FINAL REPORT

NASA CR-
147573

PUBLIC HEALTH APPLICATIONS OF REMOTE SENSING OF VECTOR BORNE AND PARASITIC DISEASES

Contract Number NAS 9-12696
Johnson Spacecraft Center
National Aeronautics
and Space Administration

(NASA-CR-147573) PUBLIC HEALTH APPLICATIONS OF REMOTE SENSING OF VECTOR BORNE AND PARASITIC DISEASES Final Report (Texas Univ.) 204 p HC $7.75 CSCL 06F

N76-22892

Unclas
G3/52 26779

The University of Texas Health Science Center at Houston
School of Public Health

FINAL REPORT

PUBLIC HEALTH APPLICATIONS OF
REMOTE SENSING OF VECTOR BORNE AND PARASITIC DISEASES

CONTRACT NUMBER NAS 9-12696

JOHNSON SPACECRAFT CENTER

NATIONAL AERONAUTICS

AND SPACE ADMINISTRATION

THE UNIVERSITY OF TEXAS HEALTH SCIENCE CENTER AT HOUSTON

SCHOOL OF PUBLIC HEALTH

TABLE OF CONTENTS

1. Introduction

2. Administrative

    A. Personnel

    B. Equipment

3. Technical

    A. Schistosomiasis

    B. Mosquito habitats

    C. Screwworm (*Cochliomyia americana*)

    D. Malaria

    E. General

4. General Conclusions

5. Appendix A - List of Personnel

6. Appendix B - List of Equipment

1. INTRODUCTION

The present contract was an outgrowth of a previous contract (NAS 9-11522), which had as its objective a survey of the entire field of public health for determination of which special fields of interest might logically benefit from the application of remote sensing techniques.

The previous contract covered such fields as air and water pollution, urban development, disaster relief, and certain infectious diseases. In conversations with NASA-JSC personnel at the termination of Contract No. NAS 9-11522 we indicated our belief that there were a relatively small number of diseases, or disease-vector combinations which might be worthy of further examination for possible remote sensing applications. Roughly simultaneously, a report was prepared by another JSC contractor, the University of West Florida (NAS 9-11872) covering many of the same areas of interest, but with particular emphasis on botanical associations. In general, that report, which appeared several months after the Final Report on Contract No. NAS 9-11522, reached the same general conclusions. Such differences as were found in the reports appear to be due to the greater experience of the University of West Florida group in botany than in investigations of disease ecology.

Prior to receipt of the request for proposal and statement of work which resulted in the present contract we indicated to JSC personnel that our primary interest was in exploring one or two aspects of the problem in detail - with heavy, almost exclusive, emphasis on the determination of so-called "ground truth" data on the biological, chemical and physical characteristics of ground waters which would or would not support the growth of significant populations of mosquitoes. For our model mosquito we chose *Culex quinquefasciatus* (Say) (= *fatigans* Weideman), a vector of St. Louis encephalitis in North America, and of filariasis (*Wuchereria bancrofti* Cobbold) in many parts of the world. We have been conducting a number of studies on this mosquito species and thus had considerable background on its biology. It also is representative of a number of mosquito species which are adapted to a greater or lesser degree to larval habitats of relatively high organic content (*Culex tarsalis*, *tritaeniorhynchus*, *Pelidus*, *Anopheles stephensi*, etc.) It had the disadvantages, from the viewpoint of remote sensing, that most of its habitats could be found in urban areas by block-by-block inspection at a far lower cost than we assumed would be the case for remote sensing, and of probably having no important botanical association. From our previous contract we had concluded that the methods of remote sensing would best be applied in biological systems in which large or moderate scale plant communities were the target of sensing, and in which these plants served as indicators of the underlying biological or disease associations.

Nevertheless, it also appeared to us that an attempt should be made to determine for at least one mosquito species whether there was or was not any feature of mosquito habitats, other than higher plants, which was reasonably associated with mosquito numbers, and which could be detected and quantified remotely. The proposal submitted to NASA did not envision actual flights, but rather a concentration on a search for characteristics which could later serve as a basis for recommendations for sensing flights.

There were three other vector-borne diseases which appeared to us to offer some promise for relatively immediate application of remote sensing - the detection of snail habitats in connection with the epidemiology of schistosomiasis; the detection of certain Anopheles breeding sites, and location of transient human populations, both in connection with malaria eradication programs; and onchocerciasis. The latter was discussed in detail in the Final Report of Contract No. NAS 9-11522. Detection of vector breeding sites in Central America appeared to offer considerable promise. Also the World Health Organization has recently undertaken the preliminary stages of a vector control program in several nations in West Africa which appears to be depending heavily on aerial application of insecticides. Plotting of the complex stream systems which support the vector would seem to be an excellent subject for remote sensing. This subject is discussed in greater detail below in the body of the report. However, no actual field studies were carried on under the current project for reasons discussed in that section.

Finally, our preliminary discussions with JSC personnel indicated a very strong interest on their part in the application of remote sensing to detection of overwintering population sites for the primary screwworm (Cochliomyia americana), even though this topic is primarily one of agricultural rather than public health implications. The basic problem was to determine whether or not screwworms overwintered in protected inter-montane nidi in Northern Mexico, and whether or not these could be detected by vegetative or other associations. If they could be - the release of sterile males, or possible other control methods could be concentrated in such areas at considerable savings in time and money. The screwworm picture became somewhat complicated at this time by the apparent breakdown of the sterile male release program of the U.S. Department of Agriculture and other factors discussed in the body of the report below.

2. ADMINISTRATION

Personnel - A list of the individuals who participated in this project is presented in Appendix A. All but one of the regular professional participants engaged in the studies were full-time faculty members, and their services were provided to the contract by the School of Public Health. The single exception, Mr. C. Olsen, joined the faculty in a research capacity for the life of the contract, supported entirely from contract funds. The majority of the technicians employed were graduate students, several of whom used part of the data collected in their studies. Most personnel were terminated well before the end of the contract period, at the completion of the field studies, and all personnel were terminated effective June 30, 1973.

Two consultants participated in the study, and are not listed in Appendix A. Dr. Robert Altman, State Entomologist of Maryland, and responsible for the mosquito control program in that State, spent several days reviewing the mosquito habitat portion of the study. Mr. William Barrett, formerly with the U.S. Department of Agriculture, The *Aedes aegypti* eradication program of the U.S. Public Health Service, and the Harris County Mosquito Control District.

Mr. Barrett participated in many of the early studies of the biology of the screwworm (Cochliomyia americana) which led up to the effort to eradicate that species in North America. His consultantship concerned the ecology of that species, and was limited to a short period.

Equipment - A list of all equipment purchased during the contract period is included as Appendix B. The last series of items on the list consists of field meteorological instruments. These were delivered to field sites in Mexico, and were receipted for by the Project Officer, Dr. Charles Barnes. Thus, while they are technically on the property books of The University of Texas they are actually in the possession of NASA personnel in Northern Mexico.

All of the other equipment (Items 1 - 24, Appendix A) is physically located at The School of Public Health at present and can be inspected there.

3. TECHNICAL

A. Schistosomiasis - The Third Quarterly Report of Contract No. NAS 9-12696 reported the initial findings of the potential applicability of remote sensing to the problem of Schistosomiasis. This section consists of a final report on these findings as well as recommendations for the use of remote sensing as an aid to the study of the diseases on St. Lucia, British West Indies. This location was selected primarily because of its small, manageable size and the existence of a Rockefeller Foundation sponsored research project.

Schistosomiasis is an important, debilitating disease of man in the tropics and subtropics. The World Health Organization in 1965 estimated the number of persons affected by this disease as at least One Hundred Fifty Million. It has been ranked as the third major cause of morbidity in warm climates.

Three species of schistosomes account for most infections in man. These are: Schistosoma mansoni, haematobium and S. japonicum. S. mansoni is considered to have originated in Africa and to have been brought to the New World with the importation of slaves.

The life cycle of this species includes dioecious adults living in the mesenteric veins of the human host. The non-operculate eggs produced by the females are voided with the feces. If the egg reaches fresh water, a ciliated miracidium can emerge, which can exist as a free-living organism for about twenty-four hours. However, if the cycle is to continue, the miracidium must encounter a snail of the genus Biomphalaria. Should this occur, the miracidium bores into the tissue of the snail, transforms into a mother sporocyst. This stage produces several daughter sporocysts which in turn produce cercariae, which emerge from the snail and if successful penetrate a nearby human. In the human the cercariae migrates in the mesenteric vein, matures and if mated the couple produces eggs, completing the cycle.

During the week of December 3, 1972, two investigators (Doctors Hacker and Gesell) traveled to San Juan, Puerto Rico and to St. Lucia, British West Indies to make preliminary inquiries into the potential application of remote sensing technology to schistosomiasis research and control. In San Juan the investigators consulted with Dr. Barnett Cline of the U.S. Public Health Service Laboratory; in St. Lucia the investigators consulted with Dr. Peter Jordan, Director, Research and Control Department, Ministry of Education and Health, Castries, St. Lucia, British West Indies, as well as Dr. R.F. Sturrock and several of their colleagues. In St. Lucia field trips were made for the purpose of examining first-hand the environmental conditions in which schistosomiasis exists.

St. Lucia is a mountainous semi-tropical island, somewhat pear-shaped with a length of about 26 miles and a width of 14 miles. The mountains rise to a peak of about 3,000 feet. Some twenty-six identified valleys comprise the major agricultural and living areas of the island. Three of these valleys: the Riche Fond Valley, the Cul de Sac Valley, and the Marquis Valley have been selected by the Research and Control Department for a comparative study of control measures. The potential control measures under study are: (1) control of the intermediate snail host, Biomphalaria glabrata (Cul de Sac Valley); (2) construction of water works with a view toward minimizing contact between the population and the waters in which the snail thrives (Riche Fond Valley); and (3) treatment of the human population to eliminate the adult Schistosoma mansoni (Marquis Valley). Each of these three potential control measures is being studied in one valley. Each could benefit to a greater or lesser extent from remote sensing technology.

Vector Control

One method being considered in St. Lucia for control of schistosomiasis is control of the intermediate host snail. The snail can be controlled either by eliminating the water that is required for survival, or by use of molluscicide. The approach being taken in St. Lucia is principally the use of molluscicide. A problem within a molluscicide program is the location of potential habitats, that is, all of those areas which have sufficient water to support populations of the snail. Bodies of water which support the snail in St. Lucia include rivers and streams, banana drains and marshes. The relationship among these bodies of water is shown in Figure 1. One type of marsh, the so-called high level marsh, is of particular concern. These marshes exist at the higher elevation on the walls of the valleys and derive their water supply from seepage. These marshes are often fairly small, that is on the order of 100 square feet, or so, and are very difficult to locate from the ground because of the density of the surrounding vegetation. The high marshes are of special significance because although snails may be controlled in the rivers, banana drains and lower marshes which are relatively easy to find, snails which are living in the high marshes may be washed down during the rainy periods to re-populate the lower bodies of water. Thus, a control program based on the use of molluscicide in the rivers, streams, banana drains and low marshes could be made ineffective or less effective by annual re-population from these hard-to-locate high marshes.

Remote sensing could be of considerable help in locating the water bodies on the islands of St. Lucia. The high marshes of special concern are notable in that they do not support the same types of vegetation which exists on the land immediately surrounding them. Trees are in abundance around these marshes. The marshes themselves support principally a species of Caladium plant known locally as "dasheen". There is a very good possibility that remote sensing imagery could distinguish these high marshes from the surrounding terrain. This, coupled with identification of the lower marshes, rivers, streams, and banana drains would seem to make remote sensing very attractive in this area.

Water Supply

The second control scheme being tested on St. Lucia consists of constructing domestic water supplies which eliminate the need for daily trips to the river on the part of the residents for the purpose of obtaining water. Elimination of this daily contact with river water reduces the opportunity for contracting the disease. A significant problem with this control measure is that the inhabitants still come in contact with water bodies for other reasons. Often they must wade small streams and drains in the course of daily activities. This control measure could be enhanced if the water bodies could then be drained or spanned with foot-bridges to further reduce the contact with snail infested waters. A second problem with providing a water supply to a population such as this is that the population is somewhat mobile. Their dwellings can be, and are, disassembled and moved to other areas. Thus, part of the problem associated with providing a water supply is to locate the dwellings to which the water must be supplied. Location of dwellings, and thus location of the inhabitants, is also a major problem with the third control measure being tested on St. Lucia. The discussion of the application of remote sensing to this problem will be deferred to the next section dealing with the control of the parasite in humans.

Human Treatment

The third method being tested on the island of St. Lucia is treatment of the infested population. Schistosoma mansoni on St. Lucia has no mammalian hosts other than human beings; thus, if the disease could be eliminated from the human population it would subsequently disappear from the snail population. A control program such as this requires the location and testing of an extremely high percentage of the population, preferably 100%. The location of inhabitants is difficult as was mentioned above. It is felt that remote sensing could be applied to the location of these dwellings. Conventional photographic imagery would be useful for those dwellings which were not under a vegetative canopy. For the dwellings under the canopy, however, more sophisticated methods would have to be employed. A cultural feature of the inhabitants of St. Lucia is that they cook in small out-buildings which have galvanized steel roofs. The fuel is typically charcoal which is burned in an earthenware "coal pot". There is every reason to believe that the sheet metal roofs of these small kitchen buildings would become several degrees Fahrenheit hotter than the surrounding jungle canopy; thus, it may be possible to use thermal infrared imagery to locate these dwellings if the measurements could be made during the times of the day when cooking was being done.

Mapping

Although a small island, the maps of the St. Lucia, are reported to be insufficient for use by the Research and Control Department. Their work would be greatly facilitated if suitable maps could be generated. This is, of course, one of the classical applications of remote sensing technology.

Field Experiment

While on St. Lucia, the investigators were able to obtain a number of photographs of Cul de Sac Valley using two 35mm cameras. One camera was loaded with infrared-sensitive black-and-white film while conventional black-and-white film was used in the second camera. By using a series of gelatin filters the investigators were able to obtain a number of exposures of the valley floor and opposing wall over a range of wave bands. Examinations of these photographs using an I^2S device have been performed. Digital and analog images were constructed. Figure 2 is an example of an analog image and Figures 3 and 4 are examples of digital images. Major vegetation groupings can be distinguished with little effort. What is actually represented by each pattern cannot be specified without ground-truth data. However, differences can be seen even using rather simple equipment and it is reasonable to expect that the more elaborate equipment associated with routine aerial photographic work will produce quite useful material. Using aerial photography at an altitude of around 3000 feet (adjusting for mountain peaks) it is felt that photographs with sufficient detail could be obtained.

Proposed Plan for Aerial Remote Sensing Coverage of St. Lucia

This section gives the proposed remote sensing coverage of St. Lucia. The recommended sensors are a RC-8 Camera with film type of color IR 2443, a multispectral system of either 1^2S or Hasselblad cameras and a thermal infrared scanner.

Three flight days should be scheduled using the multispectral system one day and the RC-8 the following day and the thermal scanner on the third day.

The altitude selected for coverage of St. Lucia would be 3,000 feet above the mean average terrain which would provide an average resultant scale of 1:6,000 feet using the 6" focal length RC-8 camera. Using these flight parameters there would be no difficulty in obtaining the following information from subsequent image analysis:

1 - Production of maps and photo mosaics

2 - Location and plotting of streams and waterways

3 - Location and plotting of high marsh lands

4 - Location and plotting of banana drains and associated waters

5 - Location of housing conditions and population density

6 - Behavior patterns - Houses vs. Fields

7 - Discrimination of bananas, coconuts and agricultural or natural plant life

8 - Urban and general land use analysis

The preliminary flight plan shown (Figure 5) depicts the desired ground coverage. Naturally it is understood that flight elevation must change due to the terrain characteristics. These changes can easily be made during the final stages of flight planning. The five NW to SE flight lines were established due to some primary signatures known to exist in these regions relating to human disease, habitats and snail study. All flight line coverage was established to provide 60% overlap and 30% sidelap for necessary stereo viewing.

Inquiries were made of reliable Air Carte agencies in the event NASA aircraft are otherwise committed. KLM Royal Dutch Air Carte is a reliable firm which has aircraft stationed at six strategic locations world-wide. Their photo processing facility is in The Hague. An example of their color IR imagery is given in Figure 6. KLM has quoted (unofficially) approximately $48,000.00 to fly the entire Island as previously described. This would involve deployment of the aircraft, flight crew and ground maintenance personnel for the aircraft and camera equipment.

This quote provides that NASA provide the film (9 rolls of color IR and an equivalent amount of black and white film for the multispectral camera). They also desire that NASA furnish them with an I^2S camera for the multispectral data acquisition and the thermal infrared scanner. KLM will process the film and be totally responsible for the quality of the material and adherence to the flight line specifications. In the event of non-acceptance they would be obligated to re-fly the mission at no additional cost.

It is their recommendation that the aircraft be staged by 15 February, due to the good seasonal weather during the period of mid-February through mid-March.

Summary and Conclusions

The situation in St. Lucia is particularly attractive from the point of view of demonstrating health applications of remote sensing technology. There are several reasons for this suitability. The Research and Control Department on St. Lucia employs approximately one hundred people at all professional and non-professional levels. Many of these could be mobilized for a short period of time for ground truth work during an overflight. A second reason for the suitability of St. Lucia is that schistosomiasis has been studied there intensively for several years, thus good information is available on the incidence and prevalence of this disease. Thirdly, the results of the remote sensing overflight could be put into immediate and profitable use by the researchers to aid in solving the above mentioned problems.

The investigators found the director and staff enthusiastic about the potential benefits that could be derived from applying remote sensing technology. Their sincerity is reflected by their offer to locate funding to carry out an experimental flight. The investigators inquired into the possibility of the political difficulties of having U.S. Nationals and U.S. Government equipment operating in St. Lucia (an independent member of the British

Commonwealth). They were assured that all of these arrangements could be handled locally.

Eighty-five percent of the gross national produce of St. Lucia can be attributed to the banana industry. There is therefore considerable interest in banana diseases. Research is carried out at the West Indies Banana Growers Research Station on St. Lucia. Doctors Hacker and Gesell met with individuals from this station and discussed the application of remote sensing technology to the early detection of banana diseases. While banana diseases may be removed from public health, it is recognized that the application of remote sensing technology is most economical when several problems are attacked with data gathered from any flight.

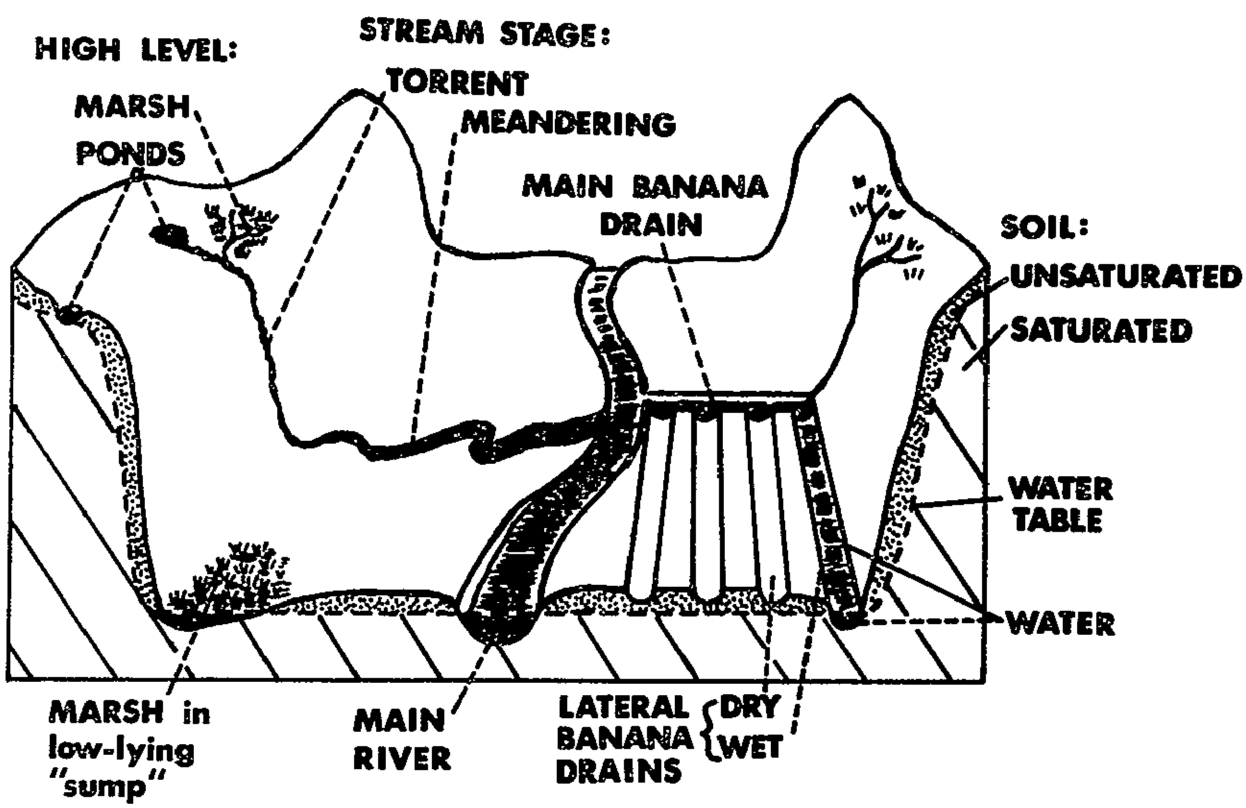
With additional ground-truth personnel during the flight, an equally important problem could be studied on St. Lucia.

In summary the principal objects to be identified and/or differentiated from the surrounding environment included banana plantations, dasheen, waterways and dwellings. Remote sensing technology including thermal infrared, multispectral photographic imagery and color infrared imagery would appear to be suitable. The three valleys presently being studied in St. Lucia could be intensively ground-truthed during overflights. The knowledge gained from this ground truth activity and imagery could then be used to an advantage in the other 23 valleys on the island. Applicability of the information gained on St. Lucia to other parts of the world where schistosomiasis is endemic would require further study. The investigators feel that the situation in

St. Lucia offers an outstanding opportunity to demonstrate the applicability of remote sensing technology to an important health problem.

Figure 1

Schematic diagram of a characteristic valley in St. Lucia illustrating major environmental features



HIGH LEVEL:
MARSH
PONDS
STREAM STAGE:
TORRENT
MEANDERING
MAIN BANANA
DRAIN
SOIL:
UNSATURATED
SATURATED
WATER
TABLE
WATER
MARSH in
low-lying
"sump"
MAIN
RIVER
LATERAL
BANANA
DRAINS
DRY
WET

Figure 2

Example of an Analog I^2S image of
Cul de Sac Valley, St. Lucia

Figure 3

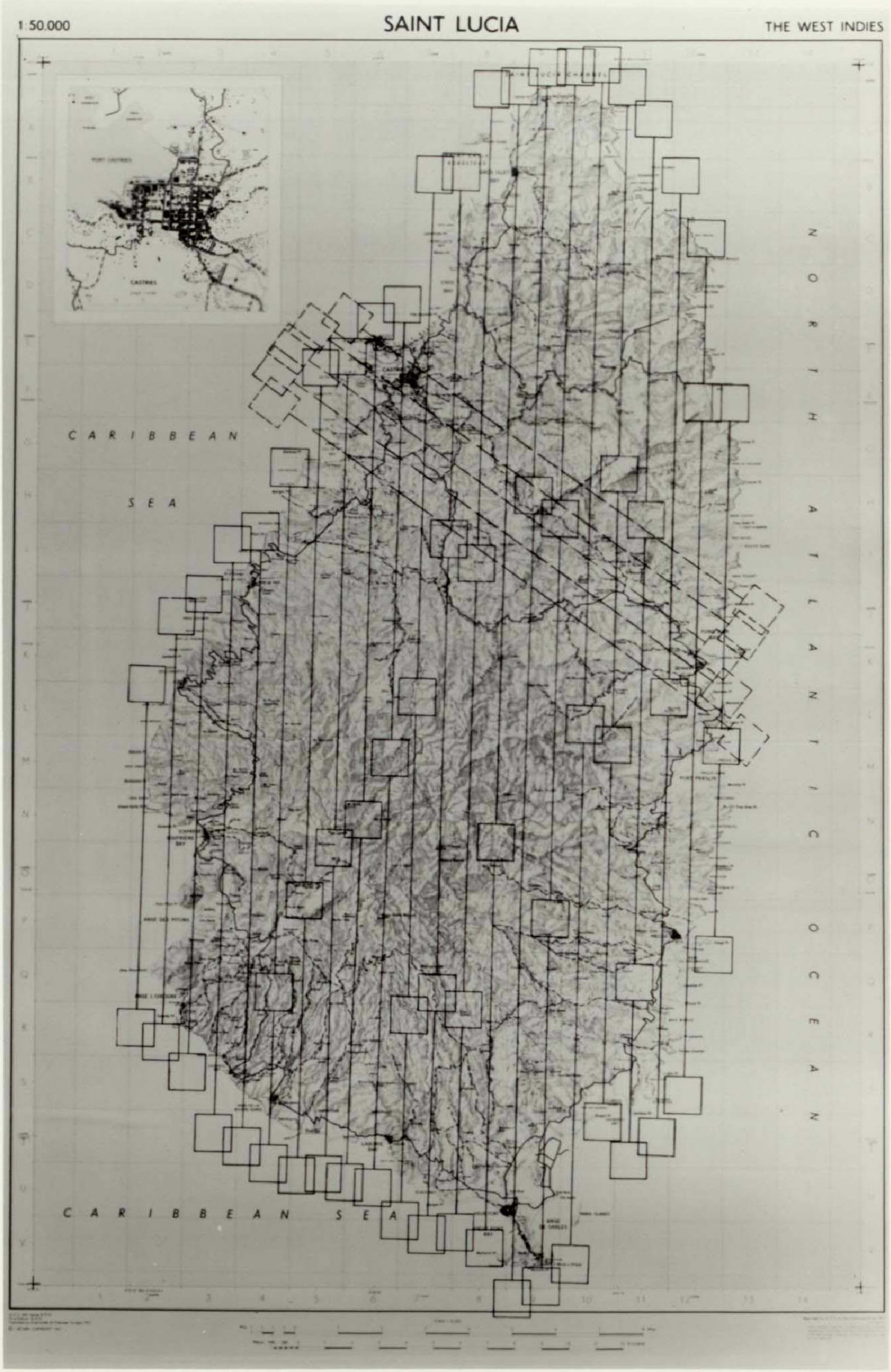
Example of a digital I^2S image of
Cul de Sac Valley, St. Lucia

Figure 4

Example of a digital I^2S image of
Cul de Sac Valley, St. Lucia

Figure 5

Proposed flight lines for aerial
remote sensing of St. Lucia



1:50,000
SAINT LUCIA
THE WEST INDIES
CARIBBEAN SEA
CARIBBEAN SEA
NORTH ATLANTIC OCEAN

Figure 6

An example of Color IR imagery
produced by KLM Air Carte

B. *Mosquito Habitats* - Characterization of Larval *Culex pipiens quinquefasciatus* Habitats.

Introduction

The development of methods for the regulation of mosquito populations became an active area of research following the recognition in the late nineteenth century that mosquitoes were responsible for the transmission of certain human diseases. The discovery and widespread use of persistent pesticides during the 1940s appeared to promise the extinction of mosquitoes and mosquito-borne diseases. However, the development of resistance to pesticides which was soon developed by the target species was not anticipated. Additionally the long-term effects of these chemicals on other populations in the ecosystem was not widely appreciated until the past decade. Greater attention is now being directed towards the application of minimal amounts of pesticides as well as the introduction of alternative control procedures.

If it were possible to forecast changes in mosquito densities, it can be demonstrated using mathematical models that less pesticide is needed to control mosquito populations. The research described in this report was undertaken to examine the possibility of applying the technology of remote sensing to the problems of forecasting the densities of certain mosquito populations.

Mosquitoes as a group utilize a wide range of aquatic habitats. Each species, however, has a more or less defined set of requirements for its larval development. Hence, one refers to a species being a container-breeder, a tree-hole-breeder, flood-pool breeder or one of numerous other possible habitat types.

Among the several factors that influence mosquito densities, the volume (or number) of suitable habitats for larval development is quite important. Currently the volume of larval habitats for a species in a given area is surveyed at intervals by ground-based searchers. This procedure is costly in time and manpower; however, for some species this method is by far the most feasible method available and can be expected to remain so for some time.

On the other hand there are species which have habitats that might be detected remotely. Should this be true, then surveillance of habitats could be accomplished routinely by airborne sensors. In all probability the cost of this method would be prohibitive, if mosquito surveillance were the sole reason for conducting an aerial survey. However, if other problems could be included in a given surveillance flight, then the remote detection of mosquito habitats could be an economically feasible venture.

The following technical report describes a study designed to examine the relationship between the densities of larval Culex pipiens quinquefasciatus and a number of environmental variables. It was anticipated that this study might uncover factors in the mosquito environment which might be remotely sensible and which could be used to detect or forecast changes in mosquito densities.

Materials and Methods

Study Sites

In north and northwest Harris County, just beyond the Houston City limits there are a number of neighborhoods in which septic tanks are used for sewage disposal. These septic tanks chronically overflow into storm ditches which line the streets in these neighborhoods. The sewage in some of these ditches is at concentrations high enough to be detectable by casual observation. Except in periods of heavy rainfall or during long periods of high evaporation and low rainfall many of these ditches have standing water, which combined with the sewage from the septic tanks provides a suitable habitat for *C. p. quinquefasciatus* larval development.

For our study two areas such as those described above were chosen. Maps of these areas, termed Area I and Area II, are shown in Figures 1 and 2, respectively.

After the general areas were selected, around 20 separate ditches in each area were located, assigned a site number and plotted on a map of the area. An attempt was made to include in the sample both ditches with mosquito populations and those without.

The size of the sites varied in length and width. Site widths were generally similar due to the method used to construct and measure the ditch. The length of the site varied more widely and was related to the amount of water in the ditch. Generally, the length varied from about 1 meter to about 5 meters and width

Figure 1

Map of Area 1

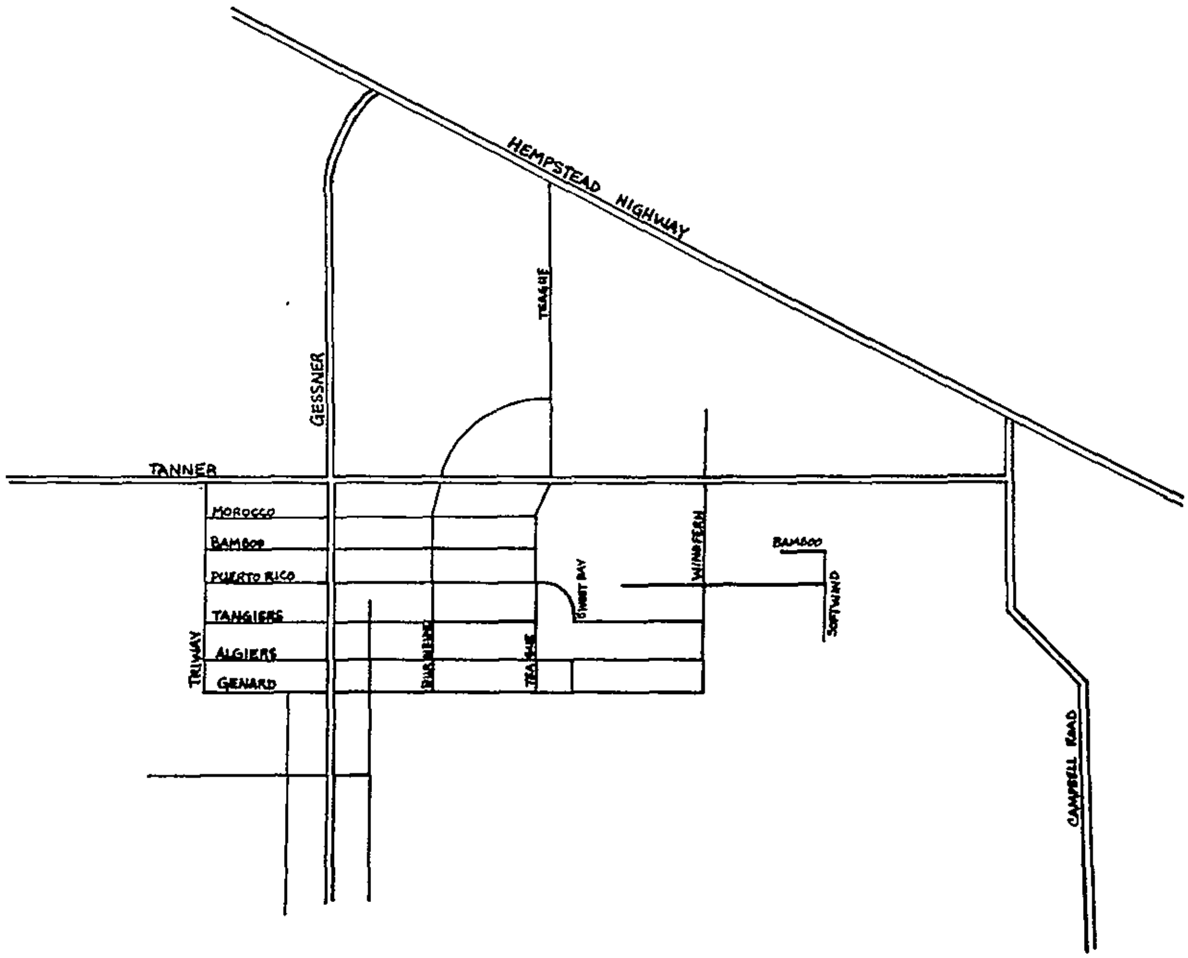

HEMPSTEAD HIGHWAY
TANNER
GESSNER
TEAGUE
MOROCCO
BAMBOO
PUERTO RICO
TANGIERS
ALGIERS
GENARD
TRIWAY
WINDFERN
SWEET BAY
BAMBOO
SOFTWIND
CAMPBELL ROAD

Figure 2

Map of Area 2

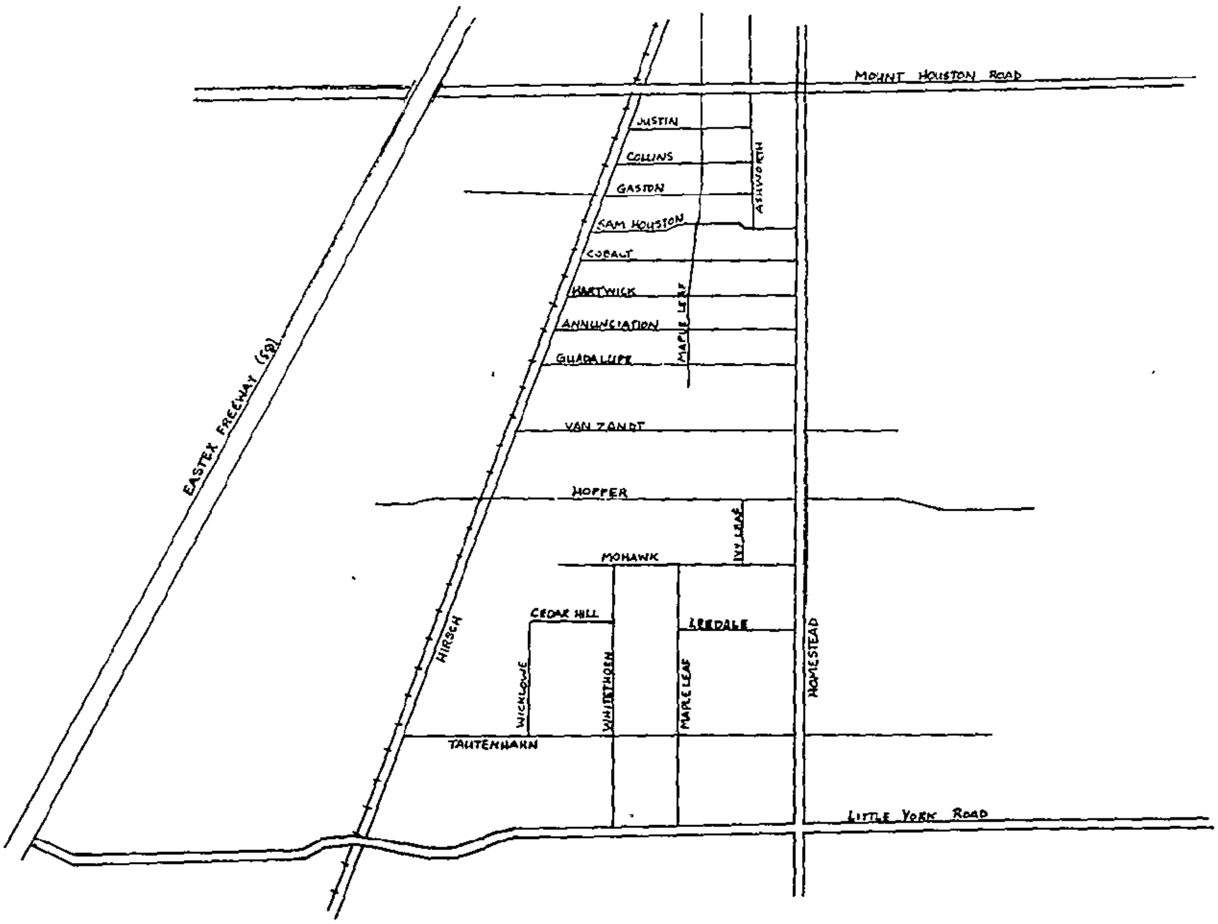

MOUNT HOUSTON ROAD
JUSTIN
COLLINS
GASTON
SAM HOUSTON
ASHWORTH
COBALT
HARTWICK
ANNUNCIATION
GUADALUPE
MAPLE LEAF
VAN ZANDT
HOPPER
EASTEX FREEWAY (59)
IVY LEAF
MOHAWK
CEDAR HILL
LEEDALE
HIRSCH
WICKLOWE
WHITETHORN
MAPLE LEAF
HOMESTEAD
TAUTENHAHN
LITTLE YORK ROAD

TABLE 1. SAMPLING DATES AND ASSIGNED WEEK NUMBER

Week No.	Month and Day of Sampling	
	Area I	Area II
1.	606	607
2.	613	614
3.	620	621
4.	627	628
5.	704	705
6.	711	712
7.	718	719
8.	725	727
9.	801	802
10.	808	809
11.	815	816
12.	822	822
13.	829	830
14.	906	907
15.	913	914
16.	920	921
17.	927	928
18.	1004	1005
19.	1011	1012
20.	1018	1019
21.	1025	1026
22.	1101	1102
23.	1108	1109
24.	1115	1116
25.	1129	1130
26.	1206	1207
27.	1213	1214
28.	103	104
29.	117	118
30.	124	125
31.	131	201
32.	207	208

varied from 0.5 to 1 meter.

After the sites were selected, a sampling scheme was established. Each site was visited once a week. If a site were dry on a sampling day this fact was recorded. If a site remained dry for several collections, then a replacement site was chosen. Up to twenty sites were sampled on a given day from each area. The sampling dates for each area are given in Table 1.

For those sites with standing water the following sampling procedures were followed:

1. Density of larval mosquitoes. An 8 oz. soup ladle was used to sample mosquitoes in the ditch. Three dips were made at predetermined locations in the site. If less than 50 larvae were captured, more dips were made until up to nine dips were made at a site. The larvae were returned to the laboratory where they were counted and the number of larvae per dip determined. The number of pupae, fourth instar, and less than fourth instar larvae were recorded and used as an estimate of mosquito density.

2. Physical characteristics. The following variables were recorded at each site:

   a. Temperature - Temperature at the time of sampling was recorded using a thermistor temperature probe and expressed as degrees Centigrade.

b. Hydrogen Ion Concentration - pH was recorded at the site using a portable pH meter.

c. Dissolved oxygen. The amount of dissolved oxygen in the water was determined using a polarigraphic oxygen probe and expressed in parts per million.

Once the above measures were completed, a sample of water was collected in a labeled polyethylene bottle and placed on ice for return to the laboratory where further analyses would be performed.

