A PRELIMINARY INVESTIGATION OF THE OVER-WINTER POPULATION CHANGES IN PLATHEMIS LYDIA (DRURY) AND PERITHEMIS DOMITIA (HAGAN) (ODONATA: ANISOPTERA) OF MONTGOMERY COUNTY, TENNESSEE

BY

J. WESLEY MARQUESS

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A Research Paper

Presented to

the Graduate Council of

Austin Peay State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

in Biology

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by

J. Wesley Marquess

August 1975

ACKNOWLEDGEMENTS

The author expresses sincere appreciation to Dr. Floyd M. Ford, Professor of Biology, Austin Peay State University, under whose guidance and direction this study was made.

Appreciation is also extended to Dr. Charles N. Boehms, Vice President for Student Affairs, Austin Peay State University and Dr. Wayne Chester, Professor of Biology, Austin Peay State University for suggestions and reading of the manuscript.

Gratitude is expressed to Mr. F. W. Richardson for the use of his pond where these studies were conducted.

Special thanks are extended to my parents, Rev. and Mrs. Odell Marquess for their many years of financial support and encouragement. Without their help this study would not have been possible.

To the Graduate Council:

I am submitting herewith a Research Paper written by J. Wesley Marquess entitled "A Preliminary Investigation of the Over-Winter Population Changes in Plathemis lydia (Drury) and Perithemis domitia (Hagan) (Odonata: Anisoptera) of Montgomery County, Tennessee". I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Biology.

Floyd M. Ford
Major Professor

Accepted for the Council:

Wayne E. Kline

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CHAPTER I

INTRODUCTION

The immature stages of anisopterous Odonata, or dragonflies, are aquatic and feed upon various insects or other organisms. Complete life cycles have been worked out for only a few, but probably the great majority have 11 to 14 nymphal instars. The length of each instar varies greatly, lasting only a few days or sometimes persisting for as long as six months (Pennak, 1953).

Emergent times vary greatly for different species of Odonata. Fletcher (unpublished), in his study of Odonata of Mark's Slough (Montgomery County, Tenn.), found emergent dates for different species ranged from April 26 until the time his project was terminated on July 1.

Corbet (1960) recognized two fairly distinct types of dragonflies according to emergent times. He described a "spring species" as one that emerged early in the spring and which had a high degree of synchrony of emergence. Studies of Anax imperator, which was termed a "spring species", showed that fifty percent of emergence took place the first three days. By the fourth day seventy-five percent had emerged. The peak of emergence was reached early in the season and flying time was short. A dragonfly can usually be recognized as a "spring species" if it over-winters in the final instar of nymphal development (Corbet, 1963).

The second type was termed a "summer species". The "summer species" showed less synchronization of emergence, emerged later in the season and flew over a longer period of time. The "summer species" overwintered in some nymphal stage other than the final instar (Corbet, 1963).

Time of emergence may be affected by a period of delayed nymphal development called diapause. During this period growth, metabolism and mitosis are slowed or stopped (Richards, 1937). Frequently, diapause occurs at a stage in the life cycle which is adapted to resist unfavorable climatic conditions (Andrewartha, 1952).

Eller (1963), conducted a two year study of a population of Pachydiplax longipennis in a permanent pond at Chapel Hill, North Carolina. His study revealed that the most reliable method to determine intermoult development was by measuring the distance between the mesial ends of the posteriomesial extensions of the compound eyes. Position of the wing sheaths was also used to determine stage of nymphal intermoult development. He found that measurement across the widest part of the head proved to be the best single indicator of instar class. Body length was useful to determine only the final two or three instarts.

Fletcher (unpublished), first observed Plathemis lydia (Drury) flying on April 26. This early emergent date would tend to categorize Plathemis lydia as a "spring species". Perithemis domitia (Hagan) was first seen flying on June 10. The later emergent time would suggest that Perithemis domitia as a "summer species". On the basis of this work these two species were chosen for the present study. The purpose of this study was (1) to determine composition of instar classes during

the period November 1974 through May 1975 (2) to determine if diapause occurred in instar classes and (3) emergent dates of the two species.

CHAPTER II

REVIEW OF THE LITERATURE

Our present knowledge of Odonata found in Tennessee can be primarily attributed to Wright (1938a). In his review of the literature he described dragonflies which had been reported in Tennessee. Later the same year he added two more species to the list (Wright, 1938b). Again, Wright (1943) reported another species and Wright and Shoup (1945) added three more to the existing list. Kormondy (1957) revised the work of Wright and added eight species to the checklist from Tennessee. Fletcher (unpublished), in a survey of Odonata of Montgomery County, Tennessee, reported two species that had not been previously cited in this area. His checklist included 12 species known to inhabit Montgomery County and a total of 73 for the state.

Corbet (1960), classified dragonflies as to "spring species" and "summer species". "Spring species" were those which underwent diapause in the final instar of nymphal development and had a synchronized emergence with an early peak and a short flight season. "Summer species" exhibited diapause in an instar other than the final, showed less snychrony in emergence and flew over a longer period of time.

Kormondy (1964), stated that there were varying degrees of synchrony in emergence among species and even variation within the same species from year to year.

Eller (1963), in a study of seasonal regulation of Pachydiplax longipennis used eye indices determined by the distance between mesial ends of the posteriomesial extensions to place nymphs into six instar

classes. In his two-year study he found that 97 to 98 percent of the population of Pachydiplax longipennis exhibited a univoltine life cycle different from that of "summer species" described by Corbet (1960).

