THE RELATIVE ABUNDANCE AND SEASONAL DISTRIBUTION OF MOSQUITOES IN LA CROSSE COUNTY, 1979 AND 1980

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ABSTRACT

The objectives of this study were to gather preliminary information on the nature of the mosquito problem in La Crosse County by (1) determining the species composition, seasonal abundance and distribution based on light trap collections, (2) correlating environmental and other factors with the data, and (3) establishing baseline data for the evaluation of vector-disease problems and necessary control measures. Standard New Jersey light traps were operated daily during the study period at six locations that are representative of the mosquito breeding habitats and potential mosquito problems in the County. A total of 339,418 mosquitoes, representing seven genera, were collected. Compiled adult and larval collection records showed 25 species present in the County. Due to its location, the Myrick Marsh trap was the most productive throughout the study, where over 50% of the females were collected. Aedes vexans was the most abundant species, comprising 80 and 87% of the total females in 1979 and 1980, respectively. Other species varied in their importance depending on the trap location and the year. Floodwater species, such as Ae. vexans, were more abundant at Myrick Marsh, while the Culex pipiens complex preferred a residential area such as Shelby. Both the C. pipiens complex and Aedes triseriatus were found frequently in discarded tires and other artificial containers. Locally, the most important disease vectors were Ae. triseriatus (La Crosse encephalitis), C. pipiens (St. Louis encephalitis), and Ae. vexans (dog heartworm). The most effective control measures were accomplished through the surveying of mosquito-breeding con-

tainers and the filling of basal tree holes with Rock Wool insulating cement. No attempt was made in analyzing the effect of ongoing adult-iciding efforts because it was felt to be beyond the scope of this study.

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INTRODUCTION

La Crosse County is situated in a setting of coulees and bluffs, and contains the confluences of several river systems. Due to its location, it provides a very suitable habitat for flood plain and container-breeding mosquitoes. The problem is compounded in that one of the mosquitoes, Aedes triseriatus, is the vector of the La Crosse strain of viral encephalitis, which is endemic to the area (Lisitza et al. 1977). In addition, vectors for the dog heartworm (Dirofilaria immitis) and the potential vectors of the St. Louis strain of viral encephalitis are also found in the area (Parry, unpublished).

The La Crosse County Mosquito Control Program was established in the spring of 1979 to evaluate and control the mosquitoes responsible for the viral encephalitis problem. Based on the clinical problems of encephalitis, it was felt that the prevention of even one case of the disease was sufficient to warrant such a program. In addition to the disease vectors, the program also monitors the pest mosquito problems in the area with implicit control measures. The City of La Crosse is very unique in that 1,500 acres of marshland is located within the city limits (Harris 1975). This creates a problem where nuisance mosquitoes interfere with outdoor activities in the summer months.

In order to understand mosquito problems, various standard methods such as larval collections, bite counts and light traps can be employed.

Light trap collection data are used to reflect seasonal distribution, frequency and abundance of adult mosquitoes. Trap locations

are chosen because they are representative of the mosquito breeding habitats and potential mosquito problems. Trap counts can often be equated with the relative human annoyance near the trap (Sjogren 1980). Early studies of trap catches by Van Derwerker (1937) indicated that a night's catch of 24 females would mean annoyance to people in the vicinity of the trap. However, he stated that different species vary in the density necessary to cause annoyance, and they may cause annoyance in different places of human activity. Therefore, light trap data are used only to approximate the times of the season when species are sufficiently numerous to warrant control measures. Light trap data can also provide general information which aids in the understanding of the epidemiology and the forcasting of vectorborne diseases. Such data are also helpful in detecting adult migrations and locating control failures.

It is essential to understand that the attraction of mosquitoes to light varies significantly from species to species. Therefore, the purpose of this study is not to determine the absolute population of mosquitoes, but rather an index of the prevalent species showing their seasonal fluctuation and abundance (U.S. Dept. HEW 1977).

The primary goal of this light trap survey was to gather preliminary information on the nature of the mosquito prolems in La Crosse County. The objectives of this study were the following:

1) To determine the species composition, relative abundance, and seasonal distribution of mosquitoes based on light trap collections.

2) To attempt to correlate environmental factors and meteorolo-

gical data with the light trap data.

3) To establish baseline data for the evaluation of vector-disease problems and necessary control measures.

LITERATURE REVIEW

The literature is replete with papers on the bionomics and control of mosquitoes. Mosquito News, a journal particularly devoted to papers on mosquitoes, contains vast amounts of literature on the bionomics and control of mosquitoes. Each issue of Mosquito News contains a bibliography section that provides a listing of many references to literature on mosquitoes and mosquito-borne diseases from over 1,200 current journals, books and reports (Sollers-Riedel 1976). In addition, the mosquito control agencies of some states such as New Jersey, Florida, California and Utah publish their research findings.

No extensive review on the bionomics and general biology of mosquitoes will be presented here for two reasons: 1) the information can be found as references in many other sources, such as Headlee (1945), Carpenter and LaCasse (1955), Barr (1958), Clements (1963), Matheson (1966), and U.S. Dept. HEW (1977); 2) the findings of other workers will be discussed throughout the text where they are pertinent. In addition, there is an excellent text by Horsfall et al. (1973) on Ae. vexans, the most important pest species in the study area.

Based on the fact that many mosquito species are attracted to light, light traps have been developed and used for several decades. The light trap used in this study has been adequately described by Headlee (1932), Mulhern (1934), Van Derwerker (1937 and 1939), and Darsie et al. (1953). They suggest that many factors may influence light trap collection and that workers must be aware of them.

Bidlingmayer (1967) had characterized these factors as environmental, operational and biological. Husbands (1976) also stressed the importance of considering species behavior, physiological conditions and environmental factors when interpreting trap data.

Wide differences have been noted in the reactions of different species of mosquitoes to light (Pritchard and Pratt 1944, Love and Smith 1957, U.S. Dept. HEW 1977). Light trap collections must therefore be used in conjunction whth other methods of sampling mosquito populations (U.S. Dept. HEW 1977). Although no single sampling method can give an absolute indication of the species present, Love and Smith (1957) concluded that the light trap was the best single method to sample a mosquito population in an area.

Even though there had been numerous studies on the biology, habitats and incidence of mosquitoes in selected areas of Wisconsin (Dickinson 1944, Allen 1950, Ryckman 1952, Roberts et al. 1956, Patel 1959, Thompson 1964, Thompson and Dicke 1965, DeFoliart et al. 1967, Silverly and DeFoliart 1968a, 1968b, Porter and Gojmerac 1970a, 1970b), no extensive light trap study in conjunction with a control district has ever been published in the State.

With the exception of preliminary research by Parry (unpublished), previous studies done in La Crosse County were mainly concerned with Ae. triseriatus, and La Crosse and other California group encephalitis viruses (Thompson et al. 1965, Thompson and Inhorn 1967, Loor and DeFoliart 1970, Moulton and Thompson 1971, Pantuwatana et al. 1972, Thompson et al. 1972, Watts et al. 1972, 1973, 1974, Beaty and Thompson 1975, Lisitza et al. 1977, Scholl and DeFoliart 1977, 1978, DeFoliart

and Lisitza 1980). In addition, extensive surveys had been done in surrounding states, including Minnesota and Iowa (Owen 1937, Rowe 1942, Barr 1958, Price 1963, Knight and Wonio 1969, Wong et al. 1970, Pinger 1971, Pinger and Rowley 1972, Balfour 1974, Sjogren 1976,1980, Barton 1978).

Studies in Wisconsin

Dickinson (1944) stated in one of the earliest published papers that mosquitoes cause man the greatest annoyance by their bite rather than by transmitting diseases in Wisconsin. He compiled a list of mosquitoes present in the state from institutional and private collections, and records from throughout the state. The list contained 39 species of 8 genera, including two genera of the subfamily Chaoborinae, which are non-biting forms and are usually omitted from the literature on mosquitoes.

Allen (1950) did a study on larval habitats and breeding sites at the University of Wisconsin Arboretum in which he found 14 species belonging to six genera. A later list on arboretum collections added 9 more species belonging to two genera (Patel 1959). These lists included Ae. canadensis, Ae. cinereus, Ae. dorsalis, Ae. excrucians, Ae. fitchii, Ae. intrudens, Ae. riparius, Ae. stimulans, Ae. triseriatus, Ae. trivittatus, Ae. vexans, Anopheles punctipennis, An. walkeri, C. restuans, C. territans, C. salinarius, Culiseta inornata, Coquillettidia perturbans, Orthopodomyia signifera, Psorophora ciliata, P. horrida, and Uranotaenia sapphirina. (The following abbreviations are used to denote the common genera: Ae.=Aedes; An.=Anopheles; C.=Culex; Cu.=Culiseta;

Coq.=Coquillettidia; P.=Psorophora; U.=Uranotaenia.)

Ryckman's survey (1952) was the only published study ever done in southwestern Wisconsin that did not deal exclusively with Ae. triseriatus. His study area was located in Lafayette County, which is southeast of La Crosse County, bordering Illinois. Larval and adult collections represented in Ryckman's study included An. punctipennis, Ae. excrucians, Ae. trivittatus, Ae. sticticus, Ae. triseriatus, Ae. vexans, C. apicalis, C. tarsalis, C. restuans, C. salinarius, Cu. inornata, and U. sapphirina.

Roberts et al. (1956) found 32 species of mosquitoes, belonging to seven genera, during a survey of potential insect vectors of vesicular stomatitis in Wisconsin. These light trap collections were made in Rusk and Washburn Counties in northwestern Wisconsin.

During his habitat and incidence study, Patel (1956) found that Ae. vexans was the most important pest mosquito at the University of Wisconsin Arboretum. He stated that a successful generation of Ae. vexans, which favored temporary breeding areas and marshes, was limited by rainfall. He based his observation on the absence of adults of this species in 1958, which was a dry season. He believed that even the numbers that migrated into the area did not build up to an annoying population. He also found that permanent marshes were favorable to C. salinarius, C. territans, Cu. inornata and Cu. minnesotae, while permanent breeding areas along lake shores favored U. sapphirina, C. territans, An. quadrimaculatus and An. punctipennis.

Thompson (1964) studied the biology of Ae. vexans in Wisconsin. He also reviewed the literature on the geographic distrubution, sys-

tematics, economic importance, and bionomics of the species extensively. He collected 26 species of 8 genera in his study in Dane County using various types of light traps and landing counts. He found that Ae. vexans was most active in prairies, residential areas, and other open situations at dusk, while Ae. triseriatus, Ae. communis and Ae. stimulans were more active in hardwood forests at this time of day. He also noted that Ae. vexans was readily attracted to light traps and the females frequented human habitations and animal shelters at dusk seeking blood meals.

Thompson and Dicke (1965) concluded that there was little correlation between the numbers of Ae. vexans obtained by light trap and by landing counts during their sampling studies at Madison. They found that the variables affecting these two sampling methods were not the same, or were not acting to the same degree. They based this conclusion on their observations that light traps did not indicate high catches of the species when the landing counts were high, and high light trap collections were taken on evenings when landing counts were very low.

During a study of the seasonal succession of bloodsucking Diptera, DeFoliart et al. (1967) found that the genera of mosquitoes that mostly hibernate as adults, such as Culiseta, Anopheles and Culex, were the first ones to appear in the spring. They observed that Cu. inornata emerged from hibernation by mid-April while Ae. canadensis, Ae. trivittatus and Ae. triseriatus did not appear until very late in May or early June.

Silverly and DeFoliart (1968b) found 26 species in light trap

studies done in a five county area in northern Wisconsin. They arranged these species into three groups. Group one consisted of the black-legged Aedes and Ae. stimulans complex. Populations of this group developed at low water temperatures and peaked in early June and with a few exceptions, dwindled rapidly. Included in the second group were Ae. canadensis, Ae. cinereus, Ae. triseriatus, Ae. vexans, Anopheles, Culex and Culiseta species; all of these species were multivoltine and their population profiles varied with the pattern of summer rains. Group three was represented by Coq. perturbans, which was characterized by one generation per year and sustained emergence.

Porter and Gojmerac (1970a) studied the nuisance mosquitoes at Point Beach State Forest in eastern Wisconsin. The predominant nuisance species collected by bite counts were Ae. stimulans, Ae. sticticus, and the Ae. abserratus-punctor complex. The authors felt that light traps were not useful in their study because Ae. stimulans, the most abundant species, was not easily attracted to light. The same researchers (Porter and Gojmerac 1970b) did another study at this forest to determine the influence of temperature on light trap catches of Ae. vexans. They found that at temperatures above 16.7^{o}C, a rise of 5/9 ^{o}C could increase the trap catch by 1.2 times.

Scholl et al. (1979) found two rare mosquito species during an investigation of diel and vertical distribution of blood feeding activity of Ae. triseriatus in Iowa County in southwestern Wisconsin. They noted the species Culicoides paraensis, which had not been previously reported from north of Tennessee in the central United States, and Culicoides guttipennis, which is a common tree hole breeding species

that occurs widely over the eastern United States.

Studies in the La Crosse Area and on *Aedes triseriatus*

The city of La Crosse is considered to be in the heart of the La Crosse (LAC) encephalitis virus endemic zone, which is comprised of southwestern Wisconsin, southeastern Minnesota, and northeastern Iowa (Lisitza et al. 1977). The La Crosse virus, the only one of the California encephalitis (CE) group known to produce illness in humans in Wisconsin (Thompson and Inhorn 1967), was originally isolated from the brain of a 4-year-old girl who died with encephalitis during 1960 in La Crosse (Thompson et al. 1965).

Thompson et al. (1972), Watts et al. (1972), Moulton and Thompson (1971), and Pantuwatana et al. (1972) found that the summer-season maintenance cycle of La Crosse virus to involve the mosquito *Ae. triseriatus*, chipmunks, and other small forest-dwelling mammals. Loor and DeFoliart (1970) stated that *Ae. triseriatus* is a deciduous forest species that breeds mainly in basal tree holes and it tends to feed in the lower strata of the forest rather than in the canopy and is relatively inactive during hours of total darkness. They found that its biting activity increased from mid-June to a peak in the second half of August and with the greatest biting occurring in the afternoons before 6 p.m. DST. Oviposition occurred at heights up to at least 6.1 m above ground but was greatest in cavities and containers at ground levels. Scholl and DeFoliart (1977) found that there was essentially no oviposition by this species prior to the last week in June, and that maximum oviposition activity continued into early September. Scholl

and DeFoliart (1978) stated that the delay of the beginning of oviposition until late June was partly due to the sex ratio of the emerging adults. The early part of the season strongly favored males while females were favored in the later part of the season. The population peaks of Ae. triseriatus in late summer and fall also corresponded to the occurrence of infections of the virus (Thompson and Inhorn 1967).

Moulton and Thompson (1971) found that small forest-dwelling mammals, especially chipmunks, serve as reservoirs for the virus in Wisconsin because they are active throughout the day and during the crepuscular periods in the lower strata of the forest. The movements of these small mammals between and within woodlots is believed to be one method by which the virus is spread through the deciduous forests of southern Wisconsin.

Watts et al. (1974) found that the types of tree holes that are of concern are the ones that can retain residual water throughout the year, especially the ones that are formed within multiple trunks that originated from the stumps of previously cut or damaged trees.

Although the basal tree hole has been incriminated as the breeding place of Ae. triseriatus in nature, it is becoming increasingly apparent that man-made containers such as discarded tires are the most common breeding sites in many clinical cases (Watts et al. 1974, Barton 1978, DeFoliart and Lisitza 1980). Watts et al. (1974) found that the minimum field infection rate of the LAC virus was 1/20 from larvae collected from old discarded tires in the backyard of a home in State Road Coulee, a neighborhood where cases of CE in children had been frequently occurring. DeFoliart and Lisitza (1980) stated that the majority of human

clinical cases of La Crosse encephalitis were contracted from mosquitoes bred in man-made containers in the vicinity of human habitations and these cases could be prevented through simple sanitation by eliminating tires and containers from areas readily colonized by female mosquitoes emigrating from their woodland habitats. Their studies indicated that Ae. triseriatus, contrary to general belief, does venture from the protection of the forest canopy rather readily. The speed with which the species infiltrates and establishes itself in these more open areas depends on the density of both vegetation cover and of water containers suitable for colonization.

Furthermore, findings by Watts et al. (1973, 1974) strongly indicated that transovarial transmission of this virus in Ae. triseriatus is the mechanism for its survival during the winter season in the north-central United States. This virus can therefore be transmitted by mosquito bite without the requirement of a prior infected blood meal. These studies provided the first evidence for the role of transovarial transmission in the overwintering of an arbovirus in a mosquito. The authors also isolated the virus from the males of the species, providing evidence that this virus can be transmitted to females during insemination or through nectar following feeding by an infected male.

Litsitza et al. (1977), Beaty and Thompson (1975) studied the prevalence rates of the overwintering virus in endemic areas around La Crosse. These studies indicated that any tree hole capable of supporting the development of Ae. triseriatus larvae in a given endemic locality is a potential overwintering site for the virus. In general, a greater number of viral isolates corresponded to a greater number of

larvae in the tree hole. Litsitza et al. (1977) also stated that a significantly higher overwintering virus prevalence rate was detected on the north slope of a study area than on the south slope, which was drier, had less ground cover and fewer chipmunks.

In addition to Ae. triseriatus, two other species may be associated with tree holes in this area. Loor and DeFoliart (1970) reported finding larvae of Ae. hendersoni, a species closely related to Ae. triseriatus found in the western U.S., and of Orthopodomyia signifera.

Besides the studies on Ae. triseriatus, mosquitoes studies in La Crosse County were limited to research by Parry (unpublished) and preliminary studies by County employees before the formal program was established. These studies indicated the problem of Ae. vexans as a pest species and the presence of Ae. triseriatus, C. pipiens and other potintial disease vectors in the area. In addition, Harris (1975), Craig (1975) conducted surveys of insects, aves and mammals in Myrick Marsh, a major mosquito breeding ground in the City of La Crosse. He concluded that mosquitoes are important to the ecology of the marsh because they make up a significant portion of the diets of fish, birds and small mammals.

Studies from Neighboring States

Extensive work on mosquitoes has been done by the Metropolitan Mosquito Control District (MMCD) in Minneapolis-St. Paul, which is only 241.4 km northwest of the City of La Crosse along the Mississippi River. The MMCD was used as a model when the program in La Crosse County was

designed. Preliminary studies indicated that many of the species found in Minnesota may also be present here, except species preferring colder or drier climates present in parts of Minnesota may not be as abundant here.

Sjogren (1976, 1980) stated that the environmental factors contributing to Minnesota's large mosquito populations include topography which results in abundant intermittent water depressions, marshes and lakes. He felt that mosquitoes are produced in Minnesota by climatic factors rather than human activity, and that annual fluctuations in mosquito populations can be predicated on the amount of annual precipitation received. He found that surface runoff from rains of 3.8 cm or more that reamin for 6-8 days are sufficient for larval development of Ae. vexans. An average of 45.7 cm of summer rainfall is received there each mosquito season, often from intense thunderstorm activity.

Sjogren (1980) stated that the mosquito fauna of Minnesota includes 50 species, twenty six of which are univoltine or multivoltine Aedes, with Ae. vexans being the major summer pest species, and accounting for 70% of the season-long annoyance caused by mosquitoes. Besides Ae. vexans, he stated that the multivoltine Aedes include Ae. cinereus, Ae. dorsalis, Ae. trivittatus and Ae. triseriatus, while the univoltine Aedes consists of spring or woodland species. He also found Coq. perturbans to be a major pest species during its June 15 to July 31 emergence periods (Sjogren 1976).

Human clinical cases of La Crosse encephalitis had been reported from Minnesota (Balfour 1974, Barton 1978, DeFoliart and Lisitza 1980). Balfour (1974) stated that La Crosse encephalitis had been documented

in 83 children hospitalized in Minnesota during the summers of 1967 through 1973. He found that prior to 1968, confirmed cases were limited to southeastern Minnesota, and since then there has been an apparent northwestward migration of the disease because cases have been recognized with increasing frequency in the western suburbs of Minneapolis. He stated that Ae. triseriatus hatches late in the spring and the disease does not occur until the latter part of June in Minnesota and ends in September when cool weather limits mosquito activity. He suggested that Ae. triseriatus can be controlled by frequent spraying to reduce adult populations and filling basal tree hole breeding sites in the localized areas of virus activity.

Barton (1978) conducted a larval survey of container habitats in Hennepin County where cases of the disease were originated and found seven species in various types of containers. The species were Ae. triseriatus, C. restuans, C. pipiens, C. tarsalis, C. territans, C. salinarius and Cu. inornata. He found that discarded tires were the most common breeding sites; other artificial containers, tree holes, and tin cans were also sampled.

Other important works on the mosquitoes of Minnesota include Owen (1937), Barr (1958) and Price (1963). Owen (1937) presented descriptions of the biology of 37 mosquitoes species found in the State. Barr (1958) presented a manual for identification of these species, and discussed the biology and the control of mosquitoes in the State. Price (1963) studied the frequency of occurrence of spring Aedes in selected habitats in northern Minnesota. He found species breeding in woodland pools and cattail marshes, such as Ae. excrucians, Ae.

fitchii, Ae. communis and Ae. stimulans to be common there.

Besides Minnesota, Ae. triseriatus has also been shown to be endemic in Iowa (Lisitza et al. 1977, Rowley, unpublished). The Iowa Mosquito-Arbovirus Research Program monitors virus and mosquito activity by New Jersey and CDC light traps placed in 8 cities throughout the State. Pinger (1971) stated that the mosquito fauna of Iowa includes 33 species of 8 genera. Rowley (unpublished) only collected 21 species in 1980, so not all the species are present each year. Wong et al. (1970) reported that pathogenic arboviruses responsible for Western Equine encephalitis, St. Louis encephalitis and California encephalitis had been found in Iowa. In addition, Pinger and Rowley (1972) stated that at least four nonpathogenic viruses such as Trivittatus, Turlock, Flanders and Cache Valley viruses have been isolated from mosquitoes in Iowa.

Rowe (1942), Pinger (1971), Pinger and Rowley(1972) found that Ae. vexans is the most abundant mosquito in Iowa. The researchers also found that the second most abundant species to be C. tarsalis. Wong et al. (1970) felt that although C. tarsalis is the vector of the Western Equine encephalitis virus, La Crosse encephalitis may be more important in Iowa than Weatern Equine encephalitis. This was confirmed by Rowley (unpublished) when he found that the encephalitis virus activity in the State in 1980 was generally restricted to La Crosse encephalitis.

MATERIALS AND METHODS

Traps utilized in this study were Standard New Jersey light traps. Each trap was equipped with a 25-watt incandescent bulb and a timing device to turn it on at dusk and off at dawn. Killing jars were attached, using Shell No-Pest Strips (Vapona) as the killing agent. All traps were driven by standard AC and were hung at above 1.8 m above the ground.

Five permanent light trap stations were established in 1979 and another one was added in 1980. All traps were located in the City of La Crosse and surrounding townships. In addition, temporary traps operated on 12-volt batteries were placed periodically at Red Cloud Park and the Boy Scouts of America Headquarters in La Crosse, Shiftar Salvage Yard in Medary, and the La Crosse Girl Scout Camp in Farmington. Sites chosen were representative of mosquito breeding habitats and potential mosquito emergence problems in the County. Light traps were operated daily from May 17 to September 30 in 1979, and May 19 to October 15 in 1980. Traps were serviced every morning by La Crosse County Mosquito Control inspectors, with specimens placed in paper containers for transport to the laboratory. Each container was marked with the locality and the date of the night in which the trap was started. After the mosquitoes were sorted from other insects, the numbers of both male and female mosquitoes were counted and recorded. Although only the females bite, males were also counted because they emerged before females and can be used as an indicator of a new brood of mosquitoes hatching. The females were then prepared for identification

by placing each one on a paper point through which a pin had been inserted. A drop of clear nail polish was used as adhesive. The specimen was labeled according to standard procedures and identified to species under an AO cycloptic microscope at 50X. The following references were used in the identification process: Pratt and Barnes (1959), Ross and Horsfall (1965), Horsfall (1972), and U.S. Dept. HEW (1977).

The number of mosquitoes collected each day was correlated with climatological data taken at the La Crosse Municipal Airport by the National Oceanic and Atmospheric Administration.

The monthly species composition for each trap location was calculated and presented as bar graphs. For the purpose of graphically portraying the seasonal abundance of each species, each season was divided into ten-day intervals (except for May and October), and the number of females mosquitoes collected during each interval was plotted. For comparison purposes, the average number of female mosquitoes (William's mean) collected each day for both years were plotted on the same graph. The daily catch (X) from each trap was transformed into the logarithm of X+1. The sum of the logarithms of X+1 for the day was then divided by the number of traps collected that day. The antilogarithm of this quotient minus one is called the William's mean, to distinquish it from the true geometric mean. This statistical method was described by Bidlingmayer (1967 and 1969).

Trap Locations

All traps are located in the City of La Crosse and adjacent townships (Shelby, Campbell, Onalaska). Along with the map showing the lo-

cations of these traps in Fig. 1, a photograph of each trap site and nearby breeding sites are shown in Plates 1-5. A description of each permanent trap location, including vegetation in the vicinity of the trap, is presented below. Vegetation near the traps are described for several reasons. First of all, the larval and pupal stages of all mosquitoes live in water and various species have been shown to prefer certain plants. A description of any nearby water sources and the aquatic vegetation is therefore necessary. Secondly, many adults prefer to rest in certain kinds of grasses and shrubs to shade themselves from the drying effects of the sun. Woodland species tend to stay inside stands of trees both day and night. In addition, short flights through vegetation had been observed for migratory species such as Ae. vexans (Horsfall 1972). Bidlingmayer (1971) found that vegetative patterns can strongly affect flight behavior of mosquitoes by reducing illumination levels, serving as a visual cue, or acting as a physical barrier. He divided the mosquitoes in his study into three groups in the way they were affected by vegetation patterns. Group one consisted of mosquitoes such as Ae. vexans and P. ciliata that are most abundant in open field and appeared in diminishing numbers toward the interior of the swamp. Group two was most abundant along the outside margin of a swamp and its members included Culiseta spp., Coq. perturbans, U. sapphirina, and An. quadrimaculatus. The third group occurred in lowest numbers in the field and in increasing numbers toward the swamp. C. restuans was the only member of this group. Finally, nectar, and to a lesser extent honey dew, are important sources of food for both males and females, even though blood is the most important one for

Figure 1. Location of light traps in the City of La Crosse and adjacent townships.*

Light Traps
1. Goose Island
2. Myrick Marsh
3. Shelby
4. French Island
5. Oak Forest
6. Division Street

*Map adapted from Peterson, P.M. 1970.

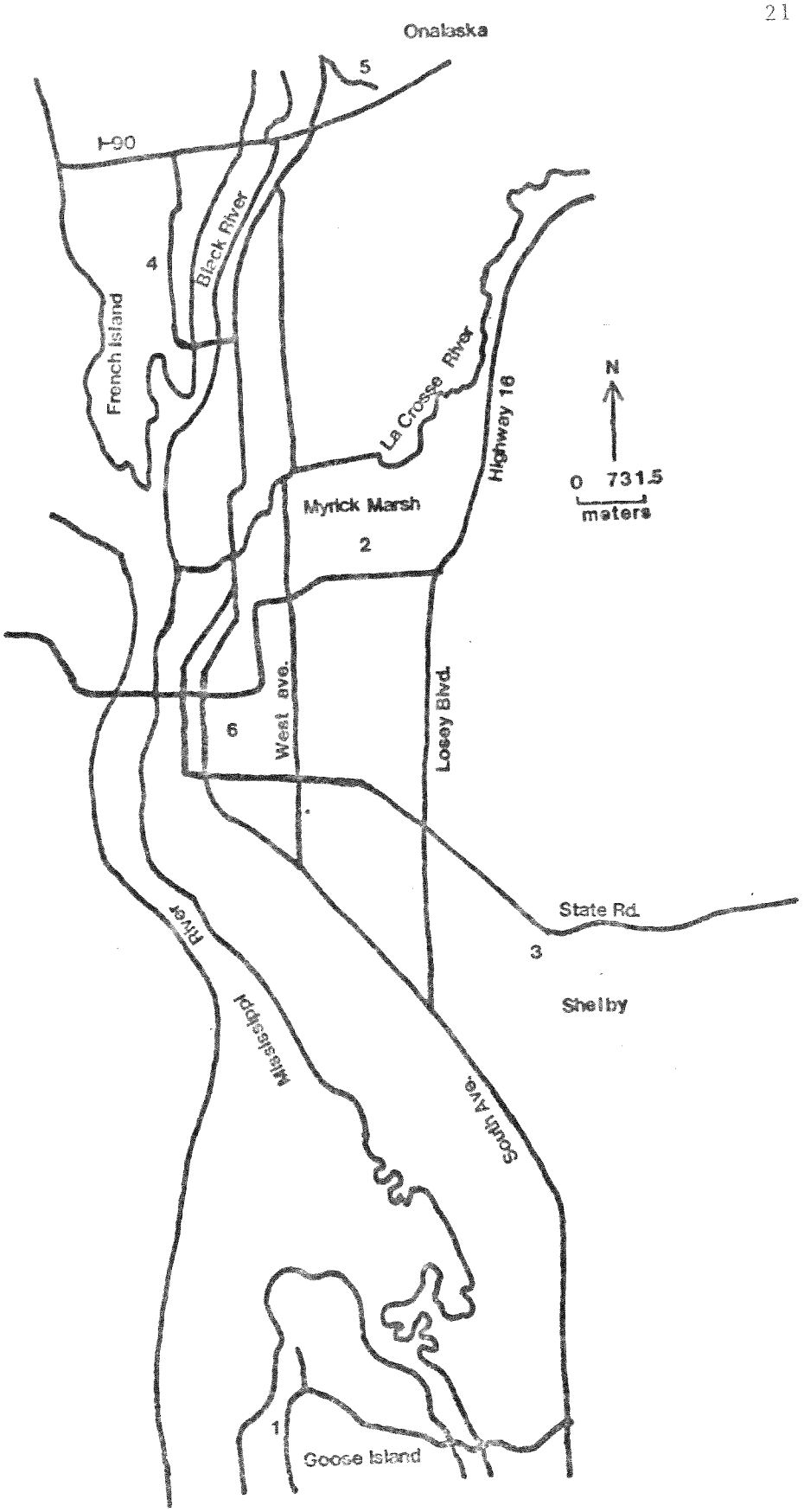

Onalaska
5
I-90
4
Black River
French Island
La Crosse River
Highway 16
N
0 731.5
meters
Myrick Marsh
2
West Ave.
Losey Blvd.
6
State Rd.
3
Shelby
River
Mississippi
South Ave.
1
Goose Island

Figure 1

Plate 1

a. The light trap at Goose Island.

b. A channel of the Mississippi River west of Goose Island.

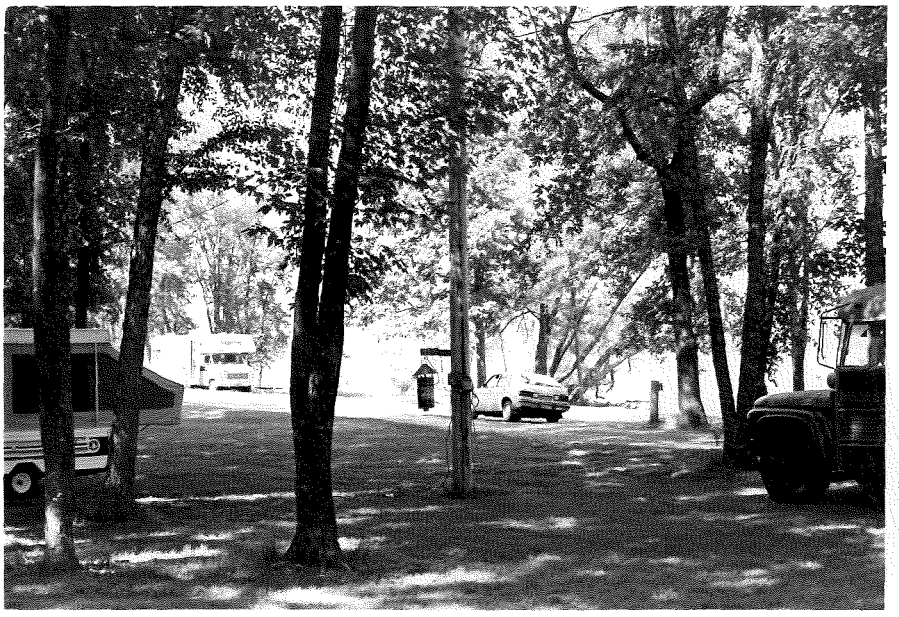


Plate 1a.



Plate 1b.

Plate 2

a. Permanent breeding sites created by the backwaters of the Mississippi River at Goose Island.

b. The light trap at Myrick Marsh.



Plate 2a.



Plate 2b.

Plate 3

a. The interface between Myrick Marsh and the cemetery, view from the north.

b. The light trap at Shelby.

Plate 4

a. The light trap at French Island.

b. The light trap at Oak Forest.



Plate 4a.



Plate 4b.

Plate 5

a. The park and forest complex near the light trap at Oak Forest, view from the south.

b. Light trap at Division Street.



Plate 5a.



Plate 5b.

females (Clements 1963).

Goose Island

The trap is located at the entrance to the camping area of Goose Island, a County park in the township of Shelby. The light trap is hung on a pole located near the swimming beach, and is located at about 46 m from a channel of the Mississippi River. Due to the presence of the river, the breeding sites in the park are either permanent or semi-permanent bodies of water. Trees in the vicinity of the trap include Acer saccharinum (siver maple), Betula nigra (river birch), Ulmus spp. (elms), Salix nigra (black willows) and Fraxinus pennsylvanica (green ash). A plantation of Pinus resinosa (red pine) is also nearby. The breeding sites in the area include marshes and swamps containing primarily Typha latifolia (cattail); Lemna trisulca (duckweed), Quercus bicolor (swamp white oak), Robinia psudo-acacia (black locust) and Azolla mexicana (aquatic fern). Sefton's (1976) study on the biomass and productivity of aquatic macrophytes in navigation pool 8 of the upper Mississippi River revealed that the major macrophytes in the upper Goose Island backwaters included Sagittaria spp. (arrowhead), Nelumbo pentapetala and Ceratophyllum demersum. Grasses around the light trap are mowed throughout the summer. However, there may be competing light sources nearby from campers, light poles and campfires.

