and Figure 11 shows the relative frequency of all detected Myrtle Warbler flight calls across the seven nights combined. There was a total of 184 detected Myrtle Warbler flight calls (Figure 11) and although the peak in detected calls occurred in the 4th hourly bin they also had smaller peaks during the 2nd, 3rd, and 5th hourly bins. The nights of September 6th, September 9th, September

23rd, and the combined distribution has statistically significant results showing a non-uniform pattern of detected Myrtle Warbler flight calls

Table 2 shows the number of detected flight calls that occurred within a five second window of a Myrtle Warbler flight call which range from a low of three out of nine total calls (33%) which occurred on the night of August 31st to a high of 37 out of 55 total calls (67%) which occurred on September 24th. There was an overall total of 101 out of 184 (55%) Myrtle Warbler flight calls which had a corresponding call detected in their call window and a R^2 value of 0.98 was calculated when a simple linear regression was made plotting the number of detected calls within a Myrtle Warbler flight call window and the number of total detected Myrtle Warbler calls throughout the nights (Figure 12a). Out of the total of 86 calls detected and identified in Myrtle Warbler call windows only 12 (14% of the total identified calls) were conspecific. The nights of August 31st, September 1st, September 14th, and September 23rd had zero incidences of a conspecific call occurring while September 24th had the most with only 8 (26% of the identified calls during the night). A R^2 value of 0.63 was calculated when a linear regression plotting the number of identified conspecific calls against the total number of identified calls within a Myrtle Warbler call window was generated (Figure 12b).

Figure 13 shows the composition of identified species detected in the five second Myrtle Warbler call windows across the seven nights. September 24th had the largest number with 31 identified calls comprised of six species and one species complex. However, September 6th had nine species and two species complexes making it the most diverse night for the Myrtle Warbler while only having 19 identified calls. August 31st had four identified calls made up by the “Vermivora” complex, September 1st had six identified calls from two species and two species complexes, September 9th with 10 identified calls representing four species and two species complexes, and September 23rd had 20 identified calls comprised of six species and one species complex. The detections within the Myrtle Warbler call window of September 14th had zero calls that could be identified down to a species or species complex. Figure 14 shows the diversity of identified calls found in the Myrtle Warbler call window from all the nights combined. There was a total of 86 identified calls made up of 12 total identified species or species complexes. Flight calls of the "Zeep" complex were the most frequent of the species identified making up 23% of the total number of the identified calls. Common Yellowthroats closely followed with 22% of the identified species, Ovenbirds with 15%, Myrtle Warblers with 14%, and Pine Warblers (*S. pinus*) with 9%. The other eight species or species complexes comprised 5% or less of the total species composition and a checklist of detected species in the Myrtle Warbler call windows and the list of species which make up the "Zeep" and "Vermivora" complexes are listed in Table 6.

Common Yellowthroat:

Figure 15 shows the relative frequencies of detected Common Yellowthroat flight calls over the course of the seven analyzed nights. The night of September 24th contained the most Common Yellowthroat detections with a total of 122 flight calls while September 14th had the fewest with only 10 calls detected. August 31st, September 1st, September 6th, September 9th, and September 23rd had detections ranging from 19 to 116 flight calls. Peaks in detected Common Yellowthroat flight calls varied between the nights with September 1st and September 14th having theirs peak in relative flight call frequency in the 1st hourly bin, September 24th in the 2nd hourly bin, September 6th and September 9th in the 4th hourly bin, and August 31st with the 6th. September 23rd had a bimodal distribution with peaks in the 1st and 3rd hourly bins. Figure 16 shows the relative frequency of detected Common Yellowthroat flight calls across all seven nights and Figure 17 displays the relative frequency of all detected Common Yellowthroat flight calls throughout the seven nights combined. There was a total of 424 detected Common Yellowthroat flight calls (Figure 17) and while their peak in detected calls was during the 3th hourly bin there were smaller, noticeable peaks during the 2nd as well as the 5th. Every night and the combined distribution, except August 31st, had statistically significant distributions indicating that there was a non-even pattern in detected Common Yellowthroat flight calls.

Table 3 shows the number of detected flight calls that occurred within a five second window of each Common Yellowthroat flight call which ranges from a high of 63% of the total calls during the night of September 24th to low of 40% occurring during the nights of September 9th, 14th, and 23rd. There was an overall total of 219 out of 424 (52%) total detected Common Yellowthroat flight calls that contained another call within their five second call window and a R^2 value of 0.94 was produced when a simple linear regression was made plotting the number of detected calls within a call window against the total number of detected calls throughout the night (Figure 18a). The number of Common Yellowthroat conspecific calls occurring within a call window ranged from 25% of the identifiable calls detected occurring on September 23rd to 55% of the total identifiable calls detected on September 24th. Out of the 282 total identified calls detected within a Common Yellowthroat call window only 108 (38%) were conspecific and when the number of conspecific calls was plotted against the total number of identified flight calls within a Common Yellowthroat call window as a linear regression a R^2 of 0.93 was produced (Figure 18b).

Figure 19 shows the species compositions of identified flight calls in Common Yellowthroat call windows across the analyzed nights. The night of September 24th contained the most identified flight calls in the Common Yellowthroat call window with a total of 100 detected calls comprised of nine species and two species complexes while September 14th had the fewest with only four calls comprised of one species and one species complex. September 6th contained the greatest species diversity of the nights with a total of 71 identified calls representing of 11 species and two species complexes. August 31st had nine identified calls comprised of four species, September 1st with 11 identified calls made by three species and one species complex, September 9th with 14 identified calls comprised of six species and one species complexes, and September 23rd with 73 identified calls from of seven species and four species complexes. Figure 20 shows the diversity of calls identified in the five second Common Yellowthroat call window from all the nights combined. There were a total of 282 detected calls identified down to 17 identified species or species complexes and Common Yellowthroats were the most frequently detected species making up 38% of the total calls. The “Zeep” complex was second with 23% and the Pine Warbler and Myrtle Warbler following with 7% and 6% respectively. The other 13 species or species complexes comprised 5% or less of the total species composition and a checklist of detected species in Common Yellowthroat call windows and the list of species which make up the “Zeep” complex is listed in Table 6.

Ovenbird:

Figure 21 shows the relative frequency of the detected Ovenbird flight calls across the seven analyzed nights. With 38 detected flight calls, September 6th had the most Ovenbird detections in a single night while September 14th had the fewest with only five. August 31st, September 1st, September 9th, September 23rd, and September 24th had numbers of detected flight calls which ranged from nine to 27. The peaks in detected relative flight call frequency varied with September 23rd having its peak in the 2nd hourly bin, September 9th in the 3rd, September 6th in the 4th, and September 24th in the 6th. August 31st had bimodal peaks in the 4th and 10th hourly bins and both September 1st and September 14th had bimodal peaks in the 4th and the 5th. Figure 22 shows the relative frequency of detected Ovenbird flight calls across all seven nights in together and Figure 23 displays the relative frequency of all detected Ovenbird flight calls throughout the seven nights combined. There was a total of 150 detected Ovenbird flight calls between the seven nights and the peak in detected calls when combined was in the 4th hourly bin with another noticeable peak in the 3rd (Figure 23). The combined distribution as well as the nights of September 6th, September 9th, September 23rd, and September 24th all had statistically significant temporal distributions of detected Ovenbird flight calls indicating a non-uniform distribution of calls across the hourly bins each night.

Table 4 shows the number of detected flight calls that occurred within a five second window of each Ovenbird flight call which ranges from a low of one call out of 5 total calls (20%) occurring during the night of September 14th and a high of 21 out of 27 total calls (78%) which was observed on September 23rd. An overall total of 82 out of

150 (55%) total detected Ovenbird flight calls contained another flight within their five second window and a R^2 value of 0.91 was produced when a simple linear regression was made plotting the number of detected calls within a call window against the number of detected calls throughout the night (Figure 24a). The nights of September 1st, September 14th, and September 24th contained zero incidences of conspecific calls occurring within an Ovenbird call window and August 31st and September 23rd both had the highest percentage of conspecific calls with 69% of their identified calls being identified as Ovenbirds. Out of the 108 total calls identified within an Ovenbird call window only 36 (33% of the total identified calls) were conspecific and a R^2 value of 0.37 was produced when the number of identified conspecific calls was plotted against the total number of identified calls within an Ovenbird call window as a linear regression.

The species compositions of the identified flight calls in the Ovenbird call window throughout the analyzed nights are shown in Figure 25. The night of September 23rd contained the most flight calls and species diversity within the Ovenbird call windows for a night with 33 identified calls made up of 11 species and three species complexes. August 31st had 13 identified calls comprised of four species, September 1st had four identified calls made up by one species and one species complex, September 6th with 24 calls from seven species and two species complexes, September 9th with 19 calls from four species, September 14th with only one identified Bay-breasted Warbler (*S. castanea*), and September 24th with 16 identified calls from four species and one species complex. Figure 26 shows the species composition of all the identified flight calls in the Ovenbird call window from all seven nights combined. A total of 108 calls were identified within individual Ovenbird call windows and were composed of 16 different species or species complexes. Ovenbirds were the most frequently identified species with 33% of the calls detected belonging to them. Myrtle Warblers were next with 13% followed by Common Yellowthroats with 12% while American Redstarts and the "Zeep" complex had 9% of the total identified calls each. The other 11 species or species complexes made up 5% or less of the total species composition and a checklist of all the species detected in Ovenbird call windows and a list of species that make up the "Zeep" complex can be found in Table 6.

Black-and-white Warbler:

Figure 27 shows the relative frequency of detected Black-and-white Warbler flight calls across the seven analyzed nights. The night of September 6th had the highest number of detections with 34 flight calls while September 14th had the lowest number of flight calls with only six detections. August 31st, September 1st, September 9th, September 23rd, and September 24th had between seven and 19 detected Black-and-white Warbler flight calls throughout their nights. Peaks of the relative detected flight call frequencies varied amongst the nights with September 1st and September 23rd having their peaks in the 1st hourly bin, September 9th in the 3rd hourly bin, and September 6th and September 14th with theirs in the 8th. September 24th had a bimodal distribution with peaks in the 4th and 7th hourly bins and August 31st had a trimodal distribution with peaks in the 3rd, 4th, and 5th hourly bins. Figure 28 shows the relative frequency distribution of detected Black-and-white Warbler flight calls across all seven nights and Figure 29 displays the relative frequency distribution of all detected Black-and-white Warbler flight calls throughout the seven nights combined. There was a total of 96 detected Black-and-white Warbler flight calls between the seven analyzed nights with peaks occurring in the 3rd, 4th, and 8th hourly bins (Figure 29). The combined distribution across the nights as well as the nights of September 6th, September 9th, September 14th, and September 23rd all had statistically significant temporal distributions of flight calls when compared to the null indicating a non-uniform pattern of flight calls across the hourly bins.

Table 5 shows the number of detected flight calls that occurred within a five second window of each Black-and-white Warbler flight call which ranged from 24 calls out of 34 total calls (71%) which occurred during the night of September 6th to one out of seven total calls (14%) observed on September 9th. An overall total of 52 out of 96 (54%) detected Black-and-white Warbler flight calls contained another call within their call window and a R^2 value of 0.99 was produced when a simple linear regression was made plotting the number of detected calls within a call window against the total number of detected calls throughout the night (Figure 30a). Only the nights of September 1st and September 6th contained conspecific calls in the Black-and-white Warbler call windows and only 10 (22% of total identified species with call windows) of the 46 total detected calls were conspecific. When the number of conspecific calls were plotted against the total number of calls detected within Black-and-white Warbler call windows a R^2 value of 0.76 was produced (Figure 30b).

The species compositions of identified flight calls within the five second call window of Black-and-white Warblers across the analyzed nights are shown in Figure 31. The night of September 6th contained the most flight calls identified within the Black-and-white Warbler call window as well as the largest number of species with 23 identified flight calls from seven species and one species complex. August 31st and September 1st both had three identified calls from two species and one species complex.

September 9th and September 14th both had only 1 identified flight call which belonged to an Ovenbird and an American Redstart respectively. September 23rd contained eight identified calls from four species and one species complex while September 24th contained 10 identified flight calls from four species and one species complex. Figure 32 shows the species composition of all the detected calls in the Black-and-white Warbler call window from all seven nights. There were a total of 46 identified flight calls within the Black-and-white Warbler call window made up of 11 different species or species complexes. Black-and-white Warblers made up the majority of with 22% of total calls with the “Zeep” complex next with 20% followed with Northern Parulas, Pine Warblers, Common Yellowthroats each with 11%. Ovenbirds consisted of 9% of the identified calls, the “Vermivora” complex with 6%, and the other four species or species complexes made up 5% or less of the total species composition and a checklist of all the species detected in Black-and-white Warbler call windows and a list of species that make up the “Zeep” and “Vermivora” complexes can be found in Table 6.

DISCUSSION

With a total of 424 detected flight calls, the Common Yellowthroat was the most commonly identified of the five analyzed species during the seven selected nights in Hampden, Maine during the 2011 fall migration season. More than doubling the numbers of detected Myrtle Warblers (184 total calls), Ovenbirds (150 total calls), and Black-and-white Warblers (96 total calls) and having a considerable amount higher than detected American Redstarts (233 total calls). However, by using acoustical surveying only birds calling within the microphone's detection range can be picked up and realistically there would be more birds flying over the site than just the ones that called that did not get detected. To the investigators' knowledge there is no data regarding how frequently individuals of specific species make flight calls during nocturnal migration which makes the use of detected flight calls to estimate total number of birds flying over a given site impossible at this time. Hüppop and Hilgerloh (2012) concluded that flight call frequency increased during conditions of high collision risk which could even further complicate using detected flight calls as an estimate of total birds flying overhead.

The temporal distribution of each of the five selected warbler species were shown to not be evenly distributed when all the detected calls across the nights were combined into one frequency distribution. Although none of the species had statistically significant d distributions that were statistically significant for each of the seven analyzed nights, the nights that did not qualify for significance for each of the other species could be attributed to low numbers of detected birds. Given that most passerines are initiating their nightly flights one hour after sunset and the overall trend observed here is that the peak in flight call frequency for all five species occurs in the 3rd, 4th, and 5th hourly bins indicates that most of the detected birds flying over Hampden are not departing from the area or intending on stopping but are in fact just passing through. Knowing that nocturnal passerine migrants usually depart one hour after sunset these data could also indicate that Hampden is not an important stopover location for most of these detected migrant warblers as they are already at least a couple hours into their nightly flight before they reach the site. However, with the occurrences in these data of birds being detected in all the hourly bins past sunset, especially hourly bins near the beginning and ends of the night, also shows that there are most likely birds departing from the Hampden area as well as stopping for the day that utilize the area.

With roughly 50% of the detected calls of the analyzed warblers containing an incidence of another flight call in their five second windows these data show that at least ~50% of the analyzed species show evidence of flying in aggregations or flocks together during the analyzed nights in Hampden. The linear regressions for each species demonstrated a very high correlation between the total numbers of birds detected and the number of incidences of potential aggregations of individuals (as determined by the presence of a flight call within an individual's call window) with the Ovenbird having the lowest with a R^2 value of 0.91 and the Black-and-white Warbler with the highest of 0.99. However, these patterns could also occur if birds aloft are randomly distributed as well. If these data showed that the majority of the calls being detected as evidence of aggregations of individuals were conspecific then probable causes would be instances individuals calling multiple times as well as conspecific flocking. Although one of the assumptions of the study was that each call represents one bird, it is unrealistic to state that this is the case for every situation. However, most of the identified calls detected within the call windows of the analyzed species (i.e. showing evidence of flying in flocks) were of different species.

The Common Yellowthroat had the highest percentage of conspecific calling in their five second call windows with only 38% of all the flight calls identified as being conspecific. The American Redstart was a close second with 36% of their identified calls being conspecific while the Ovenbird, Black-and-white Warbler, and Myrtle Warbler only had 33%, 22%, and 14% of their identified calls being conspecific respectively. The correlation between the number of conspecific calls and the number of identified calls also varied greatly with American Redstarts and Common Yellowthroats having good correlations with R^2 values of 0.94 and 0.93 while the other three species did not have as much of a correlation with Black-and-white Warblers having a R^2 of 0.76, Myrtle Warblers with 0.63, and Ovenbirds with a low of 0.37. It is interesting to note that Ovenbirds had the second highest number of detected calls within their call windows with 108 birds identified but also had the lowest incidences of conspecific calling. This could indicate that even though 55% of the detected Ovenbird flight calls showed evidence of flocking, Ovenbirds themselves are less likely to be communicating with each other or even flying together. The high percentage comprised of different species identified could indicate that if there are indeed flocks of warblers flying together at night that other species of warblers make up a great portion of these heterospecific flocks. This could mean that there must be some benefit gained from both conspecific and heterospecfic flocking during nocturnal flights or else these species would most likely not participate in them. The species diversity roughly followed the same trend as the number of identified calls did with Common Yellowthroat and Ovenbirds both having 14 individual species identified in their call windows along with having 282 and 108 identified calls respectively. The American Redstart had a total of 104 identified calls and 10 identified species, and the Myrtle Warbler and Black-and-white Warbler both had nine identified species with 86 and 46 identified calls each. These data could indicate that aggregations of birds aloft at night benefit more from increased numbers of individuals present as opposed to flying with specific species. Although the benefits of diurnal flocking as outlined in Sridhar *et al.* (2009) and Sridhar and Shanker (2014) cannot obviously be obtained during nocturnal migration. However, it could be possible that the flocking associations made during the night are carried into the morning where the species participating can benefit from such interactions. If that is the case, then the flight calls should be serving as a mean of flock recruitment, communication, or a combination of both as suggested by Hamilton (1962). Hüppop and Hilgerloh's (2012) findings that flight call frequency increases in conditions of poor visibility and collison risk supports this idea that flight calls have a social context and serve as communicaiton within participating members within a flock.

As mentioned earlier, there is a caveat to consider when using passive acoustic monitoring. Not all species (e.g. the Red-eyed Vireo (*Vireo olivaceus*)) can be monitored by detection of flight calls and the technology is limited by the ability to not only detect flight calls but to be able to identify them to species as well. Strong wind and loud background noises can make identification of flight calls to species and even detection of them very difficult. Constant background noise from crickets and frogs has made detection of species that make low frequency flight calls (e.g. thrushes and orioles) a time consuming and challenging process. Even in the most perfect conditions there are numerous species, such as the members of the "Zeep" complex, that have flight calls similar enough that they cannot be reliably differentiated from each other. However, there are just as many species that can be easily identified. Plenty of useful data can be obtained on species of conservation concern, although not of focus in this study, such as the Canada Warbler (*Cardenella canadensis*) and the Bicknell's Thrush (*C. bicknelli*) which could prove to be necessary to set up efficient conservation programs. Data revealing how migrant songbirds are using the Gulf of Maine for stopover habitat, flocking behavior, and where these species are flying will also be critical to making effective management plans that benefit turbine development as well as protecting areas necessary for successful songbird migration.