The work of Hackney (1974), on Pachydiplax longipennis in a temporary pond agrees with Eller (1963) that this species is a "summer species" with a life cycle similar to that of a "spring species".

Boehms (1971), in a study of Sympetrum vicinum, also established indices for placing individuals of this species into ten nymphal instar classes. These indices were based on head width, abdomen width and body length.

Although different stages of instar development are mentioned throughout the literature, Boehms (1971) and Eller (1963) are the only two found to establish indices for placing nymphs into instar classes.

In the survey of the literature I could find no information on the life cycles or over-wintering stages of Plathemis lydia or Perithemis domitia.

CHAPTER III

METHODS AND MATERIALS

Research Animals: Dragonflies (order Odonata) are members of class Insecta, the largest single group of animals. Insecta is included in the phylum Arthropoda, which is a group of animals with a hard exoskeleton and jointed appendages.

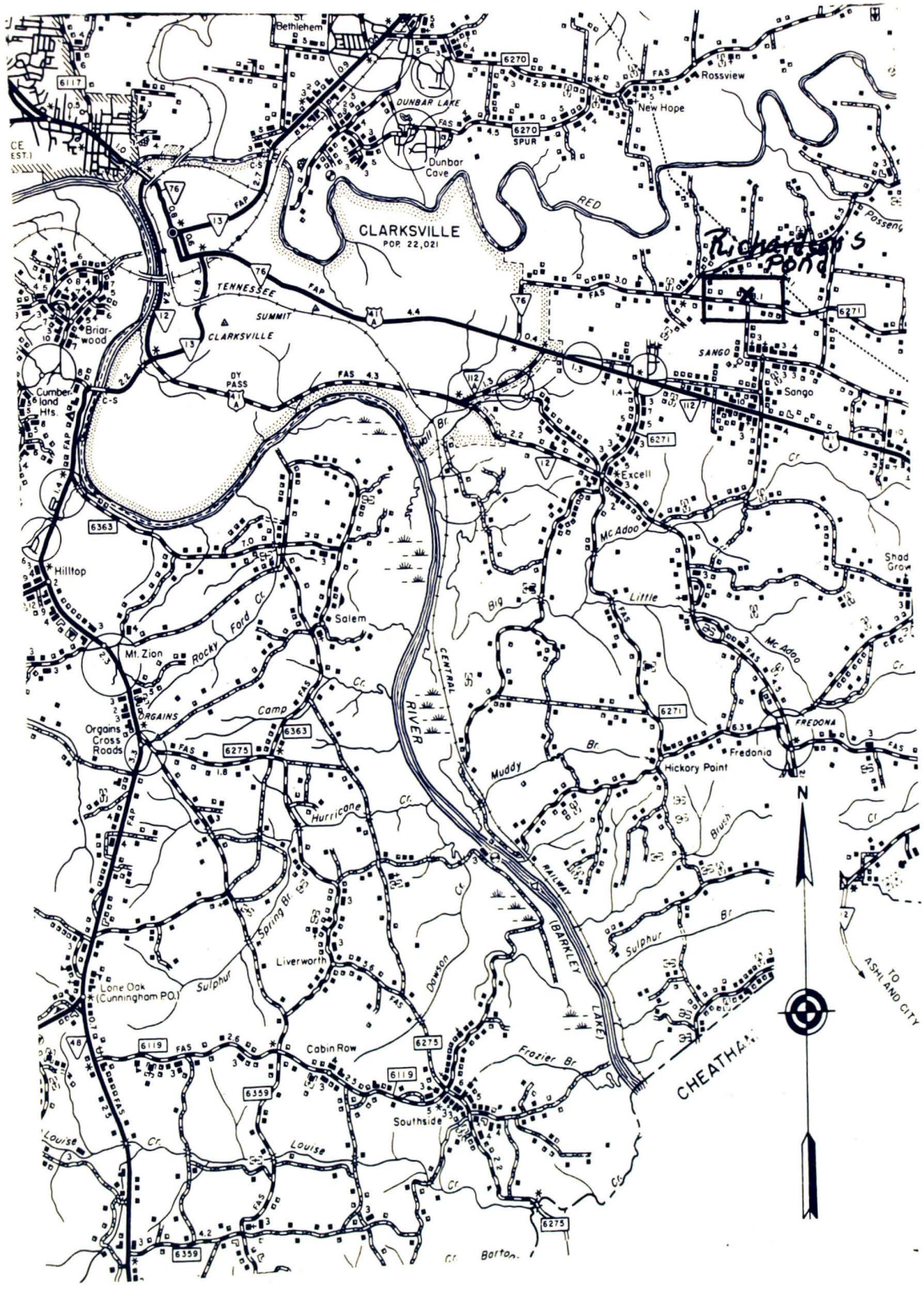
Plathemis lydia (Drury), is a widely distributed species of dragonfly (Pennak, 1953). The nymph has a hairy body and the widest part of the head is behind the eyes. Dorsal hooks are found on segments II through VI, the highest hook being located on segment V (Needham and Westfall, 1955). Paraprocts and epiprocts are equal with the cercus being one-half the length of the epiproct. There are 10 labial setae with hook while the distal margin of the ligula is crenulate (Ward and Whipple, 1959).

