VARIATION IN MORNING AWAKENING TIME OF BIRDS IN SOUTH-CENTRAL MICHIGAN

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George F. Fisler

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THESIS

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By

George F. Fisler

AN ABSTRACT OF

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Michigan State University

Department of Zoology

East Lansing, Michigan

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Approved _____

THESIS ABSTRACT

The purpose of this study was to determine at what times species of birds awakened in the morning by using the first songs and calls as the criterion of awakening time. Terms used such as night song, true night, civil and astronomical twilight, and awakening time were defined as to their use in this paper.

Data were collected during a one year period with a total of 120 morning observations used for comparisons. The awakening times of 12 species of birds were recorded. The daily awakening times, designated by the number of minutes before sunrise, were averaged for each of four arbitrary periods, and significant differences between these means were used to determine the relationships both for one species over the year and also relationships of means between the various species in each period. Graphs included showed the daily awakening time for each species through the year and the significant differences between the means both within and between species.

The major conclusions reached in this study were that there was a tendency for the awakening time curves of the species to approximate the sunrise and civil twilight curves during most of the year but with systematic deviations of the awakening time curves at certain seasons. Birds awaken earliest in the spring of the year in relation to sunrise. All species do not rise earliest at the summer solstice. The order of awakening of the various species through the year was not static but changed through the seasons. Most species.

awakened at very similar times during the fall and winter months, but, when spring arrived, the earliest rising species became earlier and remained so until late summer or fall.

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INTRODUCTION

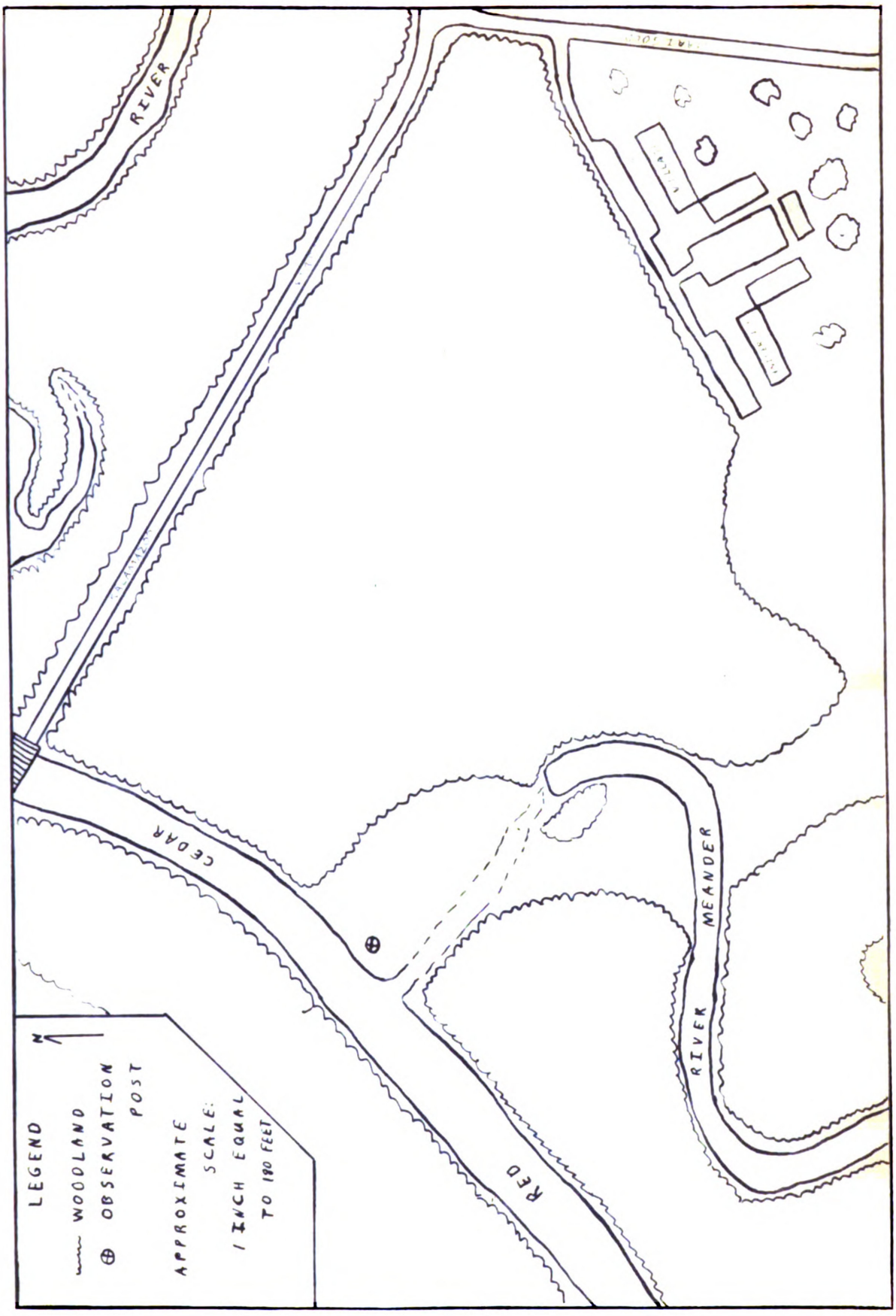
The reasonably constant sequence of awakening times of birds has been well known for many years. Many authors have commented upon the regularity with which birds first sing in the morning, each species apparently having its own particular awakening time. Nice (1943) referred to this phenomenon as the "bird clock". According to Walker (1928), Jeny in 1846 compiled a list of the sequence of the awakening times for the birds in his area. Other workers cited by Walker (1928) included Altum (1868), Godfrey (1897), and Gynzell (1903) each of whom kept lists of the first rising times of various species. The first serious study of this nature was undertaken by Wright (1912, 1913) who worked during a period of several years in the mountains of New Hampshire. Allen (1913) published some additions and corrections to Wright's (1913) work and added some more of his own records in 1915 and in 1922. Allard (1930) listed rising times of about 14 species and attempted to evaluate his records for the purpose of finding why the birds arose when they did. His work was the first serious effort in this country to establish reasons for a definite awakening time for the many species studied. Also, Allard's (1930) paper, as far as this author could determine, is the only one concerned with with the problem of awakening time in which several species of birds were systematically studied. Many authors have listed their impressions as to the awakening times of various species, while other authors have done serious studies and recorded the actual awakening times.

The best known of these is the work of Nice (1943) on the Song Sparrow. Others include Craig (1926, 1933, 1943), Taylor (1929), Emlen (1937), MacQueen (1950), Ara (1951), McCabe (1951), and King (1955). There are now many papers in the literature on the roosting flights of several species, particularly herons (Seibert, 1951), and several concerned with Robin and blackbird roosts (Abel, 1914, Nice, 1935, Howell, 1940, for example). However, few workers have conducted their awakening time studies over a full calendar year and noted the changes which occur in the rising time. Allard (1930) was the first to publish a report of awakening times based on an extended period of time (January 15 to September 1). Previously, an unpublished thesis by Walker (1928) presented a study of the problem from October to July. Nice's (1943) work contains records taken at all seasons of the year and over several years' duration.

Many authors, using a limited number of records, attempted to explain why birds rise at a particular time of morning. However, this author believes that it is necessary to have a large series of records covering all seasons of the year in order to draw reliable conclusions. There are difficulties involved in determining what the awakening time may be. No attempt will be made in this paper to offer conclusions concerning the reasons for the species arising at the times they did. The results obtained in this study will be presented concerning only the awakening times observed over the seasons.

The study area was a beech-maple-oak woodlot near the campus of Michigan State University. It was bounded on the west side by the

MAP OF STUDY AREA
RED CEDAR WOODLAND



Red Cedar River, on the north and east by well-traveled roads, and on the south by open fields and a university housing project. The observation post was located on the south bank of the river in a clearing cut through the woods. Therefore, the observer had within his range of hearing an open, grassy field, an edge habitat along the woods on both sides of the cleared field, the woods habitat, and the river edge habitat, including the woods and the open field. The accompanying map illustrates the area.

The study was begun on January 11, 1955, and terminated at the end of February, 1956. The records of January, 1955, were not used. This period was used to develop techniques which were used later during the rest of the study. The records of 120 morning field trips are presented in this paper.

METHODS

The materials required for this type of a study were few and simple. A clipboard with sheets of paper properly prepared for recording the data, a wristwatch, pencils, and a pair of 6x30 binoculars were used. A Weston Sight-light meter which measured light intensity from zero to 75 foot-candles was taken on every field trip, and the light intensity was recorded for possible further correlation with the awakening times. This meter was not accurate enough for small readings, but it did allow recording of the light intensity up to twenty minutes before sunrise on clear mornings. Temperature, general notes on the sky conditions, wind velocity and wind direction were the only weather taken on the site. The wind velocity was estimated by use of the Beaufort scale. Other weather data were taken from the local monthly climatological data sheets issued by the United States Weather Bureau in East Lansing.

Data were recorded in the following manner. The author generally reached the place of observation about one-half hour before the birds began to sing. Ability to predict the time when the birds would begin to sing became quite accurate after a few mornings of study. This one-half hour time interval was adjusted as the sunrise time varied through the year. However, the awakening time curve of the birds was not in strict accordance with the sunrise curve through the year so the adjustment of the time interval had to follow the awakening time curve of the birds also. Recognizing these conditions, the observer

was able to maintain the one-half hour period between his arrival in the area and the first song of the earliest species. The possibility of the records being biased by the author was eliminated by the selection of the criterion of awakening time.

A record of the number of individuals of each species singing or calling was made during each one minute interval. Observations continued from the time of arrival until sunrise. The observer remained in the area after sunrise to record any late risers. In compiling the data, all records of rising time exceeding ten minutes after sunrise were discarded in order to make all records constant. The ten minute period represented the minimum time after sunrise in which the author remained in the field on any given day during the year. The records of each day were transcribed on to permanent charts and graphs after returning from the field trip.

Some difficulties in recording the awakening time were encountered due to extraneous noises. First, the noise of from one to four minutes duration produced by trains on a near-by railroad sometimes rendered hearing in the vicinity quite poor. A loud, shrill song such as that of the Cardinal could be heard over the din, but the much weaker vocalization of the Yellow Warbler was difficult to hear. This factor will have to be overlooked because determination of the exact time of the first call or song was impossible. The maximum error possible due to the noise of trains in recording the data was four minutes. The noise from trains did not interrupt the observations more than 20 times during the year. The second disturbance was the noise of auto traffic from the adjacent roads. The observer believes

that this disturbance was insufficient to cause any appreciable change in the ability to hear the awakening songs or calls. A third factor was the simultaneous and loud singing of all species. The amount of noise made by the noisier birds, especially during the spring song period, was sufficient to obscure the first songs of the less vociferous species. The true error here cannot be determined. Wright (1913) and Saunders (1929) also discussed the problem of noisy birds obscuring the songs of quieter species. A fourth extraneous factor may be the bias of the observer in listening more attentively for a certain species to sing at a time which experience had taught him to expect it. This is a problem inherent in work of this nature and care must be taken to avoid it.

DEFINITIONS OF TERMS

A number of terms used in this paper require definitions. The first is the term "awakening time". Selection of a definite time as that time when a bird awakens is almost impossible. Therefore, some criterion must be designated which will more or less indicate the time when the bird becomes truly awake and active. Allard (1930) stated that it was impossible to tell when the first light reached a bird whose head was under its wing thus awakening the bird (assuming that light is the critical factor in determining awakening time). Therefore, he chose as a standard any morning song heard after astronomical twilight as the true awakening time. However, even Allard (1930) called this method only a "convenient demarkation". This author believes that Allard's (1930) method did not recognize that night songs are not limited to the period of true night. There was no indication in my study that birds recognize the termination of true night as the beginning of day by starting their activity at astronomical twilight. Rather, this study indicated that the songs uttered between astronomical twilight and the beginning of the dawn chorus were also night songs. The songs of true night and those uttered between astronomical twilight and the beginning of the dawn chorus are all sung in a like manner (a few, scattered, single utterances from one or more birds of the same species) and no distinction should be made between them. They are night songs. Thus Allard's (1930) awakening time criterion was deemed unsuitable for this study.

Wright (1913) stated that awakening time was that time when more than one bird of the same species sang at the same time. However, a bird that sings during the night will often be quickly followed by the vocalization of one or more individuals of the same species, the first bird apparently serving as a stimulus for the succeeding singers (Saunders, 1929). After the completion of this singing, these birds will not be heard again for possibly half an hour or more. Wright's (1913) criterion of awakening time did not recognize these utterances between astronomical twilight and the beginning of the dawn chorus as night songs. Craig (1943) stated that the awakening song of one bird did not influence the time of the awakening song of another. Saunders (1929) stated that birds will begin singing continuously within a few minutes after awakening, and Nice (1943) expressed this same opinion. This writer considers these early sporadic outbursts between astronomical twilight and the beginning of the dawn chorus to be night songs rather than awakening songs. Allen (1913) stated that the true awakening time occurred when more than one individual of the same species was singing regularly. This method of Allen's (1913) supplemented by Saunders' (1929) views that birds will sing continuously shortly after awakening constitutes the awakening time criterion followed in this study. However, this criterion will hold only during the song season. Later in the year when the birds become more or less silent as far as song is concerned, it is necessary to substitute the calls of the birds for the full song in the awakening time definition. Also, this definition is not acceptable for such irregularly singing species as the Crested Flycatcher (Myiarchus crinitus) and the woodpeckers. One can

assume that the first utterance of the individual is its awakening time for these birds. However, the probable awakening time of the Flickers is known because the birds roosted near the observation post of the author, and he could see the birds when they emerged from their roosting holes. But it must be remembered that the true awakening time is not known for any species discussed in this paper. The first songs and calls are only an indication of the time that the bird definitely began activity in the morning.