Wildlife acoustics has great potential in the fields on conservation biology and behavioral ecology but the lack of a common standardized system across research groups has slowed progress in the field (Blumstein *et al.,* 2011). Communication between groups conducting bioacoustical research will be key in developing standard methods to effectively use acoustical data to its fullest extent, and priority should be placed on collecting species specific data to get a more complete understanding of nocturnal migration.

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FIGURES AND TABLES

Figure 1a:

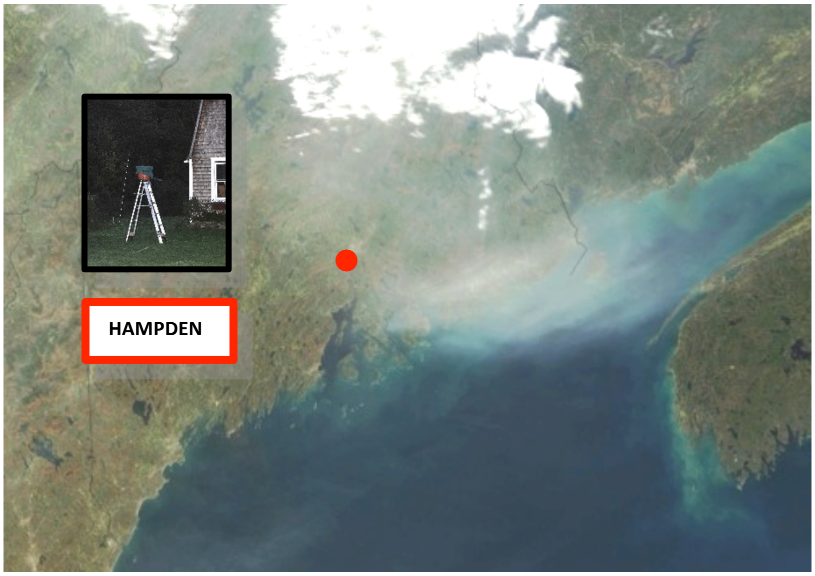


Figure 1a. The Hampden site shown in respect to the Gulf of Maine. Photos by R. Holberton.

Figure 1b:

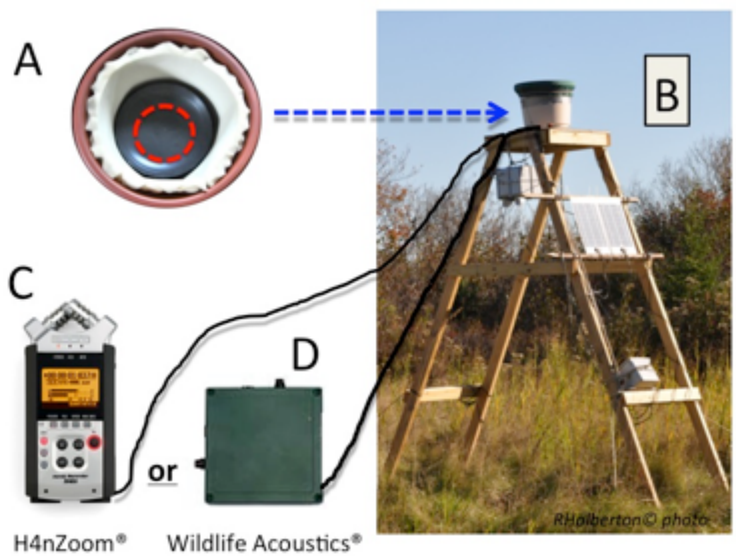


Figure 1b. The "flowerpot" microphone setup (A) was anchored to a raised platform (B). A H4n Zoom® (C) or a Song Meter SM2 (D) recorded was attached and powered by either 120 AC or a 12 V battery charged by a solar panel. Photos by R. Holberton.

Figure 2a:

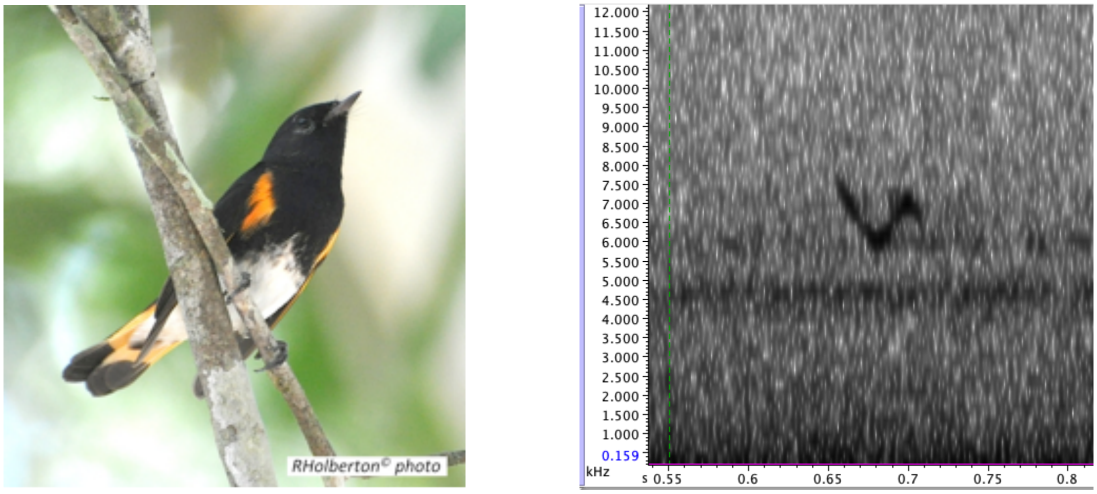


Figure 2a. The American Redstart and its corresponding flight call recorded at Hampden, Maine during the night of September 6th, 2012. (Photo courtesy of R. Holberton)

Figure 2b:

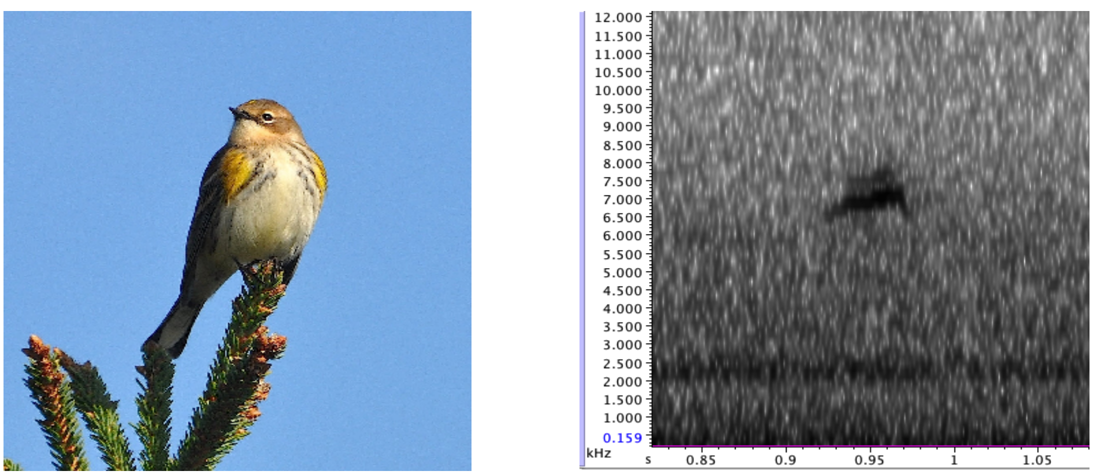


Figure 2b. The Myrtle Warbler and its corresponding flight call recorded at Hampden, Maine during the night of September, 9th. 2012. (Photo courtesy of R. Holberton)

Figure 2c:

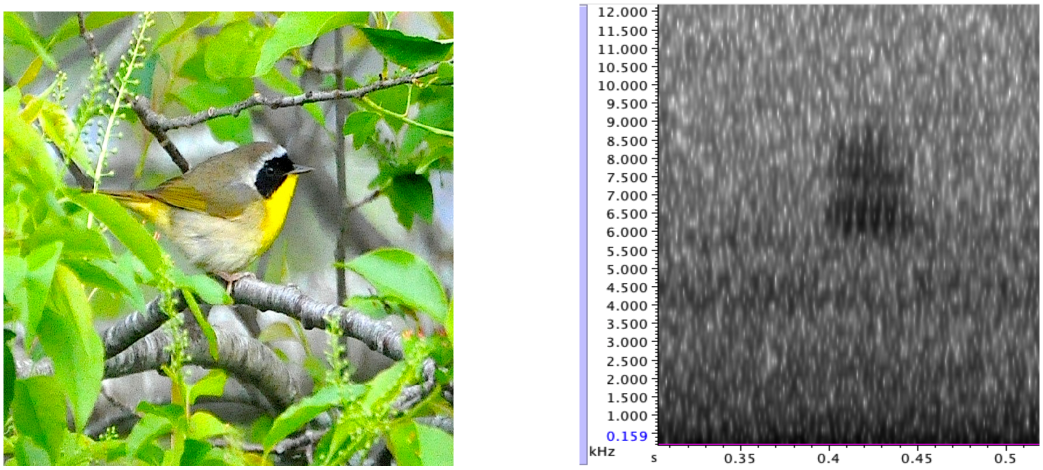


Figure 2c. The Common Yellowthroat and its corresponding flight call recorded at Hampden, Maine during the night of September, 2nd. 2012. (Photo courtesy of R. Holberton)

Figure 2d:

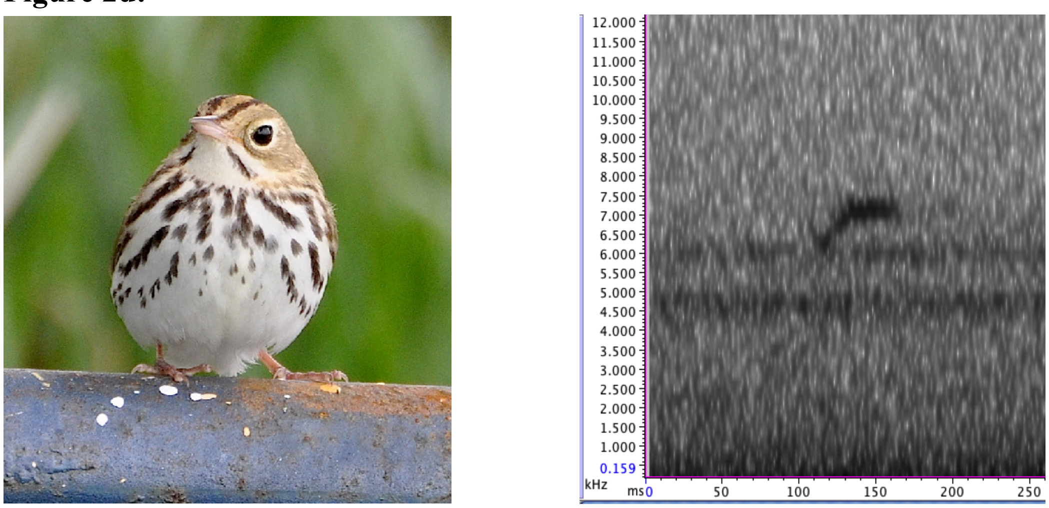


Figure 2d. The Ovenbird and its corresponding fight call recorded at Hampden, Maine during the night of September, 6th, 2012. (Photo courtesy of R. Holberton)

Figure 2e:

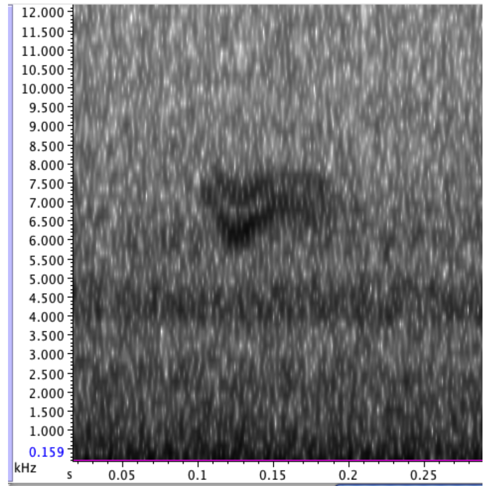


Figure 2e. The Black-and-white Warbler and its corresponding flight call recorded at Hampden, Maine during the night of September, 2nd, 2012. (Photo courtesy of R. Holberton)

Figure 3: The relative frequency of detected American Redstart flight calls throughout the analyzed nights.

$\alpha = 0.05$, df = 10, CV = 18.307

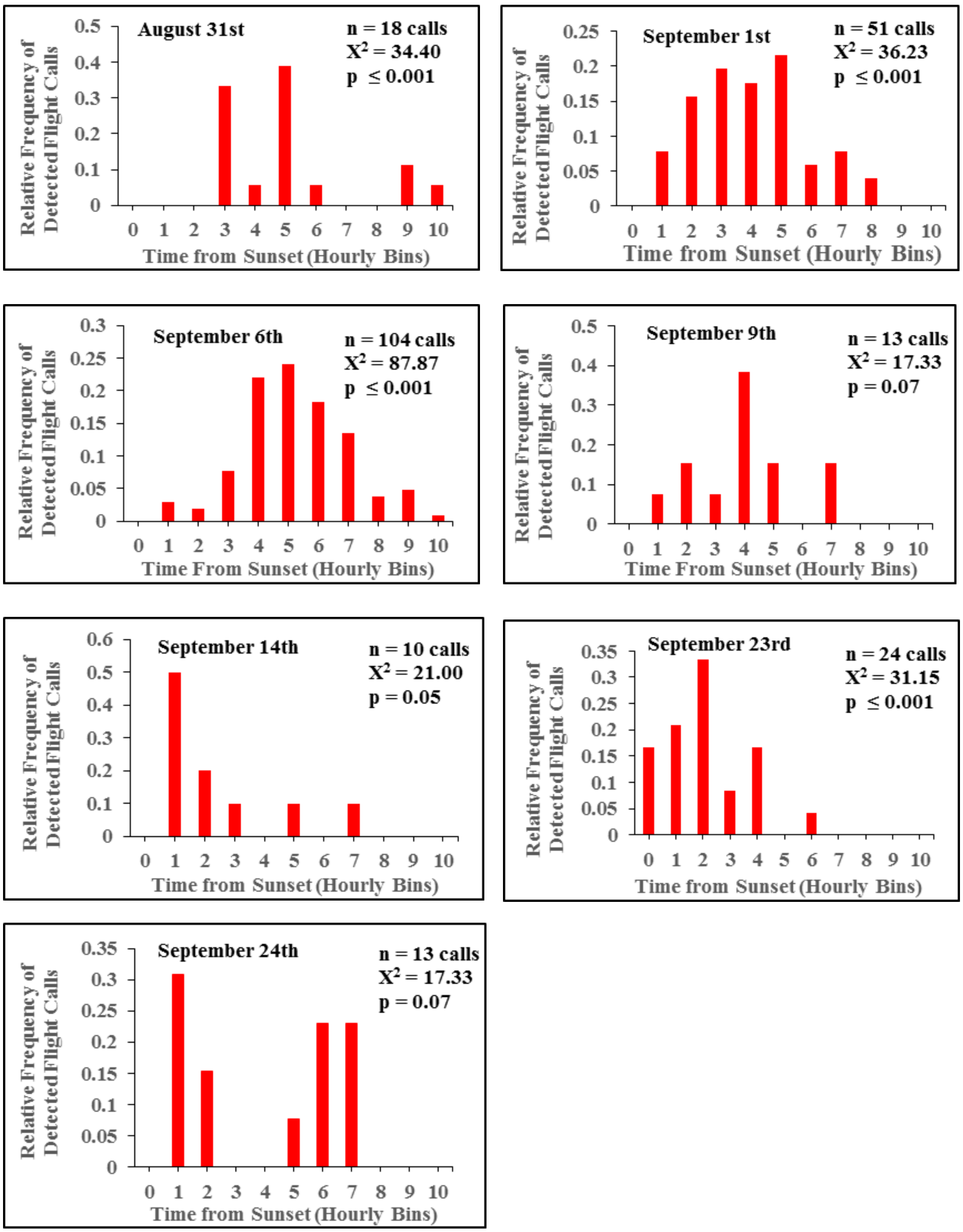


Figure 4: The relative frequency of detected American Redstart flight calls throughout all the analyzed nights together.

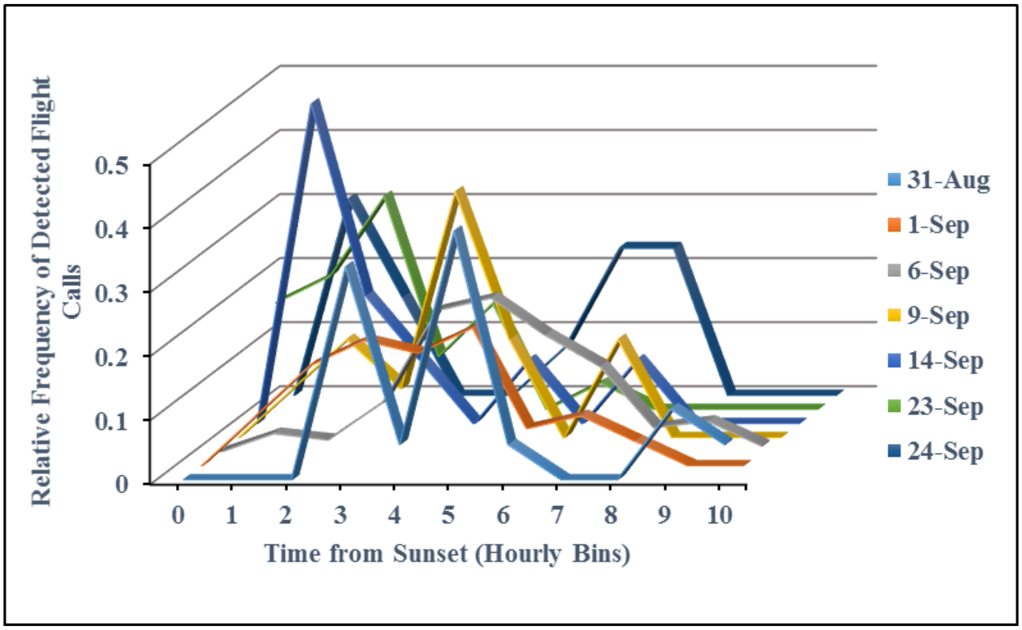


Figure 5: The relative frequency of detected American Redstart flight calls throughout all the analyzed nights combined.