Perithemis domitia (Hagan), according to Pennak (1953), also is a widely distributed species. The dorsal hooks on segments VIII and IX are the same size (Corbet, 1960). There are six lateral setae. Superior and inferior appendages are shorter than the combined length of abdominal segments VIII and IX. The lateral spines on segment IX do not reach the tip of the anal appendages.

The Study Area: A pond on the F. W. Richardson farm located on Trough Spring Road approximately six miles east of Clarksville, Tenn. was chosen as the study area (Figure 1). It covered approximately

Location of Richardson's Pond

(Tennessee Department of Highways Map)



one-fourth acre, but during the fall and winter rains enlarged to about one-half to three-fourths acre. It was used chiefly as a cattle watering source.

Little vegetation, other than Festuca ssp seeded on the banks, grew in or around the pond. In the southeast corner Celtis occidentalis and Rosa multiflora grew on the bank. The rose bush extended over and to the bottom of the pond. Salix nigra grew in the pond and several fallen logs were submerged. The southeast corner was the only area of the pond where nymphs were found. Water in this area was approximately 60 cm deep.

Materials: A fine mesh, rectangular Turtox net was used to scrape mud and debris from the bottom of the pond. After the silt was washed from the material, the debris was resuspended in water and poured into white enamel pans for sighting the nymphs. This method worked well for the larger Plathemis lydia nymphs which moved freely and were easily spotted once poured into the pans. However, the smaller Perithemis domitia nymphs, which rarely moved, were extremely difficult to separate from the debris by this method unless the green ventral surface was up. In order to spot these nymphs, the material was scattered over a large area of $2mm^2$ screen wire. Attempts were made to collect 50 nymphs of each species per week.

Nymphs were transported to the laboratory in jars of pond water. In the laboratory they were placed into individual glass bowls for measurement and study. After measurement, nymphs were returned to the pond to prevent reduction of the population. Collections were made weekly from the same collection site.

Procedures: Measurements were made with a Spencer binocular dissecting microscope with a 2x objective and 9x objectives. The right eyepiece contained a micrometer calibrated to .094 millimeters at 18x.

To determine instar class body length and distance across the widest part of the head were recorded for each nymph.

In order to establish indices for placing nymphs into instar classes, attempts were made to raise nymphs of both Plathemis lydia and Perithemis domitia in the laboratory and take the above body measurements between moults. Nymphs were placed in covered glass dishes containing strained pond water at 21° Centigrade. Blood worms were fed the nymphs and the above body measurements were made at three day intervals.

Included in the total body measurement was the distance between the anterior part of the head and the posterior end of the paraprocts. Eller (1963) found total body length to be useful in separating only the final three instars. Body length measurements were difficult since the nymphs could contract and expand the abdomen.

Eller (1963) found the distance between the mesial extensions of the posteriomesial lines of the compound eye was of value in placing nymphs into instar classes. Plathemis lydia does not have posterior-mesial lines extending from the eyes. A pigmented area does extend from the compound eyes of Perithemis domitia and the distance between these areas was recorded. This distance seemed to vary from individual to individual regardless of size and could not be utilized to place nymphs into instar classes.

For head width, measurements were taken across the widest part of the head. Eller (1963) determined that the width of the head was the single most reliable indicator of instar class. A "Head Width Index" was devised from his study to place nymphs into one of the following instar classes: Antepenultimate-minus-three (A-3), Antepenultimate-minus-two (A-2), Antepenultimate-minus-one (A-1), Antepenultimate (A), Penultimate (P), and Ultimate (U).

CHAPTER IV

RESULTS

Both Plathemis lydia and Perithemis domitia proved to be difficult to raise in the laboratory. All specimens of Plathemis lydia died within 30 days and none ever moulted. The longest surviving nymphs of Perithemis domitia was 36 days. Five of the nymphs did moult but all died within five days after moult.

Since attempts to rear nymphs through emergence were unsuccessful, it was not possible to establish indices for placing individuals into instar classes. Therefore, classifications used by Eller (1963) and Boehms (1971) were applied to data collected in this study.

Collections were made each week except the weeks of December 29 and February 9 when heavy rains prevented collections from being made. Near the end of March, heavy rains in Montgomery County caused flooding of the pond. Collections were again missed March 30 and April 7. When collections were resumed on April 13, numbers of nymphs for both species were greatly reduced. Since large numbers of Rana catesbeiana were at the pond on the April 13 collection date, it was thought that predation was the reason for disappearance of the nymphs. Dissection of six of the frogs and examination of the stomach contents revealed that only two contained body parts of dragonfly nymphs. The only other explanation that can be offered is that when the pond flooded the nymphs migrated to the outer edges of the pond onto the surrounding area which was covered with Festuca ssp. When the water receded, this resulted in the nymphs being trapped.

Numbers continued to be reduced until on May 1 two nymphs of Perithemis domitia and none of Plathemis lydia were found.

On 19 collection dates, 816 nymphs of Plathemis lydia were collected and measured. Figure 2 applies Eller's (1963) head width index to measurements of Plathemis lydia. Although the classification would probably not coincide exactly with one for this species, it appears to be close since the largest head width recorded was 4.95 millimeters wide and Plathemis lydia was first seen flying on April 13, thirteen days prior to the first sighting of this species by Fletcher (unpublished).

