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A COMPARATIVE STUDY OF CERTAIN AQUATIC INSECTS, DURING THE WINTER, IN WESTERN MASSACHUSETTS

WOODWARD - 1939

A Comparative Study of Certain Aquatic Insects, During the Winter, in Western Massachusetts.

by

Gordon Woodward

Thesis submitted in partial fulfillment for the degree of Master of Science

at

Massachusetts State College, Amherst

1939

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Map of Areas Studied

(Fig. 1)

KEY
ROADS
RAILROAD
RIVERS
ELEVATION IN FEET.
CONNECTICUT RIVER
NORTH HADLEY
MT. WARNER
MILL RIVER
GREENFIELD
NORTH AMHERST
CUSHMAN
MT. BOREAS
M.S.C.
AMHERST
COLLEGE
HOLTON
NORTH HAMPTON
CENTRAL MASS. R.R.
WORCESTER
CENTRAL VERMONT R.R.
100
200
300
400
500
600

Section I

Introduction

Section I

A Comparative Study of Certain Aquatic Insects, During the Winter, in Western Massachusetts.

Introduction

A. Statement of Approach to Subject

Much work has been done on the individual aquatic organisms in streams and ponds but less study has been made of the relation of physical factors to the insect population as a whole. This paper is a study of these ecological factors over the winter period. Quantitative methods were used in all insect collections made. This comparative study was started at the suggestion of Dr. Harvey L. Sweetman, the purpose being to determine what relations, if any, the physical factors have to the location of aquatic insect ppopulations.

The nature of the problem consisted of choosing certain representative bodies of water, of both ponds and streams, and studying their insect populations in relation to the effects of certain physical factors over the winter period. These quantitative insect samples and physical factors were taken at designated points on the selected bodies of water. This data was collected at various intervals over the winter period.

In this comparative study the following questions seemed most significant: (1) What fluctuations occur in the insect populations and physical factors of the different areas under study; (2) Is it possible to correlate these fluctations with each other; (3) If not in every respect, to what extent; (4) To what extent does the pond and stream bottom limit the insect populations; (5) To what extent does the volume and velocity of the water appear to limit the insect populations; (6) What correlation is found between the quantitative miscellaneous collections and those taken from the stream and pond bottoms?

B. Nature of Ponds and Streams, with Description of Environment

Four stream and pond localities were chosen at a short distance from Amherst, Massachusetts. Each area was designated a District, each of which was further subdivided into two stations. The stations were located so as to represent various types of stream bottoms and at the same time be readily accessible. A description of each District and its stations follows. The streams described below originate in springs and marsh lands within a few miles of Amherst. They empty into Mill River, which in turn flows into the Connecticut River at a point near North Hadley.

District I

Cushman Pond (Fig. 9) is situated near the town of

Cushman about two miles northeast of Amherst. This district, designated Cushman Pond, originates from a small spring near-by. The Central Vermont Railroad runs beside it for a short distance until the stream passes under the road bed through a culvert.

This pond is rather old which is shown by the amount of vegetation encroaching upon it and the sluggish current which moves through the middle channel. General measurements show it to be very small (75 by 150 feet) in area. The depth is remarkably constant. During normal conditions it does not exceed much more than two and one half feet in depth. At the inlet and outlet the depth of the water is approximately the same as the pond, and the channel measures about three feet in width. The pond has a small but strong spring feeding into it and a good outlet, assuring a constant change of water at all times.

In Cushman Pond there is a great profusion of aquatic vegetation. This vegetation and its photosynthetic activity are of considerable importance, since they affect greatly the oxygen content of the water. Some of these plants in their succession from the center of the pond to the shore are as follows: Ranunculus delphinifolius Torr.; Eleocharis acicularis (L.) R. and S. Leersia oryzoides (L.) Sw.; Carex stricta Lam.; Nymphozanthus advena (Ait.) Fernald; and Ludvigia palustris (L.) Ell.[1]

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1. Determined by Dr. R.E. Torrey

One side of the pond is bordered by a grove of deciduous trees while the other side opens into a meadow and onto the railroad right-of-way. The pond bottom consists of dense plant growth, leaves, twigs, and much heavy muck. The inlet and outlet are clear of much plant growth in the water, only a heavy matted deposit of plant remains being present.

Station #1

This is located in the center of the pond at some distance from the main channel. (Fig. 11)

Station #2

This station is situated ten yards above the inlet in the main channel. (Fig. 12).