The phenomenon of night song was recognized by Wright (1913), but he did not believe that it played a part in the time of awakening. Allen (1913) also recognized night song and made corrections for its influence on the awakening time. Allard (1930) wrote that "night song is not a common and regular behavior". There is some disagreement between this author and Allard (1930) on the amount of night song because of the difference in methods of choosing what constitutes the true awakening time. Even using Allard's (1930) criterion of awakening time this author found that, for the birds under his surveillance, night song was of common and regular occurrence. Other observers have published on the proneness of some species to sing at night. The frequency of night songs apparently depends on the stage of the nesting cycle and the phase of the moon. There is much night singing during the peak of the song period in the spring. There is little during the fall revival of singing and little or none during the midsummer and winter periods. More night singing was evident when the moon was full or when the sky was very clear and thus brighter than it was on less clear but moonless nights. Thus the definition of

night song derived for use in this work was as follows: night song includes those individual songs which a bird(s) will sing during the time between the end of the song period of the evening and the commencement of regular and continuous singing the next morning.

The definitions of true night, civil twilight, nautical twilight, and astronomical twilight were taken from the Smithsonian Meteorological Tables (1951). True night is the time delimited by astronomical twilight when the sky is completely dark. True night begins in the evening when the sun is 18° below the horizon and ends in the morning when the rising sun again reaches 18° below the horizon. Civil twilight is defined as the time after sunset and before sunrise when the sun is six degrees below the horizon. Originally, it was "the time after sunset or before sunrise during which, on clear days, there is enough light for ordinary outdoor occupations". Similarly, nautical twilight is defined as that time after sunset and before sunrise when the sun is 12° below the horizon. Astronomical twilight is that time when the sun is 18° below the horizon, and its limits form the boundaries of true night.

Previous workers (Allen, 1913, Wright, 1913, Allard, 1930) have used the term "awakening time" rather freely. The connotation of the term is that the songs designated as awakening songs indicated the actual rising time of the bird. However, these authors presumably meant these utterances were the first songs of the new day. Allard (1930) recognized that the awakening time of a bird was almost impossible to determine accurately as was stated earlier. The bird may be

awake for some time before it first sings. Therefore, it is incorrect to call the first songs the "awakening time". Walker (1928) termed this first song the "awakening song". Nice (1943) used this term in her work on Song Sparrows. Both workers imply that this is the birds' first song of the morning but that it is not necessarily the time at which they awakened. However, for lack of better terms, this author will continue to use both terms. "Awakening song" will indicate the first songs of the morning and "awakening time" will be that time when the "awakening song" was uttered.

RESULTS

Treatment of Data

During the year of study, the author obtained complete records for approximately 25 species. Of these, 12 were selected for discussion. They are as follows: Cardinal (Richmondena cardinalis), Catbird (Dumetella carolinensis), Crow (Corvus brachyrhynchos), Flicker (Colaptes auratus), Phoebe (Sayornis phoebe), Red-eyed Vireo (Vireo olivaceus), Robin (Turdus migratorius), Rough-winged Swallow (Stelgidopteryx ruficollis), Song Sparrow (Melospiza melodia), White-breasted Nuthatch (Sitta carolinensis), Wood Pewee (Contopus virens), and Yellow Warbler (Dendroica petechia). In Table I will be found a list of these birds giving their status in the woodlot and migration dates where applicable.

In discussing a subject as variable as the awakening time of birds over an entire yearly cycle, grouping of the data in some meaningful manner is necessary. Since the awakening time apparently varied with the seasons, the author presumed, erroneously, that seasonal grouping of the data would be wisest. However, the change of the awakening time over the year did not follow the change in the seasons. Thus the data had to be grouped in another manner in order to illustrate the change in the awakening time. The four periods selected were designed to illustrate the change in the awakening time through the

year. The periods were derived by careful inspection of graphs constructed for each species showing the awakening times, the sunrise curve, and the civil twilight curve (Grapns I through VI). The data for each species was computed for these periods. All species could not be expected to exactly fit these four periods in their awakening time trends. There were three species where the defined periods did not adequately illustrate the true awakening time trend. These exceptions will be discussed later in the species accounts. Although not completely accurate in showing the awakening time trends, grouping of the data for each species into the same four periods was necessary in order to permit comparison between species statistically. Table II lists these periods with the inclusive dates. Hereafter, references to these periods, where practical, will be made by number rather than by dates.

Each daily awakening time or each average awakening time for any period is expressed in the number of minutes before sunrise that the song or call was heard. Previous workers (Allard, 1930, Nice, 1943) have objected to use of the sunrise curve as the basis for comparison stating that the awakening time curve more closely approximates the civil twilight curve. However, by inspection of graphs I through VI, it can be seen that the awakening time curve of birds in this study did not follow rigidly either the civil twilight or the sunrise curves but deviated from both these curves during the year. Therefore, the data will be treated as "minutes before sunrise", a term which this author believes has more meaning and is more quickly understood than the term "deviation from civil twilight".

The daily awakening times for a period were averaged resulting in only one figure representing the awakening time for each species in a period. Previously, averaging awakening times has been objected to by Allard (1930) because it tends to disguise trends toward earlier or later awakening times. While this may be true, for purposes of comparison, reducing the volume of data by the use of averages of daily awakening times is necessary in order to more easily compare the results both within and between species. This was the author's reason for selecting the four periods as they are set up. The periods show adequately the trends in the time of the awakening song for most species.

This author believes that the objection by others to averaging awakening time data was initiated because pioneer workers in this field (Wright, 1913, Allen, 1913, 1915) averaged their results indiscriminately without regard to changes in the awakening time over the season. These workers then stated that this average represented the awakening time of the species. When Allen (1913, 1915) compared his results with Wright's (1913), he found there was some disagreement, especially over the awakening order of the Robin and the Song Sparrow. Allard (1930) explained the disagreements over awakening times by assuming that the difference lay in the "fact" that species arise at the same times in minutes before sunrise on any given parallel of latitude but would not be the same on different parallels of latitude. Therefore, Wright's (1913) New Hampshire awakening time averages would naturally differ from Allen's (1913, 1915) Boston averages. However, this observer believes that the pertinent difference in the research of Allen and Wright is in the fact that Allen's averages represent a longer

period of the year, and, also, his interpretation of awakening time was different. Thus it seems desirable for workers in this field to define their use of an awakening time standard. Dates of the period of the year covered and a graph which shows the change in the time of the first awakening song over that period should supplement the averages employed. Averages of daily awakening times that have been computed from carefully selected periods are reliable and do show the changes in the awakening time during the year.

The standard deviation and the standard error were computed for each species during each of the four periods that it was present in the woodlot. These will be found in Tables III through XIV. The graphical method (Dice and Leraas, 1936) was used to test the significant differences between means. This graphical test was supplemented by the use of "Student's" "t" test where necessary. Throughout the study, the 95% confidence level is considered significant. Graphs VII through XI illustrate these data. No attempt was made to distinguish the difference (if any) in the awakening times of males and females. Also, there was no distinction made between bright and dark or warm and cold mornings or any other variables in the weather. The results below are discussed for each species, and then the different species are compared. Wherever the negative sign (-) precedes a number, the number of minutes before sunrise is indicated. Similarly, a plus (+) indicates the number of minutes after sunrise.

Species Accounts

Cardinal (Richmondena cardinalis). This species was a permanent

resident of the woodlot. The usual number heard singing during the height of the song season was five. During the winter, three or four birds could be heard calling each morning. Some of these data included the singing of the female as well as that of the male. Females were observed singing on several mornings. Laskey (1944) reported that the female Cardinal frequently sang. This same author also stated that the Cardinal sang considerably at night. This observer found night singing to be more irregular and somewhat less in number of songs than reported by Laskey (1944).

The mean awakening time of the Cardinal became progressively later beginning in the spring and continuing through the winter as can be readily seen from Table III and Graph VII. From an early average in period I of -40.6, the average dropped to a low of -23.2 in period IV. This drop in the awakening time mean was not steady but regressed by "jumps". From the graph, one can see that periods I and II overlap as do periods III and IV also. Neither of these were significantly different when the means were tested. Therefore, the awakening time of the Cardinal can be divided into two periods of the year, a spring-summer early awakening and a fall-winter late awakening. The means of the four periods clearly illustrate that this species began its song activity at different times before sunrise during the year.

Song Sparrow (Melospiza melodia). The number of Song Sparrows heard singing or calling varied from ten in the spring to two in the winter. The two birds that remained in the area during the winter months

habitually roosted near the observation post of the author. Thus establishment of their awakening time was easy and quite accurate.

This species showed a decrease in the mean awakening time from period I through period IV as did the Cardinal. The means of the periods well illustrate the change in the awakening time over the year in relation to sunrise. From Graph VII, the difference between the means of the periods can be seen to be highly significant; that is, there is a real difference between all the means of the four periods (also see Table IV). The earliest awakening time was in the spring of the year, and the latest was during the winter period (IV). As with the Cardinal, the division of the data into the four periods did not include any major fluctuations in the time of the awakening song or call. To clarify Wright's (1913) and Allen's (1913) discrepancies in means and in order of awakening, further discussion of the awakening time of the Song Sparrow will be deferred until the discussion of the Robin.

Crow (Corvus brachyrhynchos). Crows were observed in the woodlot all during the year. The number of individuals varied from five or six to 30. The earliest awakening time of the Crow in relation to sunrise occurred in the spring period. The means for the other three periods were somewhat later. All the means of these latter periods fall closely together and were not significantly different (Graph VII and Table V). Therefore, the awakening time periods of the Crow could be divided into two parts. The first part consists of the spring period only, and the second encompasses the remainder of the year. This species

was the only species studied by the author that had such an arrangement of its awakening time periods.

The awakening time periods for the Crow may not be completely reliable, because the species did not roost in the woodlot at any time during the study. The records were from birds flying overhead. However, the records are more accurate than this discrepancy may lead one to believe. The Crows always came from the same direction (southwest) and were invariably heard calling before they were seen. The roost was found to be only a short distance away. Therefore, in light of these factors, the awakening times as given are thought to be quite accurate. There is some doubt in the author's mind as to whether Crows call very soon after beginning their day's activities or wait some time before vocalizing. Zimmer, quoted by Craig (1943), was of this same opinion. Thus the author believes that the data as recorded for the Crow is sufficiently accurate to warrant including in this paper.

White-breasted Nuthatch (Sitta carolinensis). At least two individuals of this species were heard and recorded throughout the study, and at times as many as five were present. The graph for this species (Graph VIII) resembles that of the Song Sparrow except that the means of the four periods are closer together. (See Table VI for the mean, standard deviation, and the standard error computed for the White-breasted Nuthatch.) This species had an awakening time mean that became later and later over the seasons beginning with period I, but the differences between periods were not as great as the means in the other

species. Period IV was the only period that differed significantly from all other periods. Thus the White-breasted Nuthatch definitely awakened later in the winter than at any other time of the year. However, during the other three periods, no distinction could be made which showed this species to arise at different times during these three periods. By referring to Graph VIII, the general trend of the means of these periods to become later as the year progressed can be seen. The only other significant difference that could be shown was between periods I and III, thus strengthening the statement that the bird arose later in relation to sunrise as the year progressed.

Flicker (Colaptes auratus). The Flicker was present in the woodlot during all four periods of the year. Only one bird was there during period IV, however, and no recordings of the awakening time were taken during that period. One possible explanation for the lack of observations of this species in period IV is that the Flicker may be an extremely late riser during that period. Thus the awakening time for period IV may not have been recorded because the observer had left the area before the Flicker awakened. Sherman (1910) stated that the Flicker generally arose " soon after sunrise ". The bird was seen in the woodlot in period IV during the afternoon only. Another possible explanation is that this species is almost silent during period IV in this regionso that the chances of hearing its awakening calls (if it gave one) are negligible. The roosting place of this bird was not located during period IV, nor was it ever seen entering or leaving

the holes that were occupied during the rest of the year. Quite possibly the Flicker did not roost in the area. This would account for the lack of any morning records for this species during period IV.

This species is the first example to be discussed where the use of arbitrary periods in computing the mean awakening time was misleading in that it partially disguised the awakening time trend. While the mean awakening times of the Flicker were considerably different, there was no significant difference of the means between any of the periods (Graph VIII and Table VII). This lack of significance indicated that the Flicker arose at about the same time during all three periods. However, this is not entirely true. Study of Graph II of the awakening time curve and the sunrise curve shows that the division between periods I and II split the Flicker records at the height of the earliest awakening time. Careful study of this graph (II) will show that the Flicker actually arose earlier and earlier from about March 22 until its earliest awakening time was reached on May 4. After this latter date, there was a decline in the earliness of awakening. The birds arose very irregularly through June to December and never again approached the early awakening time of spring.

Robin (Turdus migratorius). The number of Robins heard and recorded each morning varied but was usually about 12 except late in period III when there were fewer birds present. This species followed the pattern of awakening time means previously described for the Cardinal,, except that there were no data recorded during period IV because the species was absent from the woodlot during that period.

The means of periods I and II are not significantly different, but both differ greatly from period III. The difference in awakening time means of periods I and II from the mean of period III is apparent from Graph VIII and Table VIII. The species exhibited the greatest difference of the means between periods of any of the species studied. The Robin arose at approximately the same time during the spring-summer period, but the birds no longer arose as early with the subsidence of the song season and the approach of fall. The mean awakening time became very close to that of the other species. However, Vaurie (1946) in Pennsylvannia stated that the Robin arose earliest during mid and late summer with only the Mourning Dove (Zenaidura macroura) rising earlier. Vaurie's statements were not corroborated in this study.