3. Laboratory determinations - at the laboratory the following analyses were used:

a. Coliform bacteria. Coliform densities were estimated using "Colicounters" purchased from the Millipore Corporation. This procedure allowed estimation of coliform bacterial densities quickly and efficiently. Samples were prepared by making a 1:100 dilution using sterile water. The paddle of the counter was then dipped into the dilution and allowed to hydrate. The total number of colonies were counted and recorded after 15-20 hours of incubation at 37°C.

b. Metal Ions. The concentrations of certain metal ions was determined using an atomic absorption method. This method works on the following principal: atoms of some elements are excited when vaporized and fed into a flame. However, most elements are not easily excited in a flame and most of the atoms remain in the ground state. The unexcited atoms can absorb energy from a beam of light of the same characteristic wavelength, the beam of light coming from a hollow-cathode lamp made of the metal being determined. Since the wavelength of the light beam is characteristic of only the metal being determined the light energy absorbed by the flame is a measure of the concentration of the metal in the sample. A Beckman Atomic Absorption analyzer was used. Standard methods were followed for each metal analysis. All samples were processed through filter paper to remove sediment and suspended particles before being analyzed. The metals analyzed included: Iron, Copper, Zinc, Sodium and Manganese.

c. Carbon Analysis. Samples were collected in the field and stored at $4^{o}C$. Aliquots were then gravity filtered through Whatman No. 4 filter paper and dispensed into screw-capped tubes to be stored at $4^{o}C$ until analysis. Analysis was performed by injecting 20 micro-liter samples into a Beckman Model 915 Total Carbon Analyzer. Each sample was tested for inorganic carbon and total carbon. Standard curves were ascertained by linear regression analysis of standards (5-100ppm, abscissa) versus recorder output (ordinate). Carbon concentrations were calculated by evaluating the standard curve for the reading of each sample.

d. Nitrate Analysis. The procedure for analysis of nitrates was performed according to Standard Methods [1], p. 200. Briefly, samples were first treated with an aluminum hydroxide suspension to reduce interference from suspended organic matter [1], p. 197. Samples were then passed through a millipore 0.45 micron filter which had been thoroughly washed with redistilled water. Aliquots were then placed in one of a set of matched silica cells in a double beam

Beckman DB-G grating Spectrophotometer "referenced" with redistilled water. Absorbancy for each sample was recorded at 200 and 275 nm. Standard nitrate solutions were prepared (0.443-8.86ppm) and standard curves were prepared by linear regression analyses of standard concentrations versus absorbancies at 200nm. Absorption due to interference at 275 nm was negligible for the standards. Samples were then fitted to this standard curve after being corrected for dissolved organic material present in the sample by the following empirical formula;

$A_{220} - 2(A_{275})$ = Absorbancy of "true" nitrate.

e. Phosphate Analysis (Orthophosphate). Phosphate analysis was performed using a slightly different scheme from the Hach determination.[2] Samples were first passed through a Whatman No. 4 filter and 5 ml were then diluted to give a final molybdate solution was then added to each of two 25ml aliquots of one sample. One aliquot had no further treatment (subsequently called "untreated") while the other aliquot was treated with the standard (Hach) powder pillow reducing agent (Stannover, Stannous Chloride) yielding an intense blue color which is proportional by Beer-Lamberts relation to the concentration of orthophosphate present. Standard phosphate solutions were prepared by Standard Methods [1] (p. 232) and dilutions were performed giving a range of 0.153-3.06 ppm orthophosphate. Absorbancy was measured at 705 nm in a Bausch and Lomb Model Spectrophotometer 20 for each standard to yield the standard curve. For analysis of the samples, the Spec 20 was "blanked" each time by the "untreated" sample and then Absorbancy at 705 nm was measured and recorded for the "reduced" sample. The concentration of orthophosphate was then determined from the standard curve.

f. Turbidity. Samples were prepared by allowing an aliquot of water to settle for about one hour. Turbidity was determined with a Coleman Spectrophotometer and was expressed as the percentage of light transmitted through a column of sample water using distilled water as a reference.

g. Chlorophyll. Chlorophyll was determined using the method described by Richards and Thompson (1934).

The method relies upon acetone extraction of the chlorophyll pigment from an aliquot of filtered water and determining its concentration using a spectrophotometer set at a wavelength of 665A·. The amount of chlorophyll is then calculated from the formula:

$$\alpha\text{-Chlorophyll(mq/l)} = OD_{665} \times \frac{\text{ml 90\% Acetone}}{\text{ml sample}} \times 14.3$$

Results

Throughout this study data were recorded on forms which would permit their efficient transfer into a computer-based data bank. The first step in data processing involved scanning the data for obvious discrepancies and deletions. Once these had been isolated, corrected, or deleted when necessary, data processing involved using a computer to generate the summary statistics used for interpretation of our results.

The three statistical measures of greatest interest to us included the mean, variance and the product-moment correlation coefficient. To calculate each of these requires that replicate observations be recorded. Our experimental design was such that for a given week a determination made at a site could be considered a replicate observation for that week. We can therefore speak of a mean value for a variable for each week of the study.

On the other hand, since we made observations at some study sites for several weeks (up to 32) we can calculate a mean value for a variable at a given site, using in this instance, determinations recorded at different time intervals served as the replicate observations. We, therefore, will discuss variation in space (among sites) and time (among weeks) when interpreting the data.

A. Variation in Mosquito Densities

Our estimates of the densities of pupae, fourth instar and less

TABLE 2. MEAN PUPAE/DIP

Site	Mean	(N)
1	4.62	(28)
2	63.70	(27)
3	93.42	(13)
4	.23	(11)
5	6.30	(16)
6	19.83	(14)
7	4.30	(19)
8	125.52	(16)
9	17.57	(27)
10	.67	(24)
11	.03	(10)
12	28.38	(9)
13	65.04	(26)
14	26.57	(23)
15	0.00	(4)
16	.07	(3)
17	.22	(7)
18	0.00	(5)
19	0.00	(3)
20	13.58	(12)
21	1.06	(14)
22	3.52	(13)
23	.47	(10)
24	2.51	(3)
25	35.66	(3)
27	34.13	(5)
28	0.00	(4)
29	0.00	(2)
30	0.00	(2)
31	0.00	(3)
51	443.75	(4)
52	27.90	(4)
53	1.48	(16)
54	21.78	(16)
56	10.23	(14)
57	.12	(7)
58	67.78	(26)
59	8.30	(26)
61	.02	(11)
62	.11	(2)
63	2.92	(7)
64	0.00	(2)
69	3.15	(6)
70	0.00	(2)

TABLE 2(Cont.)MEAN LESS THAN FOURTH INSTAR/DIP

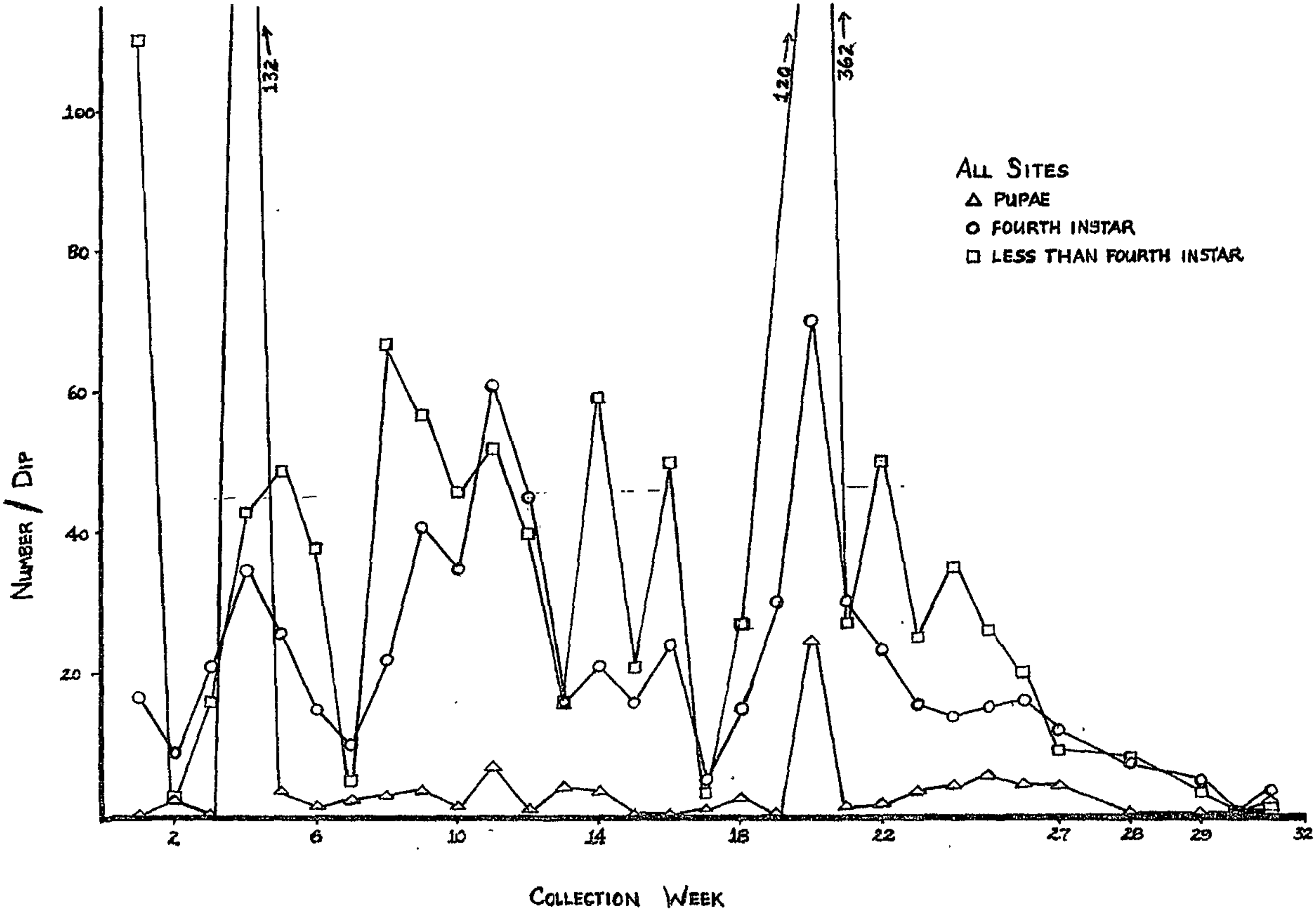
Site	Mean	(N)
1	63.60	(28)
2	58.99	(27)
3	23.26	(31)
4	17.22	(11)
5	1.14	(16)
6	.10	(14)
7	52.76	(19)
8	30.96	(16)
9	1.84	(27)
10	27.81	(24)
11	.07	(10)
12	17.12	(9)
13	24.39	(26)
14	4.33	(23)
15	0.00	(4)
16	.37	(3)
17	.08	(7)
18	.02	(5)
19	0.00	(3)
20	.96	(12)
21	8.08	(14)
22	.86	(13)
23	0.00	(10)
24	115.14	(3)
25	1.00	(3)
26	0.00	(2)
27	.64	(5)
28	.02	(4)
29	0.00	(2)
30	0.00	(2)
31	0.00	(3)
51	18.88	(4)
52	3.00	(4)
53	36.22	(16)
54	15.47	(16)
56	1.58	(14)
57	.12	(7)
58	38.66	(26)
59	2.17	(26)
61	7.35	(11)
62	1.00	(2)
63	.09	(7)
64	0.00	(2)
69	1.09	(6)
70	0.00	(2)

TABLE 2(Cont.) MEAN FOURTH INSTAR/DIP

Site	Mean	(N)
1	34.92	(28)
2	7.23	(27)
3	266.07	(13)
4	3.44	(11)
5	.19	(16)
6	41.26	(14)
7	37.46	(19)
8	8.13	(16)
9	19.47	(27)
10	48.31	(24)
11	0.00	(10)
12	.75	(9)
13	2.00	(26)
14	94.36	(23)
15	.03	(4)
16	.11	(3)
17	.72	(7)
18	0.00	(5)
19	0.00	(3)
20	10.88	(12)
21	3.25	(14)
22	.01	(13)
23	.53	(10)
24	21.55	(3)
25	0.00	(3)
26	0.00	(2)
27	117.68	(5)
28	0.00	(4)
29	0.00	(2)
30	0.00	(2)
31	0.00	(3)
51	4.87	(4)
52	7.62	(4)
53	36.19	(16)
54	167.38	(16)
56	40.60	(14)
57	.33	(7)
58	8.67	(26)
59	34.29	(26)
61	.48	(11)
62	.08	(2)
63	1.23	(7)
64	0.00	(2)
69	.08	(6)
70	0.00	(2)

Figure 3

Mosquito densities for all sites



132
120
362
100
80
60
40
20
NUMBER / DIP
ALL SITES
PUPAE
FOURTH INSTAR
LESS THAN FOURTH INSTAR
2
6
10
14
18
22
27
28
29
32
COLLECTION WEEK

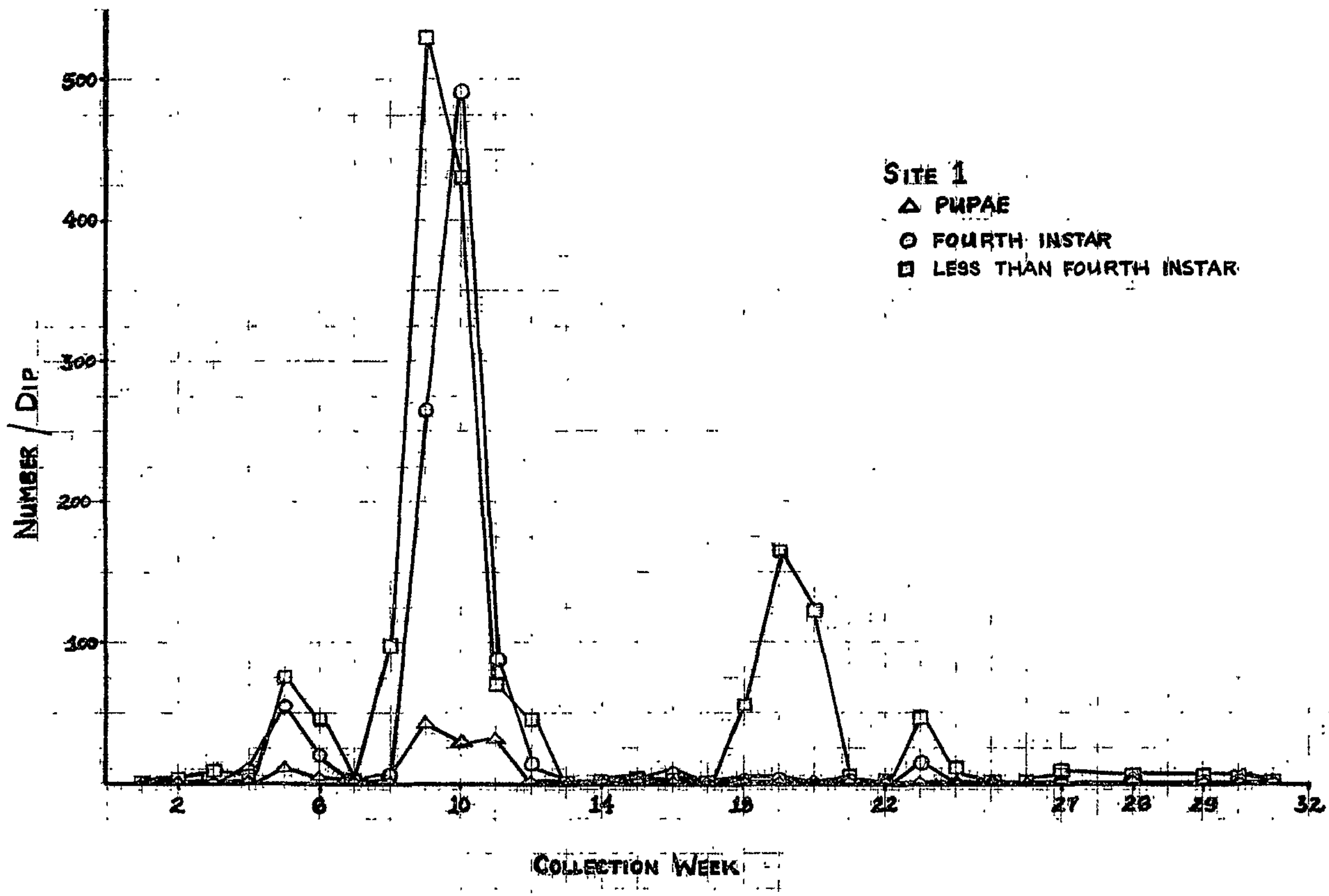
than fourth instars are relative measures. Densities are expressed as number of mosquitoes per dip. To relate these estimates to absolute densities would have required considerably more time and effort. Since absolute measures would not necessarily reduce the variance among the samples it was decided to use relative measures. In discussing the data the term "fourths" will be frequently substituted for "fourth instar larvae" while "LT fourths" will be used for "less than fourth instar" larvae.

The mean densities of pupae, fourths, and LT fourths for each site over the period of the study are given in Table 2. It can be seen that considerable variation was found among the sites. Pupae ranged from 0.0 to 443 per dip; fourth instars varied from 0.0 to 266, and LT fourths varied from 0.0 to 115. We were successful in our attempt to include in our study sites which range in densities of mosquito larvae. With these sites we have in effect set up a "natural experiment" which we can use to characterize larval mosquito habitats. From these data we can seek associations among mosquito densities and a number of physical and chemical factors. These associations can be examined further for causal relationships.

In Figure 3 we plotted the mean number of mosquito average across all sites for each time interval. Fourth and less than fourth larvae account for the bulk of the mosquitoes captured. This is due in part to mortality in the stages preceeding the pupal stage. However, the sampling procedure can also be an

Figure 4

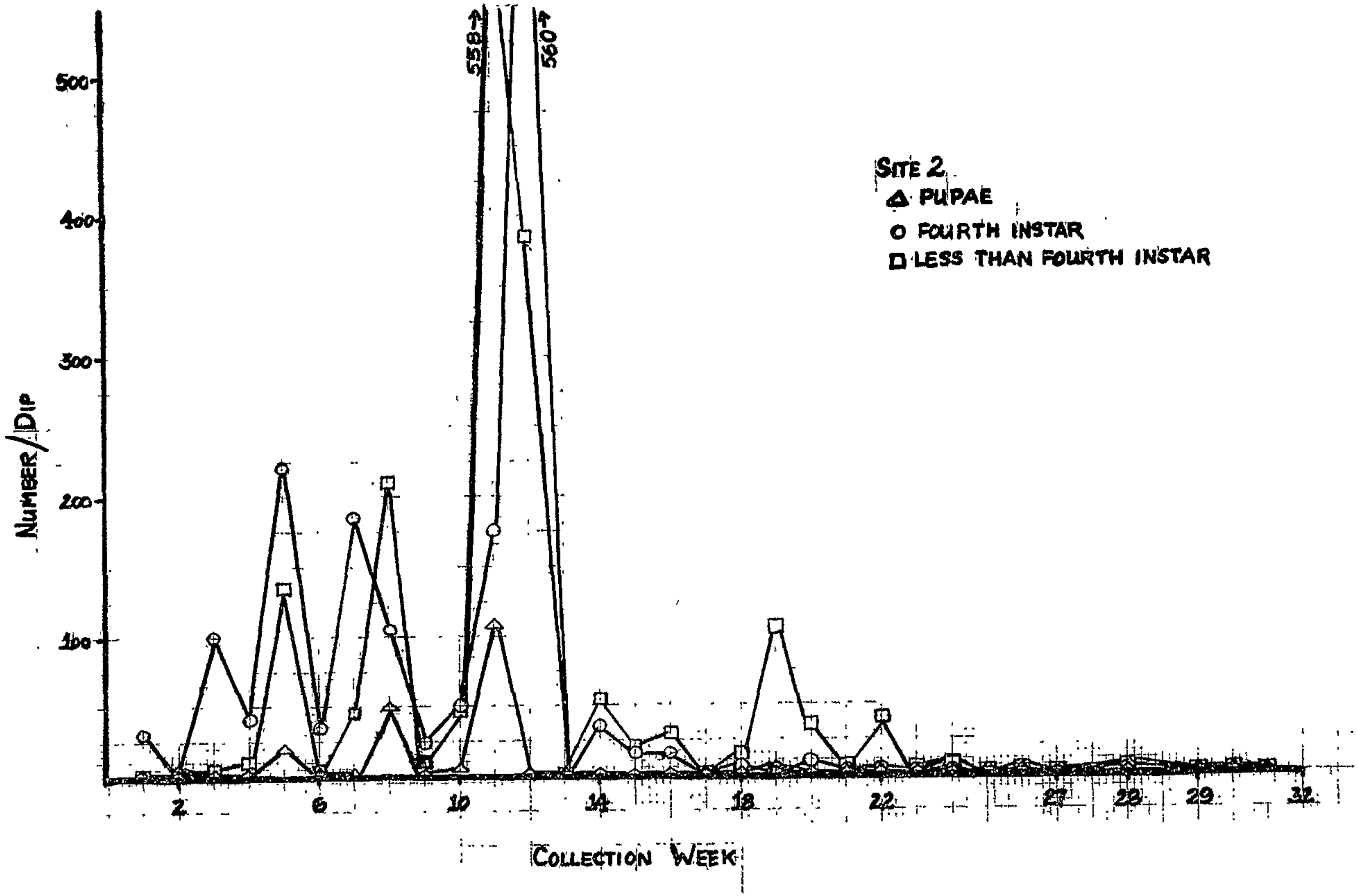
Mosquito densities for Site 1



Site 1
PUPAE
FOURTH INSTAR
LESS THAN FOURTH INSTAR
Number / Dip
500
400
300
200
100
2
6
10
14
18
22
27
28
29
32
Collection Week

Figure 5

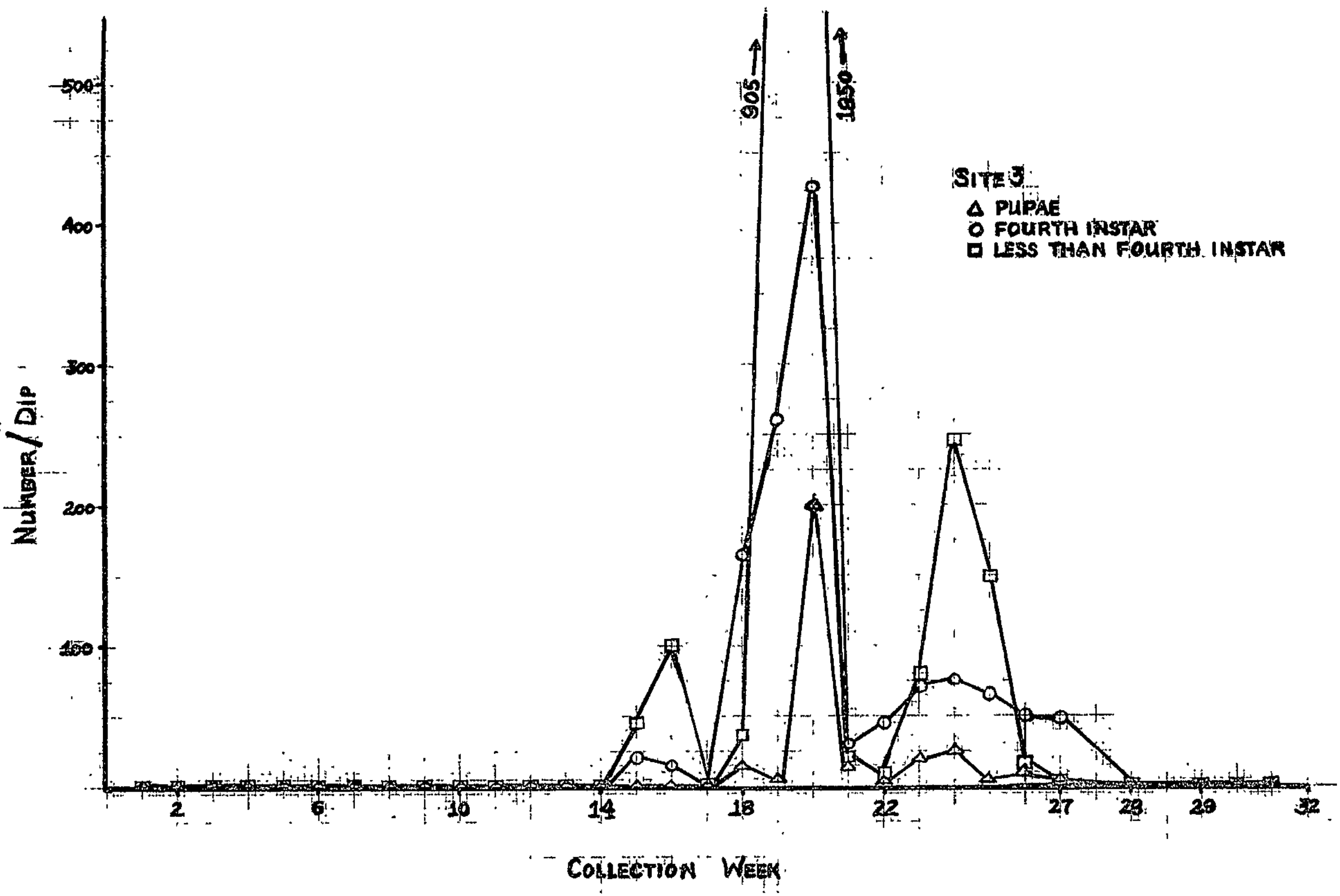
Mosquito densities for Site 2



558
560
500
400
300
200
100
NUMBER/DIP
2
6
10
14
18
22
27
28
29
32
COLLECTION WEEK
SITE 2
PUPAE
FOURTH INSTAR
LESS THAN FOURTH INSTAR

Figure 6

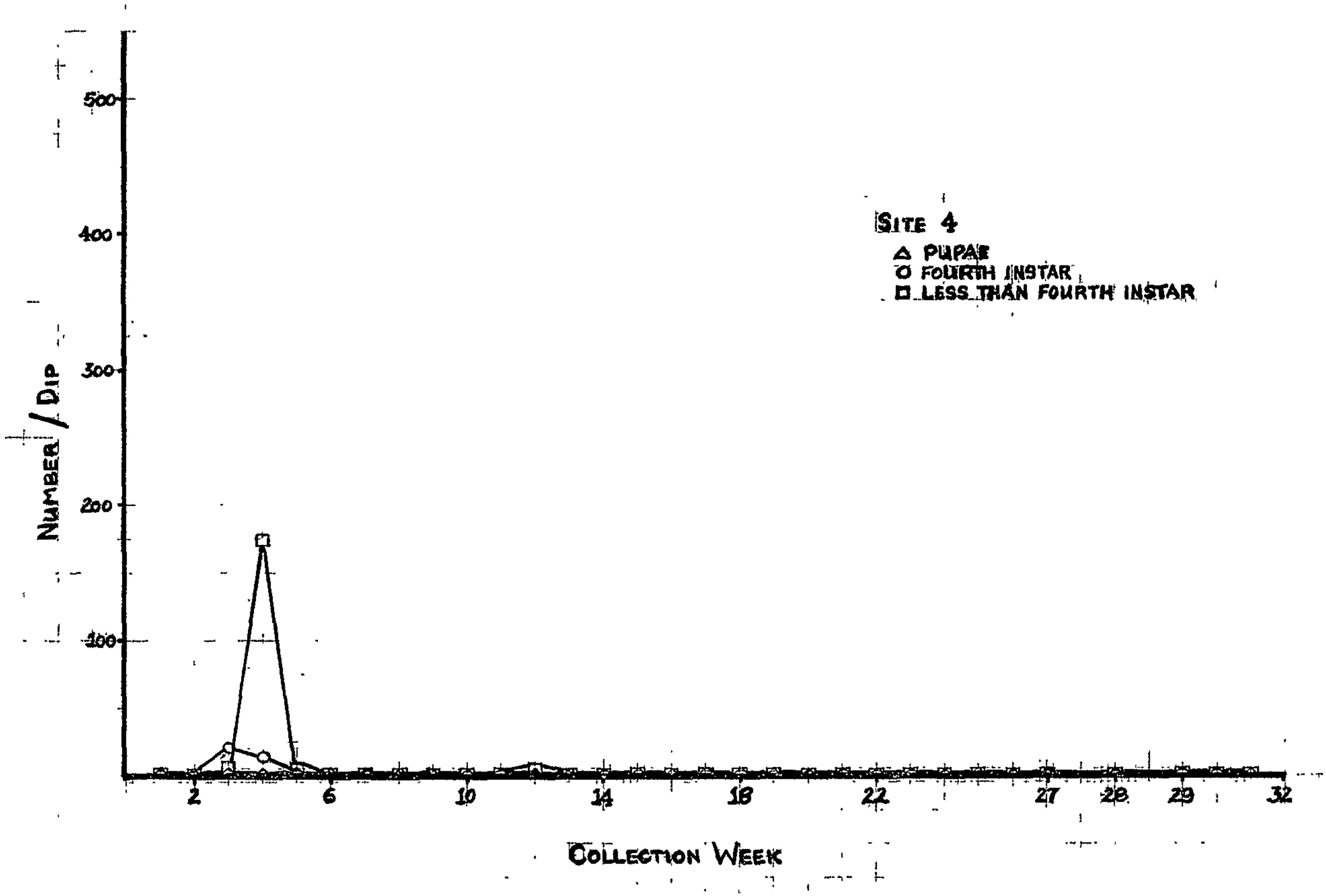
Mosquito densities for Site 3



905
1950
SITE 3
PUPAE
FOURTH INSTAR
LESS THAN FOURTH INSTAR
NUMBER / DIP
COLLECTION WEEK

Figure 7

Mosquito densities for Site 4



SITE 4
PUPAE
FOURTH INSTAR
LESS THAN FOURTH INSTAR
NUMBER / DIP
500
400
300
200
100
2
6
10
14
18
22
27
28
29
32
COLLECTION WEEK

Figure 8

Mosquito densities for Site 5

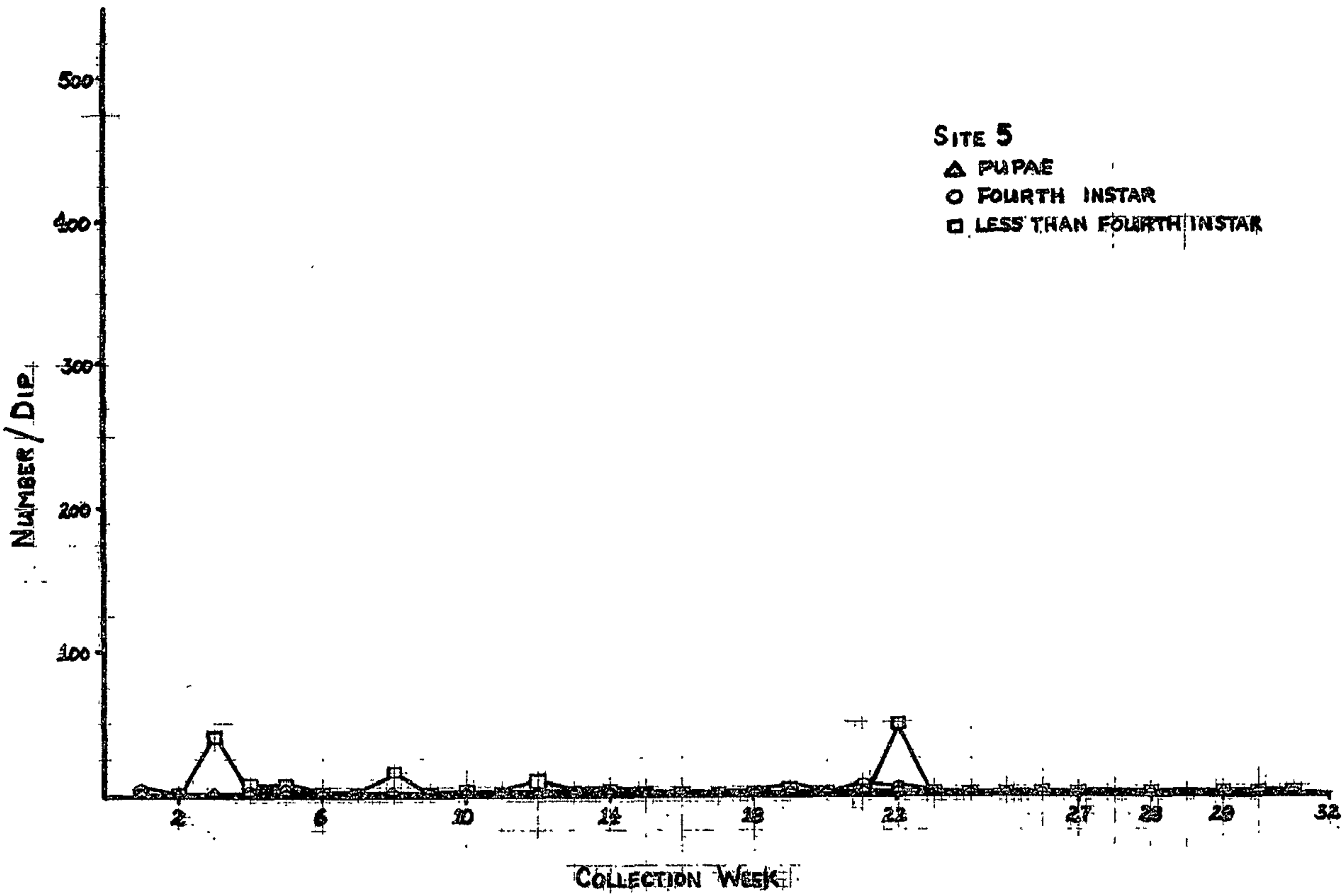
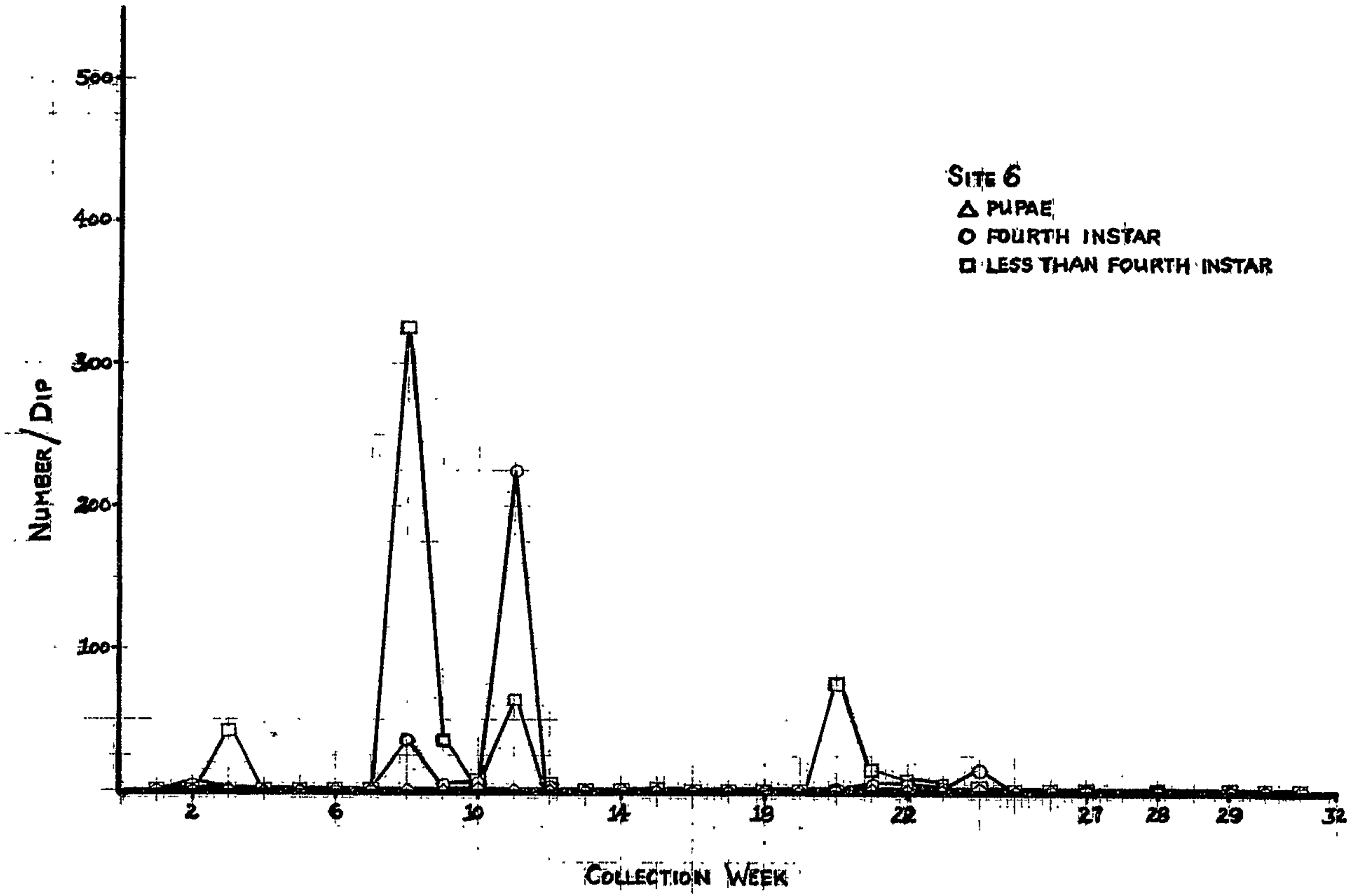

SITE 5
PUPAE
FOURTH INSTAR
LESS THAN FOURTH INSTAR
NUMBER / DIP
500
400
300
200
100
2
6
10
14
18
22
27
28
29
32
COLLECTION WEEK

Figure 9

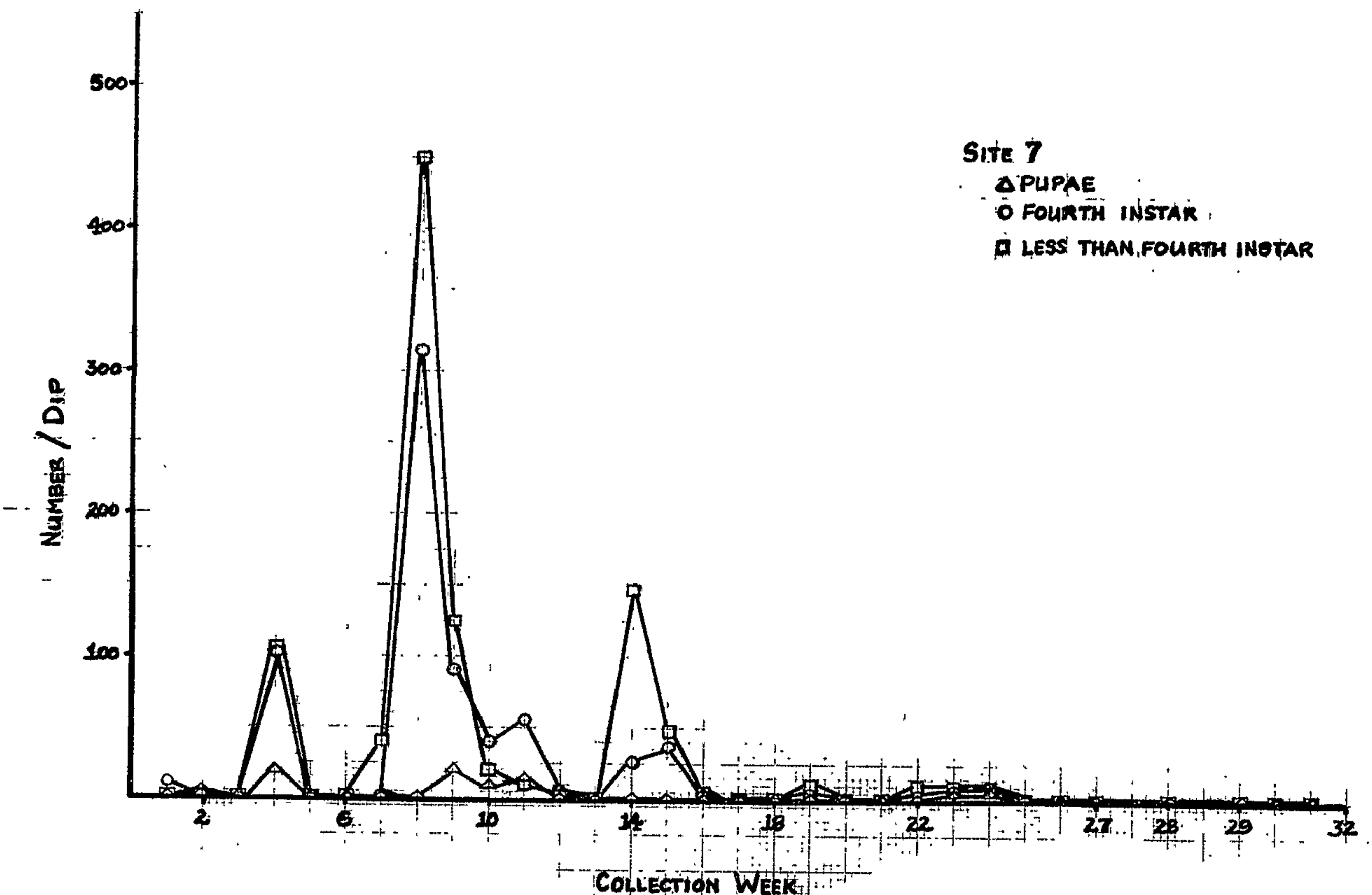
Mosquito densities for Site 6



SITE 6
PUPAE
FOURTH INSTAR
LESS THAN FOURTH INSTAR
NUMBER / DIP
500
400
300
200
100
COLLECTION WEEK
2
6
10
14
19
22
27
28
29
32