Biotic Conditions at Cushman Pond

1. Physiography	not much variety
a) Bottoms	(mud, silt, aquatic vegetation)
b) Depth	slight (6" to 3 feet)
2. Physiology	
a) Volume (impact)	not much
b) Wind (effect)	slight
c) Current	constant (slight)
d) Circulation (water)	fairly good (current & winds)
3. Habitats	
a) Arrangement	orderly
b) Distribution	horizontal & vertical

4. Plants

a) Emergents	many
b) Floating	common
c) Submerged	abundant
d) Algae	common
e) Higher plants	some

District II

North Amherst Stream (Figs. 13) flows through the town of North Amherst, due north of the center of the business section. The average width is twelve feet and the average depth ten inches. This comparatively swift stream is characterized by a gravelly, sandy bottom, with not many distinct pools but areas where there is a variation of much rubble, gravel, rocks, and sand, - to areas where there is more sand and smaller-sized gravel. At the areas where there are riffles, more sand and less mud is found. Along the banks are heavily wooded sections with much brush and fallen tree trunks; in other places there are meadows and pasture lands. Very little aquatic vegetation appears in this clear, swiftly flowing stream. A short distance up the stream from the location of this district is a low dam that deflects quite a large volume of the water through a canal to a mill nearby and is directed back into the main stream below. During the time of this study the dam in question was opened once for a cleaning out of the accumulated sand, silt, and debris.

Station #1

This is located at an area where the water is shallow and the stream wide; stream bed mainly of shifting sand and gravel although there are short pools or sluggish stretches where silt is deposited.

Station #2

This station is situated about 500 yards down stream from station #1 just above a bridge in North Amherst. This part of the stream is deep but also wide and swift; with much sand, rocks, and pebbles.

Biotic Conditions at North Amherst Stream

1. Physiography	
a) Bottoms	fair variety
b) Depth	shallow
2. Physiology	
a) Volume (impact)	fair amount
b) Wind	slight effect (temp.)
c) Current	continuous (strong)
d) Circulation (water)	very good
3. Habitats	
a) Arrangement	intermixed
b) Distribution	vertical
4. Plants	
a) Emergents	very few

b) Floating	none
c) Submerged	few
d) Algae	common
e) Higher Plants	few

District III

Pulpit Hill stream (Figs. 15) and pond (Fig.s 17) are located due north of, and just beyond, North Amherst stream, running parallel to it. The pond is surrounded on three sides by small hills with a small gully giving access to the stream. At the fourth side is a dam. The pond measures approximately 300 feet in length by 150 feet in width and averages about four to five feet in depth.

At the inlet a long wide sandbar stretches almost across the pond. Probably numerous rains and heavy storms have aided in washing the sand into it. The pond bottom ranges from mixed mud and rocks to thick black mud or sand alone. Around the pond are a few trees and a moderate amount of brush. Below the dam the stream divides for a short distance then reunites to flow under the road. Here the stream bed consists of sand, rocks, pebbles with a large amount of algae and moss clinging to the rocks. Pulpit Hill Stream was selected because it presented two good environments, easily accessible, and varying greatly in habitats.

Station #1

Below the dam. Stream bed as described above.

Station #2

A large pond, located just above Station #1. The thick mud bottom and the presence of a large sand bar makes for a considerable variation in habitat.

Biotic Conditions at Pulpit Hill Stream

1. Physiography

a) Bottoms	much variety
b) Depth	5" in stream to 7' in pond

2. Physiology

a) Volume (impact)	good deal in stream, slight in pond.
b) Wind	none in stream, some in pond
c) Current	continuous and strong in stream, slight in pond.
d) Circulation (water)	good in stream, fair in pond.

3. Habitats

a) Arrangement	varied and intermixed
b) Distribution	vertical in stream and vertical and horizontal in pond.

4. Plants

District IV

Lover's Lane Brook (Figs.19) is located just beyond Amherst, about a quarter of a mile on the road to North Amherst. It is a small stream averaging three feet in width and six inches in depth. The bottom consists of a varying mixture of sand, mud, and pebbles. The stream originates in a spring on a hill near the Massachusetts State College campus where there is a small wooded area. From there it flows through heavily grassed meadows to join Mill River.

It freezes over during the winter at frequent intervals and there is no water flow at that time. At the time of winter thaws, and in the spring, the banks can scarcely hold the surplus quantity rushing through. One of the important factors is this frequent torrential flow of water due to melting ice and snow.

Station #1

Located near the main road where the bottom consists of sand, gravel, and large rocks.