Myrick Marsh

The trap is located west of the University of Wisconsin - La Crosse Physical Plant building along the interface between the marsh and the

cemetery. Myrick Marsh is a wetland area that serves as a flood plain annually for the La Crosse River and as a reservoir for spring flood waters for the La Crosse, Mississippi, and Black Rivers. It has been described by Craig (1975) and Harris (1975). The major plant communities and their dominant species in Myrick Marsh are listed in Table 1. The light trap is hung from a green ash. Silver maples and hackberry trees are nearby. Other vegetation in the vicinity of the trap include reed canary grass, honeysuckle shrubs, smartweed, and cattail. These grasses and shrubs serve as resting places for adult mosquitoes during the day. A few butternut trees (Juglans cinerea) are about 1.5 m from the trap. Sugar maple trees (Acer saccharinum) are abundant in the cemetery south of the trap. There used to be many elm trees (Ulmus spp.) along the interface area but most of them died during the last three to four years from Dutch elm disease. The breeding area immediately north of the light trap is usually dry by July or late summer. There is no competing light source near the trap area.

Shelby

The trap is located in the backyard of the 1051 Shorewood Drive residence. It is a residential area in the township of Shelby near the State Road Coulee, where La Crosse encephalitis has shown to be endemic (Watts et al. 1974). There are many potential artificial containers, such as tree holes on the bluffs, storm ditches, tires, and buckets in the area. It is further away from the marshes and rivers than the other trap locations. Shrubs and herbaceous plants that are suitable for resting places for mosquitoes are abundant in the area. The major vegeta-

Table 1. Major plant communities and their dominant species in Myrick Marsh.

The Wet Marsh Community
Scirpus fluviatilis (bulrush)
Typha latifolia (cattail)
Sagittaria latifolia (arrowhead)
Lemna trisulca (duckweed)
Spartina pectinata (marsh grass)
Polygonum spp. (smartweed)
Phragmites communis (reed grass)
Phalaris arundinacea (reed canary grass)
The Deciduous Woods Community
Acer negundo (box elder)
Acer saccharinum (silver maple)
Quercus spp. (oak)
Juglans nigra (black walnut)
Gleditsia triacanthos (locust)
Morus spp. (mulberry)
Fraxinus pennsylvanica (green ash)
Ulmus spp. (elms)
Populus deltoides (cottonwood)*
Celtis occidentalis (hackberry)
The Grassland Community
Bromus spp. (brome grass)
Panicum spp. (panic grass)
Poa pratensis (blue grass)
Asclepias spp. (milkweed)
Ambrosia spp. (ragweeds)
Laportea canadensis (wood nettle)
Urtica dioica (stinging nettle)

*Adapted from Harris, P.A. 1975.

tion are red pine, lilac bushes (Syringa vulgaris), dogwoods (Cornus spp.), raspberries (Rubus spp.), day lilies (Hemerocallis fulva) and iris. There are a few lights coming from homes nearby but they are probably not close enough to be competing with the light trap.

French Island

The trap is located in the backyard of the 1728 Caroline Street residence. It is a residential area on French Island in the township of Campbell. The island is situated between the Mississippi and Black Rivers. There were many junk piles, discarded tires, and other containers on the island. The trap is hung from a pole by a silver maple located about five blocks east of the Mississippi River. White cedars (Thuja occidentalis), Siberian elms (Ulmus pumila) and hackberries (Celtis occidentalis) are common trees in the area. Grasses that can serve as resting places for the adults are abundant in the vicinity of the trap. Competing light sources are limited to light from homes nearby.

Oak Forest

The trap is located north of the garage building of the former Oak Forest Nursing Home in the town of Onalaska. The trap is hung from a pole next to a Norway spruce (Picea abies) near an interface of a forest. Stands of red and white pines (Pinus resinosa and P. strobus) are located nearby. A black oak (Quercus velutina) with filled tree holes is located at 7.6 m from the trap. The predominant trees in the forest are black and white oaks (Quercus alba), two species that tend to have

basal tree holes. Floor cover includes raspberries and other herbaceous plants. There is also an occassional red oak (Quercus borealis). There are signs of periodic fires throughout the forest; tree holes may be formed when these trees are resprouting. In addition to tree holes, the nearest breeding place is a marsh along the Black River about three blocks west of the trap. Junk piles with containers suitable for the breeding of mosquitoes had also been found near the trap.

Division Street

The trap is located in the backyard of the 524 Division Street residence. This trap was in operation in 1980 only. The trap is hung on a pole in an old residential neighborhood 5½ blocks from the Mississippi River. Hackberry and mulberry (Morus alba) trees are located next to the pole. Other vegetation include walnut trees (Juglan nigra) and lilac bushes. In front of the house along the street are numerous American elms and hackberry trees. Vegetation suitable for resting places for adults are common in the area, along with garages and sheds that adults can hibernate in. Competing light sources are limited to lights from nearby homes.

RESULTS AND DISCUSSION

A total of 339,418 mosquitoes were collected in La Crosse County light traps during the study period. Of these, 57,103 females and 21,331 males were collected in 1979, while 195,316 females and 65,668 males were collected in 1980. Although approximately equal numbers of males and females are produced in nature (U.S. Dept. HEW 1977), more than twice as many females as males were collected. Provost (1952) noted that males are shown to be as susceptible to light as their respective females. He thought that low numbers of males in trap collections are due to their sedentariness, thus spending too little time in flight to encounter traps with any frequency. Females also tend to travel greater distances and appear to live longer than males (U.S. Dept. HEW 1977). When trap data show approximately equal numbers of both sexes, it usually means that the collection site is in close proximity to the breeding sites since males seem to remain near where they are hatched (Gadzama 1977, U.S. Dept. HEW 1977).

Tables 2 and 3 show the monthly totals for each trap location for 1979 and 1980. The Myrick Marsh trap was the most productive throughout the study, where over 50% of the females were collected each year. As expected, the numbers of females exceeded the numbers of males collected by a large margin at most of the sites. In May of 1979 in the total from all trap locations, in September of 1979 at Shelby, and in August of 1980 at Oak Forest, the numbers of males actually exceeded the numbers of females collected. This may have resulted from many mosquitoes hatching near the collection sites during these months. The relatively

Table 2. Monthly totals of each trap location in 1979.

Month	Goose Island		Myrick Marsh		Shelby		French Island		Oak Forest		Monthly Totals	
	females	males	f	m	f	m	f	m	f	m	f	m
May	79	10[1]	357	376[2]	152	46[3]	321	561[4]	281	209[4]	1,190	1,202
June	483	80	3,544	289	446	163	318	146	588	764	5,379	1,442
July	2,226	928	5,880	651	1,992	224	1,267	149	663	110	12,028	2,062
August	1,315	116	14,451	2,848	3,325	692	2,160	812	2,862	2,351	24,113	6,819
September	943	545	8,942	5,001	2,397	2,934	1,389	714[5]	731	612[5]	14,393	9,806
Location Totals	5,037	1,679	33,174	9,165	8,312	4,059	5,455	2,328	5,125	4,046	57,103	21,331

[1] May 18 to May 31

[2] May 17 to May 31

[3] May 19 to May 31

[4] May 23 to May 31

[5] September 1 to September 24

Total: 78,434

Table 3. Monthly totals of each trap location in 1980.

Month	Goose Island		Myrick Marsh		Shelby		French Island		Oak Forest		Division Street		Monthly Totals	
	females	males	f	m	f	m	f	m	f	m	f	m	f	m
May[1]	16	4	144	67	179	10	22	3	15	9	10	6	386	99
June	6,006	2,400	33,572	9,845	7,409	2,391	4,265	2,809	4,707	6,336	6,981	4,701	62,940	28,482
July	2,517	949	19,731	1,427	7,164	464	2,257	151	1,622	209	5,117	822	38,408	4,022
August	3,072	1,846	26,838	3,148	6,239	1,348	6,496	1,823	6,903	7,637	4,426	1,004	53,974	16,806
September	1,326	244	21,867	10,244	3,701	1,638	4,669	1,213	2,772	1,203	4,406	853	38,741	15,395
October	3	4[2]	845	823[3]	19	37[4]	--	--	--	--	--	--	867	864
Location Totals	12,940	5,447	102,997	25,554	24,711	5,888	17,709	5,999	16,019	15,394	20,940	7,386	195,316	65,668

[1] All traps began 5-19 except at Division Street, shich began 5-23

[2] Oct. 1 only

[3] Oct. 1-15

[4] Oct. 1-3 and Oct. 6

Total: 260,984

large proportion of females may be due to a large migration of adults into the area. Even though the trap at Myrick Marsh is close to breeding sites, it is also in an area that serves as an interface between the City and the Marsh. Therefore about four times as many females as males are usually collected there. There were almost as many males as females at Oak Forest during the study period, perhaps because the trap was located close to a large breeding area on the Black River. However, more studies are needed to determine why the forest did not attract more migrating females.

Twenty one species, representing seven genera, were observed during the study period. Table 4 lists these species in taxonomic order. All the species were present in both years. In actuality, there may be more than 21 species present because as shown in Table 4, there are three species referred to as groups or complexes. These are groups of mosquitoes whose members are difficult to distinquish from one another as adult females, but can readily be identified to species at the larval stage. Larvae of Ae. communis of the Ae. punctor group, Ae. excrucians and Ae. fitchii of the Ae. stimulans group, and C. pipiens pipiens and C. restuans of the C. pipiens complex, and Ae. hendersoni Cockerell have been collected to date in La Crosse County. Adults positively identified as C. pipiens pipiens, C. restuans and C. salinarius of the C. pipiens complex had been collected here. If larval collections are incorporated into the list in Table 4, the fauna of La Crosse County mosquitoes would include 25 species. In addition, other species not mentioned above that are known in other parts of Wisconsin and neighboring states from situations similar to those here may also occur.

Table 4. A list of female mosquitoes collected in light traps in La Crosse County.

Order Diptera

Family Culicidae

Subfamily Anophelinae

Anopheles punctipennis (Say)
Anopheles quadrimaculatus (Say)
Anopheles walkeri Theobald

Subfamily Culicinae

Aedes canadensis (Theobald)
Aedes cinereus Meigen
Aedes dorsalis (Meigen)
Aedes punctor group*
Aedes spencerii (Theobald)
Aedes sticticus (Meigen)
Aedes stimulans group**
Aedes triseriatus (Say)
Aedes trivittatus (Coquillett)
Aedes vexans (Meigen)

Coquillettidia perturbans (Walker)

Culex pipiens complex***
Culex tarsalis Coquillett
Culex territans Walker

Culiseta inornata (Williston)
Culiseta morsitans (Theobald)

Psorophora ciliata (Fabricius)

Uranotaenia sapphirina (Osten Sacken)

*Aedes *punctor* group may include *Ae. punctor* (Kirby), *Ae. abserratus* (Felt and Young), and *Ae. communis* De Geer.

**Aedes *stimulans* group may include *Ae. stimulans* (Walker), *Ae. excrucians* (Walker), *Ae. fitchii* (Felt and Young), and *Ae. increpitus* Dyar.

***Culex *pipiens* complex may include *C. pipiens pipiens* Linnaeus, *C. restuans* Theobald, and *C. salinarius* Coquillett.

Figs. 2 and 3 show the species compositions of 1979 and 1980. Ae. vexans was the most abundant species in the County, comprising about 80% and 87% of the total females in 1979 and 1980, respectively. Other Aedes species were also abundant, comprising 11% in 1979 and 7% of the female totals in 1980. The C. pipiens complex made up about 2% of the totals each year. Other important mosquitoes included An. walkeri, which was abundant in 1979, and Coq. perturbans, which was almost as abundant as the C. pipiens complex in 1980.

Tables 5 and 6 show the number of each species collected at each trap location for the two seasons. Ae. vexans was the most common mosquito at every trap location, while the other species varied to some degree depending on the location and the year. All the floodwater species were more abundant at Myrick Marsh than elsewhere. An. walkeri showed a preference for Goose Island, although it was also abundant at Myrick Marsh. There were about twice as many of this species at Goose Island than Myrick Marsh in both years. The C. pipiens complex was most abundant at Shelby in 1980. It was also important in other residential areas such as Division Street. Although Ae. triseriatus is important medically, it was not abundant in the light trap collections.

As shown in Table 6, there was a drastic increase in the number of Coq. perturbans from 1979 to 1980, especially at Myrick Marsh. Other species such as An. walkeri, the C. pipiens complex, and Ae. trivittatus also fluctuated in numbers from one year to the other. All of the above species are easy to identify, and thus the numbers should give accurate descriptions of their abundance. Noting that some species appear abundantly in one year and others in another year, Wada (1965) conjectured

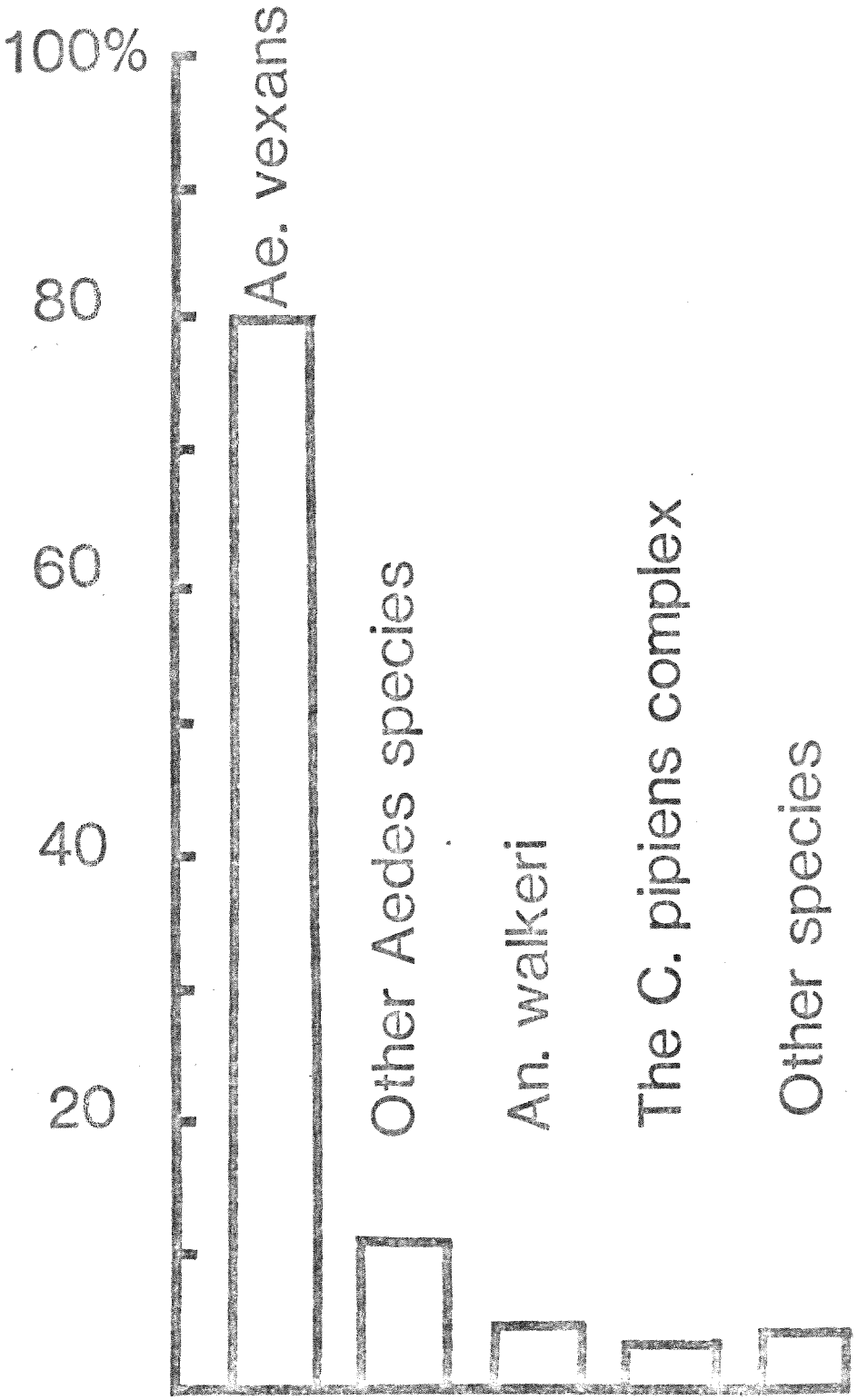


Figure 2. Species composition of light trap collections in La Crosse County in 1979.

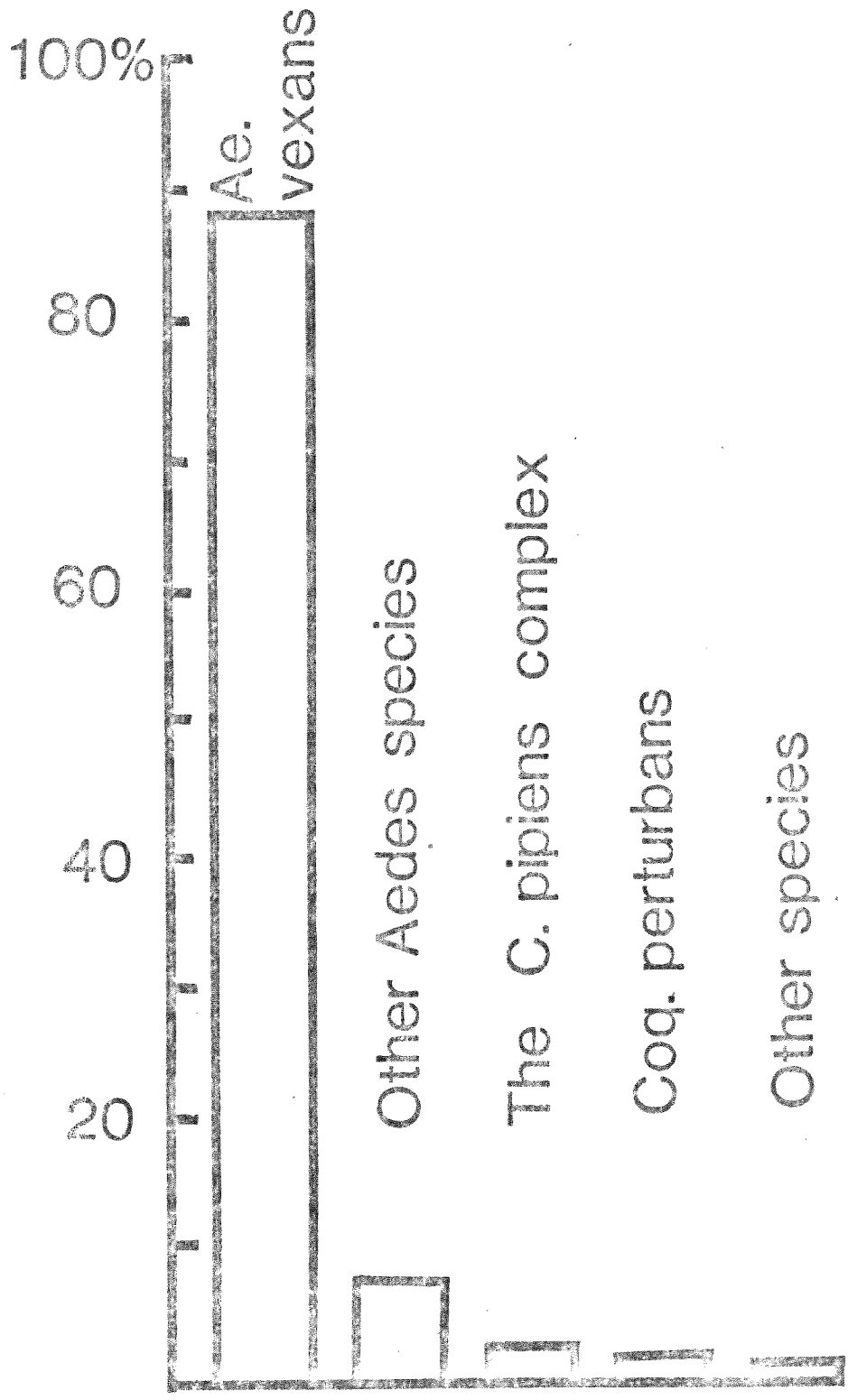


Figure 3. Species composition of light trap collections in La Crosse County in 1980.

Table 5. Mosquito species collected in La Crosse County in 1979.

Species	Goose Island	Myrick Marsh	Shelby	French Island	Oak Forest	Total	% Total
Ae. canadensis	68	747	200	171	137	1,323	2.32
Ae. cinereus	32	517	106	75	55	785	1.37
Ae. dorsalis	40	204	218	171	122	755	1.32
Ae. punctor group	0	2	0	3	0	5	*
Ae. spencerii	33	477	338	250	206	1,304	2.28
Ae. sticticus	9	64	68	96	96	333	*
Ae. stimulans group	82	793	313	319	266	1,773	3.10
Ae. triseriatus	5	14	0	1	7	27	*
Ae. trivittatus	1	36	14	22	54	127	*
Ae. vexans	2,909	28,125	6,542	4,025	3,720	45,321	79.37
An. punctipennis	65	85	74	17	35	276	*
An. quadrimaculatus	30	36	24	12	7	109	*
An. walkeri	1,374	680	27	61	76	2,218	3.88
Coq. perturbans	40	162	11	10	23	246	*
C. pipiens complex	240	699	191	83	149	1,362	2.38
C. tarsalis	10	13	8	14	12	57	*
C. territans	8	143	7	2	6	166	*
Cu. inornata	32	131	88	31	76	358	*
Cu. morsitans	8	23	12	19	32	94	*
P. ciliata	41	156	63	71	37	368	*
U. sapphirina	10	67	8	2	9	96	*
Total	5,037	33,174	8,312	5,455	5,125	57,103	--
% Total	8.82	58.10	14.56	9.55	8.98	--	--

*Less than 1% of total

Table 6. Mosquito species collected in La Crosse County in 1980.

Species	Goose Island	Myrick Marsh	Shelby	French Island	Oak Forest	Division Street	Total	% Total
Ae. canadensis	106	398	84	111	98	175	972	*
Ae. cinereus	113	1,787	167	217	186	224	2,694	1.38
Ae. dorsalis	101	451	193	141	277	120	1,283	*
Ae. punctor group	217	321	96	123	268	68	1,093	*
Ae. spencerii	248	969	181	152	177	156	1,883	*
Ae. stictícus	18	213	22	16	41	48	358	*
Ae. stimulans group	311	1,932	468	475	232	360	3,778	1.93
Ae. triseriatus	18	77	38	20	55	21	229	*
Ae. trivittatus	92	982	154	131	803	124	2,286	1.17
Ae. vexans	10,914	91,046	20,378	16,022	13,368	19,211	170,939	87.52
An. punctipennis	25	444	104	50	98	42	763	*
An. quadrimaculatus	36	15	3	1	8	1	64	*
An. walkeri	579	384	10	8	34	12	1,027	*
Coq. perturbans	40	3,025	55	26	137	32	3,315	1.70
C. pipiens complex	33	496	2,600	103	125	226	3,583	1.83
C. tarsalis	14	11	12	9	15	12	73	*
C. territans	30	148	81	27	37	75	398	*
Cu. inornata	7	107	17	17	26	4	178	*
Cu. morsitans	16	31	4	37	8	2	98	*
P. ciliata	2	71	14	11	1	4	103	*
U. sapphirina	20	89	30	12	25	23	199	*
Total	12,940	102,997	24,711	17,709	16,019	20,940	195,316	--
% Total	6.62	52.73	12.65	9.07	8.20	10.72	--	--

*Less than 1% of total

that this was due to the close relationship existing between mosquito abundance and meteorological factors. The main factor was thought to be the unstableness of breeding habitats, which is influenced by rainfall and temperature. The effect of these and other factors on light trap data will be discussed later.

Figs. 4 and 5 show the seasonal distributions of adult females during the study period. Although there seemed to be two major hatches each year, the emergence patterns for the two seasons were very different. The main differences were the numbers and sizes of the hatches.

Some females were already present when the traps were turned on in 1979. The seasonal distribution pattern of Ae. vexans in Fig. 6 shows that there were actually three broods of the species in 1979, with the first one resulting from flooding due to melting snow and rain. Also included in this first group of females were scattered hatches of An. walkeri, as shown in Fig. 7, the Ae. stimulans group, Ae. canadensis, and Ae. communis of the Ae. punctor group. In addition, species coming out of hibernation such as Cu. inornata and the C. pipiens complex, as shown in Figs. 8 and 9, respectively, were also present.

The second hatch of females in 1979 included Ae. vexans and other multivoltine species such as An. walkeri, Ae. canadensis, Ae. cinereus, and the C. pipiens complex. Also included here was the main hatch of Coq. perturbans, as shown in Fig. 10.

The third and largest hatch of the season appeared from August through the middle of September. As shown in the climatological data in Table 7, the City of La Crosse received an above average amount of rainfall during these months, resulting in large hatches of Ae. vexans

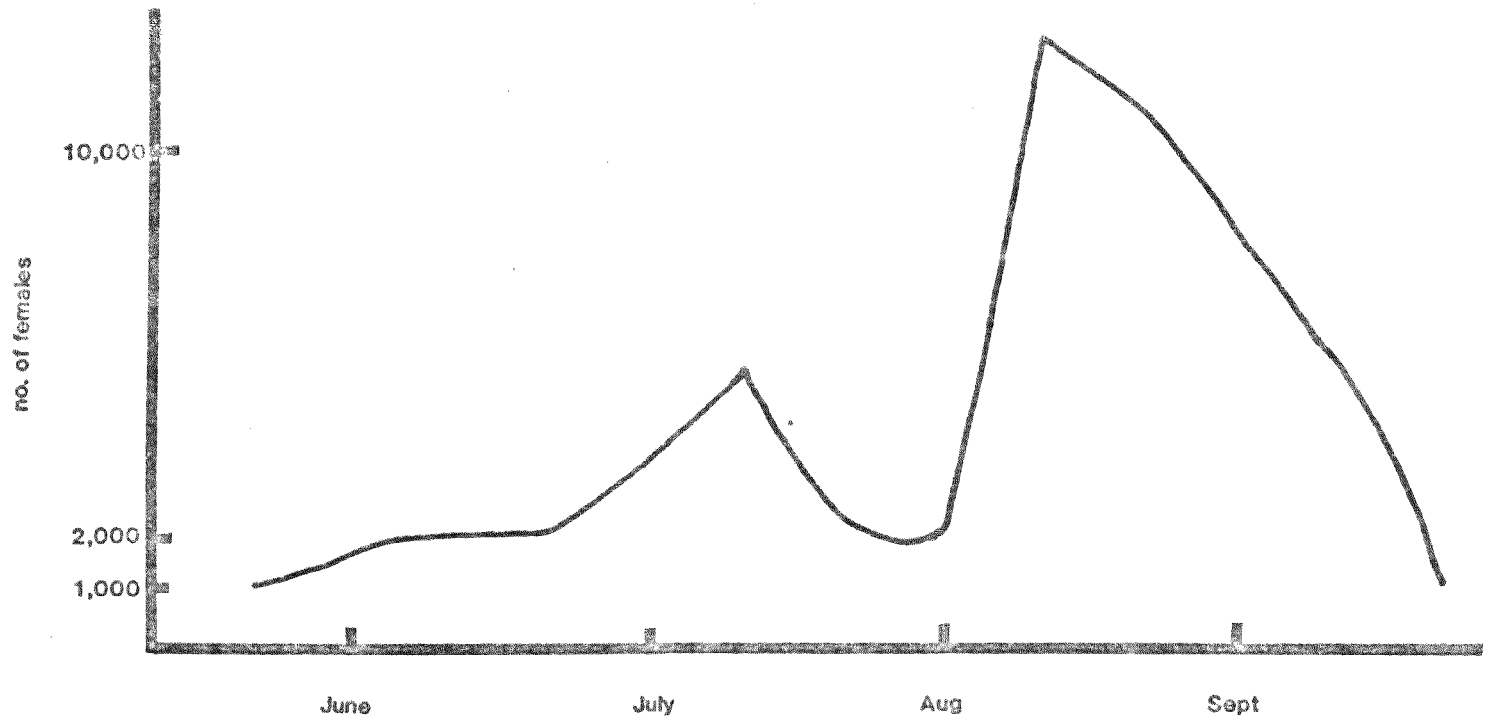


Figure 4. Seasonal distribution of adult female mosquitoes in 1979.

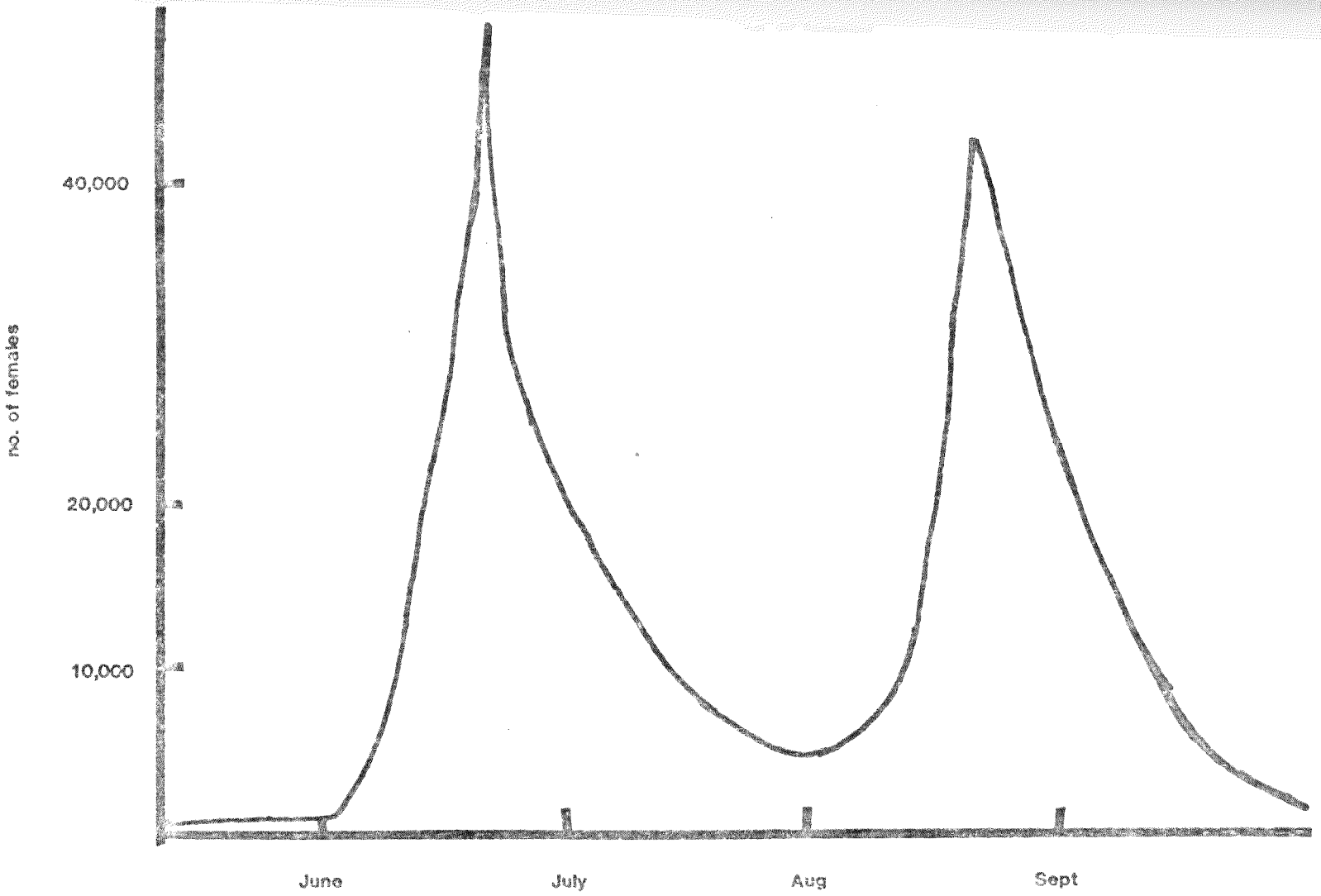


Figure 5. Seasonal distribution of adult female mosquitoes in 1980.