Figure 10

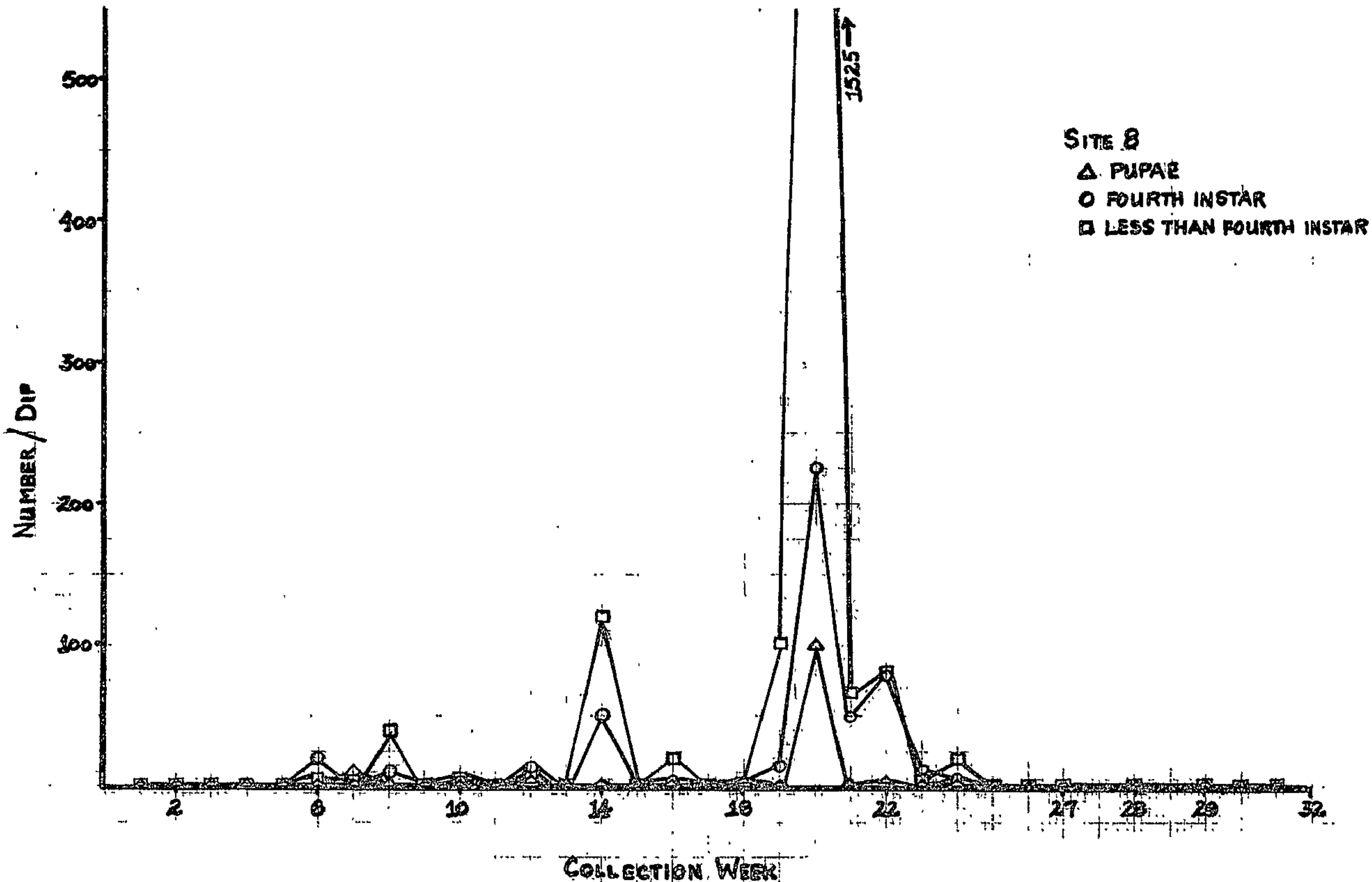
Mosquito densities for Site 7



SITE 7
PUPAE
FOURTH INSTAR
LESS THAN FOURTH INSTAR
NUMBER / DIP
500
400
300
200
100
2
6
10
14
18
22
27
28
29
32
COLLECTION WEEK

Figure 11

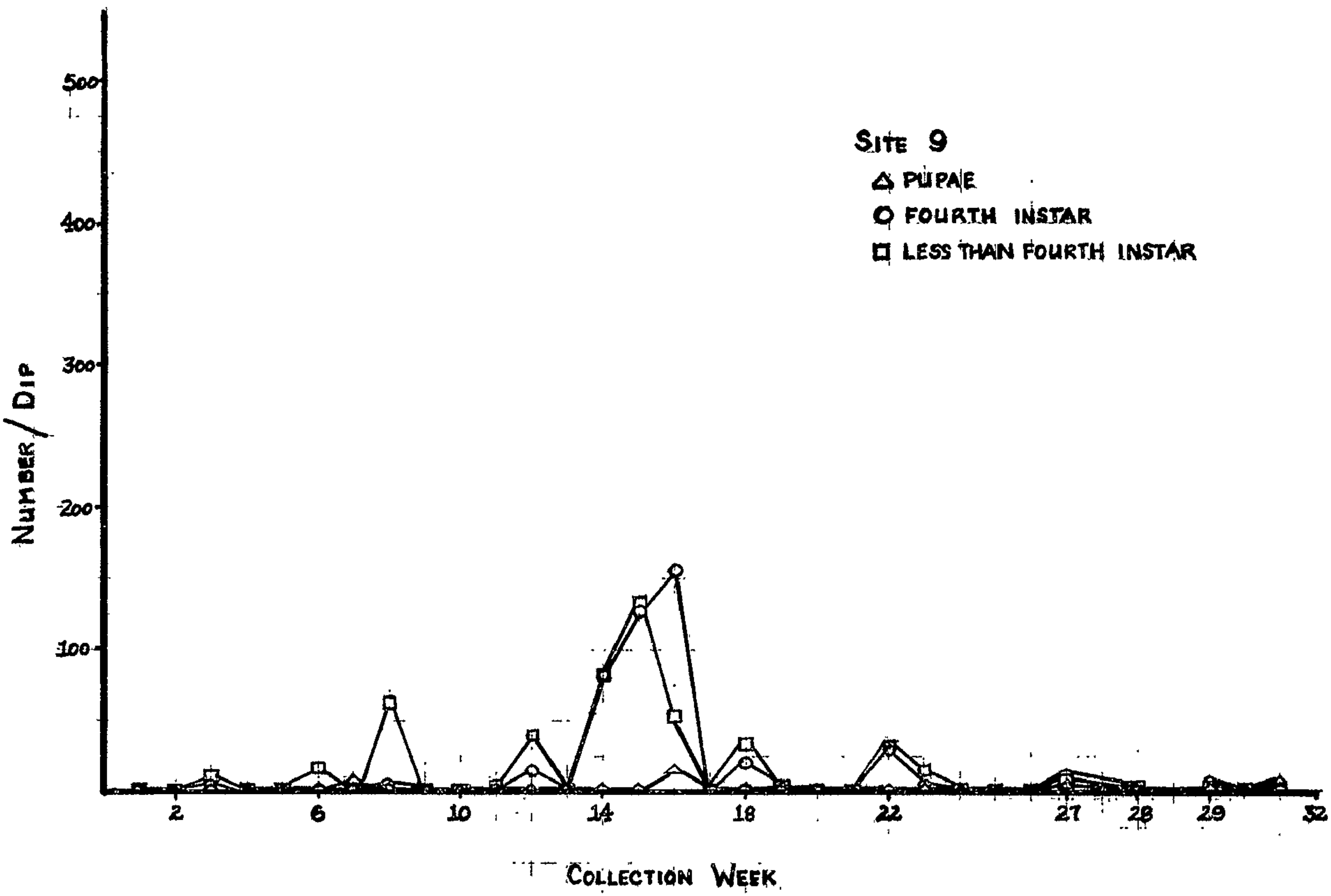
Mosquito densities for Site 8



Site 8
PUPAE
FOURTH INSTAR
LESS THAN FOURTH INSTAR
1525
500
400
300
200
100
Number / Dip
2
6
10
14
18
22
27
28
29
32
Collection Week

Figure 12

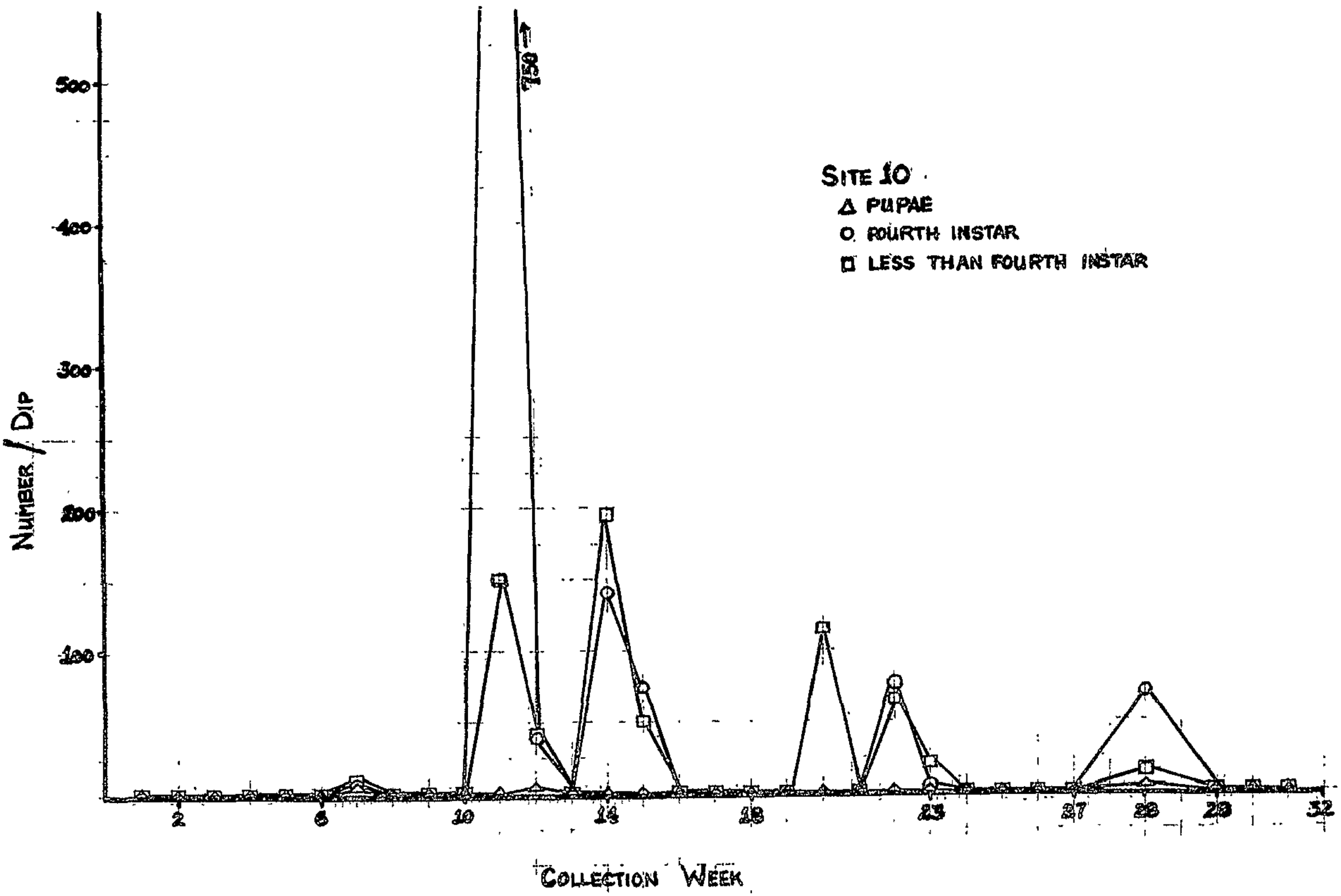
Mosquito densities for Site 9



Site 9
PUPAE
FOURTH INSTAR
LESS THAN FOURTH INSTAR
Number / Dip
500
400
300
200
100
2
6
10
14
18
22
27
28
29
32
Collection Week

Figure 13

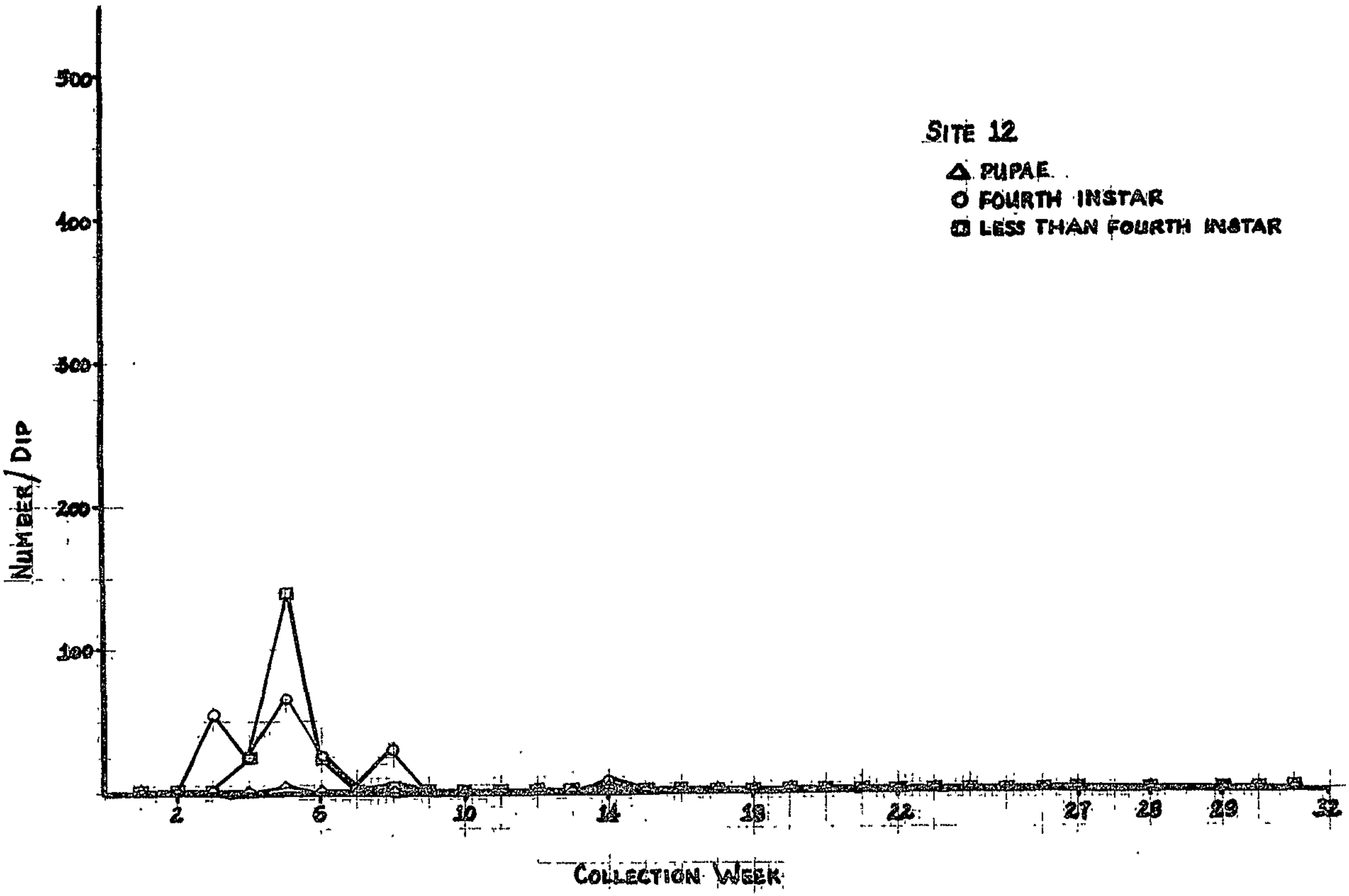
Mosquito densities for Site 10



Site 10
△ Pupae
○ Fourth instar
□ Less than fourth instar
Number / Dip
Collection Week
750
500
400
300
200
100
2
6
10
14
18
27
32

Figure 14

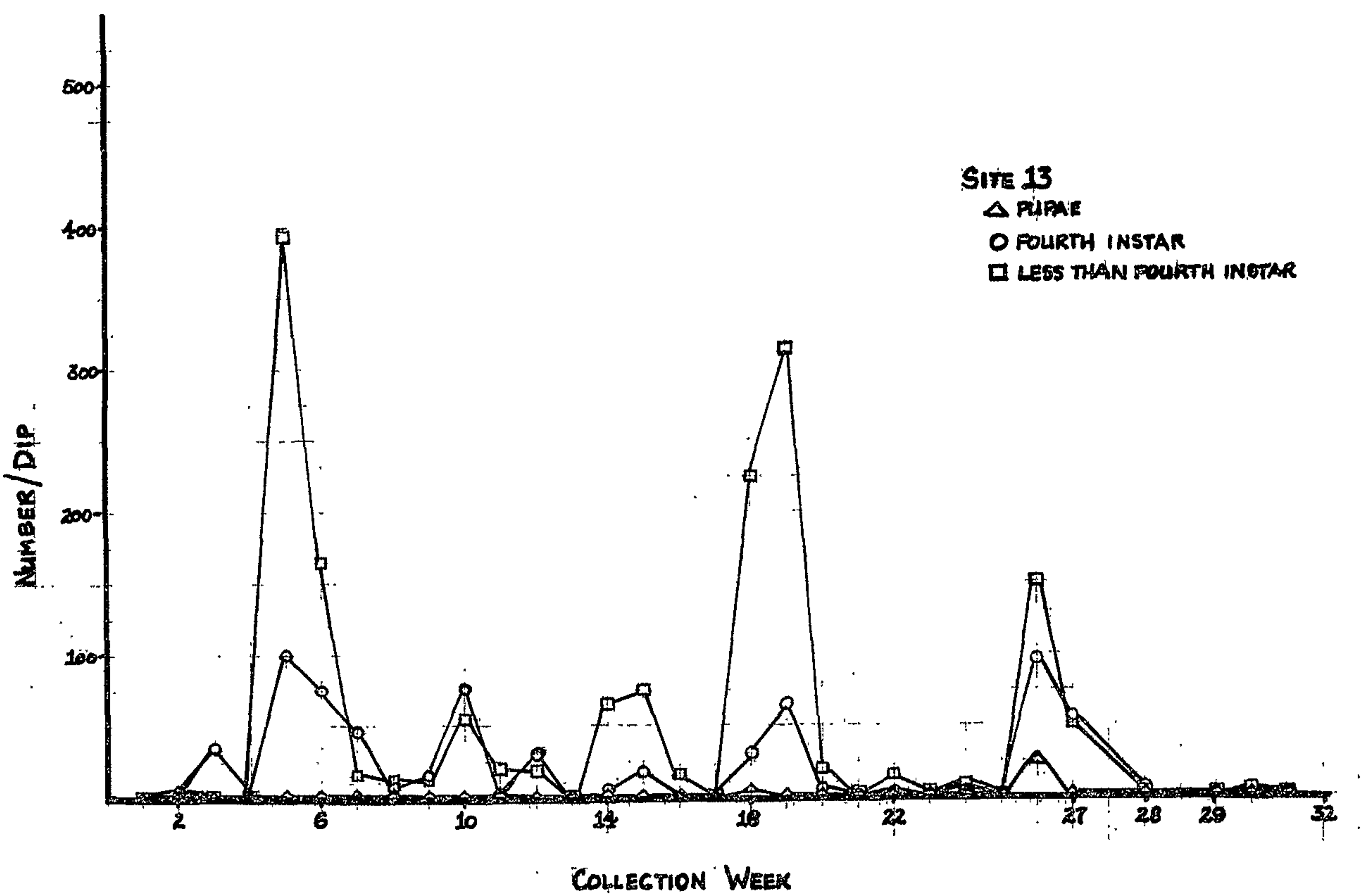
Mosquito densities for Site 12



SITE 12
PUPAE
FOURTH INSTAR
LESS THAN FOURTH INSTAR
NUMBER / DIP
COLLECTION WEEK
500
400
300
200
100
2
6
10
14
18
22
27
28
29
32

Figure 15

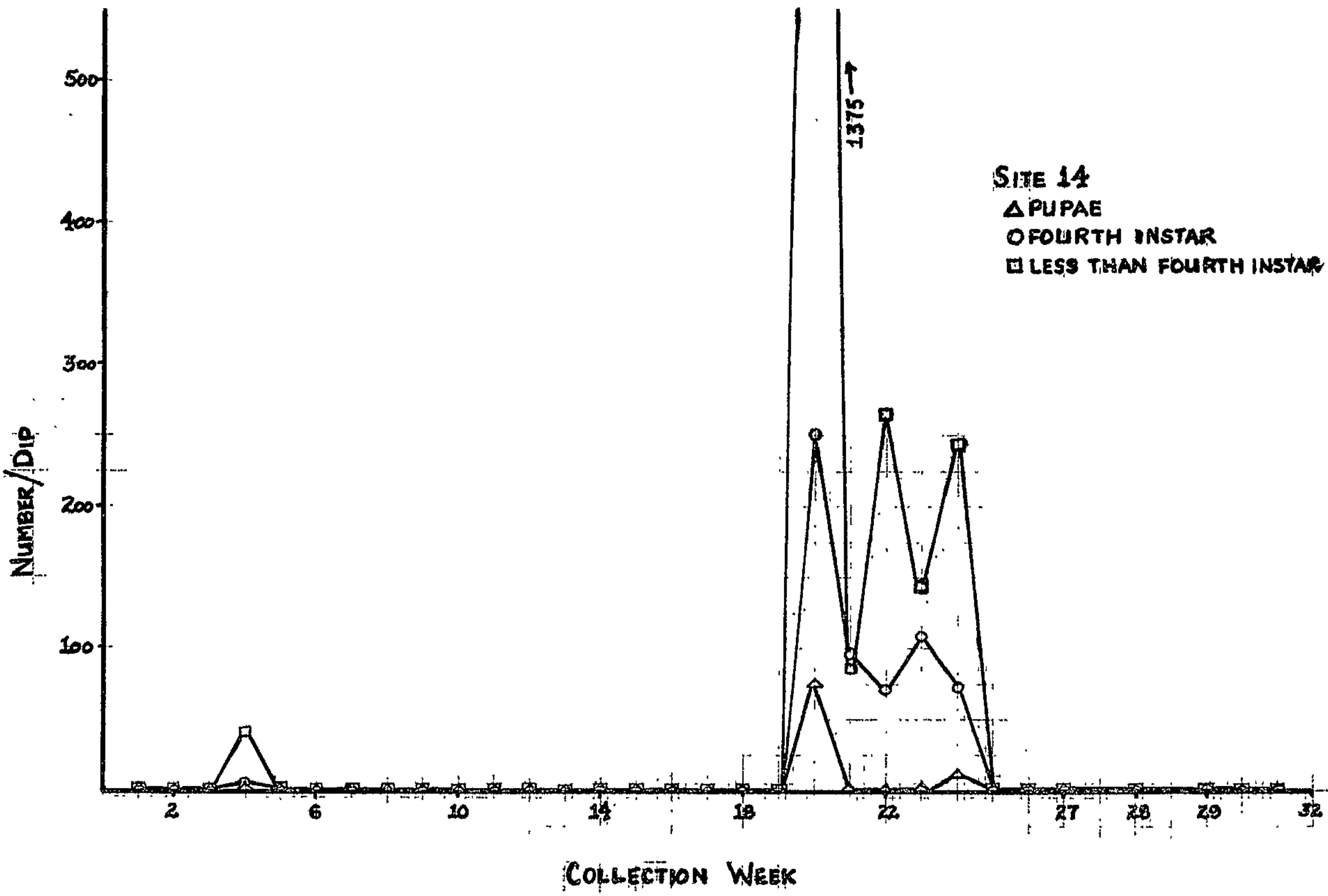
Mosquito densities for Site 13



SITE 13
PUPAE
FOURTH INSTAR
LESS THAN FOURTH INSTAR
NUMBER/DIP
500
400
300
200
100
2
6
10
14
18
22
27
28
29
32
COLLECTION WEEK

Figure 16

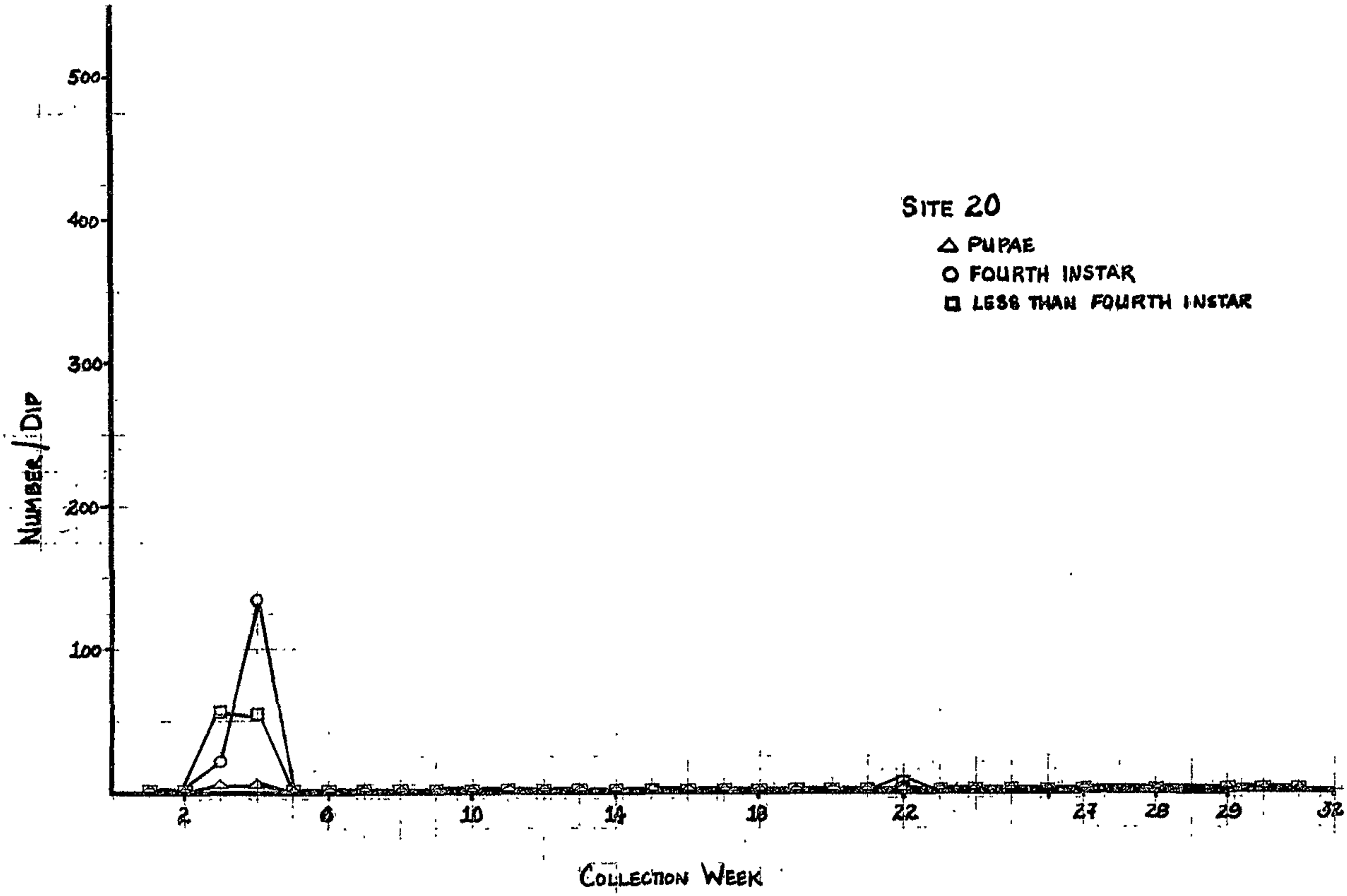
Mosquito densities for Site 14



500
400
300
200
100
NUMBER/DIP
1375
SITE 14
PUPAE
FOURTH INSTAR
LESS THAN FOURTH INSTAR
2
6
10
14
18
22
27
28
29
32
COLLECTION WEEK

Figure 17

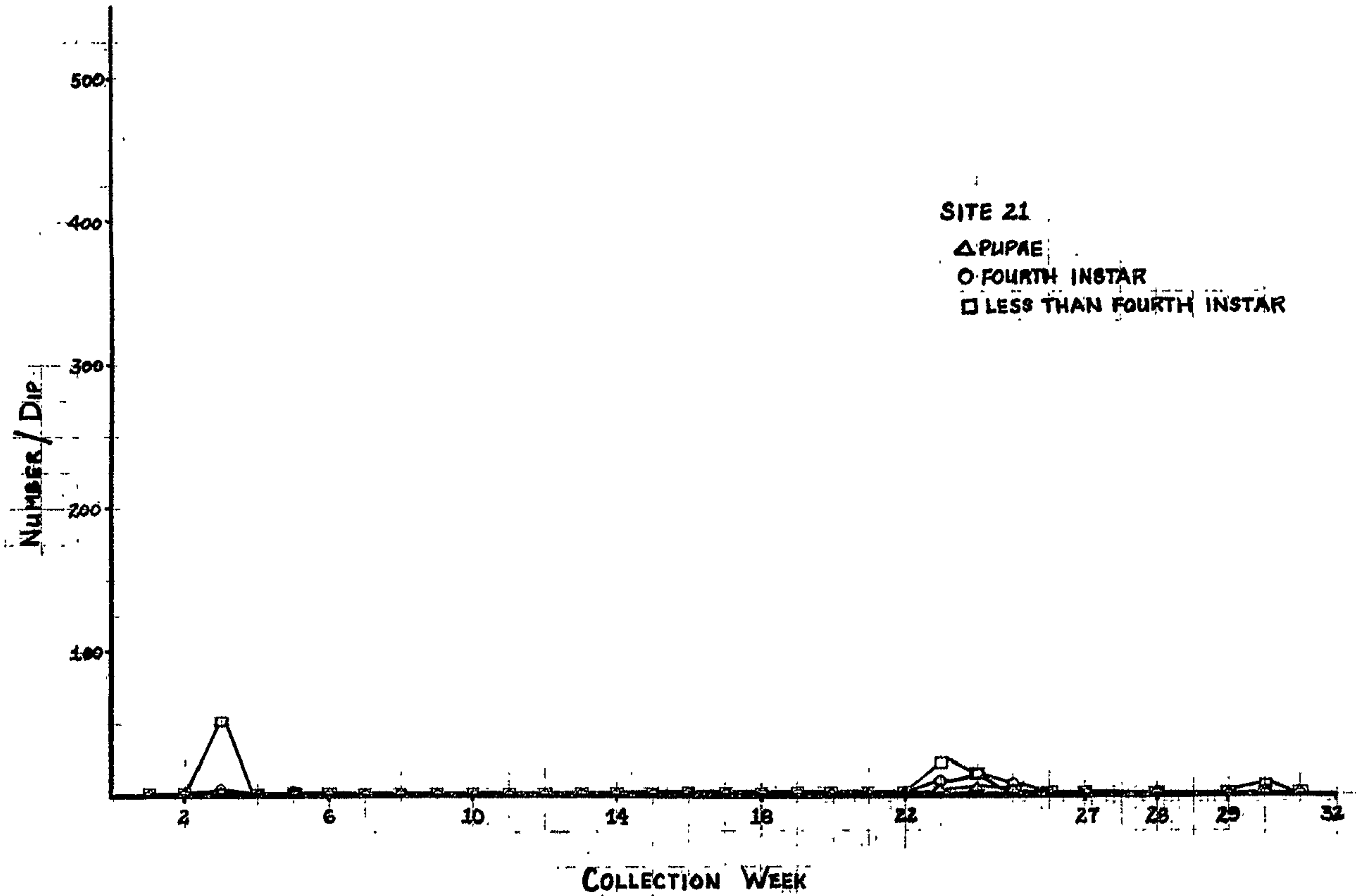
Mosquito densities for Site 20



SITE 20
PUPAE
FOURTH INSTAR
LESS THAN FOURTH INSTAR
NUMBER/DIP
500
400
300
200
100
2
6
10
14
18
22
27
28
29
32
COLLECTION WEEK

Figure 18

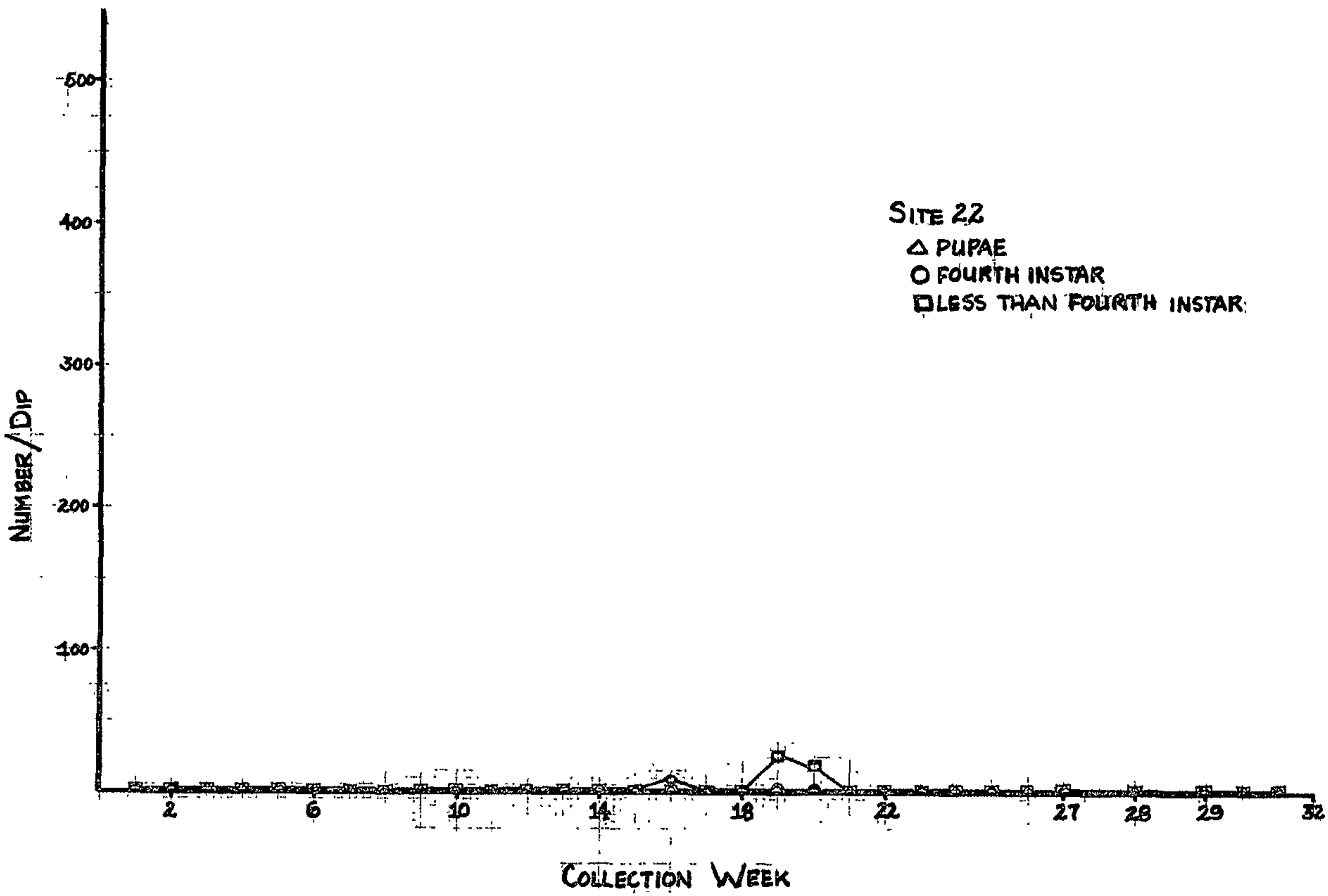
Mosquito densities for Site 21



500
400
300
200
100
Number / Dip
2
6
10
14
18
22
27
28
29
32
Collection Week
SITE 21
PUPAE
FOURTH INSTAR
LESS THAN FOURTH INSTAR

Figure 19

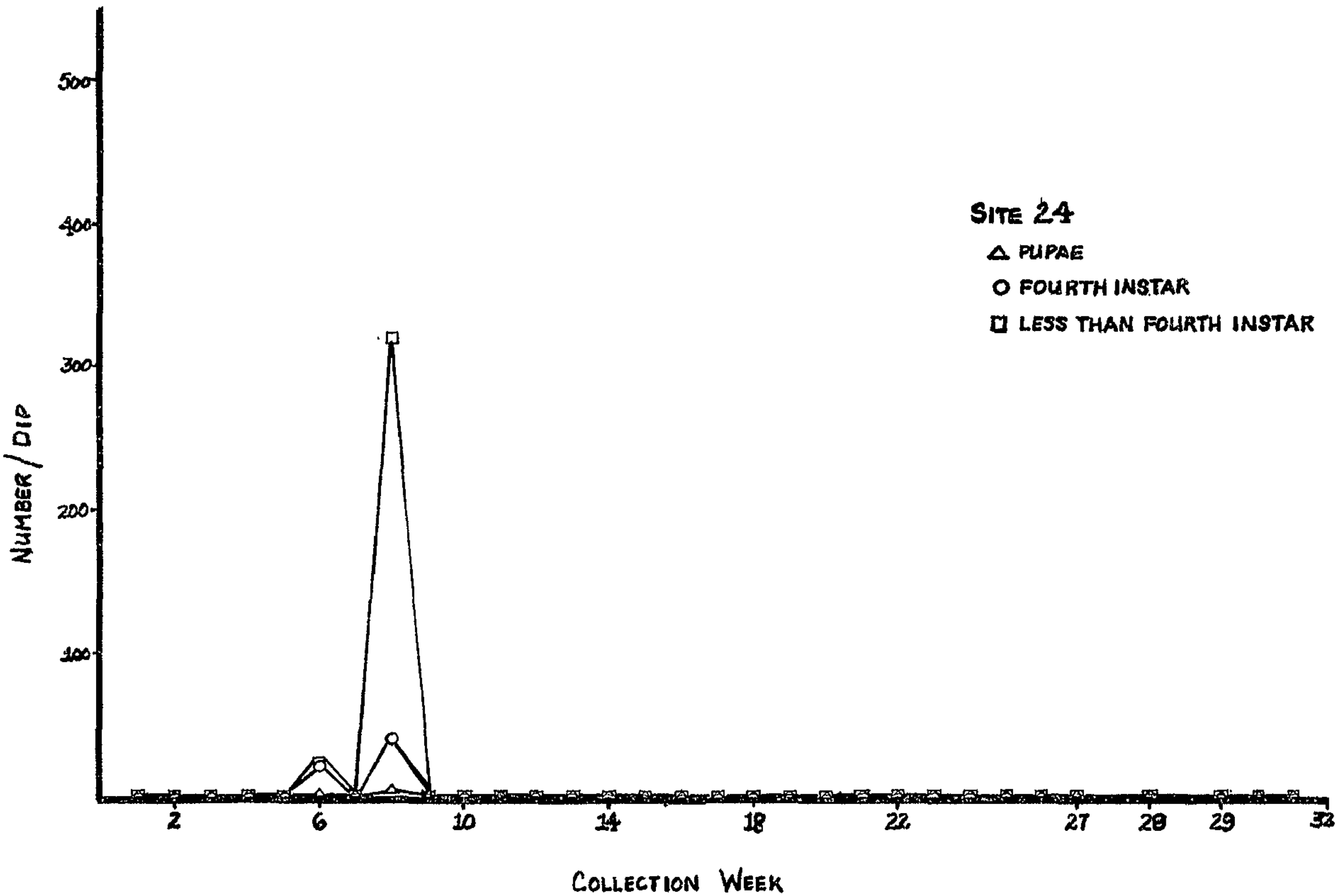
Mosquito densities for Site 22



Site 22
△ PUPAE
○ FOURTH INSTAR
□ LESS THAN FOURTH INSTAR
Number/Dip
500
400
300
200
100
2
6
10
14
18
22
27
28
29
32
Collection Week