According to Bent (1949) male Robins roost in large flocks during the nesting season rather than individually near their nests. This kind of activity was not observed at any time during this study. Each morning that records were made the songs of the various individuals always came from the different nesting areas. If these male birds did roost at some site other than the woodlot, they apparently flew into the area long before they were in song. The supposition that they flew into the area before singing is very doubtful, because little movement of birds was observed in the early morning before singing began.

The Robin is a species that did not sing much at night. The Song Sparrow indulged in much night song (Nice, 1943), and thus by

using Wright's (1913) criterion of awakening time one would find that the Song Sparrow arose earlier than the Robin. This author believes that this may be the reason for the disagreement between Wright (1913) and Allen (1913) concerning the order of awakening of the Robin and the Song Sparrow. Nice (1943) was of the opinion that both Wright's (1913) and Allard's (1930) records included night songs of the Song Sparrow. Wright's (1913) average awakening time for the Song Sparrow was -73 while this author's was -33. Allen (1915) gave -29 3/8 as an average for the Song Sparrow. Wright's (1913) average for the Robin was -64, and Allen's (1913) was -63. (Allen arrived at a -53 2/3 average for the Robin in 1915.) This author found the average awakening time for a period comparable to the data of these authors to be -62 for the Robin. The differences between the observations of these authors in the awakening times of the Song Sparrow and the Robin and also the order of awakening of the two species seems to be the discrepancies in the averages for the Song Sparrow. The average for the Robin was constant between the three sets of data. Allard (1930) stated that the disagreement over which species was the earlier riser was the "fact" that birds of higher latitudes (Wright's records) would sing earlier in the morning than birds of lower latitudes (Allen's records). However, this author believes that the major difference between the awakening times of these two species is found in the difference of the awakening time criterion used and the much greater amount of night song indulged in by the Song Sparrow. Therefore, this author also believes that the Robin is the earlier riser of the two species.

Phoebe (Sayornis phoebe). The Phoebe was present in the woodlot during periods I and II only. The reason for the birds' absence during period III is not known. The number of birds during periods I and II was usually three but occasionally only two could be heard.

This species was the anomaly among the birds studied because it arose earliest during the second period of residency in the woodlot which was during period II. All other species studied arose earliest during their first period in the woodlot. The average awakening time for the Phoebe during period I was -20.0, while the average for period II was -31.4 (Table IX). The means of these two periods are significantly different (Graph IX). At present the author is unable to determine why the Phoebe should differ from the other species studied in this respect. There were no notable fluctuations in the awakening times during the periods except near the end of period II when the birds tended to give their awakening song a little later.

Red-eyed Vireo (Vireo olivaceus). The Red-eyed Vireo was present in the woodlot during periods II and III. This species arose earliest during period II (Table X and Graph IX). A slight overlapping of the lines representing periods II and III will be noted on the graph. The test for significance of the means between the two periods showed the means to be significantly different. After reaching their latest awakening time in August and September, the Red-eyed Vireo arose earlier in October, thus exhibiting a very definite fall revival of song as well as an earlier awakening time. The similarity of periods

II and III was caused by the birds exhibiting this decided change in their fall awakening time. While this phenomenon occurred for several species, nowhere was it so marked as with the Red-eyed Vireo. For example, mid-August awakening times were about +4 to -5, while for the first half of October the records were -11, -6, -14, and -12. After these four records were taken, the species was no longer heard in the area. The above information shows the change in the awakening time of the Red-eyed Vireo within one period (III), and, along with the Flicker, illustrates inaccuracy in the periods as defined in determining the trend of awakening time over the seasons. In period II there was no fluctuation of the awakening time.

Wood Pewee (Contopus virens). The Wood Pewee was present in the woodlot during periods II and III. It followed the pattern of rising earliest in the first period during which it was present. The mean of period II is significantly different from the mean of period III (Table XI and Graph IX). This bird, as did most other species, awakened later as the season progressed into fall.

The song of the Wood Pewee in the early morning and late evening is unique. This song was first described as such by Oldys (1902, 1904) who applied the term "twilight song" to it. Oldys (1904) stated that this twilight song lasted about 20 minutes and was not restricted to any particular season, at least while the species was in his area. Saunders (1929) wrote that the twilight song lasted 40 minutes or more and was limited to the time from June to late July. Craig (1943) in his extensive work on the song of the Wood Pewee, divided the

twilight song into a prelude, a rhythmic portion, and a postlude. The rhythmic portion which is the true twilight song lasted from 16 to 32 minutes (average 24½) and was sung from the time of the birds' arrival in the spring until August and September. This observer found that the twilight song was sung from the time of arrival until just before it left the area in September. During the morning the song lasted from the time the bird began singing until about ten minutes before sunrise, a period varying between five and 50 minutes. There were no major fluctuations of the awakening time within any given period, but there was a tendency toward later rising during the latter part of period III.

Wright (1913) found the Wood Pewee to be the earliest riser of all the species he studied. However, Allen (1915) aptly pointed out that the Wood Pewee sings much at night and so Wright's (1913) records undoubtedly reflect his use of night songs as awakening songs. Craig (1943) stated that the Wood Pewee was one of the earliest birds to sing in the morning. He also wrote that all Wood Pewees for which he had records awakened at about the same time with only mild variations in this time. There was no difference in the east-west awakening times and only slight variations in the north-south data (records taken between 34° to 45° north latitude and 68 3/4° to 97 1/2° west longitude). Craig (1943) also stated that the awakening time became earlier in relation to sunrise as the season advanced, and then, after reaching its earliest rising time, became later in relation to sunrise until the birds left on their fall migration. This author obtained the same results from this study.

Catbird (Dumetella carolinense). The Catbird was present in the woodlot during periods II and III, and its earliest awakening time average occurred in period II. The mean of this period (Graph X and Table XII) is significantly different from the mean of period III.

The awakening time of the Catbird was quite regular, and it appeared to be the most regular riser of the species studied. During one portion of period II, the daily awakening times were -41, -40, -39, -40, and -38. In period III, there was one sequence of awakening times as follows; -28, -29, -29, -29, -23, and -28. During the same days that the above records were taken other species were much more variable.

The termination of the awakening time records of the Catbird differed from that of the other species. Most of the other species studied gave their awakening songs or calls later immediately before they left on the fall migration. The awakening time of the Catbird, in contrast, remained constant until the birds departed from the area.

No less than four birds were recorded as singing or calling in determining the awakening time of the Catbird.

Yellow Warbler (Dendroica petechia). The Yellow Warbler was present in the woodlot during the very last part of period I (two awakening time records), all of period II, and part of period III. Because of the lack of sufficient records in periods I and III, no attempt will be made to present conclusions concerning the awakening times during these periods. The reason for the lack of data in period I was the absence of the birds. During period III, however, the species was

present but did not sing or call often enough in the early morning to permit the recording of the awakening time.

The Yellow Warbler was a reasonably constant riser (Graphs VI, X and Table XIII). However, this species is the last of the birds included in this study that exhibited extreme variations of the awakening time within a period. After June 29, the Yellow Warbler began rising several minutes later than it had been rising before that date. From June 29 until the last reliable record was taken on August 2, the awakening time of this species was consistently later than it had been during the first of the period.

Chapman (1907) quoted Jones as stating that there was a decided decrease in the amount of singing of the Yellow Warbler after mid-July. A similar decrease was noted in the present study after August 1 after which time the birds almost ceased singing. Until that time, there had been five birds whose awakening times were recorded every morning.

Rough-winged Swallow (Stelgidopteryx ruficollis). This species was present in the woodlot during period II only. Although there were few records for this bird (12), they were included because early rising tendencies have been attributed to members of the swallow family. The birds roosted about 150 yards up-stream from the observer, and it was their habit to fly back and forth over the river in front of the observer. The author is quite certain that these calls were the first morning utterances of this species as their twittering could be heard quite some distance. Graph X and Table XIV present the data on the awakening time of the Rough-winged Swallow.

DISCUSSION

The Awakening Time Curve

It is a well known fact that birds rise earlier in the spring and summer than at any other time of the year. Any field worker can observe that birds do not rise as early in the winter as they do during the summer. The data presented in this paper has shown that the awakening time curve of several species of birds became not only earlier in relation to clock time but also in relation to the sunrise and civil twilight curves. Then, after the birds reached their earliest rising time, the awakening time curve again more closely coincided with the sunrise and civil twilight curves as fall approached. Other authors have concurred in these findings, notably Walker (1928), Allard (1930), Craig (1943), and Nice (1943). However, Emlen (1937) has observed a female Mockingbird (Mimus polyglottos) that awakened later in relation to the time of sunrise as the nesting season approached.

Allard (1930) and Nice (1943) have stated that the awakening time curve more closely approximates the civil twilight curve than it does the sunrise curve. Allard (1930) stated that the earliest rising time occurred at the summer solstice. This is what lead him to believe that the awakening time curve was a duplicate of the civil twilight curve. Careful scrutinizing of graphs I through VI will show that this is not true, at least for the birds in this study. The awakening

time curve did not follow the civil twilight curve any more closely than it followed the sunrise curve. The earliest awakening times were reached either before, at, or after the summer solstice.

The period of the earliest mean awakening time for the permanent residents and the earliest migrants (except the Phoebe) for this study was period I. The remaining species had their earliest awakening time means during the first period in which they were present. The general statement may be made that the mean awakening time of a migrating species will be earliest in that period during which it is first present in the area while the mean awakening time of a permanent resident will be earliest in period I. It is obvious, not only from this statement, but, in addition, from perusal of the limits of the periods as used in this paper (Table II), that some birds will have their earliest awakening times before the summer solstice. Other species will have their earliest awakening times either corresponding with or after the summer solstice.

Order of Awakening

Since there is a definite order of awakening, an analysis of this order within each period would be of interest. For each species during each period, the graphical method (Dice and Leraas, 1936) was used to test for significant differences of the means. A range of four standard errors with the mean as the mid-point was plotted on the graph for each species. Significant differences of the means can be discerned by the lack of overlap of the line for one species with the

line of another. Broad overlap of these lines indicated no significant differences of the means. Slight overlap or any doubtful cases were tested by the use of the "t" test. Graphs VII through XI were constructed in this manner.

The difficulty of discerning which species of birds arose before other species was enormous during certain periods because of the extent of the overlapping of the lines representing four standard errors. To facilitate reading of Graph XI, Tables XV through XVIII were made. Explanation of these tables is presented with Table XV.

The awakening order of the various species was easily discernible during period I. Graph XI and Table XV show that the Robin was the earliest riser. The Song Sparrow and the Cardinal, although having very different means, were not significantly different. The means of the Crow and the Phoebe were significantly different when tested, but the means of the White-breasted Nuthatch and the Flicker were not. Therefore, the species observed in this study, for the most part, did rise at significantly different times during period I.

Periods II and III were the two most complicated periods in distinguishing the order of awakening. Written descriptions of the order of awakening of the species during these periods would serve no purpose. One can discern the general pattern of the awakening order by studying Graph XI and Tables XVI and XVII.

Period IV is depicted in Graph XI and Table XVIII. This period is much easier to evaluate than the two preceding periods mainly because there were only four species recorded. The Cardinal was the

earliest riser, while the mean of the Song Sparrow did not differ significantly from that of the Crow. Thus these two species arose essentially at the same time. The White-breasted Nuthatch followed as the latest riser.

The above comparison of the order of awakening times of the species by periods has shown the apparent futility of trying to establish an exact, unchanging order of awakening. However, one should notice that the total range of awakening times, as computed by allowing two standard deviations above and below the mean for the earliest and the latest rising species, was from +9 to -103 minutes from sunrise in period I, a range of 112 minutes. In period II, the range was 97 minutes (+4 to -93). In period III, the range was reduced to 63 minutes (+7 to -56), and in period IV, the range covered only 40 minutes (+5 to -35). This reduction of the range of awakening time indicated that there was a tendency for the various species to reduce their awakening times to a narrower range as the season progressed. All of the species studied arose at more similar times in the winter than they did in the spring. This statement can be shown further and more conclusively by computing the range of awakening times for those species that were permanent residents. In period I, the range was 73 minutes for these species, in period II 50 minutes, in period III 50 minutes, and in period IV 40 minutes. From these data, the pattern for the species of this study appeared to be that birds vary considerably over the seasons in their awakening times, but a definite pattern existed in which all species tended to rise within a shorter period of time during each

morning as the seasons progressed (beginning with period I). The species awakening times were reduced to a "base level" in the late fall and winter. As spring approached, the earlier rising species arose much earlier than the later rising species and thus widened the range of awakening times once more.

In the comparison of all species, the failure of the ranges of periods I and II in differing from each other was due to the Robin. This species remained at its earliest awakening time during period II and thus equalized the total ranges of periods I and II. For species that were permanent residents, the difference in the ranges of periods I and II was 23 minutes. Periods II and III for these species were identical, however, indicating a summer-fall equilibrium of awakening time. The range of awakening times during period IV was the smallest of any of the periods.

Changes in the Order of Awakening

Walker (1928) was of the opinion that the order of awakening times between species did not change through the year. Allard (1930), having a different opinion, stated that the order did change. This observer believes that some species change their relative sequence of awakening times through the seasons. In Table XIX will be found listed the periods and the relative positions of the four species that were permanent residents. The means of the Song Sparrow and the Cardinal were not significantly different during the year except in period IV when the Cardinal arose earlier. However, in period I, the average

of the awakening times of the Song Sparrow was five minutes earlier than the average of the Cardinal. The original records revealed that in almost every instance the Song Sparrow arose before the Cardinal during this period. Therefore, the Song Sparrow and the Cardinal did change their order of awakening during the year if one considers the field observations valid. The "t" test between these periods showed no significant differences in the means of these two species. The Crow and the White-breasted Nuthatch maintained their same order of awakening throughout the year.