$\alpha = 0.05$, df = 10, CV = 18.307

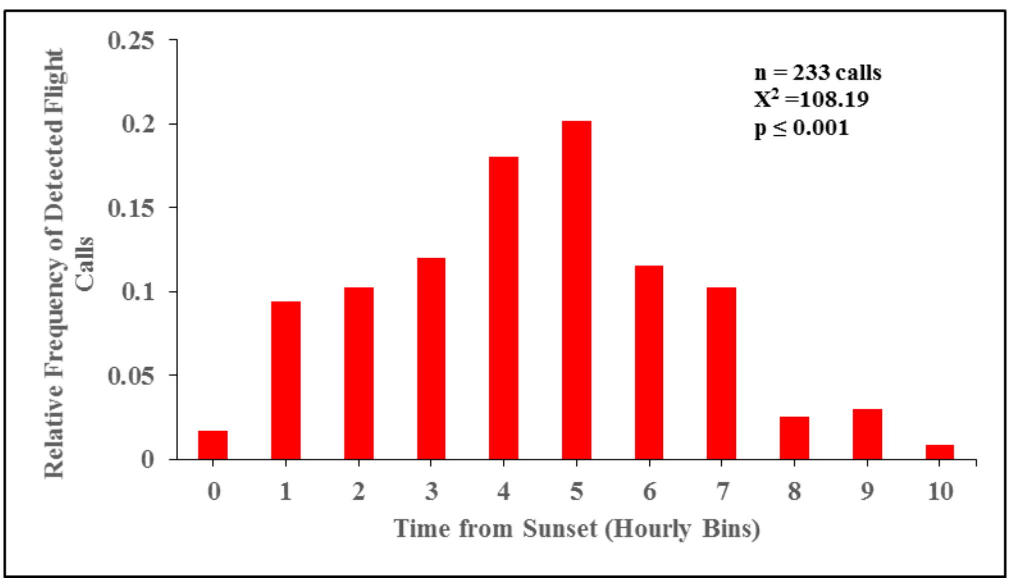


Table 1: The number of American Redstart flight calls detected each night and the number of detected flight calls that had another call detected within a five second window.

Date	Total number of detected flight calls	Number of detected flight calls containing another flight call within a five second window (% of total calls)	Number of American Redstart calls detected within an American Redstart five second window (% of identified calls)
August 31	18	5 (28%)	0 (0%)
September 1	51	20 (39%)	4 (40%)
September 6	104	60 (58%)	21 (41%)
September 9	13	4 (31%)	2 (50%)
September 14	10	5 (50%)	4 (80%)
September 23	24	16 (67%)	6 (26%)
September 24	13	5 (38%)	0 (0%)
Total	233	115 (49%)	37 (36%)

Figure 6a: The correlation between the total number of American Redstart flight calls detected and the number of American Redstart flight calls containing another flight call within a five second window per night.

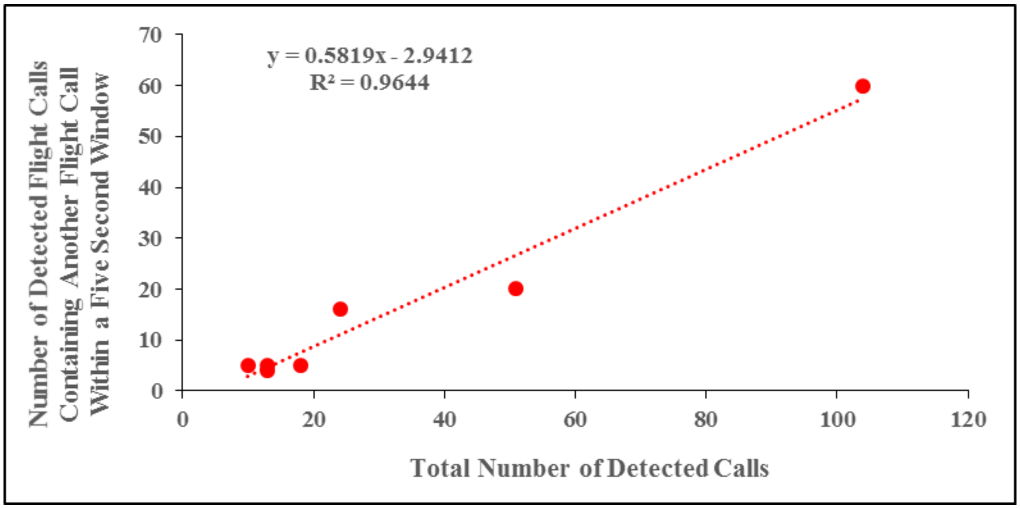


Figure 6b: The correlation between the total numbers of identified calls detected in the five second window of American Redstart flight calls and the number of conspecific American Redstart flight calls over each night.

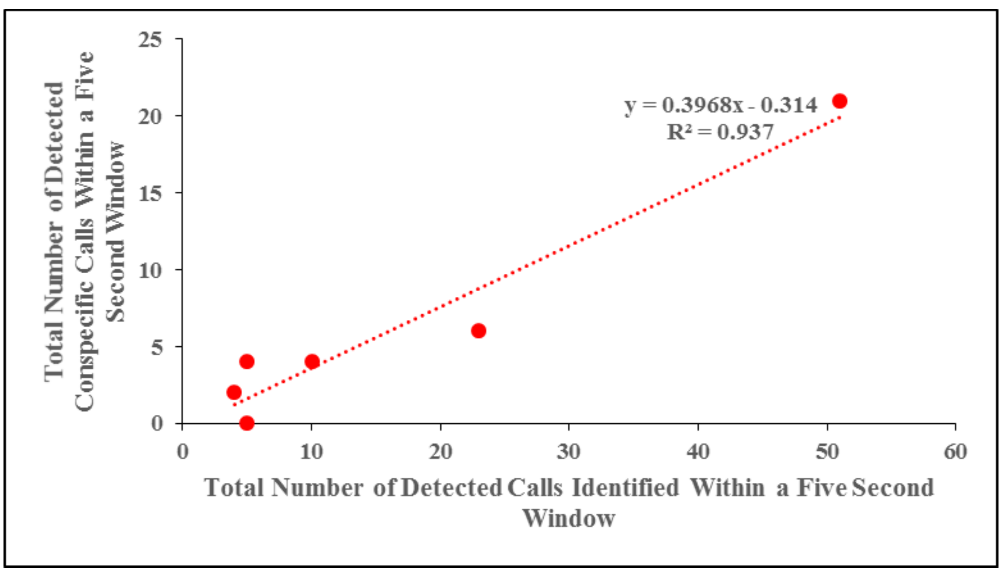
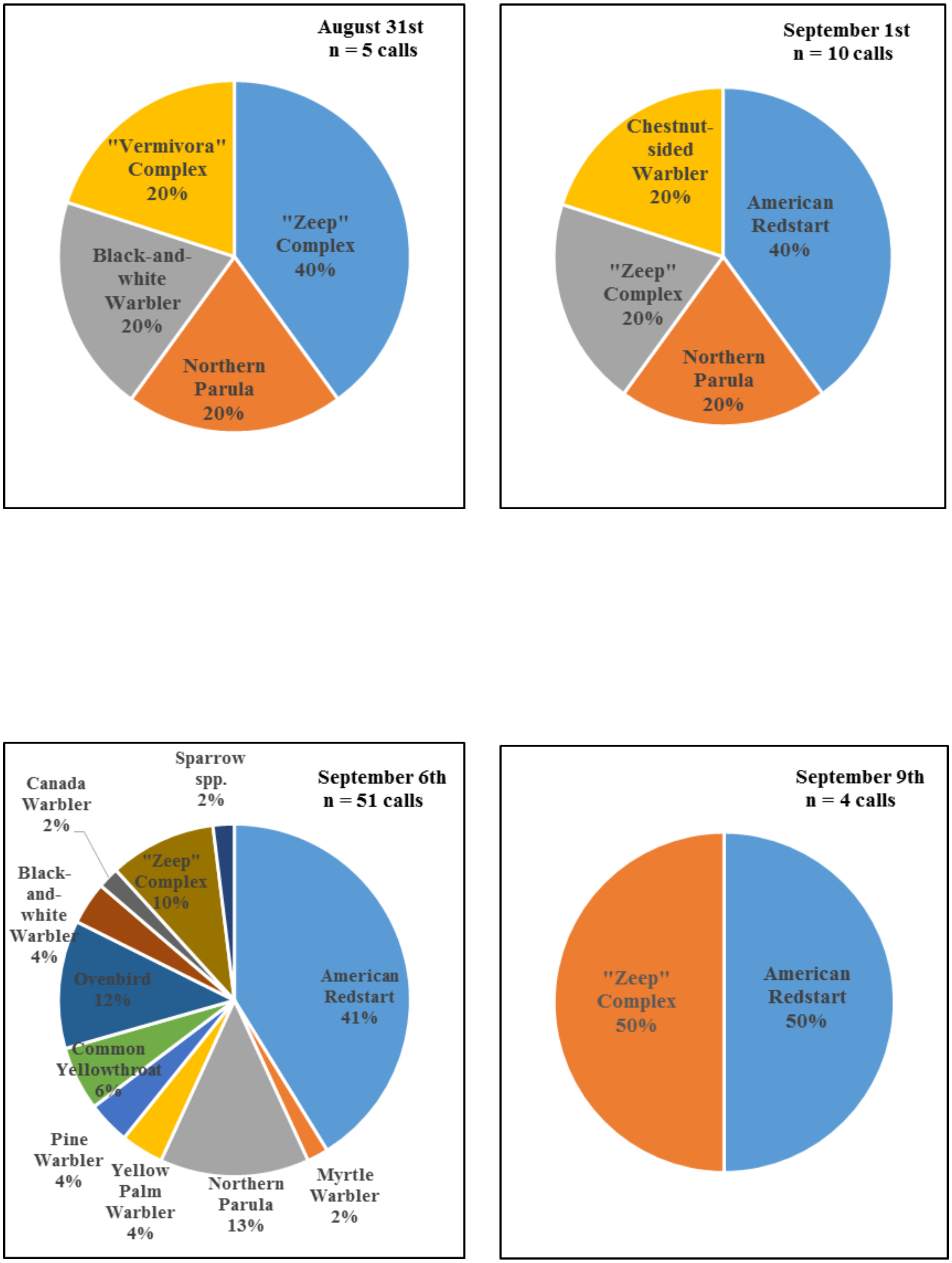
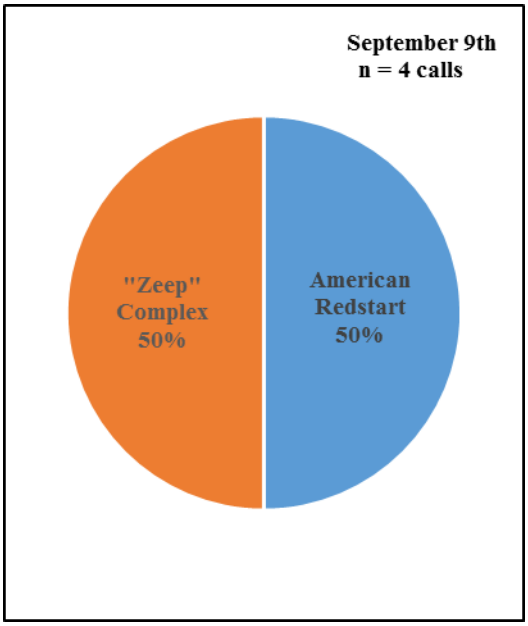
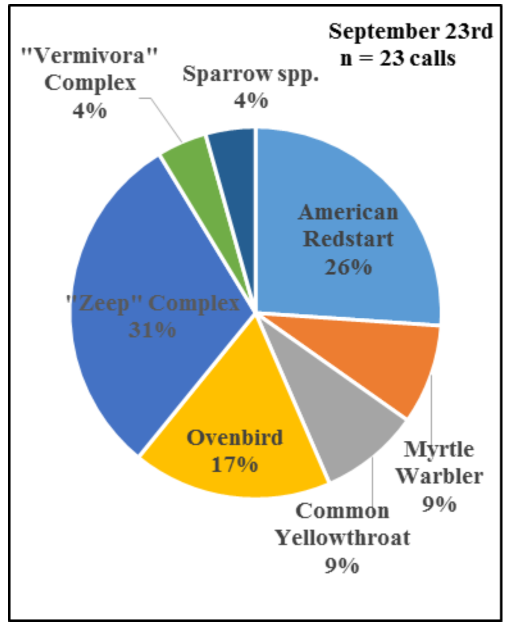


Figure 7: The composition of the detected species in the five second window of American Redstart flight calls detected throughout the analyzed nights.




September 9th
n = 4 calls
"Zeep" Complex 50%
American Redstart 50%


September 23rd
n = 23 calls
"Vermivora" Complex 4%
Sparrow spp. 4%
American Redstart 26%
"Zeep" Complex 31%
Ovenbird 17%
Myrtle Warbler 9%
Common Yellowthroat 9%

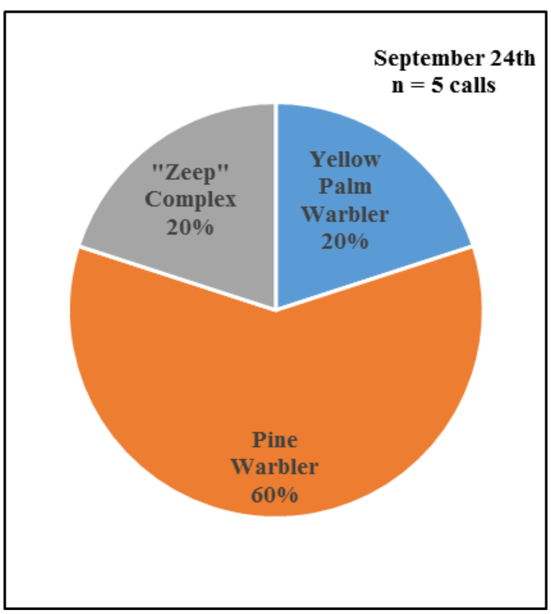

September 24th
n = 5 calls
"Zeep" Complex 20%
Yellow Palm Warbler 20%
Pine Warbler 60%

Figure 8: The composition of the detected species in the five second window of American Redstart flight calls detected throughout the analyzed nights combined.

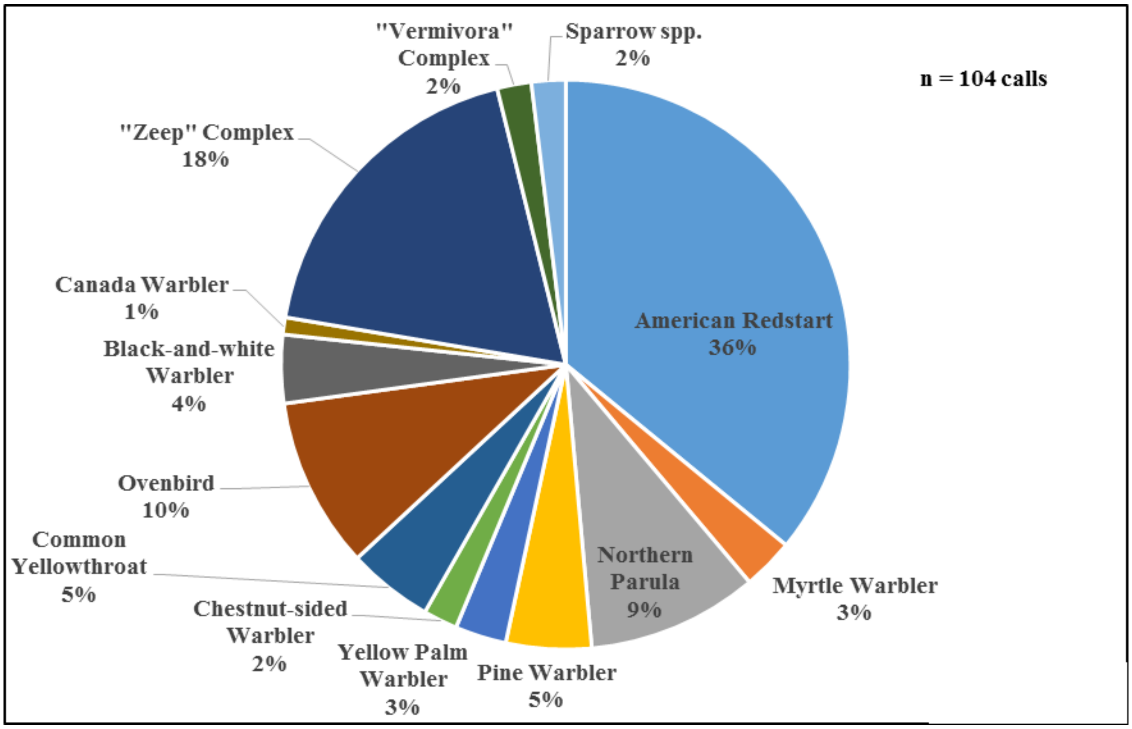


Figure 9: The relative frequency of detected Myrtle Warbler flight calls throughout all the analyzed nights.