Figure 20

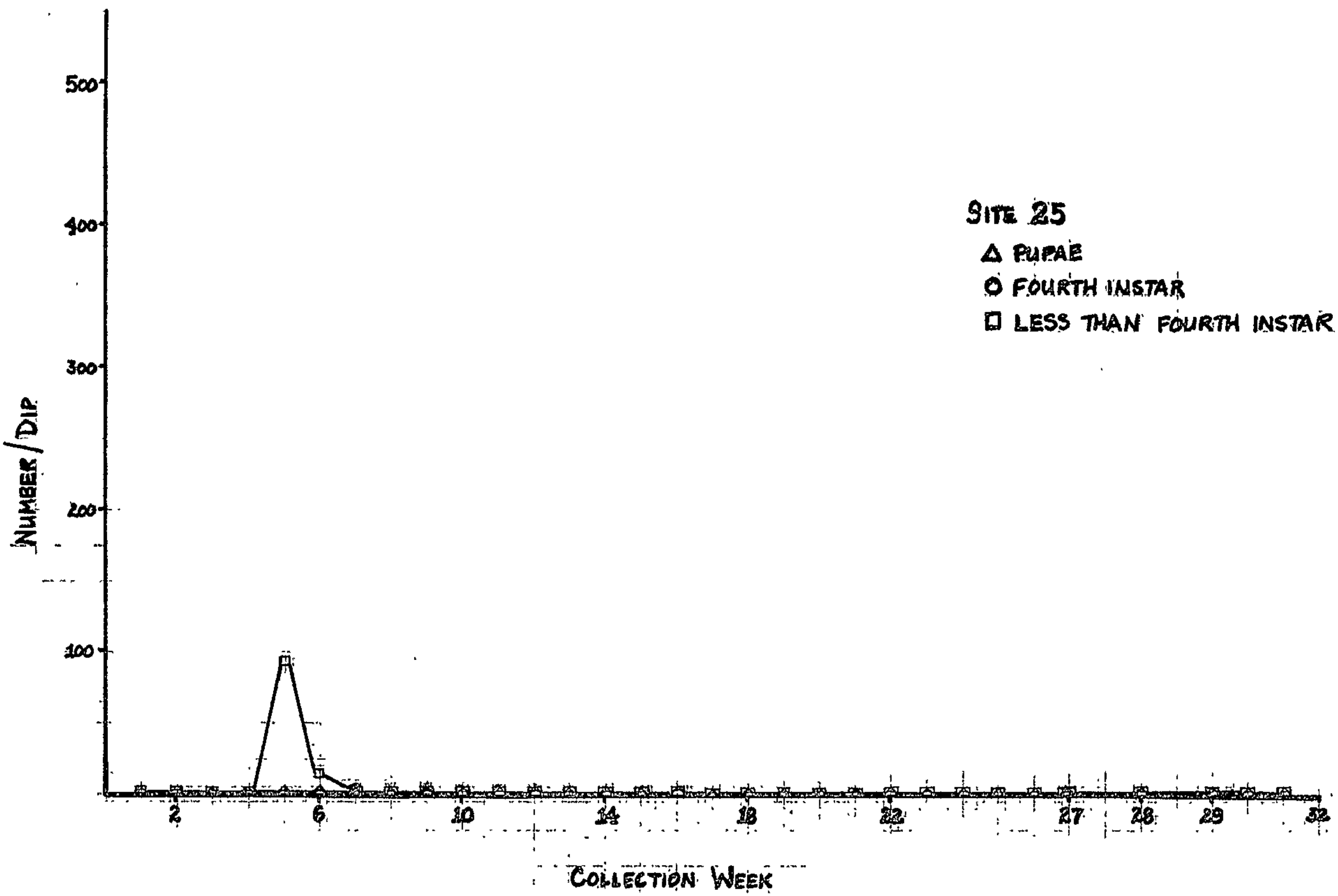
Mosquito densities for Site 24



SITE 24
PUPAE
FOURTH INSTAR
LESS THAN FOURTH INSTAR
NUMBER / DIP
500
400
300
200
100
2
6
10
14
18
22
27
28
29
32
COLLECTION WEEK

Figure 21

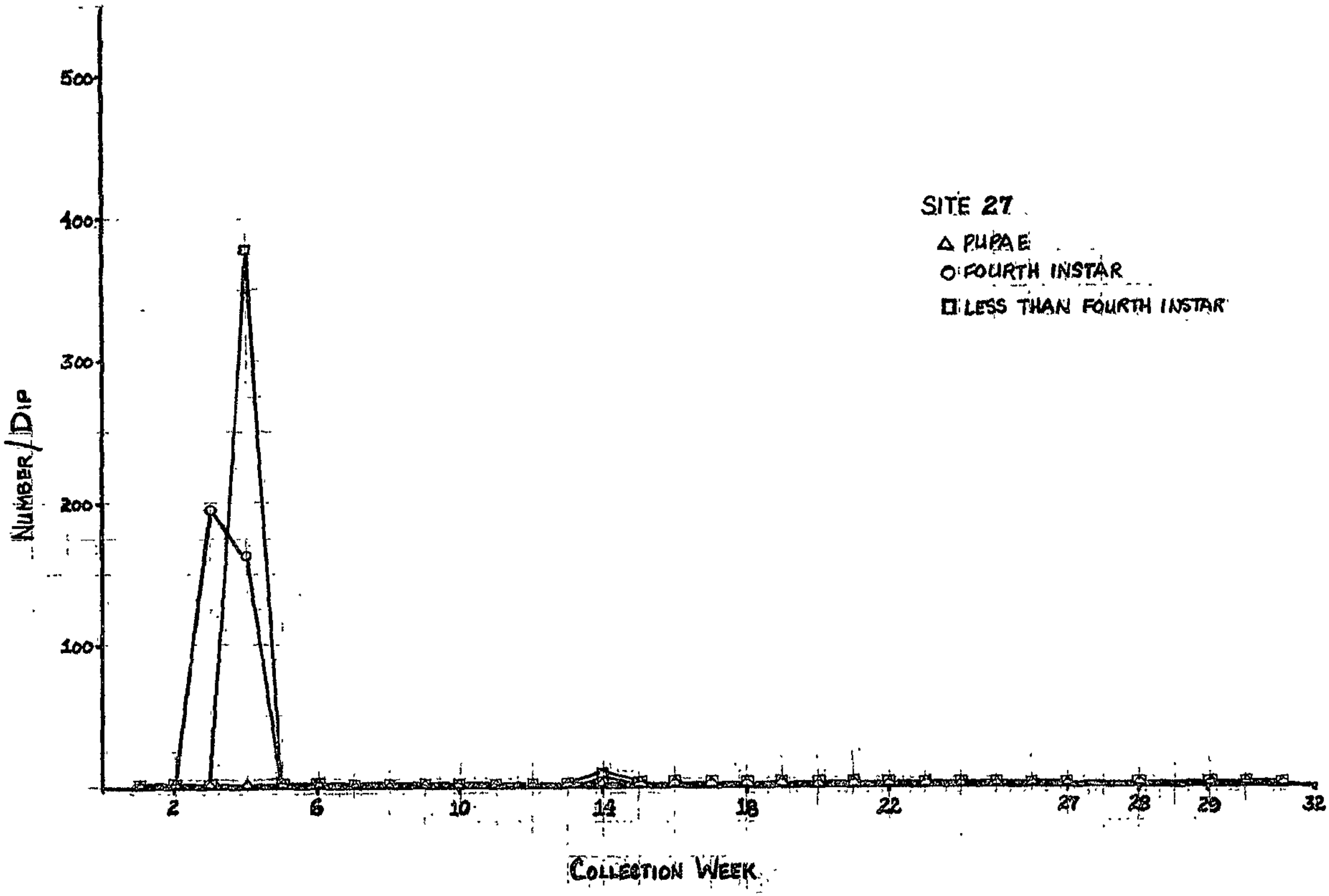
Mosquito densities for Site 25



SITE 25
PUPAE
FOURTH INSTAR
LESS THAN FOURTH INSTAR
500
400
300
200
100
NUMBER / DIP
2
6
10
14
18
22
27
28
29
32
COLLECTION WEEK

Figure 22

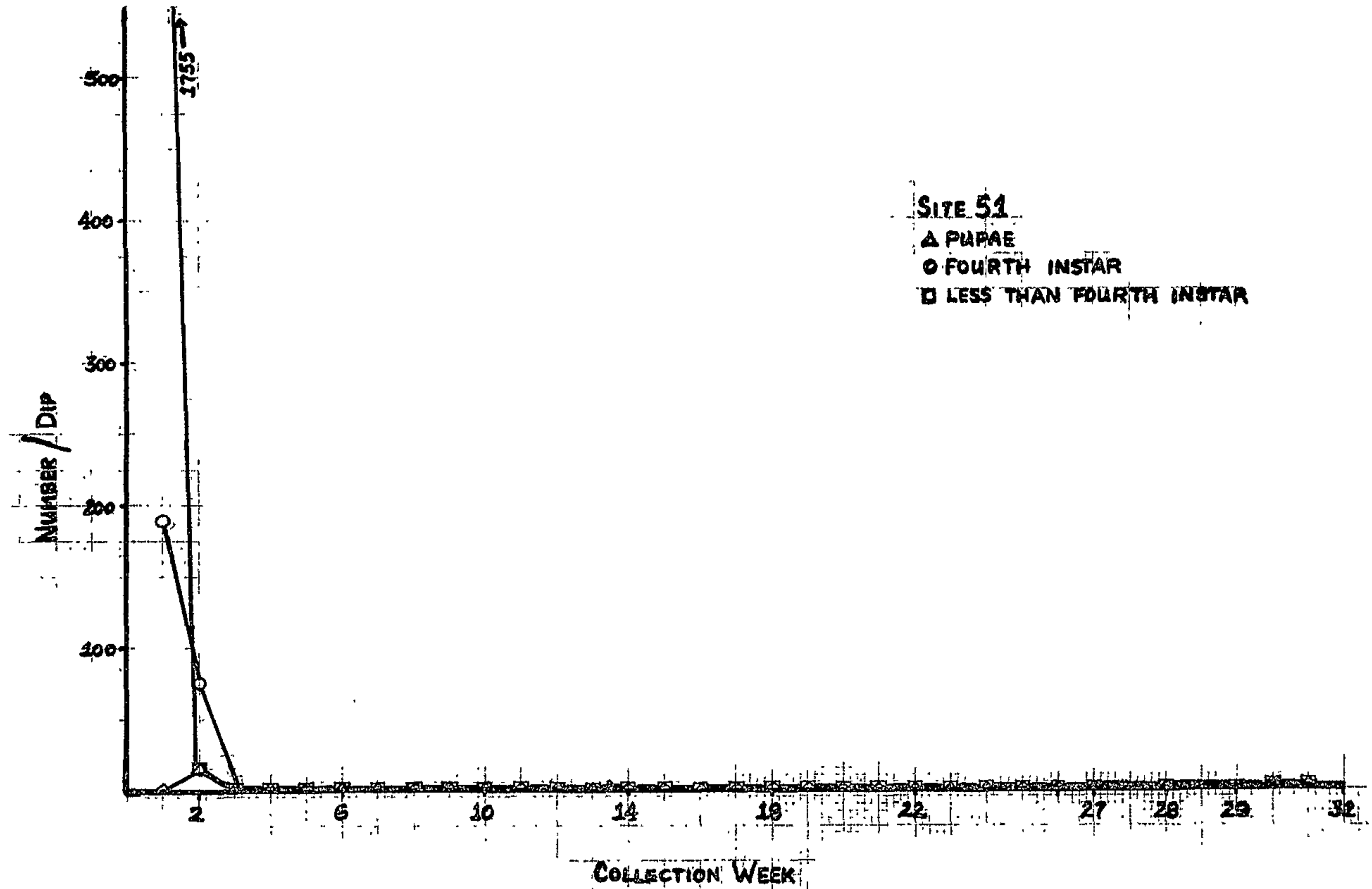
Mosquito densities for Site 27



SITE 27
△ PUPAE
○ FOURTH INSTAR
□ LESS THAN FOURTH INSTAR
NUMBER / DIP
500
400
300
200
100
2
6
10
14
18
22
27
28
29
32
COLLECTION WEEK

Figure 23

Mosquito densities for Site 51



Site 51
PUPAE
FOURTH INSTAR
LESS THAN FOURTH INSTAR
1755
500
400
300
200
100
Number / Dip
2
6
10
14
18
22
27
28
29
32
Collection Week

Figure 24

Mosquito densities for Site 52

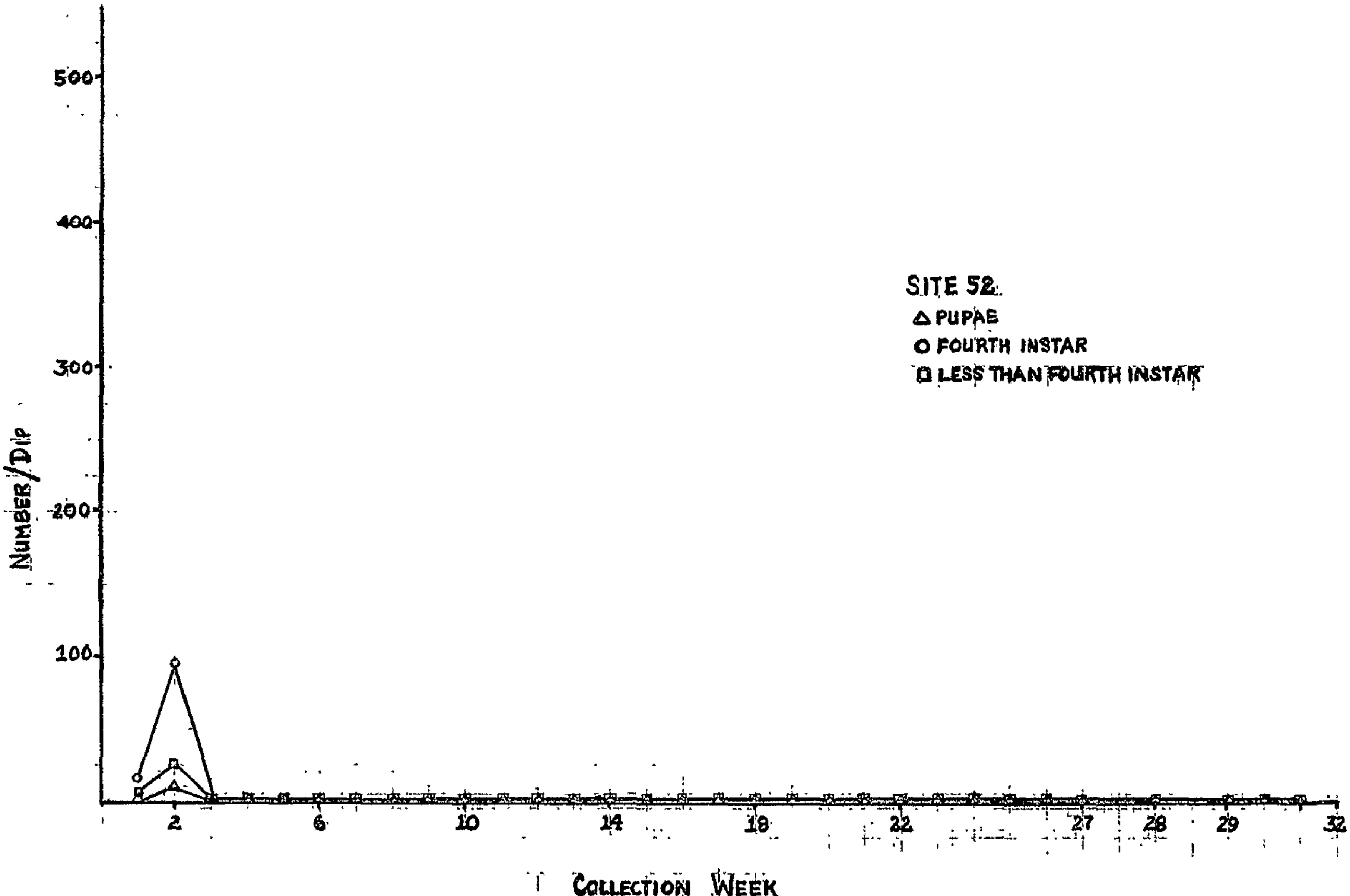
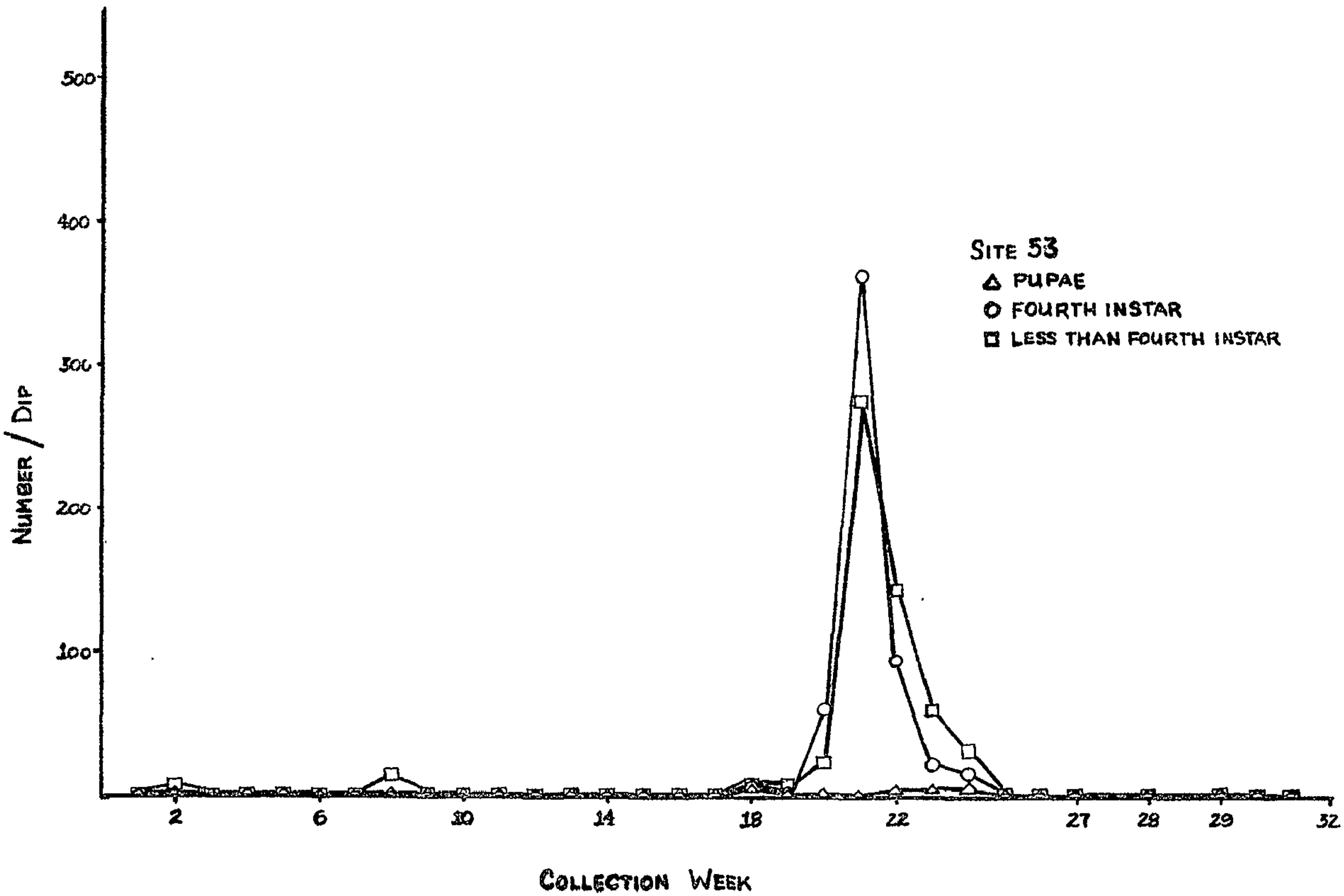

SITE 52
△ PUPAE
○ FOURTH INSTAR
□ LESS THAN FOURTH INSTAR
NUMBER/DIP
500
400
300
200
100
2
6
10
14
18
22
27
28
29
32
COLLECTION WEEK

Figure 25

Mosquito densities for Site 53

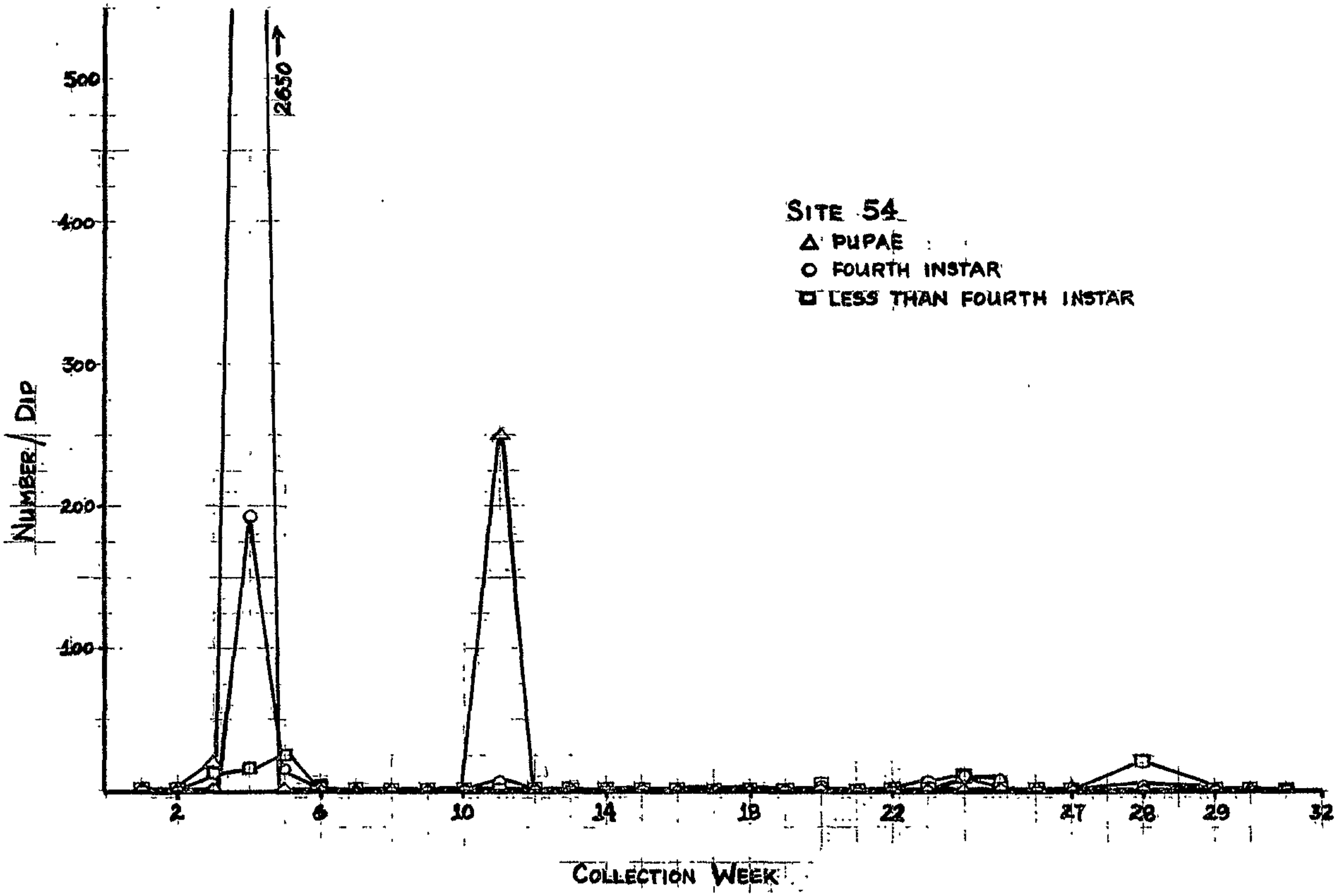
C, 2



Site 53
PUPAE
FOURTH INSTAR
LESS THAN FOURTH INSTAR
500
400
300
200
100
Number / Dip
2
6
10
14
18
22
27
28
29
32
Collection Week

Figure 26

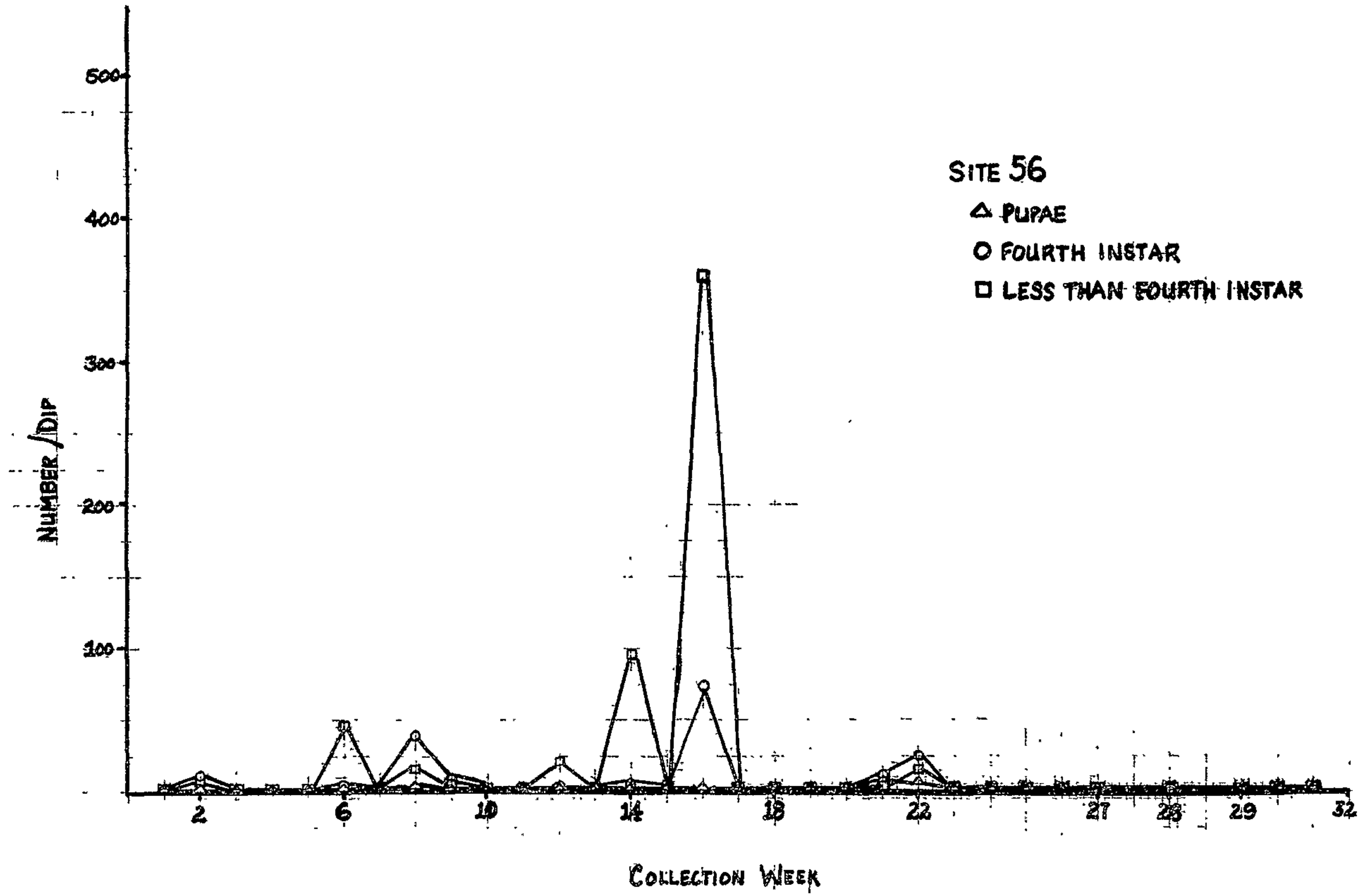
Mosquito densities for Site 54



SITE 54
PUPAE
FOURTH INSTAR
LESS THAN FOURTH INSTAR
NUMBER / DIP
500
400
300
200
100
2650
2
6
10
14
18
22
27
28
29
32
COLLECTION WEEK

Figure 27

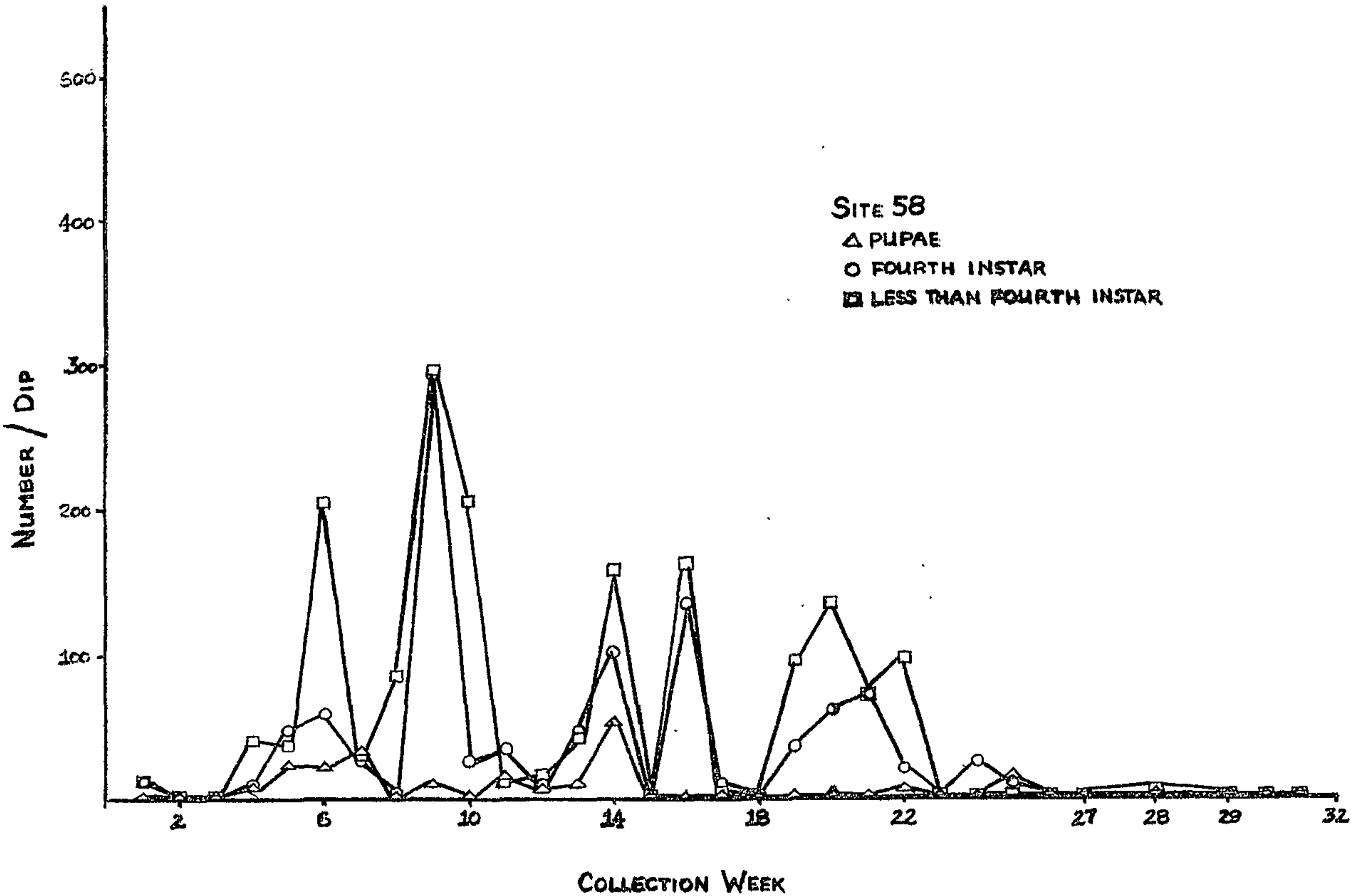
Mosquito densities for Site 56



SITE 56
PUPAE
FOURTH INSTAR
LESS THAN FOURTH INSTAR
NUMBER /DIP
500
400
300
200
100
COLLECTION WEEK
2
6
10
14
18
22
27
28
29
32

Figure 28

Mosquito densities for Site 58



Site 58
△ Pupae
○ Fourth instar
☐ Less than fourth instar
Number / Dip
500
400
300
200
100
2
6
10
14
18
22
27
28
29
32
Collection Week

Figure 29

Mosquito densities for Site 59

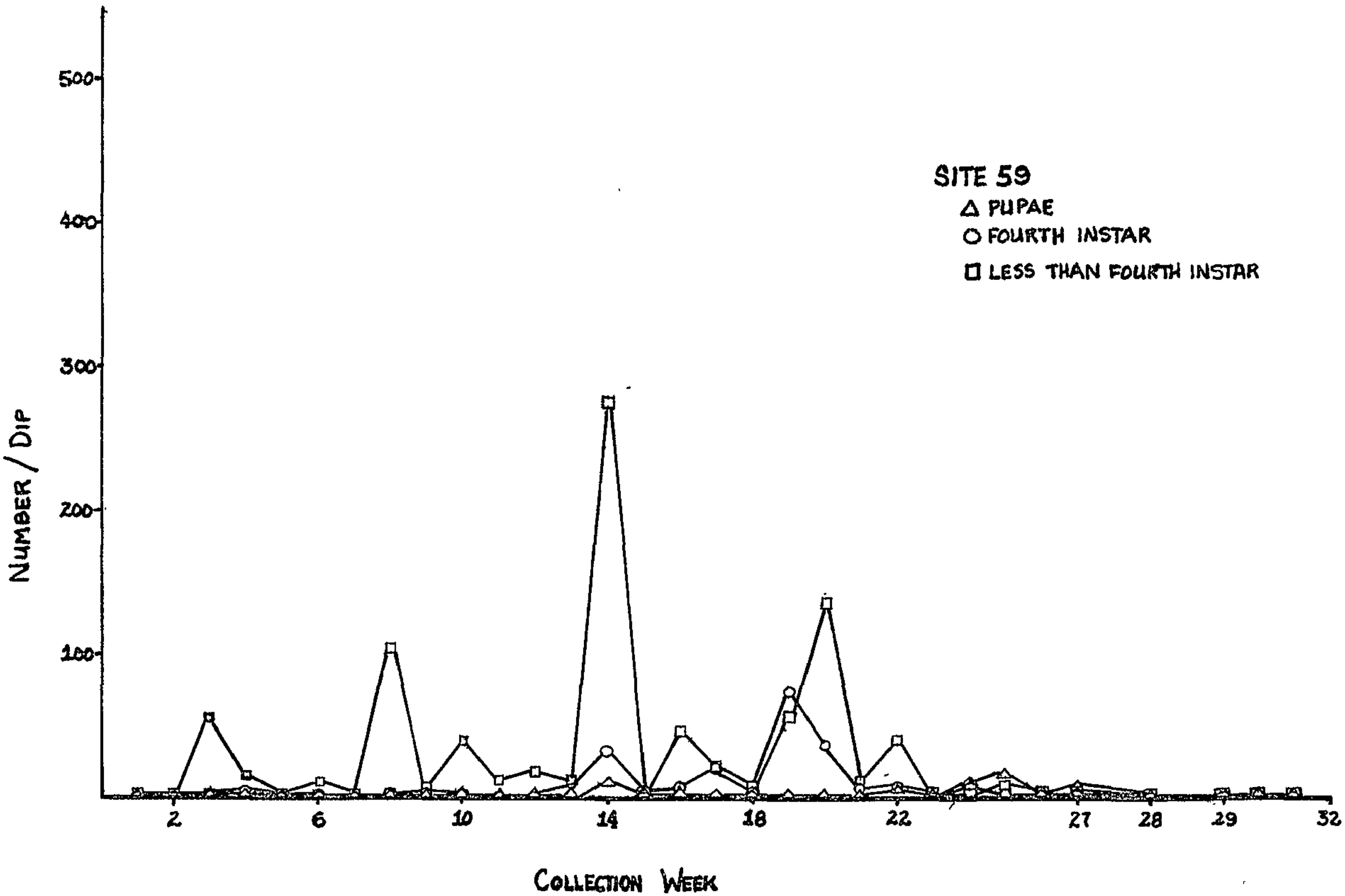
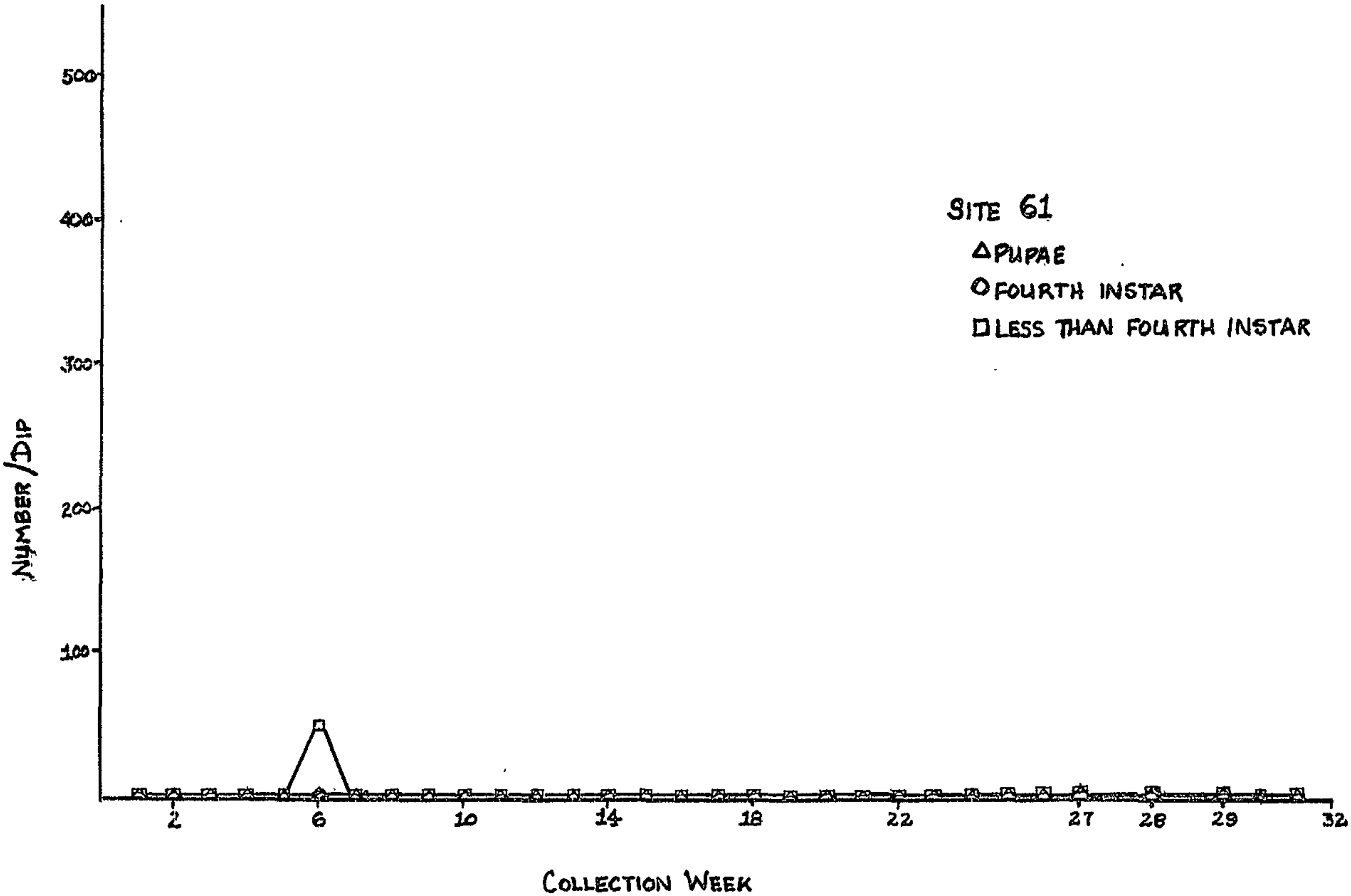