Other changes in the order of awakening times are shown in Table XX. The Robin and the Catbird reversed their sequence between periods II and III, and the Phoebe and the Crow exchanged places in the awakening order between periods I and II. Records indicated that there may have been a change in the order of awakening between the Red-eyed Vireo and the Crow during periods II and III. The difference of the means of these two species was so great during period III that the author believes that the Red-eyed Vireo and the Crow changed their order of awakening. However, this change was represented in the means only, for the means of period III did not test significantly different.

The comparison of the change in the order of awakening of species during the year did not show the gradual transition that occurred as these birds changed their order of awakening. There were days during the observations when the species changing their awakening order were rising at the same time. This did not last long but was observable in the field. Thus one can not only observe a change in the order of

awakening from the data, but one can also observe this change as it is accomplished in the field.

Wright (1913) and Allen (1913, 1915) did not indicate that any change in the order of awakening took place. This is undoubtly due to the paucity of data that they had. Also, their data were collected during a number of years and over such a small portion of the year that any change in thw awakening order was probably not noticeable to either author. Walker (1928) did not detect any change in the awakening order from her data which were collected from October through July. Allard (1930) stated that species did vary in awakening order through the seasons. His work extended from January through August. The results of this study showed that the greatest change in the order of awakening occurred between the months of February and November while December through January saw no change in the order of awakening. Thus Walker (1928) could easily have overlooked any change in the order of awakening that may have occurred. The results of this study agreed in general with Allard (1930); that is, the order of awakening changes over the year for many species.

Ranking of Species as Early or Late Risers

Many authors who have written on the awakening times of birds have expressed opinions as to the relative earliness of lateness of this time for different species and families. For the most part they have agreed. However, most of them were considering only the period of intense singing. This will introduce error into their statements

because the time of awakening not only becomes later and later in relation to sunrise during the year, but, also, the order of awakening changes. Therefore, any statements as to the earliness or lateness of the awakening time of a species should include the time of year during which the data were collected. Since most observers have gathered their data in the spring and early summer, comparable records in this study include data form periods I and II. In Table XXI the author has arbitrarily divided the species into four categories according to his computed means and his beliefs as to the relative awakening times during the seasons. The terms "earliness" and "lateness" of awakening for all periods are based on period I-II. Consequently there were no early risers in periods III and IV. The following comparisons with the results of other authors were based on this author's period I-II.

There is considerable agreement concerning the species which are extremely early risers in relation to sunrise. Wright (1913), Allen (1915), Allard (1930), and Wallace (1955) all consider the Robin to be a very early riser. The Song Sparrow is considered to be an early riser (Wright, 1913, Allen, 1913, 1915, Nice, 1943), although its position in the "bird clock" has been disputed. Oldys (1904), Wright (1913), and Craig (1943) considered the Wood Pewee to be an early riser. No statements as to the position of the Catbird or the Cardinal were found in the literature.

The Rough-winged Swallow and the Phoebe were in the "middle" rising group. Published evidence indicates that both the swallow and the flycatcher families are early risers. Wright (1913) and Allen (1913)

stated that swallows were early risers. Allen (1922) stated that the Kingbird (Tyrannus tyrannus) was one of the earliest risers, and Wright (1913) and King (1955) stated that the Alder Flycatcher (Empidonax traillii) was a very early riser. Wright (1913) considered that the Wood Pewee was the earliest rising species. MacQueen (1950) published records showing that the Least Flycatcher (Empidonax minimus) was an early riser. However, the results of this study showed that two of the three species observed representing these two families were not early risers. Of course, it is not essential that all members of a family rise at the same or nearly the same times. But generalized statements as to the awakening time of an entire family of birds should not be made until substantiated by sufficient observations.

The Crow, Yellow Warbler, and the Red-eyed Vireo were in the "late" rising group in this study. Allen (1913, 1915) stated that Crows were early risers (average -42) while Wright (1913) stated that they were comparatively late (average -26). This study indicated that Crows were late risers. Wright (1913) considered warblers in general to be early while Saunders (1929) considered them late risers. Allen (1913) stated that warblers as a family were not late, but he also wrote that the Yellow Warbler was one of the latest rising of the family. Bent (1953), however, stated that the Yellow Warbler was an early riser. Little has been written concerning the awakening time of vireos. Wright (1913) found the average of 22 records of the Red-eyed Vireo to be -31. This author found the average for this species to be -25 for 24 records.

The last group of species has been termed "very late" because this

group differed so greatly in awakening time from the other three groups. Many observers have agreed that woodpeckers were late risers (Wright, 1913, Bussman, 1933), some even stating that certain species did not arise until after sunrise (Sherman, 1910, Tanner, 1941). Apparently there is little known concerning the awakening time of the White-breasted Nuthatch. Wright (1913) gave one record of +10, and Tyler (1916) published one record of +19 stating that this pecies was a late riser. This author found the White-breasted Nuthatch was a late riser, but considerably earlier in awakening time than the two records above indicate.

The various species did not retain their same ranking as early or late risers as the season progressed. By referring to Table XXI, one can see that only the late risers maintained the same rank throughout the entire year. This again shows the fact that the birds all tended to awaken within a narrower range of time in minutes each day as the seasons advanced toward winter. However, one observer has found that this is not true. Vaurie (1946) stated that both the Robin and the Song Sparrow were early risers in mid and late summer. This study did not corroborate these findings of Vaurie (1946).

SUMMARY AND CONCLUSIONS

1. The awakening time curves of most species of birds approximates the sunrise and civil twilight curves during the year but with systematic deviations during some seasons.

2. The average awakening time of a species is a useful figure in illustrating the variation in awakening time during the year if determined by the use of periods of relatively constant awakening times.

3. It is obvious that birds awaken earlier in that time of year when the sun rises earliest; that is, they rise earlier according to the clock.

4. It is not so obvious that species of birds also awaken earliest in the spring (periods I and II) in relation to the sunrise and civil twilight curves.

5. All species do not awaken earliest in relation to sunrise at the summer solstice.

6. Permanent residents rise earliest in relation to sunrise during period I as designated in this paper (most of March and all of April).

7. Migrating species rise earliest in relation to sunrise for about one month immediately after arriving on their nesting grounds. (There are certain exceptions which do not sing for about a week after arrival. These species then quickly reach a "peak" of early rising.)

8. The order of awakening for certain species may vary through the year.

9. The mean awakening time of birds varies most from species to species during the spring and early summer, the range of difference being least during the fall and winter periods.

10. Comparison of the observations in the present study with work of others suggests that some species arise at about the same time before sunrise regardless of moderate differences of latitude and longitude.

APPENDIX

I Tables

II Graphs

I TABLES

TABLE I

STATUS OF SPECIES IN THE WOODLOT

Species	Status	First Date	Last Date
Cardinal	permanent	---	---
Catbird	summer	May 4	October 11
Crow	permanent	---	---
Flicker	permanent	---	---
Phoebe	summer	March 22	July 20
Red-eyed Vireo	summer	May 16	October 15
Robin	summer	March 13	November 12
Rough-winged Swallow	summer	May 6	June 4
Song Sparrow	permanent	---	---
White-breasted Nuthatch	permanent	---	---
Wood Pewee	summer	May 18	September 19
Yellow Warbler	summer	April 28	September 6

TABLE II

ARBITRARY PERIODS OF AWAKENING TIMES
WITH INCLUSIVE DATES

Period	Dates
I	March 7 to April 30
II	May 1 to July 30
III	August 1 to November 30
IV	December 1 to March 6

TABLES III THROUGH XIV CONTAIN PERTINENT DATA FOR EACH SPECIES

TABLE III

CARDINAL

Period	Number of Records	Range*	Mean*	Standard Deviation	Standard Error
I	21	17-68	40.6	14.46	2.69
II	31	26-46	35.5	4.89	0.88
III	34	12-46	26.8	7.93	1.36
IV	23	8-33	23.2	5.75	1.77

TABLE IV

SONG SPARROW

Period	Number of Records	Range	Mean	Standard Deviation	Standard Error
I	21	26-76	45.9	13.54	2.96
II	30	23-40	33.6	4.60	0.84
III	34	16-36	25.8	4.74	0.81
IV	20	+2-29	17.8	7.89	1.77

* The range and mean for each period in Tables III through XIV are expressed in the number of minutes before sunrise except where a plus (+) sign indicates minutes after sunrise.

TABLE V

CROW

Period	Number of Records	Range	Mean	Standard Deviation	Standard Error
I	21	11-34	25.9	6.54	1.43
II	32	+2-28	18.5	6.98	1.23
III	34	7-34	19.0	5.67	0.97
IV	23	+8-27	16.3	8.55	1.78

TABLE VI

WHITE-BREASTED NUTHATCH

Period	Number of Records	Range	Mean	Standard Deviation	Standard Error
I	22	+3-19	11.9	4.85	1.03
II	21	+6-20	9.7	6.50	1.42
III	24	+10-21	6.2	6.62	1.35
IV	15	+5-10	1.7	3.59	0.93

TABLE VII

FLICKER

Period	Number of Records	Range	Mean	Standard Deviation	Standard Error
I	10	+6-16	7.2	8.01	2.53
II	9	+6-24	1.3	7.75	2.58
III	14	+9-17	5.1	5.91	1.58

TABLE VIII

ROBIN

Period	Number of Records	Range	Mean	Standard Deviation	Standard Error
I	20	27-95	61.6	20.55	4.60
II	28	22-86	63.5	14.98	2.83
III	20	17-40	25.9	5.80	1.30

TABLE IX

PHOEBE

Period	Number of Records	Range	Mean	Standard Deviation	Standard Error
I	12	3-32	20.0	7.65	2.21
II	26	22-42	31.4	6.00	1.18

TABLE X

RED-EYED VIREO

Period	Number of Records	Range	Mean	Standard Deviation	Standard Error
II	24	1-37	24.8	10.79	2.20
III	10	+4-35	13.8	12.28	3.89

TABLE XI

WOOD PEWEE

Period	Number of Records	Range	Mean	Standard Deviation	Standard Error
II	23	+8-57	44.6	17.41	3.63
III	15	9-48	26.7	14.76	3.81

TABLE XII

CATBIRD

Period	Number of Records	Range	Mean	Standard Deviation	Standard Error
II	29	2-63	43.1	12.42	2.30
III	24	18-38	29.5	4.21	0.86

TABLE XIII

YELLOW WARBLER

Period	Number of Records	Range	Mean	Standard Deviation	Standard Error
II	28	10-31	21.9	6.44	1.22

TABLE XIV

ROUGH-WINGED SWALLOW

Period	Number of Records	Range	Mean	Standard Deviation	Standard Error
II	12	13-48	34.5	10.98	3.17

TABLE XV

RELATIVE SEQUENCE OF AWAKENING
FOR PERIOD I

1. Robin (61.6)

2. Song Sparrow (45.9) —————— 3. Cardinal (40.6)

4. Crow (25.9)
⋮
5. Phoebe (20.0)

6. White-breasted Nuthatch (11.2)— 7. Flicker (7.2)

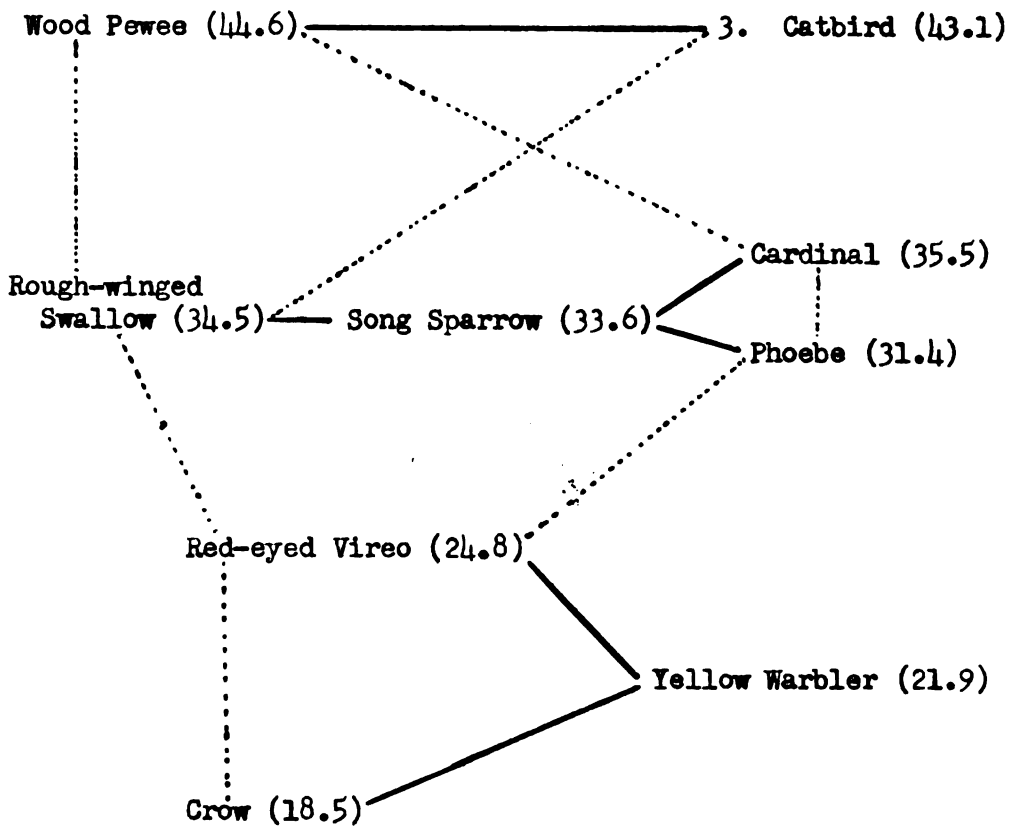
Explanation of Tables XV, XVI, XVII, and XVIII.