$\alpha = 0.05$, df = 10, CV = 18.307

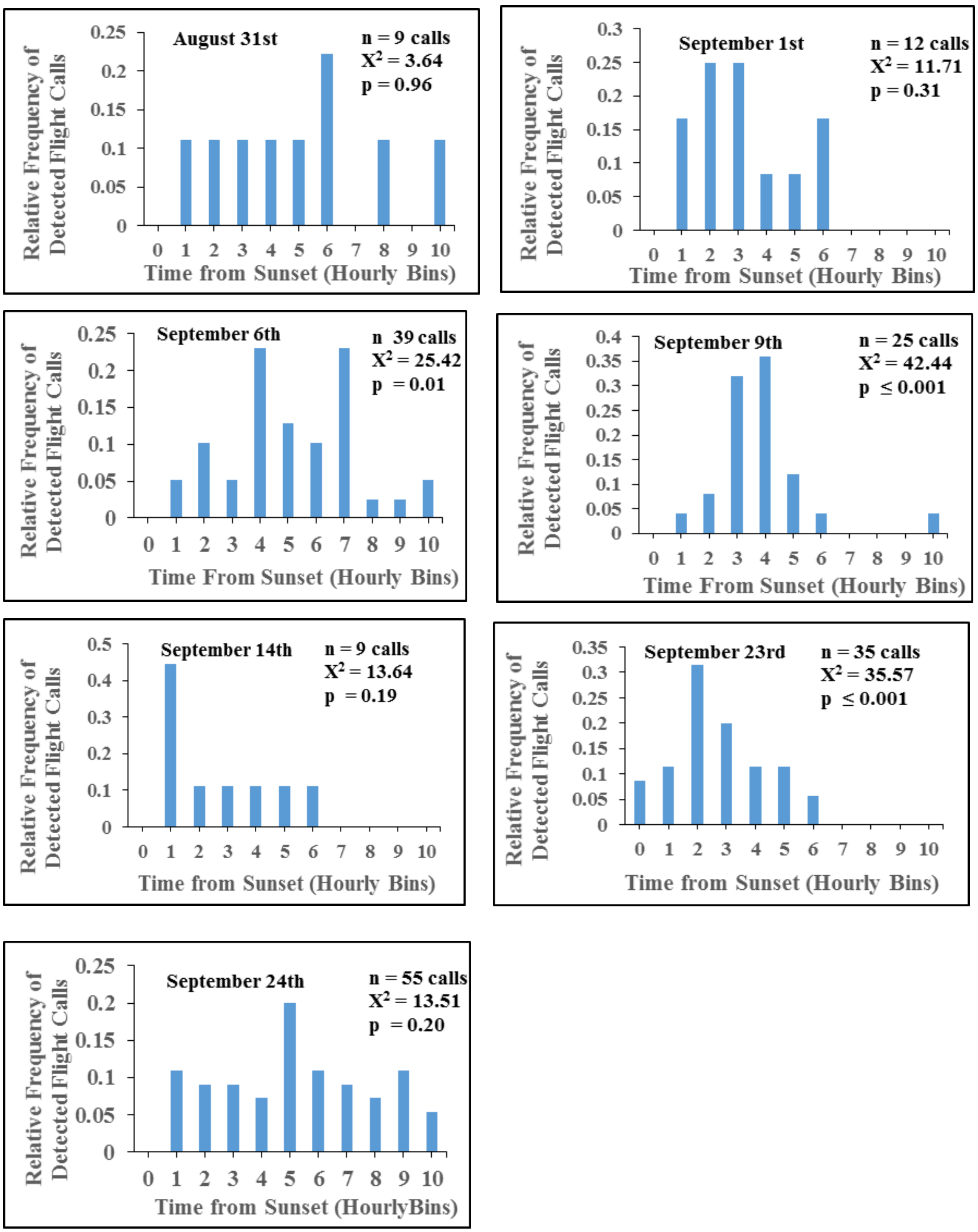


Figure 10 The relative frequency of detected Myrtle Warbler flight calls throughout all the analyzed nights together.

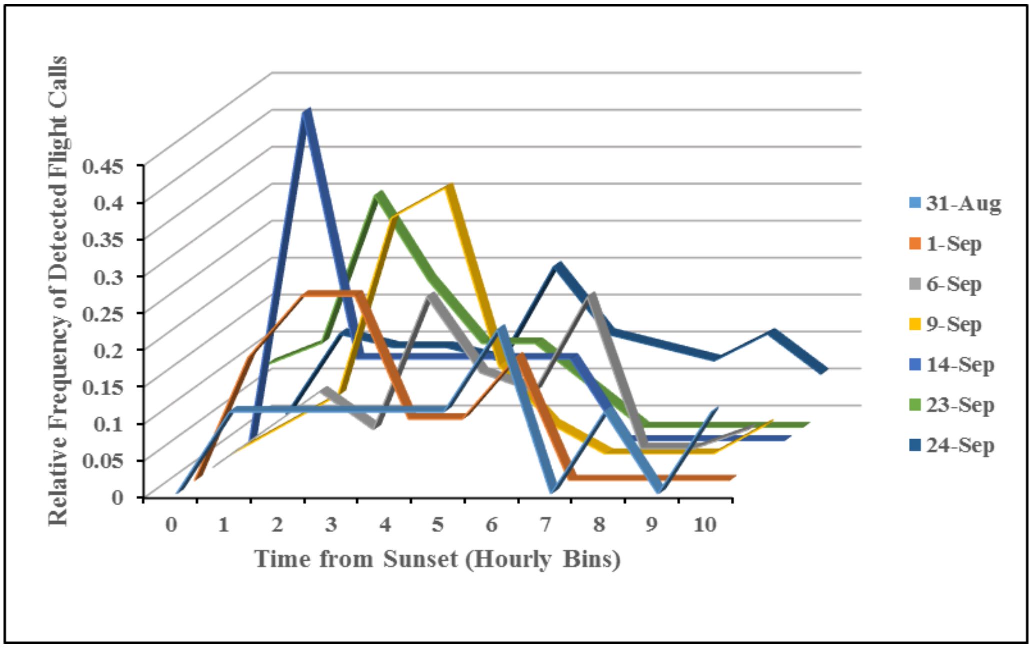


Figure 11: The relative frequency of detected Myrtle Warbler flight calls throughout all the analyzed nights combined.

$\alpha = 0.05$, df = 10, CV = 18.307

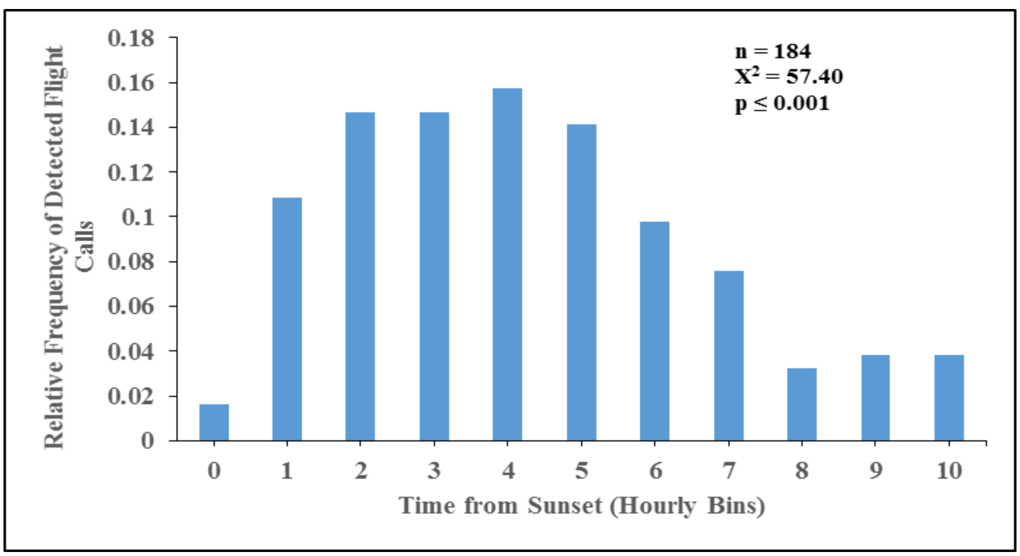


Table 2: The number of Myrtle Warbler flight calls detected each night and the number of detected flight calls that had another call detected within a five second window.

Date	Total number of detected flight calls	Number of detected flight calls containing another flight call within a five second window (% of total calls)	Number of Myrtle Warbler calls detected within a Myrtle Warbler five second window (% of identified calls)
August 31	9	3 (33%)	0 (0%)
September 1	12	6 (50%)	0 (0%)
September 6	39	24 (62%)	2 (11%)
September 9	25	11 (44%)	2 (20%)
September 14*	5	2 (40%)	N/A
September 23	35	18 (51%)	0 (0%)
September 24	55	37 (67%)	8 (14%)
Total	184	101 (55%)	12 (14%)

* No calls detected within a call window were of a good enough quality to be identified down to species

Figure 12a: The correlation between the total number of Myrtle Warbler flight calls detected and the number of Myrtle Warbler flight calls containing another flight call within a five second window per night.

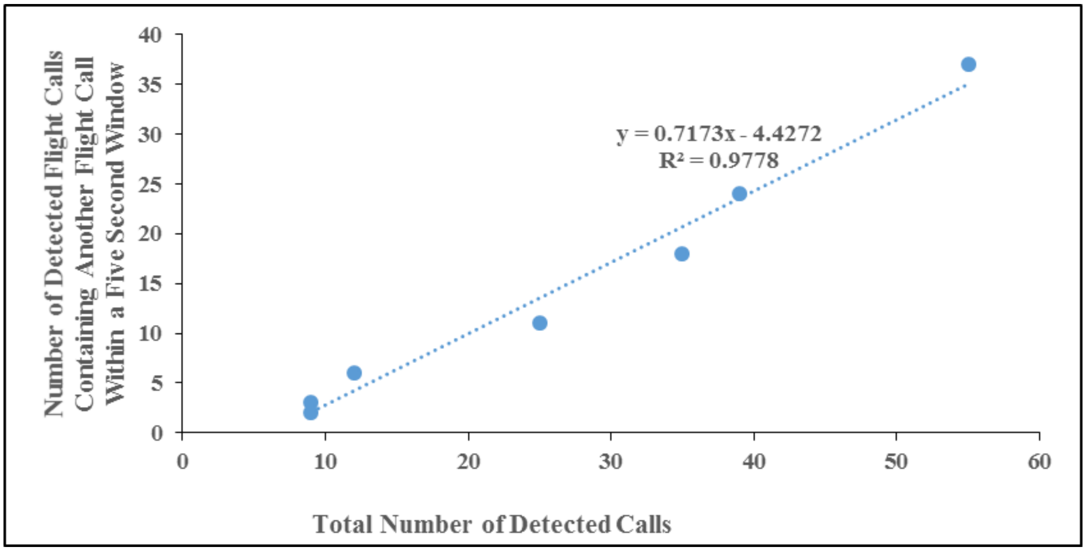


Figure 12b: The correlation between the total numbers of identified calls detected in the five second window of Myrtle Warbler flight calls and the number of conspecific Myrtle Warbler flight calls over each night.

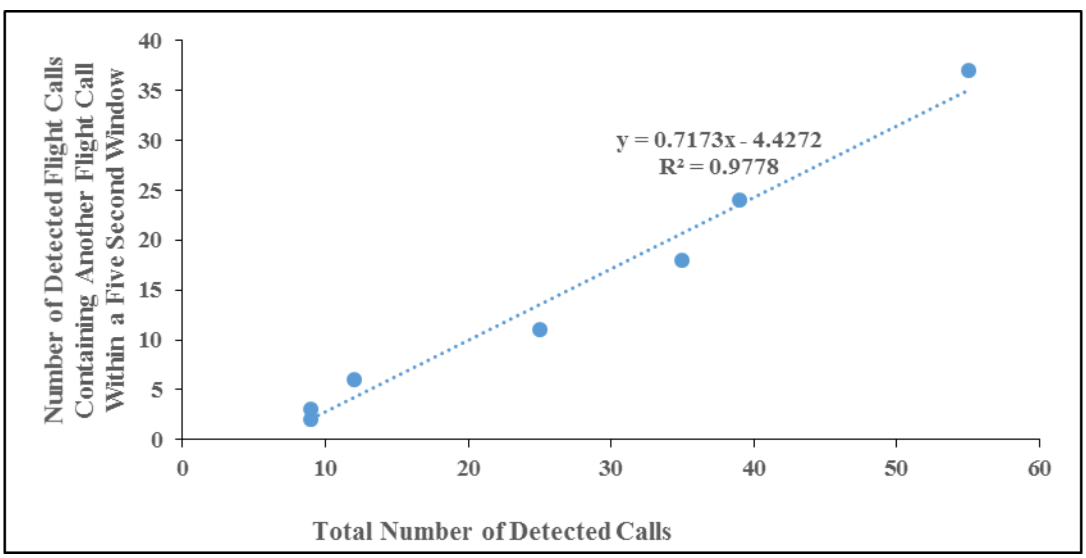
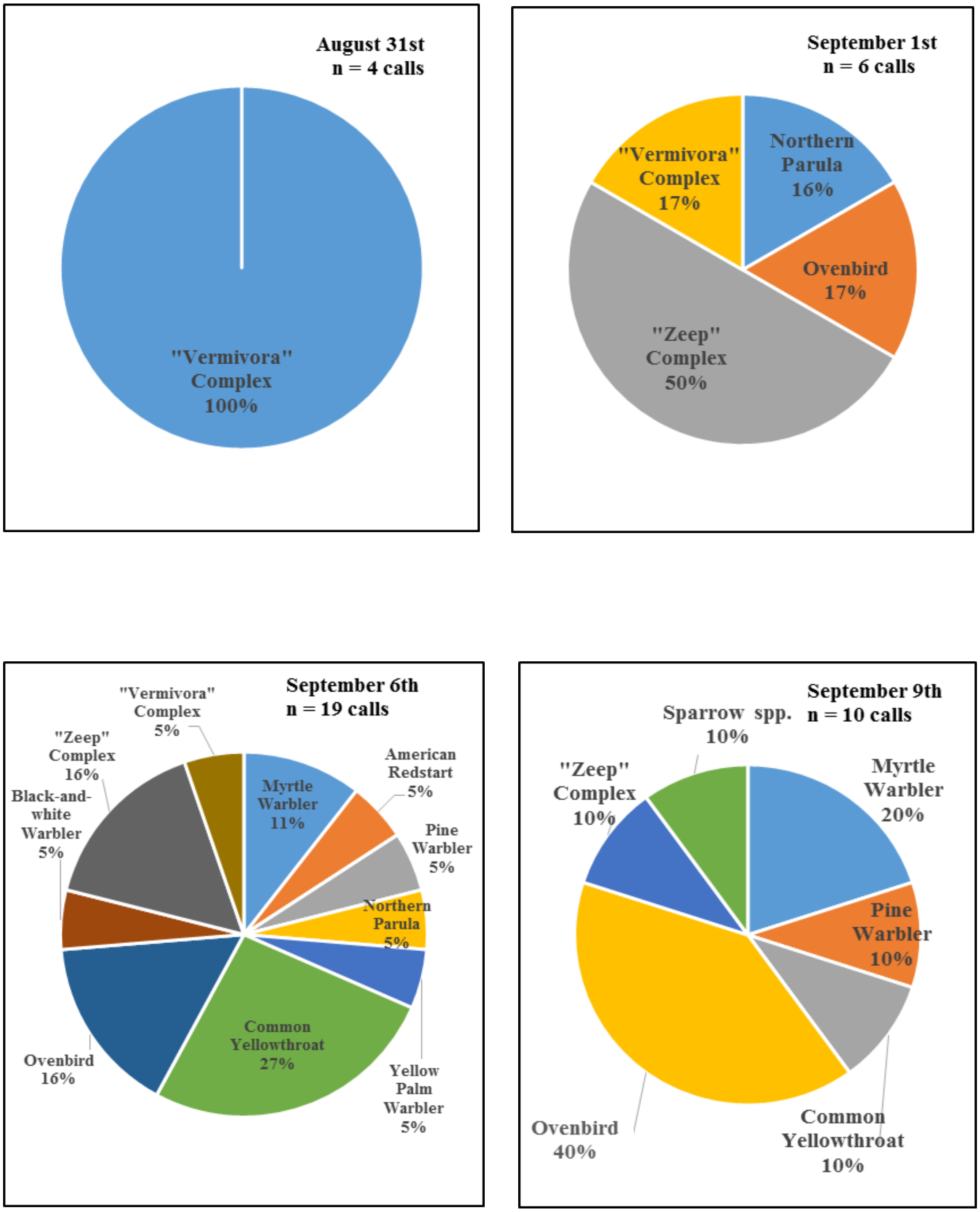


Figure 13: The composition of the detected species in the five second window of Myrtle Warbler flight calls detected throughout the analyzed nights.



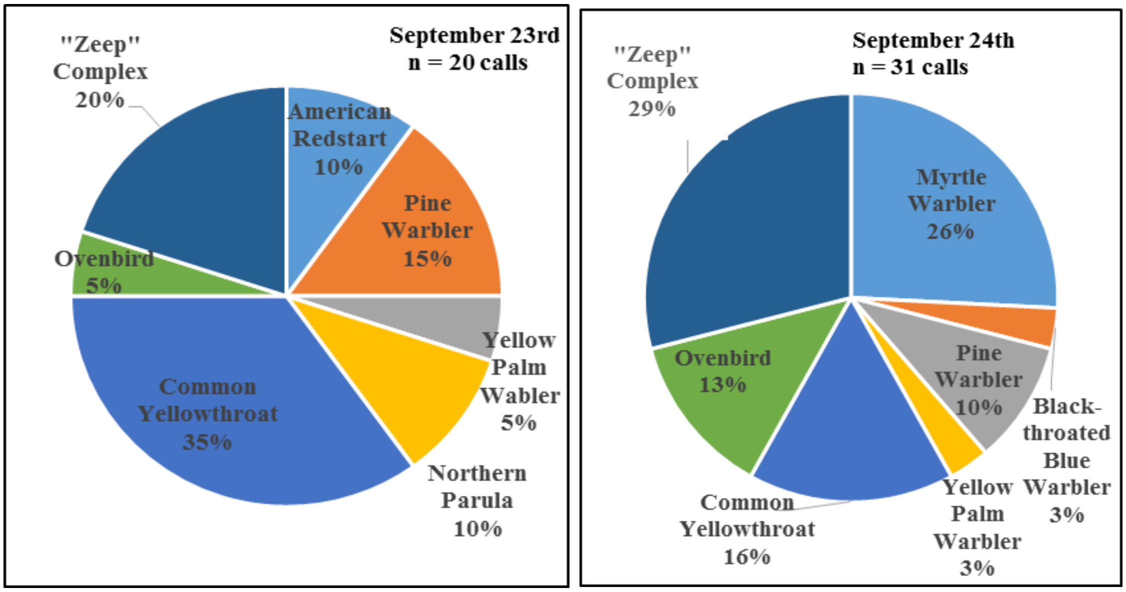


Figure 14: The composition of the detected species in the five second window of Myrtle Warbler flight calls detected throughout the analyzed nights combined.