The percent composition for each instar class using head width of Plathemis lydia was computed for each collection date (Table I). The population had become relatively stable by the December 1 collection date and the population consisted of five instar classes: A-2, A-1, A, P, and U. After the February 2 collection date, only three instar classes remained in the population. The largest number of individuals were in the Penultimate instar class with an average of 72 percent for February, 66 percent for March and 60 percent for April (Figure 3). The Antepenultimate class comprised the second largest group of nymphs with 28 percent in February, 20.5 percent in March and 36.5 percent in April. April 27 was the last collection date that nymphs of Plathemis lydia were found, therefore there are no data for this species beyond that date.

When Boehms' Head Width Index data were applied to the measurements of Plathemis lydia measurements of this species fell within the limits of instar classes VII through X. The minimum measurement of Class VII

Figure 2. Range of head width of specimens of Plathemis lydia for each collection date. Heavy vertical line (▮) represents range of head width. Dot (•) represents only one specimen collected or more than one specimen with the same head width. Horizontal line is the mean. Instar classes are according to Eller's (1963) classification.

U - Ultimate

P - Penultimate

A - Antepenultimate

A-1 - Antepenultimate-1

A-2 - Antepenultimate-2

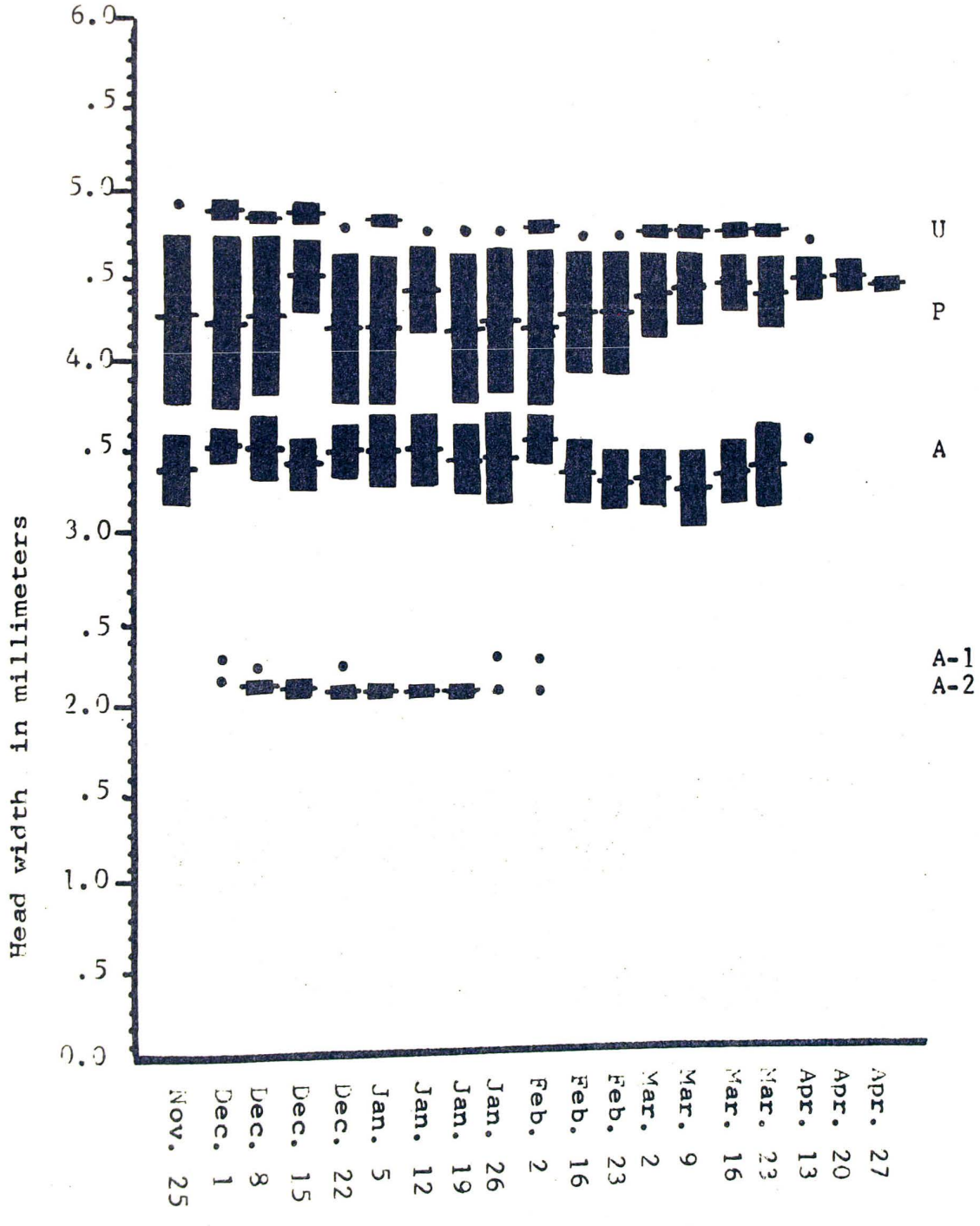

Head width in millimeters
6.0
.5
5.0
.5
4.0
.5
3.0
.5
2.0
.5
1.0
.5
0.0
U
P
A
A-1
A-2
Nov. 25
Dec. 1
Dec. 8
Dec. 15
Dec. 22
Jan. 5
Jan. 12
Jan. 19
Jan. 26
Feb. 2
Feb. 16
Feb. 23
Mar. 2
Mar. 9
Mar. 16
Mar. 23
Apr. 13
Apr. 20
Apr. 27

TABLE I

Percent Composition of Instar Classes for *Plathemis lydia* per Field Collection from November 25, 1974 to April 27, 1975.