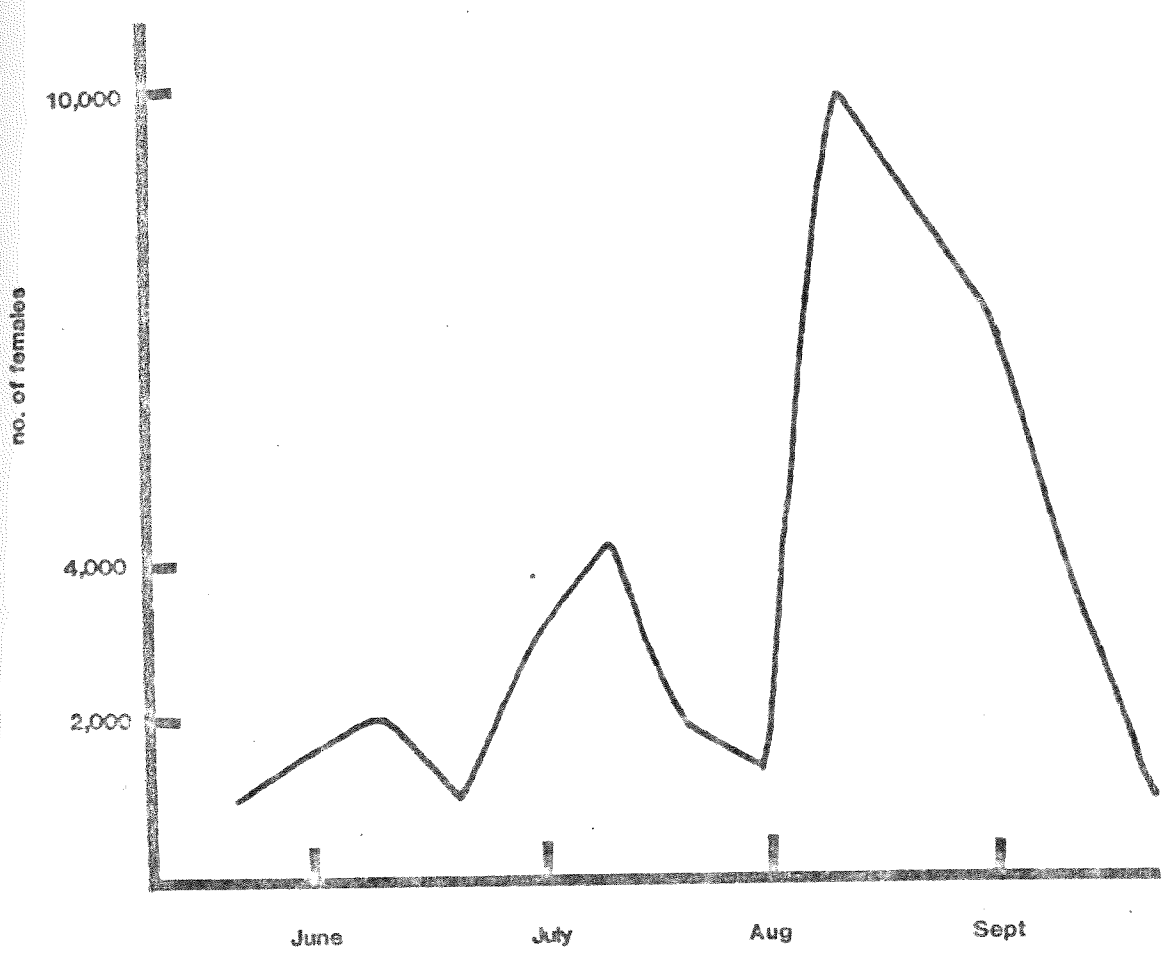


Figure 6. Seasonal distribution of Aedes vexans in 1979.

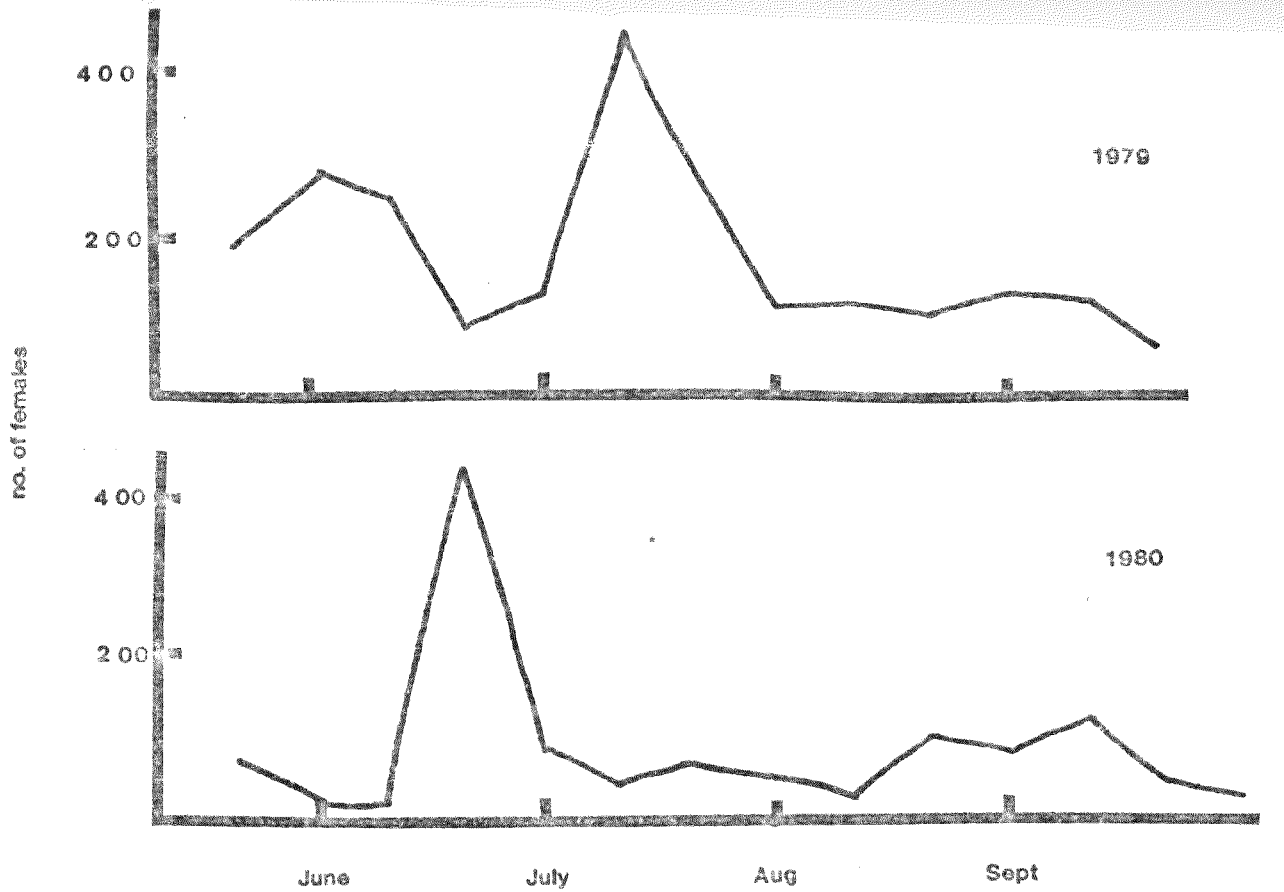


Figure 7. Seasonal distribution of Anopheles walkeri in 1979 and 1980.

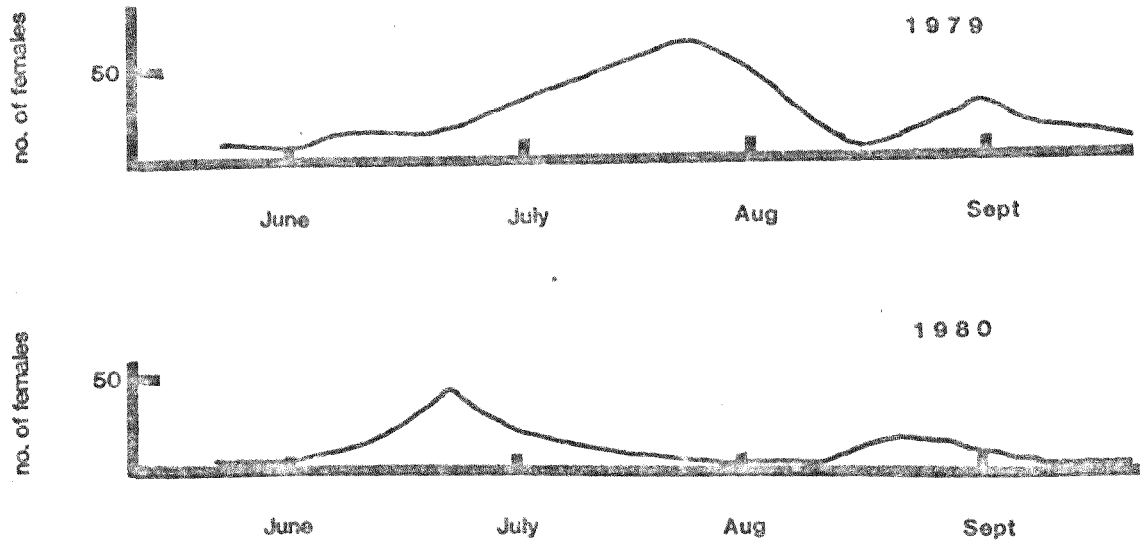


Figure 8. Seasonal distribution of Culiseta inornata in 1979 and 1980.

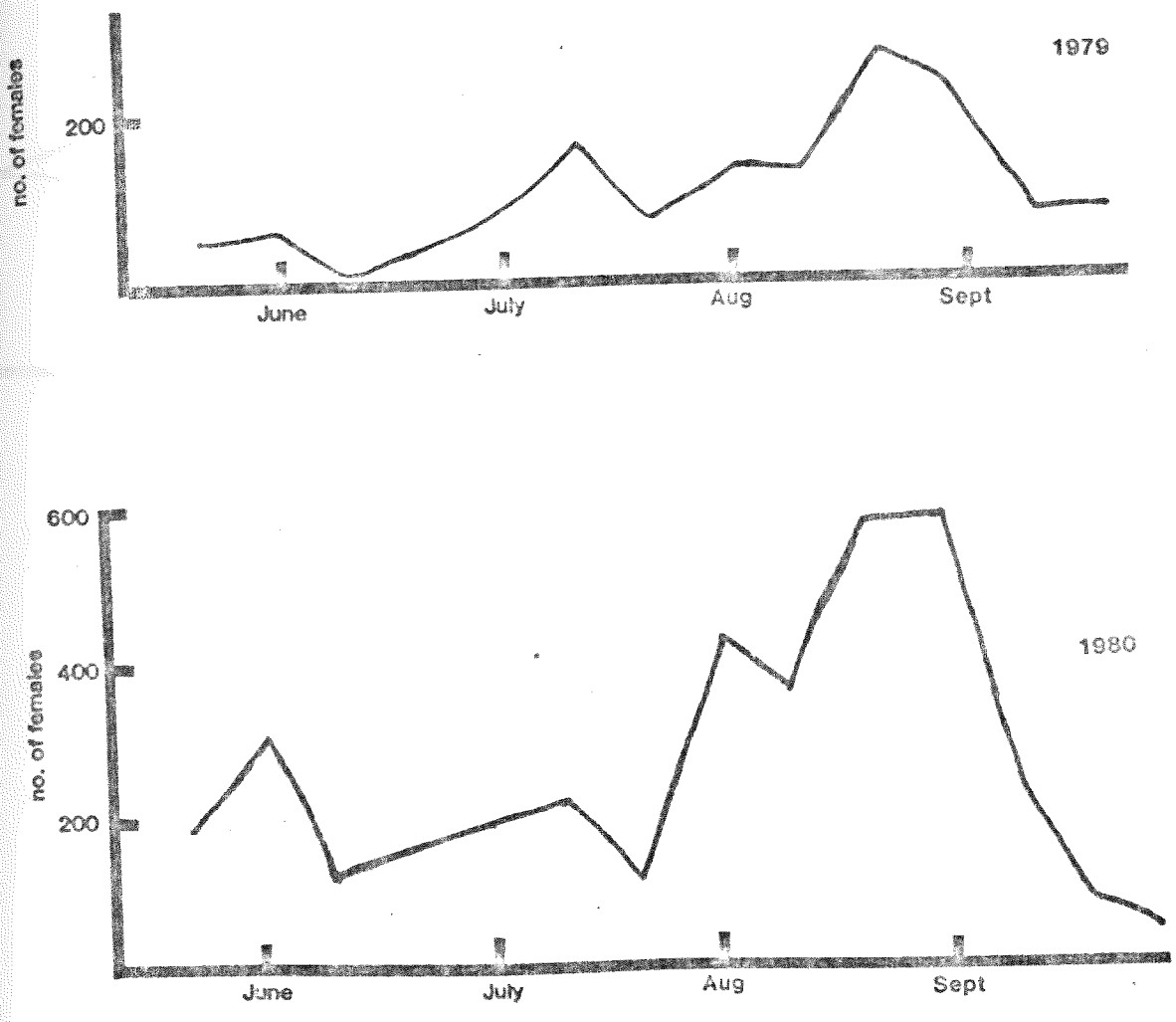


Figure 9. Seasonal distribution of the Culex pipiens complex in 1979 and 1980.

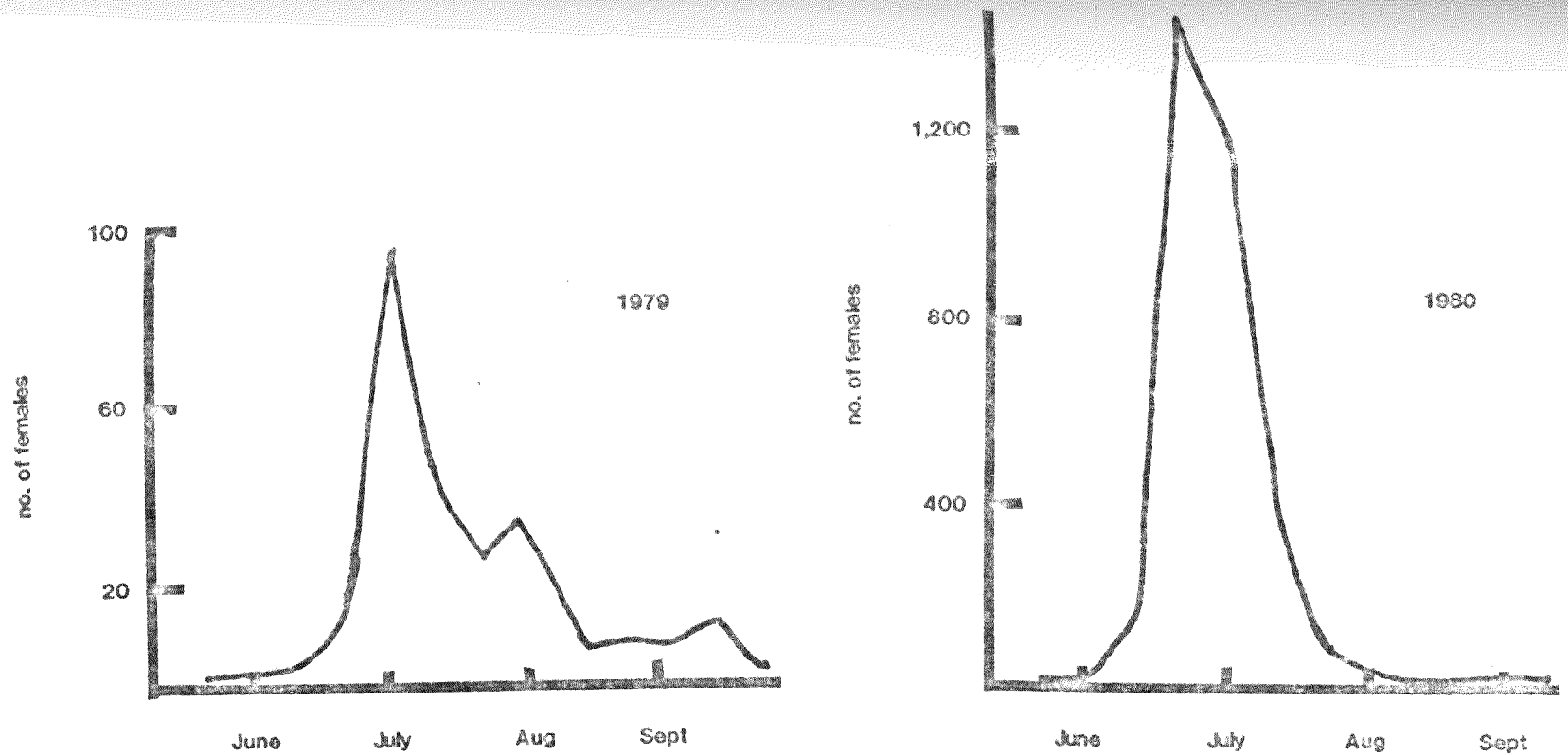


Figure 10. Seasonal distribution of Coquillettidia perturbans in 1979 and 1980.

Table 7. Climatological data of the City of La Crosse during the study period.*

Average Temperatures (°C)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1978	--	--	--	--	--	--	--	--	--	--	2.1	-6.7
1979	-14.4	-10.8	0.4	7.6	14.4	19.6	22.3	20.4	17.1	8.7	1.6	-2.1
1980	-7.5	-7.8	-1.3	9.7	17.1	21.3	25.7	23.4	17.6	7.3	--	--
Record												
mean	-9.2	-6.8	-0.1	8.6	15.1	20.2	22.8	21.4	16.8	10.4	1.8	-5.4
max	-4.2	-1.7	4.7	13.9	20.8	25.7	28.5	27.1	22.4	15.7	6.0	-1.3
min	-14.2	-11.9	-5.0	3.2	9.4	14.7	17.1	15.8	11.2	5.1	-2.5	-9.6

Snowfall (cm)

1978-79 season	151.4
1979-80 season	81.3
Record mean	108.0

Precipitation (cm)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1979	6.1	1.7	5.1	4.5	14.4	4.0	8.9	19.2	1.3
1980	4.1	0.9	1.7	4.4	6.7	9.1	5.7	25.0	21.6
Record mean	2.9	2.7	4.7	6.6	9.3	11.7	9.6	9.1	9.7

*Adapted from National Oceanic and Atmospheric Administration (NOAA), 1979 and 1980.

and the C. pipiens complex, as shown in Figs. 6 and 9, respectively.

As shown in Fig. 5, there were only two main hatches of mosquitoes in 1980, coinciding with the two broods of Ae. vexans shown in Fig. 11. There was not an earlier hatch of Ae. vexans as in May of 1979. As shown in Table 7, there were milder temperatures and less snowfall in the winter of 1979-1980. This may explain the absence of the early hatch, which is usually due to spring floods caused by snowmelt. As shown in Fig. 9, there was already a large population of the C. pipiens complex present when the traps were turned on in 1980. Due to the milder winter, the first hatch of An. walkeri, which usually results from overwintered eggs in the water, may had already emerged by the time the traps were turned on. This was shown by declining numbers of this species during May (Fig. 7).

However, the high amount of rainfall during May did result in the first hatches of Ae. vexans and other floodwater species, and broods of the C. pipiens complex and An. walkeri, as shown in Figs. 5, 7, 9 and 11. The annual hatch of Coq. perturbans, as shown in Fig. 10, also contributed to this group.

The second hatch of 1980 (Fig. 5), appeared in August and September from rainfall received during this period. Table 7 shows that an above average amount of precipitation occurred during these months. In addition to large broods of Ae. vexans and the C. pipiens complex (Figs. 11 and 9), there were also large hatches of Ae. cinereus and Ae. trivittatus (Figs. 12 and 13). Late appearing species, such as An. punctipennis C. territans and U. sapphirina (Figs. 14, 15 and 16), also contributed to the large population of females that hatched during this period.

Figure 11. Seasonal distribution of Aedes vexans in 1980.

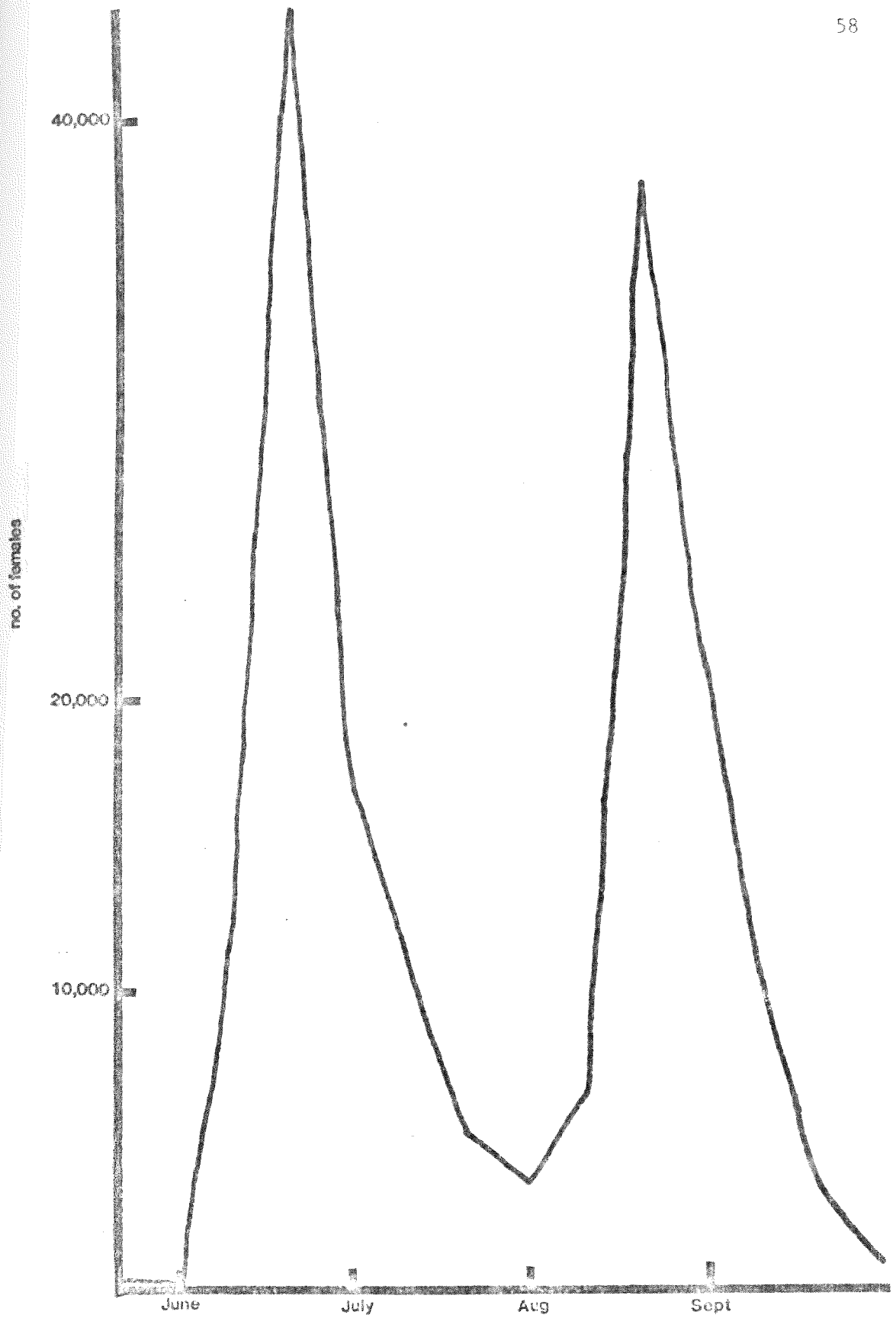


Figure 11

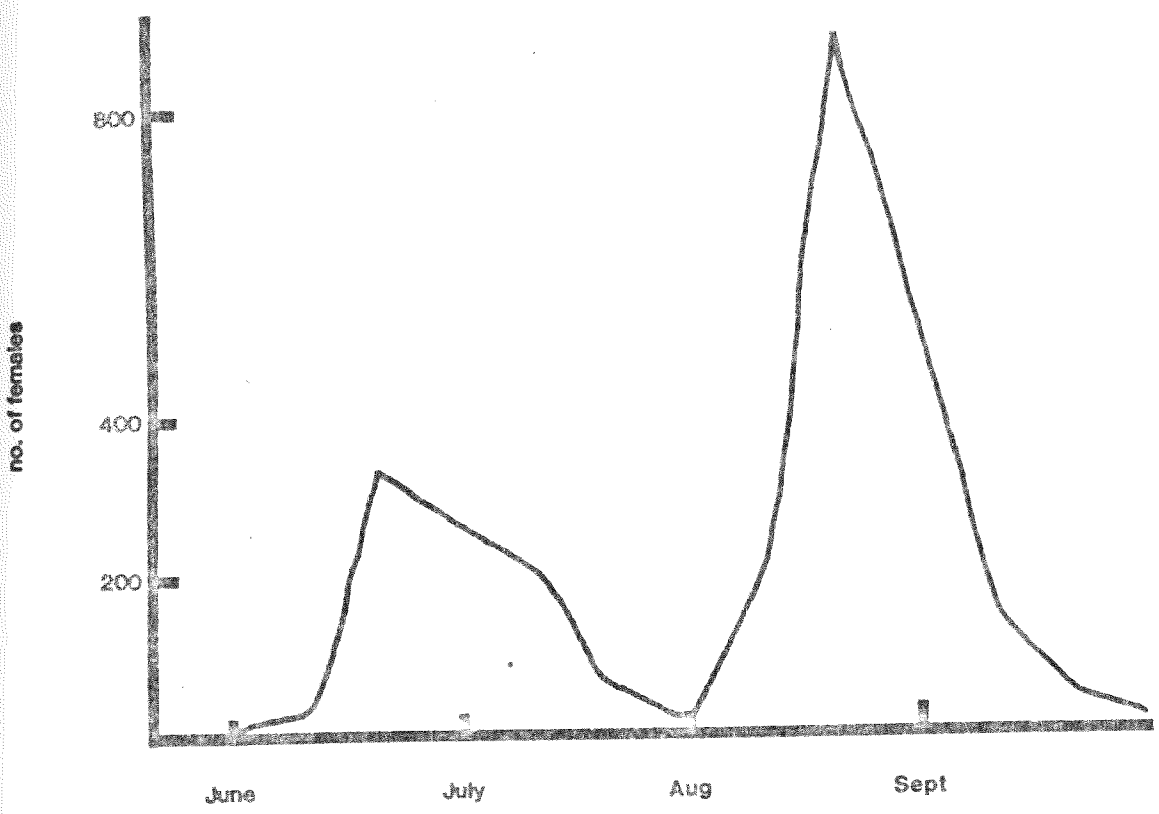


Figure 12. Seasonal distribution of Aedes cinereus in 1980.

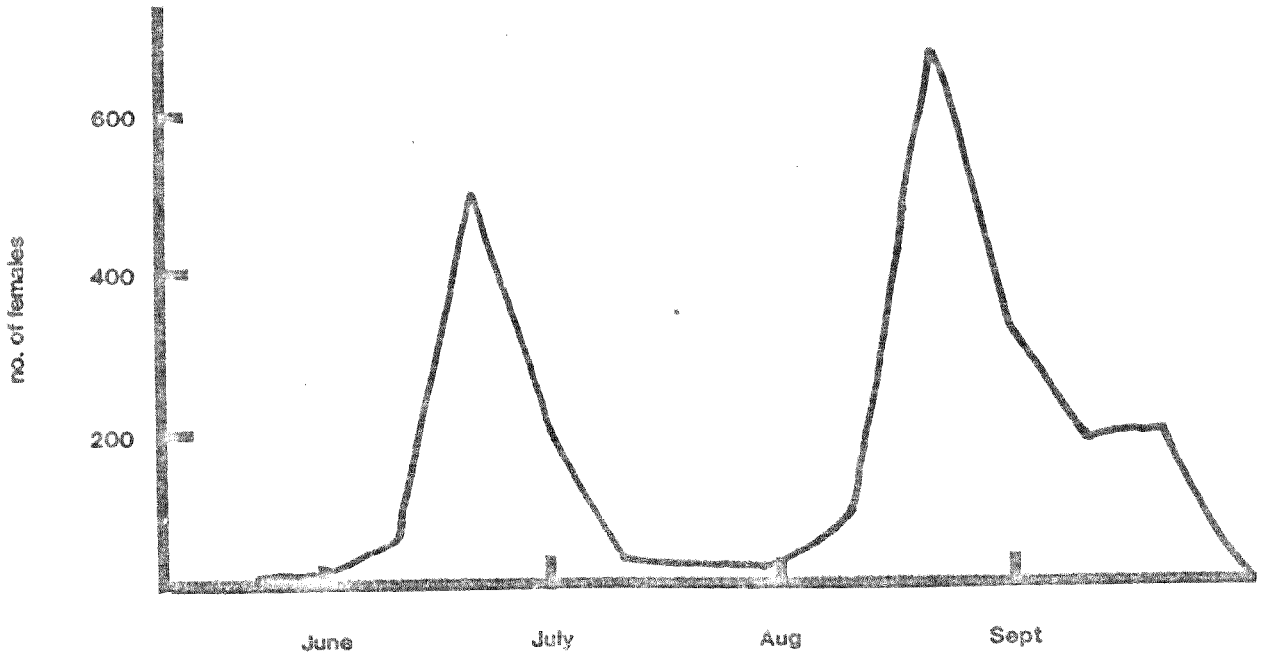


Figure 13. Seasonal distribution of Aedes trivittatus in 1980.

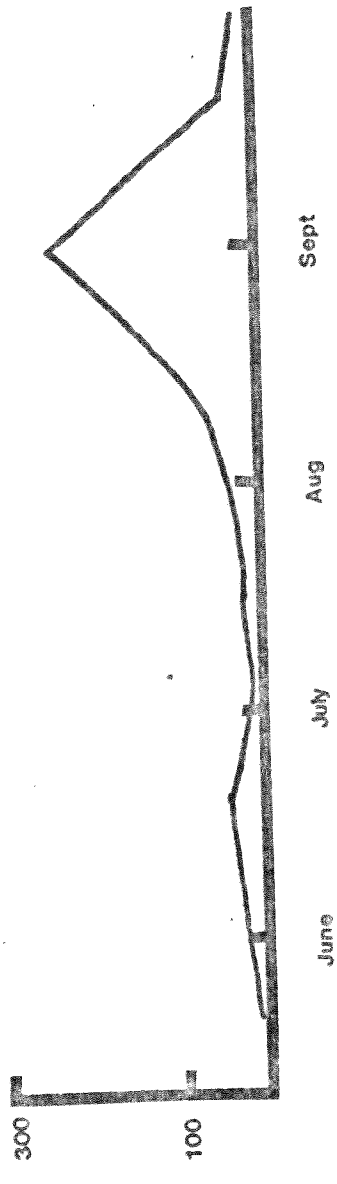


Figure 14. Seasonal distribution of Anopheles punctipennis in 1980.

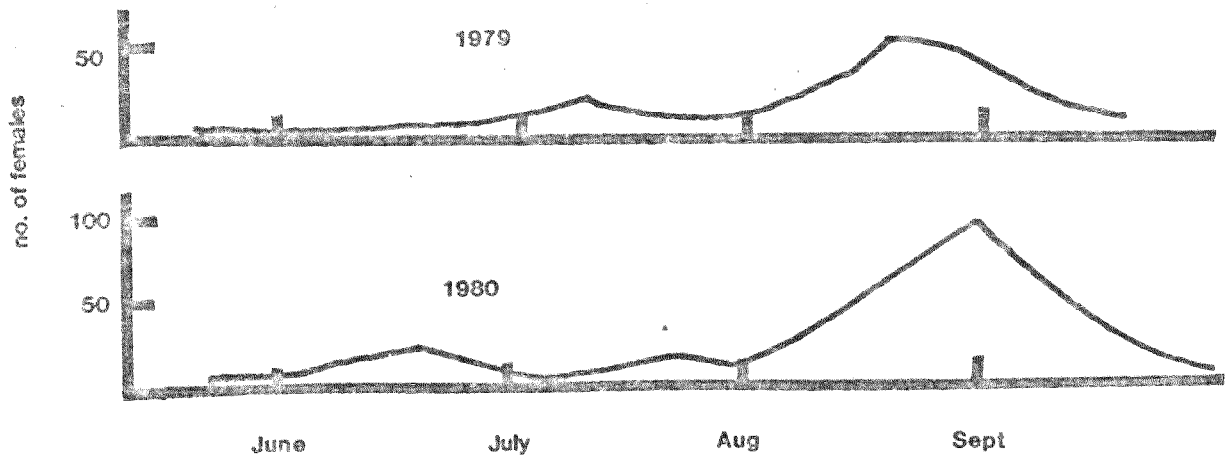


Figure 15. Seasonal distribution of Culex territans in 1979 and 1980.

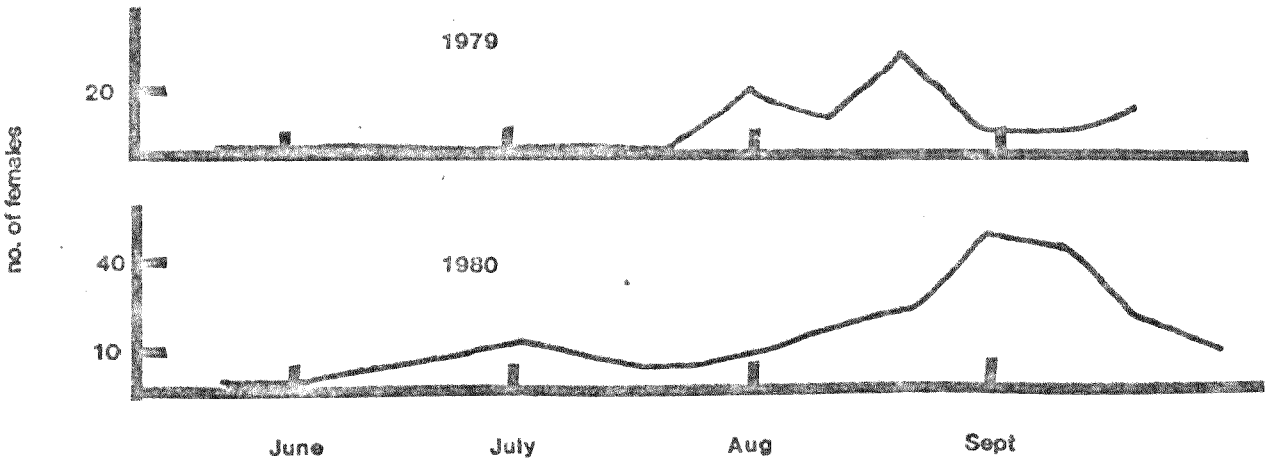


Figure 16. Seasonal distribution of Uranotaenia sapphirina in 1979 and 1980.

Overall, there was a three-fold increase in the number of females from 1979 to 1980. In order to determine if the presence of the additional trap at Division Street in 1980 was responsible for this increase, the average number of females per day per trap, plotted as William's means, are shown on the same graph. As Fig. 17 shows, there was a drastic increase in the average number of females from 1979 to 1980 throughout most of the season. The only time that the average number of females in 1979 exceeded that of 1980 was in May and early June. When the totals from each trap locations shown in Tables 2 and 3 are compared, it is apparent that there was also an approximately three-fold increase of females from one year to the next. Therefore, the females collected from Division Street, as a whole, did not contribute directly to the large increase in 1980. There was a larger catch from each of the traps.