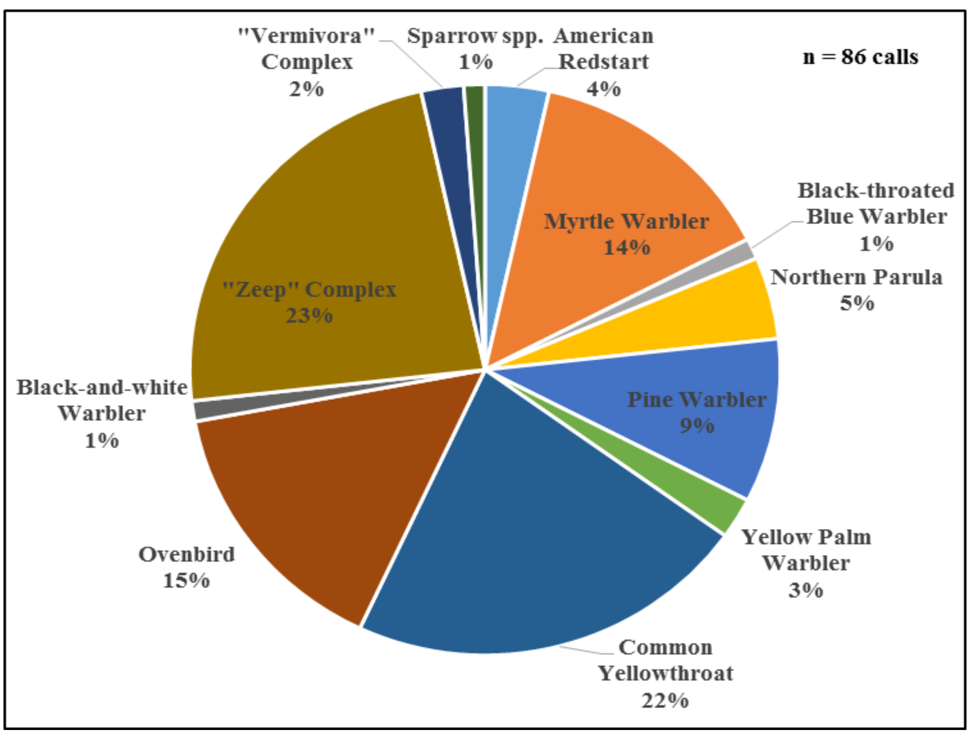


Figure 15: The relative frequency of detected Common Yellowthroat flight calls throughout all the analyzed nights.

$\alpha = 0.05$, df = 10, CV = 18.307

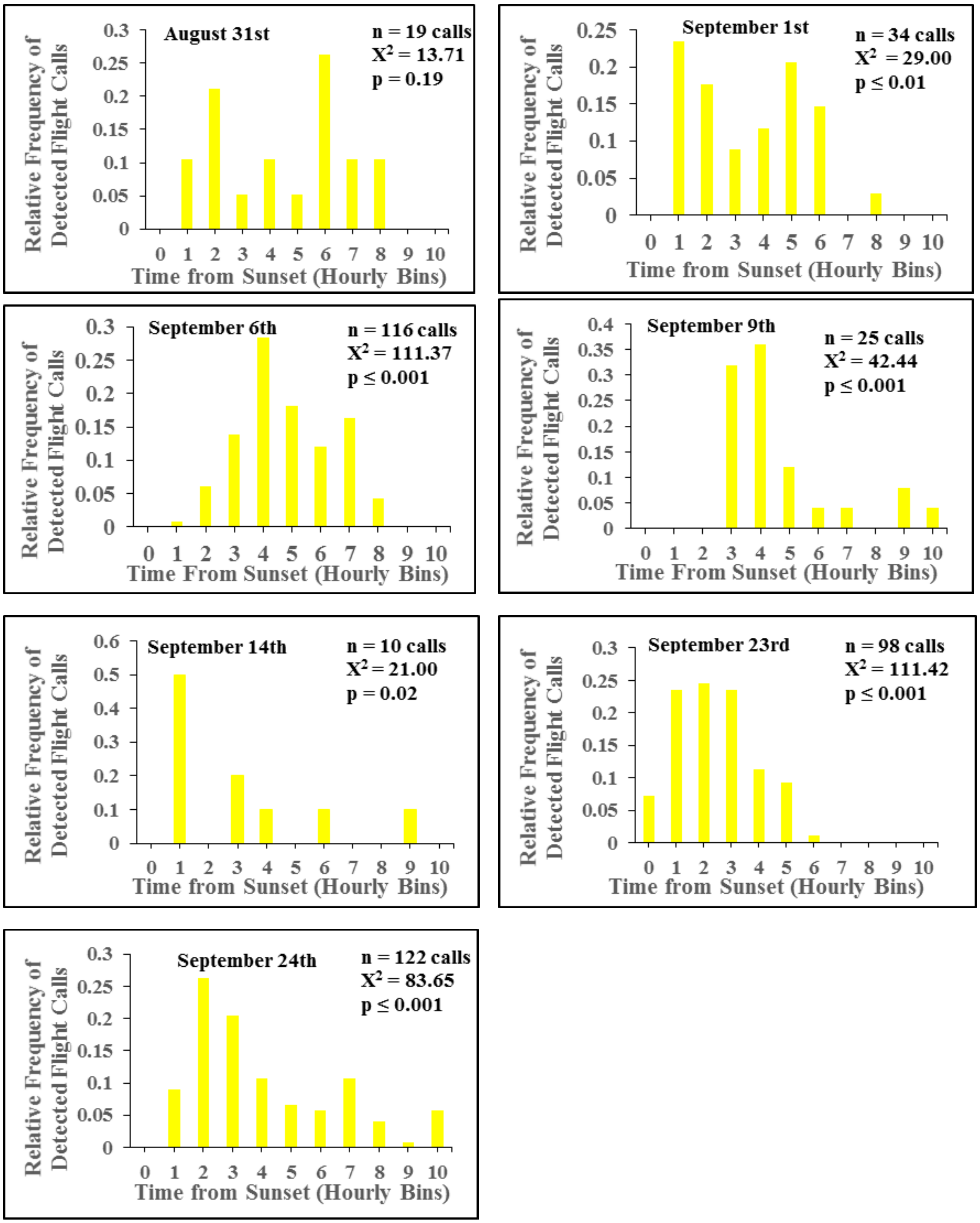


Figure 16: The relative frequency of detected Common Yellowthroat flight calls throughout all the analyzed nights together.

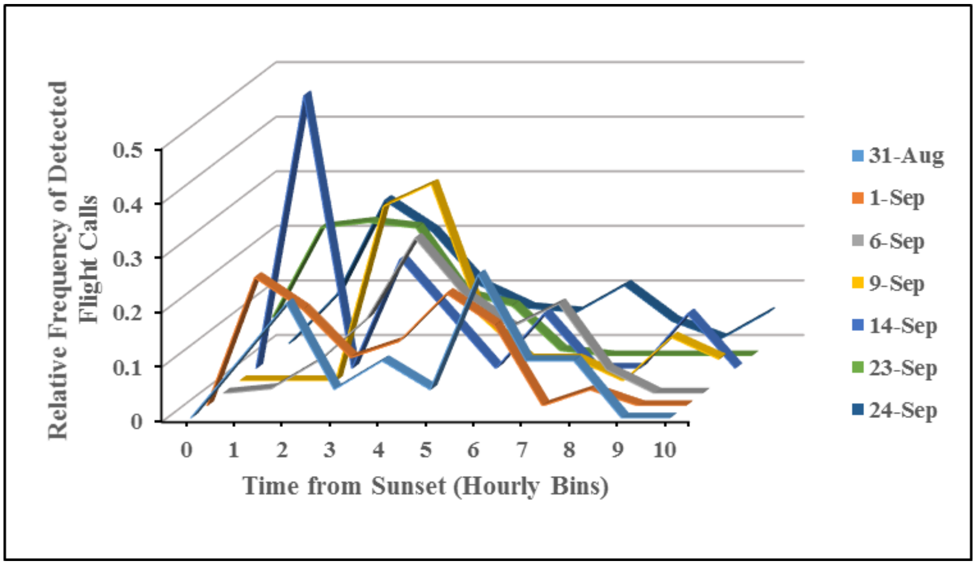


Figure 17: The relative frequency of detected Common Yellowthroat flight calls throughout all the analyzed nights combined.

α = 0.05, df = 10, CV = 18.307

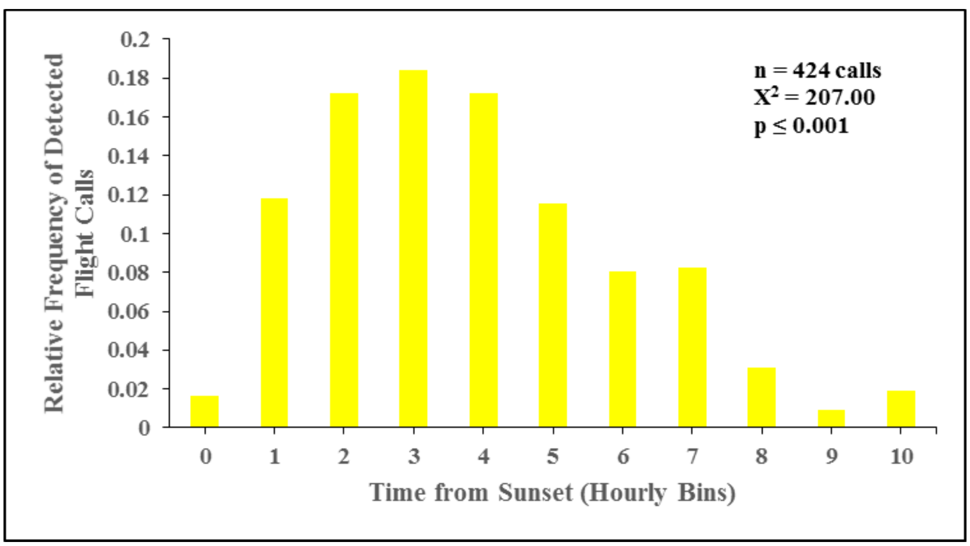


Table 3: The number of Common Yellowthroat flight calls detected each night and the number of detected flight calls that had another call detected within a five second window.

Date	Total number of detected flight calls	Number of detected flight calls containing another flight call within a five second window (% of total calls)	Number of Common Yellowthroat calls detected within a Common Yellowthroat five second window (% of identified calls)
August 31	19	9 (47%)	4 (45%)
September 1	34	10 (29%)	6 (55%)
September 6	116	70 (60%)	30 (42 %)
September 9	25	10 (40%)	4 (29%)
September 14	10	4 (40%)	2 (50%)
September 23	98	39 (40%)	18 (25%)
September 24	122	77 (63%)	44 (44%)
Total	424	219 (52%)	108 (38%)

Figure 18a: The correlation between the total number of Common Yellowthroat flight calls detected and the number of Common Yellowthroat flight calls containing another flight call within a five second window per night.

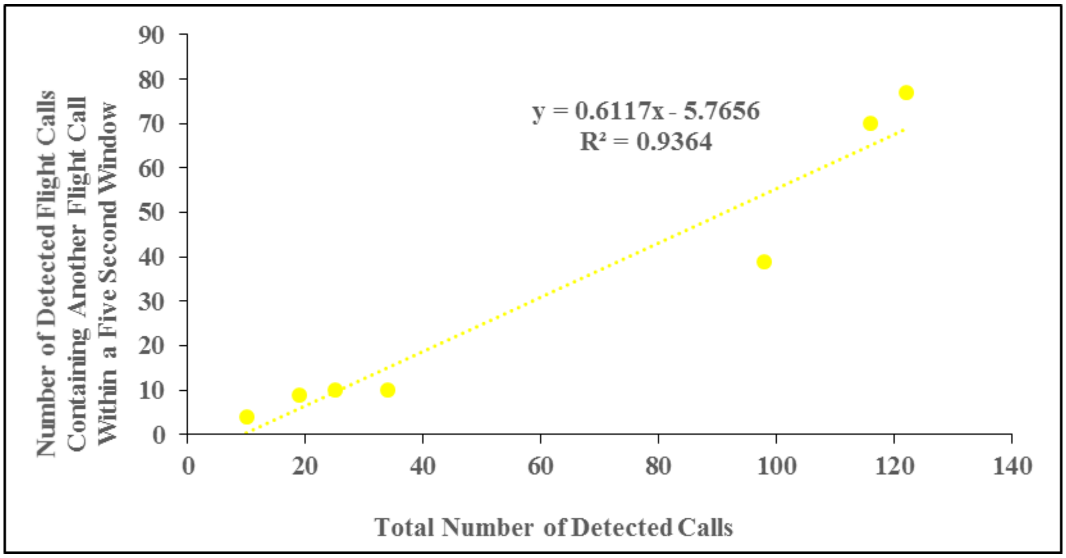


Figure 18b: The correlation between the total numbers of identified calls detected in the five second window of Common Yellowthroat flight calls and the number of conspecific Common Yellowthroat flight calls over each night.

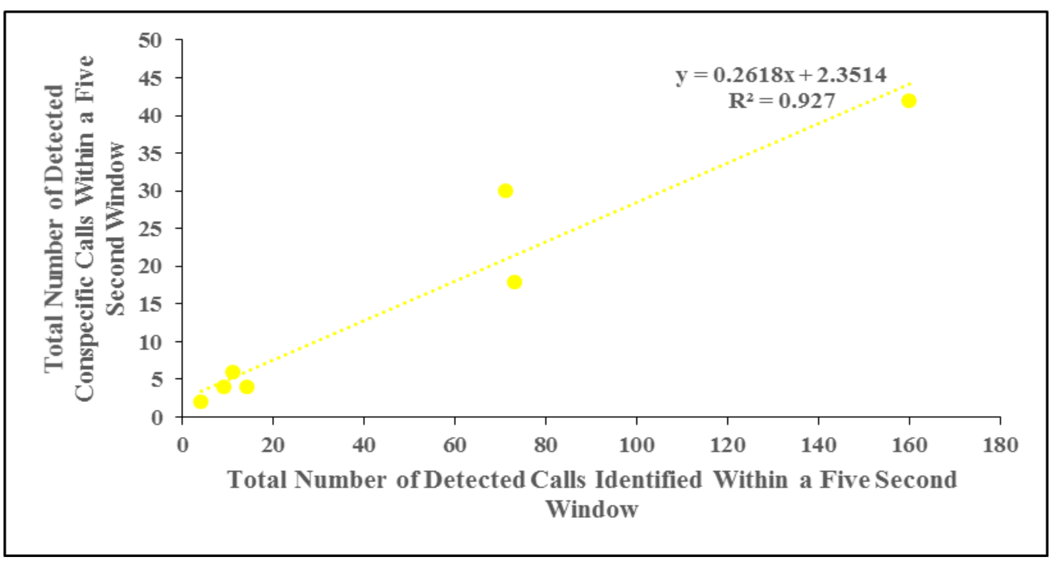
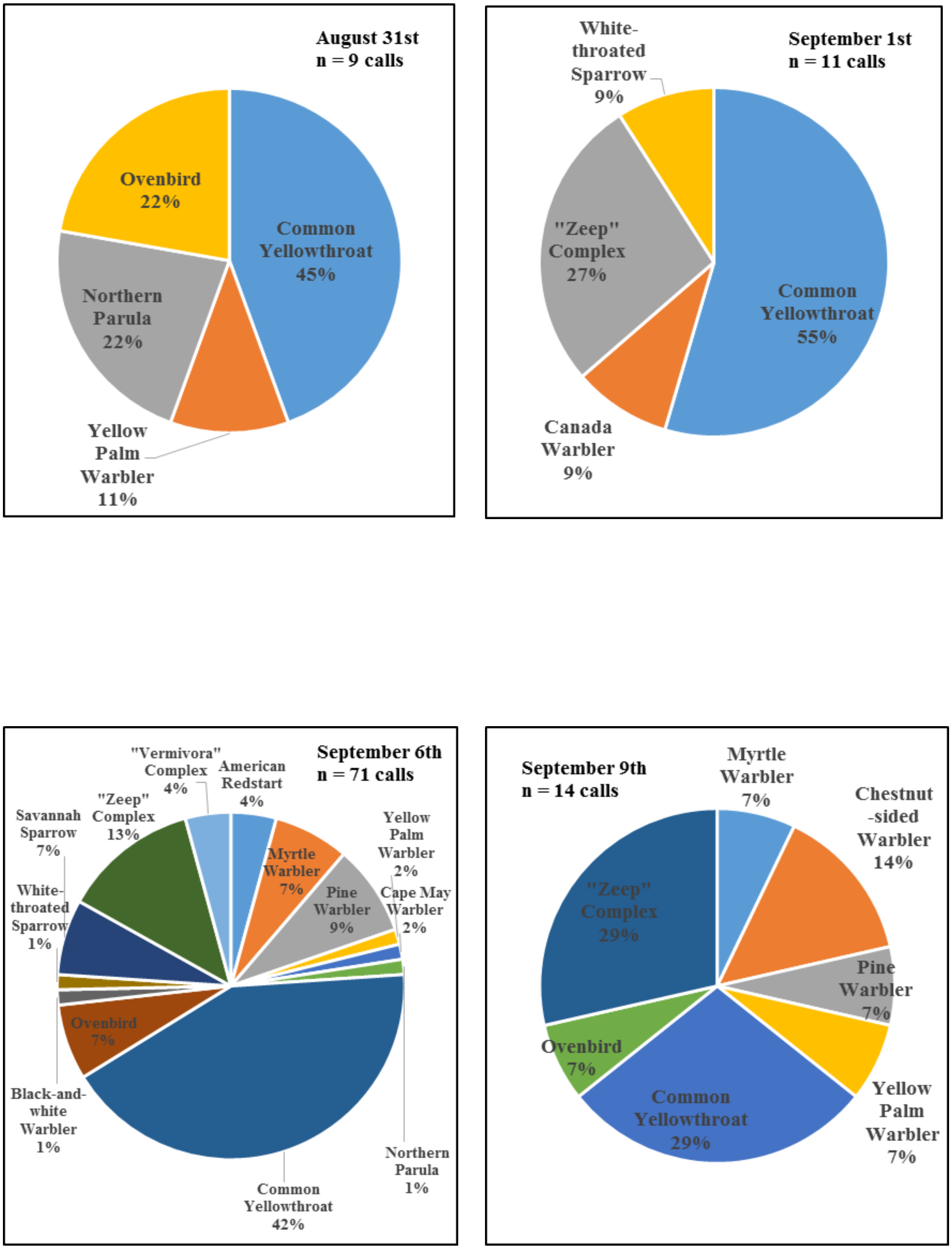
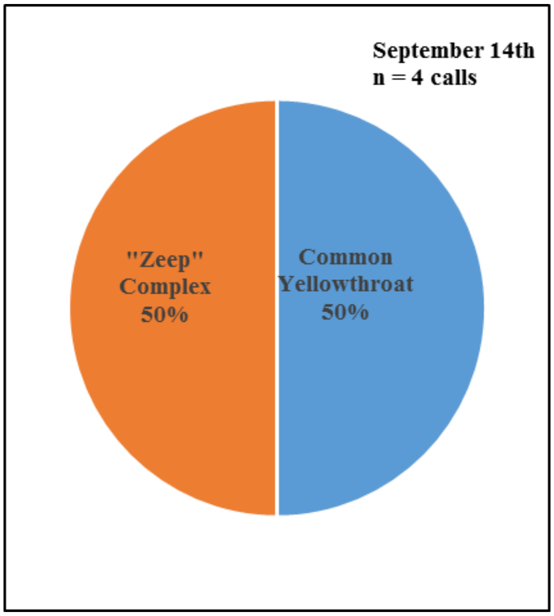
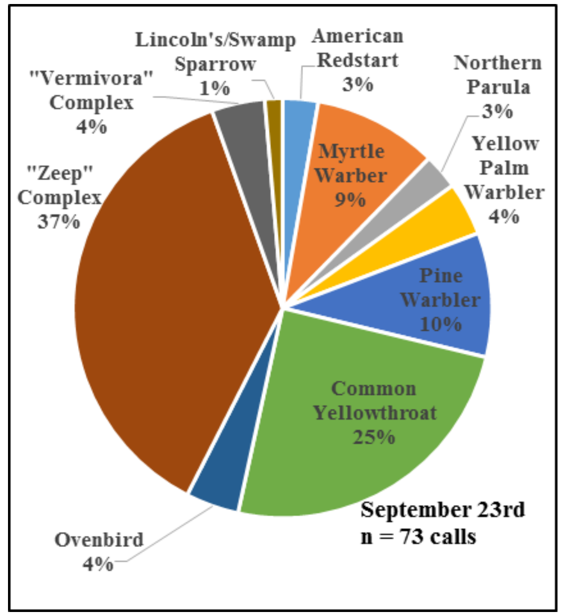


Figure 19: The composition of the detected species in the five second window of Common Yellowthroat flight calls detected throughout the analyzed nights.