SITE 59
PUPAE
FOURTH INSTAR
LESS THAN FOURTH INSTAR
500
400
300
200
100
NUMBER / DIP
2
6
10
14
18
22
27
28
29
32
COLLECTION WEEK

Figure 30

Mosquito densities for Site 61



SITE 61
PUPAE
FOURTH INSTAR
LESS THAN FOURTH INSTAR
NUMBER/DIP
500
400
300
200
100
2
6
10
14
18
22
27
28
29
32
COLLECTION WEEK

Figure 31

Mosquito densities for Site 63

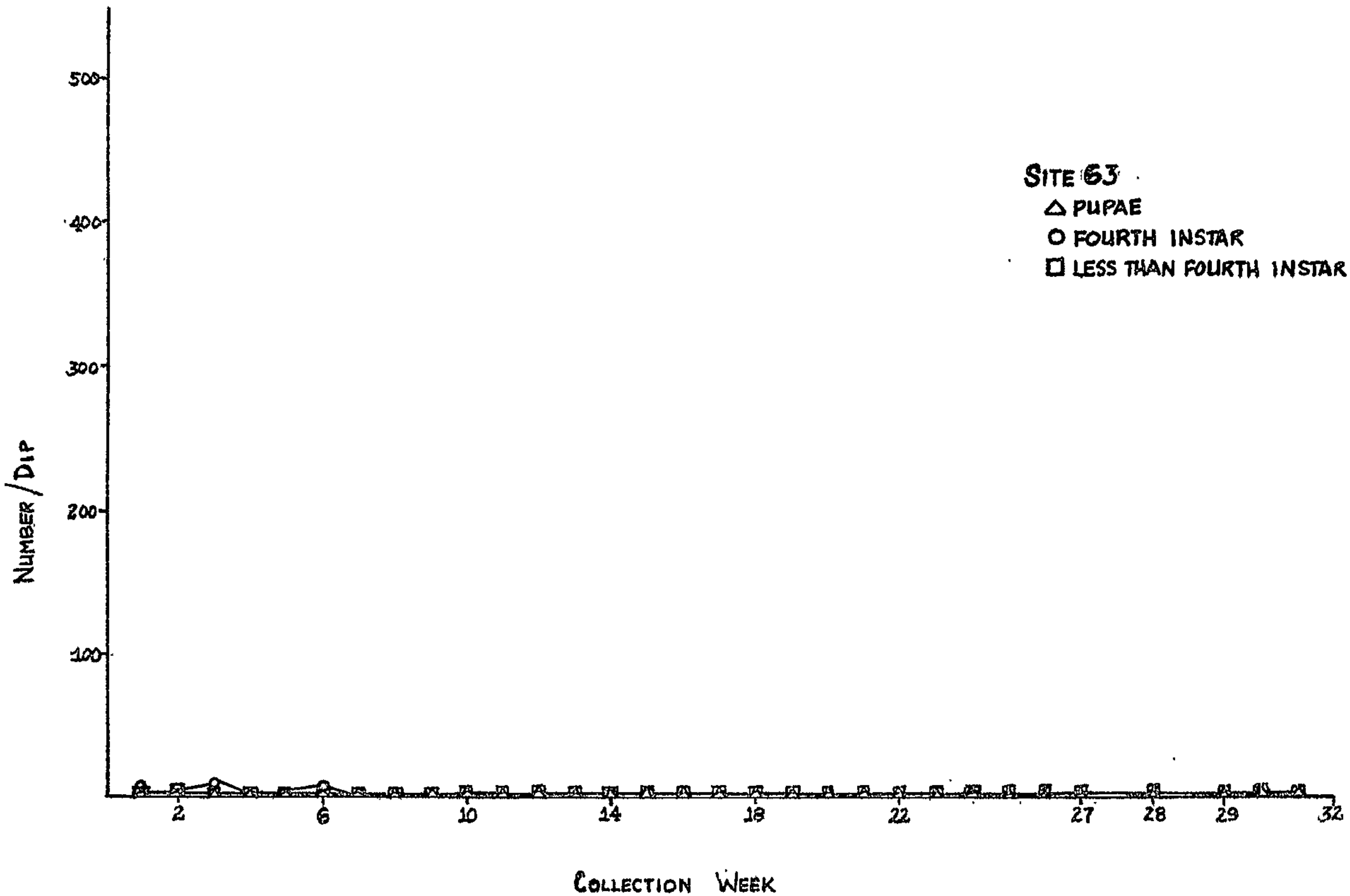
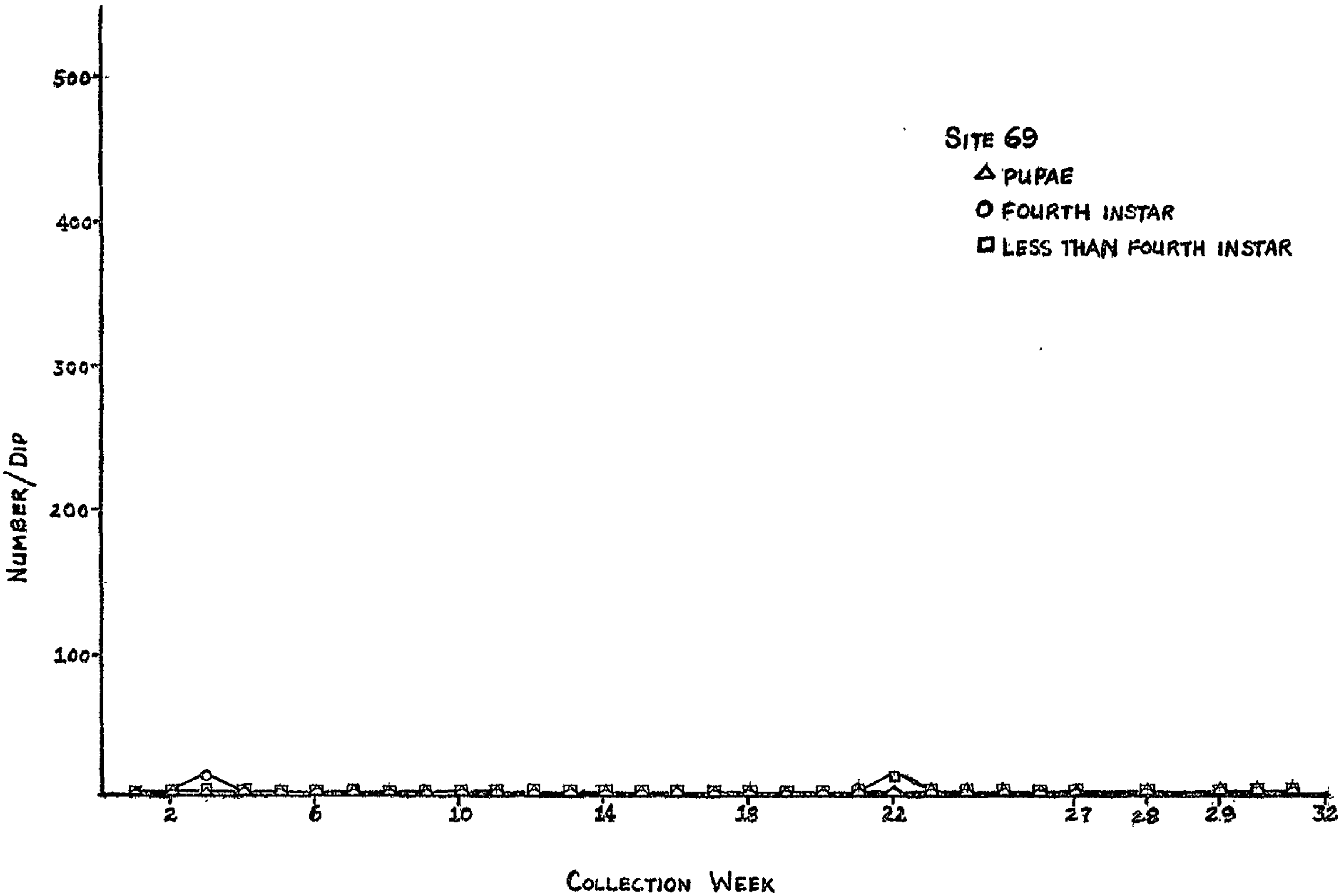

Site 63
PUPAE
FOURTH INSTAR
LESS THAN FOURTH INSTAR
NUMBER / DIP
500
400
300
200
100
2
6
10
14
18
22
27
28
29
32
COLLECTION WEEK

Figure 32

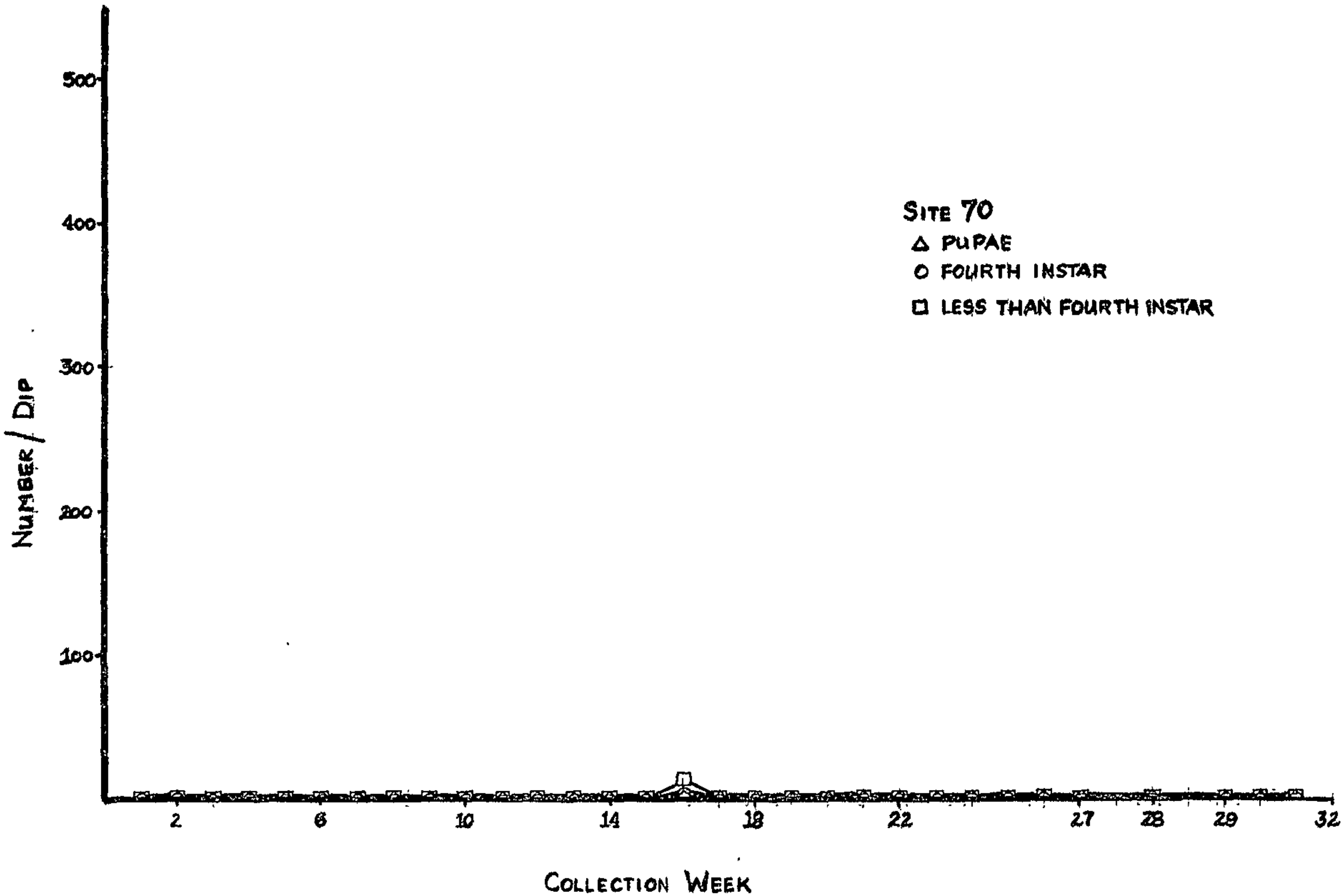
Mosquito densities for Site 69



Site 69
PUPAE
FOURTH INSTAR
LESS THAN FOURTH INSTAR
NUMBER/DIP
COLLECTION WEEK
500
400
300
200
100
2
6
10
14
18
22
27
28
29
32

Figure 33

Mosquito densities for Site 70


Site 70
PUPAE
FOURTH INSTAR
LESS THAN FOURTH INSTAR
Number / Dip
500
400
300
200
100
2
6
10
14
18
22
27
28
29
32
Collection Week

important factor. Since our concern is with relative densities, no attempt was made to dissociate the sources of variation. From the figures it can be seen that mosquito densities vary during the study period. However, it is not until Week 22 (early November) that a trend can be seen. In November the densities of mosquitoes begins to decline until Week 31 (early February) at which time field studies were terminated.

The densities of mosquitoes at each site as a function of sampling week were plotted for each site (Figures 4 through 33). Those sites where no mosquitoes were captured during the study were not plotted. These sites are 11, 15, 16, 17, 18, 19, 23, 26, 28, 29, 30, 31, 62, 64.

The individual sites might be expected to follow the general pattern seen in the pooled figure. However, it can be seen that dynamics of the sites varied considerably.

B. Variation in Chemical and Physical Factors

The mean values of the variables studied are given for each site in Table 3. Considerable variation among the sites for each of the variables is apparent as was the case with mosquito densities. The mean values of the variables under study was determined for each sampling week and the results plotted in Figures 34 through 44. Again, no marked seasonal trend can be seen in these variables which simplifies our analysis.

TABLE 3.	DISSOLVED OXYGEN	pH	CONDUCTIVITY
1	3.9 (30	7.1 (30)	7.398E+02 (30)
2	4.1 (31)	7.1 (31)	6.816E+02 (31)
3	4.4 (18)	7.1 (18)	4.151E+02 (18)
4	7.2 (24)	7.1 (24)	4.596E+02 (24)
5	2.3 (20)	6.9 (20)	7.118E+02 (20)
6	2.1 (16)	6.9 (16)	9.072E+02 (16)
7	1.3 (20)	7.2 (20)	1.275E+03 (20)
8	2.5 (20)	7.0 (20)	9.506E+02 (20)
9	6.0 (30)	7.4 (30)	7.040E+02 (30)
10	6.9 (28)	7.4 (30)	6.783E+02 (28)
11	5.7 (27)	6.9 (27)	3.714E+02 (27)
12	4.8 (23)	6.9 (23)	5.556E+02 (23)
13	2.6 (29)	7.0 (29)	5.887E+02 (29)
14	2.4 (29)	6.8 (29)	5.327E+02 (29)
15	1.9 (6)	5.8 (6)	5.983E+02 (6)
16	.9 (5)	5.6 (5)	5.788E+02 (5)
17	5.8 (23)	6.9 (23)	3.411E+02 (23)
18	10.0 (23)	7.3 (23)	1.963E+02 (23)
19	10.9 (27)	7.1 (27)	1.114E+03 (27)
20	2.9 (13)	6.6 (13)	4.518E+02 (13)
21	4.2 (16)	6.9 (16)	3.943E+02 (16)
22	11.7 (18)	7.0 (18)	6.404E+02 (18)
23	12.8 (18)	7.6 (18)	6.217E+02 (18)
24	.7 (3)	4.6 (3)	3.893E+02 (3)
25	.6 (5)	5.6 (6)	5.678E+02 (5)
26	.2 (3)	4.5 (3)	4.683E+02 (3)
27	1.0 (7)	5.9 (7)	6.600E+02 (7)
28	5.0 (6)	6.2 (6)	5.262 E+02 (6)
29	2.8 (2)	8.5 (2)	4.750E+02 (2)
30	5.2 (5)	6.0 (5)	7.086E+02 (5)
31	6.1 (3)	5.0 (3)	4.293E+02 (3)
51	3.0 (6)	7.7 (6)	7.250E+02 (6)
52	2.1 (6)	5.1 (6)	6.083E+02 (6)
53	2.9 (21)	9.9 (21)	2.313E+03 (21)
54	7.0 (17)	40.0 (17)	7.745E+02 (17)
55	2.0 (2)	8.4 (2)	0.0 (2)
56	4.4 (28)	7.1 (28)	1.033E+03 (28)
57	7.0 (25)	8.0 (25)	4.031E+02 (25)
58	2.6 (30)	6.2 (30)	6.225E+02 (30)
59	3.6 (31)	6.3 (31)	8.762E+02 (31)
61	1.3 (13)	8.5 (13)	3.033E+03 (13)
62	.7 (5)	7.7 (5)	6.240E+02 (5)
63	1.4 (10)	6.6 (10)	8.865E+02 (10)
64	8.3 (28)	8.1 (28)	3.295E+02 (28)
65	3.3 (6)	5.9 (6)	2.130E+02 (6)
66	2.9 (5)	8.6 (5)	2.540E+02 (5)
69	9.4 (14)	7.1 (14)	3.139E+02 (14)
70	4.3 (21)	7.2 (21)	1.127E+03 (21)
71	5.9 (16)	6.6 (16)	2.490E+02 (16)

TABLE 3(Cont.)	NITRATE	PHOSPHATE	TURBIDITY
1	18.6 (12)	36.7 (10)	1.5 (16)
2	4.5 (12)	37.6 (10)	8.0 (16)
3	5.2 (12)	34.2 (10)	4.4 (16)
4	5.1 (10)	10.4 (9)	2.8 (11)
5	7.3 (3)	7.6 (1)	59.6 (7)
6	4.8 (4)	3.8 (2)	9.6 (7)
7	4.3 (4)	15.4 (2)	25.6 (8)
8	10.1 (5)	23.7 (3)	5.5 (10)
9	4.8 (12)	35.5 (10)	3.1 (16)
10	4.3 (10)	26.9 (8)	2.9 (14)
11	2.5 (11)	24.1 (9)	3.6 (16)
12	3.6 (9)	18.7 (9)	4.4 (11)
13	5.3 (12)	25.8 (10)	5.0 (16)
14	3.6 (12)	36.7 (10)	14.4 (17)
15			2.3 (2)
16			10.4 (2)
17	4.3 (12)	27.8 (10)	3.4 (14)
18	2.7 (12)	20.6 (10)	3.3 (13)
19	3.6 (11)	5.5 (9)	3.1 (15)
20	2.7 (9)	16.9 (7)	3.3 (11)
21	5.4 (6)	17.9 (5)	6.2 (6)
22	4.0 (2)	19.5 (1)	11.6 (7)
23	3.2 (3)	8.0 (1)	7.9 (5)
27			42.0 (1)
51	2.2 (1)		2.0 (2)
52	4.4 (2)		1.8 (11)
53	2.9 (8)	24.0 (7)	7.8 (10)
54	3.0 (10)	21.6 (8)	5.6 (10)
56	4.2 (10)	17.5 (7)	3.8 (12)
57	1.1 (11)	7.4 (8)	3.9 (13)
58	3.5 (11)	17.4 (8)	7.9 (14)
59	2.9 (10)	16.3 (8)	5.3 (13)
64	1.6 (10)	6.7 (7)	6.2 (13)
65	3.2 (1)		4.0 (1)
66	3.2 (1)		4.2 (1)
69	1.1 (10)	6.8 (8)	5.2 (10)
70	3.4 (4)	14.1 (2)	6.0 (9)
71	3.8 (7)	9.2 (5)	4.9 (8)

TABLE 3(Cont.)	Inorganic Carbon	Total Carbon	Coliform Bacteria
1	90.0 (30)	178.9 (30)	801.0 (30)
2	88.5 (28)	197.1 (29)	6956.3 (31)
3	76.5 (18)	177.3 (18)	4210.4 (18)
4	68.1 (20)	308.5 (21)	3313.7 (22)
5	95.1 (18)	452.7 (19)	5495.8 (19)
6	119.9 (16)	307.8 (15)	1662.9 (17)
7	154.2 (19)	347.9 (18)	2098.2 (20)
8	123.8 (19)	219.6 (18)	2707.9 (20)
9	115.2 (30)	200.9 (29)	1148.5 (31)
10	101.5 (30)	161.7 (27)	1037.2 (28)
11	37.6 (26)	74.7 (26)	608.6 (28)
12	73.1 (23)	265.1 (22)	3069.2 (22)
13	123.9 (30)	270.9 (29)	1495.7 (30)
14	115.4 (30)	283.3 (29)	2737.3 (30)
15	209.3 (4)	155.8 (3)	1087.0 (4)
16	158.8 (5)	215.3 (4)	1244.0 (5)
17	64.9 (21)	124.2 (20)	3830.0 (22)
18	35.4 (20)	73.1 (20)	434.4 (21)
19	87.7 (27)	124.3 (27)	403.6 (28)
20	91.6 (13)	169.4 (13)	1058.6 (11)
21	79.6 (14)	333.2 (14)	1364.0 (14)
22	93.1 (16)	226.5 (17)	2283.9 (19)
23	112.3 (16)	234.3 (17)	2215.4 (14)
24	245.9 (2)	440.6 (2)	5600.0 (2)
25	302.1 (3)	558.4 (3)	4375.0 (4)
26	658.5 (2)	1404.6 (2)	419.5 (2)
27	191.2 (6)	493.4 (6)	1506.6 (6)
28	73.3 (5)	112.0 (5)	150.0 (4)
29	106.3 (1)	170.1 (1)	5.0 (1)
30	63.9 (4)	109.9 (4)	25025.2 (4)
31	60.5 (2)	84.6 (2)	.5 (2)
51	111.8 (2)	119.4 (3)	2300.6 (3)
52	84.0 (2)	100.7 (3)	6033.3 (3)
53	238.3 (19)	523.0 (20)	2688.2 (17)
54	80.2 (15)	293.9 (16)	4977.0 (13)
55	87.3 (2)	323.8 (1)	2000.0 (1)
56	91.1 (25)	164.6 (26)	7635.3 (23)
57	23.4 (22)	65.3 (23)	570.5 (21)
58	64.7 (27)	135.5 (28)	7816.4 (22)
59	59.1 (26)	103.7 (26)	8317.7 (25)
60	38.8 (1)	102.1 (1)	3900.0 (1)
61	123.5 (10)	165.9 (11)	18983.0 (11)
62	66.2 (3)	117.5 (3)	2250.0 (2)
63	84.3 (8)	166.9 (8)	48474.8 (8)
64	25.0 (24)	87.4 (25)	970.3 (23)
65	33.7 (4)	59.6 (5)	200.6 (5)
66	32.4 (5)	57.0 (6)	141.2 (5)
69	33.0 (14)	111.0 (15)	170.8 (10)
70	116.1 (20)	226.4 (21)	32637.4 (19)
71	22.3 (13)	61.4 (13)	442.1 (10)

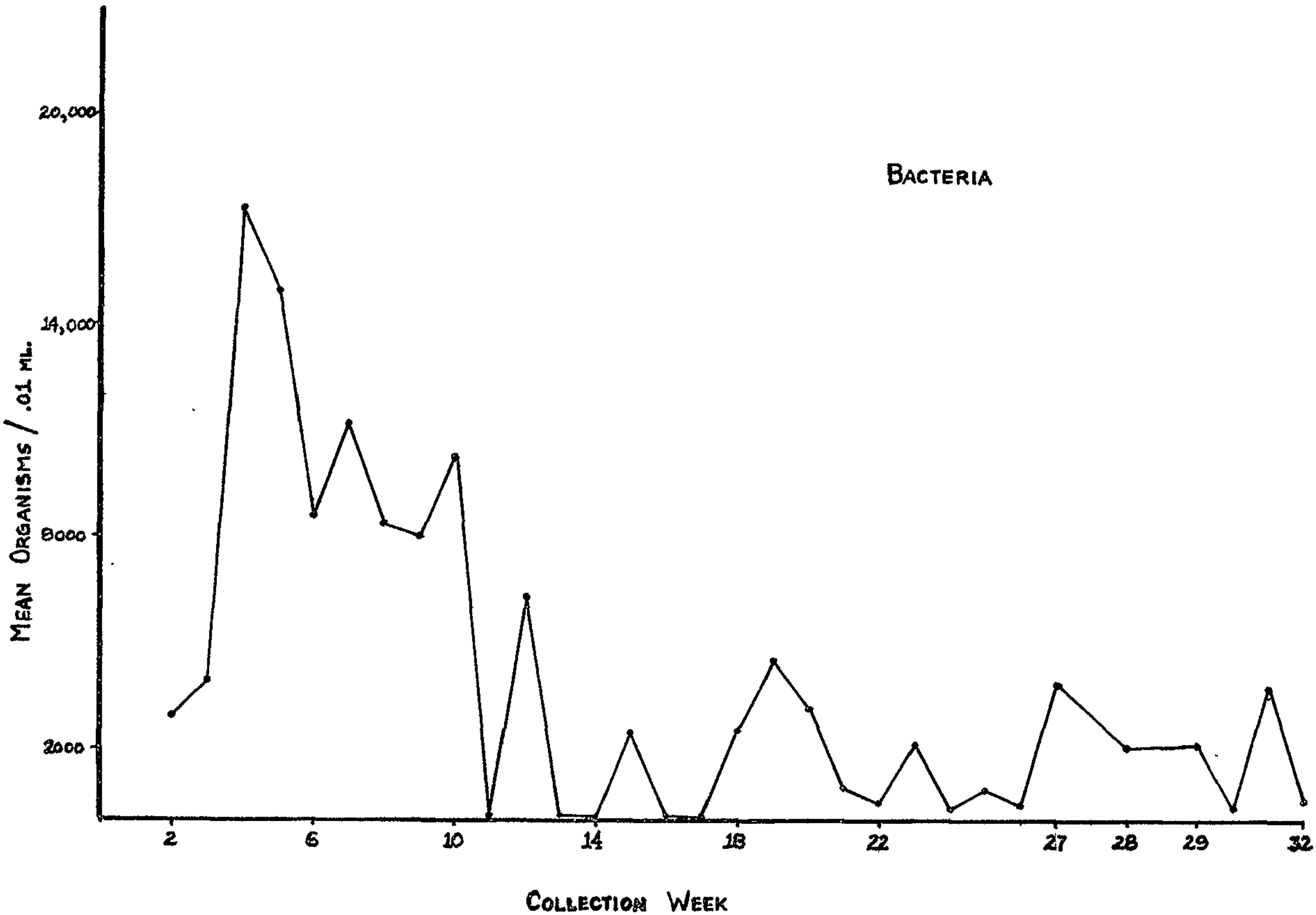
TABLE 3(Cont.)	ZINC	COPPER	IRON
1	36.9 (29)	64.0 (30)	92.6 (30)
2	51.0 (28)	50.5 (29)	108.2 (29)
3	62.1 (17)	71.9 (18)	425.8 (18)
4	44.3 (21)	42.3 (21)	302.3 (21)
5	46.2 (18)	32.5 (19)	311.7 (19)
6	53.3 (15)	55.0 (16)	475.7 (16)
7	83.7 (18)	41.4 (19)	452.0 (19)
8	74.7 (18)	56.5 (19)	288.2 (18)
9	52.3 (29)	41.8 (30)	328.3 (30)
10	45.1 (27)	50.3 (28)	240.6 (28)
11	34.5 (26)	47.4 (27)	915.5 (27)
12	98.3 (22)	85.7 (22)	1488.0 (23)
13	69.2 (29)	41.4 (30)	221.3 (30)
14	60.4 (29)	27.2 (30)	148.6 (31)
15	14.7 (3)	41.4 (3)	129.4 (3)
16	39.2 (4)	0.0 (4)	73.8 (3)
17	104.9 (20)	39.4 (21)	164.8 (22)
18	37.3 (20)	55.8 (21)	388.0 (21)
19	29.9 (27)	30.5 (27)	280.5 (28)
20	54.1 (11)	67.0 (12)	896.2 (12)
21	38.7 (12)	52.6 (13)	421.0 (13)
22	43.5 (18)	17.0 (17)	441.3 (18)
23	34.2 (16)	55.2 (19)	475.1 (17)
24	41.5 (2)	0.0 (2)	110.8 (2)
25	31.1 (4)	0.0 (3)	110.7 (4)
26	38.3 (2)	0.0 (2)	0.0 (2)
27	24.2 (7)	29.4 (7)	345.1 (7)
28	30.5 (5)	28.7 (5)	727.3 (5)
29	62.3 (1)	0.0 (1)	881.8 (1)
30	39.9 (4)	0.0 (4)	482.6 (4)
31	35.8 (2)	0.0 (2)	146.7 (2)
51	47.7 (2)	85.4 (1)	338.7 (2)
52	53.3 (2)	44.8 (2)	440.9 (2)
53	177.7 (17)	84.0 (17)	945.6 (18)
54	153.4 (14)	61.7 (15)	873.5 (14)
55			
56	72.6 (22)	37.1 (24)	314.5 (23)
57	75.6 (21)	46.7 (22)	1753.9 (22)
58	282.1 (24)	49.4 (24)	712.8 (25)
59	205.8 (23)	50.8 (24)	561.7 (24)
60	53.2 (1)	89.7 (1)	1832.8 (1)
61	43.1 (9)	30.8 (10)	293.7 (9)
62	104.8 (2)	0.0 (2)	2832.9 (1)
63	167.7 (7)	44.3 (8)	99.0 (8)
64	49.0 (22)	46.4 (23)	775.2 (23)
65	26.8 (4)	0.0 (4)	1222.8 (4)
66	15.8 (4)	45.0 (4)	1275.5 (4)
69	92.7 (12)	67.2 (13)	699.2 (13)
70	65.5 (18)	43.9 (20)	101.0 (19)
71	73.9 (13)	74.8 (13)	1004.8 (14)

TABLE 3(Cont.)

	SODIUM	MANGANESE
1	207.3 (26)	27.1 (2)
2	187.0 (26)	0.0 (2)
3	271.3 (14)	*********
4	156.6 (17)	71.2 (2)
5	66.6 (17)	0.0 (2)
6	90.7 (13)	0.0 (1)
7	107.4	71.2 (2)
8	112.2 (16)	*********
9	196.3 (26)	0.0 (2)
10	148.1 (23)	50.8 (3)
11	96.9 (23)	40.7 (20)
12	233.3 (19)	178.2 (1)
13	172.4 (25)	0.0 (2)
14	113.7 (25)	0.0 (2)
15	64.1 (2)	*********
16	100.1 (3)	*********
17	155.3 (16)	71.0 (1)
18	127.5 (17)	106.7 (1)
19	225.2 (25)	0.0 (2)
20	154.5 (9)	261.0 (2)
21	98.3 (11)	143.5 (2)
22	73.7 (16)	0.0 (2)
23	54.1 (16)	0.0 (2)
24	47.2 (2)	*********
25	55.0 (3)	*********
26	69.1 (20)	*********
27	51.4 (6)	76.2 (2)
28	90.8 (5)	*********
29	116.6 (1)	*********
30	96.6 (4)	81.5 (1)
31	83.3 (2)	*********
51	10.3 (2)	*********
52	15.6 (3)	*********
53	168.1 (17)	0.0 (1)
54	134.4 (13)	157.1 (2)
56	126.8 (20)	81.5 (1)
57	82.6 (17)	0.0 (1)
58	73.6 (22)	157.1 (2)
59	89.1 (21)	58.0 (2)
60	35.3 (1)	*********
61	280.4 (10)	108.8 (1)
62	39.4 (2)	71.0 (1)
63	53.3 (8)	0.0 (2)
64	55.6 (21)	125.6 (2)
65	16.3 (5)	428.2 (1)
66	18.7 (5)	178.2 (1)
69	75.0 (10)	0.0 (1)
70	73.3 (17)	40.7 (2)
71	55.3 (9)	*********

Figure 34

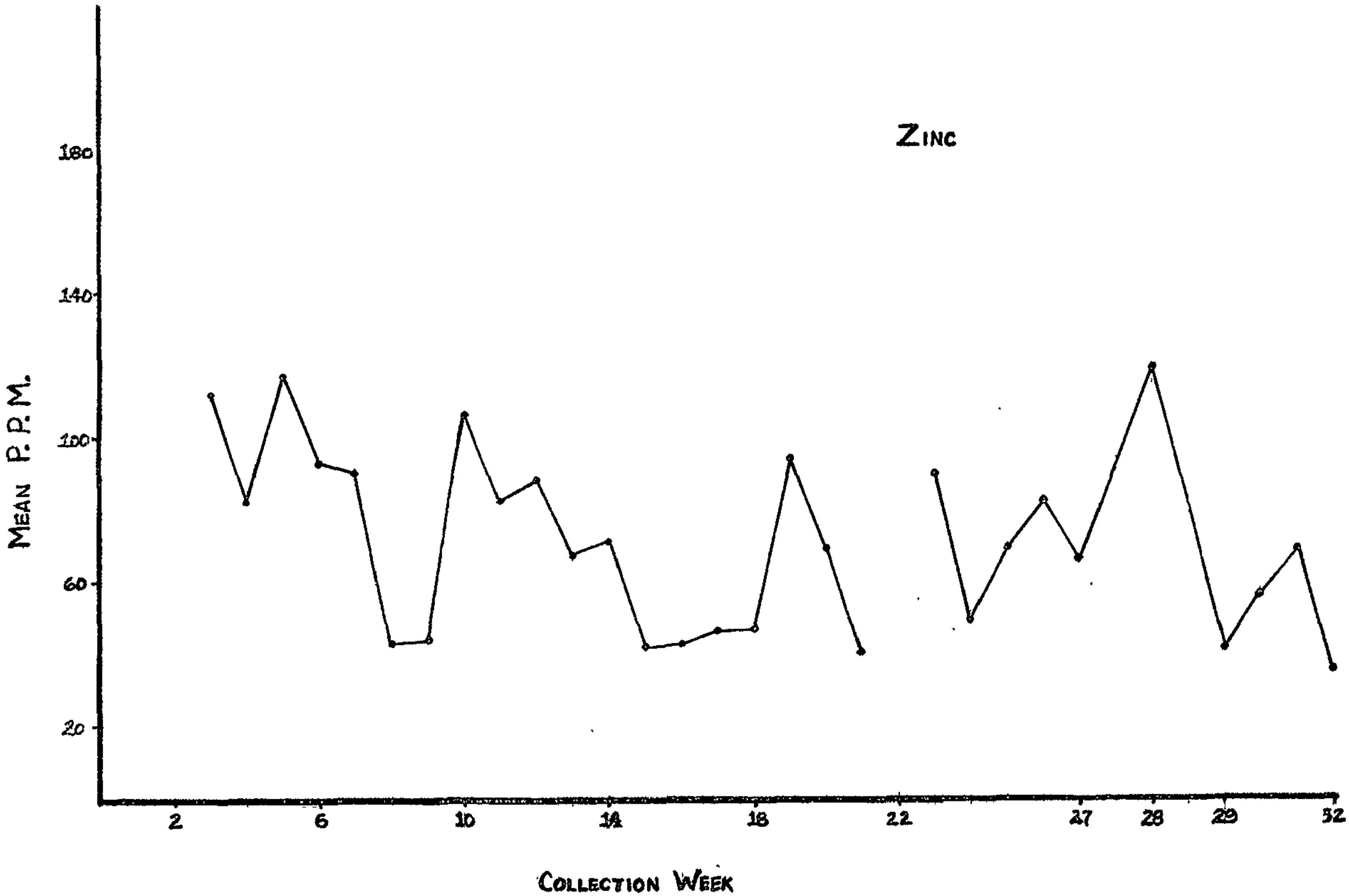
Changes in Mean Concentration of Bacteria During Study Period



Bacteria
Mean Organisms / .01 ml.
20,000
14,000
8000
2000
2
6
10
14
18
22
27
28
29
32
Collection Week

Figure 35

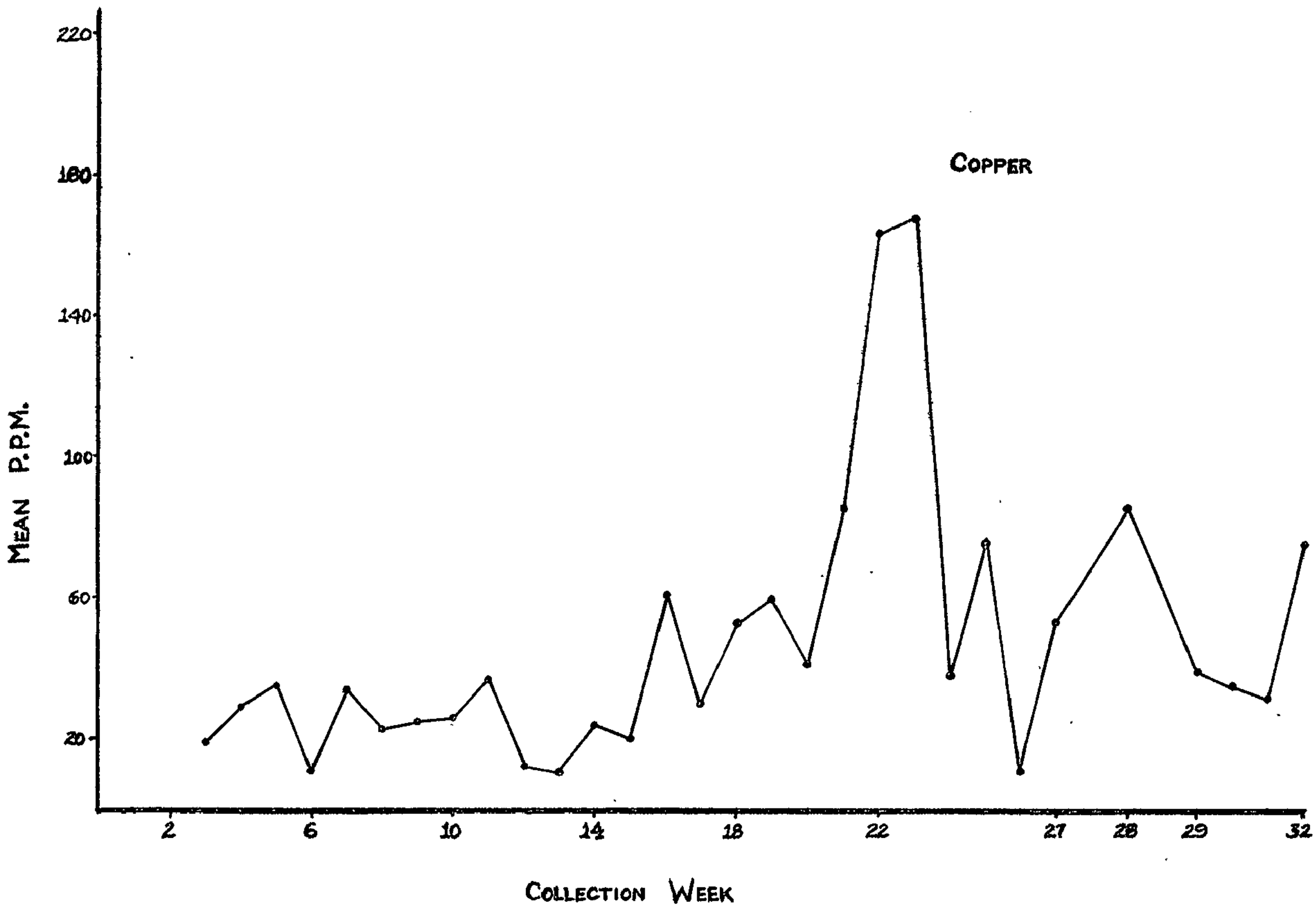
Changes in Mean Concentration of Zinc During Study Period