Station #2

Situated about three hundred yards up stream just above an old washed out dam; bottom mostly mud, sand and gravel.

Biotic Conditions at Lover's Lane Brook

1. P hysiography
    - a) Bottoms — intermixed
    - b) Depth — shallow
2. Physiology
    - a) Volume (impact) — very little in normal condition; very great during flood.

b) Wind	absent
c) Current	continuous (strong)
d) Circulation	very good

3. Habitats

a) Arrangement	varied and intermixed
b) Distribution (of insects)	vertical

4. Plants

a) Emergents	absent
b) Floating	absent
c) Submerged	absent
d) Algae	some
e) Higher plants	few

C. Collection of Data

The physical data collected at each station consisted of: oxygen content, hydrogen ion concentration, temperature of water, alkalinity, and free carbon dioxide content. Tests for these factors were made at frequent intervals and a progressive record kept. In addition the normal rate of flow and volume of water passing a given point were recorded. The above results appear in tables (1-8) at the close of this paper.

In taking samples from these areas, quantitative methods were used as far as available equipment and time permitted. While the weather was warm and clear the physical data were determined in the field. During the winter months, sealed water samples were brought into the laboratory and analyzed before much change in temperature had occurred. The bottom and miscellaneous samples were put into large mouthed bottles and the contents determined later. After separation from the debris in these bottles, the insects found were transferred to 5% Formalin.

Summary of conditions peculiar to this locality.

This locality is situated in the Connecticut River Valley about six to eight miles from the river. The land elevation in this area under study, ranges from 200 to 300 feet above sea level. It is a rolling type of land with a gradation from 100 feet in elevation near the river to 500 feet at the highest points (i.e., Mt. Warner and Mt. Boreas, see (Fig.1).

On September 21 (1938) wind and rain, of hurricane proportions, swept through this area uprooting numerous trees which blocked roads and streams. The rushing torrents of water in the streams considerably altered stream beds and banks. This comparative study was started shortly after the storm was over.

Section II

Review of Literature

Section II

Review of Literature

A. Historical account

The first attempts at studying limnology, although not designated by that name, were the early marine explorations. These explorations consisted mainly of hunting for museum specimens. From this extensive study there developed what we call today, limnology.

In America, Birge and Juday, Needham and Lloyd, Chapman, Welch and many others have done extensive work in this field.

Chapman (1931) found that some of the most important contributing factors to wide expansion of limnology were: (1) interest in evolution prompted universities to establish field laboratories; (2) the interest in propagation of fish for sport and economic reasons by the Bureau of fisheries; (3) investigations of water systems for sanitary purposes by various cities. All of these agencies have aided in the present accumulation of data and knowledge.

B. The aquatic environment

1. Water as a medium

The properties of water make it ideal as a medium which contains the essentials necessary for aquatic life.

Whipple (1927) shows that water is used as a standard for many physical measurements and is considered the most universal chemical agent. He also shows that it does not conduct heat as easily as some liquids. Another of its important assets is that it reaches its maximum density at 4° C, and then, when cooled below this temperature, expands and becomes much lighter.

Water has a great surface tension and it is this salient factor which enables many adult insects, for example, the adults of certain Coleoptera and Hemiptera, to live in water.

Water makes a good heat screen because the longer length light waves are absorbed. These are the heat waves.

Kendall (1927) states, "instead of being a substance which can be neglected, water is perhaps the most reactive of all substances". Water is chemically inert and stable. With these two ideas in mind it would seem right to accept the fact that water apparently is reversible in its reactions and therefore the substances (solutes) recovered from the water come out of solution unchanged. In addition to this, "more substances are soluble in water than in any other substances."

It may be said then that in the water medium, the possible range for every species is determined by climate; the possible habitat, by the distribution of water and land; and the actual habitat, by presence of food, shelter, and enemies, and by the competition of groups of aquatic insects.

2. Hydrogen-ion (pH)

In acid solutions there are hydrogen-ions, in alkaline solutions hydroxyl-ions. Therefore it may be said that the balance of the dissociated hydrogen and hydroxyl-ions will control the acidity, alkalinity, and neutrality. Neutrality exists between acidity and alkalinity.

There is much to be done in the hydrogen-ion field, but some good investigations have already been carried out by Shelford (1923, 1925, 1929). He shows in his work that altitude increases hydrogen-ion content, probably due to an increase of the salt content of the water. Rains also probably increase the hydrogen-ion content due to a dilution of the buffer.