The species are in their approximate awakening order from top to bottom. No lines between species indicate that their means are significantly different. Lines between species indicate the means of the species in question are not significantly different. Dotted lines between two species indicate that the means were tested with the "t" test and were found significantly different. The 95% confidence level was considered significant. Figures in parentheses are the means during the period in minutes before sunrise.

TABLE XVI

RELATIVE SEQUENCE OF AWAKENING
FOR PERIOD II

1. Robin (63.5)



11. White-breasted Nuthatch (9.7)

12. Flicker (1.3)

TABLE XVII

RELATIVE SEQUENCE OF AWAKENING
FOR PERIOD III

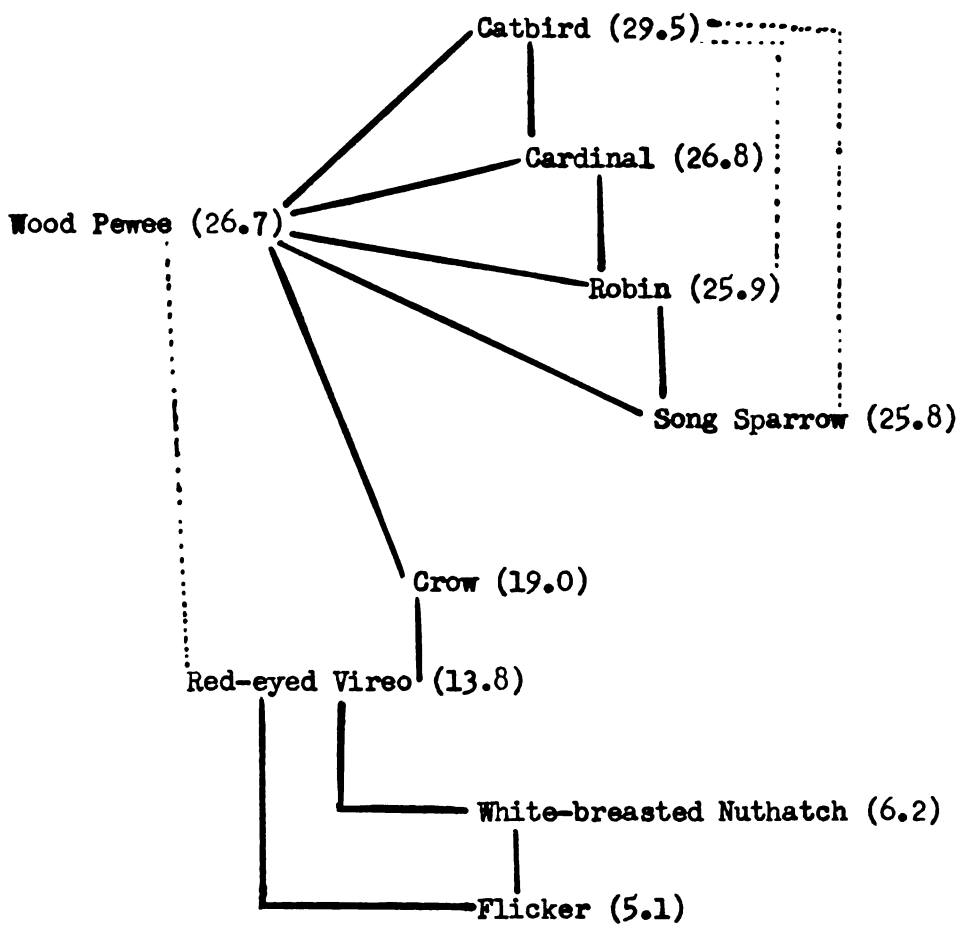


TABLE XVIII

RELATIVE SEQUENCE OF AWAKENING
FOR PERIOD IV

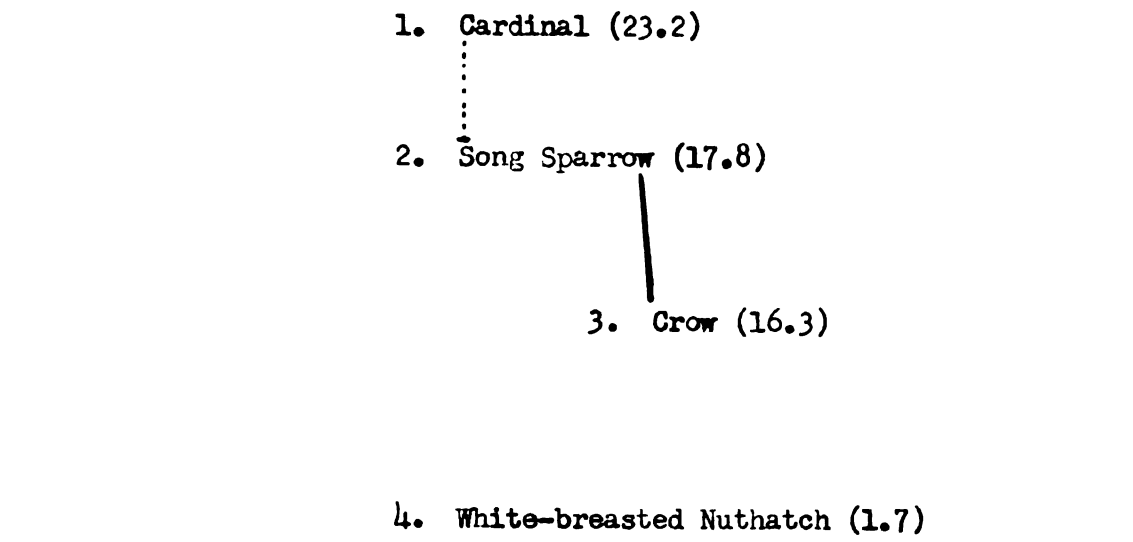


TABLE XIX

CHANGE IN THE ORDER OF AWAKENING TIMES OVER THE FOUR PERIODS AS ILLUSTRATED BY THE FOUR PERMANENT RESIDENT SPECIES

Period	Species
I	1. Song Sparrow (45.9) Cardinal (40.6) 3. Crow (25.9) 4. White-breasted Nuthatch (11.9)
II	1. Cardinal (35.5) Song Sparrow (25.8) 3. Crow (18.5) 4. White-breasted Nuthatch (9.7)
III	1. Cardinal (26.8) Song Sparrow (25.8) 3. Crow (19.0) 4. White-breasted Nuthatch (6.2)
IV	1. Cardinal (23.2) 2. Song Sparrow (17.8) Crow (16.3) 4. White-breasted Nuthatch (1.7)

In this table note the gradual shift in awakening order of the Song Sparrow and the Cardinal as the season progresses. Also note the continuity of the positions of the White-breasted Nuthatch and the Crow. There was no significant difference in the rising time between the Crow and Song Sparrow during period IV. Figures in parentheses are the means during the period in minutes before sunrise.

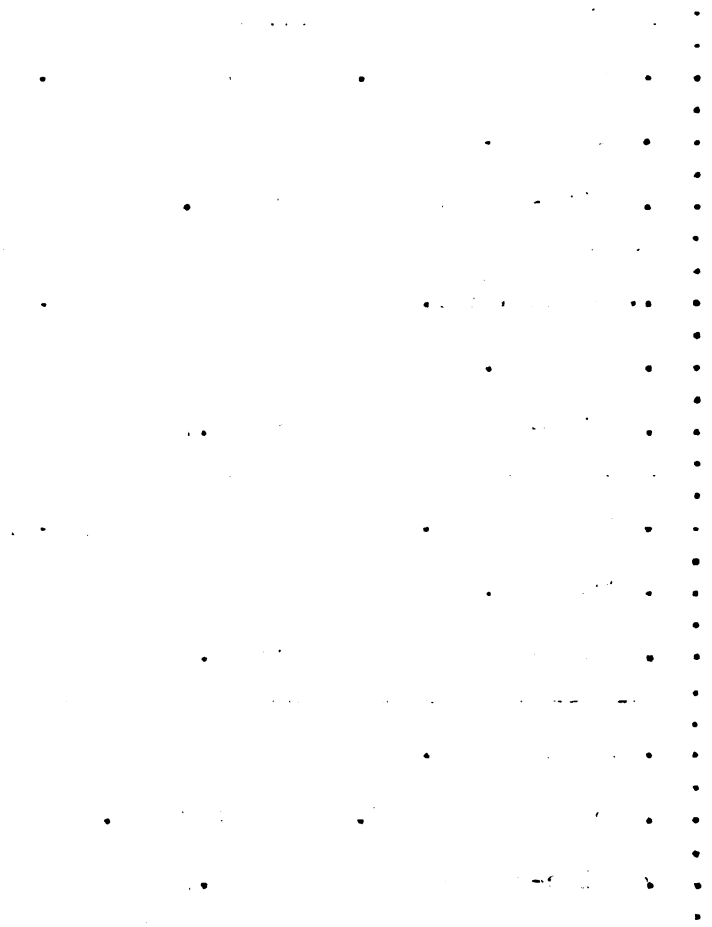


TABLE XX

CHANGE IN THE ORDER OF AWAKENING TIMES OF SEVERAL SPECIES

Period II	Period III
Robin (63.5)	Catbird (29.5)
Catbird (43.1)	Robin (25.9)
Period I	**Period II**
Crow (25.9)	Phoebe (31.4)
Phoebe (20.0)	Crow (18.5)
Period II	**Period III**
Red-eyed Vireo (24.8)	Crow (19.0)
Crow (18.5)	Red-eyed Vireo (13.8)
	These do not test significantly different at the 95% level, but there is a great difference in the means suggesting a change in the awakening order.

Figures in parentheses are the means during the period in minutes before sunrise.

TABLE XXI

RANKING OF SPECIES BY RISING TIME

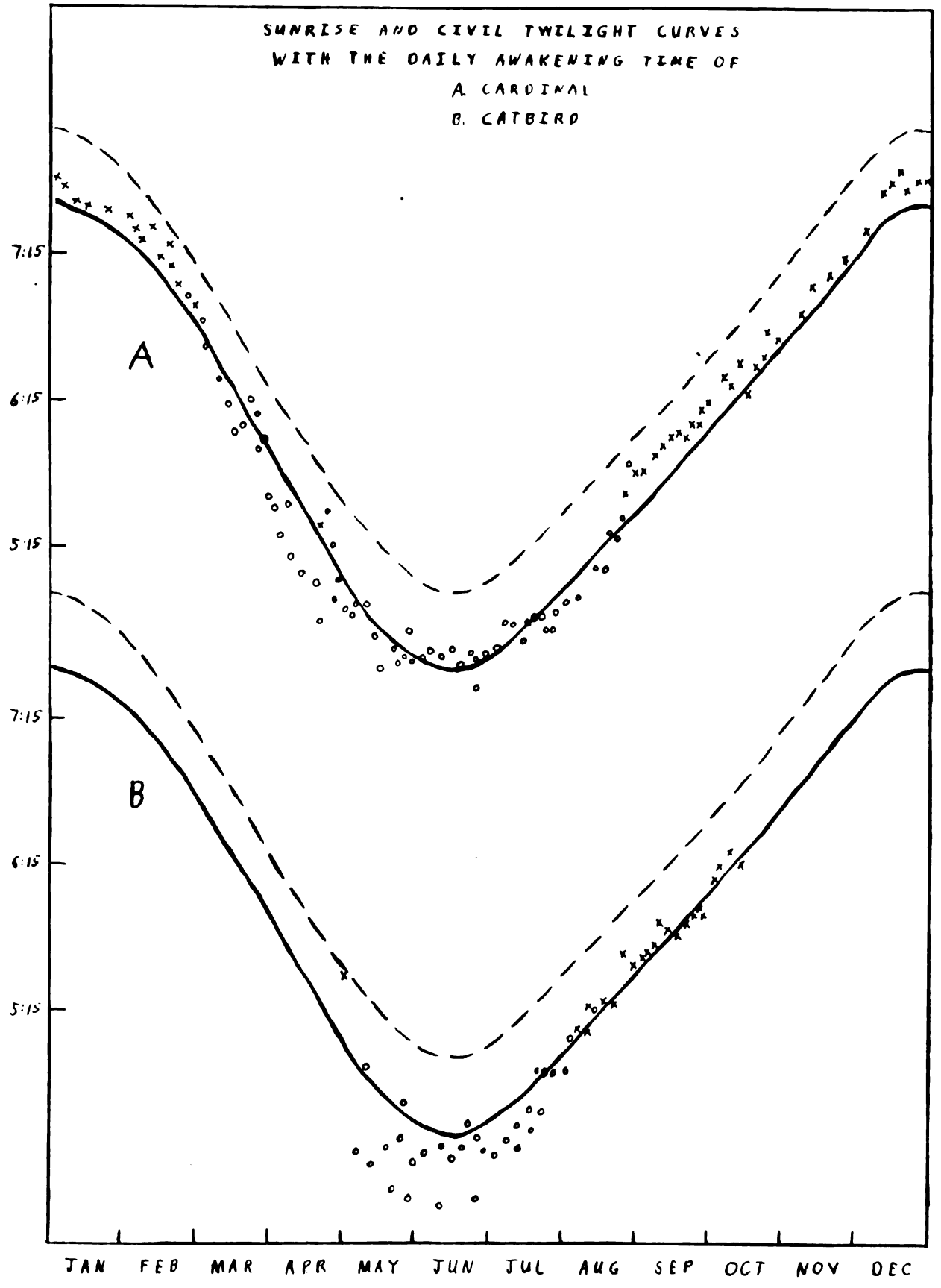
Period	Early	Middle	Late	Very Late
I-II	Cardinal Catbird Robin Song Sparrow Wood Pewee	Phoebe Rough-winged Swallow	Crow Red-eyed Vireo Yellow Warbler	Flicker White-breasted Nuthatch
III	(None)	Cardinal Catbird Robin Song Sparrow Wood Pewee	Crow Red-eyed Vireo	Flicker White-breasted Nuthatch
IV	(None)	Cardinal	Crow Song Sparrow	Flicker (presumably) White-breasted Nuthatch