Zinc
Mean P. P. M.
180
140
100
60
20
2
6
10
14
18
22
27
28
29
52
Collection Week

Figure 36

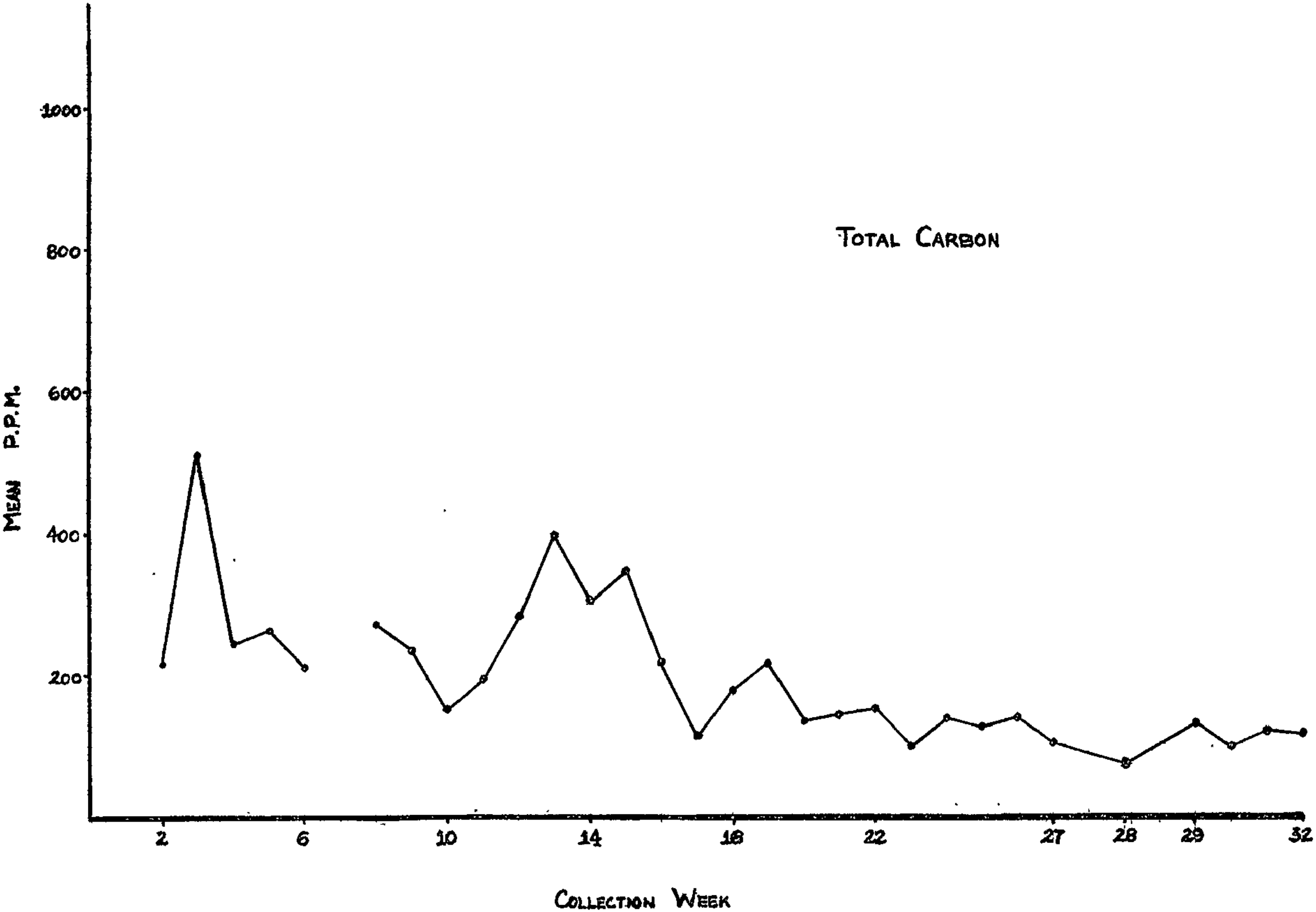
Changes in Mean Concentration of Copper During Study Period



COPPER
MEAN P.P.M.
220
180
140
100
60
20
2
6
10
14
18
22
27
28
29
32
COLLECTION WEEK

Figure 37

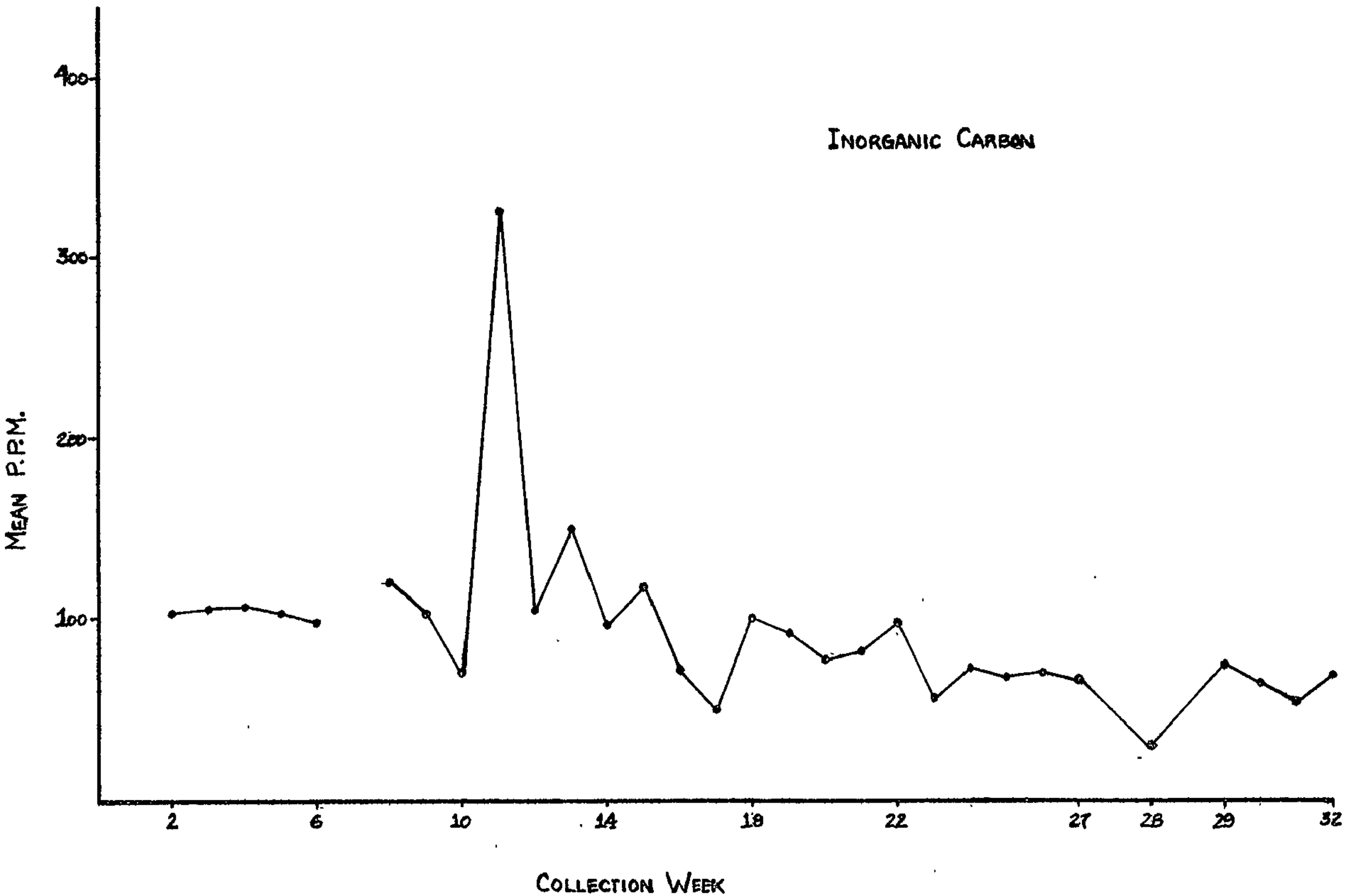
Changes in Mean Concentration of Total Carbon During Study Period



Total Carbon
1000
800
600
400
200
Mean P.P.M.
2
6
10
14
18
22
27
28
29
32
Collection Week

Figure 38

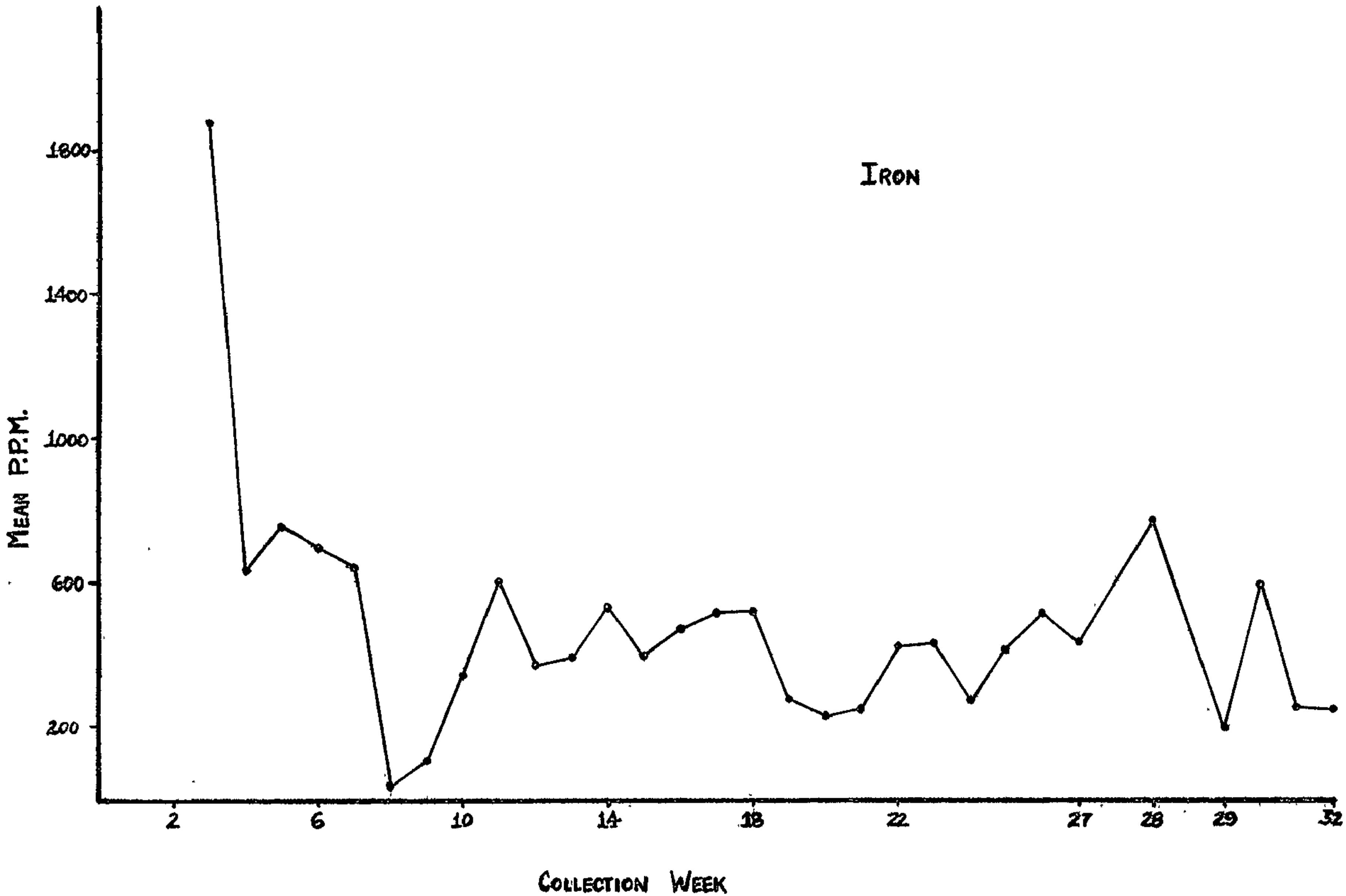
Changes in Mean Concentration of Inorganic Carbon During Study Period



Inorganic Carbon
Mean P.P.M.
400
300
200
100
2
6
10
14
18
22
27
28
29
32
Collection Week

Figure 39

Changes in Mean Concentration of Iron During
Study Period



Iron
Mean P.P.M.
1800
1400
1000
600
200
2
6
10
14
18
22
27
28
29
32
Collection Week

Figure 40

Changes in Mean Concentration of Sodium During Study Period

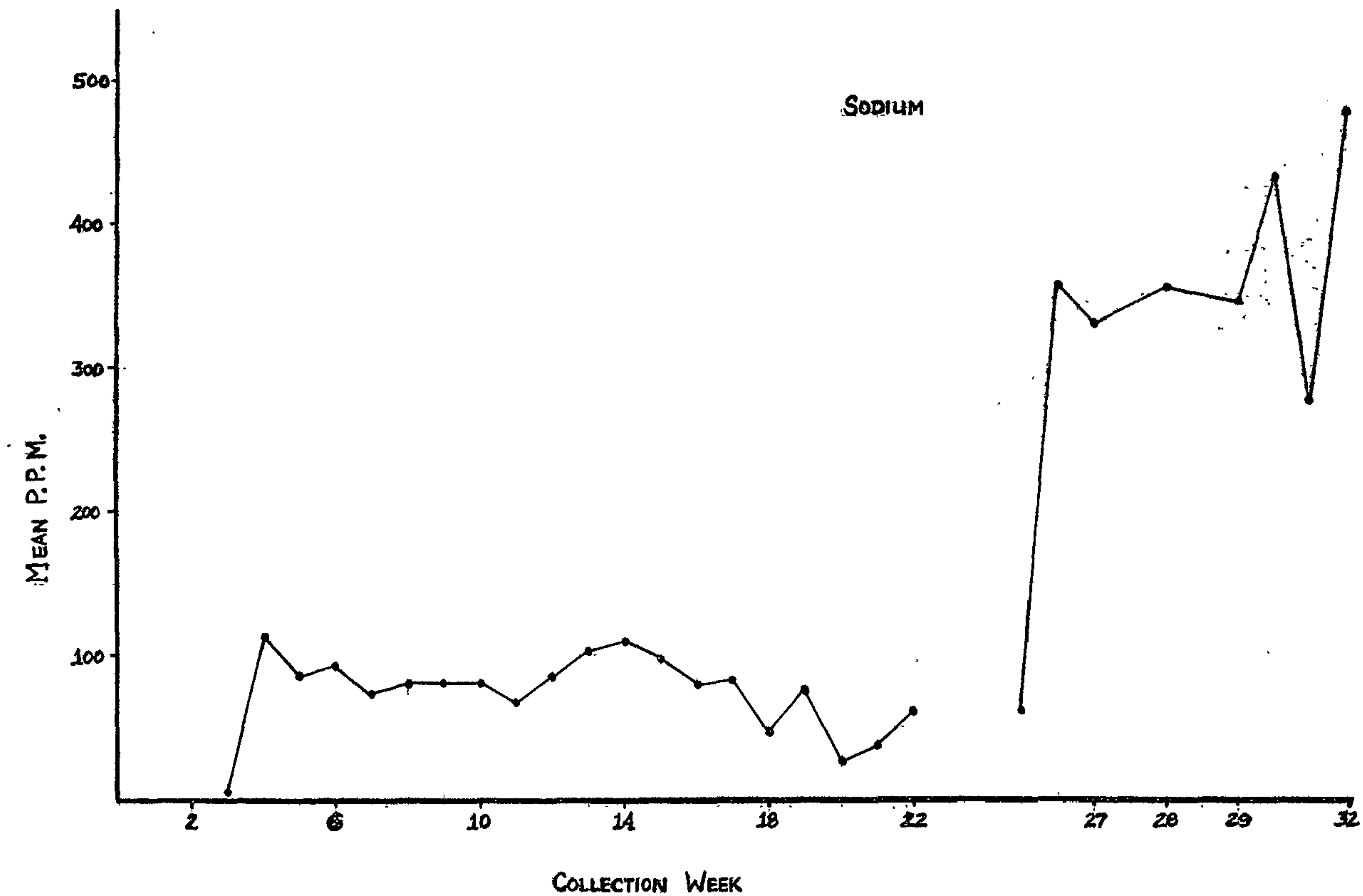
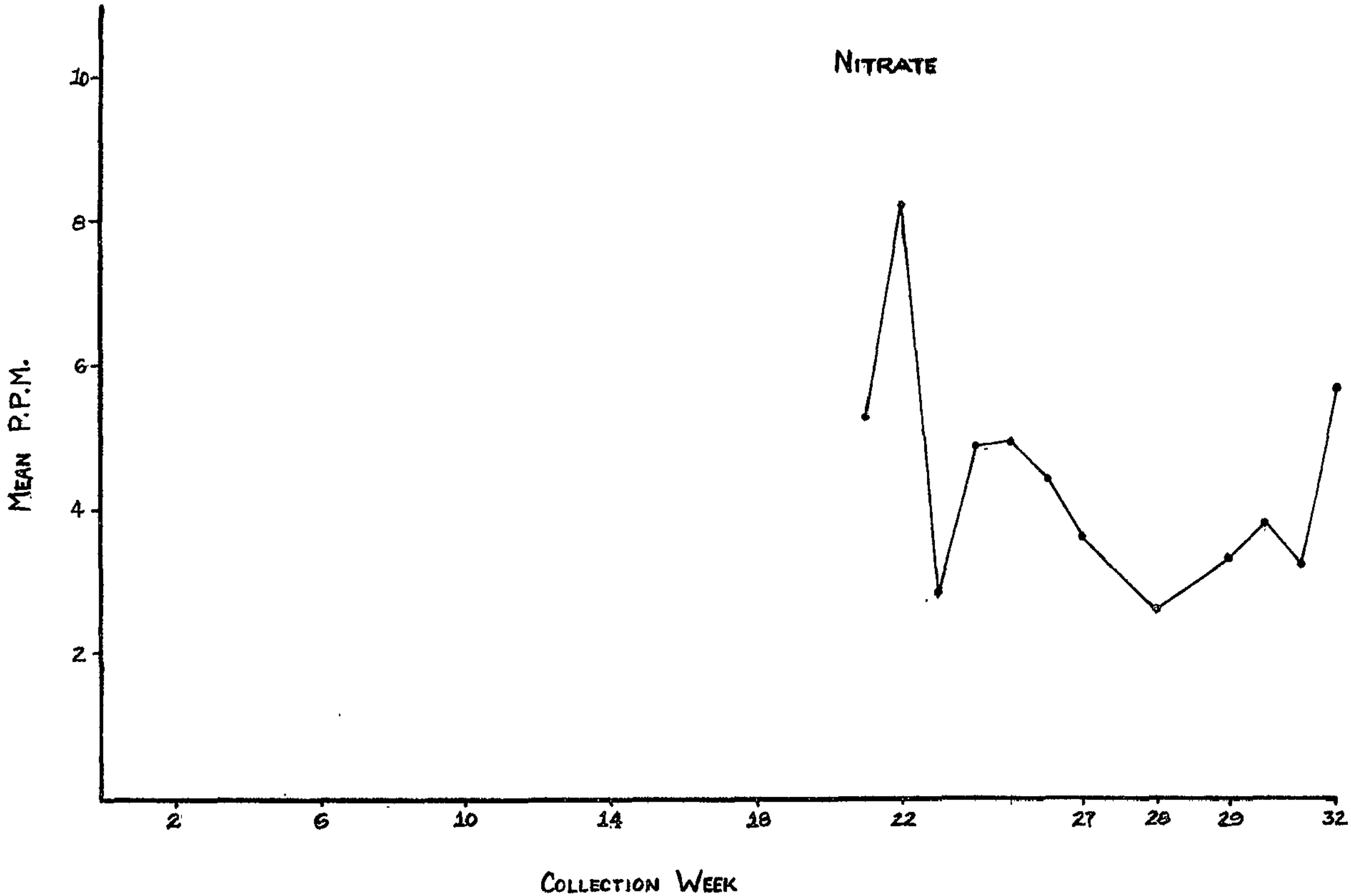

Sodium
Mean P.P.M.
500
400
300
200
100
2
6
10
14
18
22
27
28
29
32
Collection Week

Figure 41

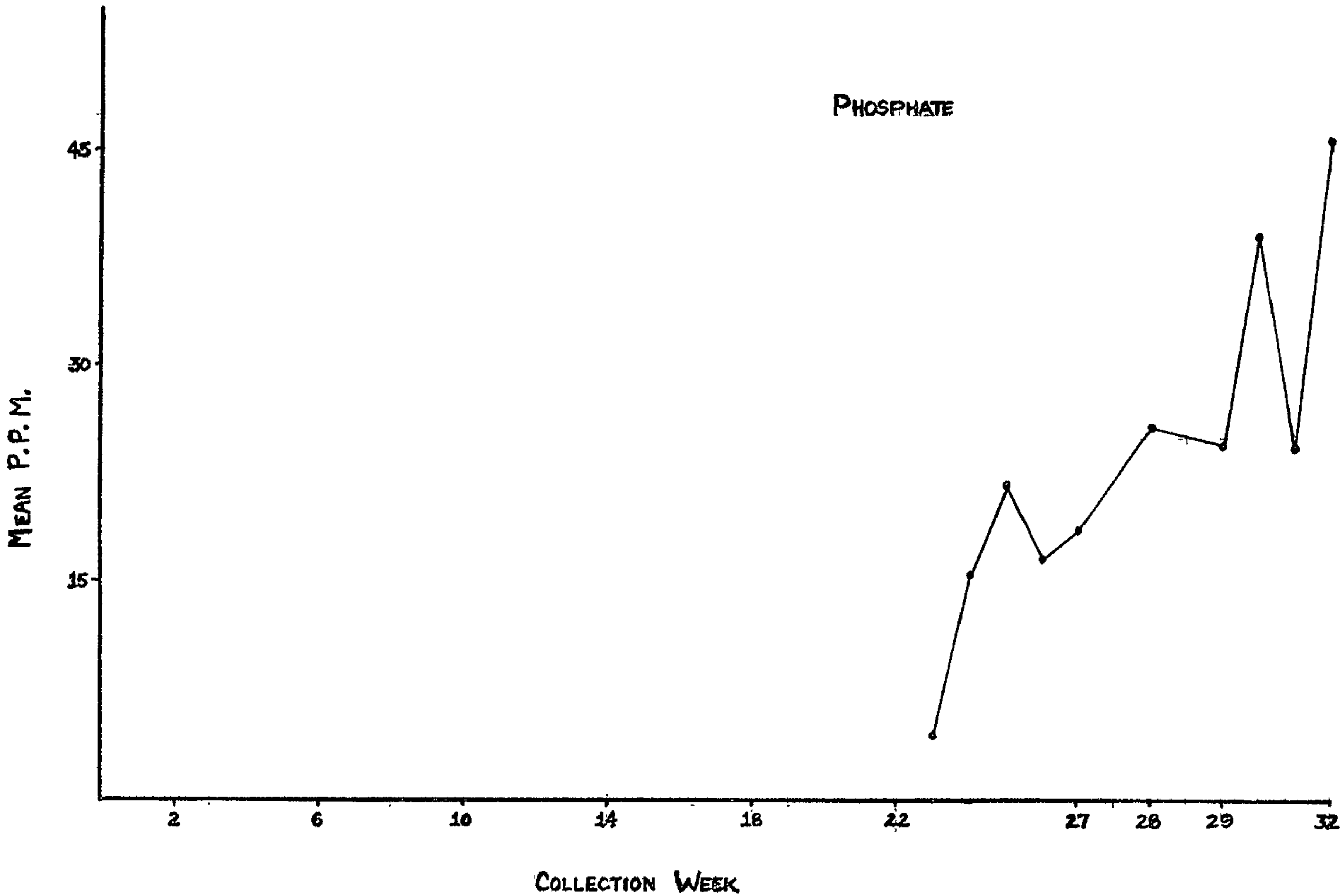
Changes in Mean Concentration of Nitrate During Study Period



Nitrate
Mean P.P.M.
10
8
6
4
2
2
6
10
14
18
22
27
28
29
32
Collection Week

Figure 42

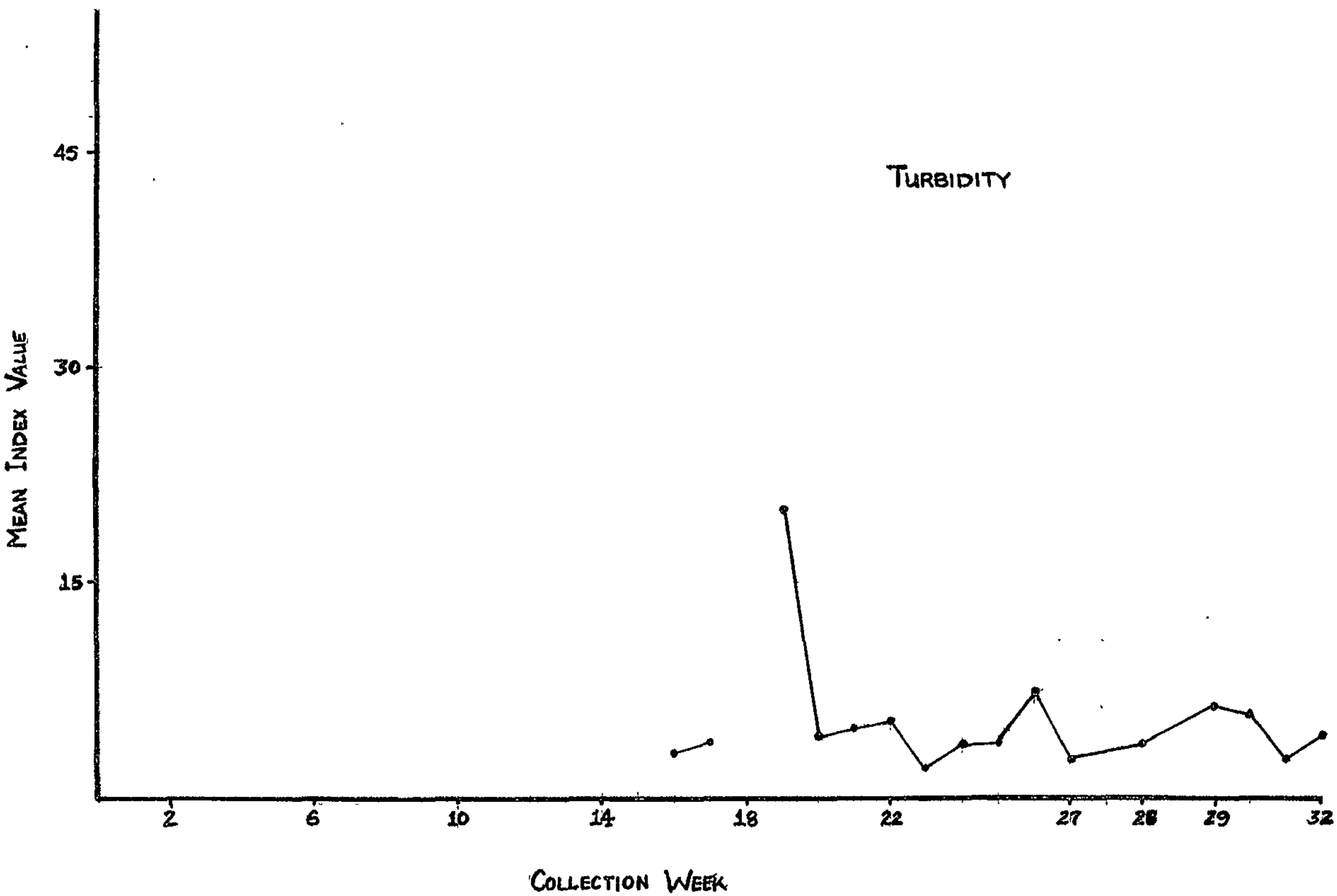
Changes in Mean Concentration of Phosphate During Study Period



Phosphate
Mean P.P.M.
45
30
15
2
6
10
14
18
22
27
28
29
32
Collection Week

Figure 43

Changes in Mean Concentration of Turbidity During Study Period


Turbidity
Mean Index Value
45
30
15
2
6
10
14
18
22
27
28
29
32
Collection Week

C. Correlation Among the Variables

Correlation coefficients were calculated for paired observations using the product-moment method. A table of critical values for correlation coefficients is included in this report. (Table 4) The table gives critical values for two levels of significance (0.01 and 0.05) for a range of paired observations. Each table of calculated coefficients in this report includes the number of paired observations in parenthesis following each correlation coefficient.

Correlation coefficients were generated for each physical, chemical and biological variable paired with the density of pupae, fourth instars and less than fourth instars. These results are given in Table 5. The coefficients are quite low and most do not differ significantly from a hypothetical coefficient of zero. A notable exception is a negative correlation between the amount of dissolved oxygen and the density of fourth instar larvae.

The coefficients in Table 5 were calculated over the entire set of data. The data were further partitioned by week and by site and correlation coefficients calculated. These results are given in Tables 6 through 31. In examining these tables a number of significant correlation coefficients can be found scattered among the large number of coefficients calculated. However, no trend or clustering of coefficients occurs.

TABLE 4. Critical Values for Correlation Coefficients

No. Paired Observations	α	Crit. Val.
3	0.05	.997
	0.01	1.000
4	0.05	.950
	0.01	.990
5	0.05	.878
	0.01	.959
6	0.05	.811
	0.01	.917
7	0.05	.754
	0.01	.874
8	0.05	.707
	0.01	.834
9	0.05	.666
	0.01	.798
10	0.05	.632
	0.01	.765
11	0.05	.602
	0.01	.735
12	0.05	.576
	0.01	.708
13	0.05	.553
	0.01	.684
14	0.05	.532
	0.01	.661
15	0.05	.514
	0.01	.641
16	0.05	.497
	0.01	.623
17	0.05	.482
	0.01	.606

TABLE 4 (Cont.) Critical Values for Correlation Coefficients

No. Paired Observations	α	Crit. Val.
18	0.05	.468
	0.01	.590
19	0.05	.456
	0.01	.575
20	0.05	.444
	0.01	.561
21	0.05	.433
	0.01	.549
22	0.05	.423
	0.01	.537
23	0.05	.413
	0.01	.526
24	0.05	.404
	0.01	.515
25	0.05	.396
	0.01	.505
26	0.05	.388
	0.01	.496
27	0.05	.381
	0.01	.487
28	0.05	.374
	0.01	.478
29	0.05	.367
	0.01	.470
30	0.05	.361
	0.01	.463
31	0.05	.355
	0.01	.456
32	0.05	.349
	0.01	.449

TABLE 4(Cont.) Critical Values for Correlation Coefficients

No. Paired Observations	α	Crit. Val.
37	0.05	.325
	0.01	.418
42	0.05	.304
	0.01	.393
47	0.05	.288
	0.01	.372
52	0.05	.273
	0.01	.354
62	0.05	.250
	0.01	.325
72	0.05	.232
	0.01	.302
82	0.05	.217
	0.01	.283
92	0.05	.205
	0.01	.267
102	0.05	.195
	0.01	.254
127	0.05	.174
	0.01	.228
157	0.05	.159
	0.01	.208
202	0.05	.138
	0.01	.181
302	0.05	.113
	0.01	.148
402	0.05	.098
	0.01	.128
502	0.05	.088
	0.01	.115

TABLE 5. Correlation Coeficients for Mosquito Densities and Various Physical and Chemical Factors

Variable	Correlation Coefficient (N)		
	Pupae	Fourth Instar	LT Fourth Instar
pH	0.037 (482)	0.023 (482)	-0.032 (479)
Dissolved Oxygen	-0.027 (482)	- .104 (482)	- .062 (479)
Conductivity	0.054 (482)	0.081 (482)	0.092 (479)
Coliform Bacteria	-0.013 (424)	0.018 (424)	-0.036 (421)
Iron	0.023 (414)	-0.021 (414)	-0.058 (411)
Copper	0.055 (413)	0.000 (413)	0.006 (410)
Zinc	0.076 (396)	0.023 (396)	0.043 (393)
Sodium	0.014 (383)	-0.067 (383)	-0.082 (380)
Inorganic Carbon	0.021 (422)	0.082 (422)	0.040 (419)
Total Carbon	-0.003 (425)	0.040 (425)	0.014 (422)
Nitrate	0.004 (131)	0.031 (131)	0.082 (131)
Phosphate	- .112 (90)	- .154 (90)	- .112 (90)
Turbidity	-0.011 (192)	-0.015 (192)	-0.015 (192)
Chlorophyl	-0.015 (144)	-0.017 (144)	-0.082 (144)

TABLE 6. Correlation of Mosquito Densities with Hydrogen Ion Concentration. (Number in parentheses is the number of paired observations)

Week No.	Correlation Coefficient		
	Pupae	Fourth Instar	LT Fourth Instar
1	**********	-.125 (15)	-.135 (15)
2	-.075 (22)	-.011 (22)	-.030 (22)
3	.076 (20)	-.042 (20)	-.210 (17)
4	.482 (19)	.096 (19)	-.388 (19)
5	-.089 (18)	.229 (18)	.249 (18)
6	-.155 (16)	-.086 (16)	-.053 (16)
7	-.170 (21)	-.074 (21)	.063 (21)
8	-.165 (25)	.047 (25)	-.105 (25)
9	.058 (17)	.012 (17)	.034 (17)
10	.083 (18)	.009 (18)	-.021 (18)
11	-.003 (21)	.260 (21)	.094 (21)
12	.300 (14)	-.030 (14)	.011 (14)
13	.500 (2)	.607 (2)	.683 (2)
14	-.067 (20)	.083 (20)	.120 (20)
15	.501 (16)	.437 (16)	.265 (16)
16	.122 (17)	.155 (17)	.373 (17)
17	**********	.253 (6)	.351 (6)
18	.002 (13)	-.126 (13)	.084 (13)
19	-.133 (14)	-.027 (14)	-.216 (14)
20	-.008 (14)	.070 (14)	.112 (14)
21	.209 (19)	.244 (19)	.309 (19)
22	.244 (18)	.578 (18)	.414 (18)
23	.283 (15)	.141 (15)	.062 (15)
24	.067 (16)	.136 (16)	.267 (16)
25	.067 (5)	-.597 (5)	-.506 (5)
26	-.040 (8)	.052 (8)	-.081 (8)
27	.175 (9)	.408 (9)	.025 (9)
28	.338 (11)	.172 (11)	.108 (11)
29	.092 (9)	-.041 (9)	.178 (9)
30	.416 (8)	.602 (8)	-.634 (8)
31	-.102 (6)	.685 (6)	.658 (6)

TABLE 7. Correlation of Mosquito Densities with Hydrogen Ion Concentration. (Number in parentheses is the number of paired observations)

Site	Pupae	Fourth Instar	LT Fourth Instar
		Correlation Coefficients	
1	.084 (26)	.042 (26)	.169 (26)
2	.013 (26)	.086 (26)	.086 (26)
3	.085 (12)	.422 (12)	.379 (12)
4	-.287 (9)	.152 (9)	.058 (9)
5	.238 (15)	.226 (15)	.132 (15)
6	.183 (15)	.096 (13)	.013 (13)
7	.173 (17)	.112 (17)	.109 (17)
8	.114 (15)	.137 (15)	.047 (15)
9	.013 (26)	.051 (26)	.052 (26)
10	.108 (22)	.060 (22)	.106 (22)
11	*********	-.387 (9)	-.422 (9)
12	.139 (8)	-.486 (8)	-.146 (7)
13	.199 (25)	-.242 (25)	-.499 (24)
14	.153 (22)	-.257 (22)	.185 (22)
15	*********	-.842 (2)	*********
16	.945 (2)	-.529 (2)	.945 (2)
17	.709 (6)	.508 (6)	.482 (6)
18	*********	*********	*********
19	*********	.145 (2)	*********
20	.190 (11)	.128 (11)	.188 (11)
21	.343 (12)	.393 (12)	.426 (12)
22	.246 (12)	-.084 (12)	.808 (12)
23	*********	*********	*********
24	.000 (1)	.000 (1)	.000 (1)
25	*********	.749 (2)	-.691 (2)
26	*********	*********	*********
27	.051 (4)	-.661 (4)	-.130 (3)
28	*********	*********	-.923 (2)
29	*********	*********	*********
30	*********	*********	*********
31	*********	*********	*********
51	-.477 (3)	.793 (3)	.935 (3)
52	.455 (3)	.595 (3)	.546 (3)
53	-.479 (14)	.085 (14)	.057 (14)
54	.175 (15)	.113 (15)	.014 (15)
56	.249 (13)	.078 (13)	-.037 (13)
57	.645 (5)	.172 (5)	.781 (5)*
58	-.174 (25)	.023 (25)	.169 (25)
59	-.101 (25)	.169 (25)	.159 (25)
60	*********	*********	*********
61	.154 (9)	-.806 (9)	.115 (9)
63	.234 (6)	.361 (6)	.264 (6)
69	.295 (5)	.196 (5)	.311 (5)
70	*********	*********	*********
62	.000 (1)	.000 (1)	.000 (1)
64	*********	*********	*********

TABLE 8. Correlation of Mosquito Densities with Dissolved Oxygen. (Number in parentheses is the number of paired observations)

Week No.	Correlation Coefficients		
	Pupae	Fourth Instar	LT Fourth Instar
1	*********	.324 (15)	.373 (15)
2	-.192 (22)	-.057 (22)	-.152 (22)
3	-.087 (20)	-.288 (20)	-.389 (17)
4	-.113 (19)	-.290 (19)	-.245 (19)
5	-.217 (18)	-.255 (18)	-.294 (18)
6	-.137 (16)	-.287 (16)	-.233 (16)
7	.081 (21)	-.137 (21)	-.195 (21)
8	-.138 (25)	-.186 (25)	-.267 (25)
9	-.175 (17)	-.191 (17)	-.173 (17)
10	-.078 (18)	-.076 (18)	-.012 (17)
11	-.101 (21)	.015 (21)	-.071 (21)
12	.265 (14)	.112 (14)	.175 (14)
13	.610 (2)	.706 (2)	.773 (12)
14	-.121 (20)	-.241 (20)	-.313 (20)
15	.393 (16)	.471 (16)	.289 (16)
16	.207 (17)	.131 (17)	-.041 (17)
17	*********	.370 (6)	.295 (6)
18	-.377 (13)	-.217 (13)	-.149 (13)
19	-.094 (14)	.033 (14)	-.084 (14)
20	-.158 (14)	-.102 (14)	-.079 (14)
21	-.177 (19)	-.397 (19)	-.397 (19)
22	.035 (18)	-.084 (18)	.006 (18)
23	-.426 (15)	-.175 (15)	-.107 (15)
24	-.239 (16)	-.079 (16)	.010 (16)
25	-.678 (5)	-.2-5 (5)	-.148 (5)
26	.660 (8)	.690 (8)	.731 (8)
27	-.171 (9)	.381 (9)	.414 (9)
28	.344 (11)	.248 (11)	.608 (11)
29	.125 (9)	.080 (9)	-.169 (9)
30	.298 (8)	.443 (8)	-.597 (8)
31	-.341 (6)	.569 (6)	.896 (6)