September 14th
n = 4 calls
"Zeep" Complex 50%
Common Yellowthroat 50%


Lincoln's/Swamp Sparrow 1%
American Redstart 3%
"Vermivora" Complex 4%
Northern Parula 3%
Myrtle Warber 9%
Yellow Palm Warbler 4%
"Zeep" Complex 37%
Pine Warbler 10%
Common Yellowthroat 25%
September 23rd
n = 73 calls
Ovenbird 4%

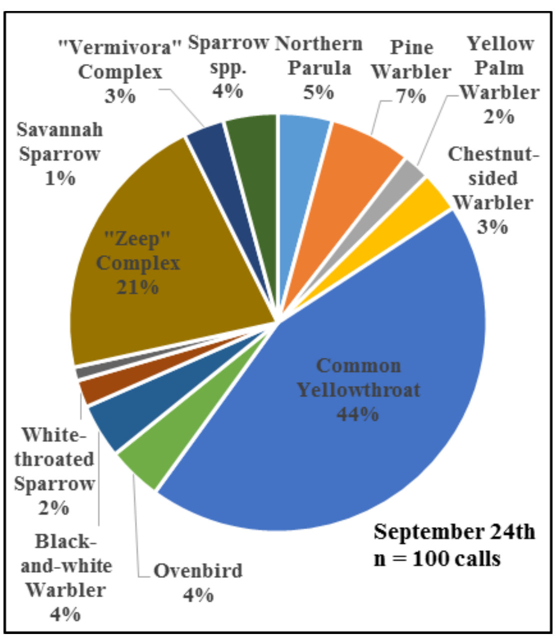

"Vermivora" Complex 3%
Sparrow spp. 4%
Northern Parula 5%
Pine Warbler 7%
Yellow Palm Warbler 2%
Savannah Sparrow 1%
Chestnut-sided Warbler 3%
"Zeep" Complex 21%
Common Yellowthroat 44%
White-throated Sparrow 2%
Black-and-white Warbler 4%
Ovenbird 4%
September 24th
n = 100 calls

Figure 20: The composition of the detected species in the five second window of Common Yellowthroat flight calls detected throughout the analyzed nights combined.

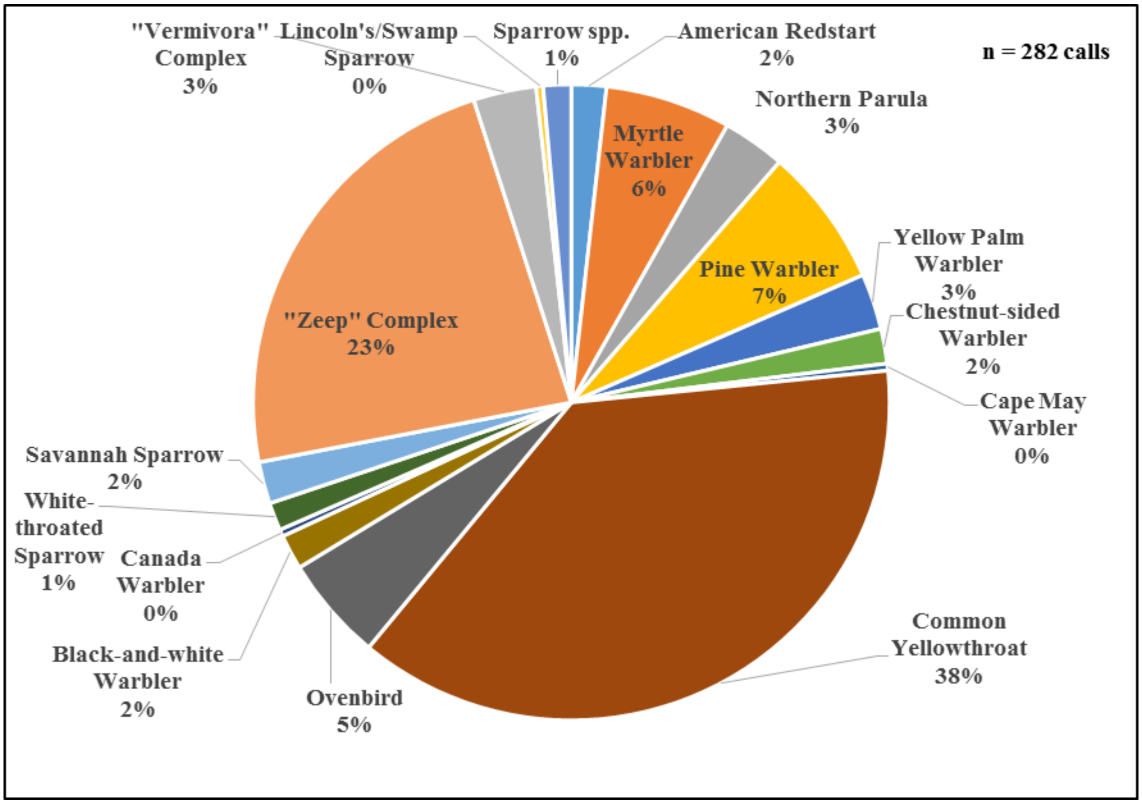


Figure 21: The relative frequency of detected Ovenbird flight calls throughout all the analyzed nights.

α = 0.05, df = 10, CV = 18.307

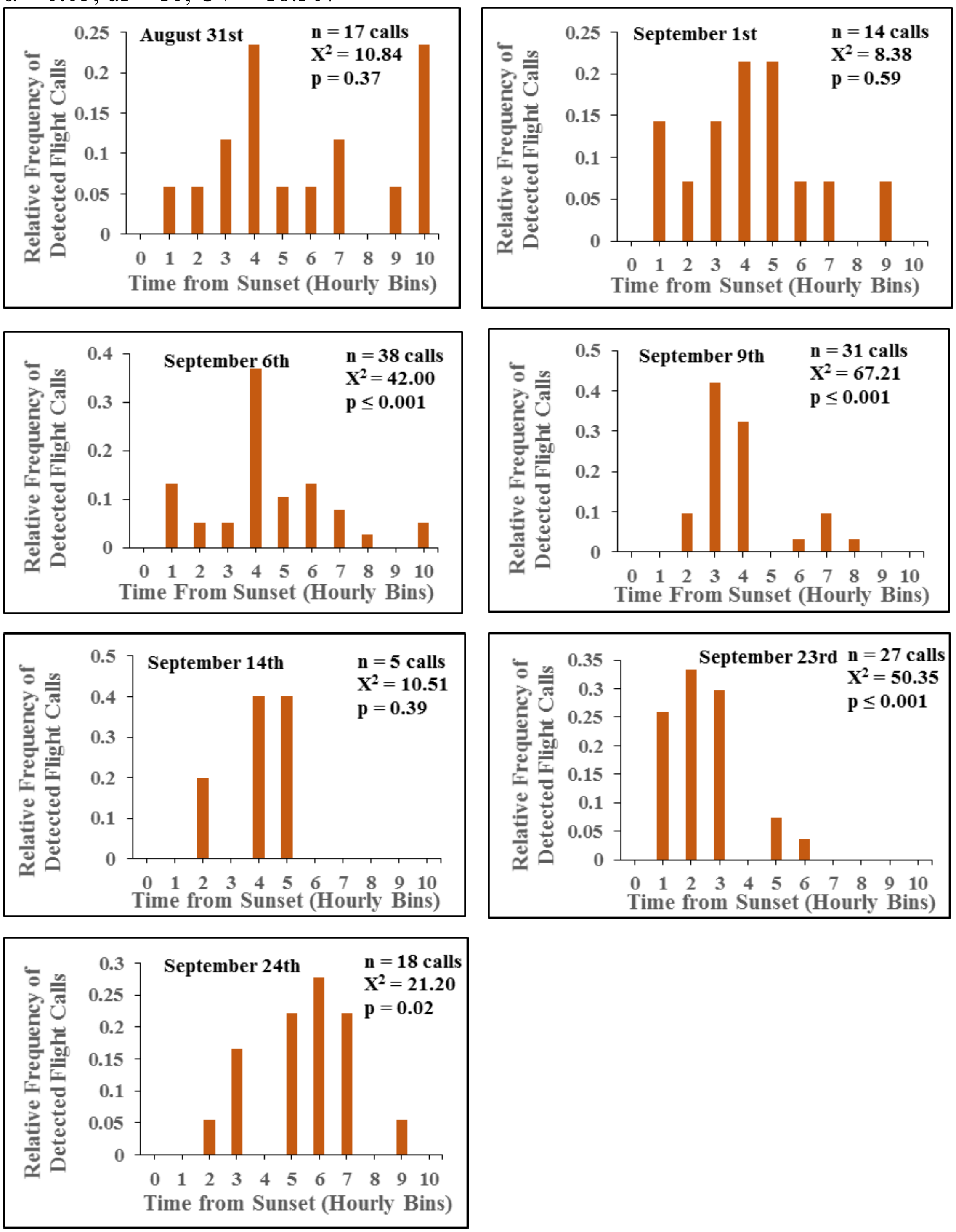


Figure 22: The relative frequency of detected Ovenbird flight calls throughout all the analyzed nights together.

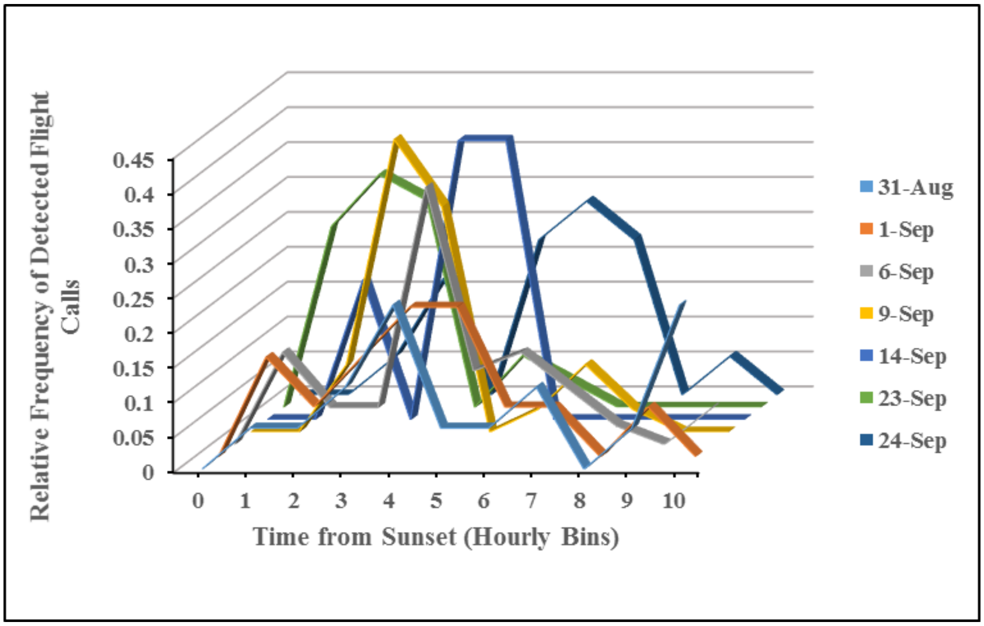


Figure 23: The relative frequency of detected Ovenbird flight calls throughout all the analyzed nights combined.

$\alpha = 0.05$, df = 10, CV = 18.307

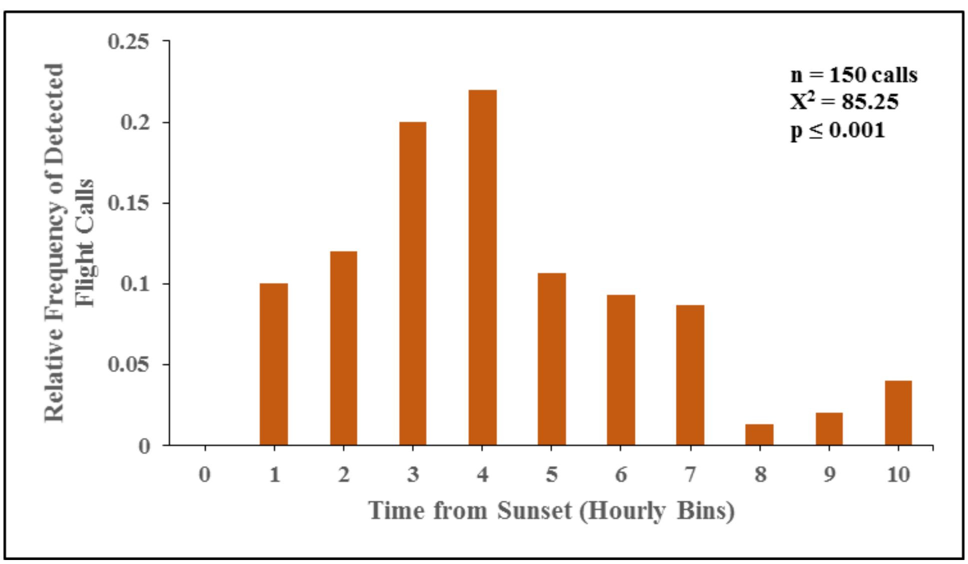


Table 4: The number of detected Ovenbird flight calls and the number of occurrences of another flight call within in a five second window around a detected call.

Date	Total number of detected flight calls	Number of detected flight calls containing another flight call within a five second window (% of total calls)	Number of Ovenbird calls detected within an Ovenbird five second window (% of identified calls)
August 31	17	7 (41%)	9 (69%)
September 1	14	4 (29%)	0 (0%)
September 6	38	22 (58%)	13 (25%)
September 9	31	18 (58%)	8 (69%)
September 14	5	1 (20%)	0 (0%)
September 23	27	21 (78%)	6 (25%)
September 24	18	9 (50%)	0 (0%)
Total	150	82 (55%)	36 (33%)

Figure 24a: The correlation between the total number of Ovenbird flight calls detected and the number of Ovenbird flight calls containing another flight call within a five second window per night.

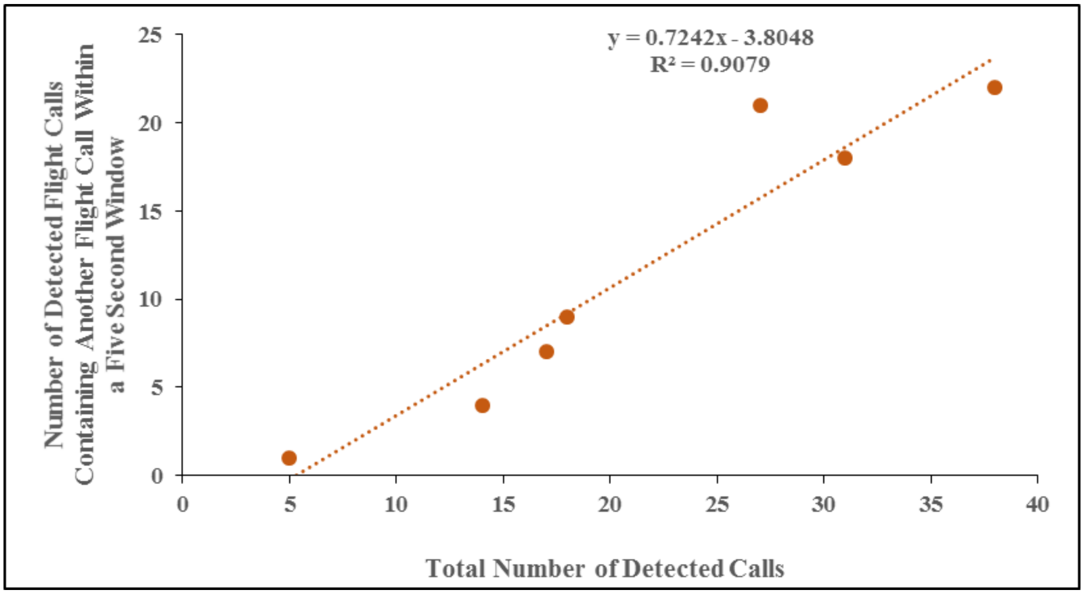


Figure 24b: The correlation between the total numbers of identified calls detected in the five second window of Ovenbird flight calls and the number of conspecific Ovenbird flight calls over each night.