II GRAPHS

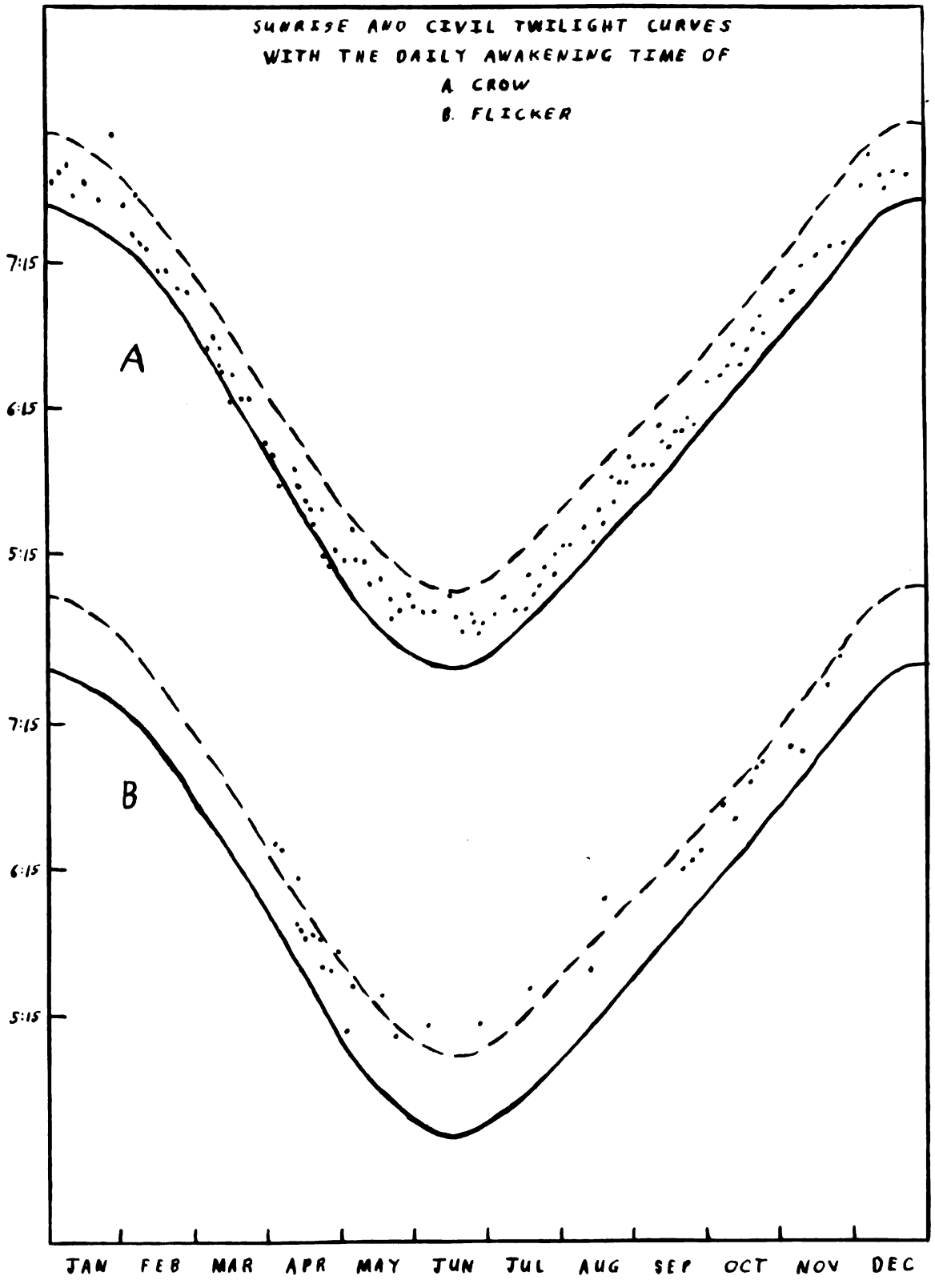
Explainations of Graphs I-VI

These graphs illustrate the sunrise curve (dashed line), the civil twilight curve (solid line), and the daily awakening times of 12 species discussed. Symbols representing the awakening time are circles (o) indicating singing, crosses (x) indicating calls, and dots (•) indicating the awakening utterances when no distinction was made between calls and songs. The time of morning (E.S.T.) is given on the left of the graph and the months of the year at the bottom.

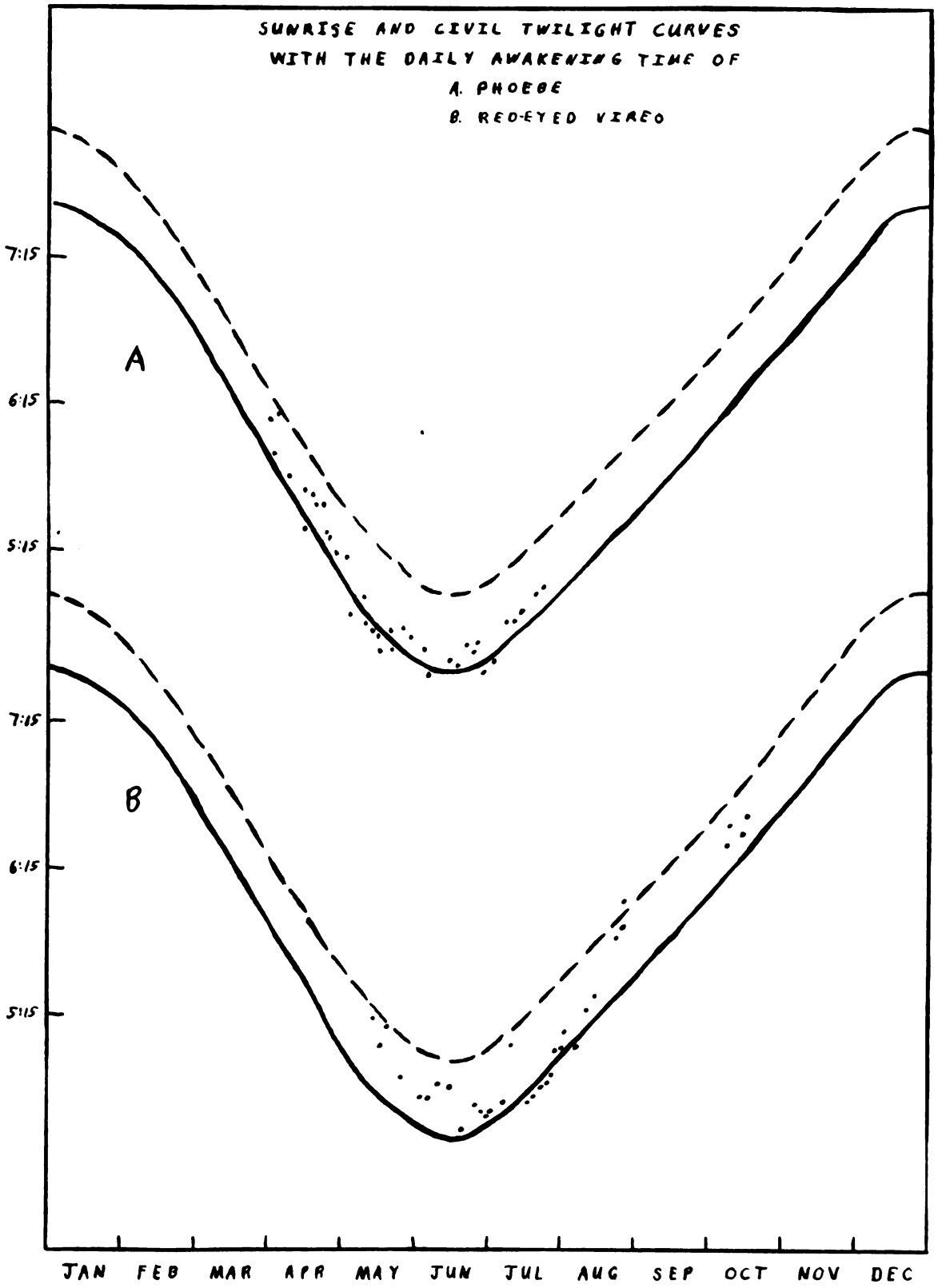
GRAPH I


SUNRISE AND CIVIL TWILIGHT CURVES
WITH THE DAILY AWAKENING TIME OF
A. CARDINAL
B. CATBIRD
7:15
6:15
5:15
A
7:15
6:15
5:15
B
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

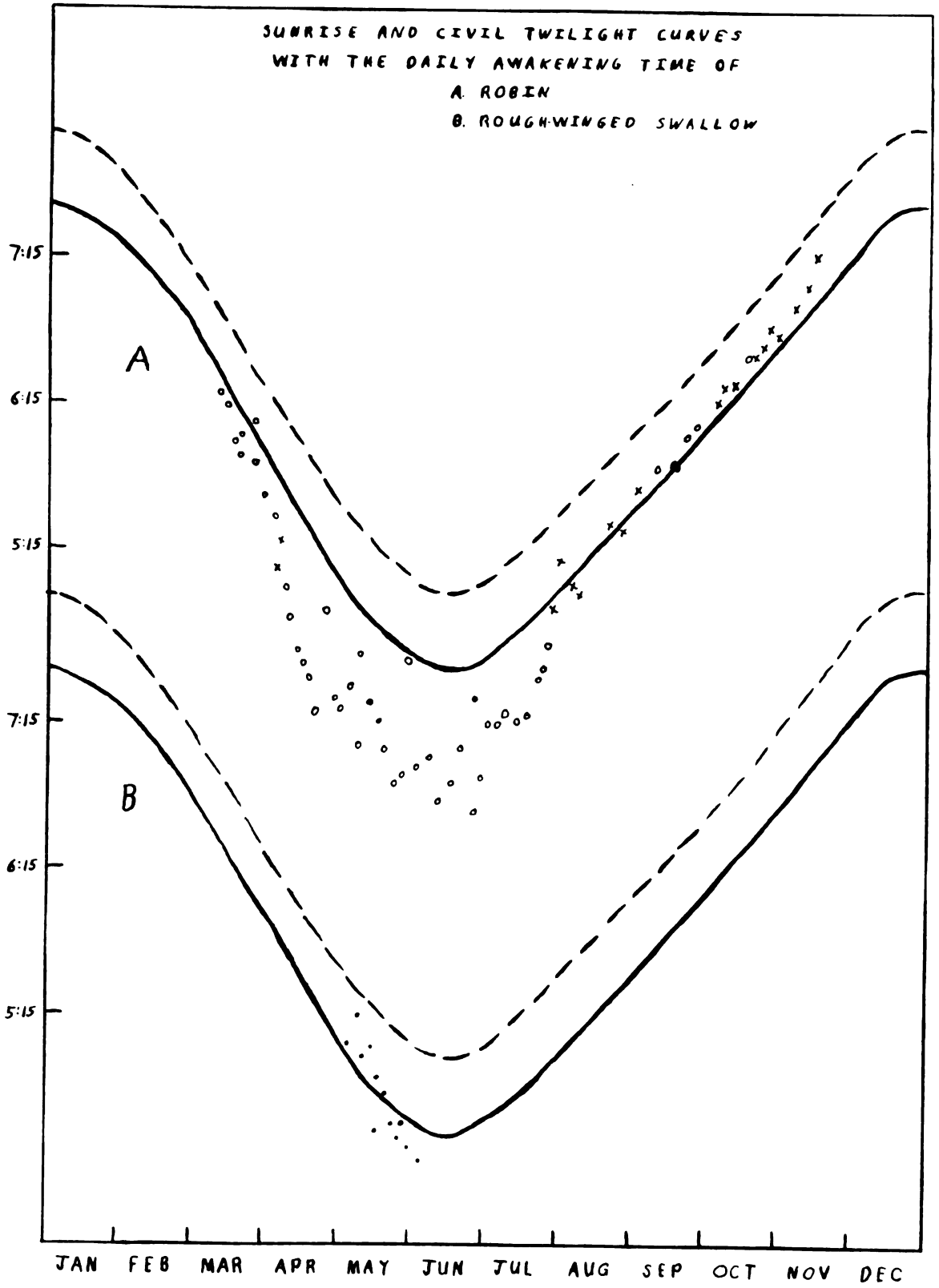
GRAPH II


SUNRISE AND CIVIL TWILIGHT CURVES
WITH THE DAILY AWAKENING TIME OF
A. CROW
B. FLICKER
7:15
6:15
5:15
A
7:15
6:15
5:15
B
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