N = Number of specimens collected
A-3 = Three stages preceding the Antepenultimate
A-2 = Two stages preceding the Antepenultimate
A-1 = One stage preceding the Antepenultimate
A = Antepenultimate
P = Penultimate
U = Ultimate

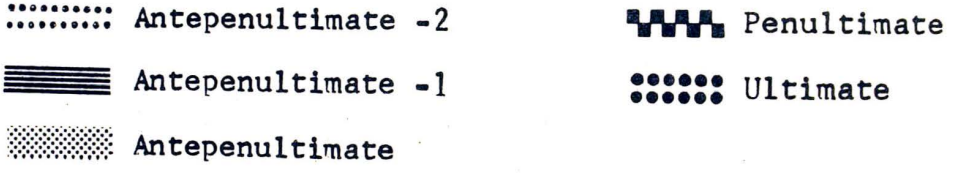
Date	N	A-3	A-2	A-1	A	P	U
Nov. 25	50	0.0	0.0	0.0	16.0	82.0	2.0
Dec. 1	50	0.0	2.0	2.0	16.0	74.0	6.0
Dec. 8	50	0.0	4.0	0.0	24.0	62.0	10.0
Dec. 15	50	0.0	8.0	0.0	20.0	62.0	10.0
Dec. 22	50	0.0	4.0	2.0	24.0	60.0	10.0
Jan. 5	50	0.0	8.0	0.0	26.0	60.0	6.0
Jan. 19	50	0.0	6.0	0.0	28.0	58.0	8.0
Jan. 26	50	0.0	2.0	2.0	16.0	78.0	2.0
Feb. 2	50	0.0	2.0	4.0	14.0	72.0	8.0
Feb. 16	50	0.0	0.0	0.0	24.0	72.0	4.0
Feb. 23	50	0.0	0.0	0.0	24.0	72.0	4.0
Mar. 2	50	0.0	0.0	0.0	24.0	66.0	10.0
Mar. 9	50	0.0	0.0	0.0	24.0	64.0	12.0
Mar. 16	50	0.0	0.0	0.0	22.0	66.0	12.0
Mar. 23	50	0.0	0.0	0.0	24.0	68.0	8.0

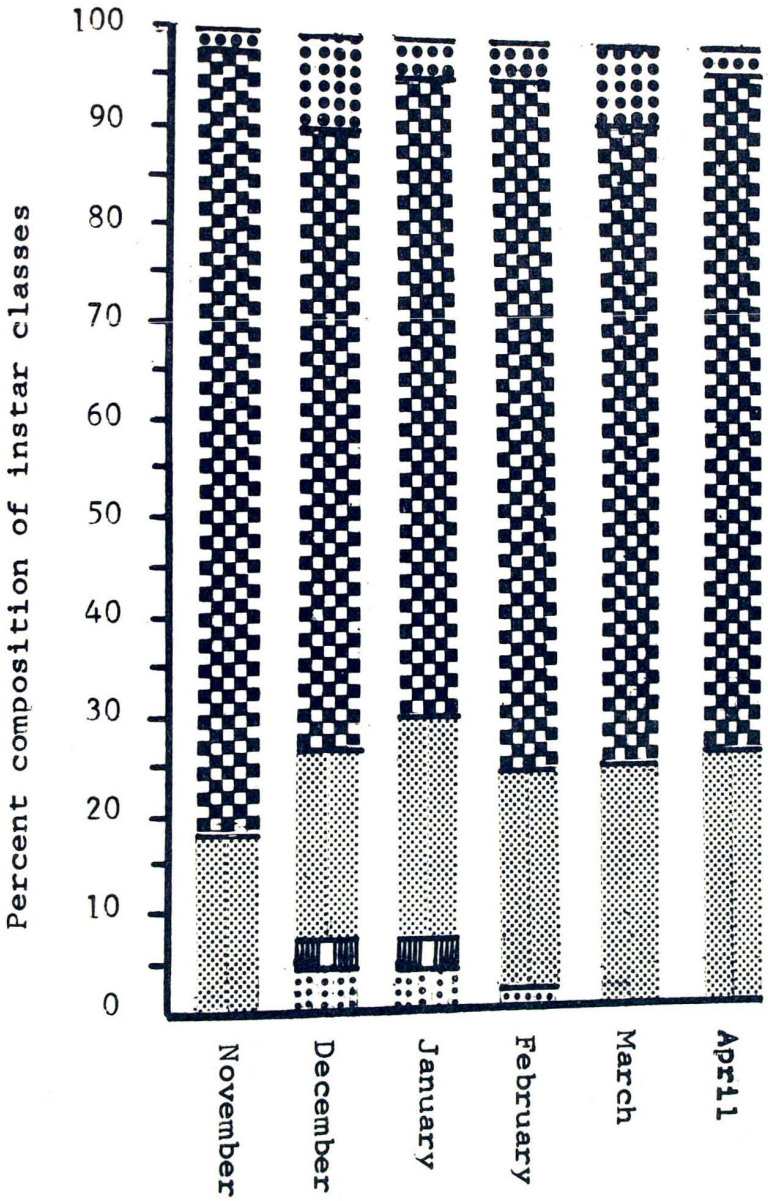
TABLE I

(continued)

Date	N	A-3	A-2	A-1	A	P	U
Apr. 13	10	0.0	0.0	0.0	10.0	80.0	10.0
Apr. 20	4	0.0	0.0	0.0	0.0	100.0	0.0
Apr. 27	2	0.0	0.0	0.0	0.0	100.0	0.0

Figure 3. Percent monthly average of instar classes of Plathemis lydia classified according to Eller's (1963) head width index.