Species Composition and Abundance at Each Trap Location

Goose Island:

Ae. vexans was the most abundant species at Goose Island both years, comprising 58 and 84% of the totals in 1979 and 1980, respectively. An. walkeri was also an important species (see Figs. 18-20). In 1979, there were more of this species than Ae. vexans in May and June. The reason why there were so many more An. walkeri in 1979 than 1980 is not known. Being a permanent water breeder, it is very sensitive to water levels. The difference in the amount of snowmelt and rainfall patterns in the two years probably contributed to the different population levels.

The species abundances and compositions for the two seasons were very different. As shown in Table 8, An. walkeri, the C. pipiens com-

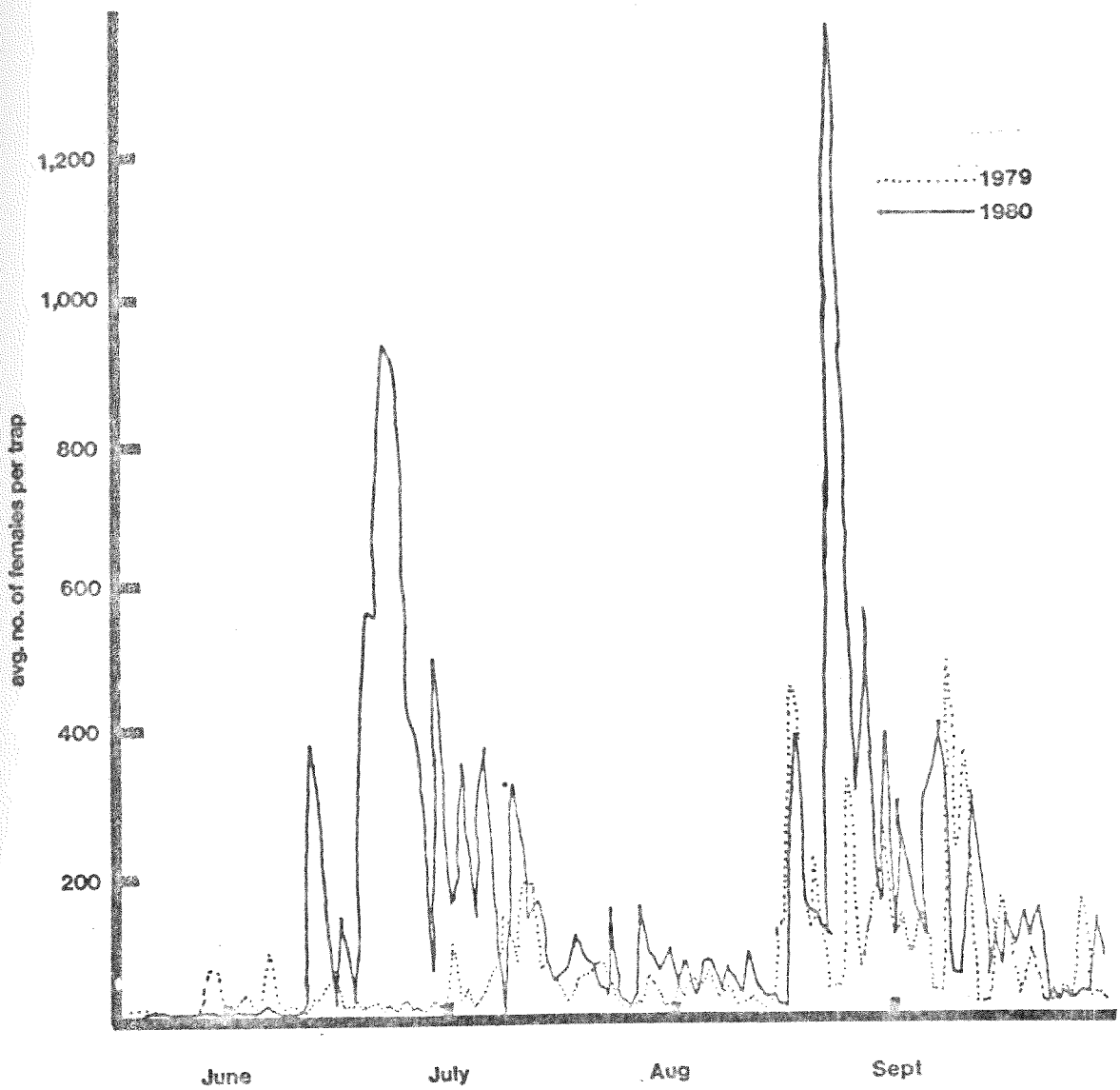


Figure 17. The daily average number of females per trap, shown as William's means, during the study period.

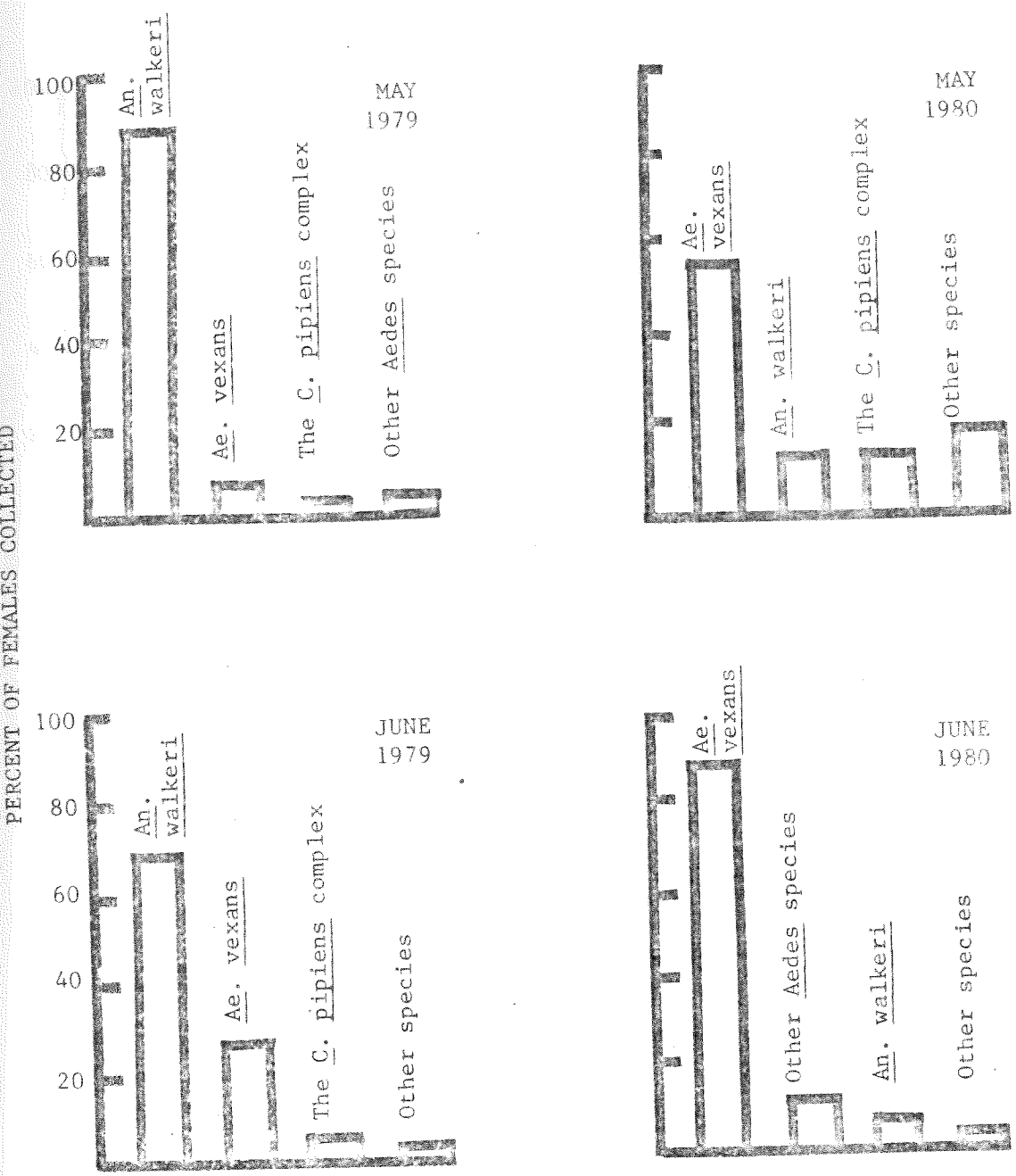


Figure 18. Species composition of mosquitoes collected at Goose Island during May and June.

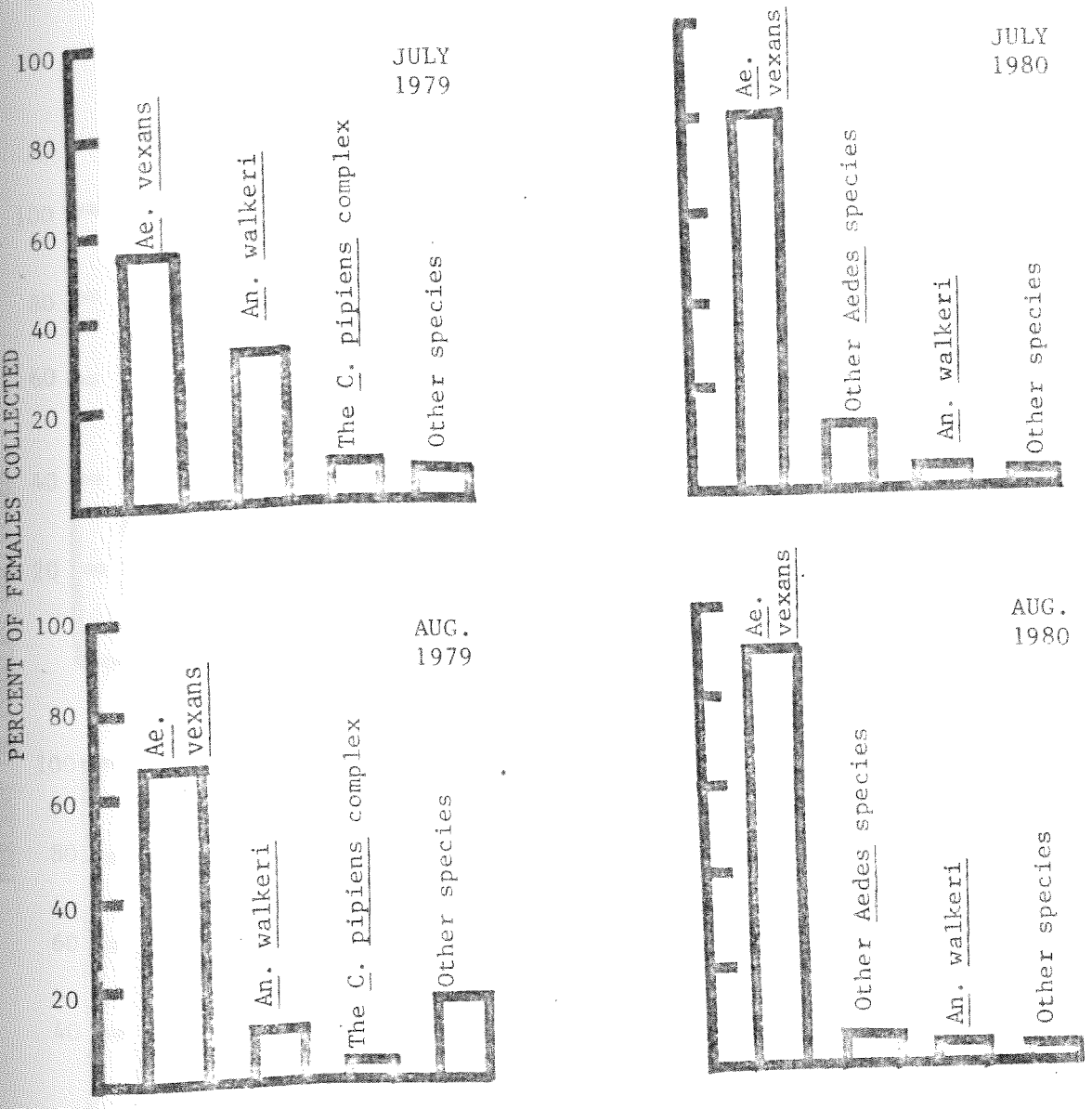


Figure 19. Species composition of mosquitoes collected at Goose Island during July and August.

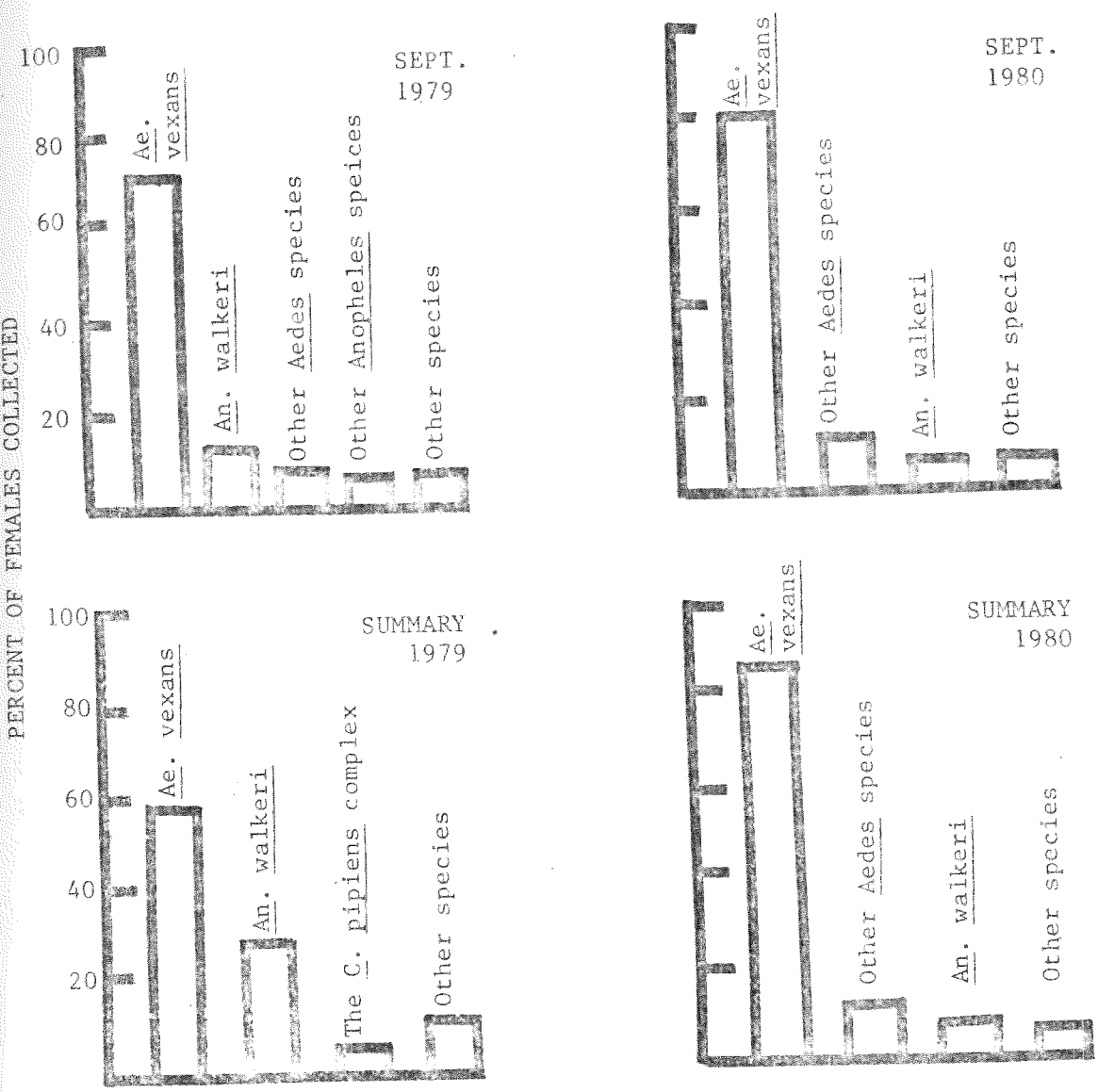


Figure 20. Species composition of mosquitoes collected at Goose Island, September and season summary, 1979 and 1980.

Table 8. Mosquito species collected at Goose Island.*

	1979						1980					
	May	June	July	Aug.	Sept.	Total	May	June	July	Aug.	Sept.	Total
Ae. canadensis			46	11	11	68		43	23	17	23	106
cinereus	1		8	21	2	32		67	26	2	18	113
dorsalis				28	12	40		34	16	32	19	101
punctor group						0		49	137	26	5	217
spencerii				17	16	33	2	156	18	42	30	248
sticticus			3		6	9			7	2	9	18
stimulans group		1	7	54	20	82		178	75	39	19	311
triseriatus	1	2	2			5		13	3	0	2	18
trivittatus		1				1		59	11	16	6	92
vexans	5	130	1,215	889	670	*2,909	9	5,034	2,068	2,737	1,063	10,911
An. punctipennis			30	22	13	65			4	14	7	25
quadrimaculatus				6	24	30		3	16	3	14	36
walkeri	70	329	713	150	112	1,374	2	329	82	86	80	579
Coq. perturbans		1	28	9	2	40		19	12	5	4	40
C. pipiens complex	1	15	156	55	13	240	2	3	4	17	7	33
tarsalis	1	2	3	2	2	10	1		4	6	3	14
territans				2	6	8			7	18	5	30
Cu. inornata		1		23	8	32		1	1	1	4	7
morsitans		1		6	1	8		11	3	0	2	16
P. ciliata			15	11	15	41		1	0	0	1	2
U. sappharina				9	1	10		6	0	9	5	20
Total	79	438	2,226	1,315	934	5,037	16	6,006	2,517	3,072	1,326	12,937

*These totals for 1980 do not include data for Oct., during which three Ae. vexans were collected.

plex, and a few other species were more abundant in 1979 than 1980, while the Ae. punctor group was found only in 1980. Aedes species other than Ae. vexans were more abundant in 1980 (Table 8). Many of these mosquitoes probably had migrated from other areas. Due to problems with identification, the numbers of Ae. dorsalis, Ae. spencerii, Ae. sticticus and the Ae. stimulans group may not be accurate.

Both the populations of Ae. triseriatus and Ae. trivittatus increased in 1980. As shown in Table 8, there was a decline in the number of Ae. triseriatus after June. There was an extensive tree hole filling program (using Rock Wool insulating cement) that summer at Goose Island, and it may have contributed to the decrease of the species. The increased population of Ae. trivittatus was similar to elsewhere in the County.

Compared to other trap locations, Goose Island was less productive, especially in 1980 (see Tables 2 and 3). In 1979, Goose Island produced slightly less than French Island and Oak Forest, but was still the least productive one. In 1980, Goose Island produced only 6% of all the females collected. This may have been due to competing light sources in the vicinity of the trap, such as light poles and lights from campers. It is also known that permanent bodies of water may produce fewer mosquito larvae because there are adequate numbers of predators to keep the larvae at lower densities. In addition, wave actions in deep and open waters, as noted in the marsh area and the Mississippi River channel, prevent the breeding of mosquitoes.

Myrick Marsh:

The most abundant species at Myrick Marsh was Ae. vexans, comprising 85 and 88% of the totals in 1979 and 1980, respectively. The species compositions of this trap location are shown in Figs. 21-25. There is usually a variety of important species present in May, while Ae. vexans becomes much more abundant the rest of the summer (Fig.21).

As shown in Table 9, all Aedes species, except for Ae. canadensis, were more abundant in 1980. Ae. cinereus became the second most abundant Aedes species in August and September. There was almost as many of this species than all the other Aedes species (excluding Ae. vexans) combined (see Figs. 23 and 24). There were also increases in the populations of Ae. trivittatus and Ae. triseriatus. The population of Ae. triseriatus here in 1980 did not decline during the summer like the one at Goose Island. The tree hole survey and filling program around Myrick Marsh was not very extensive. However, there was a decrease of An. walkeri and the C. pipiens complex, as in Goose Island. There was a dramatic increase in the number of Coq. perturbans in 1980, making it an important species in June and July (see Table 9 and Fig. 22).

As shown in Tables 2 and 3, the trap at Myrick Marsh was the most productive, where over 50% of the females were collected. The factors that influenced the population changes at Myrick Marsh will be discussed later on in the text.

Shelby:

Like Goose Island and Myrick Marsh, Ae. vexans was the most abundant species here, comprising 79 and 82% of the totals in 1979 and 1980, respectively. However, the C. pipiens complex seemed to be more impor-

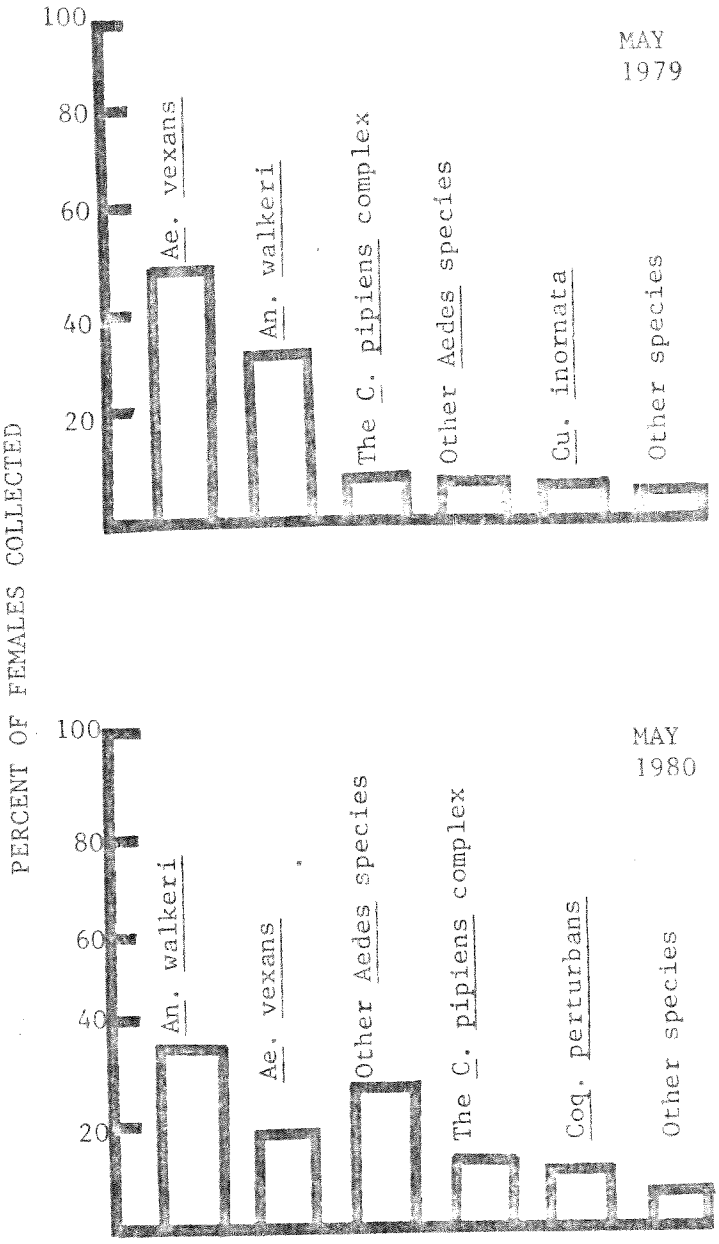


Figure 21. Species composition of mosquitoes collected at Myrick Marsh during May.

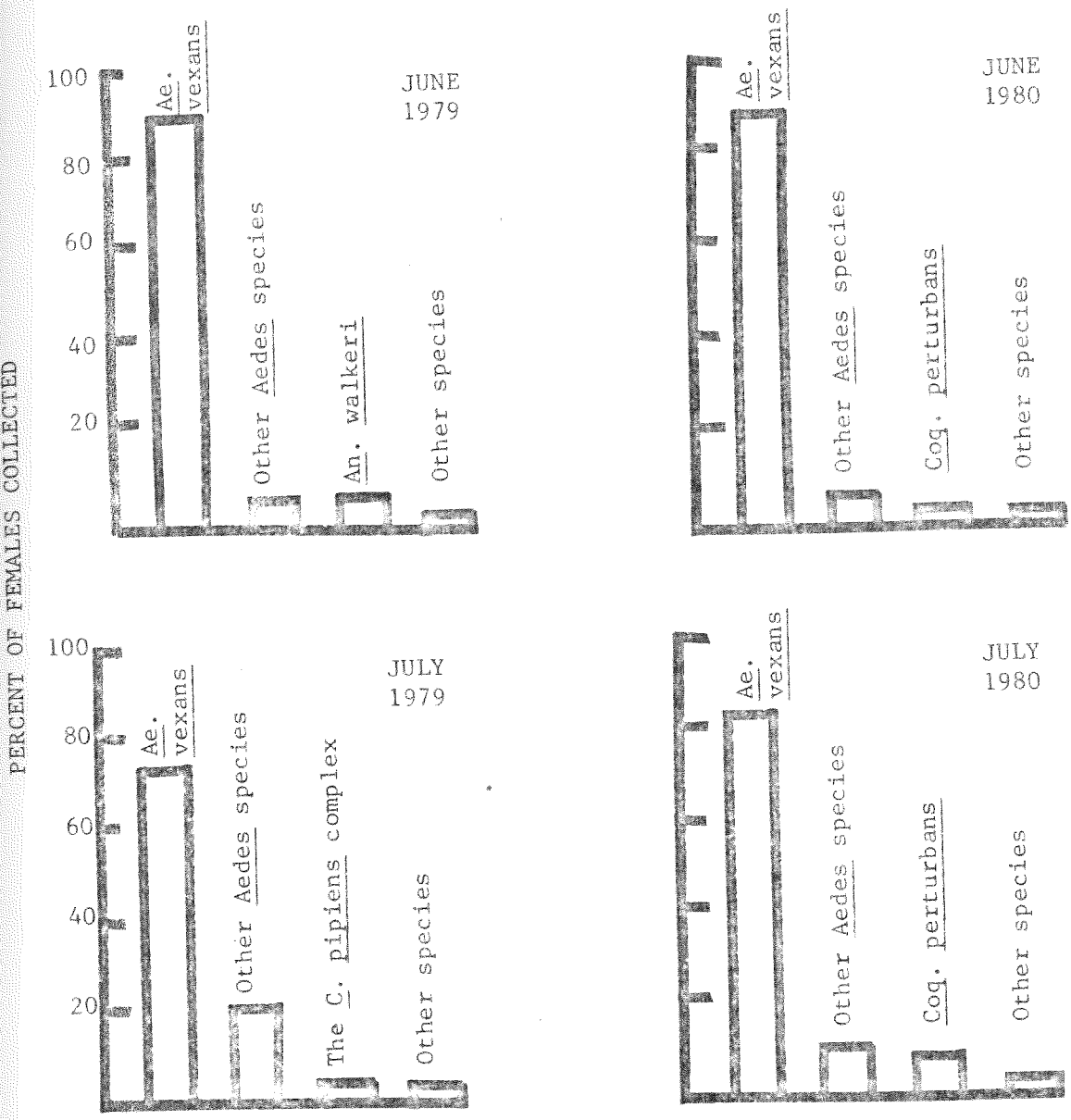


Figure 22. Species composition of mosquitoes collected at Myrick Marsh during June and July.

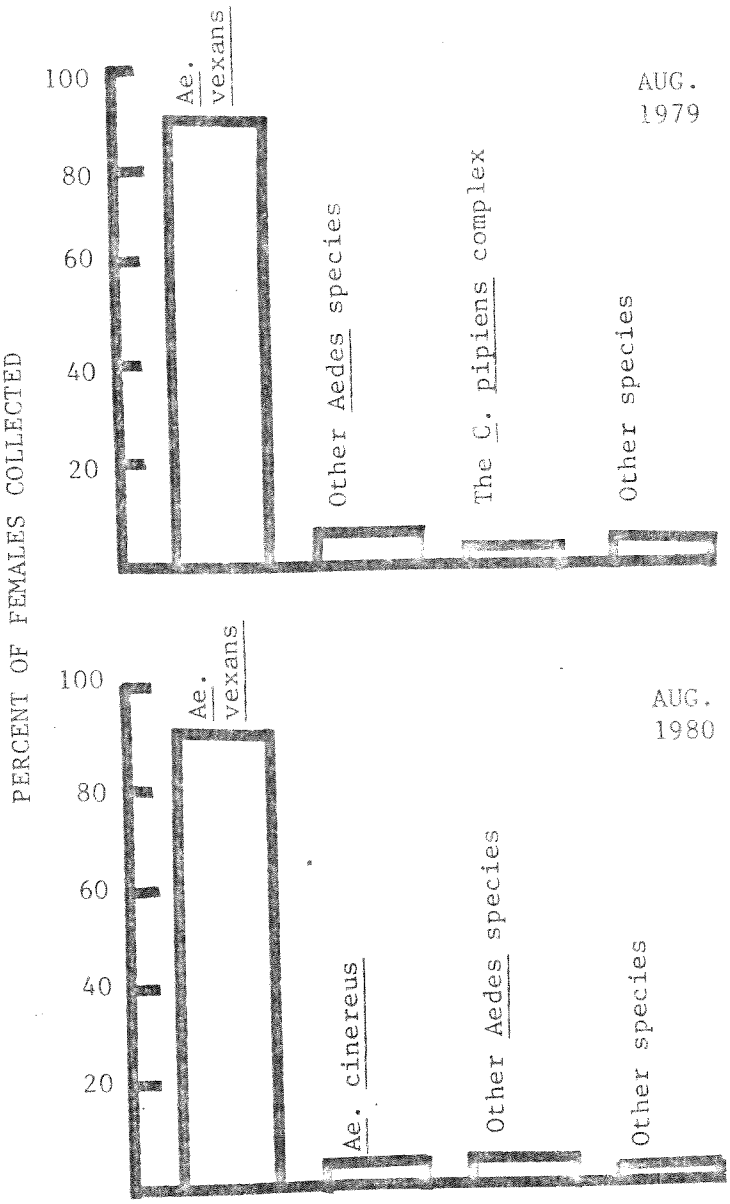


Figure 23. Species composition of mosquitoes collected at Myrick Marsh during August.

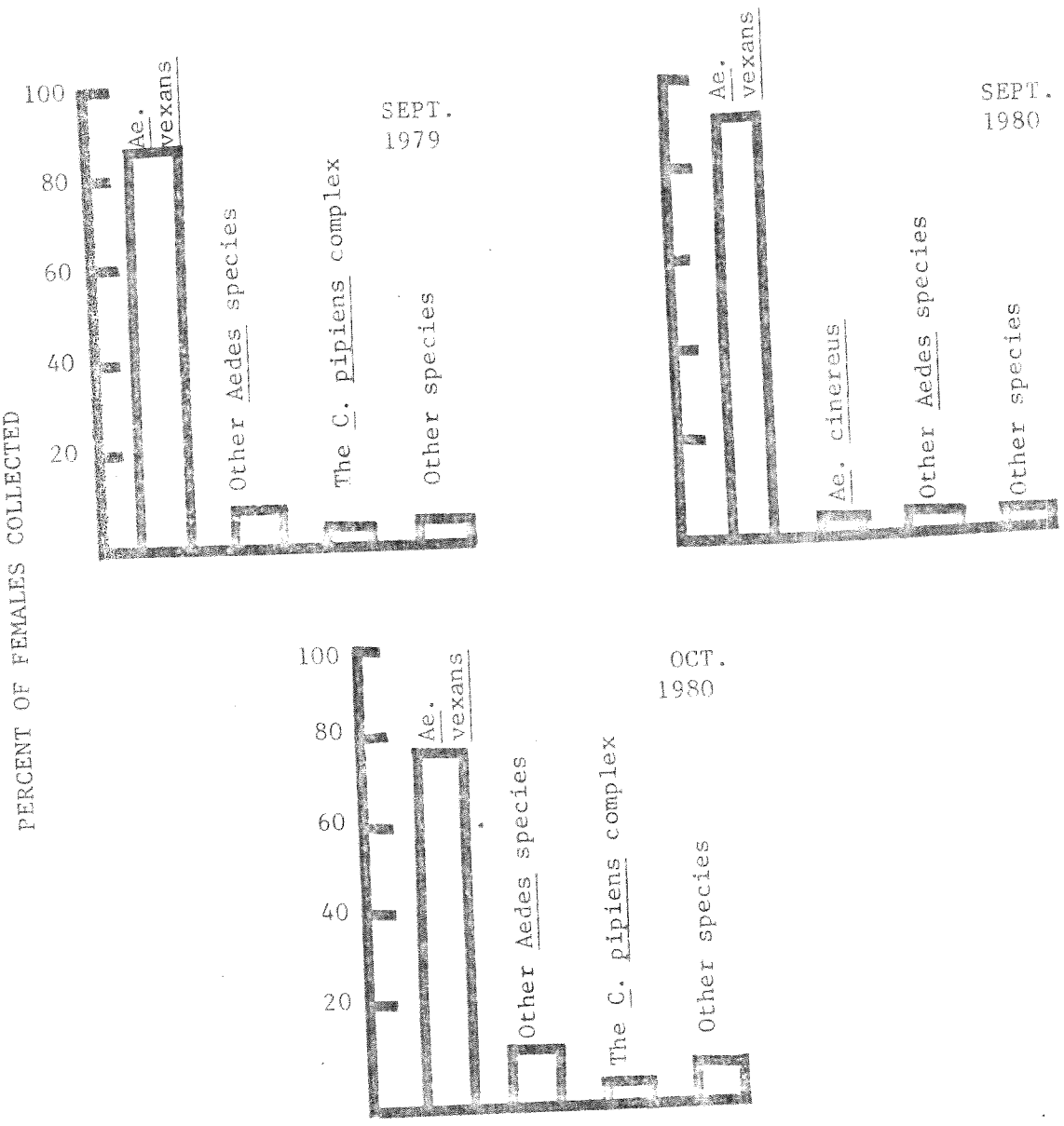


Figure 24. Species composition of mosquitoes collected at Myrick Marsh during September and October.