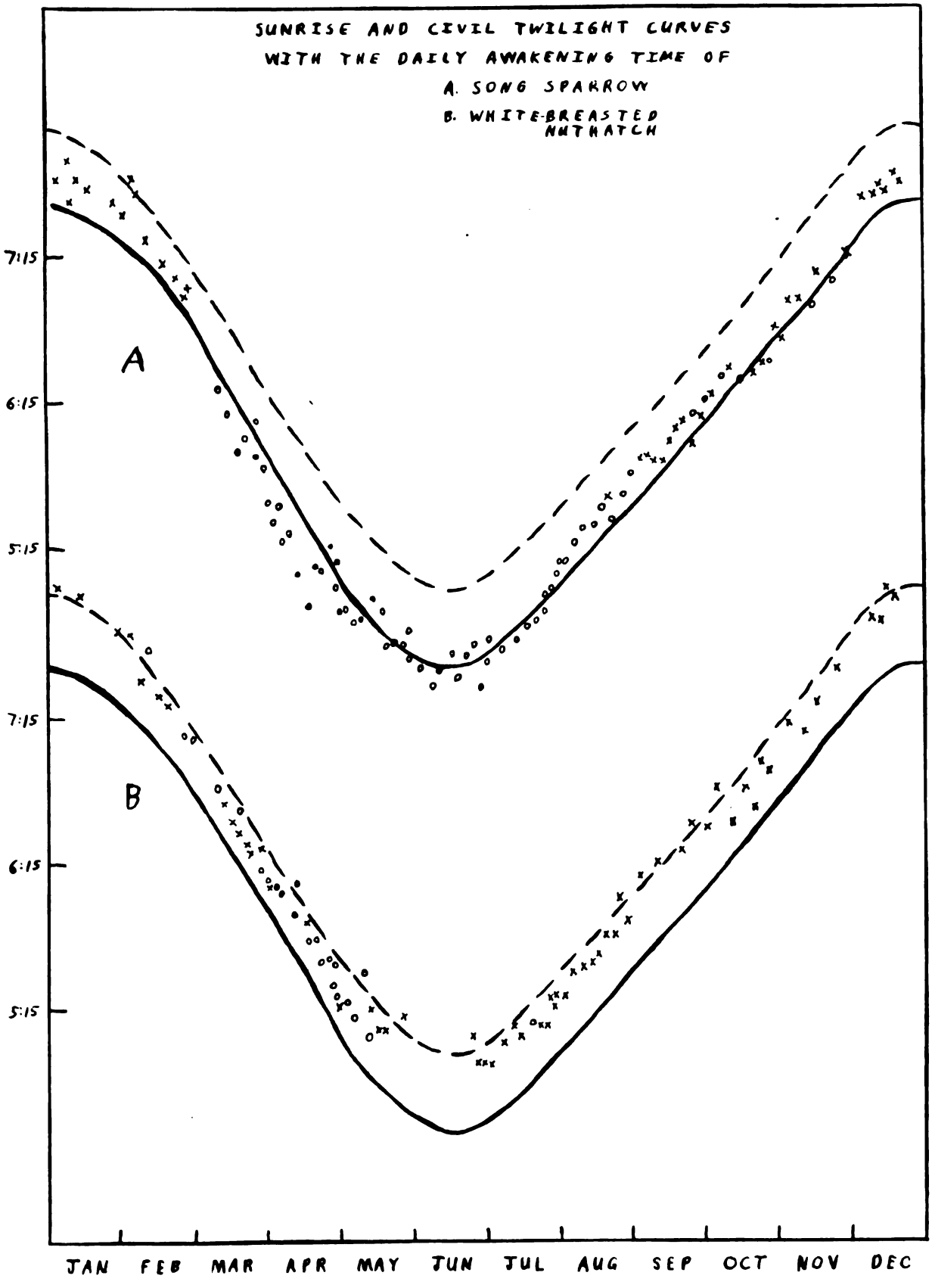
GRAPH III


SUNRISE AND CIVIL TWILIGHT CURVES
WITH THE DAILY AWAKENING TIME OF
A. PHOEBE
B. RED-EYED VIREO
7:15
6:15
5:15
A
7:15
6:15
5:15
B
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

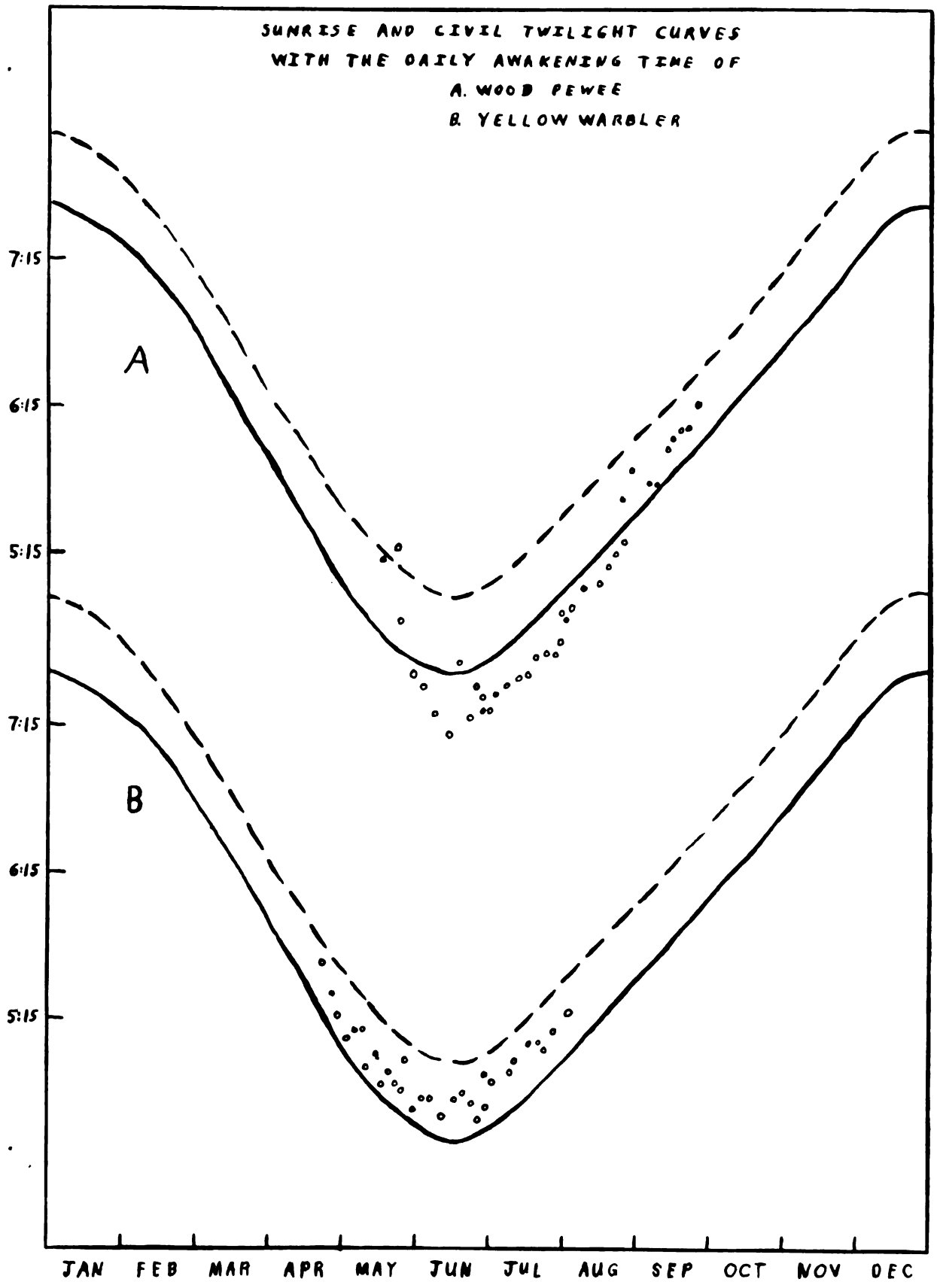
GRAPH IV


SUNRISE AND CIVIL TWILIGHT CURVES
WITH THE DAILY AWAKENING TIME OF
A. ROBIN
B. ROUGH-WINGED SWALLOW
7:15
6:15
5:15
A
7:15
6:15
5:15
B
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

GRAPH V

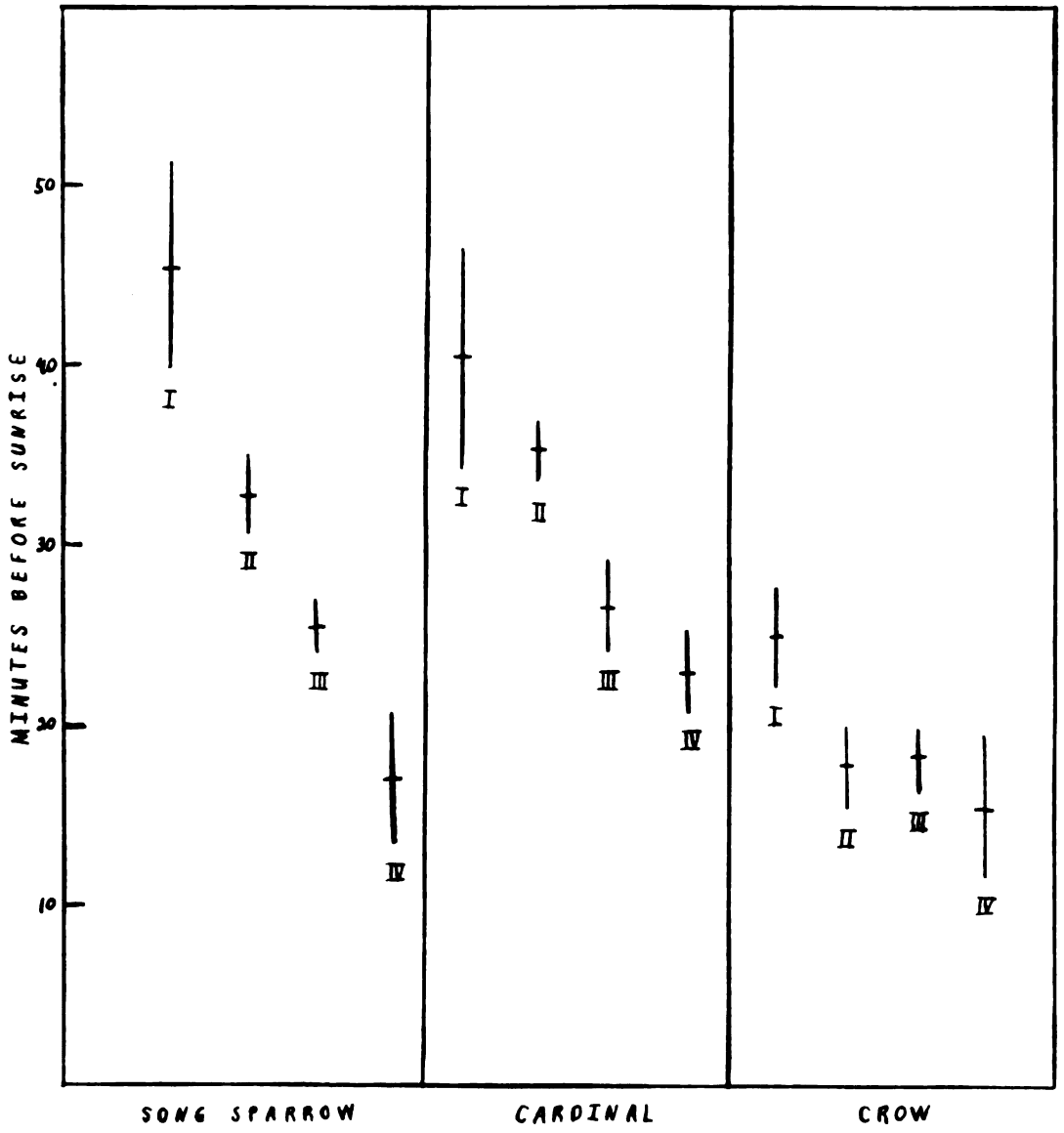

SUNRISE AND CIVIL TWILIGHT CURVES
WITH THE DAILY AWAKENING TIME OF
A. SONG SPARROW
B. WHITE-BREASTED NUTHATCH
7:15
6:15
5:15
A
7:15
6:15
5:15
B
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

GRAPH VI


SUNRISE AND CIVIL TWILIGHT CURVES
WITH THE DAILY AWAKENING TIME OF
A. WOOD PEWEE
B. YELLOW WARBLER
7:15
6:15
5:15
A
7:15
6:15
5:15
B
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