Percent composition of instar classes
100
90
80
70
60
50
40
30
20
10
0
November
December
January
February
March
April

was 1.911 millimeters. The smallest nymph of Plathemis lydia measured 2.1 millimeters. The largest head width of Plathemis lydia was 4.95 millimeters which exceeded the maximum head width of Class X by .65 millimeters. Therefore, using this classification, all nymphs would be placed into the final four instars on nymphal development.

A total of 819 nymphs of Perithemis domitia were collected and measured. Figure 4 illustrates the instar classification of this species by head width according to Eller's (1963) system of classification.

The percent instar class distribution was computed using head width of Perithemis domitia for each collection date (Table II). According to this classification the population of Perithemis domitia was composed of five instar classes with no ultimate instars found.

During November the population consisted of: Antepenultimate-3, 31 percent; Antepenultimate-2, 25 percent; Antepenultimate-1, 37 percent and Antepenultimate, seven percent. (Figure 5).

By the end of December the population consisted of: Antepenultimate-3, three percent; Antepenultimate-2, 18 percent; Antepenultimate-1, 40 percent; Antepenultimate, 22 percent and Penultimate, 17 percent. Although these figures fluctuated somewhat during the winter months, these five instar classes persisted until the month of May. Weekly collections during May produced only two nymphs; one Antepenultimate-1, one Antepenultimate.

Figure 4. Range of head width of specimens of Perithemis domitia for each collection date. Heavy vertical line (▮) represents range of head width. Dot (•) represents only one specimen collected or more than one specimen with the same head width. Horizontal line is the mean. Instar classes are according to Eller's (1963) classification.