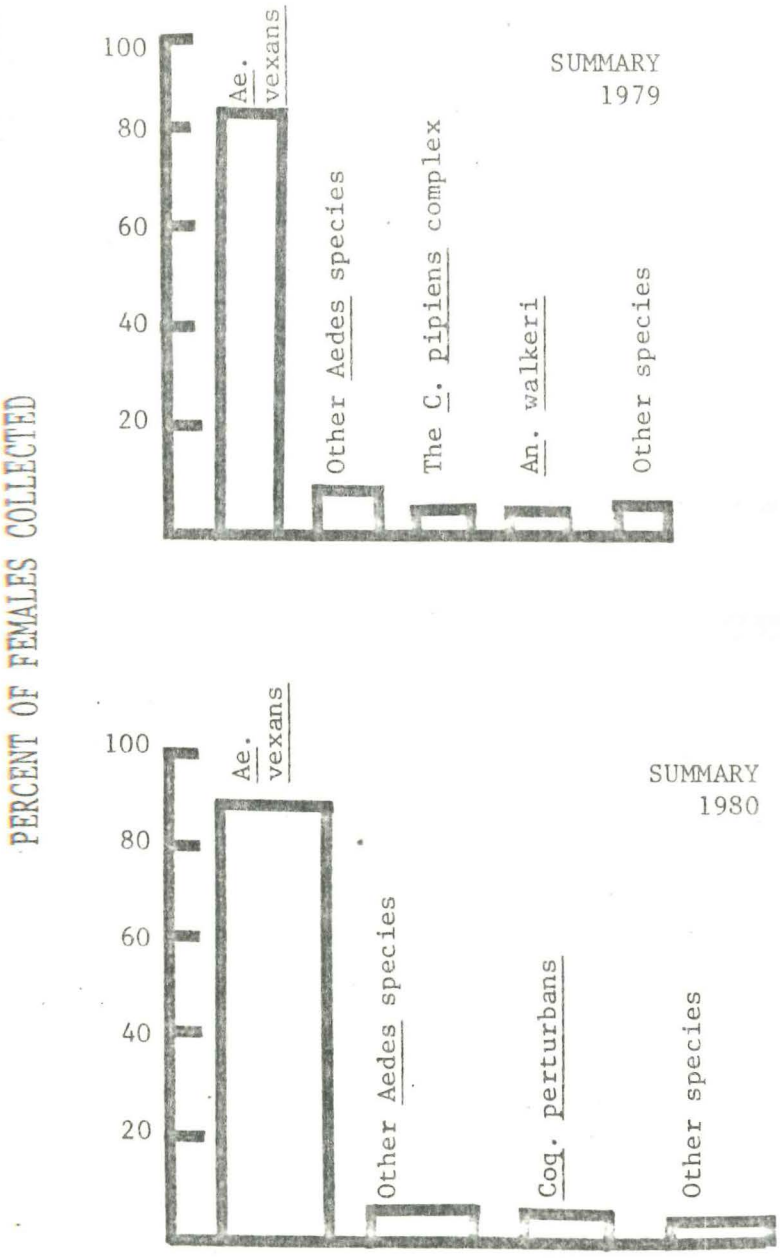


Figure 25. Species composition of mosquitoes collected at Myrick Marsh in 1979 and 1980.

Table 9. Mosquito species collected at Myrick Marsh.

	1979						1980						
	May	June	July	Aug.	Sept.	Total	May	June	July	Aug.	Sept.	Oct.	Total
Ae. canadensis	6	115	524	50	52	747	3	263	77	35	12	8	398
cinereus	11	32	216	168	90	517	4	186	361	699	532	5	1,787
dorsalis			30	109	65	204	2	212	87	82	54	14	451
punctor group					2	2	2	60	172	31	50	6	321
spencerii			102	147	228	477	18	239	424	149	105	34	969
sticticus			10	16	38	64	7	59	43	57	45	2	213
stimulans group	5	84	251	289	164	793	1	808	421	443	247	12	1,932
triseriatus			4	2	8	14		26	14	5	29	3	77
trivittatus	2		10	10	14	36		220	168	250	333	11	982
vexans	170	2,985	4,306	12,960	7,704	28,125	24	29,757	16,223	24,667	19,720	655	91,046
An. punctipennis	2	2	14	38	29	85	2	41	10	149	231	11	444
quadrimaculatus			1	2	33	36		6	1	2	6		15
walkeri	108	248	68	108	148	680	50	123	63	40	97	11	384
Coq. perturbans		8	109	34	11	162	11	1,461	1,531	18	4		3,025
C. pipiens complex	25	47	124	256	247	699	17	30	73	156	189	31	496
tarsalis	4	6		3		13		1		6	1	3	11
territans		1	12	96	34	143		12	8	24	94	10	148
Cu. inornata	19	6	21	52	33	131	2	22	8	5	56	14	107
morsitans	1		14	8		23		13	6	1	5	6	31
P. ciliata	4	10	63	52	27	156	1	32	28	3	7		71
U. sappharina			1	51	15	67		1	13	16	50	9	89
Total	357	3,544	5,880	14,451	8,942	33,174	144	33,572	19,731	26,838	21,867	845	102,997

tant here than at the other traps. The species compositions of this trap location are shown in Figs. 26-28. The C. pipiens complex comprised 2 and 10% of the totals in 1979 and 1980, respectively (Fig. 28). As shown in Table 10, there was a large increase in the population of this species in 1980. Surveys by County employees in the residential neighborhood where the trap is located showed the presence of many mosquito-breeding containers in the area. Larvae of C. pipiens pipiens, C. restuans, Ae. triseriatus and Cu. inornata were found in buckets, tires, wading pools, birdbaths, and storm ditches. These habitats were either eliminated or treated.

Due to the nature of its breeding places, the C. pipiens complex seemed to emerge from many different sites at various times throughout the summer. Although there were a few distinct peaks in the seasonal distribution patterns shown in Fig. 9, the population of this complex never reached zero. A closer look at the daily emergence pattern, shown in Fig. 29, shows that there were numerous hatches of this complex throughout the season.

As shown in Table 10, adults of Ae. triseriatus were only present in 1980. The presence of this species at Shelby is significant because of the close proximity of the trap to State Road Coulee, an area where LAC strain of viral encephalitis is endemic. Without the elimination of some of its habitats by County employees, the species would probably be more abundant.

Although this trap was not too close to the breeding sites of Ae. vexans, the species was still abundant here, probably due to its extensive flight range. Unlike the other traps, there were not large increases

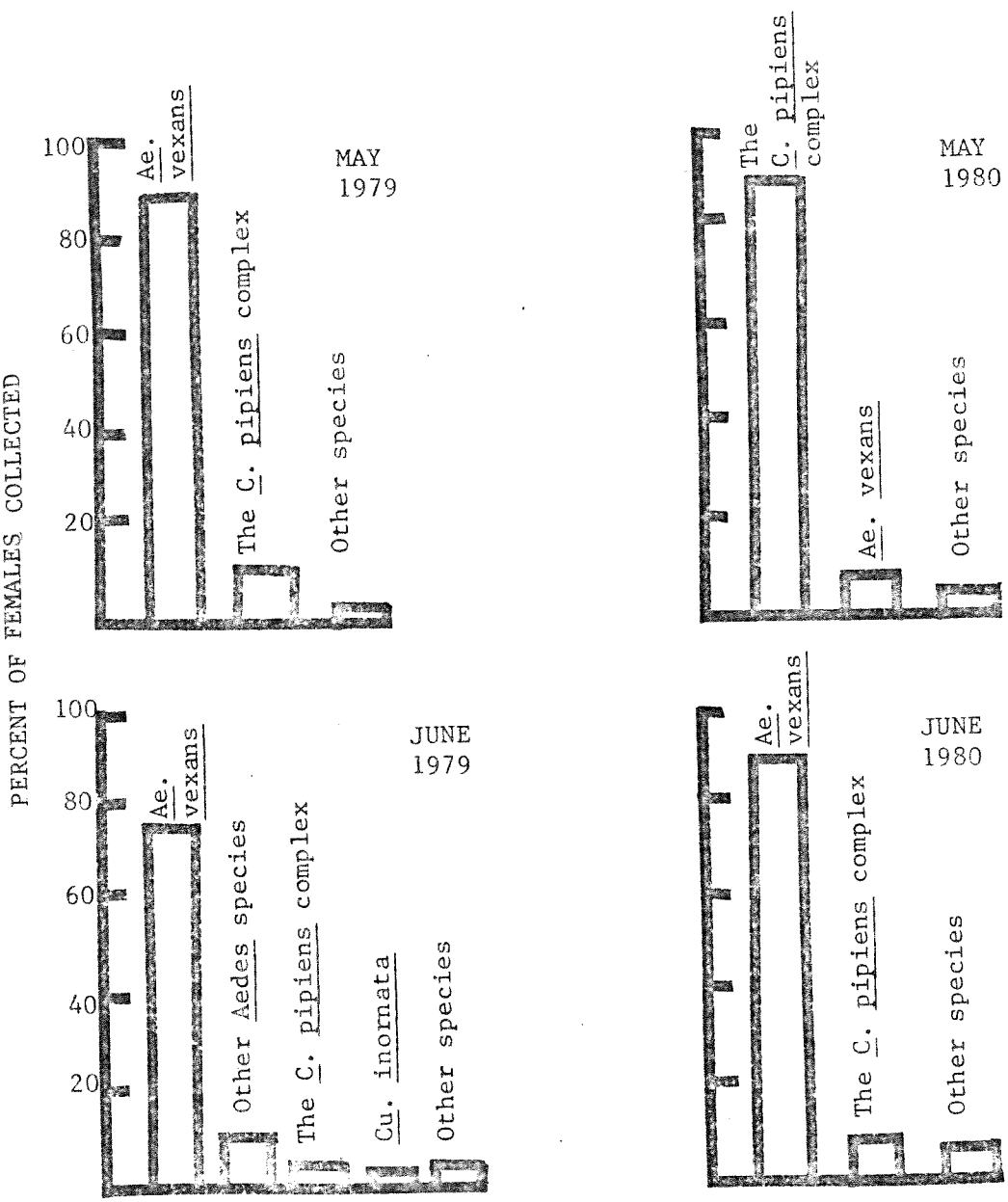


Figure 26. Species composition of mosquitoes collected at Shelby during May and June.

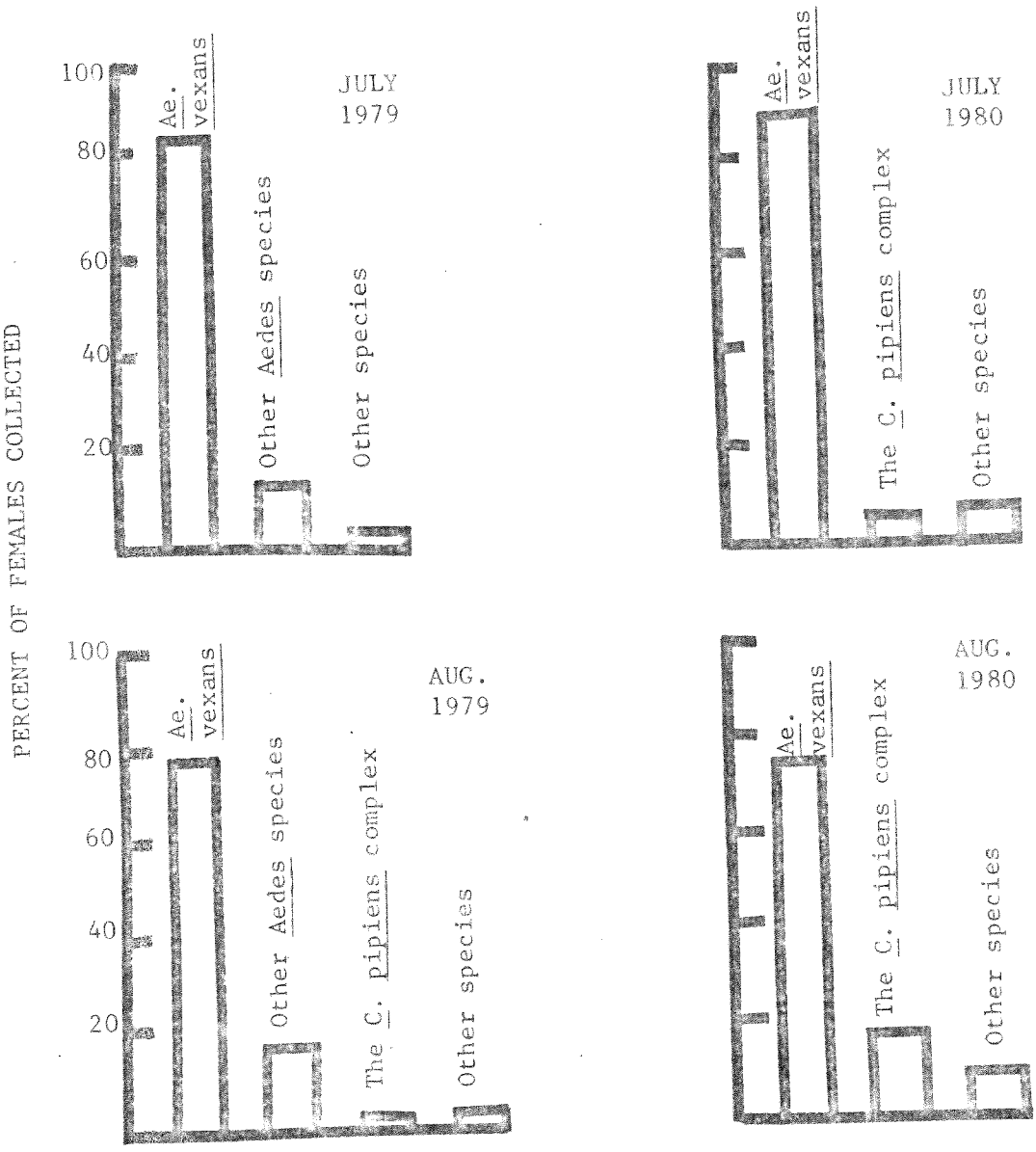


Figure 27. Species composition of mosquitoes collected at Shelby during July and August.

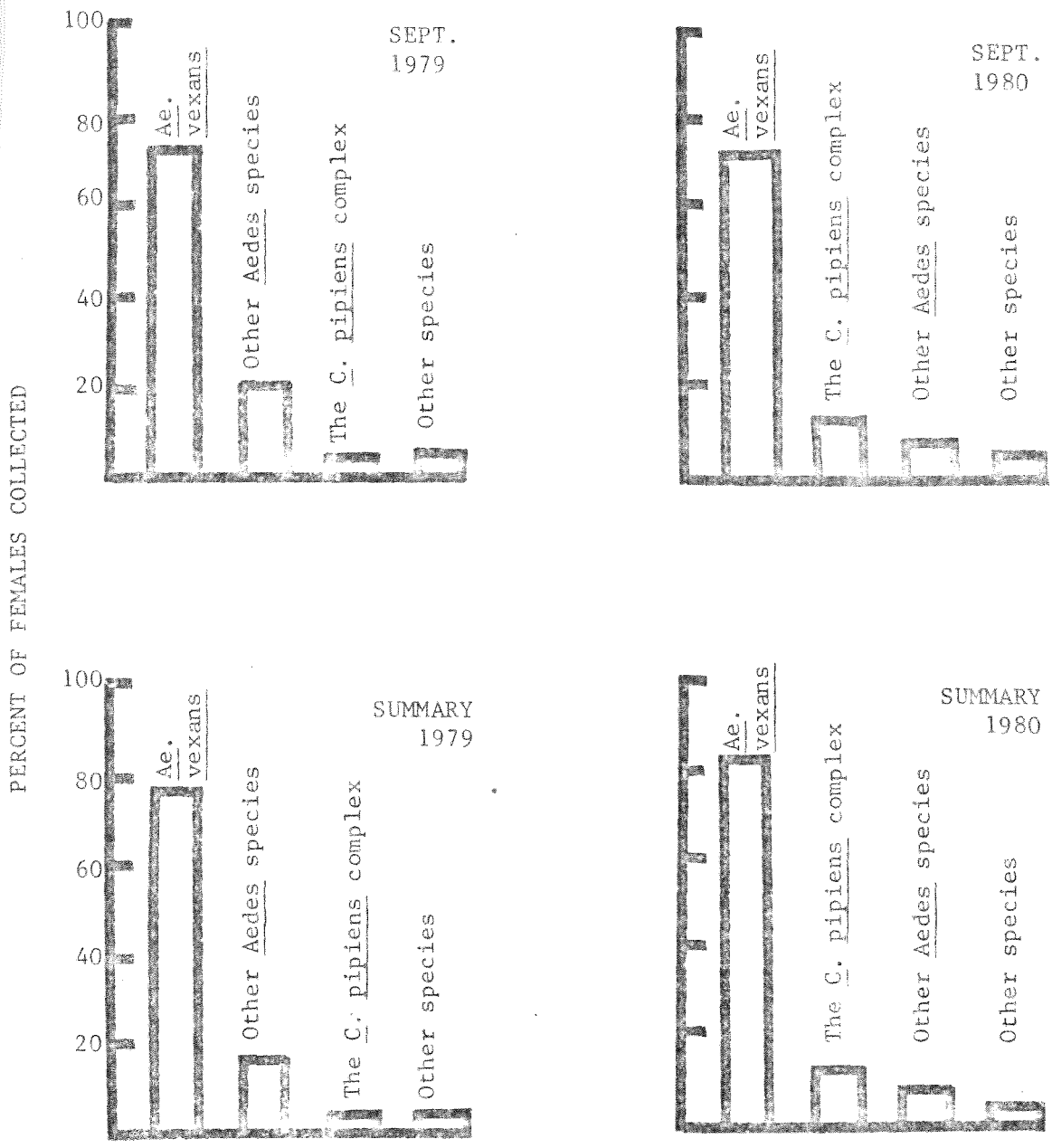


Figure 28. Species composition of mosquitoes collected at Shelby, September and season summary, 1979 and 1980.

Table 10. Mosquito species collected at Shelby.*

	1979						1980					
	May	June	July	Aug.	Sept.	Total	May	June	July	Aug.	Sept.	Total
Ae. canadensis		20	72	49	59	200	1	44	19	18	2	84
cinereus	1	3	14	55	33	106		12	53	27	75	167
dorsalis			18	146	54	218	1	43	31	83	35	193
punctor group						0		29	30	31	6	96
spencerii			11	129	198	338		43	55	37	45	180
sticticus			4	25	39	68		1	9	8	4	22
stimulans group		18	71	139	85	313		93	139	152	84	468
triseriatus						0		18		7	13	38
trivittatus		9		4	1	14		55	2	81	16	154
vexans	135	341	1,723	2,597	1,746	6,542	10	6,551	6,394	4,665	2,744	20,364
An. punctipennis		1	5	49	19	74		12	8	26	56	102
quadrimaculatus				12	12	24		1			2	3
walkeri		6	3	11	7	27		2	2	1	5	10
Coq. perturbans		1	1		9	11	2	9	43	1		55
C. pipiens complex	15	19	13	79	65	191	163	478	370	1,077	511	2,599
tarsalis			4	2	2	8				5	7	12
territans			2		5	7		3	5	20	53	81
Cu. inornata	1	16	14	16	41	88	2	1			13	16
morsitans		2	6	2	2	12			2		2	4
P. ciliata		10	29	7	17	63		14				14
U. sappharina			2	3	3	8			2		28	30
Total	152	446	1,992	3,325	2,397	8,312	179	7,409	7,164	6,239	3,701	24,692

*These totals for 1980 do not include data for Oct., during which one Ae. spencerii, 14 Ae. vexans, two An. punctipennis, one C. pipiens complex, and one Cu. inornata were collected.

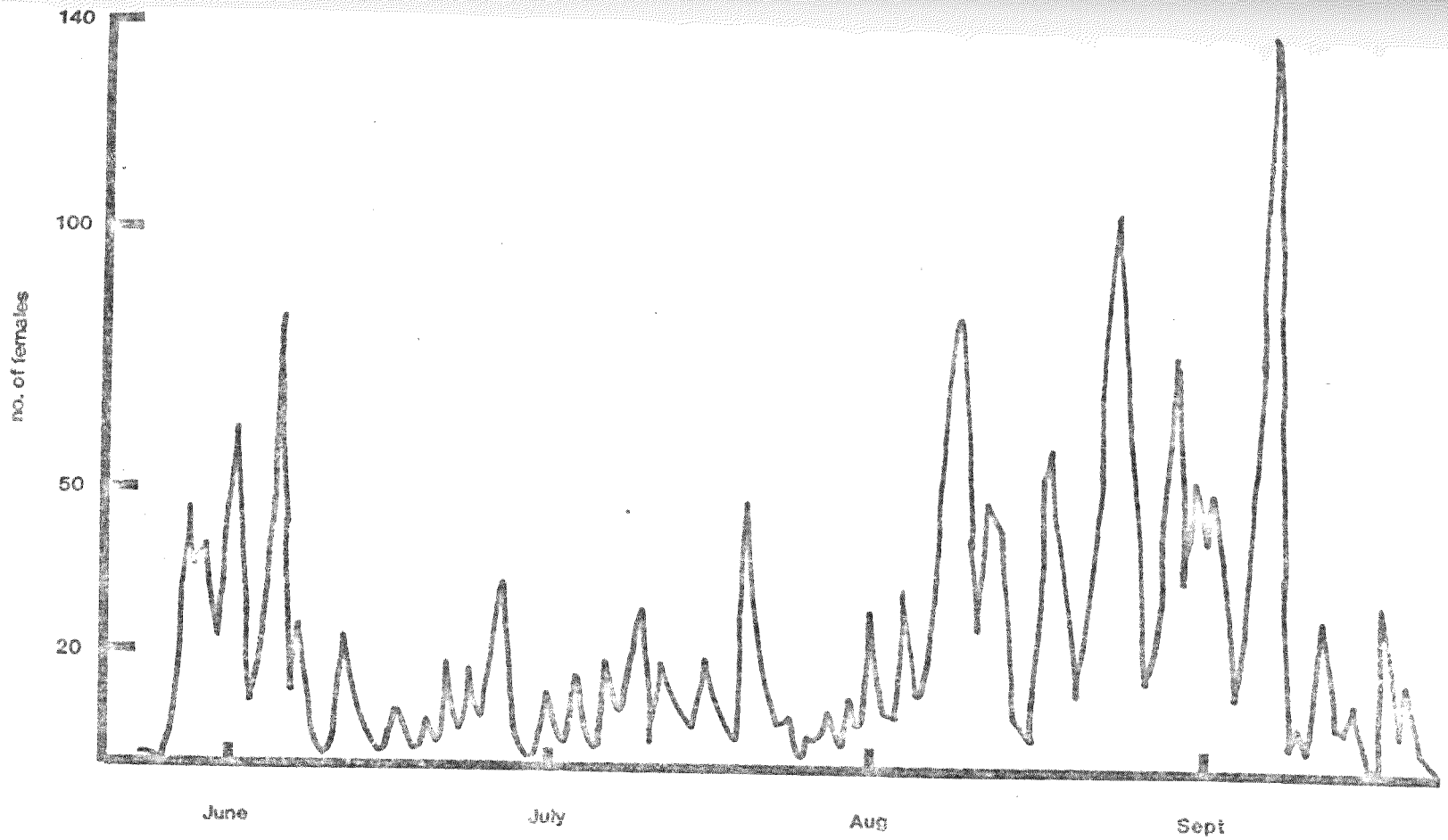


Figure 29. Daily emergence pattern of the Culex pipiens complex in 1980 at Shelby.

of other Aedes species in 1980, except for the Ae. punctor group and Ae. trivittatus. This trap was second to Myrick Marsh in the numbers of females collected, comprising 13 and 14% in 1979 and 1980, respectively (Tables 2 and 3).

French Island:

Ae. vexans was the most abundant species here throughout the study period, comprising 74 and 90% of the totals in 1979 and 1980, respectively. The species compositions of this trap location are shown in Figs. 30-32. Other Aedes species were also abundant here. In 1979, An. walkeri and P. ciliata were important in June and July, as shown in Figs. 30 and 31.

Besides Ae. vexans, there were large increases in populations of Ae. triseriatus, Ae. trivittatus, and the C. pipiens complex (Table 11). Extensive surveys of container breeding habitats in the vicinity of the trap should be initiated because both Ae. triseriatus and members of the C. pipiens complex have characterically short flight ranges.

This trap is placed closer to houses or buildings than the other traps. It is located within 2 m of a home, so there are probably more competing light sources at this trap than the other locations. As shown in Tables 2 and 3, only 9% of all the females collected came from this trap.

Oak Forest:

Ae. vexans was the most abundant species here, comprising 73 and 83% of the totals in 1979 and 1980, respectively. The species composi-

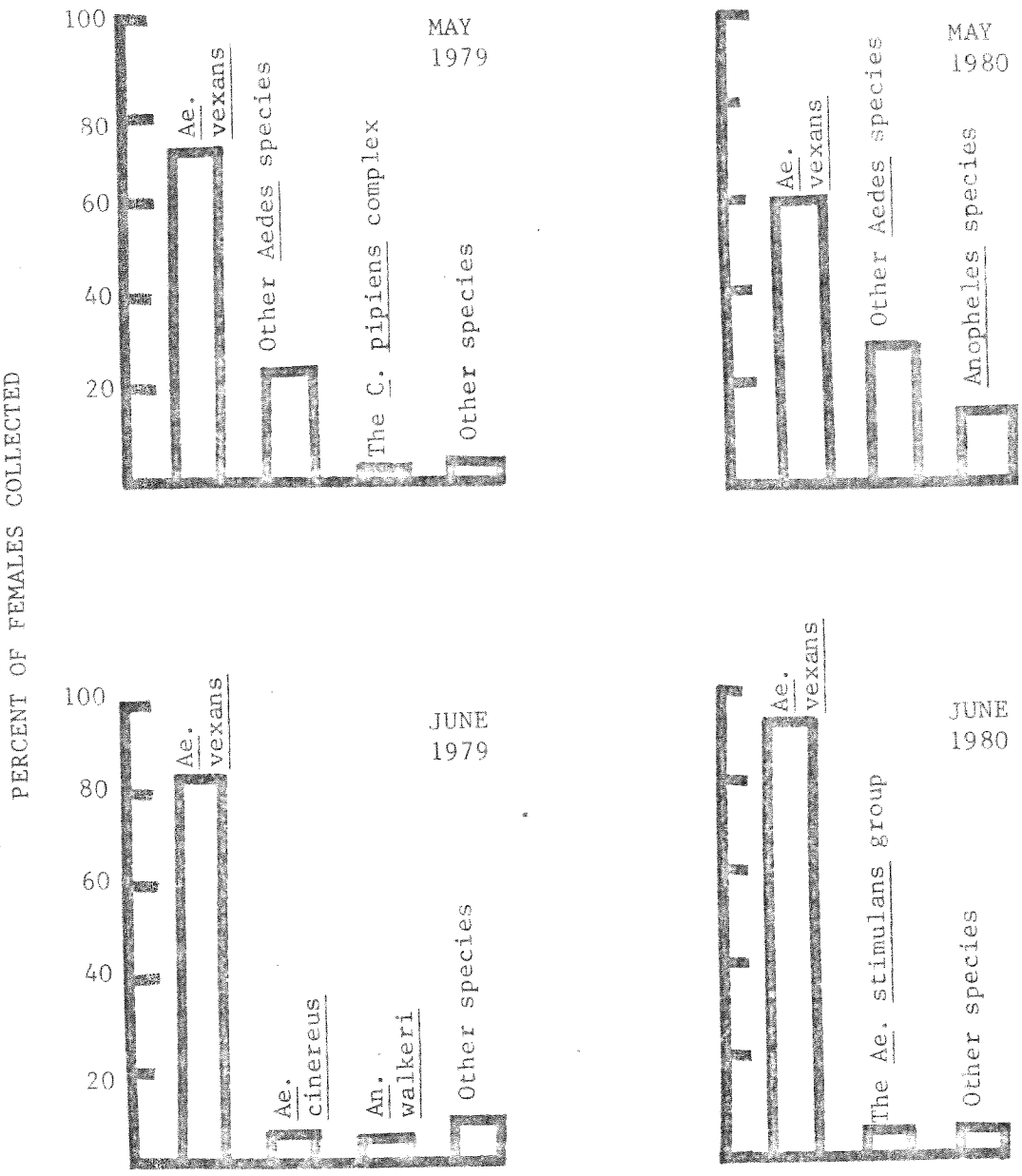


Figure 30. Species composition of mosquitoes collected at French Island during May and June.

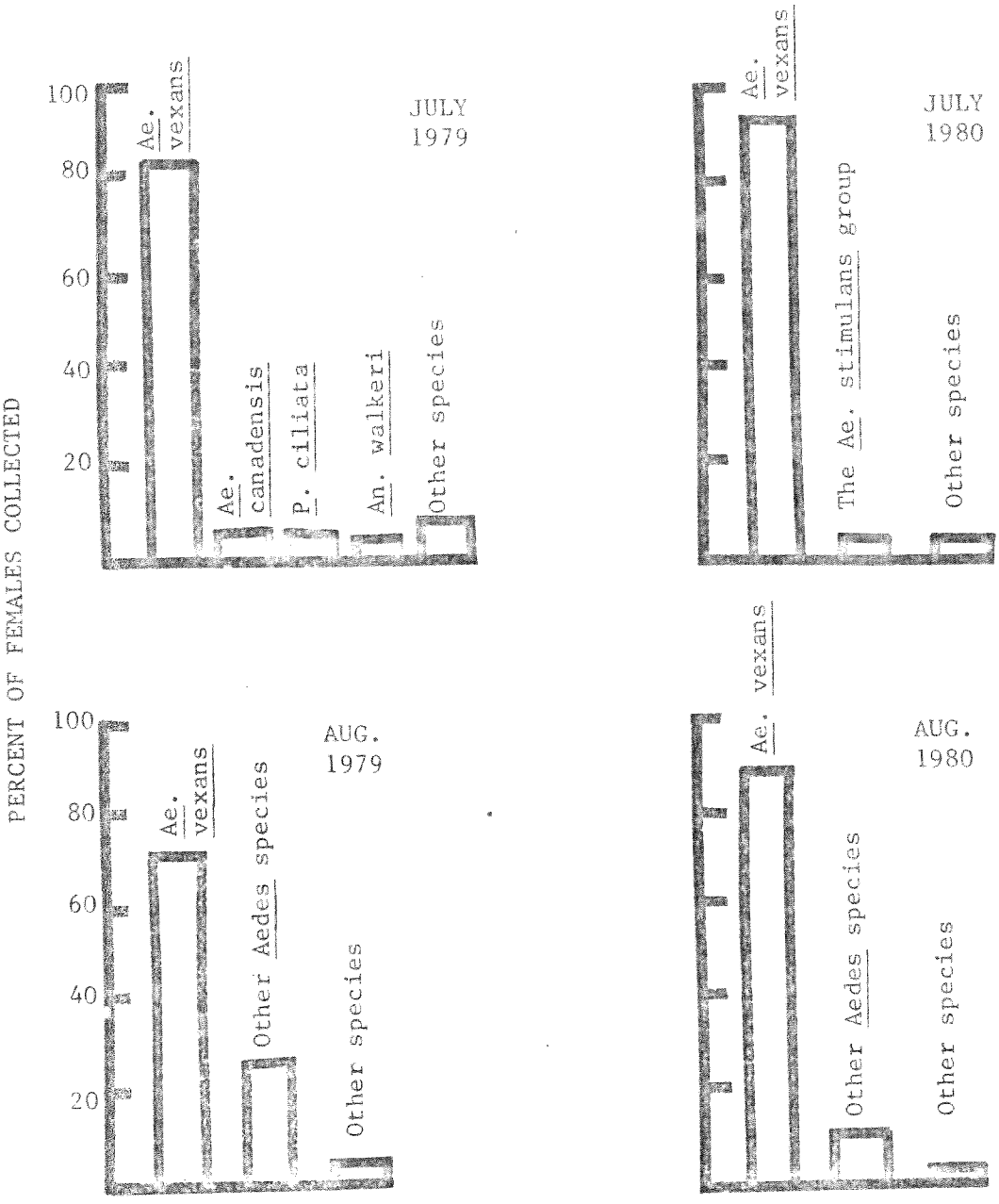


Figure 31. Species composition of mosquitoes collected at French Island during July and August.