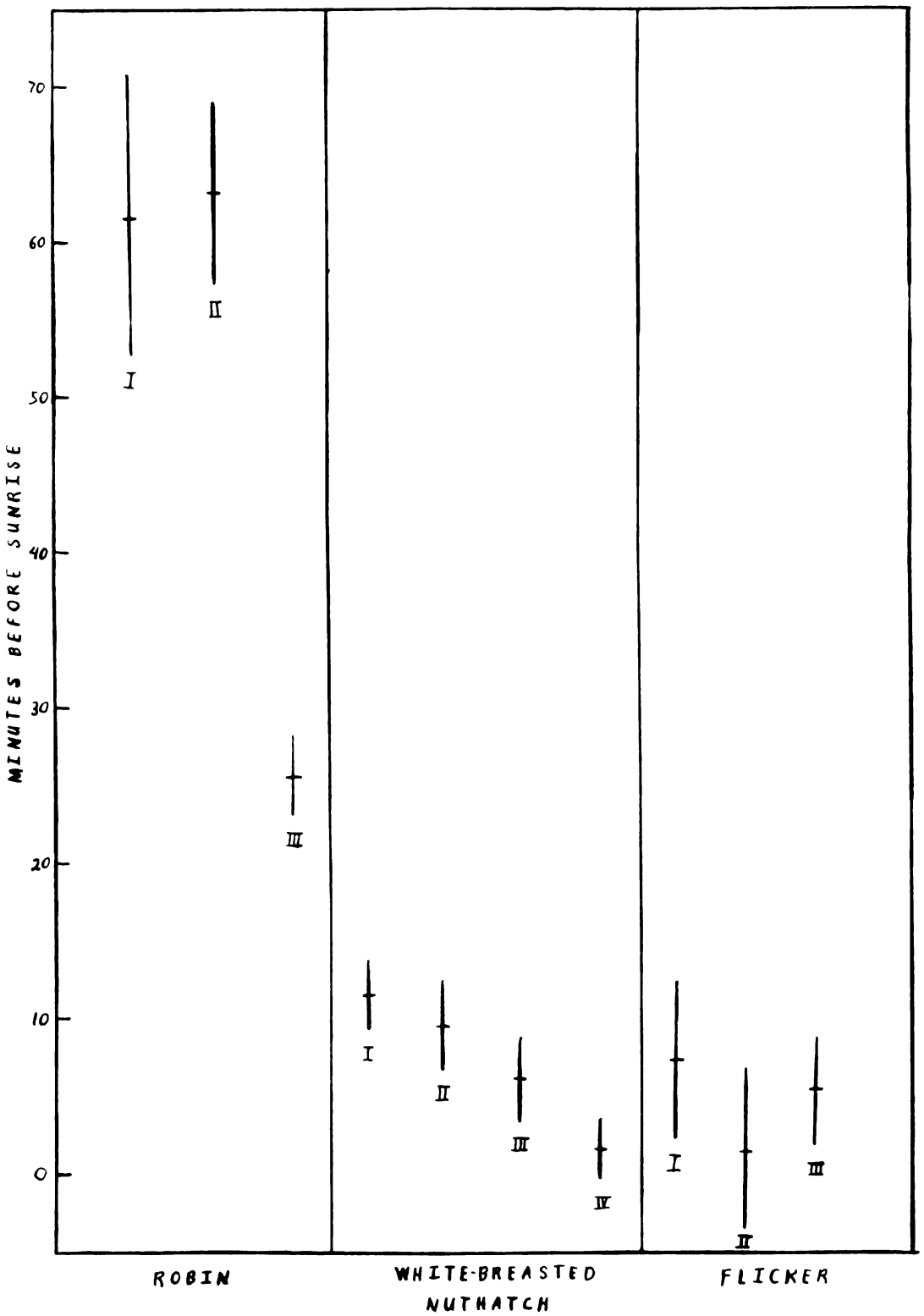
GRAPH VII

SIGNIFICANT DIFFERENCE OF MEANS



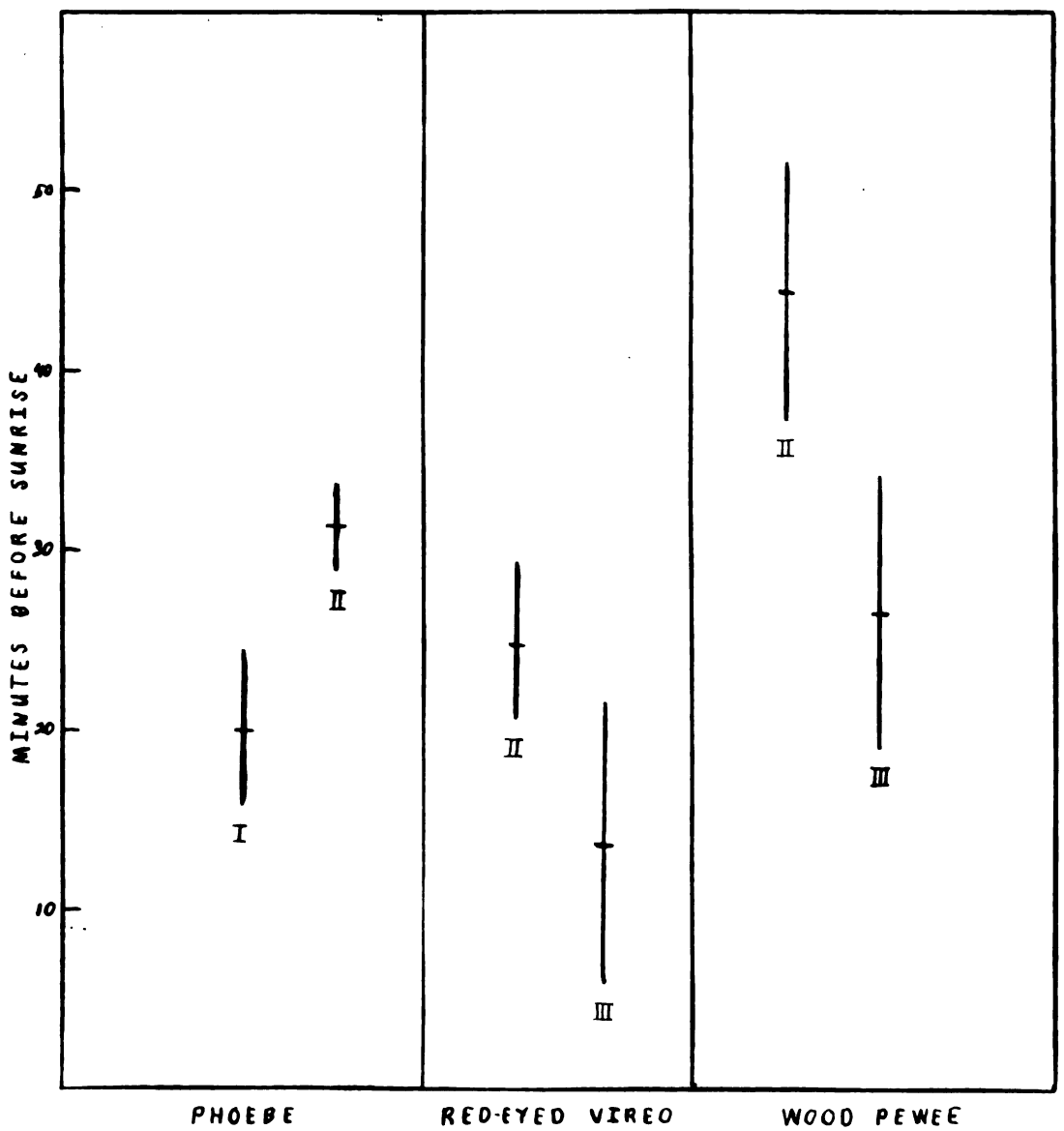
GRAPH VIII

SIGNIFICANT DIFFERENCE OF MEANS



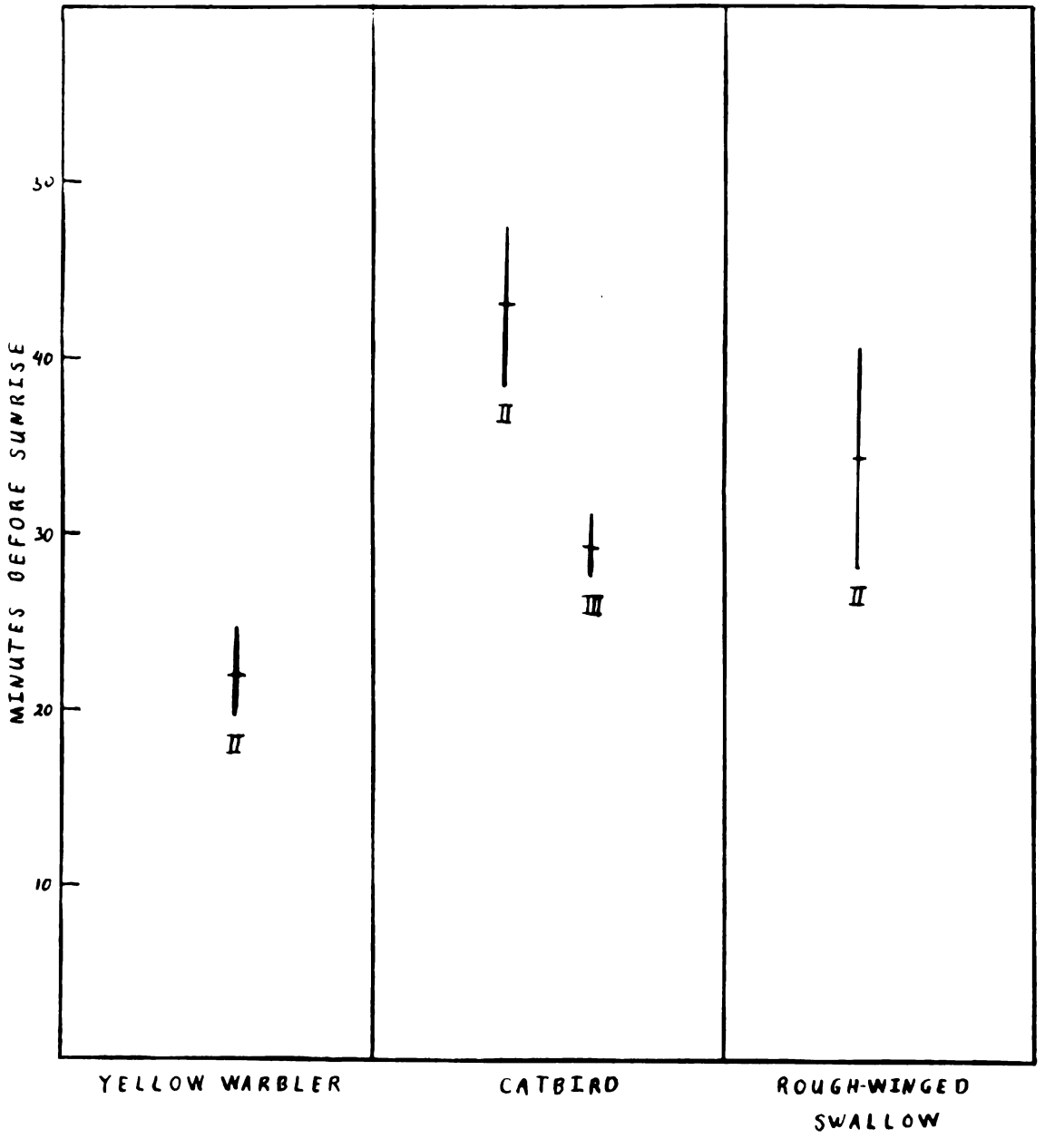
GRAPH IX

SIGNIFICANT DIFFERENCE OF MEANS



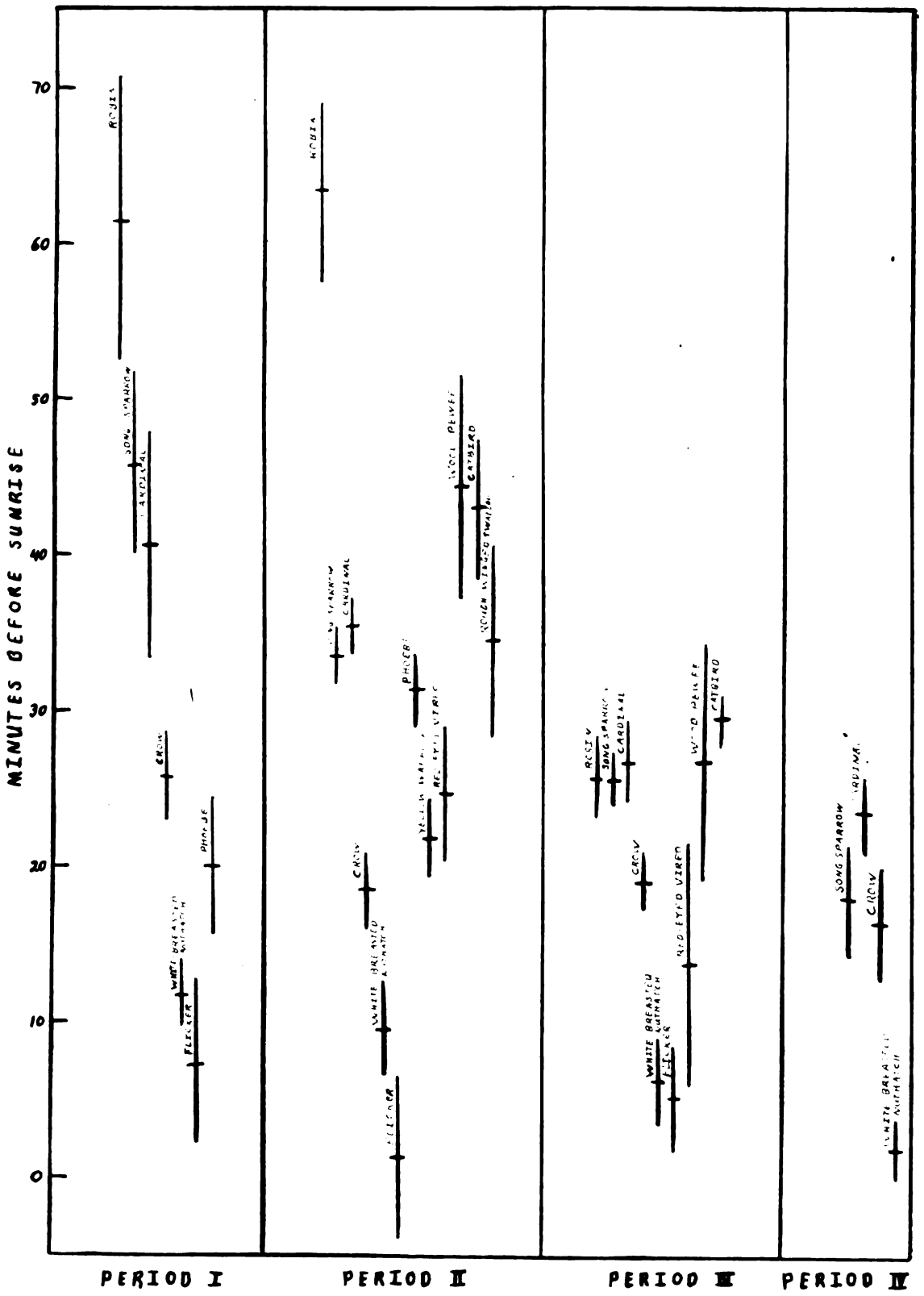
GRAPH X

SIGNIFICANT DIFFERENCE OF MEANS



GRAPH XI

SIGNIFICANT DIFFERENCE OF MEANS



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