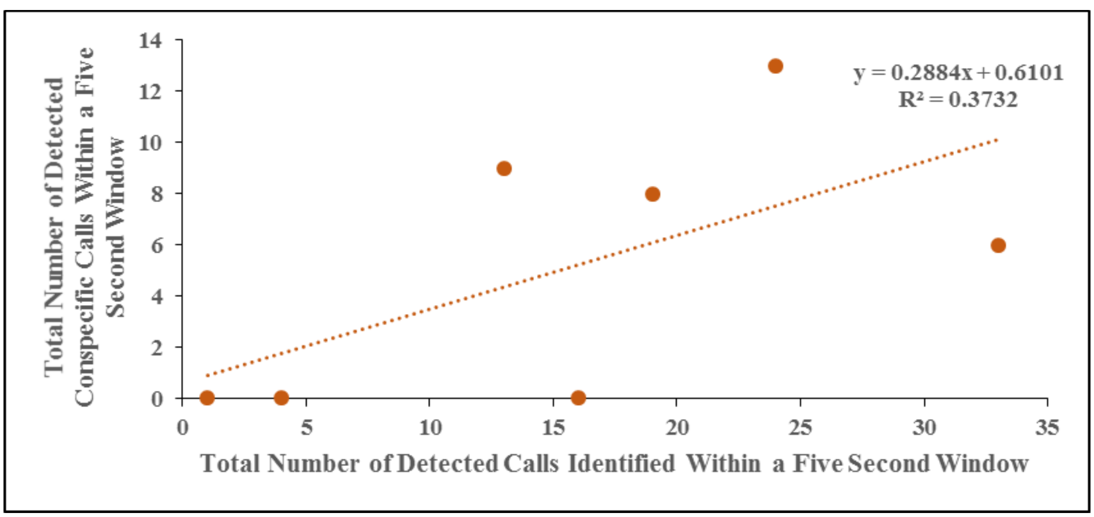
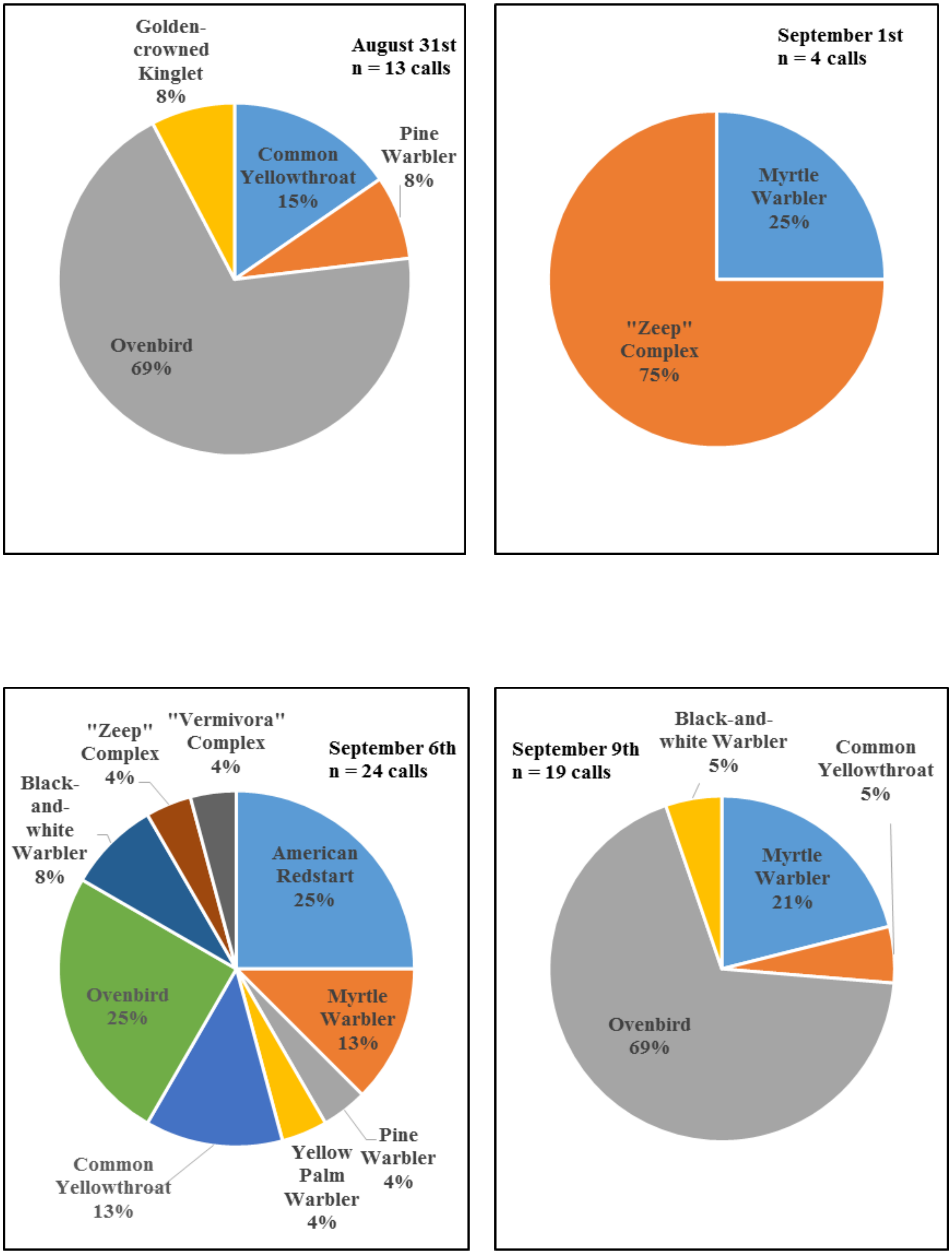
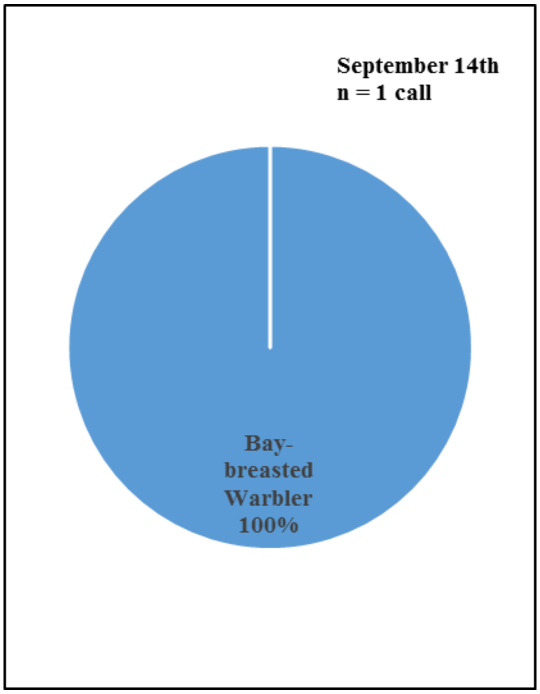
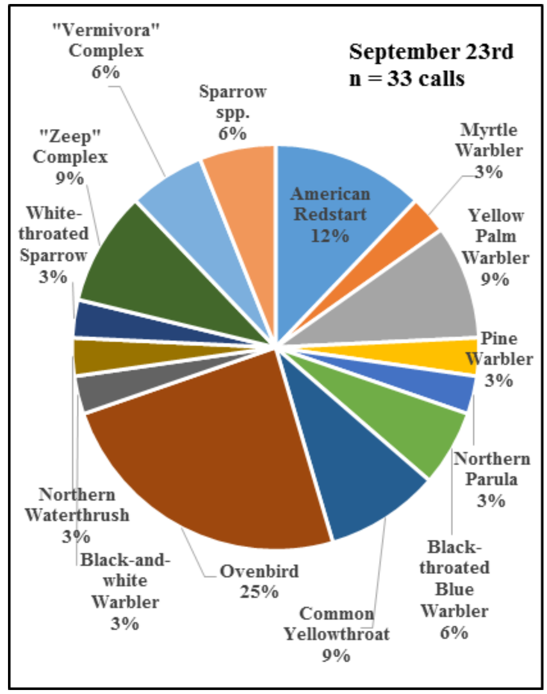


Figure 25: The composition of the detected species in the five second window of Ovenbird flight calls detected throughout the analyzed nights.




September 14th
n = 1 call
Bay-breasted Warbler 100%


September 23rd
n = 33 calls
"Vermivora" Complex 6%
Sparrow spp. 6%
"Zeep" Complex 9%
White-throated Sparrow 3%
American Redstart 12%
Myrtle Warbler 3%
Yellow Palm Warbler 9%
Pine Warbler 3%
Northern Parula 3%
Black-throated Blue Warbler 6%
Common Yellowthroat 9%
Ovenbird 25%
Black-and-white Warbler 3%
Northern Waterthrush 3%

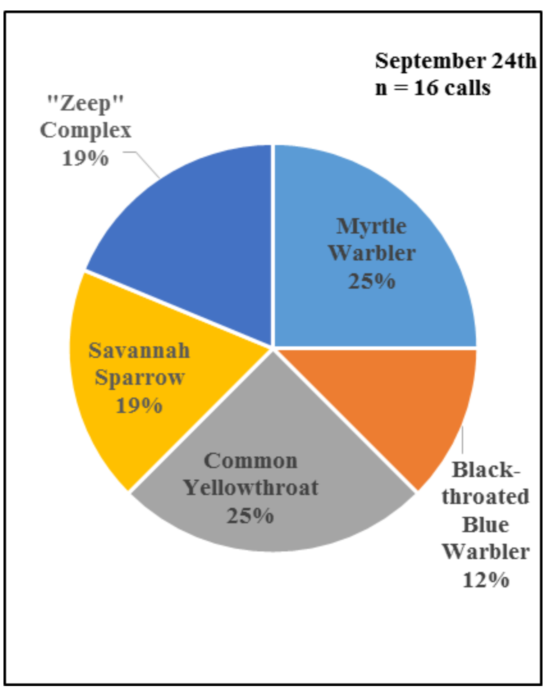

September 24th
n = 16 calls
"Zeep" Complex 19%
Myrtle Warbler 25%
Savannah Sparrow 19%
Common Yellowthroat 25%
Black-throated Blue Warbler 12%

Figure 26: The composition of the detected species in the five second window of Ovenbird flight calls detected throughout the analyzed nights combined.

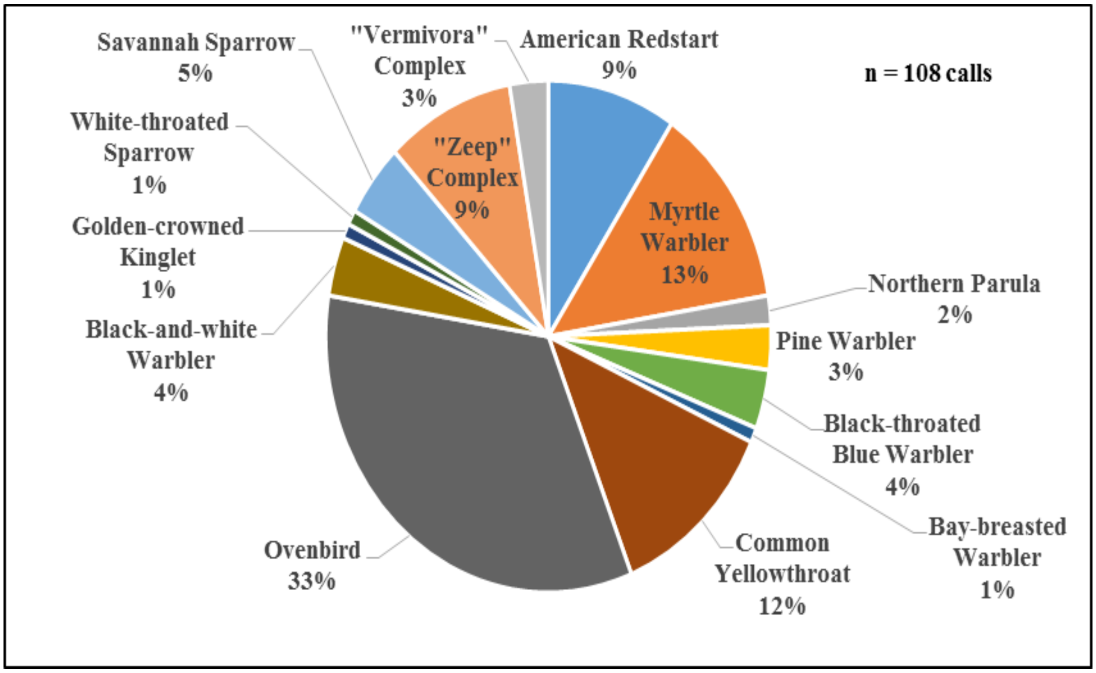


Figure 27: The relative frequency of detected Black-and-white Warbler flight calls throughout all the analyzed nights.

$\alpha = 0.05$, df = 10, CV = 18.307

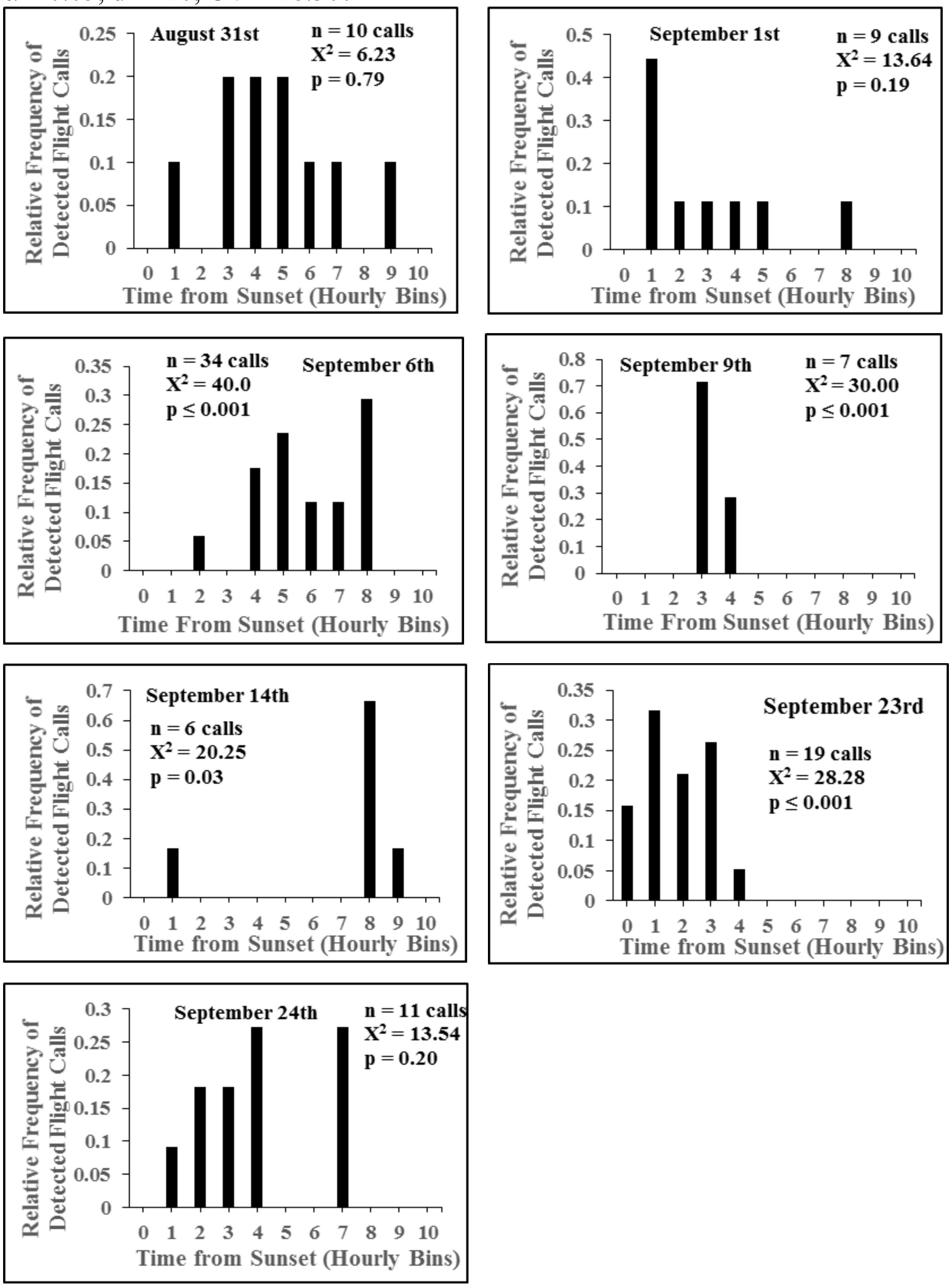


Figure 28: The relative frequency of detected Black-and-white Warbler flight calls throughout all the analyzed nights together.

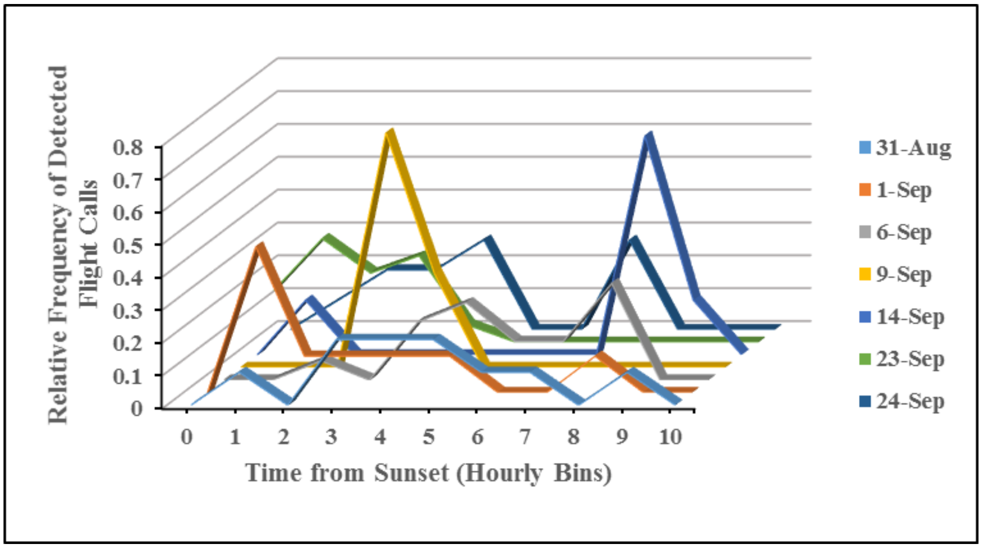


Figure 29: The relative frequency of detected Black-and-white Warbler flight calls throughout all the analyzed nights combined.

$\alpha = 0.05$, df = 10, CV = 18.307

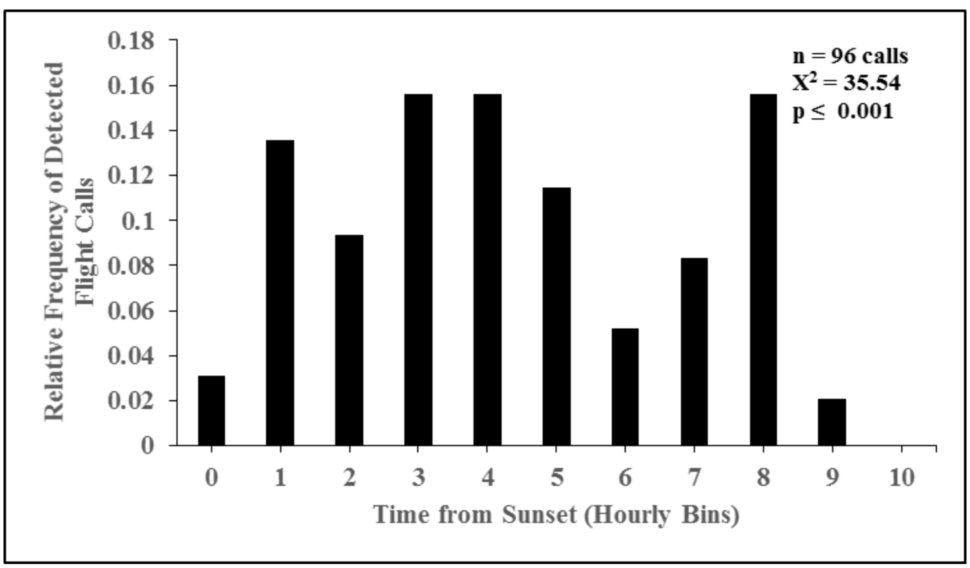


Table 5: The number of detected Black-and-white Warbler flight calls and the number of occurrences of another flight call within in a five-second window around a detected call.