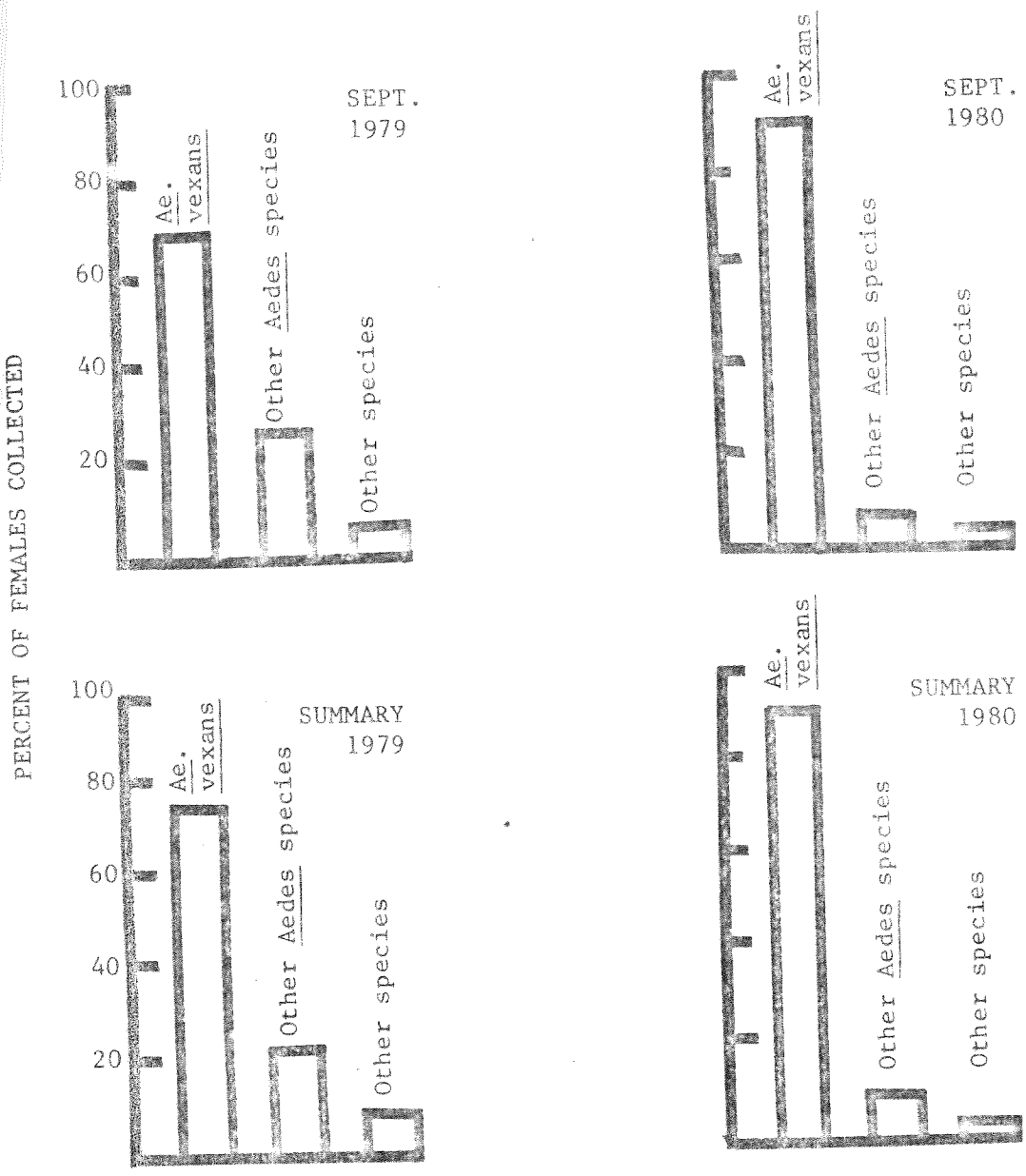


Figure 32. Species composition of mosquitoes collected at French Island, September and season summary, 1979 and 1980.

Table 11. Mosquito species collected at French Island.

	1979						1980					
	May	June	July	Aug.	Sept.	Total	May	June	July	Aug.	Sept.	Total
Ae. canadensis	17	6	40	89	19	171		66	8	31	6	111
cinereus		16	13	17	29	75		3	4	147	63	217
dorsalis	29	1		89	52	171		47	13	41	40	141
punctor group				3		3		23	36	50	14	123
spencerii	2		7	100	141	250	4	13	2	67	66	152
sticticus				68	28	96		2		7	7	16
stimulans group	19	2	31	180	87	319	2	123	81	208	61	475
triseriatus		1				1		8	2	6	4	20
trivittatus	7			8	7	22		1	2	105	23	131
vexans	229	261	1,052	1,513	970	4,025	13	3,949	2,086	5,735	4,239	16,022
An. punctipennis			6	6	5	17	2		1	15	32	50
quadrimaculatus				8	4	12		1				1
walkeri	1	12	36	8	4	61	1	2	1	1	3	8
Coq. perturbans	1	1	6	2		10		13	12	1		26
C. pipiens complex	8	4	13	36	22	83		9	5	19	70	103
tarsalis		5		1	8	14		2	1	6		9
territans		1		1		2		1		9	17	27
Cu. inornata	5	3	3	15	5	31			3		14	17
morsitans			8	10	1	19		1		32	4	37
P. ciliata	3	5	52	5	6	71				11		11
U. sappharina				1	1	2		1		5	6	12
Total	321	318	1,267	2,160	1,389	5,455	22	4,265	2,257	6,496	4,669	17,709

tions of this trap are shown in Figs. 33-35. Like the rest of the light traps, there were increased populations of Ae. trivittatus and Ae. triseriatus. Ae. trivittatus was an important species in 1980, comprising 5% of the total (Table 12 and Fig. 35).

The presence of Ae. triseriatus and the C. pipiens complex indicates that there may be artificial containers in the vicinity of the trap. Oak trees that are prone to basal tree hole formations are abundant in the forest and park areas near the light trap. Although few tree holes were filled in 1979 and 1980, more extensive monitoring is needed in the future due to the presence of these species.

As shown in Figs. 33-35 and Table 12, Aedes species were the predominant mosquitoes present, comprising 91 and 97% of the totals females collected here in 1979 and 1980, respectively. Since there is no suitable breeding sites in the vicinity of the trap, most of the Aedes species probably came from the marsh complex about three blocks west of the trap area.

Division Street:

Like all the other trap locations, Ae. vexans was the most abundant species here, comprising 92% of the total. Species compositions of the trap is shown on Figs.36 and 37. The graph for May is misleading because of the small sample size obtained during that month.

As shown in Table 13 and Fig. 37, 98% of all females collected here were Aedes species. Since there are no suitable breeding sites nearby, these females represented adults that had migrated in from Myrick Marsh, other marshes along the rivers, and the La Cresent area of Minnesota.

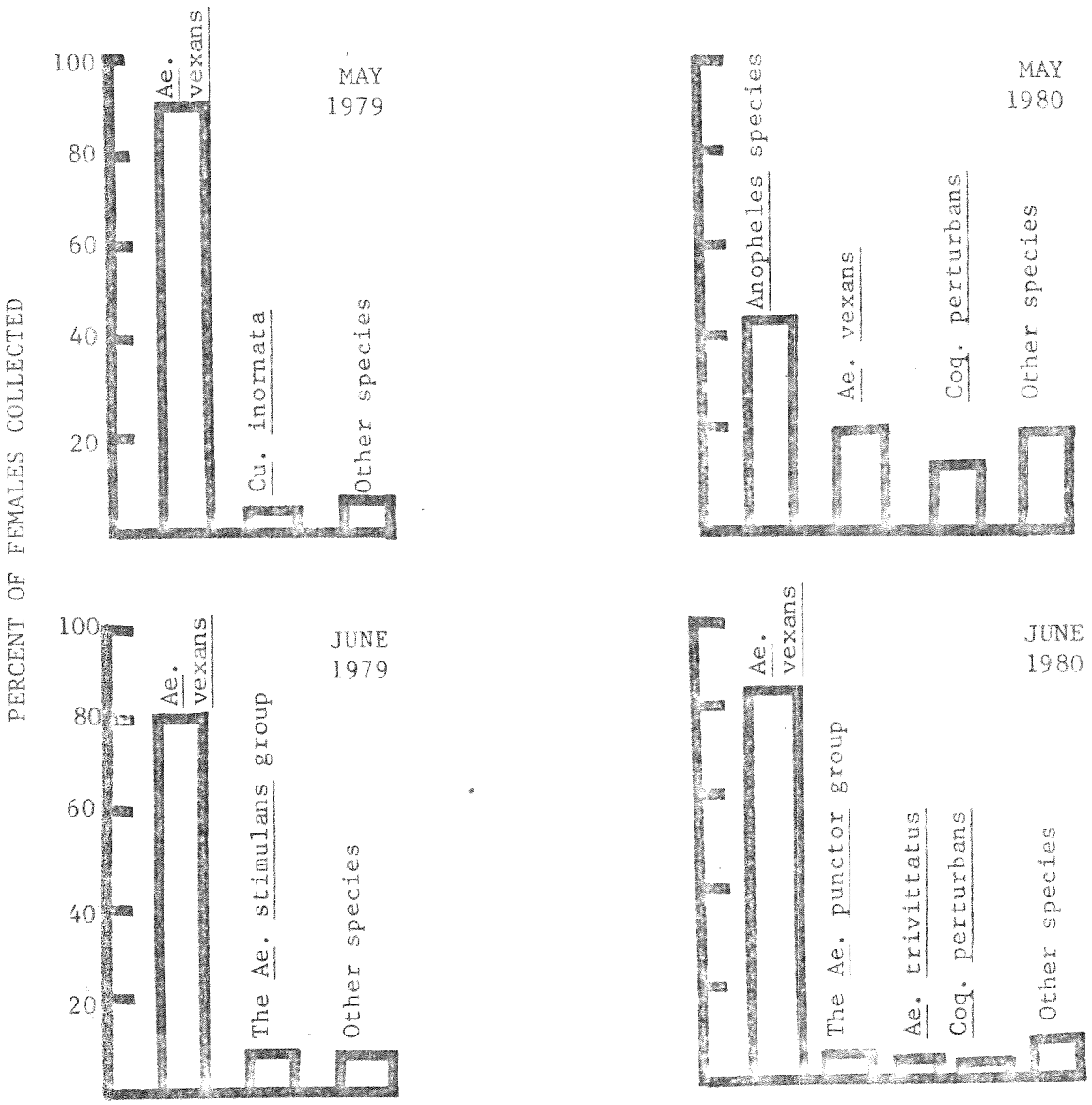


Figure 33. Species composition of mosquitoes collected at Oak Forest during May and June.

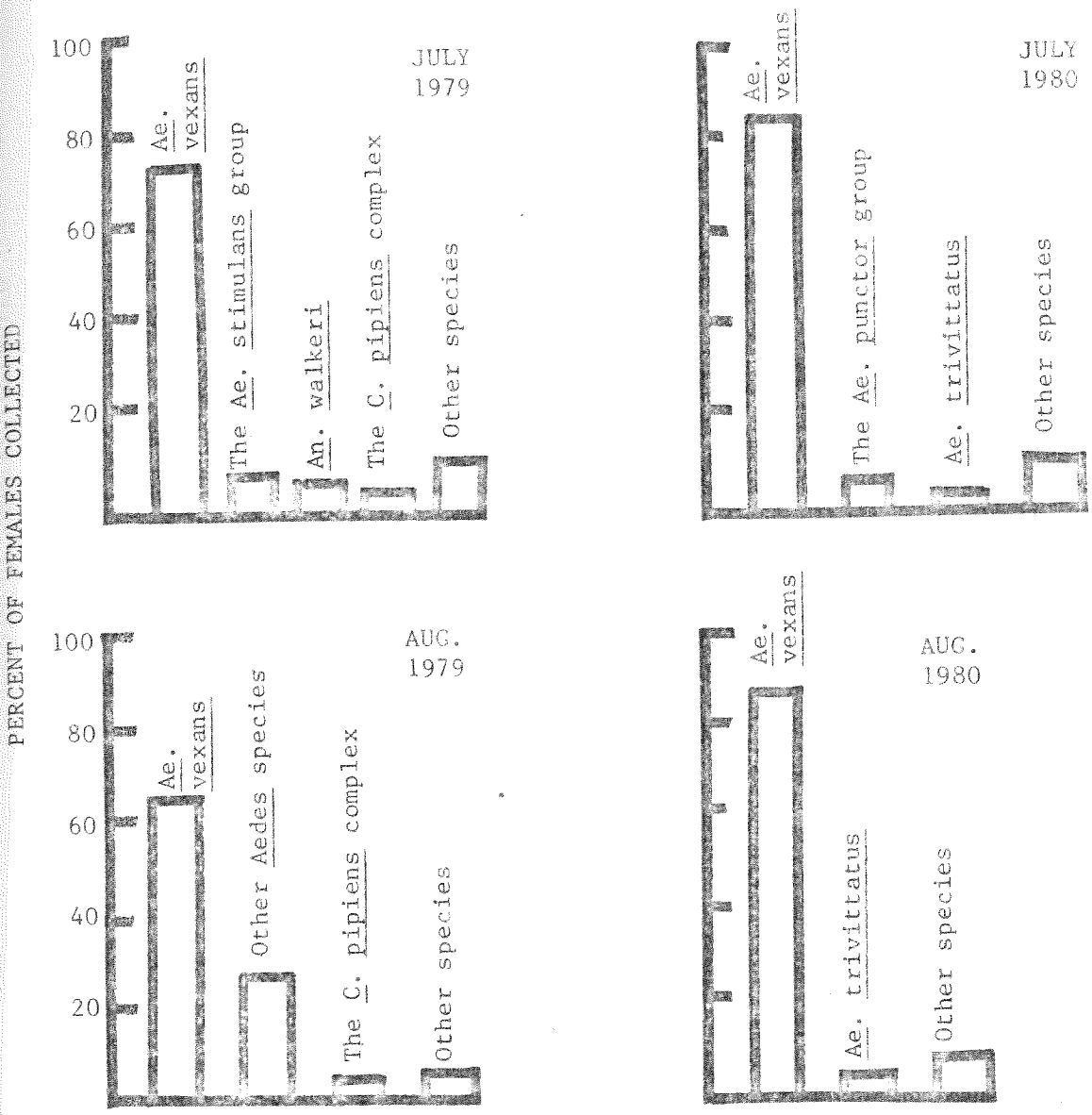


Figure 34. Species composition of mosquitoes collected at Oak Forest during July and August.

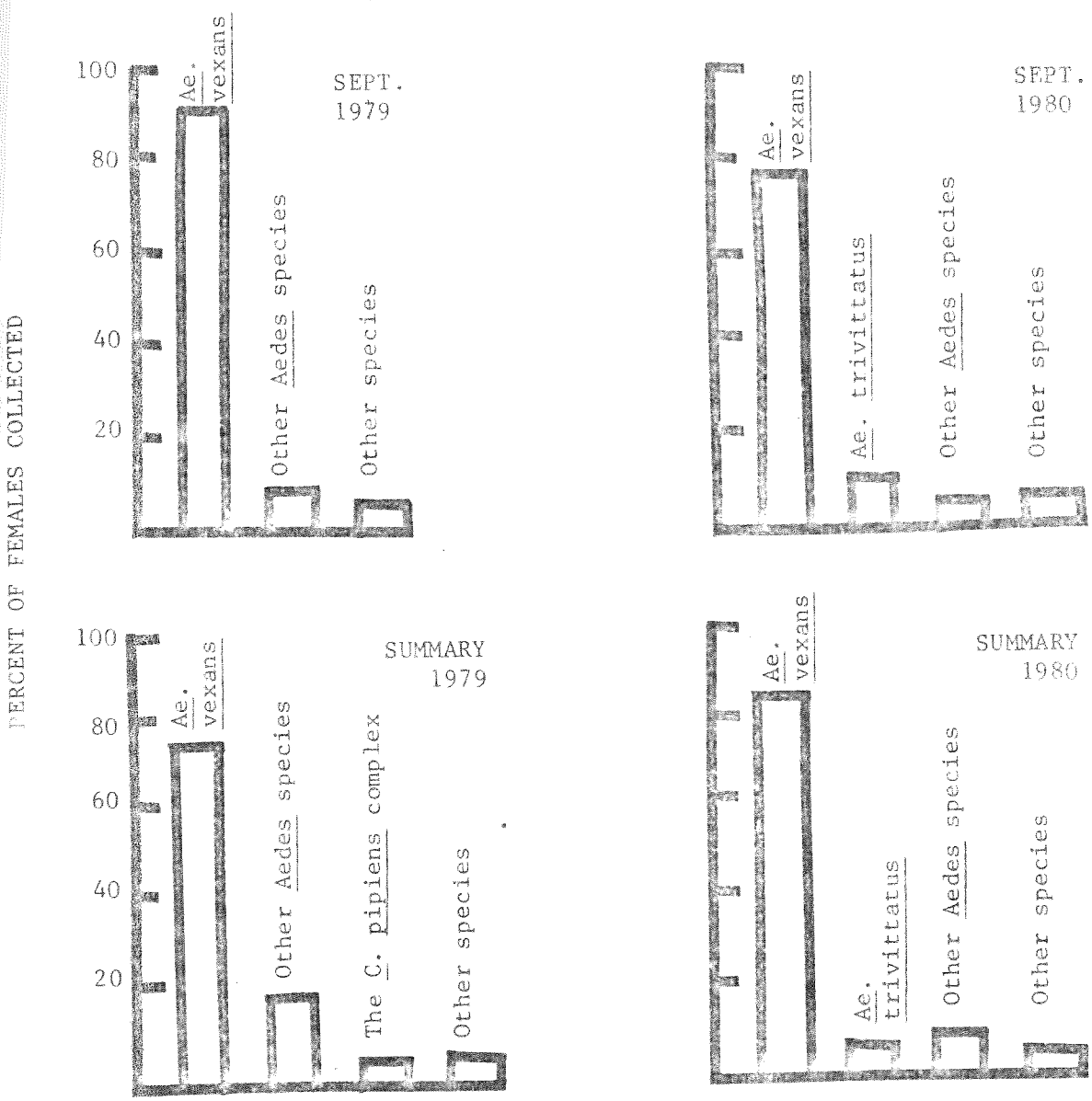


Figure 35. Species composition of mosquitoes collected at Oak Forest, September and season summary, 1979 and 1980.

Table 12. Mosquito species collected at Oak Forest.

	1979						1980					
	May	June	July	Aug.	Sept.	Total	May	June	July	Aug.	Sept.	Total
Ae. canadensis	8	4	7	107	11	137		47	6	33	12	98
cinereus		16	14	22	3	55		66	44	68	8	186
dorsalis		4		108	10	122		47	5	169	56	277
punctor group						0		179	62	19	8	268
spencerii	3	1		181	21	206	2	62	29	38	46	177
sticticus				94	2	96		12	14	11	4	41
stimulans group	4	35	43	174	10	266		69	36	100	27	232
triseriatus	1	2			4	7		5	1	37	12	55
trivittatus		1	2	48	3	54		173	36	306	288	803
vexans	254	479	486	1,885	616	3,720	3	3,893	1,355	5,986	2,131	13,368
An. punctipennis	1	3	1	19	11	35	2	3	2	37	54	98
quadrimaculatus				2	5	7		1		4	3	8
walkeri		18	35	17	6	76	5	6	3	4	16	34
Coq. perturbans		77	9	5	2	23	2	118	14	3		137
C. pipiens complex	3		30	104	5	149		13	11	48	53	125
tarsalis			4	6	2	12		1	1	8	5	15
territans				1	5	6		5	1	19	12	37
Cu. inornata	7	3	8	52	7	76	1	4		1	20	26
morsitans		3	9	20		32				2	6	8
P. ciliata		6	15	11	5	37		1				1
U. sappharina				6	3	9		2	2	10	11	25
Total	281	588	633	2,862	731	5,125	15	4,707	1,622	6,903	2,772	16,019

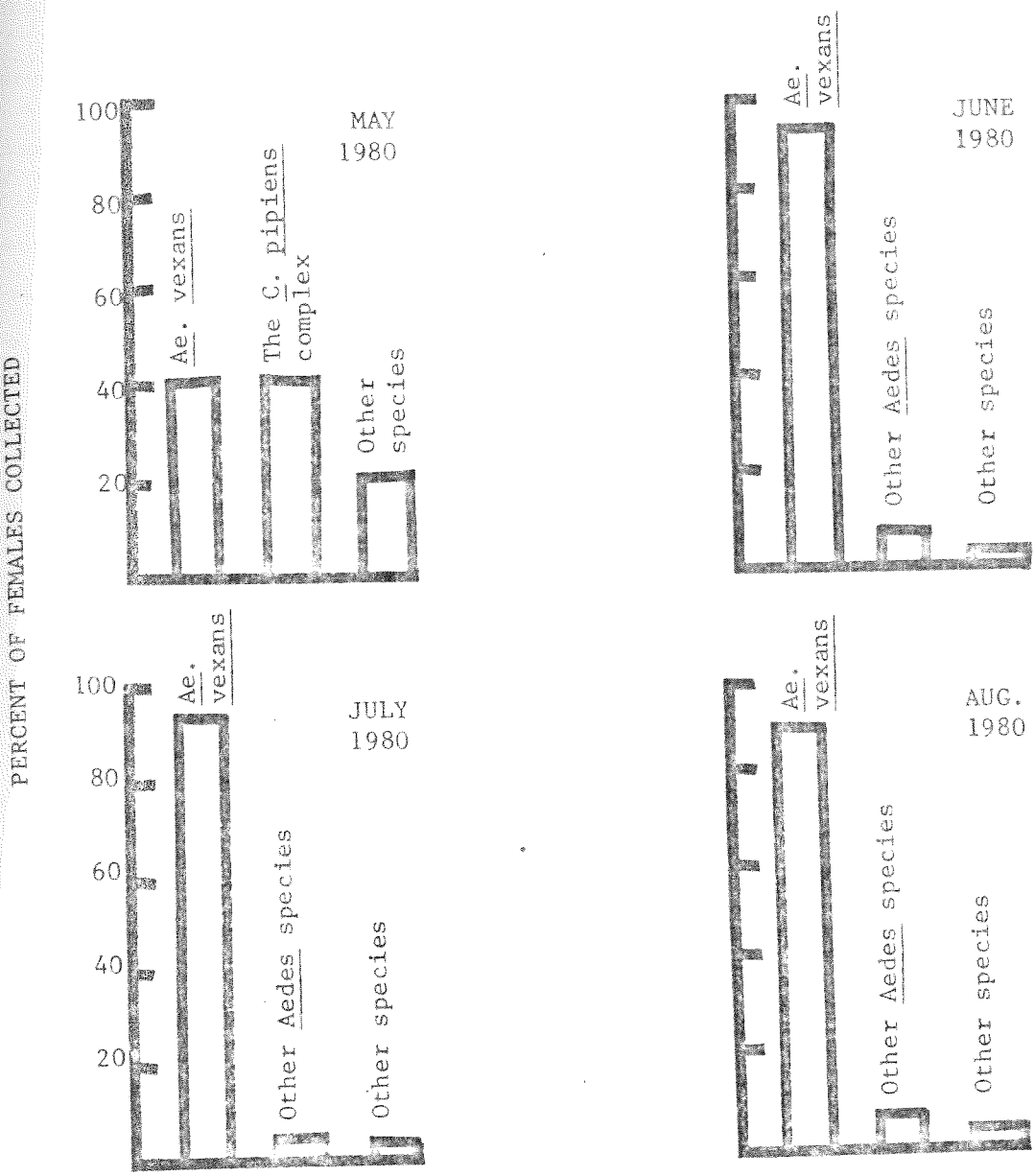


Figure 36. Species composition of mosquitoes collected at Division Street during May through August.

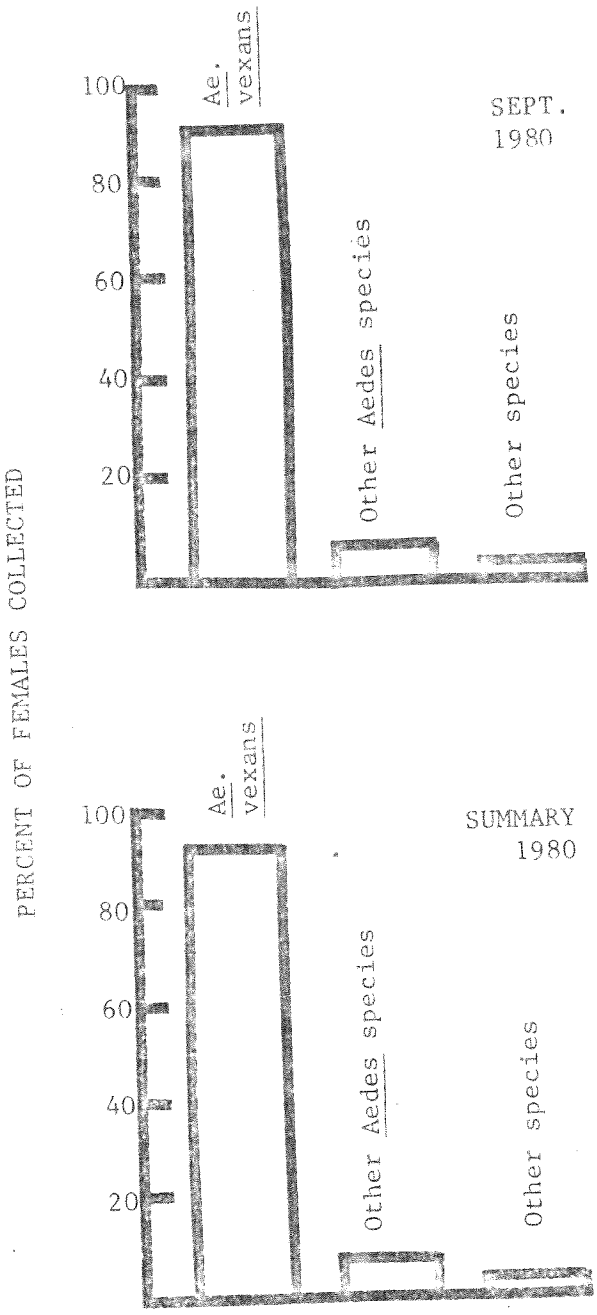


Figure 37. Species composition of mosquitoes collected at Division Street, September and season summary.

Table 13. Mosquito species collected at Division Street.

	1980 May	June	July	Aug.	Sept.	Total
Ae. canadensis		105	23	16	31	175
cinereus		16	15	122	71	224
dorsalis		60	13	37	10	120
punctor group		21	32	11	4	68
spencerii		36	45	33	42	156
sticticus	1	21	15	6	5	48
stimulans group		146	65	46	103	360
triseriatus		15	1		5	21
trivittatus		40	6	41	37	124
vexans	4	6,441	4,797	3,965	4,004	19,211
An. punctipennis	1	5	2	10	24	42
quadrimaculatus					1	1
walkeri		4		3	5	12
Coq. perturbans		10	22			32
C. pipiens complex	4	41	67	82	32	226
tarsalis		2	2	6	2	12
territans		12	6	40	17	75
Cu. inornata		2			2	4
morsitans					2	2
P. ciliata		4				4
U. sappharina			6	8	9	23
Total	10	6,981	5,117	4,426	4,406	20,940

Although there is an abundance of old and large trees in the neighborhood, they are mainly elms and hackberry trees, which are not prone to basal tree hole formations. Therefore, the Ae. triseriatus and C. pipiens complex populations probably came from artificial containers nearby. The trap, being located in an old residential neighborhood, produced less of the C. pipiens complex than expected. Since this light trap was only in operation during one season, it is difficult to determine if the species abundance and composition data presented here are typical of this light trap location.

Factors Influencing Light Trap Data

Much has been written concerning factors that influence light trap collections, including works by Bidlingmayer (1967), Provost (1959), and Barr et al. (1960,1963). These factors can be characterized as environmental, operational and biological. Bidlingmayer (1967) divided the environmental factors into two categories: meteorological and positional. Meteorological factors include rainfall, temperature, humidity, wind and light. Mulhern (1975) stated that climatological factors are important because they help to determine which species can exist in the area indirectly by influencing types of vegetative cover. Positional factors include habitats, distance from breeding area, competing attractants, food sources, and predators. As in Pinger's (1971) thesis, these positional factors are placed under operational factors in this paper because they are determined by trap placement. Other operational factors include the type of trap and light source used, efficiency differences among similar traps, and any other factors associated with equipment or

techniques. Bidlingmayer (1967) defined biological factors as the inherent behavior patterns such as characteristic responses of different species and behavior changes during the life of an individual mosquito due to its physiological state. The expression of these behavior patterns is often modified or suppressed by environmental factors.

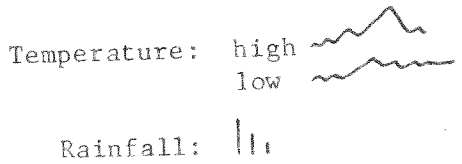
Environmental or meteorological factors

Among the various meteorological factors that can influence light trap data, Husbands and Reed (1969) found that temperature and rainfall have the most influence upon the values obtained. The combination of these two factors seems to have even a greater influence than either does alone. Figs. 38 and 39 show the daily emergence patterns, along with the rainfall and temperature ranges, during the study period.

Rainfall is the main factor that exerts a recognizable influence on mosquito abundance in La Crosse County. In addition to determining the availability of breeding places, the amount of rainfall in a season also influences the number of broods per year and the size of each hatch.

Siogren (1976) felt that populations of Ae. vexans can be predicted in advance by precipitation data alone. Clark and Wray (1967) reported mosquito annoyance approximately 15 days after a flooding rain of 2.54 cm (1 inch) or more in a 24-hour period. Even 1.02 cm of rain within a 24-hour period is enough to produce a small brood exceeding 20 Ae. vexans females per night. Rowe (1942) found periods of increased mosquito abundance within 10 to 20 days after periods of increased precipitation, with higher populations ocurring after prolonged periods of heavy rains, providing that the temperature is at or rises to a minimum of 15.6°C (60°F) within 24 hours after the rain.

Figure 38. The total number of female mosquitoes per day versus rainfall and temperature in 1979.



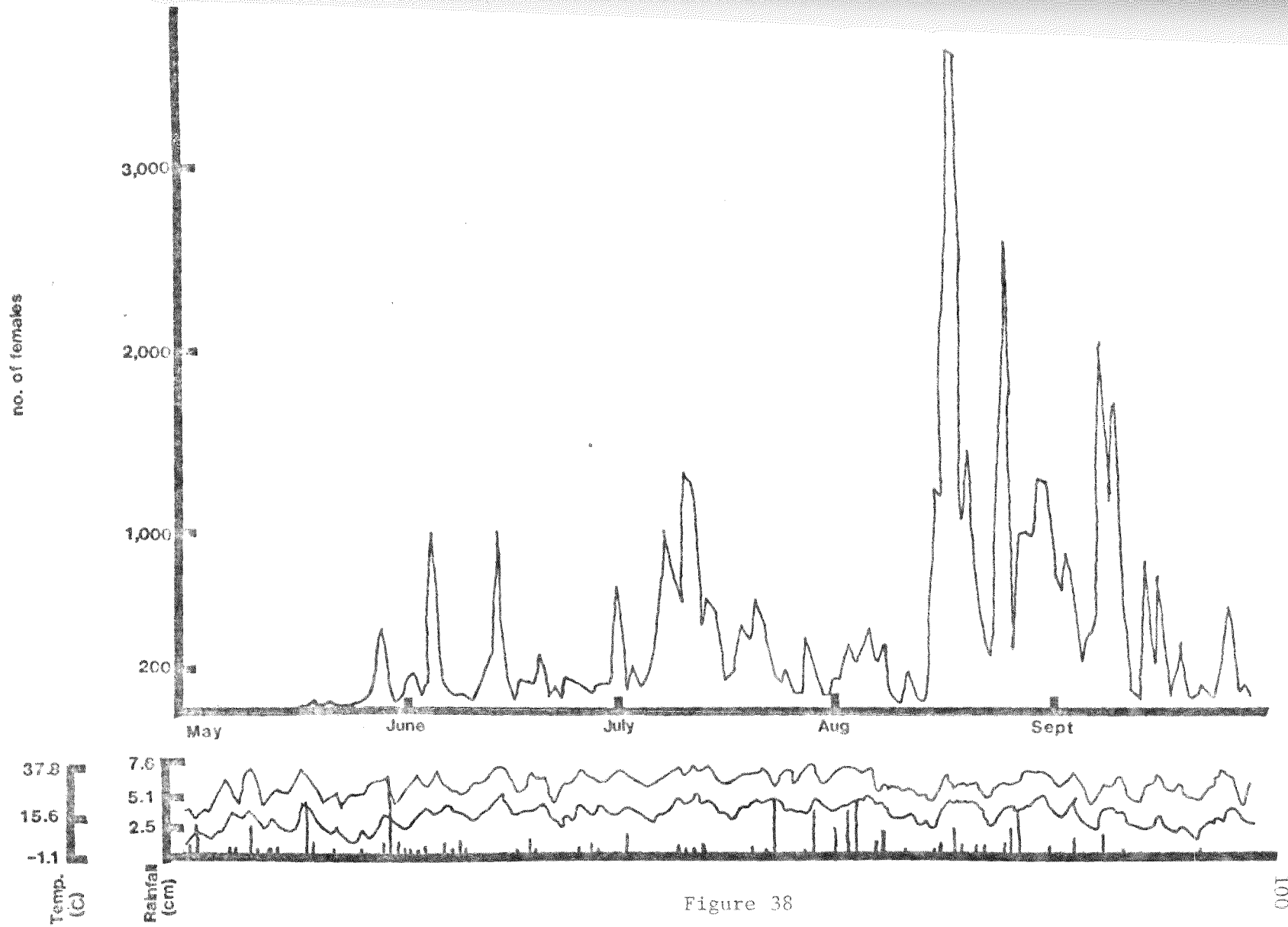
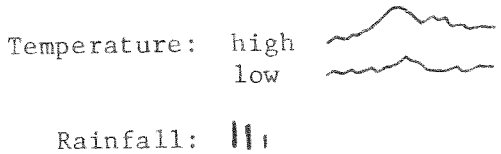

no. of females
3,000
2,000
1,000
200
May
June
July
Aug
Sept
37.8
15.6
-1.1
Temp. (C)
7.6
5.1
2.5
Rainfall (cm)

Figure 38

Figure 39. The total number of female mosquitoes per day versus rainfall and temperature in 1980.