TABLE 9. Correlation of Mosquito Densities with Dissolved Oxygen. (Number in parentheses is the number of paired observations)

Site	Correlation Coefficients		
	Pupae	Fourth Instar	LT Fourth Instar
1	-.362 (26)	-.325 (26)	-.298 (26)
2	-.229 (26)	-.380 (26)	-.295 (26)
3	-.162 (12)	-.056 (12)	-.061 (12)
4	-.252 (9)	.743 (9)	.017 (9)
5	-.218 (15)	-.212 (15)	-.085 (15)
6	.552 (13)	-.064 (13)	-.046 (13)
7	-.002 (17)	-.297 (17)	-.225 (17)
8	-.022 (15)	-.068 (15)	-.041 (15)
9	.229 (26)	-.165 (26)	-.268 (26)
10	-.230 (22)	-.176 (22)	-.239 (22)
11	*********	-.498 (9)	-.217 (9)
12	-.451 (8)	-.451 (8)	-.501 (8)
13	.290 (25)	.113 (25)	-.063 (25)
14	.126 (22)	.229 (22)	.140 (22)
15	*********	.538 (2)	*********
16	.500 (2)	-.995 (2)	.500 (2)
17	-.289 (6)	-.581 (6)	-.571 (6)
18	*********	*********	-.333 (3)
19	*********	.049 (2)	*********
20	-.075 (11)	-.169 (11)	-.122 (11)
21	-.029 (12)	.003 (12)	-.255 (12)
22	-.014 (12)	-.182 (12)	-.022 (12)
23	*********	-.187 (9)	-.150 (9)
24	.000 (1)	.000 (1)	.000 (1)
25	*********	.500 (2)	-.884 (2)
26	*********	*********	*********
27	.178 (4)	-.521 (4)	.774 (4)
28	*********	*********	-.315 (2)
29	*********	*********	*********
30	*********	*********	*********
31	*********	*********	*********
51	-.915 (3)	.156 (3)	.500 (3)
52	.646 (3)	.641 (3)	.635 (3)
53	.137 (14)	-.230 (14)	-.212 (14)
54	-.218 (15)	-.225 (15)	-.200 (15)
56	.072 (13)	.095 (13)	-.033 (13)
57	.791 (5)	.282 (5)	.648 (5)
58	-.336 (25)	-.357 (25)	-.442 (25)
59	.020 (25)	.422 (25)	.041 (25)
60	*********	*********	*********
61	.078 (9)	-.019 (9)	.122 (9)
63	-.161 (6)	-.159 (6)	-.498 (6)
69	.143 (5)	-.503 (5)	.082 (5)
70	*********	*********	*********
62	.000 (1)	.000 (1)	.000 (1)
64	*********	*********	*********

TABLE 10. Correlation of Mosquito Densities with Conductivity. (Number in parentheses is the number of paired observations)

Week No.	Correlation Coefficients		
	Pupae	Fourth Instar	LT Fourth Instar
1	**********	.235 (15)	.233 (15)
2	.165 (22)	.147 (22)	.188 (22)
3	.576 (20)	.045 (20)	.132 (17)
4	.054 (19)	-.033 (19)	.111 (19)
5	-.011 (18)	-.031 (18)	-.022 (18)
6	-.004 (16)	-.095 (16)	.205 (16)
7	-.127 (21)	-.035 (21)	.013 (21)
8	-.057 (25)	.179 (25)	.115 (25)
9	-.056 (17)	-.063 (17)	-.045 (17)
10	-.100 (18)	-.080 (18)	-.084 (18)
11	-.100 (21)	.054 (21)	.077 (21)
12	.262 (14)	-.087 (14)	-.076 (14)
13	-.518 (2)	-.624 (2)	-.698 (2)
14	-.228 (20)	.064 (20)	.003 (20)
15	.795 (16)	.601 (16)	.612 (16)
16	-.139 (17)	.045 (17)	.403 (17)
17	**********	-.386 (6)	-.305 (6)
18	.264 (13)	-.042 (13)	-.036 (13)
19	-.021 (14)	-.228 (14)	-.204 (14)
20	.146 (14)	.114 (14)	.211 (14)
21	.045 (19)	.640 (19)	.647 (19)
22	.205 (18)	.627 (18)	.395 (18)
23	-.115 (15)	-.110 (15)	.006 (15)
24	.092 (16)	.039 (16)	.159 (16)
25	-.373 (5)	.652 (5)	.628 (5)
26	-.047 (8)	.034 (8)	-.158 (8)
27	-.040 (9)	.270 (9)	.233 (9)
28	-.266 (11)	.278 (11)	-.143 (11)
29	-.062 (9)	-.129 (9)	.011 (9)
30	-.238 (8)	-.171 (8)	.243 (8)
31	-.390 (6)	.041 (6)	.340 (6)

TABLE 11. Correlation of Mosquito Densities with Conductivity. (Number in parentheses is the number of paired observations)

Site	Correlation Coefficients		
	Pupae	Fourth Instar	LT Fourth Instar
1	-.132 (26)	-.051 (26)	.096 (26)
2	.054 (26)	.099 (26)	.128 (26)
3	.126 (12)	.257 (12)	.221 (12)
4	.435 (9)	.210 (9)	.058 (9)
5	.454 (15)	.642 (15)	.444 (15)
6	-.755 (13)	.035 (13)	.275 (13)
7	-.364 (17)	.707 (17)	.140 (17)
8	.385 (15)	.519 (15)	.437 (15)
9	-.151 (26)	.179 (26)	.371 (26)
10	.031 (22)	.140 (22)	.376 (22)
11	**********	.106 (9)	-.056 (9)
12	.049 (8)	.260 (8)	.098 (8)
13	-.210 (25)	.252 (25)	.337 (24)
14	.074 (22)	.052 (22)	.152 (22)
15	**********	**********	**********
16	.952 (2)	.088 (2)	.952 (2)
17	.527 (6)	.923 (6)	.558 (6)
18	**********	**********	-.268 (3)
19	**********	-.968 (2)	**********
20	.532 (11)	.532 (11)	.618 (11)
21	.535 (12)	-.467 (12)	.166 (12)
22	-.260 (12)	.149 (12)	.190 (12)
23	**********	-.355 (9)	-.371 (9)
24	.000 (1)	.000 (1)	.000 (1)
25	**********	-.827 (2)	-.530 (2)
26	**********	**********	**********
27	.912 (4)	-.155 (4)	-.358 (3)
28	**********	**********	.257 (2)
29	**********	**********	**********
30	**********	**********	**********
31	**********	**********	**********
51	.585 (3)	.845 (3)	.577 (3)
52	.777 (3)	.836 (3)	.823 (3)
53	.132 (14)	.212 (14)	.286 (14)
54	.415 (15)	.388 (15)	.168 (15)
56	-.070 (13)	.070 (13)	.310 (13)
57	-.442 (5)	-.324 (5)	.043 (5)
58	.127 (25)	.296 (25)	.426 (25)
59	-.199 (25)	-.103 (25)	-.071 (25)
60	**********	**********	**********
61	-.130 (9)	.067 (9)	.149 (9)
63	-.078 (6)	.192 (6)	-.025 (6)
69	-.211 (5)	.940 (5)	.082 (5)
70	**********	**********	**********
62	**********	1.000 (1)	1.000 (1)
64	**********	**********	**********

TABLE 12. Correlation of Mosquito Densities with Coliform Bacteria. (Number in parentheses is the number of paired observations)

Week No.	Correlation Coefficients		
	Pupae	Fourth Instar	LT Fourth Instar
1	*********	*********	*********
2	.726 (13)	-.256 (13)	-.227 (13)
3	-.104 (20)	.153 (20)	-.221 (17)
4	-.109 (19)	-.242 (19)	-.140 (19)
5	.319 (16)	-.114 (16)	-.218 (16)
6	-.186 (15)	-.022 (15)	-.318 (15)
7	.080 (20)	-.073 (20)	-.022 (20)
8	.019 (25)	.026 (25)	-.085 (25)
9	.078 (17)	-.054 (17)	-.101 (17)
10	-.065 (18)	-.137 (18)	-.239 (18)
11	-.115 (21)	-.141 (21)	-.152 (21)
12	-.281 (14)	.643 (14)	.613 (14)
13	-.868 (2)	-.925 (2)	-.958 (2)
14	.040 (19)	-.065 (19)	-.062 (19)
15	-.221 (16)	-.146 (16)	.044 (16)
16	-.119 (15)	.525 (15)	.355 (15)
17	*********	.861 (6)	.875 (6)
18	-.168 (12)	-.184 (12)	-.122 (12)
19	.329 (14)	.438 (14)	.389 (14)
20	-.042 (14)	.054 (14)	-.110 (14)
21	.044 (19)	.128 (19)	.116 (19)
22	-.111 (13)	.063 (13)	.392 (13)
23	.340 (7)	.217 (7)	.180 (7)
24	.043 (16)	-.022 (16)	-.058 (16)
25	.000 (1)	.000 (1)	.000 (1)
26	.097 (8)	.169 (8)	-.022 (8)
27	.657 (9)	-.148 (9)	-.276 (9)
28	.105 (6)	.172 (6)	.136 (6)
29	.133 (9)	-.099 (9)	-.328 (9)
30	-.218 (6)	-.044 (6)	.813 (6)
31	-.417 (5)	-.676 (5)	-.464 (5)

TABLE 13. Correlation of Mosquito Densities with Coliform Bacteria. (Number in parentheses is the number of paired observations)

Site	Correlation Coefficients		
	Pupae	Fourth Instar	LT Fourth Instar
1	.091 (24)	.087 (24)	.048 (24)
2	-.116 (25)	.038 (25)	-.143 (25)
3	.087 (11)	.477 (11)	.469 (11)
4	-.299 (8)	.610 (8)	.934 (8)
5	-.222 (14)	-.236 (14)	-.004 (14)
6	-.297 (13)	-.201 (13)	.124 (13)
7	.063 (16)	.289 (16)	.269 (16)
8	-.187 (14)	-.342 (14)	-.240 (14)
9	.123 (26)	-.170 (26)	-.133 (26)
10	-.026 (21)	-.210 (21)	-.362 (21)
11	*********	-.322 (9)	-.136 (9)
12	.216 (8)	.150 (8)	.146 (7)
13	-.073 (24)	-.180 (24)	-.211 (23)
14	-2.20 (21)	-.303 (21)	-.247 (21)
15	*********	1.000 (1)	*********
16	-.746 (2)	-.485 (6)	-.746 (2)
17	-.185 (6)	.556 (6)	-.280 (3)
18	*********	*********	.126 (3)
19	*********	-.306 (2)	*********
20	-.367 (8)	-.318 (8)	-.442 (8)
21	-.173 (10)	-.138 (10)	-.301 (10)
22	-.340 (12)	-.145 (12)	.310 (12)
23	*********	-.290 (6)	-.503 (6)
24	.000 (1)	.000 (1)	.000 (1)
25	*********	.945 (2)	-.363 (2)
26	*********	*********	*********
27	-.340 (4)	.905 (4)	1.000 (3)
28	*********	*********	.803 (2)
29	*********	*********	*********
30	*********	*********	*********
31	*********	*********	*********
51	*********	.000 (1)	*********
52	*********	.000 (1)	*********
53	.107 (9)	-.036 (9)	-.116 (9)
54	-.095 (11)	-.099 (11)	-.120 (11)
56	-.054 (10)	-.140 (10)	-.253 (10)
57	-.461 (3)	-.395 (3)	.449 (3)
58	.295 (19)	-.049 (19)	-.163 (19)
59	-.122 (20)	-.065 (20)	-.206 (20)
60	*********	*********	*********
61	-.141 (7)	.848 (7)	-.101 (7)
63	.081 (4)	.207 (4)	-.068 (4)
69	-.328 (3)	.964 (3)	.944 (3)
70	*********	*********	*********

TABLE 14. Correlation of Mosquito Densities with Iron Concentration. (Number in Parentheses is the number of paired observations)

Site	Correlation Coefficients: Pupae	Fourth Instar	LT Fourth Instar
1	.073 (24)	.246 (24)	.052 (24)
2	.339 (24)	.264 (24)	.243 (24)
3	-.264 (11)	-.339 (11)	-.287 (11)
4	-.229 (7)	.644 (7)	-.286 (7)
5	-.056 (14)	.153 (14)	.774 (14)
6	.065 (12)	.017 (12)	-.217 (12)
7	.171 (15)	.171 (15)	.122 (15)
8	-.014 (13)	.102 (13)	.067 (13)
9	.253 (25)	.408 (25)	.145 (25)
10	-.009 (22)	.328 (22)	-.146 (22)
11	*********	.153 (9)	.433 (9)
12	.376 (7)	.575 (7)	.619 (6)
13	.137 (24)	.308 (24)	.052 (23)
14	.053 (21)	.060 (21)	.100 (21)
15	*********	*********	*********
16	*********	*********	*********
17	-.287 (5)	-.487 (5)	-.334 (5)
18	*********	*********	.187 (3)
19	*********	*********	**********
20	.754 (9)	.306 (9)	.833 (9)
21	.023 (10)	-.041 (10)	.416 (10)
22	.744 (12)	.057 (12)	-.100 (12)
23	*********	-.206 (7)	-.265 (7)
24	.000 (1)	.000 (1)	.000 (1)
25	**********	.954 (2)	.262 (2)
26	*********	*********	*********
27	-.152 (4)	-.295 (4)	-.736 (3)
28	*********	*********	.667 (2)
29	*********	*********	*********
30	*********	*********	*********
31	*********	*********	*********
51	*********	*********	*********
52	*********	*********	*********
53	-.170 (11)	-.158 (11)	-.178 (11)
54	-.083 (10)	-.139 (10)	-.012 (10)
56	-.252 (10)	.483 (10)	.647 (10)
57	-.086 (3)	-.136 (3)	-.596 (3)
58	.458 (19)	-.142 (19)	.035 (19)
59	.099 (19)	.031 (19)	.208 (19)
61	.436 (6)	.295 (6)	.412 (6)
63	.875 (4)	.925 (4)	-.003 (4)
69	.335 (4)	.926 (4)	-.112 (4)
70	*********	*********	*********

TABLE 15. Corrleation of Mosquito Densities with Iron Concentration. (Number in parentheses is the number of paired observations)

Week No.	Correlation Coefficients		
	Pupae	Fourth Instar	LT Fourth Instar
1	*********	*********	**********
2	*********	*********	**********
3	.294 (20)	.074 (20)	.263 (17)
4	.030 (18)	-.009 (18)	-.345 (18)
5	.102 (17)	.007 (17)	.013 (18)
6	.827 (16)	.339 (16)	.625 (16)
7	.809 (21)	.025 (21)	.252 (21)
8	.089 (25)	.315 (25)	.138 (25)
9	.249 (17)	-.267 (17)	-.218 (17)
10	-.064 (18)	-.051 (18)	.124 (18)
11	-.112 (21)	-.072 (21)	-.107 (21)
12	.259 (14)	-.312 (14)	-.316 (14)
13	*********	*********	*********
14	.226 (19)	-.047 (19)	-.011 (19)
15	-.213 (16)	-.077 (16)	-.114 (16)
16	.428 (16)	.387 (16)	.165 (16)
17	*********	*********	*********
18	.214 (12)	-.241 (12)	-.305 (12)
19	-.249 (14)	-.100 (14)	-.282 (14)
20	-.199 (14)	-.157 (14)	-.199 (14)
21	.183 (12)	-.247 (12)	-.271 (12)
22	-.176 (18)	.069 (18)	-.149 (18)
23	-.165 (15)	-.066 (15)	-.036 (15)
24	.097 (11)	-.085 (11)	-.184 (18)
25	.000 (1)	.000 (1)	.000 (1)
26	.060 (8)	.064 (8)	.124 (8)
27	.075 (8)	.539 (8)	.874 (8)
28	.009 (11)	.022 (11)	.382 (11)
29	.329 (6)	-.155 (6)	-.030 (6)
30	.231 (7)	-.138 (7)	-.347 (7)
31	.262 (6)	-.164 (6)	.197 (6)

TABLE 16. Correlation of Mosquito Densities with Copper Concentration. (Number in parentheses is the number of paired observations)

Site	Correlation Coefficients		
	Pupae	Fourth Instar	LT Fourth Instar
1	*********	-.159 (24)	-.189 (24)
2	-.179 (24)	-.254 (24)	-.239 (24)
3	.066 (11)	-.030 (11)	-.037 (11)
4	.119 (7)	-.323 (7)	-.227 (7)
5	.208 (14)	.655 (14)	.262 (14)
6	.213 (12)	-.219 (12)	-.232 (12)
7	-.454 (15)	-.382 (15)	-.338 (15)
8	-.299 (14)	-.067 (14)	-.285 (14)
9	-.077 (25)	.054 (25)	-.050 (25)
10	-.287 (22)	.139 (22)	.096 (22)
11	*********	-.486 (9)	-.208 (9)
12	.082 (7)	-.431 (7)	-.175 (6)
13	-.169 (24)	-.374 (24)	-.292 (23)
14	.157 (21)	.437 (21)	.326 (21)
15	*********	*********	*********
16	*********	*********	*********
17	1.000 (5)	.688 (5)	.911 (5)
18	*********	*********	1.000 (3)
19	*********	*********	**********
20	-.320 (9)	-.111 (9)	-.277 (9)
21	.355 (10)	.438 (10)	.006 (10)
22	-.087 (12)	-.160 (12)	.149 (12)
23	*********	-.323 (7)	-.153 (7)
24	*********	*********	*********
25	*********	*********	*********
26	*********	*********	*********
27	.719 (4)	-.650 (4)	-.556 (3)
28	*********	*********	-.500 (2)
29	*********	*********	*********
30	*********	*********	*********
31	*********	*********	*********
51	*********	*********	*********
52	*********	*********	*********
53	.262 (11)	-.072 (11)	.237 (11)
54	.340 (10)	.370 (10)	.420 (10)
56	.286 (10)	-.030 (10)	-.207 (10)
57	.274 (3)	.313 (3)	.492 (3)
58	-.219 (18)	.151 (18)	.074 (18)
59	.220 (19)	-.131 (19)	.175 (19)
60	*********	*********	*********
61	.157 (6)	.366 (6)	.202 (6)
63	.793 (4)	.360 (4)	-.498 (4)
69	.507 (4)	.353 (4)	.526 (4)
70	*********	*********	*********

TABLE 17. Correlation of Mosquito Densities with Copper Concentration. (Number in parentheses is the number of paired observations)

Week No.	Correlation Coefficients		
	Pupae	Fourth Instar	LT Fourth Instar
1	*********	*********	*********
2	*********	*********	*********
3	.238 (20)	-.200 (20)	-.015 (17)
4	.398 (18)	.182 (18)	-.196 (18)
5	.296 (17)	.458 (17)	.086 (17)
6	-.177 (16)	-.260 (16)	-.021 (16)
7	.157 (21)	-.190 (21)	.097 (21)
8	-.168 (25)	-.191 (25)	-.316 (25)
9	-.095 (16)	.281 (16)	.097 (16)
10	-.258 (17)	-.241 (17)	-.174 (17)
11	-.143 (21)	.087 (21)	-.009 (21)
12	-.153 (14)	-.151 (14)	-.147 (14)
13	*********	*********	*********
14	-.036 (19)	-.132 (19)	.149 (19)
15	.060 (16)	-.061 (16)	-.055 (16)
16	.135 (16)	-.290 (16)	-.476 (16)
17	*********	-.355 (6)	-.278 (6)
18	-.134 (13)	-.260 (13)	-.324 (13)
19	.528 (14)	.247 (14)	.331 (14)
20	.052 (14)	.063 (14)	.022 (14)
21	-.164 (12)	-.149 (12)	-.100 (12)
22	-.404 (18)	.239 (18)	.142 (18)
23	.631 (15)	.221 (15)	.196 (15)
24	-.257 (11)	-.244 (11)	-.256 (11)
25	.000 (1)	.000 (1)	.000 (1)
26	*********	*********	*********
27	-.145 (8)	.126 (8)	-.318 (8)
28	.375 (11)	-.012 (11)	-.008 (11)
29	-.269 (6)	-.326 (6)	-.364 (6)
30	.485 (7)	.666 (7)	.588 (7)
31	-.274 (6)	-.230 (6)	-.192 (6)

TABLE 18. Correlation of Mosquito Densities with Zinc Concentration. (Number in parentheses is the number of paired observations)

Week No.	Correlation Coefficients		
	Pupae	Fourth Instar	LT Fourth Instar
1	**********	**********	**********
2	**********	**********	**********
3	.348 (20)	-.220 (20)	-.151 (17)
4	.393 (18)	.118 (18)	-.257 (18)
5	.346 (16)	.075 (17)	-.031 (17)
6	.859 (16)	.361 (16)	.627 (16)
7	.823 (21)	.008 (21)	.333 (21)
8	.029 (25)	.176 (25)	.272 (25)
9	.146 (17)	.541 (17)	.351 (17)
10	-.063 (18)	.066 (18)	.322 (18)
11	-.067 (21)	-.265 (21)	-.132 (21)
12	.351 (14)	-.002 (14)	.018 (14)
13	**********	**********	**********
14	.817 (19)	.410 (19)	.612 (19)
15	-.165 (16)	-.285 (16)	-.127 (16)
16	-.069 (16)	.362 (16)	.370 (16)
17	**********	.054 (6)	.026 (6)
18	-.101 (13)	-.207 (13)	-.102 (13)
19	-.030 (14)	.178 (14)	-.002 (14)
20	-.055 (14)	.091 (14)	-.039 (14)
21	-.402 (12)	-.157 (12)	-.141 (12)
22	**********	**********	**********
23	-.179 (15)	-.220 (15)	-.216 (15)
24	.184 (11)	.031 (11)	.071 (11)
25	1.000 (1)	1.000 (1)	1.000 (1)
26	.510 (8)	.518 (8)	.457 (8)
27	.494 (8)	.012 (8)	-.112 (8)
28	-.073 (11)	-.264 (11)	.220 (11)
29	.630 (6)	.601 (6)	-.004 (6)
30	-.183 (7)	.230 (7)	.102 (7)
31	-.276 (6)	-.659 (6)	-.426 (6)

TABLE 19. Correlation of Mosquito Densities with Zinc Concentration. (Number in parentheses is the number of paired observations)

Site	Correlation Coefficients		
	Pupae	Fourth Instar	LT Fourth Instar
1	.091 (23)	.166 (23)	.217 (23)
2	.024 (23)	.534 (23)	.246 (23)
3	.060 (10)	.311 (10)	.399 (10)
4	-.168 (7)	.063 (7)	-.748 (7)
5	-.105 (13)	-.039 (13)	.848 (13)
6	-.184 (11)	.009 (11)	-.237 (11)
7	.175 (14)	.283 (14)	.238 (14)
8	-.030 (13)	-.133 (13)	-.072 (13)
9	-.082 (24)	-.192 (24)	-.228 (24)
10	-.289 (21)	-.237 (21)	-.143 (21)
11	**********	-.386 (9)	.238 (9)
12	.862 (7)	.764 (7)	.964 (6)
13	-.016 (23)	.008 (23)	-.105 (20)
14	-.101 (20)	-.158 (20)	-.105 (20)
15	**********	**********	**********
16	.000 (1)	.000 (1)	.000 (1)
17	**********	-.035 (4)	-.048 (4)
18	**********	**********	.821 (3)
19	**********	**********	**********
20	-.331 (8)	-.094 (8)	-.435 (8)
21	.357 (9)	.314 (9)	.244 (9)
22	.139 (12)	-.245 (12)	.177 (12)
23	**********	-.095 (7)	-.553 (7)
24	1.000 (1)	1.000 (1)	1.000 (1)
25	**********	.945 (2)	-.363 (2)
26	**********	**********	**********
27	.516 (4)	-.975 (4)	-.968 (3)
28	**********	**********	-.500 (2)
29	**********	**********	**********
30	**********	**********	**********
51	**********	**********	**********
52	**********	**********	**********
53	-.148 (10)	.470 (10)	.127 (10)
54	.109 (10)	.148 (10)	.056 (10)
56	-.253 (9)	-.126 (9)	.225 (9)
57	.285 (3)	.276 (3)	.074 (3)
58	.428 (18)	-.049 (18)	.314 (18)
59	-.014 (18)	.180 (18)	.070 (18)
61	.358 (6)	.421 (6)	.331 (6)
63	.796 (4)	.394 (4)	-.261 (4)
69	-.726 (3)	.320 (3)	.293 (3)
70	**********	**********	**********

TABLE 20. Correlation of Mosquito Densities with Sodium Concentration. (Number in parentheses is the number of paired observations)

Week No.	Correlation Coefficients		
	Pupae	Fourth Instar	LT Fourth Instar
1	**********	**********	**********
2	**********	**********	**********
3	-.341 (19)	-.182 (19)	-.407 (16)
4	.314 (19)	.216 (19)	-.223 (19)
5	-.131 (17)	-.128 (17)	-.191 (17)
6	-.115 (16)	-.165 (16)	.114 (16)
7	.204 (20)	.041 (20)	.162 (20)
8	-.046 (25)	.116 (25)	.071 (25)
9	.056 (17)	-.024 (17)	.044 (17)
10	.082 (18)	.100 (18)	.034 (18)
11	.108 (21)	.050 (21)	.148 (21)
12	-.129 (14)	.001 (14)	-.017 (14)
13	.726 (2)	.808 (2)	.863 (2)
14	-.130 (15)	.017 (15)	-.048 (15)
15	.798 (16)	.740 (16)	.644 (16)
16	-.125 (12)	-.081 (12)	-.055 (12)
17	**********	-.376 (6)	-.317 (6)
18	.114 (13)	-.097 (13)	-.138 (13)
19	-.006 (14)	-.380 (14)	-.279 (14)
20	.189 (14)	.134 (14)	.200 (14)
21	-.014 (19)	.512 (19)	.510 (19)
22	.041 (13)	.034 (13)	.008 (13)
23	**********	**********	**********
24	**********	**********	**********
25	-.158 (2)	.732 (2)	1.000 (2)
26	-.268 (8)	-.242 (8)	-.321 (8)
27	.003 (9)	-.301 (9)	-.049 (9)
28	-.370 (6)	-.146 (6)	-.264 (6)
29	-.300 (9)	-.148 (9)	-.462 (9)
30	.525 (7)	.497 (7)	.212 (7)
31	-.229 (6)	-.227 (6)	-.213 (6)

TABLE 21. Correlation of Mosquito Densities with Sodium Concentration. (Number in parentheses is the number of paired observations)

Site	Correlation Coefficients: Pupae	Fourth Instar	LT Fourth Instar
1	-.143 (22)	-.122 (22)	-.182 (22)
2	-.151 (22)	-.263 (22)	-.240 (22)
3	-.212 (8)	-.305 (8)	-.296 (8)
4	.380 (7)	-.729 (7)	.205 (7)
5	-.173 (14)	-.146 (14)	.599 (14)
6	-.288 (10)	.274 (10)	.099 (10)
7	-.234 (13)	-.016 (13)	.045 (13)
8	-.114 (12)	-.168 (12)	-.120 (12)
9	.014 (23)	-.092 (23)	-.141 (23)
10	-.092 (19)	-.133 (19)	-.222 (19)
11	**********	-.268 (9)	-.137 (9)
12	.088 (8)	-.065 (8)	.064 (7)
13	.033 (22)	-.208 (22)	-.258 (21)
14	-.156 (19)	-.260 (19)	-.221 (19)
15	**********	**********	**********
16	1.000 (1)	1.000 (1)	1.000 (1)
17	-.023 (5)	.692 (5)	.288 (5)
18	**********	**********	.027 (3)
19	**********	**********	**********
20	-.225 (7)	.076 (7)	-.334 (7)
21	.620 (8)	.287 (8)	-.362 (8)
22	.447 (11)	-.051 (11)	-.081 (11)
23	**********	.401 (7)	.324 (7)
24	.000 (1)	.000 (1)	.000 (1)
25	**********	.996 (2)	.053 (2)
26	**********	**********	**********
27	.726 (4)	-.567 (4)	-.048 (3)
28	**********	**********	-.347 (2)
29	**********	**********	**********
30	**********	**********	**********
31	**********	**********	**********
51	**********	.000 (1)	**********
52	**********	.000 (1)	**********
53	-.160 (9)	-.132 (9)	-.088 (9)
54	.059 (11)	.071 (11)	-.105 (11)
56	.755 (8)	-.401 (8)	.251 (8)
57	-.541 (3)	-.514 (3)	.010 (3)
58	-.178 (18)	-.217 (18)	-.247 (18)
59	.825 (17)	-.112 (17)	-.245 (17)
60	**********	**********	**********
61	.113 (7)	-.005 (7)	.124 (7)
63	-.899 (4)	-.695 (4)	.415 (4)
69	-.576 (2)	-.649 (2)	-.702 (2)
70	**********	**********	**********

TABLE 22. Correlation of Mosquito Densities with Inorganic Carbon Concentration. (Number in parentheses is the number of paired observations)

Week No.	Correlation Coefficients		
	Pupae	Fourth Instar	LT Fourth Instar
1	**********	**********	**********
2	.274 (22)	.226 (22)	.234 (22)
3	.136 (20)	.744 (20)	.292 (17)
4	.148 (19)	.241 (19)	.152 (19)
5	-.181 (17)	-.081 (17)	.195 (17)
6	-.118 (16)	-.126 (16)	.053 (16)
7	**********	**********	**********
8	-.009 (25)	.266 (25)	.475 (25)
9	-.272 (16)	-.212 (16)	-.238 (16)
10	-.048 (18)	-.021 (18)	-.037 (18)
11	.041 (9)	-.325 (9)	-.268 (9)
12	-.015 (14)	-.188 (14)	-.210 (14)
13	-.505 (2)	-.612 (2)	-.687 (2)
14	-.298 (19)	.055 (19)	-.098 (19)
15	-.029 (16)	-.010 (16)	-.045 (16)
16	-.225 (16)	-.195 (16)	.084 (16)
17	**********	-.383 (6)	-.234 (6)
18	.246 (13)	-.078 (13)	.037 (13)
19	.023 (14)	-.155 (14)	-.126 (14)
20	.138 (14)	.151 (14)	.196 (14)
21	.055 (18)	.728 (18)	.734 (18)
22	.154 (18)	.663 (18)	.451 (18)
23	.235 (15)	.291 (15)	.453 (15)
24	.132 (16)	.044 (16)	.043 (16)
25	.144 (4)	.348 (4)	.265 (4)
26	-.189 (8)	-.187 (8)	-.111 (8)
27	-.371 (9)	.166 (9)	.290 (9)
28	-.390 (11)	.005 (11)	-.251 (11)
29	.188 (6)	.151 (6)	.202 (6)
30	.419 (7)	.389 (7)	.499 (7)
31	.335 (6)	.089 (8)	-.463 (6)

TABLE 23. Correlation of Mosquito Densities with Inorganic Carbon Concentration. (Number in parentheses is the number of paired observations)

Site	Correlation Coefficients		
	Pupae	Fourth Instar	LT Fourth Instar
1	-.428 (24)	-.352 (24)	-.470 (24)
2	.094 (23)	.160 (23)	.143 (23)
3	.008 (11)	.021 (11)	.007 (11)
4	-.294 (6)	.127 (6)	-.336 (6)
5	.279 (12)	.121 (12)	.173 (12)
6	.570 (12)	.594 (12)	.272 (12)
7	-.168 (15)	.284 (15)	.279 (15)
8	.395 (13)	.475 (13)	.435 (13)
9	-.293 (25)	-.064 (25)	.170 (25)
10	.100 (21)	.353 (21)	.364 (21)
11	**********	.820 (7)	.629 (7)
12	.123 (8)	.281 (8)	.184 (7)
13	.087 (24)	-.103 (24)	.044 (23)
14	-.057 (21)	-.073 (21)	-.051 (21)
15	**********	.000 (1)	**********
16	.999 (2)	-.259 (2)	.999 (2)
17	.499 (5)	.861 (5)	.433 (5)
18	**********	**********	**********
19	**********	.784 (2)	**********
20	.782 (10)	.722 (10)	.812 (10)
21	-.016 (10)	-.121 (10)	-.312 (10)
22	-.404 (9)	-.188 (9)	-.203 (9)
23	**********	.761 (7)	.356 (7)
24	1.000 (1)	1.000 (1)	1.000 (1)
25	**********	-.997 (2)	.045 (2)
26	**********	**********	**********
27	-.158 (4)	.642 (4)	.573 (3)
28	**********	**********	.630 (2)
29	**********	**********	**********
30	**********	**********	**********
31	**********	**********	**********
51	1.000 (1)	1.000 (1)	1.000 (1)
52	1.000 (1)	1.000 (1)	1.000 (1)
53	.488 (12)	.209 (12)	.317 (12)
54	.401 (12)	.403 (12)	.086 (12)
56	.424 (11)	.454 (11)	.181 (11)
57	-.327 (4)	-.190 (4)	.169 (4)
58	.178 (21)	.397 (21)	.470 (21)
59	-.129 (20)	-.378 (20)	-.317 (20)
61	.453 (7)	.430 (7)	.487 (7)
63	.547 (5)	.012 (5)	.514 (5)
69	-.310 (5)	.987 (5)	-.024 (5)
70	**********	**********	**********
62	**********	**********	**********

TABLE 24. Correlation of Mosquito Densities with Total Carbon Concentration. (Number in parentheses is the number of paired observations)

Week No.	Correlation Coefficients		
	Pupae	Fourth Instar	LT Fourth Instar
1	**********	*********	*********
2	.008 (22)	-.101 (22)	-.133 (22)
3	.262 (20)	.205 (20)	..312 (17)
4	-.035 (19)	-.054 (19)	-.152 (19)
5	-.009 (17)	.096 (17)	.007 (17)
6	-.169 (16)	.129 (16)	.025 (16)
7	*********	*********	*********
8	-.006 (25)	.201 (25)	.330 (25)
9	.067 (18)	-.218 (17)	-.098(17)
10	-.004 (18)	.004 (18)	.044 (18)
11	-.101 (11)	-.102 (11)	.154 (11)
12	-.334 (14)	-.161 (14)	-.2-4 (14)
13	-.362 (2)	-.479 (2)	-.564 (2)
14	-.113 (2)	.041 (19)	-.198 (19)
15	.019 (16)	.037 (16)	.111 (16)
16	-.196 (16)	.282 (16)	-.082 (16)
17	*********	.447 (6)	-.279 (6)
18	.335 (13)	.017 (13)	.042 (13)
19	-.050 (14)	-.213 (14)	-.229 (14)
20	.281 (14)	.306 (14)	.324 (14)
21	.011 (19)	.673 (19)	.686 (19)
22	.187 (18)	.642 (18)	.402 (18)
23	.320 (15)	.309 (15)	.446 (15)
24	.196 (16)	.100 (16)	.074 (16)
25	.351 (4)	.196 (4)	.103 (4)
26	.191 (8)	.218 (8)	.126 (8)
27	-.369 (9)	.295 (9)	.310 (9)
28	-.532 (10)	-.102 (10)	-.241 (10)
29	.239 (6)	.242 (6)	.261 (6)
30	.385 (7)	.356 (7)	.464 (7)
31	.364 (6)	.200 (6)	-.110 (6)

TABLE 25. Correlation of Mosquito Densities with Total Carbon Concentration. (Number in parentheses is the number of paired observations)

Site	Correlation Coefficients		
	Pupae	Fourth Instar	LT Fourth Instar
1	.081 (25)	-.010 (25)	-.015 (25)
2	.207 (24)	.374 (24)	.258 (24)
3	-.176 (11)	-.267 (11)	-.127 (11)
4	-.419	.471 (7)	-.353 (7)
5	.033 (13)	-.355 (13)	-.057 (13)
6	-.573 (11)	.222 (11)	.299 (11)
7	-.291 (14)	.139 (14)	.171 (14)
8	.193 (13)	.191 (13)	.228 (13)
9	-.134 (24)	.411 (24)	.540 (24)
10	-.094 (20)	-.007 (20)	.105 (20)
11	*********	.524 (7)	*********
12	-.190 (7)	.296 (7)	-.099 (6)
13	-.084 (23)	.033 (23)	.012 (22)
14	-.181 (20)	.315 (20)	-.221 (20)
15	*********	*********	*********
16	*********	1.000 (1)	*********
17	.240 (5)	.678 (5)	.464 (5)
18	*********	*********	*********
19	*********	.295 (2)	*********
20	.696 (10)	.667 (10)	.724 (10)
21	.029 (10)	-.014 (10)	.894 (10)
22	-.202 (11)	-.170 (11)	-.167 (11)
23	*********	.727 (7)	.289 (7)
24	1.000 (1)	1.000 (1)	1.000 (1)
25	*********	-.901 (2)	-.401 (2)
26	*********	*********	*********
27	-.216 (4)	.684 (4)	-.109 (3)
28	*********	*********	-.331 (2)
29	*********	*********	*********
30	*********	*********	*********
31	*********	*********	*********
51	1.000 (1)	1.000 (1)	1.000 (1)
52	1.000 (1)	1.000 (1)	1.000 (1)
53	.332 (13)	.037 (13)	.120 (13)
54	-.055 (13)	-.045 (13)	.275 (13)
56	-.338 (12)	-.017 (17)	.154 (12)
57	-.433 (5)	-.375 (5)	.060 (5)
58	.593 (22)	.108 (22)	.176 (22)
59	-.420 (20)	-.163 (20)	-.723 (20)
60	*********	*********	*********
61	-.041 (8)	-.294 (8)	-.098 (8)
62	*********	*********	*********
63	-.328 (5)	.058 (5)	-.417 (5)
69	-.267 (5)	.970 (5)	.054 (5)
70	*********	*********	**********

BLE 26. Correlation of Mosquito Densities with Nitrate Concentration. (Number in parentheses is the number of paired observations)

ek No.	Correlation Coefficients		
	Pupae	Fourth Instar	LT Fourth Instar
1	**********	**********	**********
2	**********	**********	**********
3	**********	**********	**********
4	**********	**********	**********
5	**********	**********	**********
6	**********	**********	**********
7	**********	**********	**********
8	**********	**********	**********
9	**********	**********	**********
10	**********	**********	**********
11	**********	**********	**********
12	**********	**********	**********
13	**********	**********	**********
14	**********	**********	**********
15	**********	**********	**********
16	**********	**********	**********
17	**********	**********	**********
18	**********	**********	**********
19	**********	**********	**********
20	**********	**********	**********
21	-.022 (19)	-.151 (19)	-.152 (19)
22	-.023 (18)	.131 (18)	.044 (18)
23	.210 (15)	.177 (15)	.303 (15)
24	-.080 (15)	-.076 (15)	-.002 (15)
25	.372 (4)	.432 (4)	.344 (4)
26	-.029 (8)	.019 (8)	.018 (8)
27	-.501 (9)	.060 (9)	-.089 (9)
28	.226 (11)	.374 (11)	-.124 (11)
29	-.134 (9)	.019 (9)	-.005 (9)
30	-.069 (7)	.018 (7)	.655 (7)
31	.076 (6)	-.237 (6)	-.392 (6)

TABLE 27. Correlation of Mosquito Densities with Nitrate Concentration. (Number in parentheses is the number of paired observations)