Date	Total number of detected flight calls	Number of detected flight calls containing another flight call within a five second window (% of total calls)	Number of Black-and-white Warbler calls detected within a Black-and-white Warbler five second window (% of identified calls)
August 31	10	4 (40%)	0 (0%)
September 1	9	4 (44%)	2 (40%)
September 6	34	24 (71%)	8 (40%)
September 9	7	1 (14%)	0 (0%)
September 14	6	1 (17%)	0 (0%)
September 23	19	12 (63%)	0 (0%)
September 24	11	6 (55%)	0 (0%)
Total	96	52 (54%)	10 (22%)

Figure 30a: The correlation between the total number of Black-and-white Warbler flight calls detected and the number of Black-and-white Warbler flight calls containing another flight call within a five second window per night.

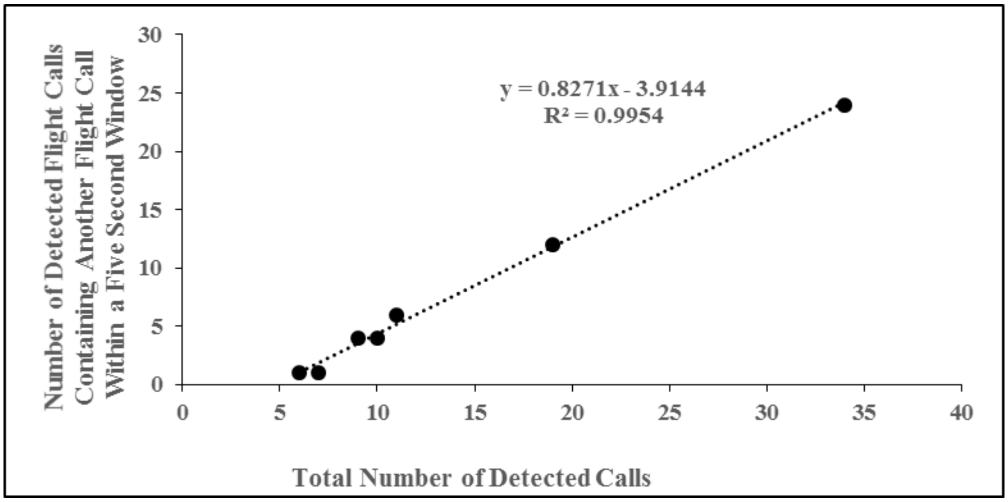


Figure 30b: The correlation between the total numbers of identified calls detected in the five second window of Black-and-white Warbler flight calls and the number of conspecific Black-and-white Warbler flight calls over each night.

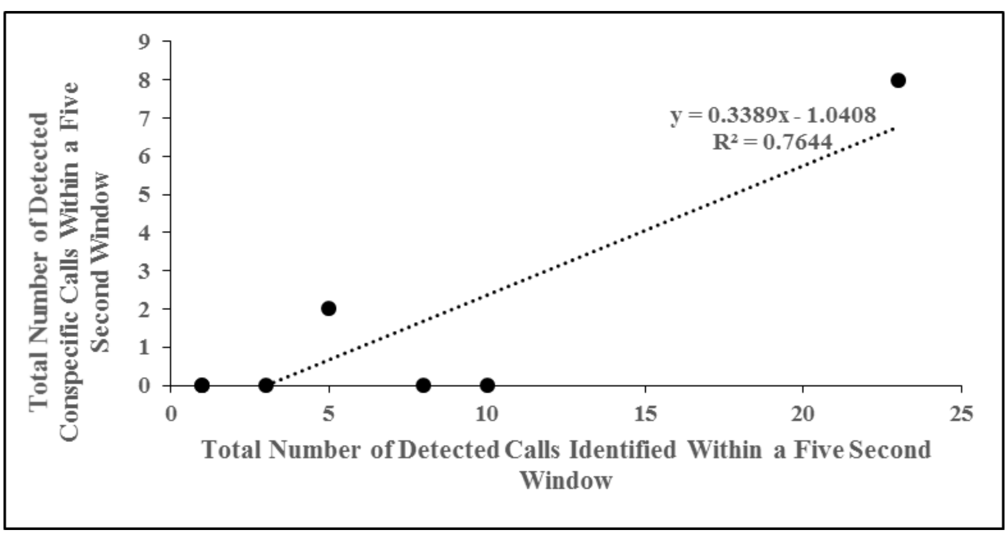
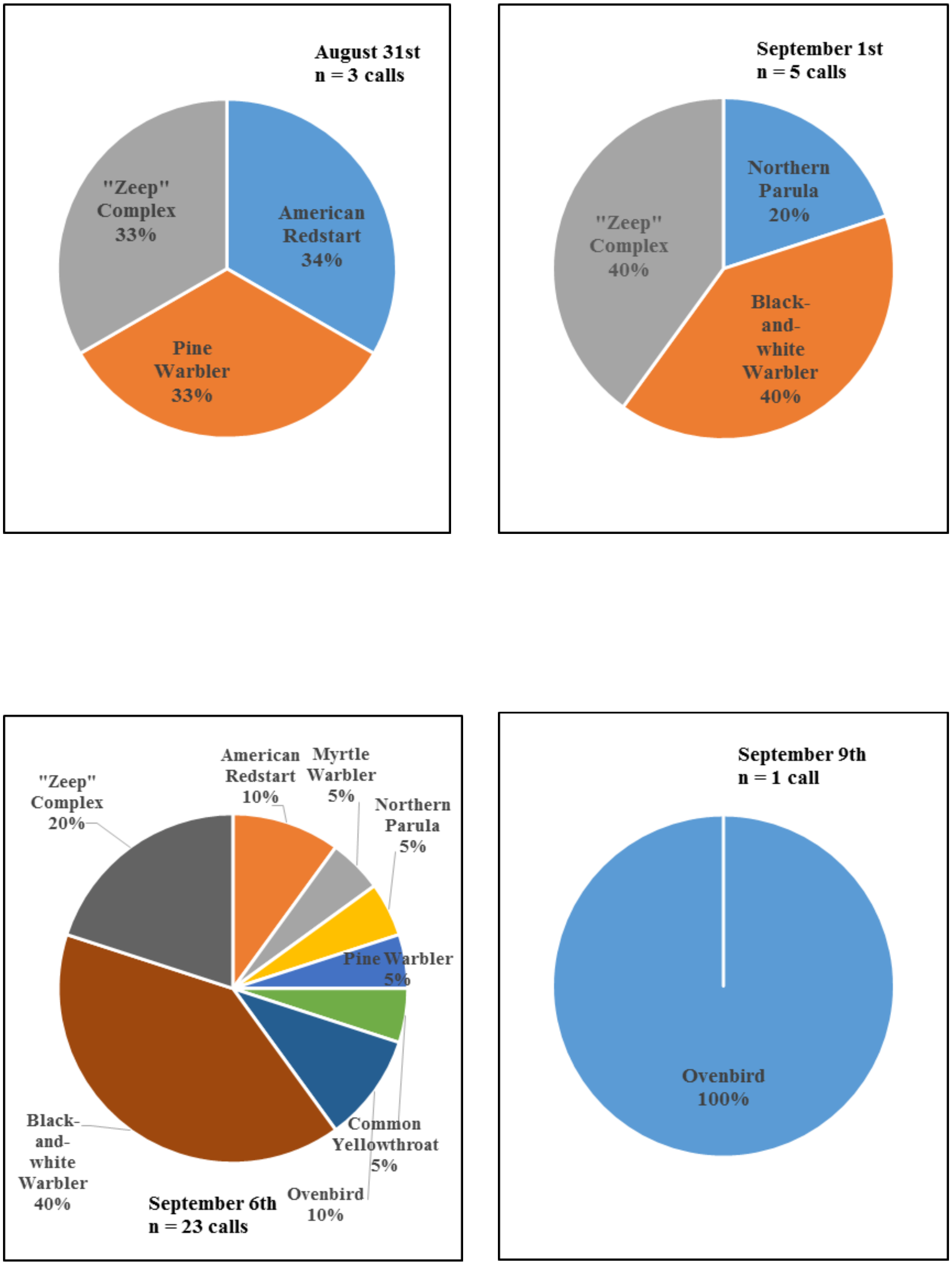
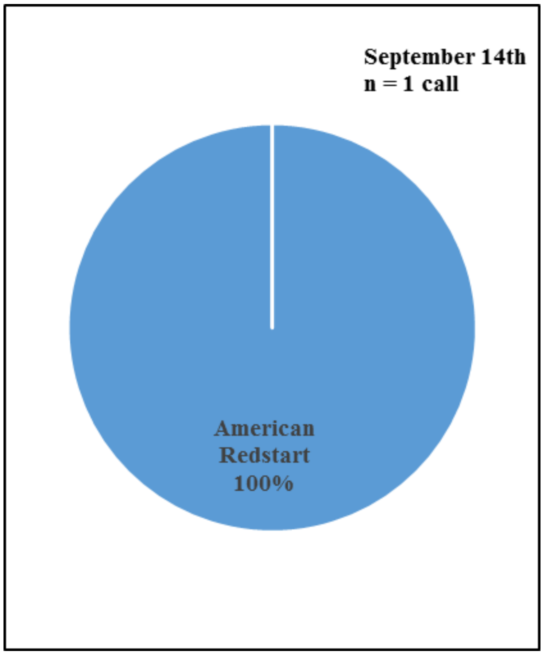
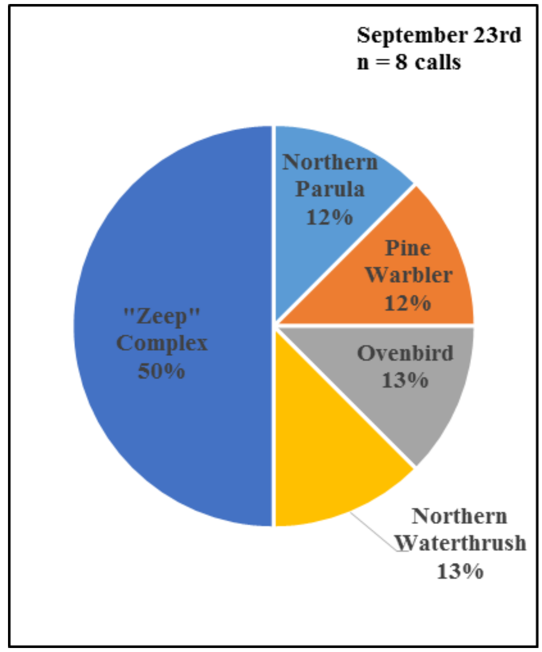


Figure 31: The composition of the detected species in the five second window of Black-and-white Warbler flight calls detected throughout the analyzed nights.




September 14th
n = 1 call
American
Redstart
100%


September 23rd
n = 8 calls
Northern
Parula
12%
Pine
Warbler
12%
"Zeep"
Complex
50%
Ovenbird
13%
Northern
Waterthrush
13%

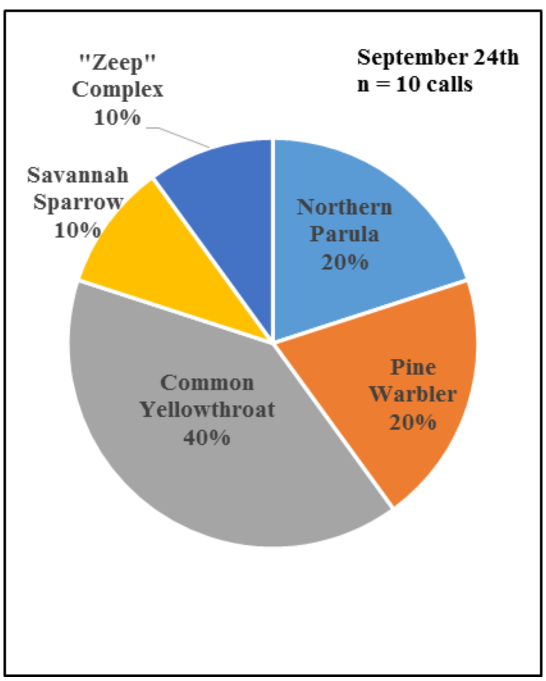

September 24th
n = 10 calls
"Zeep"
Complex
10%
Savannah
Sparrow
10%
Northern
Parula
20%
Pine
Warbler
20%
Common
Yellowthroat
40%

Figure 32: The composition of the detected species in the five second window of Black-and-white Warbler flight calls detected throughout the analyzed nights combined.

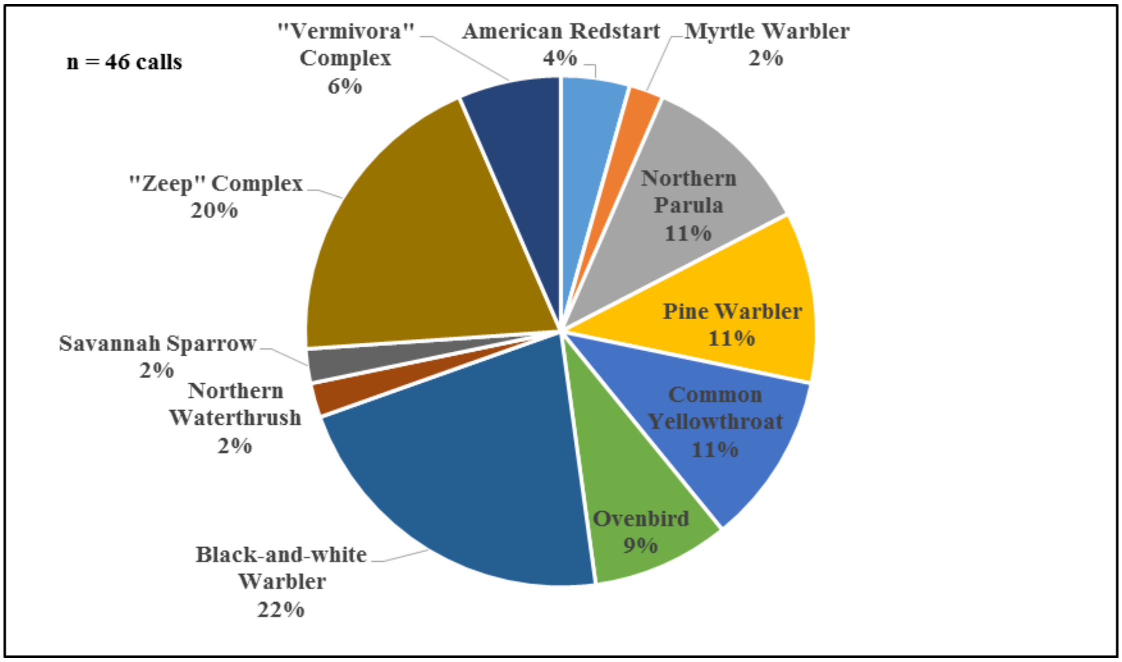


Table 6: A checklist of the identified species in the call windows of the five analyzed species.

Species	**American Redstart**	**Myrtle Warbler**	**Common Yellowthroat**	**Ovenbird**	**Black-and-white Warbler**
American Redstart (*Setophaga ruticilla*)	x	x	x	x	x
Myrtle Warbler (*S. coronata coronata*)	x	x	x	x	x
Northern Parula (*S. americana*)	x	x	x	x	x
Pine Warbler (*S. pinus*)	x	x	x	x	x
Yellow Palm Warbler (*S. palmarum hypochrysea*)	x	x	x	x	
Chestnut-sided Warbler (*S. pensylvanica*)	x		x		
Black-throated Blue Warbler (*S. caerulescens*)		x		x	
Cape May Warbler (*S. trigina*)			x		
Bay-breasted Warbler (*S. castanea*)				x	
Common Yellowthroat (*Geothylpis trichas*)	x	x	x	x	x
Ovenbird (*Seiurus aurocapillus*)	x	x	x	x	x
Black-and-white Warbler (*Mniotilta varia*)	x	x	x	x	x
Canada Warbler (*Cardenilla canadensis*)	x		x		
Northern Waterthrush (*Parkesia noveboracensis*)				x	x
Golden-crowned Kinglet (*Regulus satrapa*)				x	
Savannah Sparrow (*Passerculus*			x	x	x

sandwichensis)					
White-throated Sparrow (*Zonotrichia albicollis*)			x	x	
"Zeep" Complex[1]	x	x	x	x	x
"Vermivora" Complex[2]	x	x	x	x	x
Lincoln's/Swamp Sparrow[3]			x		
Sparrow spp.[4]	x	x	x		
Total	13	12	17	16	11

1. The "Zeep" Complex consists of the Yellow Warbler (*S. petechia*), Magnolia Warbler (*S. magnolia*), Blackpoll Warbler (*S. striata*), Blackburnian Warbler (*S. fusca*), Cerulean Warbler (*S. cerulea*), Worm-eating Warbler (*Helmitheros vermivorum*), Louisiana Waterthrush (*Parkesia motacilla*) Connecticut Warbler (*Oporornis agilis***),** and Hooded Warbler (*S. citrina*).

2. The "Vermivora" complex consists of the Blue-winged Warbler (*Vermivora cyanoptera*), Golden-winged Warbler (*V. chrysoptera*), Tennessee Warbler (*Oreothlypis peregrina*), Orange-crowned Warbler (*O. celata*), Nashville Warbler (*O. ruficapilla*), Black-throated Green Warbler (*S. virens*), and Mourning Warbler (*G. philadelphia*).

3. Lincoln Sparrow (*Melospiza lincolnii*) or Swamp Sparrow (*M. georgiana*)

4. New World Sparrow (Emberizidae) Species

AUTHOR'S BIOGRAPHY

David Bridges grew up in Augusta, Maine and first came to the University of Maine in the fall of 2009. Graduating with a B.S. in Biology, he is going to continue onwards with his education, beginning a graduate program in the summer of 2014. Eventually he would like to earn a PhD and work at a university teaching and conducting research. While at the University of Maine he has had the amazing opportunity to conduct research in a wide variety of fields under numerous amazing faculty members and has done everything from living on a remote seabird colony to isolating pathogenic *Escherichia coli* from wildlife scat. David has also been in the University of Maine Symphonic Band, Biology Club, Wildlife Society, and has been an active member of Greek Life. s