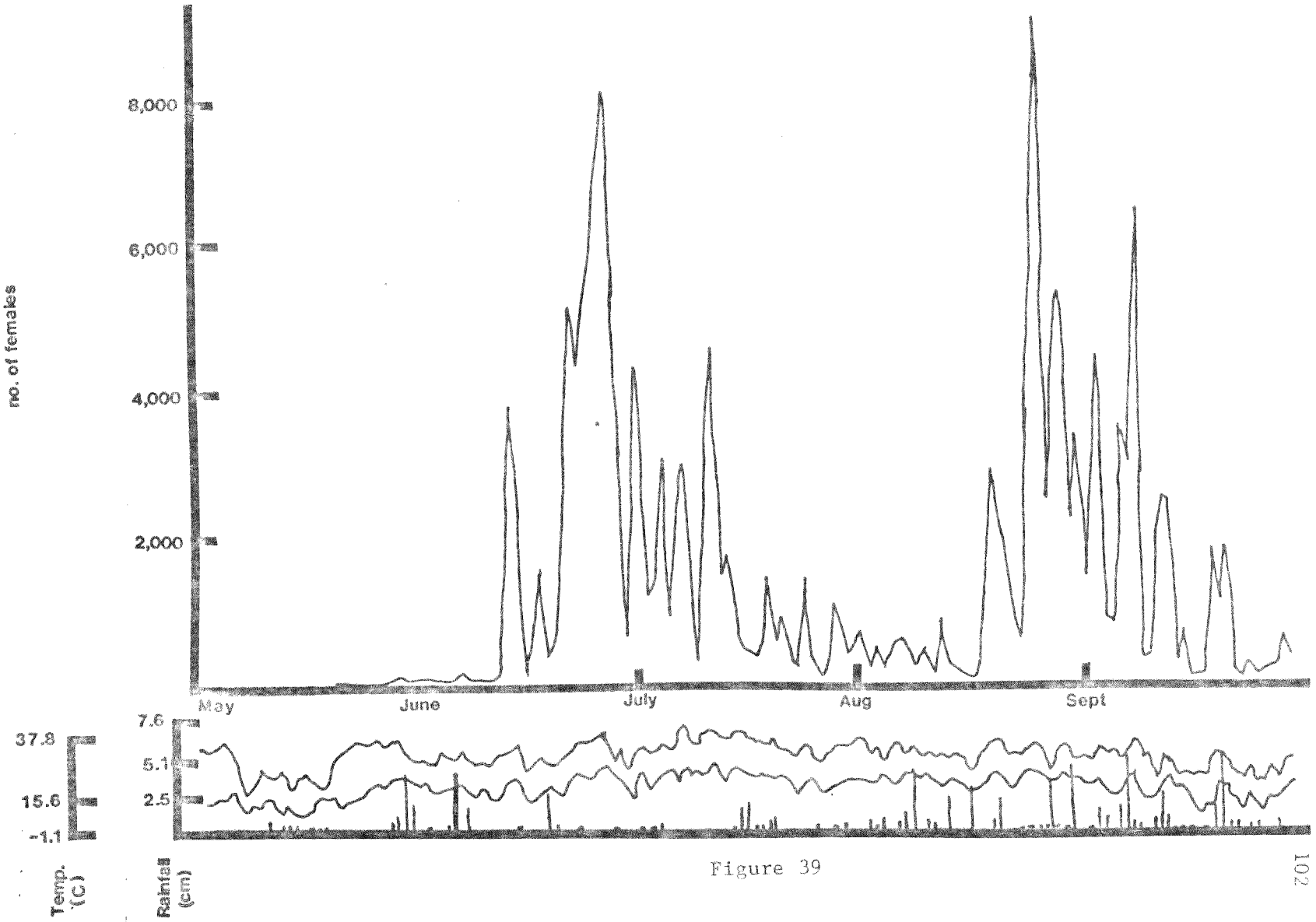

no. of females
8,000
6,000
4,000
2,000
May
June
July
Aug
Sept
37.8
15.6
-1.1
Temp. (C)
7.6
5.1
2.5
Rainfall (cm)

Figure 39

De Kruijf et al. (1973) found that the pattern of rainfall is important to the development of adedine eggs, which require a drying period before they can be hatched. Therefore, the alternation of wet and dry periods is important. Rain is also important in maintaining the water levels of the breeding places. Since development of the aquatic stages usually requires 10 to 21 days, the length of time that the pools remain wet helps to determine how many adults will emerge (Wada 1965).

On the other hand, heavy rains, especially when associated with high winds, can reduce flight activity and the availability of suitable resting sites (Hayes and Downs 1980), and thus reduce trap counts. Locally, thunderstorms have been observed to reduce trap counts during the evenings. Local climatological data showed that thunderstorms occurred 39 days in 1979 and 56 days in 1980 during the study period (NOAA 1979 and 1980).

As Figs. 38 and 39 show, major peaks in the populations occurred within 15 to 20 days after rainfall of 2.54 cm (1 inch) or more. Prolonged rains in August of 1980 produced high numbers of mosquitoes. The large amount of summer rainfall contributed to the presence of large semi-permanent bodies of water which permitted the mosquitoes to reach population levels not attained when this amount of rainfall is absent, and is no doubt the most important factor causing the heavy populations of mosquitoes in La Crosse County. Table 7 shows that 47.2 cm and 27.0 cm of rainfall were recorded from April through September during 1979 and 1980, respectively.

Temperatures of the air and water are major regulators in the growth activity and life functions of all stages of the mosquito (Mulhern 1975).

Temperature levels of the water, which were not recorded during this study, can affect egg conditioning, hatching, and the activity and development of the larval stages. In addition, temperature, along with light and other stimuli, also affects hibernation and aestivation. Locally, temperature is probably more important in determining the beginning and end of a breeding season than directly influencing the season itself. For example, temperatures can influence the time of snowmelt, which along with rainfall, determines the time and size of the spring brood. Winter temperatures determines how many hibernating adults, and species that overwinter as eggs and larvae in the water, can survive. Temperatures in the spring and fall can influence the length of the mosquito season, which is an important criteria from the pest mosquito control standpoint.

Bradley and Mc Neel's (1935) data indicated a significantly greater number of mosquitoes was collected on nights when temperatures were 21.1°C (70°F) or above. Porter and Gojmerac (1970b) found that at above 16.7°C (62°F), a rise of 5/9 °C (1°F) can increase the trap catch by 1.2 times, and Headlee (1932) found that temperatures lower than 15.6°C (60°F) inhibit mosquito flight. However, Bidlingmayer (1967) failed to find significant correlations between temperatures and the numbers of mosquitoes collected. In La Crosse County, temperature does not seem to be a significant factor except when the minimum temperature falls below 12.8°C-15.6°C. On colder evenings such as on 7-27, 8-1, 8-10, 8-14, and 9-13 in 1979, and 9-4, 9-9, 9-16, and 9-22 in 1980, there were definite drops in trap counts. Besides the milder winter temperatures, 1980 also had higher than average temperatures during July and August, as shown in Table 7.

Along with more frequent rainfall, these higher temperatures contributed to the higher numbers of mosquitoes collected in 1980.

Other meteorological factors that may influence light trap data include humidity, wind and light. Headlee (1932) and Clements (1963) found that increased relative humidity correlated with flight activity. This is especially true for Ae. vexans, which Platt et al. (1958) found present in greater numbers in light traps when the relative humidity was between 60 and 90%. They found that C. pipiens was most active when the relative humidity was 94-95%, but its activity fell sharply near saturation. Local climatological data showed that the average relative humidity varied between 65 and 85% in 1979, and 64 and 87% in 1980 (NOAA 1979 and 1980). Values in the nineties are very frequently recorded during the summers here.

Wind influences the flight and dispersal of mosquitoes and the migration of adults into the area, and therefore can affect trap counts. Headlee (1932) found that mosquitoes fly with light winds but cease to fly when winds are greater than 16.1 km per hour. Hollingsworth et al. (1961) found that light traps shielded from prevailing winds are more efficient in collecting insects than those in more exposed locations. Prevailing winds in the summer here are southerly, with speeds averaging around 11.3-14.5 km per hour (NOAA 1979 and 1980).

Light is another meteorological factor that can influence trap data. Since light traps are operated at night, the effect of daylight and sunlight will not be discussed here. However, sunlight does influence trap counts indirectly through action on other organisms and processes in the environment, such as food growth, temperature rise with light absorption,

and vegetative growth (Mulhern 1975). Light attraction and photoperiods will be discussed under biological factors because they affect species behavior, and light intensity will be discussed under operational factors.

Various authors have observed the effects of moon light and moon phases on light trap collection. Bowden (1973) and Bidlingmayer (1967) found that moon light can compete with the light of the trap and reduce the contrast between the artificial light source and its background. Pratt (1944) and Provost (1959) found that light trap collections of many species show fluctuations on a four-week cycle correlating with the phases of the moon. The largest collections are made during the dark phase. Provost (1959) reported larger catches of Anopheles, Culex, Coquillettidia, Uranotaenia, Aedes and Psorophora with New Jersey traps at new moon compared to the ones collected at full moon. There is no doubt that moon phase can affect light trap data. However, a detailed examination of this factor, as it influenced the data presented here, is beyond the scope of this study.

Operational factors

Since all trap locations are equipped with similar light traps and light bulbs, trap placement is probably a more important factor than the equipment. However, instances of malfunctioning traps, timers, bulbs, etc., were noted, so that these factors were taken into account when the data were interpreted.

It is obvious that different results can be obtained by choosing different trap locations. The purpose of this study was not to choose locations that would provide identical results, but rather to choose

locations that were representative of the various habitats. This was achieved, as evidenced, by the slightly different species composition obtained at each trap location.

The most important operational factor in this study is the identification process. Since 1979 was the first year that this program was in operation, no reference collection was available for verifying questionable identifications. Identification errors were unavoidable because of the number of inexperienced workers involved in the process, especially in 1979. Therefore only data from 1980 were used in analyzing the seasonal distribution and abundance of some of the uncommon species. No attempt was made in analyzing the effect of ongoing adulticiding efforts with the trap counts because it was felt to be beyond the scope of this study.

Biological factors

One of the most important biological factors influencing trap results is the natural mosquito mortality rate. Some species are known for their longevity, so the presence of a particular mosquito in a light trap does not necessarily mean that it has just emerged as an adult. Therefore, losses due to natural mortality and the emergence of new adults are both responsible for changes in the size of mosquito populations. Locally, mortality due to natural events, rather than control efforts, is often responsible for reductions in trap counts.

Other important biological factors include the responses of mosquitoes to light, their activity periods, and flight behaviors. It is well known that some species of mosquitoes are more attracted to light than others. Love and Smith (1957) found U. sappharina and Ae. vexans to

have high indexes of attractiveness to light, while Ae. triseriatus has the lowest. Knight (1954) noted that some species are even "repelled" by light and others may be more attracted at certain times during their adult life. Chandler (1977) stated that for species insensitive to light, trap catches represent only those mosquitoes flying in close proximity to the trap. Therefore, light trap sampling is somewhat biased.

Flight habits also vary greatly among species. Most anophelines have a maximum flight range of only 1.6 km while Ae. vexans can fly up to 32 km or more. Extreme flights up to 177 km had been documented (Matheson 1966). Husbands and Reed (1969) stated that the flight behavior of a species may also change depending on age. For example, gonotrophically active females may move toward sources for oviposition and avoid locations where the traps may be. This would affect trap locations such as Division Street, Shelby and Oak Forest, where there are no suitable oviposition sites for floodwater species in their immediate vicinities.

Although most indigenous species in La Crosse County are more active in the evenings, a few species, such as Ae. triseriatus, are not. Therefore, day-flying species are usually not adequately sampled. Furthermore, flight behavior such as swarming can be influenced by environmental factors such as temperature, humidity, light and wind (Mulhern 1975).

The Importance, Distribution, and Life History of Each Species

Although there are over twenty species of mosquitoes in La Crosse

County, not all of them are of medical and economical importance. The indigenous species that have been incriminated as major disease vectors include Ae. triseriatus, Ae. vexans, Ae. canadensis, C. pipiens, C. tarsalis, and An. quadrimaculatus. In addition, almost all of the species have shown to be a potential or laboratory vector of one or more diseases. However, the associations of some species with diseases are limited to the finding of pathogens in the bodies of specimens. More importantly, the presence of a vector in an area does not necessarily mean that the disease is also present.

The medical and economical significance of each species, along with their seasonal distributions and life histories, are discussed below. The following abbreviations are used to denote the various diseases that may occur in the County: LAC (La Crosse strain); CE (California encephalitis); SLE (St. Louis encephalitis); WEE (Western equine encephalitis); EEE (Eastern equine encephalitis).

Aedes canadensis (Theobald)

Ae. canadensis is a floodwater species that is a suitable host for the dog heartworm. In addition, viruses of five strains of CE, including LAC, had been isolated from field specimens (U.S. Dept. HEW 1977, Cassani 1977).

Larvae are found in cool clean woodland pools with leaf-covered bottoms. There may be more than one generation per season and Horsfall (1972) has observed hatching even in the fall. The adults usually remain in the woods near their larval sites, where they are serious pests.

As shown in Fig. 40, there seems to be more than one brood per

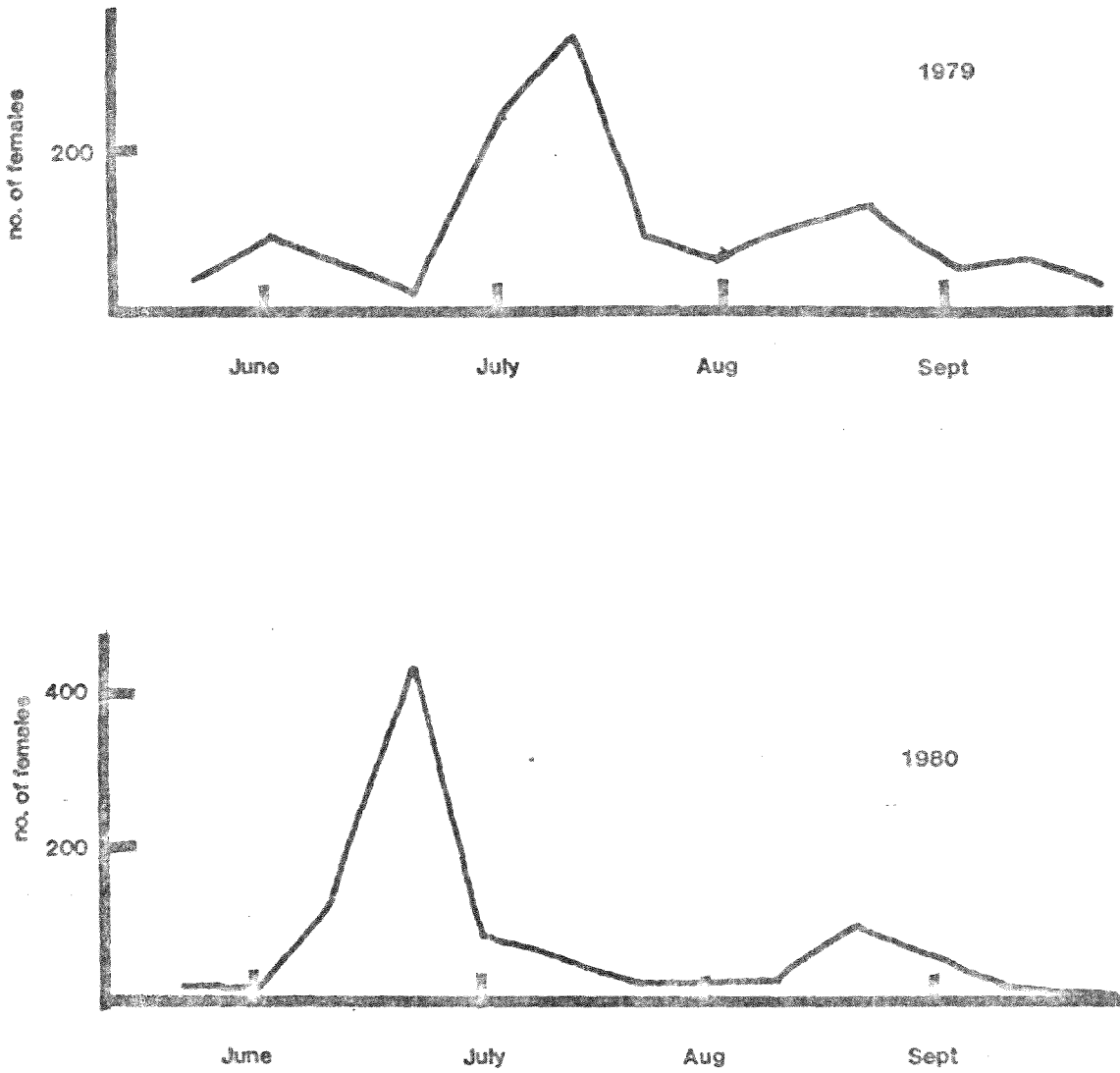


Figure 40. Seasonal distribution of Aedes canadensis in 1979 and 1980.

season in the La Crosse area. Since the adults can live for several months and can be difficult to identify, it is not known if there were actually four separate hatches in 1979. The seasonal distribution pattern shown for 1980 is probably more typical of this species.

Aedes cinereus Meigen

Ae. cinerus is a floodwater species that is occasionally important as a pest in the northern states (U.S. Dept. HEW 1977). It is also a potential vector of dog heartworm (Cassani 1977). Barr (1958) considered it to be important as a pest species only in wooded areas near its breeding sites, due to its limited flight range.

Larvae of the species are collected frequently throughout the spring and summer in La Crosse County. As shown in Tables 5 and 6, the adults comprised about 1.4% of the collections in both years. Although it is usually considered an univoltine species (U.S. Dept. HEW 1977, Matheson 1966, Horsfall 1972), there is definitely more than one brood per season here, as shown in Fig. 12. There was a large second hatch in late August of 1980. Porter and Gojmerac (1970a) found that a second hatching of this species can occur if pools are flooded again to the same size they have been in the spring. Silverly and DeFoliart (1969a) found larvae occurring throughout the summer, and as late as October 23, in northern Wisconsin. Wada (1965) also found it to be late in appearance with adults appearing from June 22 to August 25.

Locally, the larvae of this species seem to appear later in the spring than those of Ae. vexans, and the two species are often found together in Myrick Marsh, where the adults are also the most abundant.

Aedes dorsalis (Meigen)

Ae. dorsalis is a potential vector of WEE and SLE. In addition, LAC virus had been isolated from wild specimens (Cassani 1977). It is a severe pest of man and cattle in the plains of northern U.S. and Canada (Matheson 1966, U.S. Dept. HEW 1977).

There is more than one generation per year with larvae developing in irrigated pastures and wastewater pools. The adults are known to migrate great distances (Horsfall 1972), and thus some of this species collected here may have come from surrounding states, where it is more common. Locally, it is not very abundant and as shown in Fig. 41, its seasonal distribution pattern is similar to other floodwater species.

The Aedes punctor group

This is a group of univoltine spring Aedes that is not important medically but can be serious pests in the northern U.S. and Canada (Matheson 1966, Horsfall 1972, U.S. Dept. HEW 1977). Ae. communis, the only member of the group that was found here as larva, is abundant and is among the first species to appear in April.

Not much is known about the seasonal distribution of the adults here because only five specimens were collected in 1979 and there were difficulties in identification. As shown in Fig. 42, there was a major hatch in June, followed by a possible second brood. Matheson (1966) found the adults to be long-lived and active until August. Silverly and DeFoliart (1968b) thought that a delayed hatch or possibly a second generation occurs in northern Wisconsin.

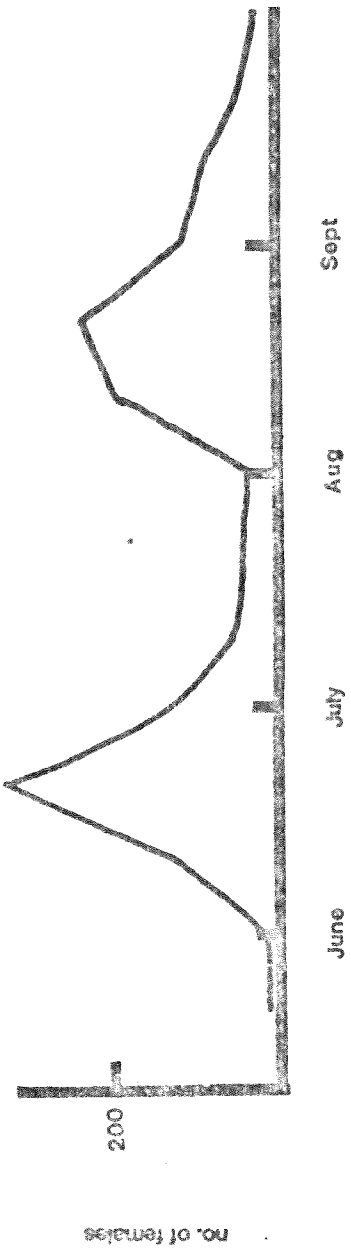


Figure 41. Seasonal distribution of Aedes dorsalis in 1980.

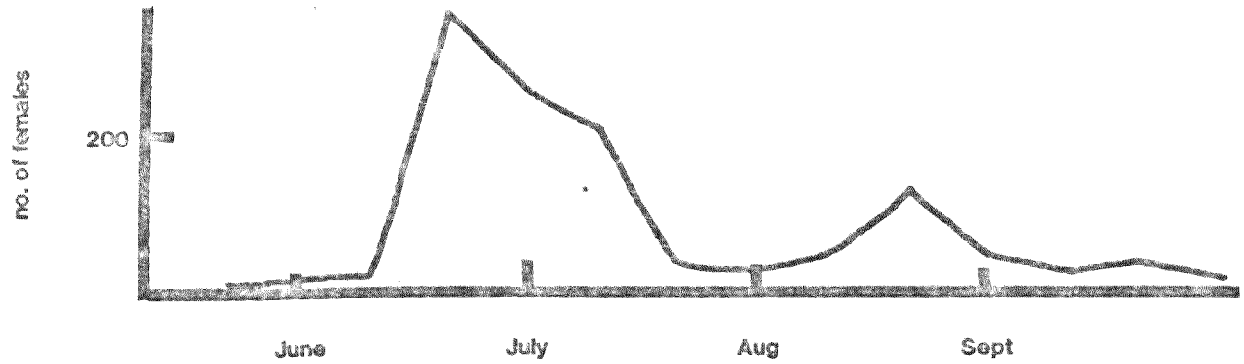


Figure 42. Seasonal distribution of the Aedes punctor group in 1980.

Aedes spencerii (Theobald)

Ae. spencerii is a serious pest of man and livestock, and often migrates into cities. It has been known to attack during the day (U.S. Dept. HEW 1977). This is a dominant species of the prairies of Minnesota, but it does not seem to be of importance here. The larvae appear early in the spring in shallow, weedy pools. Horsfall (1972) reported one generation per year, while Matheson (1966) found at least three broods per season. Locally, there seems to be more than one hatch per season. As shown in Fig. 43, its distribution pattern is similar to other floodwater species.

Aedes sticticus (Meigen)

Although Ae. sticticus was found to be uncommon in this study, it is a ferocious and major pest species in wooded areas along rivers (Barr 1958). In addition, it is a potential vector of dog heartworm (Cassani 1977). The species usually has only one brood per season, following spring floods (U.S. Dept. HEW 1977). Its distribution in La Crosse County is unclear. Since no larva has been found locally, and the adults are long-lived and are capable of flight up to 48 km, it is difficult to determine its importance here.

The Aedes stimulans group

The Ae. stimulans group consists of four woodland species that are common in the northern states. Only two of them, Ae. fitchii and Ae. excrucians, have been found as larvae in La Crosse County. Both species are potential vectors of dog heartworm (Cassani 1977).

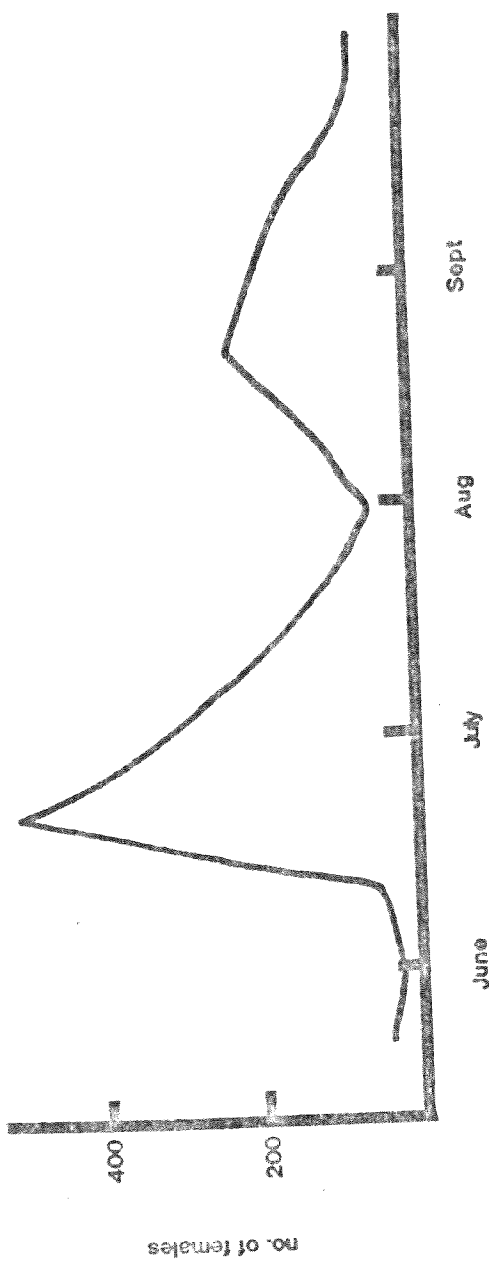


Figure 43. Seasonal distribution of Aedes spencerii in 1980.

These cold water species have one generation per year, but the adults are long-lived and can be found as late as September (Wada 1965). Ae. excrucians breeds in grassy woodland pools, while Ae. fitchii prefers more open cattail marshes. In La Crosse, both species are common in the spring and early summer. Although the four species are often found together in the field, their larvae usually develop at different rates. Wada (1965) reported delayed hatches of Ae. excrucians. He also reported that hatchings had been observed in the fall in Illinois.

They are annoying woodland pest mosquitoes during the day (U.S. Dept. HEW 1977) and are known to migrate to open areas at night (Horsfall 1972). Price (1963) found Ae. excrucians to be the dominant pest species at Itasca State Park, while Porter and Gojmerac (1970a) reported Ae. stimulans as the dominant species at Point Beach State Forest.

Locally, these species seem to be common in the spring and occur throughout the season. However, due to difficulties with identification, their seasonal distribution here is unclear, and they may not be as abundant as they are shown in Tables 5 and 6.

Aedes triseriatus (Say)

The biology of this medically important species has already been discussed in the "literature review" section. Although Ae. triseriatus only made up less than 1% of the catch each year, it might have been more abundant than indicated by the light trap data. A light trap is usually not considered a good sampling method for this species due to its apparently low index of attractiveness to light (Love and Smith 1957), its short flight range (U.S. Dept. HEW 1977), and the fact that it is more

active during daytime (Loor and DeFoliart 1970).

Trap placement seems to be very important in determining the abundance of this species in light trap collections. As shown in Table 14, this species was most abundant at Myrick Marsh, Oak Forest, and Shelby. Basal tree holes were probably the most important breeding sites at Myrick Marsh and Oak Forest, but artificial containers were largely responsible for the population at Shelby. Nevertheless, all Ae. triseriatus were probably produced near the trap sites due to its characteristically short flight range. Most importantly, this study indicates that Ae. triseriatus does enter light traps if they are placed close to its breeding sites. In 1979, a temporary light trap was placed at Shiftar Salvage Yard in Medary, where larvae of this species had been found breeding in discarded tires. The trap was located within a woodlot adjacent to a huge pile of tires (the tire pile is shown in Plate 6). During one evening, over 3,000 Ae. triseriatus females were collected. This confirms similar findings by MMCD in Minnesota (personal communications) that this species does enter light traps if they are in close proximity to breeding areas.

As shown in Tables 5 and 6, more adults were collected in 1980 than in 1979. Due to the small sample size in 1979, only the seasonal distribution of 1980 is shown in Fig. 44. Although there seemed to be two major hatches like other flooewater species, this is not the complete representation of its distribution. Oviposition traps, which are also used by the control program, are probably more reliable for measuring its abundance and distribution because they are placed inside woodlots and forested areas where the species is the most abundant.

Table 14. Distribution of *Aedes triseriatus* collected from light traps in 1980.

Date	Goose Island	Myrick Marsh	Shelby	French Island	Oak Forest	Division Street
6-13						1
6-14					2	
6-19		1				
6-21		3			2	2
6-22		3			1	
6-23	1	2		2		2
6-24			2			
6-25	5	8	5	4		3
6-26	2	2	1			7
6-27	4	4	9			
6-28		3				
6-30	1			2		
7-2		2				
7-6		1				1
7-7		1		1		
7-10		4				
7-11	3	2			1	
7-12		1				
7-15		3				
7-18				1		
8-2					1	
8-6					1	
8-25			2		2	
8-26		1			3	
8-27			2			
8-28				1	5	
8-29		4	1	5	10	
8-30					15	
9-1		5			2	3
9-2		2			1	
9-3		5			2	
9-4						1
9-5		2				
9-6		9	5			
9-7				2		
9-8				1	2	1
9-12			1			
9-13		4	3	1		
9-19				2		
9-21			4			
10-6		3				



Plate 6. The pile of tires at Shiftar's Salvage Yard where larvae of *Aedes triseriatus* had been found.

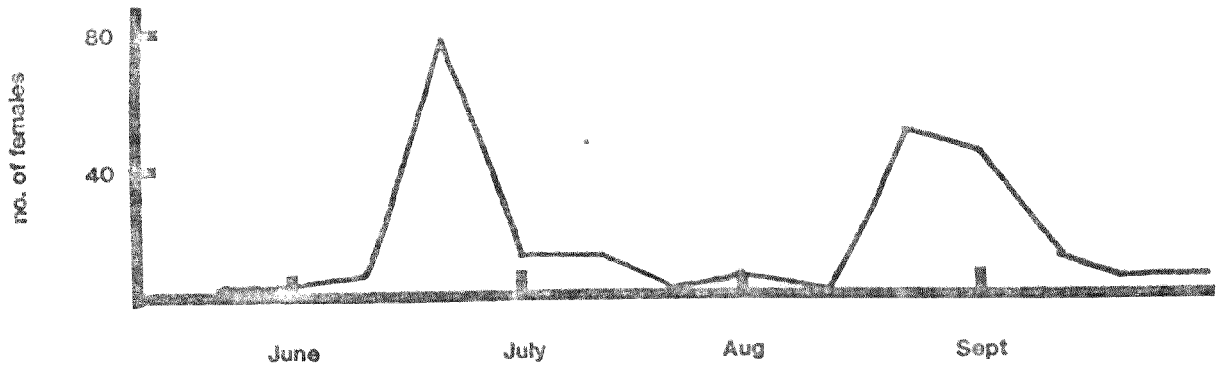


Figure 44. Seasonal distribution of Aedes triseriatus in 1980.

Theoretically, Ae. triseriatus can be eliminated from this area, and thus eliminating the disease. Extensive surveys and tree hole filling programs, along with public education, have been initiated in the County. Control programs were successful in reducing the number of cases of viral encephalitis within the City of La Crosse in 1980. Only one case of LAC encephalitis, originating from a tire, was reported in the County in 1980, as compared to 22 cases reported in 1979 (Gundersen, personal communications).

Aedes trivittatus (Coquillett)

Ae. trivittatus is a potential vector of LAC encephalitis and dog heartworm (Cassani 1977). The larvae occur in floodwater pools and temporary rain pools, spending most of their time concealed in bottom vegetation. Therefore, larvae are seldom found even though the adults may be abundant (U.S. Dept. HEW 1977). Adults rest on grasses and other vegetation near their breeding sites during the day and will bite when disturbed. Locally, no larvae have been found, but adults were abundant in 1980, comprising 1% of the total. As shown in Table 6, the species was present in great numbers at both Myrick Marsh and Oak Forest, where Ae. triseriatus was also the most abundant. This species may be of importance locally due to its link with LAC virus and the apparent association with Ae. triseriatus in the traps.

Its seasonal distribution pattern is shown in Fig. 13. There was more than one generation per season. As both Tables 9 and 12 show, this species was the most abundant in August and September in 1980.

Aedes vexans (Meigen)

Ae. vexans, the inland floodwater mosquito, is probably the most widespread species in the United States and the most abundant and troublesome mosquito in many areas (U.S. Dept. HEW 1977). Clarke (1937) found that this species comprises 95% of all the mosquitoes in the midwest. The medical importance of Ae. vexans should not be overlooked since it is a major vector of dog heartworm (Cassani 1977) and has been found to be naturally or experimentally infected with viruses of SLE, WEE, CE and EEE (U.S. Dept. HEW 1977).

Horsfall et al. (1973) found Ae. vexans populations to be a product of terrain of low topographic relief wherever shallow, transient, ground pools occur in grassy or forested regions. Its eggs are deposited on dry ground subjected to inundation. However, Matheson (1966) stated that all the eggs do not hatch at the same time, so successive broods may develop after each flooding. Locally, larvae have been found in marshes, roadside puddles, rain pools and other temporary bodies of fresh water. The numbers and sizes of generations per season are largely dependent upon rainfall. Horsfall et al. (1973) found that adults often invade cities 9 to 12 days after larval habitats are flooded. The pattern of rainfall during a season is also important due to the need for drying periods between hatches. Populations of the species can reach extremely high numbers when heavy rains are evenly spaced throughout the summer. This may be the cause of the heavy population here in 1980. The rainfall patterns, shown in Fig. 39, were fairly evenly spaced throughoutout the season, especially from July through September.

The flight range of Ae. vexans cannot be underestimated. Distances

of 16-24 km are rather common, with longer distances often reported. This migration factor allows it to become a serious pest even in cities and towns remote from breeding sites. This is certainly true for trap locations such as Shelby and Division Street, where the species is still abundant, even though no suitable breeding sites are nearby.

The longevity of the adults can complicate control efforts. Even after successful attempts within an area, adults from surrounding areas often migrate in. Therefore a "buffer" zone is usually needed to prevent influxes of this species into urban areas. The problem in La Crosse is compounded by the fact that there are no control efforts in the surrounding counties, including the ones across the river in Minnesota.

Sjogren (1980) stated that the control of Ae. vexans is further complicated by the fact that during the dry periods, natural aquatic insects predators are often eliminated. The marshes, including parts of Myrick Marsh, usually become dry in late summer, thus preventing the overwintering of fish or predatory insect forms.