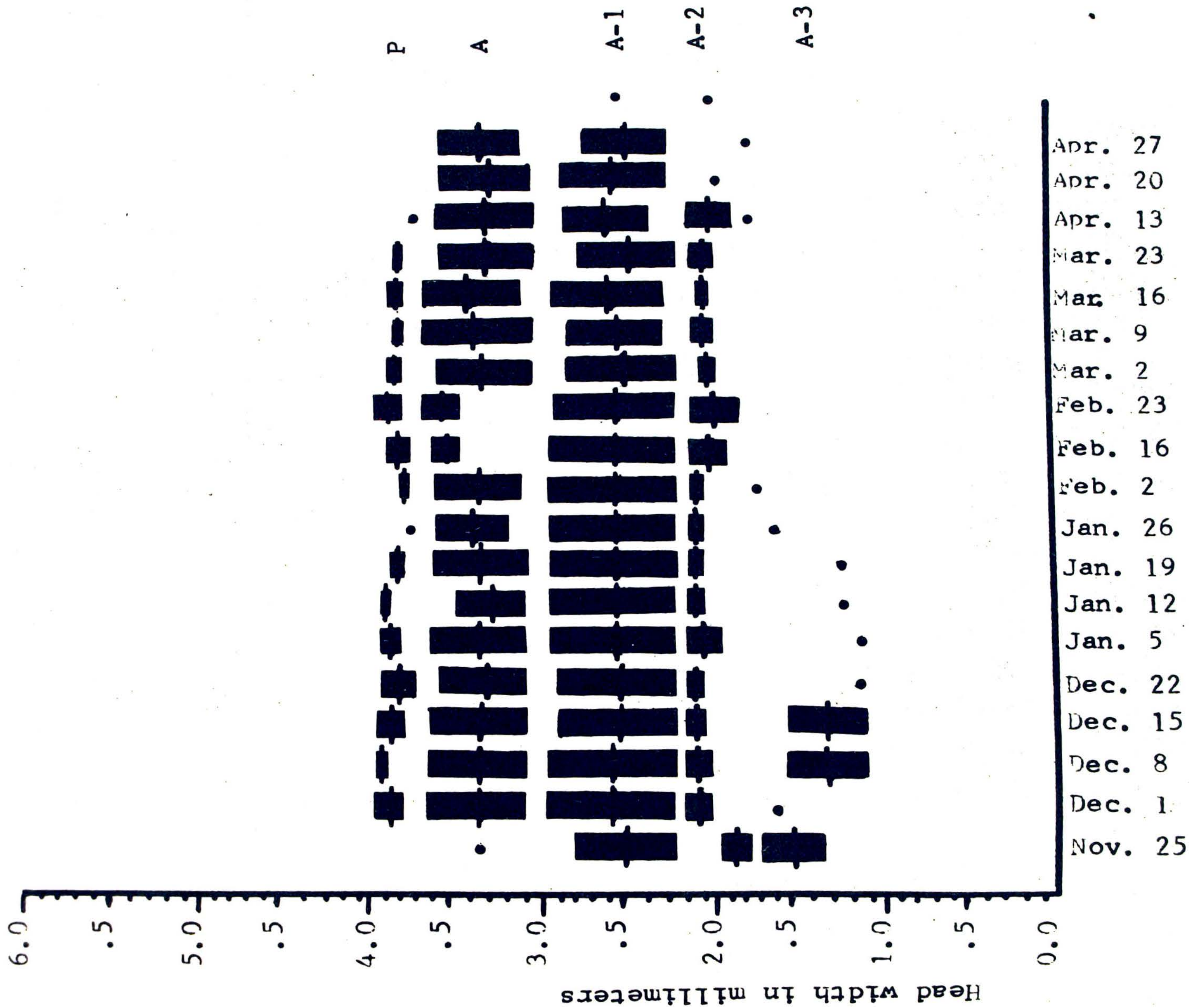
P - Penultimate

A - Antepenultimate

A-1 - Antepenultimate-1

A-2 - Antepenultimate-2

A-3 - Antepenultimate-3



P
A
A-1
A-2
A-3
Apr. 27
Apr. 20
Apr. 13
Mar. 23
Mar. 16
Mar. 9
Mar. 2
Feb. 23
Feb. 16
Feb. 2
Jan. 26
Jan. 19
Jan. 12
Jan. 5
Dec. 22
Dec. 15
Dec. 8
Dec. 1
Nov. 25
6.0
.5
5.0
.5
4.0
.5
3.0
.5
2.0
.5
1.0
.5
0.0
Head width in millimeters

TABLE II

Percent Composition of Instar Classes for *Perithemis domitia* per Field Collection from November 25, 1974 to May 1, 1975.

N = Number of specimens collected
A-3 = Three stages preceding the Antepenultimate
A-2 = Two stages preceding the Antepenultimate
A-1 = One stage preceding the Antepenultimate
A = Antepenultimate
P = Penultimate
U = Ultimate

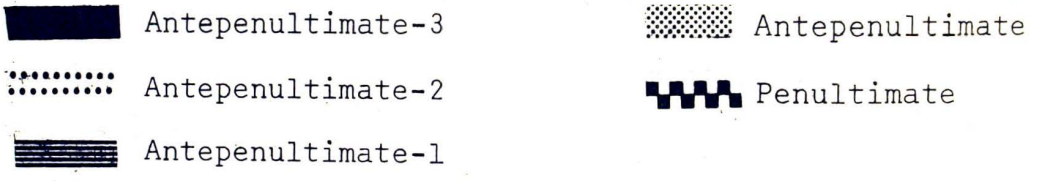
Date	N	A-3	A-2	A-1	A	P	U
Nov. 25	16	31.0	25.0	37.0	7.0	0.0	0.0
Dec. 1	50	2.0	16.0	50.0	14.0	18.0	0.0
Dec. 8	50	4.0	20.0	34.0	26.0	16.0	0.0
Dec. 15	50	4.0	20.0	46.0	18.0	12.0	0.0
Dec. 22	50	2.0	22.0	52.0	8.0	16.0	0.0
Jan. 5	50	2.0	22.0	58.0	10.0	8.0	0.0
Jan. 12	50	2.0	22.0	56.0	10.0	10.0	0.0
Jan. 19	50	2.0	20.0	54.0	10.0	10.0	0.0
Jan. 26	50	2.0	10.0	58.0	14.0	16.0	0.0
Feb. 2	50	2.0	18.0	54.0	14.0	12.0	0.0
Feb. 16	50	0.0	24.0	36.0	10.0	30.0	0.0
Feb. 23	50	0.0	22.0	34.0	20.0	24.0	0.0
Mar. 2	50	0.0	32.0	30.0	16.0	22.0	0.0
Mar. 9	50	0.0	32.0	34.0	14.0	20.0	0.0