Site	Correlation Coefficients: Pupae	Fourth Instar	LT Fourth Instar
1	-.457 (9)	-.192 (9)	.359 (9)
2	-.453 (8)	-.213 (8)	.809 (8)
3	-.087 (6)	-.244 (6)	-.423 (6)
4	**********	**********	**********
5	1.000 (1)	1.000 (1)	.000 (1)
6	-.744 (3)	-.396 (3)	.885 (3)
7	.258 (3)	.223 (3)	.413 (3)
8	.754 (4)	.799 (4)	.696 (4)
9	-.367 (9)	.596 (9)	.517 (9)
10	-.459 (7)	.585 (7)	.779 (7)
11	**********	**********	**********
12	**********	**********	**********
13	.011 (9)	-.036 (9)	-.039 (9)
14	.650 (6)	.295 (6)	.567 (6)
15	**********	**********	**********
16	**********	**********	**********
17	**********	**********	**********
18	**********	**********	**********
19	**********	**********	**********
20	.420 (6)	.044 (6)	.462 (6)
21	-.518 (5)	-.500 (5)	-.275 (5)
22	1.000 (1)	1.000 (1)	1.000 (1)
23	**********	**********	**********
24	**********	**********	**********
25	**********	**********	**********
26	**********	**********	**********
27	**********	**********	**********
28	**********	**********	**********
29	**********	**********	**********
30	**********	**********	**********
31	**********	**********	**********
51	**********	**********	**********
52	**********	**********	**********
53	.847 (5)	.068 (5)	.323 (5)
54	.086 (8)	.554 (8)	-.227 (8)
56	1.000 (1)	.000 (1)	.000 (1)
57	**********	**********	**********
58	.466 (8)	.804 (8)	.642 (8)
59	.144 (6)	.697 (6)	.861 (6)
60	**********	**********	**********
61	**********	**********	**********
63	**********	**********	**********
69	.143 (2)	.359 (9)	.128 (2)
70	**********	**********	**********

LE 28. Correlation of Mosquito Densities with Phosphate Concentration. (Number in parentheses is the number of paired observations)

k No.	Correlation Coefficients: Pupae	Fourth Instar	LT Fourth Instar
1	**********	**********	**********
2	**********	**********	**********
3	**********	**********	**********
4	**********	**********	**********
5	**********	**********	**********
6	**********	**********	**********
7	**********	**********	**********
8	**********	**********	**********
9	**********	**********	**********
10	**********	**********	**********
11	**********	**********	**********
12	**********	**********	**********
13	**********	**********	**********
14	**********	**********	**********
15	**********	**********	**********
16	**********	**********	**********
17	**********	**********	**********
18	**********	**********	**********
19	**********	**********	**********
20	**********	**********	**********
21	**********	**********	**********
22	**********	**********	**********
23	.445 (15)	.662 (15)	.663 (15)
24	.252 (16)	.148 (16)	.125 (16)
25	1.000 (1)	1.000 (1)	1.000 (1)
26	-.192 (8)	.099 (8)	-.139 (8)
27	-.902 (9)	-.070 (9)	.248 (9)
28	-.296 (11)	-.220 (11)	-.291 (11)
29	.232 (9)	.071 (9)	.602 (9)
30	-.192 (7)	.088 (7)	.228 (7)
31	.189 (6)	-.085 (6)	-.376 (6)

TABLE 29. Correlation of Mosquito Densities with Phosphate Concentration. (Number in parentheses is the number of paired observations)

Site	Correlation Coefficients Pupae	Fourth Instar	LT Fourth Instar
1	-.618 (7)	-.596 (7)	-.653 (7)
2	.639 (6)	.292 (6)	-.348 (6)
3	-.466	-.322 (4)	.124 (4)
4	**********	**********	**********
5	**********	**********	**********
6	.000 (1)	.000 (1)	.000 (1)
7	1.000 (1)	.000 (1)	.000 (1)
8	-.443 (2)	.846 (2)	-.453 (2)
9	.344 (7)	.055 (7)	-.867 (7)
10	-.618 (5)	-.359 (5)	-.818 (5)
11	**********	**********	**********
12	**********	**********	**********
13	-.179 (7)	-.116 (7)	-.164 (7)
14	-.206 (4)	-.648 (4)	-.217 (4)
15	**********	**********	**********
16	**********	**********	**********
17	**********	**********	**********
18	**********	**********	**********
19	**********	**********	**********
20	.492 (4)	.558 (4)	.383 (4)
21	-.527 (4)	-.574 (4)	-.888 (4)
22	**********	**********	**********
23	**********	**********	**********
24	**********	**********	**********
25	**********	**********	**********
26	**********	**********	**********
27	**********	**********	**********
28	**********	**********	**********
29	**********	**********	**********
30	**********	**********	**********
31	**********	**********	**********
51	**********	**********	**********
52	**********	**********	**********
53	-.396 (4)	-.505 (4)	-.512 (4)
54	-.167 (6)	-.430 (6)	-.116 (6)
56	**********	**********	**********
57	**********	**********	**********
58	.267 (5)	.294 (5)	-.408 (5)
59	.004 (4)	.113 (4)	-.038 (4)
60	**********	**********	**********
61	**********	**********	**********
63	**********	**********	**********
69	**********	.000 (1)	.000 (1)
70	**********	**********	**********

3LE 30. Correlation of Mosquito Densities with Turbidity. (Number in parentheses is the number of paired observations)

ek No.	Correlation Coefficients		
	Pupae	Fourth Instar	LT Fourth Instar
1	**********	**********	**********
2	**********	**********	**********
3	**********	**********	**********
4	**********	**********	**********
5	**********	**********	**********
6	**********	**********	**********
7	**********	**********	**********
8	**********	**********	**********
9	**********	**********	**********
10	**********	**********	**********
11	**********	**********	**********
12	**********	**********	**********
13	**********	**********	**********
14	-.142 (10)	-.124 (10)	-.274 (10)
15	**********	**********	**********
16	-.106 (14)	-.161 (14)	-.305 (14)
17	I (6)	-.756 (6)	-.777 (6)
18	**********	**********	**********
19	-.160 (14)	-.162 (14)	-.187 (14)
20	-.065 (14)	-.007 (14)	-.042 (14)
21	-.085 (19)	.084 (19)	.075 (19)
22	-.128 (18)	-.081 (18)	-.122 (18)
23	.099 (15)	.256 (15)	.278 (15)
24	.392 (16)	.344 (16)	.236 (16)
25	-.213 (4)	.351 (4)	.328 (4)
26	.917 (8)	.879 (8)	.956 (8)
27	-.093 (6)	.832 (6)	.929 (6)
28	-.326 (11)	-.148 (11)	-.059 (11)
29	-.129 (9)	-.264 (9)	-.211 (9)
30	-.321 (7)	-.321 (7)	-.274 (7)
31	-.192 (6)	-.182 (6)	.011 (6)

TABLE 31. Correlation of Mosquito Densities with Turbidity. (Number in parentheses is the number of paired observations)

Site	Correlation Coefficients		
	Pupae	Fourth Instar	LT Fourth Instar
1	.228 (12)	.126 (12)	-.193 (12)
2	-.128 (12)	.729 (12)	.335 (12)
3	-.343 (9)	.030 (9)	-.013 (9)
4	**********	**********	**********
5	-.652 (4)	-.612 (4)	-.379 (4)
6	-.162 (4)	-.196 (4)	-.065 (4)
7	-.273 (6)	.625 (6)	.666 (6)
8	.270 (8)	.297 (8)	.339 (8)
9	-.193 (12)	.039 (12)	.088 (12)
10	-.407 (9)	.184 (9)	.411 (9)
11	**********	.883 (2)	**********
12	**********	**********	**********
13	.954 (12)	.814 (12)	.389 (12)
14	.195 (9)	.064 (9)	.207 (9)
15	**********	**********	**********
16	**********	**********	**********
17	1.000 (1)	1.000 (1)	1.000 (1)
18	**********	**********	**********
19	**********	**********	**********
20	-.512 (7)	.224 (7)	.662 (7)
21	.316 (4)	.205 (4)	-.402 (4)
22	.553 (5)	-.122 (5)	-.100 (5)
23	**********	**********	**********
24	**********	**********	**********
25	**********	**********	**********
26	**********	**********	**********
27	**********	**********	**********
28	**********	**********	**********
29	**********	**********	**********
30	**********	**********	**********
31	**********	**********	**********
51	**********	**********	**********
52	**********	**********	**********
53	-.043 (9)	.231 (9)	.123 (9)
54	-.313 (8)	-.424 (8)	-.139 (8)
56	-.526 (4)	-.707 (4)	-.617 (4)
57	.000 (1)	.000 (1)	.000 (1)
58	.693 (13)	.168 (13)	.178 (13)
59	-.112 (10)	-.155 (10)	-.149 (10)
60	**********	**********	**********
61	**********	**********	**********
63	**********	**********	**********
69	-.230 (3)	-.810 (3)	-.241 (3)
70	**********	**********	**********

Discussion

The thesis of this report is that a female C. p. quinquefasciatus undergoes a selection process before depositing a raft of eggs on a body of water. This implies that she can sense and differentiate among those chemical and physical features of a pool that will allow (or at least not interfere with) the successful development of larvae to the adult stage. This is not to say that she applies volition-oriented behavior. Instead the argument is projected that her behavior is instinctive, under genetic control, and occurs as the result of natural selection.

If the factors used by a female mosquito in selecting larval habitats were known, the suitability of a site for the larvae could be predicted by determining the presence and/or level of this factor at the site. This problem could be approached using two experimental designs. The first is to place a female (or small population of females) in a cage with a choice of oviposition sites. With appropriate replication and experimental design one could demonstrate what preferences for larval site are shown by a female mosquito.

The mosquito literature is dotted with these "cage-type" experiments. Generally, only a few factors are considered, these rarely in more than a few combinations of factors and levels of factor. In the very simplified environment it has been quite possible to demonstrate that female mosquitoes are able to discriminate between and among sites which differ chemically and/or physically.

Under natural conditions the female mosquito is faced with discriminating among many variables simultaneously. To set up a cage-experiment setting each factor at several levels with replication would be prohibitive in space and supplies not to mention manpower. However, one could then systematically search for the various types and levels of interaction among the variables. The range of levels for each factor could be determined from data on natural habitats.

Even though the above experimental design could help untangle the interactions that might influence site selection by ovipositing females, might well be difficult to extrapolate to a natural environment. This difficulty arises from the fact that in many natural settings the "whole" seems on first examination to be greater than the sum of the "parts". This paradox is resolved when interactions are uncovered and defined.

Because of thse arguments, we chose to use an analytical approach to the problem of site selection by female mosquitoes. We first examined the variation among several sites to determine if there existed any strong correlations between mosquito densities and these chemical and physical factors. Using this approach, however, we were able to uncover only a single significant correlation. The negative relationship between the density of fourth instar larvae and amount of dissolved oxygen is difficult to interpret since larvae use air siphons for respiration. This correlation may result from some other interaction which remains to be uncovered.

Little significance can be attached to the scattered correlation coefficients which are shown to be significantly different from a hypothetical coefficient of zero. There is no trend or clustering in the occurrence of these coefficients. That is, they do not appear in groups or in runs.

Our selection of sites may have influenced the correlation coefficients. We selected sites which physically seemed suitable for development of the mosquito. However, a number of the sites never had mosquitoes developing in them during the course of the study. Since the study areas were quite small, it seems reasonable to assume that the sites were discovered by gravid female mosquitoes. We, therefore, conclude that the sites were not used by females due to the presence (or absence) of certain physical, chemical, or biological constituents. However, the lack of any <u>strong</u> correlations between mosquito densities and the several variables examined suggests that the selection of a site by a female mosquito is severely confounded by the number of interacting factors.

It has been long recognized that *C. p. quinquefasciatus* uses sewage-contaminated water for larval development. We, therefore, were surprised to find no correlation between coliform bacteria and mosquito densities. However, site selection was such that all sites appeared to be suitable superficially for development of this mosquito. If we had included "pure" water, for example, samples from swimming pools, then we could expect to find a significant correlation between bacteria and mosquito densities. Our interest, though, was in uncovering these factors in sites which correlated with change in mosquito densities. Accordingly, we directed our attention only toward sites which appeared suitable for larval development.

In conclusion, it appears that among the variables examined there are none that correlate strongly with mosquito densities. The application of remote sensing technology does not appear feasible.

C. Screwworm, *Cochliomyia homnivorax*

As noted in the introductory material, the screwworm studies were initiated largely because of an in-house NASA interest in this subject. The screwworm fly female very seldom deposits her eggs in humans. While there have been several epidemic outbreaks described in the literature these have generally been quite small (50 cases or so), circumscribed, and limited in time. The real effect on human health and well-being may be the secondary effect of deprivation of protein. However, this does not appear to have been a serious problem, even before the advent of the more potent pesticides and more recently the sterile-male release program. Therefore, the problem of the screwworm may better be regarded as essentially a problem for veterinary parasitology, animal husbandry and agricultural economics.

At the time the initial discussions were held with NASA personnel concerning the request for proposal for the present contract several points were brought forward:

1. That NASA had concluded, or substantially so, agreements with agricultural authorities in Mexico, and with the U.S. Department of Agriculture, for a field station to be located in Northern Mexico, with the U.S.D.A. to supply automotive transport and technician assistance. The primary requisite for this station, tentatively to be located in Linares, Nuevo Leon,

was that it permit a sampling of a transect from relatively high altitude to sea-level on the Gulf of Mexico - on the premise, or report, that screwworms managed to overwinter in protected pockets along such a transect, and then to spread into adjacent areas with the onset of favorable weather conditions.

2. That none of the then available School of Public Health faculty had the requisite knowledge of Diptera ecology and population dynamics, combined with the ability to speak Spanish. The latter was believed to be essential for field studies.

On these bases, and with the understanding that he was to move with his family in a relatively short time to the field site at Linares, the School of Public Health recruited Dr. Paul Rodriguez from a postdoctoral fellowship at the University of Notre Dame. Dr. Rodriguez' primary training was in the field of insect ecology and genetics. He spent a period of orientation at the Johnson Spacecraft Center and prepared a bibliography on screwworm ecology which was presented in the Second Quarterly Report and will not be presented again here. In addition, Dr. Rodriguez spent a period of familiarization at the Johnson Spacecraft Center.

Prior to Dr. Rodriguez' arrival in Houston Doctors Hacker and

Scanlon participated in discussions at the U.S.D.A. Screwworm Eradication Project laboratories at Mission, Texas (24 May 1972). At these meetings it became apparent that final arrangements for cooperative USDA-NASA-SPH studies could not be completed until at least January 1973, providing more than enough time for Dr. Rodriguez to become familiar with the situation. A number of consultations were also held with Mr. William Barrett, then with the Harris County Mosquito Control District, who had considerable experience with the biology and ecology of screwworms in Texas. Among the other items discussed with Mr. Barrett was the difficulty and expense of sampling relatively low levels of screwworm populations using available traps or the animal wounding method. Since the primary purpose of the study was to understand the population dynamics of the species, as related to overwintering and subsequent multiplication and dispersal, it appeared that a rather large effort would be needed to gather statistically significant data; and consequently that rather extensive cooperation of U.S.D.A. and Mexican authorities would be required. The screwworm flies tend to disperse over a rather wide range, and tend to be found in rather small absolute numbers as compared with other higher flies in the same habitats. The latter unfortunately tends to enter bait traps in much larger number, and must be separated from the primary screwworm flies. Use of wounded penned animals is somewhat more selective as a sampling method, but obviously this requires considerable logistic support. The proposal had not envisioned the assignment of anyone other than Dr. Rodriguez to the project.

Dr. Rodriguez participated in planning meetings at NASA-Goddard Space Center in July 1972, and at Mission, Texas in August of that year. At the GSC meetings the roles of Nimbus and Itos satellites in the Mexican project were discussed, and the cooperation of U.S.D.A. was again explored. At the Mission meeting, and at a later meeting there in September, more detailed plans were discussed. However, the primary attention of the U.S.D.A. group at that time was focused on the breakdown of the sterile fly barrier, which had permitted some 66,000 cases to occur in cattle in Texas alone to that point. The U.S.D.A.-Mission scientists indicated that they were willing to cooperate in long term studies of the application of remote sensing to screwworm ecology, but that their primary efforts must be directed to solving the question of why the sterile male technique had apparently broken down.

Dr. Rodriguez visited Mexico City, Chapongo, and the test site area, between Puebla and Veracruz from 28 November to 5 December 1972. In Mexico City meetings were held during the first two days with the Agricultural Attache at the U.S. Embassy and with Ingeniero Sergio Padilla Guzman of the Comision Nacional Del Expacia Exterior. Possible arrangements and procedures for residency of Dr. Rodriguez in Mexico were discussed with the former. Remote sensing and the screwworm ecology project in the Veracruz area were discussed with the latter, Ing. Padilla.

On 30 November contacts were made with members (specifically Doctors Heflin and Werring) of APHIS in Mexico - a joint commission for Hoof and Mouth Disease and Screwworm Eradication. Several hours were spent talking to Dr. Marco A. Villasenor, director of the Mexican Screwworm Eradication Program. Further discussion on remote sensing and the screwworm project were held in a joint meeting with Dr. Villasenor and Ing. Sergio Padillas. A verbal cooperative agreement was established. A meeting with Dr. Manuel Mendez Palma of CONACYT (Consejo Nacional de Ciencia y Technologia) later that afternoon proved to be encouraging. His office was informed about remote sensing and the screwworm ecological study program was also discussed.

The following day (1 December 1972) meetings were held at the Agricultural College in Chapingo (approximately 20 miles Southeast of Mexico City) with INIA officials and staff. The program was again discussed with Dr. Rodolfo Moreno D., the sub-director; Dr. Juan Antonio Sifuentes A., Head of the Department of Entomology, and Ing. Hermenegildo Velasco Pascual, entomologist at the Centro de Investigaciones Agricolas del Sureste, Campo Cotaxtla, Veracruz.

Much enthusiasm was displayed by Doctors Moreno and Sifuentes and Ing. Velasco; tentative arrangements were made to secure some of the necessary personnel and equipment to carry out the project.

On 2 December the central and southern regions of the proposed test site (Cordoba to La Tinaja to Tierra Blanca to Presa

Miguel Aleman) were visited and studied extensively. During a major portion of the trip Dr. Rodriguez was able to discuss the screwworm problem in that area with Ing. Velasco. Laboratory facilities and equipment were checked at Campo Cataxtla that evening. The laboratories are in sad shape and in need of painting and reconditioning. Although a small "functional" screwworm lab is available, equipment for the most part is meager. A small weather station is located within Campo Cataxtla.

The northern section (Veracruz to Huatusco to Cordoba to Veracruz) was observed and studied thoroughly on 3 December. Before returning to Mexico City on 4 December, a meeting with Ing. Velasco was held at Campo Cotaxtla, approximately 18 miles east of Veracruz. Ing. Jose Alavez Ramirez was introduced to the group. Brief discussions were also held with Dr. Juan Villanueva Barradas, Director, Centro de Investigaciones Agricolas del Sureste, Campo Cotaxtla. Among several items, budgetary expenses, personnel, materials and equipment were discussed with Ings. Velasco and Alavez. Pilot experiments were planned for January or February of 1973. Living costs, housing, family accommodations were looked into at Cordoba and Fortin de las Flores before returning to Mexico City.

Another Joint Technical Conference - Screwworm Eradication Program at Mission, Texas was attended on 6 December 1972. The current screwworm situation was reported for Texas, the Southwest, Puerto Rico and Mexico. The progress of the Mexico Program, current and future research on the screwworm fly, and budget and financing were also discussed.

A follow-up meeting with U.S.D.A. officials was held that evening after the Joint Conference. The main purpose of the meeting was to try again to implement the screwworm ecological study in Mexico. The main items discussed were general results of the Mexico meetings, the three proposed test sites in Mexico, U.S.D.A. participation in the screwworm ecology study, and the financing of the project. It was apparent that U.S.D.A. was unwilling to support the remote sensing project in the Linares or Veracruz test site areas. Rather a possible program, U.S.D.A. suggested, could be developed in the Tampico test site area if the ecological - remote sensing studies were coordinated with sterile fly drop - release investigations. The ecological studies, however, would be secondary since the sterile fly research was of top priority for the screwworm eradication program. This was contrary to the concept on which the original project was based - ground truth studies on native flies or reliable sensor - detectable characteristics of the environment associated with key factors in the life history of the screwworm fly.

In December 1972, Dr. Scanlon visited Dr. Bushland, in charge of investigations at the U.S.D.A.-Mission screwworm laboratory, and Mr. Taylor, regional director for the Agricultural Research Service in South Texas, to determine whether or not a field station, and field studies could be established at a suitable site in North Mexico in the near future. Even with the intrusions of the flies into Texas, California, Arizona, etc. it would not be possible to conduct the studies originally contracted for in these states, since the flies probably do not overwinter at present in the United States.

Dr. Bushland expressed a continued desire to cooperate, but again emphasized the necessity for U.S.D.A. to limit its resources as much as possible to the present barrier zone, and to determine the reasons for failure of the sterile-male release program. He stated that he would appreciate Dr. Rodriguez' help in such studies. Dr. Bushland again emphasized the logistical and financial problems involved in the type of detailed population studies which would be required for the work proposed, and doubted that he could divert much of his limited resources to this project. Dr. Taylor indicated that he was hopeful of supplying field assistance, but that the decision really rested with Dr. Bushland.

Dr. Rodriguez submitted his resignation effective 31 March 1973. The short time remaining until the proposed end of the period of field work (July, 1972), or the end of the entire contract period (October, 1973) did not make it feasible to obtain the services of another full-time investigator. Therefore, Mr. William Barrett was taken on as a consultant. Mr. Barrett was either sole or joint author on a number of the most important studies on screwworm ecology which were published prior to World War II when the screwworm problem was at its height in Texas. Mr. Barrett spent several days at JSC, and indicated his belief that the primary utility of remote sensing in the screwworm project (sterile male release) might be the detection of small ponds, streams, sinks and other residual water bodies during dry periods. Presumably the survival of the flies might be enhanced in such sites, and selected release of sterile males might be more effective in such areas. Up until at least recently males were released on a rectangular pattern, rather than at more targeted sites. However, as beneficial as this possible use for remote sensing may be, it does not address directly the original question posed in this contract.

At the time Mr. Barrett was employed as a consultant a number of meteorological instruments were purchased, at the request of the technical monitor, and dispatched to Mexico. These were to be placed along the transect which was originally envisioned in the project. The instruments were delivered to Dr. Barnes in Mexico, and it is understood that at the time of the writing of this final report some initial field work has been undertaken.

D. Malaria

In the response to request for proposal malaria was mentioned as one of the serious public health problems which might have several ecological or epidemiological aspects which might be studied by remote sensing. Preliminary arrangements were made for study of two such possibilities in Thailand, in cooperation with the SEATO Medical Research Laboratory (U.S. Army Medical Service) and the World Health Organization. Both organizations expressed interest in the possibilities, and both had technical help to provide "ground "truth". Travel funds for the investigator (Dr. Scanlon) were included in the proposal. However, immediately prior to the departure of the investigator we were informed by the technical monitor that NASA-JSC had no interest in the project, neither from the technical viewpoint, nor from the geographical viewpoint.

Dr. Scanlon was in Indonesia during late June and July as a consultant to the U.S. Embassy concerning malaria programs, and took the opportunity to evaluate several possible applications of remote sensing in malaria programs there and in Thailand - at no expense to the contract. These are: the location of nidal breeding sites of the important malaria vector *Anopheles balabacensis*, and the human population study mentioned above.

One of the earliest suggested applications of remote sensing considered by the Public Health Ecology section of MSC was the detection of breeding sites of *Anopheles balabacensis* in Southeast Asia. This was based on the report by Scanlon and Sandhinand that this species was often associated with the spiny palm *Salacca*. *A. balabacensis* appears to be one of the most efficient malaria vectors known. It is a very serious problem in many countries in Southeast Asia, in forested areas or forest margins, and is not usually susceptible to the usual malaria eradication procedures. Any system which might deliniate its breeding habitats in jungle areas would assist in larval control measures should these be necessary. The association with *Salacca* has not been investigated further in detail. However, Dr. D.G. Gould and his associates at the U.S. Army Medical Component-SEATO (SEATO Medical Research Laboratory) have been investigating malaria transmitted by this species in the Bu Phram Valley of Thailand for several years. *A. balabacensis* appears to be associated with *Salacca* there but insufficient work has been done to give a clear-cut answer. During the monsoon season the mosquito spreads through the valley and presents a serious problem. During the dry season, however, the vector tends to contract back to wetter areas, and it is believed that at the height of the dry season it may be restricted to limited areas along the hills surrounding the valley. Since control of the adult stages has proven to be extremely difficult it is believed that if these remaining pockets of breeding could be located easily at the height of the dry season it might be possible to attack the breeding sites. Finding them by ground survey is an extremely difficult task due to the heavy vegetation, lack of trails and the tremendous amount of time required.

Arrangements have been made by Dr. Gould to have U.S. Air Force units in Thailand make surveillance flights over the area at at least monthly intervals. Late in the report period Dr. Gould visited the School and JSC to discuss details of the projected flights, including the choice of cameras, films and operational altitude. Mr. Olsen advised him and may participate in interpreting the films obtained. The basic hypothesis involved is that trees growing in the wet areas where A. balabacensis survives the dry season should have a detectable difference in reflectivity of the leaves. It may also be possible to follow up on the original suggestion of a vegetative association with Salacca (or some other plant).

One of the early problems encountered in malaria eradication programs was the finding and treatment of the shelters of fringe or mobile populations. It should be emphasized that the basic doctrine of malaria eradication requires that every human shelter receive an application of residual insecticide, at approximately six monthly intervals, and for as many cycles as required to interrupt transmission.

As early as 1961 an expert panel of malariologists noted that failures to obtain eradication might often be due to the difficulty in locating fringe populations of humans, particularly those who spent part of the year in forested areas away from their permanent villages. Anyone who has worked in tropical areas has encountered these problems, and will realize the virtual impossibility of locating such population units by ground reconnaissance alone. It is a frequent experience in such areas to follow a trail toward what should be a human settlement, only to discover on arrival that the population in question has moved some time before. The 1961 ICA panel noted that - "In some countries, planes or helicopters may be borrowed or hired for use in scouting out isolated habitations. In all malaria eradication programs it is important to have adequate provision for finding all fringe habitations in which persons may become infected with malaria."

Despite this admonition, there is relatively little evidence that aircraft have been used in this role. Furthermore, under some jungle conditions (where the transmission problem may be most acute) it may be very difficult to obtain up-to-date evidence. Temporary shelters are often built and abandoned in a matter of months - while the planning for a spray campaign over such difficult terrain may require up-to-date information. Frequently, spraying is possible only over short seasonal periods. Much of what has been said above about malaria may extend to other disease control campaigns as well - any, in fact, which require contacting individuals and small family groups.

In Thailand, the investigator has frequently encountered the problem of contacting isolated groups in the jungle, and has noted that almost always such groups, even when engaged in clandestine operations, such as illegal cutting of timber, keep a small fire going day and night. The same observation was made during this period in the forested mountainous area of West Java. To locate dwellings in an area where malaria transmission was continuing despite many rounds of spraying it was necessary to walk for over four hours. On arriving in the area an attempt was made to determine the number of houses present, but no accurate assessment could be made because of the limited time available, the multiplicity of trails with intervening jungle and hills. One might follow one of these trails for an hour or two only to find an abandoned hut or two. Even with highly dedicated personnel the incentive for this wears out rapidly. Anopheles balabacensis was collected in this area of West Java - but other vectors are important in other parts of Asia, Africa and Tropical America.

All of the houses in the West Java site had fires burning day and night. NASA photograph number S-67-14774 illustrates an experiment in which NASA and the Forest Service showed small fires under dense stands of spruce - detected by far infrared imagery. It appears that this might provide an accurate and rapid method for locating humans in temporary shelters, even under heavy vegetation. Such imagery could be combined with aerial photographs or topographic maps, to guide ground parties to active centers of isolated human populations. The Bendix corporation is producing a thermal mapper (TMLN-2) which appears to be particularly useful in detection of forest fires. Among their exhibits is a photograph of the Kenai Spur Road, 18 August 1969, showing burning and smoldering fires which were impossible to find by visual means (altitude 2000 feet, 150 MPH, 3.7-5.5 microns). This is the type of apparatus which could give the information needed; particularly since at the settings used roads, houses and vegetative areas are easily distinguishable. (Figure 1)

Before the trip to Thailand, the Chairman of the Malaria Section of the World Health Organization in Geneva was contacted and tentative permission was obtained to enlist the assistance of WHO malaria personnel in Thailand in assessing the importance of fringe or scattered human populations in their problem areas of continued transmission. An effort was also to be made to determine if suitable equipment and aircraft might be available in-country which might be used for this purpose (probably through military civic action). None of these activities were undertaken, due to withdrawal of official NASA support, and WHO Geneva was informed that the project had been suspended.

Subsequently, several photographic missions have been flown by the U.S. Air Force in Thailand to study the vegetation types in the Bu Phram Valley. None of the results are available here at present.

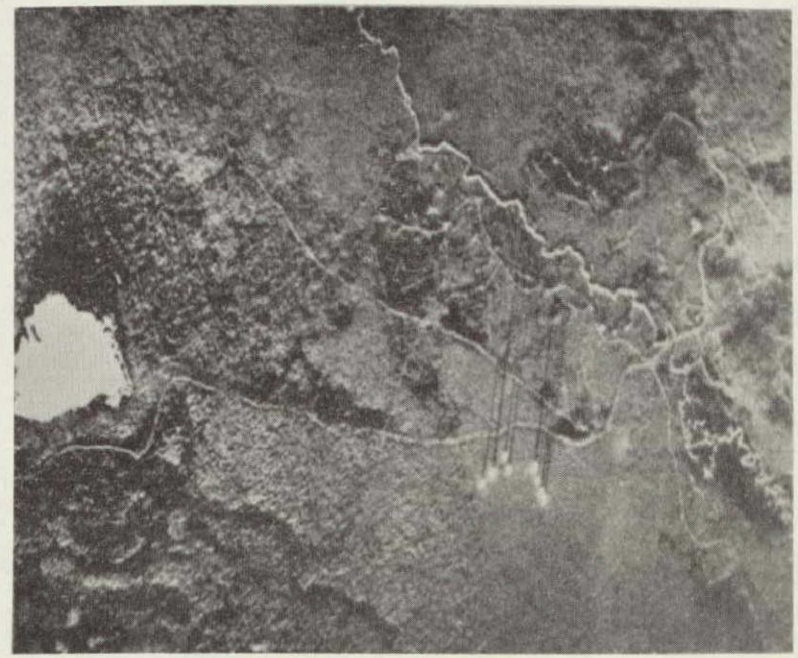
Figure 1

Fire Detection Experiments
Dense Spruce Stand

NASA S-67-14774

FIRE DETECTION EXPERIMENTS
DENSE SPRUCE STAND

AERIAL PHOTO



INFRARED IMAGE

E. General

A small number of additional diseases were examined briefly for possible remote sensing potential, but none of them appeared to offer sufficient promise at this time to permit further exploration - either because of the technical aspects, or because of the practical impossibility of obtaining the necessary ecological data.

In the report of Contract No. NAS 9-11522 we noted that because of the snail involvement in the life cycle of *Fasciola hepatica* (liver fluke) it might be amenable to the same sensing of vegetational association as the snail host of schistosomiasis. However, an examination of the available literature indicated that a large number of snail species, with varying ecologies, may serve as vectors, that almost any aquatic or semi-aquatic vegetation may serve as harborage for the snails, and as anchoring points for the metacercariae of the fluke; and that a wide variety of ruminants may serve as definitive hosts. Under the circumstances the ecological web is so complicated that it seems unlikely that remote sensing could do much more than identify pastures with low-lying swampy areas - information well known to the landholders. Furthermore, this problem is one of interest primarily to agriculturists and veterinary health workers, since man is relatively infrequently infested by the fluke.

Further consideration was given to remote sensing of the aquatic habitats of the Simuliid vectors of onchocerciasis. This is a serious human disease problem in several parts of the world, and one in which (as noted in the report of Contract NAS 9-11522) there does appear to be some utility for remote sensing techniques to plot the small streams with which some of the vectors are associated. However, no funds for additional field work were included in the present contract, and NASA-JSC personnel indicated that there was no interest in work in Central America - the nearest site at which additional ground truth work could be done. It appears that there was little chance of scheduling sensing flights in the onchocerciasis areas, even if additional ground truth data had been accumulated. This still does appear to be a somewhat promising area for further study should conditions permit it.

C.3

4. GENERAL

In addition to the studies reported here we are aware of remote sensing studies on mosquito habitats conducted in the New Orleans area, and plans for further work in the Galveston area. Both of these involve primarily salt-marsh *Aedes* mosquitoes. The configuration of the marsh habitat is such that this type of work should offer considerable promise. However, *precise* associations of mosquito larval populations and species of marsh vegetation will be required if the method is to work. It may well turn out that the degree of association of mosquito larvae with particular types of vegetation which can be identified by remote sensing techniques will be far less rigid than had been supposed. While the concept of targeting the delivery of pesticides to particular portions of marshes, rather than broadcast delivery has obvious good aspects as far as protection of the environment and cost go, it may well be that the distribution of larvae in the marsh will be in such a patchy fashion that only patterned (strip) delivery of pesticides will be possible, given present application technology. Still, the salt marsh mosquitoes seem to offer the best prospects for demonstration of the practical utility of remote sensing.

As in the final report of the previous contract, we have not really assessed the element of cost, nor have we attempted to determine precisely what the costs of application of remote sensing may be on an hourly or other basis. However, aside from straight color, color infrared, or black and white photography from relatively unsophisticated aircraft, it seems unlikely that most public health units could afford to employ remote sensing methods on their own. They could accept such a service from NASA or another federal agency; or participate in a larger program, such as Skylab or ERTS, in which the cost of public health applications would be minimized. When one considers the communicable diseases in particular, it is well to remember that the most important of these from the viewpoint of remote sensing no longer occur in the United States. Almost all mosquito control in this country, for instance, is for human comfort, rather than disease control. Where vector-borne diseases are still highly important, in the tropical and developing world, public health expenditures may be as little as a dollar or less per capita, per annum.

After an exhaustive study of the entire spectrum of communicable disease we have obviously discovered relatively few to which we believe the remote sensing technique may be applied on technical grounds. NASA-JSC personnel have examined one (anthrax) which we have not considered extensively. Several public health authorities on federal and local levels have expressed interest in remote sensing in the several years since we first undertook these studies - but few or none have made any actual use of the techniques (such as New Orleans), and then on a one-time basis. This certainly does not mean that further research in the most promising elements of remote sensing in communicable (particularly vector-borne) disease should be ignored. It does suggest that a realistic appraisal should soon begin to look into the questions of cost and support in an era when NASA may not be able to support such work, and when it must be funded on the basis of utility to the public health community.

ACKNOWLEDGEMENTS

We wish to acknowledge the contributions of all of the personnel listed in Appendix A - particularly the field workers. We also wish to acknowledge the cooperation and patience of the Rockefeller Foundation personnel at St. Lucia; and the U.S. Department of Agriculture scientists at the Mission, Texas Screw-worm Laboratory.

Special thanks are due to Mrs. Dana Crisp for preparation of the graphs and to Mrs. Elaine Akey for her preparation of the periodic and final reports.

Appendix A - List of Personnel

Irshad Ahmad - 50%
Research Statistical Aide
Hired: 4-24-72
Terminated: 5-31-72

Mrs. Elaine Akey
Secretary III
NO SALARY

Mrs. Carmen Bateman - 100%
Clerk Typist I
Hired: 5-22-72
Terminated: 11-5-72

Mark A. Bourgeois - 50%
Research Statistical Aide
Hired: 4-24-72
Terminated: 6-1-72

Lynane Eifler - 50%
Research Statistical Aide
Hired: 6-10-72
Terminated: 9-25-72

Dr. Thomas F. Gesell
Assistant Professor of Health Physics
NO SALARY

Michael Gray - 50%
Research Statistical Aide
Hired: 10-3-72
Terminated: 6-30-73

Dr. Carl S. Hacker
Assistant Project Manager
NO SALARY

Mrs. Genevie Lopez - 100%
Secretary II
Hired: 1-25-71
Terminated: 3-30-73

Nancy Maier - 50%
Research Statistical Aide
Hired: 4-26-72
Terminated: 6-30-73

Fred M. Miller - 50%
Research Statistical Aide
Hired: 4-3-72
Terminated: 10-24-72

Thomas Milligan - 50%
Research Statistical Aide
Hired: 10-3-72
Terminated: 6-25-73

Calvin B. Olsen
Assistant Research Geographer
Hired: 6-1-72
Terminated: 5-31-73

Dr. Paul Rodriguez
Assistant Research Biologist
Hired: 7-1-72
Terminated: 3-31-73

David P. Sanner - 50%
Research Statistical Aide
Hired: 6-1-72
Terminated: 8-31-72

Dr. John E. Scanlon
Project Manager
NO SALARY

Debra L. Magin Scheel - 100%
Clerk Typist I (Replacement)
Hired: 10-30-72
Terminated: 6-30-72

Appendix A - List of Personnel, Continued

Jane L. Valentine - 30%
Research Associate
Hired: 6-1-72
Terminated: 4-11-73

Panduka Wijeyaratne - 50%
Research Statistical Aide
Hired: 12-29-72
Terminated: 6-30-73

Matthew Yates - 50%
Research Technician III
Hired: 4-3-72
Reappointed: Research Associate
Hired: 9-25-72
Terminated: 1-1-73

Appendix B - List of Equipment

1) Simpson Model 260-6P Volt Ohm Meter
P.O. # UH-C-34895
UT Equipment # PH 1958

2) Weather Measurement Corporation
Model H311-S Hygrothermograph with Spring-Wound Clock
P.O. # UH 26449

3) Prismatic Compass
P.O. # UH 25809

4) Nephelos Standards, Set of 5 (In Carrying Case)
P.O. # UH 23328

5) Sedrick-Rafter Counting Chambers (3)
P.O. # UH 21024

6) Sears Storage Building
P.O. # UH 20682
UT Equipment # PH 1871

Sears Heater
P.O. # UH 20682
UT Equipment # PH 1872

Sears Air Conditioner
P.O. # UH 20682
UT Equipment # PH 1873

7) Conductivity Cell, Sproule (LabLine)
P.O. # UH 19408

8) Beckman Electromate Portable pH Meter
P.O. # UH 17963

9) Programmable Desk Calculator
P.O. # UH 18170
UT Equipment # PH 1814

10) Printer-Plotter
P.O. # UH 18170
UT Equipment # PH 1815

11) Nepho-Colorimeter, Model 9
Coleman
P.O. # UH 17985
UT Equipment # PH 1846

Appendix B - List of Equipment, Continued

12) Shaker, Test-Tube
P.O. # UH 17985
UT Equipment # PH 1806

13) Magnetic Stirrer - Hot Plate
Corning (Model PC-351)
P.O. # UH 17985
UT Equipment # PH 1805

14) Analytical Balance (Model H-18)
P.O. # UH 17985
UT Equipment # PH 1804

15) Oxygen Meter, Model 54RC
P.O. # UH 17985
UT Equipment # 1803

16) Calibration Chamber - YSI
P.O. # UH 17985

17) Lectro Mho-Meter, Portable
Mark IV, LabLine
P.O. # UH 17985
UT Equipment # PH 1802

18) Incubator, Model 310, "National" Series 300
P.O. # UH 17985
UT Equipment # 1801

19) #7600 SM-Z Zoom Stereo Microscope
P.O. # UH 17961
UT Equipment # PH 1823

20) Stereo Illuminator
P.O. # UH 17961
UT Equipment # 1824

21) SM-Z Zoom Stereo #7600
P.O. # UH 25989

22) Stereo Illuminator - Model 2
P.O. # UH 25989

23) Digital Data Logger with Sensor Groups
P.O. # UH 18160

24) Nikon Photography Equipment
(Not All Received)
P.O. # UH 02080

Appendix B - List of Equipment, Continued

25) P.O. # UH-3 18635 (Purchased from Science Associates, Inc. Shipped to USDA Screwworm Research Center - Marked For: American Embassy, Mexico City, Mexico)

a) Hygrothermographs (23)
b) Clear Vu Rain Gage (23)
c) Max-Min Soil Thermometer (10)
d) Soil Thermometer (6^{o}) (2)
e) Soil Thermometer (8^{o}) (1)
f) Soil Thermometer (12^{o}) (1)
g) Watch Altitude Barometer (1)
h) Yacht Barometer (1)
i) Dew Point & Extra Thermometer (1)
j) Replacement Thermometer (1)
k) Casella Cup Counter Anemometer (1)
l) Pyroheliograph (1)
m) Psychron 7-38^{o}C (2)
n) Replacement Thermometer (2)
o) Max-Min Thermometer (34)