As mentioned earlier, Ae. vexans is the most abundant species in La Crosse County. The seasonal distribution patterns of 1979 and 1980 are shown in Figs. 6 and 11, respectively. Since both the males and females are attracted to light, light trap sampling is a very good method for monitoring the abundance of this species. All traps collected high numbers of Ae. vexans. At Myrick Marsh, which is a major breeding ground for the species, there were over 90,000 Ae. vexans females collected in 1980.

Anopheles punctipennis (Say)

Although Cassani (1977) stated that this species is a potential vector of dog heartworm, malaria and LAC encephalitis, it might not be important medically because of its preference for the non-human host. It does not enter homes as readily as An. quadrimaculatus but it can be a vicious biter outdoors (U.S. Dept. HEW 1977).

Matheson (1966) found that the larva of this species breeds in a wide variety of habitats, including rain barrels, roadside puddles, swamps, spring pools, open ponds, running water, and along margins of streams and lakes. It has been found to prefer cooler temperatures (Matheson 1966, Owen 1937, Horsfall and Morris 1952). No larva has been collected locally, but Owen (1937) had found it along the Minnesota-Wisconsin boundary in the Mississippi River, especially in the spring and fall. Daggey et al. (1941) found it to be common in southeastern Minnesota.

The adult females overwinter in well-protected shelters and are the first anophelines to appear in the spring. They are present throughout the season, depending on rainfall and available breeding grounds. As shown in Tables 5 and 6, this species was more abundant in 1980 than in 1979, with most of them collected at Myrick Marsh. This species was not as abundant as An. walkeri, but more abundant than An. quadrimaculatus. The seasonal distribution of this species in La Crosse County is not clear because different patterns occurred during the seasons. In both years, adults were present by late May. In 1980, there was a great increase of the species in mid-August to late September (Fig. 14).

Anopheles quadrimaculatus Say

Besides being the most important vector of human malaria in the U.S. (Matheson 1966, U.S. Dept. HEW 1977), An. quadrimaculatus is also a potential vector of dog heartworm and can transmitt SLE and WEE in the laboratory (Cassani 1977). It is a pest because it enters houses and actively seeks human victims inside. However, Owen (1937) and Matheson (1966) stated that it is probably not an important species in the northern part of its range because it is not very abundant here.

The larva breeds mostly in permanent bodies of clear quiet water which contain a fair amount of aquatic vetetation, with the most favorable temperature for development between 29.4°C and 32,2°C (U.S. Dept. HEW 1977). Only one larva of this species had been found in La Crosse County during the study period.

Due to the small numbers collected and possible mistakes in identification, the seasonal distribution of this species in La Crosse County cannot be determined. However, Horsfall (1972) reported two to three generations a year in central Illinois and Peters (1943) found it to have four generations in Minnesota. Daggey et al. (1941) found it to be the most numerous anopheline in the Mississippi River Valley in southeastern Minnesota as judged by captures in resting places. Furthermore, Bradley (1943), Hagmann and Feldlaufer (1972) stated that An. quadrimaculatus is not readily attracted by light. Therefore, light trap data is not a good method to determine the abundance and distribution of this species.

Anopheles walkeri Theobald

An. walkeri is a good laboratory vector of malaria although its epidemiological importance in relation to the disease is undetermined (U.S. Dept. HEW 1977). It is also a potential vector of dog heartworm (Cassani 1977).

Larvae occur in permanent bodies of water that are overgrown with emergent vegetations. Horsfall (1972) found that they are unable to survive in fluctuating water levels unless the site can support vegetation that rises and falls with the water level. The adults tend to rest in the emergent vegetation of their breeding sites during the day and often enter houses at night to feed on humans since they are attracted to light (U.S. Dept. HEW 1977).

As shown in Fig. 7, there was more than one generation per year. In Minnesota, there are four generations a year (Horsfall 1972, Matheson 1966). It is an important pest species locally, comprising 4% of the total in 1979, as shown in Table 5. At Goose Island, where the breeding sites possess some degree of permanency, this species represented 70-90% of the females collected in May and June. Although no larva has been found, the data still probably give accurate descriptions of its abundance here because the adults do not migrate far.

Two factors might have been responsible for the drastic decrease in the population of this species from 1979 to 1980. The precipitation pattern of 1980 might not have been favorable to the permanency that this species requires. In addition, this species overwinters as an egg in the water (Horsfall 1972, U.S. Dept. HEW 1977). The lack of snow cover, which usually acts as an insulation layer, in the winter of 1979-

80, might have affected its survival rate.

Coquillettidia perturbans (Walker) (formerly Mansonia perturbans)

Cassani (1977) stated that this species has been found naturally infected with the virus of EEE and CE, and has been infected experimentally with SLE and dog heartworm. However, the medical importance of the species here is unknown because its role in the epidemiology of encephalitis has not been established (U.S. Dept. HEW 1977). Nevertheless, this species can become a serious pest because it is a fierce biter that attacks both day and night. Matheson (1966) found that it is a strong flier and readily enters houses.

There is only one generation per year (U.S. Dept. HEW 1977, Horsfall 1972), but Sjogren (1976), Silverly and DeFoliart (1968b) found that its emergence is sustained over a long period of time. Sjogren (1976) stated that this species is a serious pest during its June 15 to July 31 emergence period in Minnesota. As shown in Fig. 10, there was only one brood per season here. In 1979, there appeared to be two additional minor hatches. This is probably due to error in identification because an inexperienced worker can confuse this species with C. tarsalis, which tends to migrate into the area in late summer. However, a second brood had been observed in Florida (U.S. Dept. HEW 1977). Since the larvae breed in permanent or semipermanent bodies of water, Silverly and DeFoliart (1968b) found the production of this species to be largely independent of precipitation patterns.

Matheson (1966) stated that the larvae descend to the bottom of marshes and ponds and attach themselves by their air tubes to the stems

or roots of aquatic plants such as sedges, cattails, duckweed, and arrowhead. Due to its unique habits, only one larva has ever been collected here.

As shown in Tables 5 and 6, this species was much more abundant in 1980 than in 1979. In 1980, the adults emerged earlier and constituted 1.7% of the total catch. One possible explanation is that the species overwinters as partially grown or mature larva and the milder temperatures in the 1979-80 winter may have allowed more larvae to survive.

The Culex pipiens complex

This complex is mainly consist of C. pipiens pipiens, the "northern house mosquito", and C. restuans. Both species are major vectors of SLE and potential vectors of dog heartworm. In addition, C. pipiens is a potential vector of WEE and C. restuans is capable of transmitting EEE.

Both species develop prolifically in rain barrels, tin cans, storm sewers, catch basins, gutters, cesspools, polluted ground pools and any other artificial containers. Horsfall (1972) found that the number of egg rafts deposited by C. pipiens at one site may reach vast numbers. In warm weather, eggs can hatch within a day or two. They hibernate as adults and breed throughout the summer.

Since the adults do not usually migrate far, extensive surveys of potential habitats are possible, as carried out in the Shelby area in 1980. Both species were found in rain barrels, sotrm ditches, and discarded tires in residential areas. Although C. restuans is supposed to be more rural in its occurrence and prefer avian hosts, it is found to be equally abundant in light traps and artificial containers in La Crosse

County. The control of these species is possible through the elimination of artificial containers and the education of the public.

In La Crosse County, the C. pipiens complex is important, comprising 2% of the total females collected each year (Tables 5 and 6). It is more abundant in residential areas such as Shelby, where it made up 10% of the population total in 1980. These species are attracted to light, so light trap data give accurate representation of their abundance.

Due to the availability of breeding places and its short development period in hot weather, there can be numerous hatches throughout one season (Fig. 29). These hatches can overlap to such an extent that differentiation of individual broods are sometimes impossible. As shown in Fig. 9, the level of population of the species may never reach "zero" during the summer.

C. salinarius resembles C. pipiens and C. restuans only in appearance. It prefers more permanent types of breeding places. Since the adults are so rare here and no larva has been found, its importance in La Crosse County is unknown.

Culex tarsalis Coquillett

Jenkins (1950) found C. tarsalis to be the most important vector of WEE and probably SLE in the U.S. It is widely distributed and is abundant west of the Mississippi River. It is important both as pest and as vector of encephalitis to man and horses (U.S. Dept. HEW 1977).

Matheson (1966) stated that it overwinters as an adult and enters houses frequently. The larva breeds in all kinds of ground pools, roadside ditches, rainbarrels, irrigation waters and foul pools. Tables 5

and 6 show that only a small number of adults were collected during the study period. Since only one larva has been found in a tire locally and the adults are capable of extended flight (Horsfall 1972), it is not known if the adults collected were from here or from neighboring states such as Minnesota and Iowa, where the species is abundant.

Culex territans Walker (formerly C. apicalis)

Although it is a potential vector of dog heartworm (Cassani 1977), C. territans is not an important species here because it prefers to bite cold blooded animals, such as frogs, over humans. Larvae are found in relatively permanent ponds and marshes that are well supplied with aquatic vegetation, preferably in rather cool waters (U.S. Dept. HEW 1977). Unlike other species of the genus, adults are rarely found near or inside dwellings (Matheson 1966).

As shown in Tables 5 and 6, most of the individuals of this species were collected at Myrick Marsh, where frogs are common. Fig. 15 shows that there were two and three broods per season in 1979 and 1980, respectively. The greatest collections were made in August and early September. It is not known why this species does not become plentiful until late summer since it prefers cool water. Headlee (1945) found that in New Jersey the first brood of larvae does not appear until late May and the adults are among the last species outdoors. Barr (1958) found that most adults appeared from late June to August in Minnesota and Wada (1965) found it to be late appearing in Edmonton. In central Illinois, Horsfall (1972) found the larvae associated with duckweed and mean summer temperatures of 24-25^{o}C. No larva of the species was found during the study

period.

Culiseta inornata (Williston)

Although Cassani (1977) stated that Cu. inornata is a potential vector of WEE, dog heartworm and CE, it is probably not significant medically becuase it seldom feeds on man (U.S. Dept. HEW 1977). However, it can become a problem in Wisconsin because it is a serious pest of livestock and other domestic animals.

This species breeds in temporary pools throughout spring and summer, and overwinters as an adult. The larva are frequently found in cold water and adults had been found out of hibernation even when snow is still on the ground. In La Crosse County, the larvae are usually abundant in May and the adults are among the first ones to be collected by light traps. Hagmann and Feldlaufer (1972) found that this species is not attracted to light. Therefore light trap data may not be a true indication of its abundance. In 1979, large numbers of this species were collected initially in May, as shown in Fig. 8. These were probably the adults emerging from hibernation. Fig. 8 shows that this species was not abundant until September in 1980. Hanec and Brust (1967), Fanara and Mulla (1974) had indicated that for unknown reasons, the females of Cu. inornata do not fly in July and August when immatures cannot survive the high temperatures.

Culiseta morsitans (Theobald)

Very little is known about this species except that it is not a pest of man or domestic animals, and is of no medical importance. It is ca-

pable of breeding in extremely shallow ground pools. The local distribution of this species cannot be analyzed due to the small number of adults collected, as shown in Tables 5 and 6. Some adults identified as this species may be Cu. minnesotae Barr, which is a rare species known only from Minnesota, northern Illinois and Wisconsin. Both species are difficult to identify, and the latter one is not included in the most common key used in the identification process (Pratt and Barnes 1959).

Psorophora ciliata (Fabribius)

Although P. ciliata is of no medical importance, it can be a very annoying pest when present in numbers, because this vicious mosquito attacks both day and night (U.S. Dept. HEW 1977). The population profile of this species, like other floodwater mosquitoes, varies with the pattern of summer rains. As shown in Fig. 45, there were three broods in 1979 and two in 1980. Matheson (1966) and Horsfall (1972) found that the larvae of this species are predacious upon larvae of other mosquito species that are often associated with it, including Ae. vexans and Ae. trivittatus. A fourth instar larva can consume three or four larvae in one day (U.S. Dept. HEW 1977). One P. ciliata larva collected during this study was 15 mm in length. The adults are also large in size and may attain a wingspread of 15 mm. The largest adult collected here was 10 mm in length.

Uranotaenia sapphirina (Osten Sacken)

U. sapphirina is not important here, because it is of no medical importance and it rarely bites man. As shown in Fig. 16, there was more

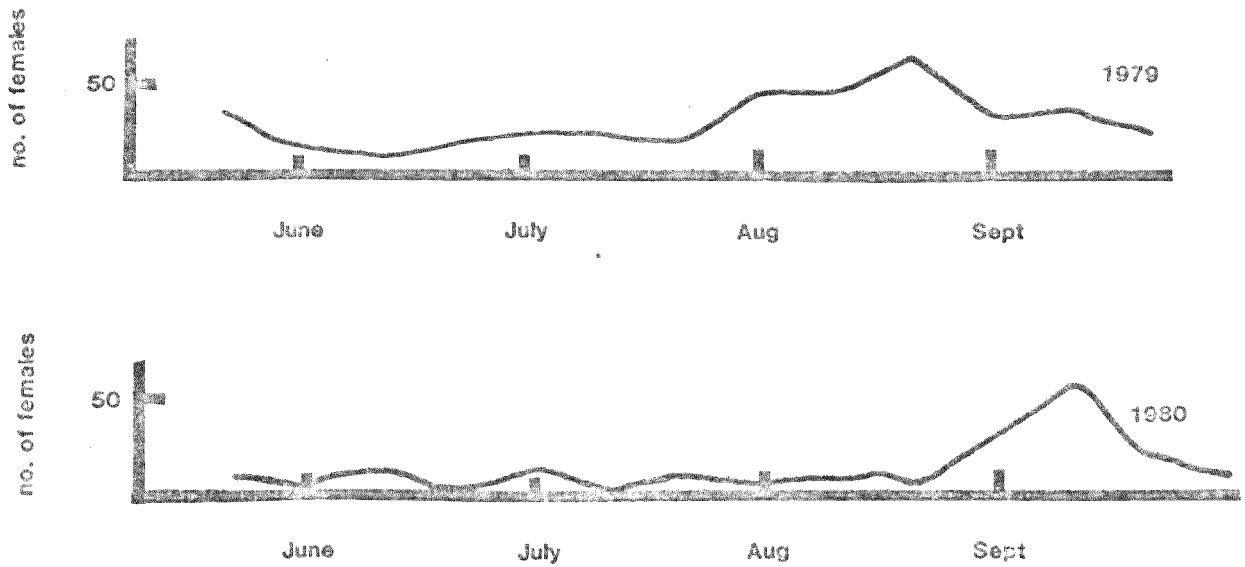


Figure 45. Seasonal distribution of Psorophora ciliata in 1979 and 1980.

than one generation each season, with the greatest numbers of adults collected in late August and early September. Porter and Gojmerac (1970a) found that most individuals of this species emerged from mid to late August and into September at Point Beach State Forest.

The larvae inhabit water where mats of filamentous algae, layers of duckweed, or dense stands of emergent herbs occur. In central Illinois, Horsfall and Morris (1952) found that surface vegetation of duckweed combined with a mean temperature of 24-25^{o}C produced the greatest larval abundance of this species. It has been occasionally found in tree holes and pot holes (U.S. Dept. HEW 1977). As shown in Tables 5 and 6, most of the adults in La Crosse County were collected at Myrick Marsh, where dense mats of duckweed are abundant in the summer. The frequent association of the larvae with duckweed often makes them difficult to collect; only one larva of the species was collected at Goose Island during the study period.

SUMMARY AND CONCLUSIONS

1. A total of 339,418 mosquitoes, including 57,103 and 195,316 females in 1979 and 1980, were collected from light traps during the study period.
2. Combined adult and larval collection records showed 25 species, of seven genera, to be present in the area.
3. Due to its location, the Myrick Marsh trap was the most productive throughout the study, where over 50% of the females were collected.
4. Ae. vexans was the most important pest species, comprising 80 and 87% of the total females in 1979 and 1980, respectively.
5. Aedes species other than Ae. vexans comprised 11 and 7% of the totals in 1979 and 1980. Other important species included the C. pipiens complex, Coq. perturbans, and An. walkeri.
6. Floodwater species were more abundant at Myrick Marsh than elsewhere, while the C. pipiens complex showed a preference for Shelby, comprising 10% of the total there in 1980.
7. Rainfall was found to be the most important meteorological factor in the County, influencing both the abundance and distribution of mosquitoes. It contributed to the three-fold increase in the number of broods in each season, and fluctuating populations of various species from year to year.
8. The first group of mosquitoes, which included Ae. vexans, Ae. canadensis, the Ae. stimulans group, Ae. communis, and An. walkeri, resulted from snowmelt and rains in the spring. Also Cu. inornata and the C. pipiens complex, overwintering as adults, were noted.

9. Subsequent hatches consisted of multivoltine floodwater species, the C. pipiens complex, and the annual hatch of Coq. perturbans. C. territans, An. punctipennis and U. sapphirina were found to be late-appearing species.

10. Both Ae. triseriatus and the C. pipiens complex were found frequently breeding in discarded tires and other artificial containers.

11. The extensive flight range of species such as Ae. vexans made the control of this species difficult in La Crosse County. Since this species can fly in from extreme distances, adulticiding to establish a "buffer zone" is probably needed in the out-lying area for control.

12. In spite of its apparently low index of attractiveness to light, Ae. triseriatus does enter light traps if they are placed in close proximity to its breeding sites.

13. The important disease vectors in the County are Ae. triseriatus (La Crosse encephalitis), the C. pipiens complex (SLE), and Ae. vexans (dog heartworm). Potential vectors of LAC encephalitis include Ae. trivittatus, An. punctipennis and Cu. inornata. In addition, specimens of Ae. vexans, Ae. dorsalis and Coq. perturbans have been found to be naturally infected with this virus.

14. The survey of artificial containers and the filling of tree holes with Rock Wool insulating cement suggested success in reducing the number of cases of LAC encephalitis in La Crosse County.

LITERATURE CITED

Allen, D.G. 1950. A survey of mosquitoes and mosquitoes studies in Wisconsin. M.S. Thesis, Univ. of Wisconsin, Madison, 63pp.

Balfour, H.H., Jr. 1974. California (La Crosse virus) encephalitis in Minnesota. Minnesota Med. 57:876-81.

Barr, A.R. 1958. The mosquitoes of Minnesota (Diptera: Culicinae; Culicidae). Univ. Minn. Agric. Exp. Stn. Tech. Bull. 228, 154pp.

_____, T.A. Smith, and M.M. Boreham. 1960. Light intensity and the attractiveness of mosquitoes to light traps. J. Econ. Entomol. 53:876-80.

_____, _____, _____, and K.E. White. 1963. Evaluation of some factors affecting the efficiency of light traps in collecting mosquitoes. J. Econ. Entomol. 56:123-7.

Barton, W.I. 1978. Seven mosquito species in container habitats in Minnesota. Mosq. News. 38:287.

Beaty, B.J. and W.H. Thompson. 1975. Emergence of La Crosse virus from endemic foci. Fluorescent antibody studies of overwintered Aedes triseriatus. Am J. Trop. Med. Hyg. 24:685-91.

Bidlingmayer, W.L. 1967. A comparison of trapping methods for adult mosquitoes: species response and environmental influence. J. Med. Entomol. 4:200-20.

_____. 1969. The use of logarithms in analyzing trap collections. Mosq. News. 29:635-40.

_____. 1971. Mosquito flight paths in relation to the environment. 1. Illumination levels, orientation, and resting areas. Entomol. Soc. Am. Ann. 64:1121-31.

Bowden, J. 1973. The influence of moonlight on catches of insects in light-traps in Africa. Part I. The moon and moonlight. Bull. Entomol. Res. 63:113-28.

Bradley, G.H. and T.E. Mc Neel. 1935. Mosquito collections in Florida with the New Jersey light trap. J. Econ. Entomol. 28:780-6.

_____. 1943. Determination of densities of populations of Anopheles quadrimaculatus on the wing. Proc. Ann. Mtg. N.J. Mosq. Exterm. Assoc. 30:22-7.

Carpenter, S.J. and W.J. La Casse. 1955. Mosquitoes of North America (north of Mexico). Univ. Calif. Press, Berkeley, 360pp.

Cassani, J.R. 1977. A survey of mosquitoes (Diptera: Culicidae) of Mt. Pleasant and environs, Isabella County, Michigan. M.S. Thesis, Central Michigan Univ., Mount Pleasant, 72pp.

Chandler, J. 1977. The use of light traps to study flight activity and seasonal abundance of mosquitoes of medical importance on the Kano plain, Kenya. Int. J. Environ. Stud. 10:191-5.

Clarke, J.L. 1937. New and significant experiences in mosquito control in the DesPlaines Valley Mosquito Abatement District. Reprint from Proc. 24th Ann. Mtg. N.J. Mosq. Exterm. Assoc., March 17-19, 16pp.

Clarke, J.L., Jr. and F.C. Wray. 1967. Predicting influxes of Aedes vexans into urban areas. Mosq. News. 27:156-63.

Clements, A.N. 1963. The physiology of mosquitoes. Macmillan Co., N.Y. 393pp.

Craig, C.D. 1975. Some ecological aspects of Myrick Marsh with an emphasis on animal population. M.S. Thesis, Univ. of Wisconsin-La Crosse, La Crosse, 99pp.

Daggy, R.H., O.J. Muegge, and W.A. Riley. 1941. A preliminary survey of the anopheline mosquito fauna of southeastern Minnesota and adjacent Wisconsin areas. Publ. Hlth. Rpts. 56:883-95.

Darsie, R.F., Jr., D. Mac Creary, and L.A. Stearn. 1953. Analysis of mosquito-trap collections at Delaware City and Lewes, Delaware, for the twenty-year period, 1932-1951. Proc. 40th Ann. Mtg. N.J. Mosq. Exterm. Assoc. 1953:169-90.

DeFoliart, G.R., M.R. Rao, and C.D. Morris. 1967. Seasonal succession of bloodsucking Diptera in Wisconsin during 1965. J. Med. Entomol. 4:363-73.

_____ and M.A. Lisitza. 1980. Activity by Aedes triseriatus in open terrain. Mosq. News. 40:650-1.

De Kruijf, H.A.M., J.P. Woodall, and A.T. Tang. 1973. The influence of accumulated rainfall and its pattern on mosquito (Diptera) populations in Brazil. Bull. Entomol. Res. 63:327-33.

Dickinson, W.E. 1944. The mosquitoes of Wisconsin. Milwaukee Publ. Museum Bull. 8:269-365.

Fanara, D.M. and M.S. Mulla. 1974. Population dynamics of larvae of Culex tarsalis Coquillett and Culiseta inornata (Williston) as related to flooding and temperature of ponds. Mosq. News. 34: 98-104.

Gadzama, N.M. 1977. The distribution of populations of adult mosquitoes

at Ahmadu Bello Univ., Zaria, Nigeria. Savanna. 6:179-89.

Hagmann, L.E. and M.F. Feldlaufer. 1972. Mosquito populations in Northwest New Jersey based on light trap collections. Proc. N.J. Mosq. Exterm. Assoc. 59:198-202.

Hanec, W. and R.A. Brust. 1967. The effect of temperature on the immature stages of Culiseta inornata (Diptera: Culicidae) in the laboratory. Can. Entomol. 99:59-64.

Harris, P.A. 1975. The avifauna of Myrick Marsh. M.S. Thesis, Univ. of Wisconsin-La Crosse, La Crosse, 106pp.

Hayes, J. and T.D. Downs. 1980. Seasonal changes in an isolated population of Culex pipiens quinquefasciatus (Diptera: Culicidae): a time series analysis. J. Med. Entomol. 17:63-9.

Headlee, T.J. 1932. The development of mechanical equipment for sampling the mosquito fauna and some results of its use. Proc. N.J. Mosq. Exterm. Assoc. 19:106-26.

_____. 1945. The mosquitoes of New Jersey and their control. Rutgers Univ. Press, New Brunswick, 326pp.

Hollingsworth, J.P., C.P. Briggs, III, P.A. Glick, and H.M. Graham. 1961. Some factors influencing light trap collections. J. Econ. Entomol. 54:305-8,

Horsfall, W.R. and A.P. Morris. 1952. Surface conditions limiting larval sites of certain marsh mosquitoes. Entomol. Soc. Am. Ann. 45:492-8.

_____. 1972. Mosquitoes. Their bionomics and relation to disease. Hafner Publishing Co., N.Y., 723pp.

_____, H.W. Fowler, Jr., L.J. Moretti, and J.R. Larsen. 1973. Bionomics and embryology of the inland floodwater mosquito Aedes vexans. Univ. Illinois Press, Urbana, 211pp.

Husbands, R.C. and D.E. Reed. 1969. A comparison of larval mosquito species occurrence and light trap data. Calif. Mosq. Control Assoc. Proc. 37:101-8.

_____. 1976. Light traps and the significance of collection data. Bull. Soc. Vector Ecol. 3:17-26.

Jenkins, D.W. 1950. Bionomics of Culex tarsalis in relation to western equine encephalomyelitis. Am. J. Trop. Med. 30:909-16.

Knight, K.L. 1954. Mosquito light trap collections at Yukon, Florida for the six-year period, 1948-1953. Proc. N.J. Mosq. Exterm. Assoc. 41:251-7.

_____ and M. Wonio. 1969. Mosquitoes of Iowa. Iowa Agric. Home Econ. Exp. Stn. Spec. Rep. No. 61, 79pp.

Lisitza, M.A., G.R. DeFoliart, T.M. Yuill, and M.G. Karandinos. 1977, Prevalence rates of La Crosse virus (California encephalitis group) in larvae from overwintered eggs of Aedes triseriatus. Mosq. News. 37:745-50.

Loor, K.A. and G.R. DeFoliart. 1970. Field observations on the biology of Aedes triseriatus. Mosq. News. 30:60-4.

Love, G.J. and W.W. Smith. 1957. Preliminary observations on the relation of light trap collections to mechanical sweep net collections in sampling mosquito populations. Mosq. News. 17:9-14.

Matheson, R. 1966. Handbook of the mosquitoes of North America. Hafner Publishing Co., N.Y., 314pp.

Moulton, D.W. and W.H. Thompson. 1971. California group virus infections in small, forest-dwelling mammals of Wisconsin. Am. J. Trop. Med. Hyg. 20:474-82.

Mulhern, T.D. 1934. A new development in mosquito traps. Proc. N.J. Mosq. Exterm. Assoc. 21:137-140.

_____. 1975. A training manual for California mosquito control agencies. CMCA Press, Visalia, Calif.

National Oceanic and Atmospheric Administration (NOAA). 1979. Local climatological data. Annual summary with comparative data. La Crosse, Wisconsin. National Climatic Center, Asheville, N.C., 4pp.

_____. 1980. Local climatological data. Annual summary with comparative data. La Crosse, Wisconsin. National Climatic Center, Asheville, N.C., 4pp.

Owen, W.B. 1937. The mosquitoes of Minnesota, with special reference to their biologies. Univ. Minn. Agric. Exp. Stn. Tech. Bull. 126, 75pp.

Pantuwatana, S., W.H. Thompson, D.M. Watts, and R.P. Hanson. 1972. Experimental infection of chipmunks and squirrels with La Crosse and Trivittatus viruses and biological transmission of La Crosse virus by Aedes triseriatus. Am. J. Trop. Med. Hyg. 21:476-81.

Patel, R.C. 1959. Studies on the habitat and incidence of mosquitoes in University of Wisconsin Arboretum. Ph.D. Thesis, Univ. of Wisconsin, Madison, 97pp.

Peters, H.T. 1943. Studies on the biology of Anopheles walkeri Theobald. J. Parasitol. 29:117-22.

Peterson, P.M. 1970. A survey of the gastro-intestinal helminths habored by cats and dogs from the La Crosse, Wisconsin area. M.S. Thesis, Univ. of Wisconsin-La Crosse, La Crosse, 147pp.

Pinger, R.R., Jr. 1971. Occurrence and seasonal distribution of mosquitoes associated with arbovirus activity in Iowa. M.S. Thesis, Iowa State Univ., Ames, 99pp.

_____ and W.A. Rowley. 1972. Occurrence and seasonal distribution of Iowa mosquitoes. Mosq. News. 32:234-41.

Platt, R.B., G.J. Love, and E.L. Williams. 1958. A positive correlation between relative humidity and distribution and abundance of Aedes vexans. Ecology. 39:167-9.

Porter, C.H. and W.L. Gojmerac. 1970a. Mosquitoes of Point Beach State Forest. Research Report Number 53, College of Agric. and Life Sci., Univ. of Wisconsin, Madison, 16pp.

_____. 1970b. Temperature; its influence on light trap catches of Aedes vexans (Meigen). Mosq. News. 30:54-6.

Pratt, H.D. 1944. Studies on the comparative attractiveness of 25-, 50-, and 100- watt bulbs for Puerto Rican anopheles. Mosq. News. 4:17-8.

_____ and R.C. Barnes. 1959. Identification of some common female mosquitoes of the United States. U.S. Dept. of Health, Educatino, and Welfare, Center for Disease Control, Atlanta, 39pp.

Price, R.D. 1963. Frequency of occurrence of spring Aedes (Diptera: Culicidae) in selected habitats in northern Minnesota. Mosq. News. 23:324-9.

Pritchard, A.F. and H.D. Pratt. 1944. A comparison of light trap and animal bait trap Anopheline mosquito collections in Puerto Rico. Publ. Hlth. Rep. 59:221-33.

Provost, M.W. 1952. The dispersal of Aedes taeniorhynchus. I. Preliminary studies. Mosq. News. 12:174-90.

_____. 1959. The influence of moonlight on light-trap catches of mosquitoes. Entomol. Soc. Am. Ann. 52:261-71.

Roberts, R.H., R.J. Dicke, R.P. Hansen, and D.H. Ferris. 1956, Potential insect vectors of vesicular stomatitis in Wisconsin. J. Inf. Dis. 98:121-6.

Ross, H.H. and W.R. Horsfall. 1965, A synopsis of the mosquitoes of

Illinois (Diptera, Culicidae). Illinois Natural History Survey Biological Notes No. 52, Urbana, 50pp.

Rowe, J.A. 1942. Mosquito light trap catches from ten Iowa cities, 1940. Iowa State College J. Sci. 16:487-518,

Ryckman, R.E. 1952. Ecological notes in mosquitoes of Lafayette County, Wisconsin (Diptera: Culicidae). Am. Midl. Nat. 47: 469-70.

Scholl, P.J. and G.R. DeFoliart. 1977. Aedes triseriatus and Aedes hendersoni: vertical and temporal distribution as measured by oviposition. Environ. Entomol. 6:355-8.

_____. 1978. The influence of seasonal sex ratio on the number of annual generations of Aedes triseriatus. Entomol. Soc. Am. Ann. 71:677-9.

_____, B.R. Miller, W.R. Atchley, and G.R. DeFoliart. 1979. Diel man-biting activity of Culicoides guttipennis and C. paraensis in southern Wisconsin. Mosq. News. 39:288-90.

Sefton, D.F. 1976. The biomass and productivity of aquatic macrophytes in navigation pool 8 of the upper Mississippi River. M.S. Thesis, Univ. of Wisconsin-La Crosse, La Crosse, 175pp.

Silverly, R.E. and G.R. DeFoliart. 1968a. Mosquito studies in northern Wisconsin. I. Larval studies. Mosq. News. 28:149-54.

_____. 1968b. Mosquito studies in northern Wisconsin. II. Light trapping studies. Mosq. News. 28:162-7.

Sjogren, R.D. 1976. Mosquito control in Minnesota: techniques used in metropolitan and rural programs. Mosq. News. 36:432-6.

_____. 1980. Control of Aedes vexans in the midwest: current status and future needs. Mosq. News. 40:341-6.

Sollers-Riedel, H. 1976. The challenge of coping with mosquito literature. Mosq. News. 36:540-3.

Thompson, P.H. 1964. The biology of Aedes vexans in Wisconsin (Culicidae: Diptera). Ph. D. Thesis, Univ, of Wisconsin, Madison, 206pp.

_____ and R.J. Dicke. 1965. Sampling studies with Aedes vexans and some other Wisconsin Aedes. Entomol. Soc. Am. Ann. 58:927-30.

Thompson, W.H., B Kalfayan, and R.O. Anslow. 1965. Isolation of California encephalitis group virus from a fatal human illness. Am. J. Epidemiol. 81:245-53.

_____ and S.L. Inhorn. 1967. Arthropod-borne California group viral encephalitis in Wisconsin. Wisconsin Med. J. 66: 250-3.

_____, R.O. Anslow, R.P. Hanson, and G.R. DeFoliart. 1972. La Crosse virus isolations from mosquitoes in Wisconsin, 1964-1968. Am. J. Trop. Med. Hyg. 21:90-6.

U.S. Dept. of Health, Education and Welfare (HEW). 1977. Mosquitoes of public health importance and their control. HEW Publ. No. (CDC) 77-8140, 55pp.

Van Derwerker, R.J. 1937. The relation of mosquito trap catches to human comfort. Proc. N.J. Mosq. Exterm. Assoc. 24:25-30.

_____. 1939. Effective and intelligent use of the New Jersey mosquito trap for mosquito control in a local area. Proc. N.J. Mosq. Exterm. Assoc. 26:199-212.

Wada, Y. 1965. Population studies on Edmonton mosquitoes. Quaestiones entomologicae. 1:187-222.

Watts, D.M., C.D. Morris, R.E. Wright, G.R. DeFoliart, and R.P. Hanson. 1972. Transmission of La Crosse virus (California encephalitis group) by the mosquito Aedes triseriatus. J. Med. Entomol. 9: 125-7.

_____, S. Pantuwatana, G.R. DeFoliart, T.M. Yuill, and W.H. Thompson. 1973. Transovarial transmission of La Crosse virus (California encephalitis group) in the mosquito, Aedes triseriatus. Science. 182:1140-1.

_____, W.H. Thompson, T.M. Yuill, G.R. DeFoliart, and R.P. Hanson. 1974. Overwintering of La Crosse virus in Aedes triseriatus. Am. J. Trop. Med. Hyg. 23:694-700.

Wong, Y.W., D.C. Dorsey, M.J. Humphrey, and W.J. Hausler. 1970. Arbovirus encephalitis surveillance in Iowa. Health Lab. Sci. 7:117-23.