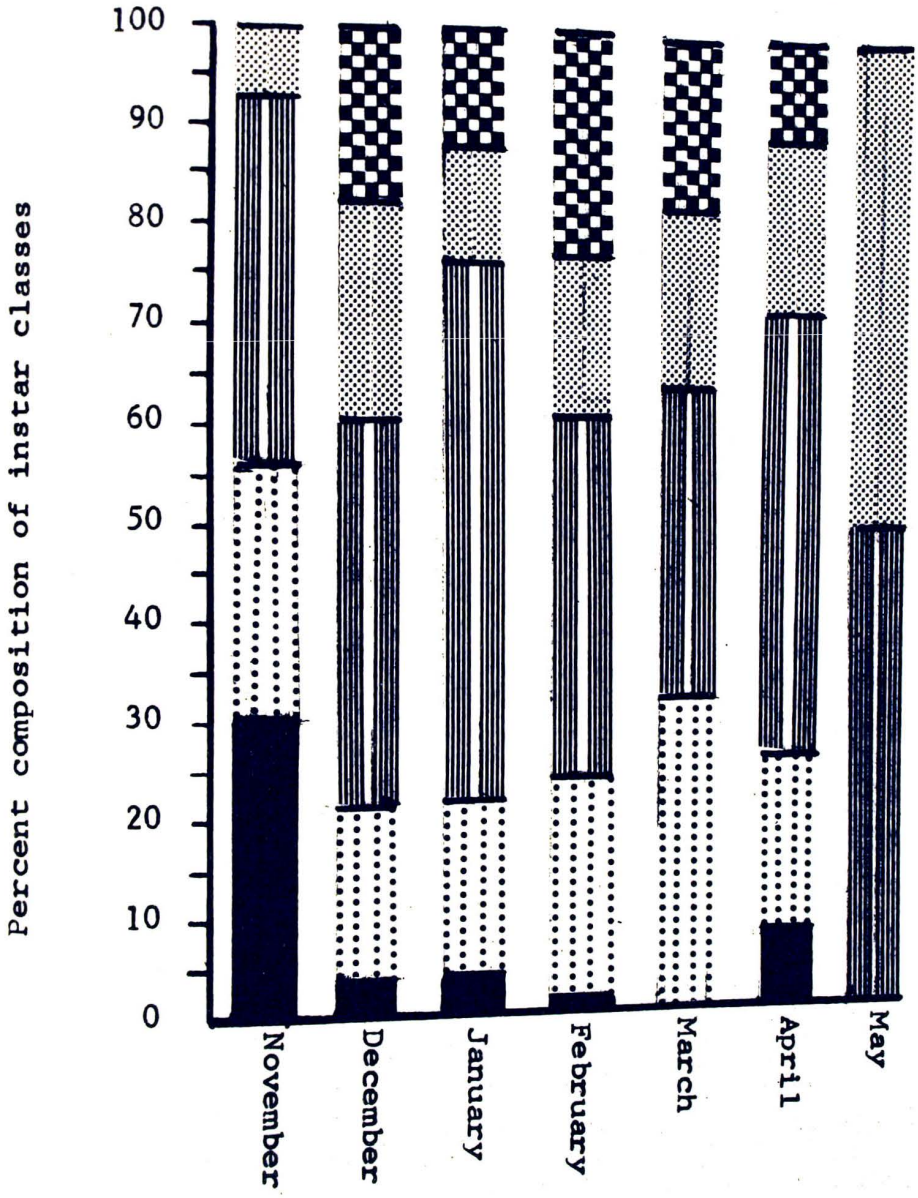
TABLE II

(continued)

Date	N	A-3	A-2	A-1	A	P	U
Mar. 16	50	0.0	30.0	34.0	20.0	16.0	0.0
Mar. 23	50	0.0	32.0	32.0	16.0	20.0	0.0
Apr. 13	25	4.0	12.0	56.0	20.0	8.0	0.0
Apr. 20	10	10.0	30.0	40.0	10.0	10.0	0.0
Apr. 27	7	14.2	0.0	42.8	42.8	0.0	0.0
May 1	2	0.0	50.0	50.0	0.0	0.0	0.0

Figure 5. Percent monthly average for instar classes of Perithemis domitia classified according to Eller's (1963) head width index.




Percent composition of instar classes
100
90
80
70
60
50
40
30
20
10
0
November
December
January
February
March
April
May

Using Boehms' (1971) head width index data the measurements of Perithemis domitia fell within range of Classes V through X. The minimum measurement of Class V was found to be .882 millimeters. The smallest specimen of Perithemis domitia measured 1.15 millimeters. The widest head width of Perithemis domitia was 4.0 millimeters. The maximum measurement of Class X was 4.3 millimeters. Therefore using this classification, all nymphs would be placed in the final six instar classes.

Perithemis domitia was first observed in flight on June 12.

CHAPTER V

DISCUSSION

Both Plathemis lydia and Perithemis domitia overwinter in nymphal instars.

Applying the classification system adapted from Eller (1963), the population structure was determined for each species. Based on present observations, no conclusive statement concerning presence or absence of diapause during nymphal development can be made. However, since development continued in both species until February 1 and migration did occur to a minor extent from one instar to another between collections, it is postulated that development was retarded due to low temperature. Therefore, nymphs could have possibly been in quiescence rather than diapause. Due to flooding of the pond in March when temperatures would have been sufficient for morphogenesis to resume no conclusive data were collected.

Fletcher's (unpublished) studies and personal observations indicated Plathemis lydia in flight sufficiently early that some had to overwinter in the final instar. This was confirmed by collections throughout the winter. According to the classification of Eller (1963), three to ten percent ultimates were found in the population during each month of collection. Based on the work of Corbet (1960) this is sufficient evidence to conclude that Plathemis lydia is a "spring species" or at least an intermediate type such as Pachydiplax longipennis studied by Eller (1963) and Hackney (1974) which is a "summer species" with an univoltine life cycle similar to a "spring species".

No nymphs of Perithemis domitia were classified as ultimate instars. On the last collection date in May Antepenultimate and Antepenultimate-minus-one made up the population. From that time until Perithemis domitia was observed flying on June 12 was sufficient time for this species to migrate through the final two instars. Based on this information, along with the observations of Fletcher (unpublished), Perithemis lydia would be considered a "summer species".

Since data are inconclusive in some areas of this study, it is suggested that nymphs of both species be reared at constant temperatures in the laboratory to establish indices for placing them into instar classes and determine whether or not they undergo diapause in the nymphal stage.

CHAPTER VI

SUMMARY

This study was undertaken to investigate the patterns of development in Plathemis lydia and Perithemis domitia in Montgomery County, Tennessee, from November 1974 through May 1975. Areas investigated were: (1) instar class composition of the over-wintering population, (2) changes in instar classes during the period of study and (3) emergent dates of the two species.

Both species over-winter as nymphal instars but changes in instar classes continued through the February 2 collection date. After this period the population was relatively stable until floods terminated the project. Since the project was terminated at a time when morphogenesis should have been resumed, no conclusive statement can be made concerning the presence or absence of diapause during nymphal development. However, changes in the population during the collection period possibly indicate that both species may undergo quiescence rather than diapause.

Three to ten percent of Plathemis lydia nymphs were classified as ultimate instars during the winter collection dates. This indicates that Plathemis lydia is a "spring species" or an intermediate type. This species was first observed flying on April 13.

Perithemis domitia over-wintered in nymphal instars other than ultimate. It should be termed a "summer species". Perithemis domitia was first observed flying on June 12.

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