Hydrogen and hydroxyl-ions are important due to their ability to carry electrical charges. Power (1929), Creaser (1930), and Coeting (1933) have shown in their work that even very small changes in hydrogen-ion concentration may result in enormous changes in the physical properties of substances and these may all enter into the functioning of the animal mechanism.

Creaser (1930) has found that for some organisms it is possible to find definite zones in whichthey must remain in order to maintain normal living metabolism. On the other hand, Stickney (1922) has found in experiments, that certain dragonfly nymphs were apparently unharmed in an acidity of (pH) one. Philip (1927) demonstrated that aquatic insects could be transferred from one part of a lake to another, easily making the adjustment of widely differing hydrogen-ion values. He stresses the fact that there is a possibility that the aquatic insects may ocercome such a change by producing a physiological reaction to counteract it.

Gutsell (1929) explains that aquatic organisms may be directly effected by the action of non-ionized substances or anions. This may vary with the substance and with the organisms.

In conclusion, Chapman (1931) states that, "the hydrogen-ion concentration, as expressed by the pH value, may be a measure of general conditions in the environment including certain physical and biotic factors. It would therefore be difficult to distinguish cause from effect in measuring an environment by this factor alone".

3. Oxygen (O_2)

Whipple (1927) gives the following information: The air of the atmosphere ordinarily contains 79.2 percent of nitrogen, 20.5 percent of oxygen, 0.03 percent of carbon dioxide, and small traces of other gases. Water is known to absorb them in the following percentages: oxygen, 34.91;

and nitrogen, 65.09. Chapman found that absorption of these gases is directly influenced by pressure because the volume of gas is decreased by increased pressure. Temperature reduces the solubility of the gas.

Water in a stream or shallow pond is well exposed to the atmosphere and tends to stay in equilibrium with it. In streams the rapids, falls, and swift flowing water tend to keep it in close contact with the air. In shallow ponds the flow of water also tends to help in keeping the surface well aerated. If a pond is choked with aquatic plants and decaying debris, there probably will be a great interchange of oxygen and carbon dioxide, especially, close to the bottom. Photosynthesis will produce a high oxygen content with plenty of light in spring, summer and fall, except at night, then the production of carbon dioxide may change the nature of the gas content.

Craser (1930) explains that the temperature and oxygen relation in a stream is a limiting factor on the aquatic organisms present only when the increased solvent power of cold water tends to keep dissolved oxygen above the minimum that is required for the aquatic organisms to live.

The minimum oxygen requirement, or that amount below which the aquatic organisms present will die, varies with the temperature of the water and the actual minimum is seldom reached in natural waters below 20° C. If the minimum is reached under such circumstances it is probably due to oxygen-consuming organisms. Chapman (1931) has shown that a polluted stream with a low oxygen content can be better oxygenated in several ways, namely: (1) increasing the number of falls and rapids; (2) reforestation in order to provide adequate shaded areas so that the water may remain cool; (3) increase of the stream velocity; and (4) by the storing of water adjoining the water system which then may later be turned into it.

Allee and Oosting (1934) have explained some of the important sources of error in testing for the presence of free oxygen in water. In using Winklers method,[1] they found that error occurs if iodine is present in water, because it may either be absorbed or adsorbed upsetting the normal reaction. Also, if there is more than 0.005 mg. of nitrogen per litre, a special modification with permanganate is used. Lastly, if the water should contain ferrous iron the permanganate modification mentioned above is used. With a low free oxygen content more care must be taken because of greater chance for the above errors.

1. For description of Winkler's method see page44 section III under Oxygen.

4. Free Carbon Dioxide (CO_2)

Chapman (1931), explains that there are four important sources of free carbon dioxide: the atmosphere, decomposition of organic material, respiration of organisms, and spring or ground waters. From the experiments of Gutsell (1929) it has been shown that animals can live in high concentrations of carbon dioxide, in some cases as high as 40 parts per million; also, that in the presence of a large quantity of oxygen, a much higher concentration of carbon dioxide may be tolerated. Gutsell has further shown; that a high concentration of carbon dioxide is always associated with low oxygen and that, in natural ponds, water with a high carbon dioxide content usually has an odor of sulphur compounds. It is possible then to use this odor as an indicator of the presence of substances in the water which may be harmful to the aquatic insect population. Gutsell also found that in spring water, the free carbon dioxide content increases in the early spring and gradually continues to rise as summer approaches. Springs are true ground waters. Due to the action of soil badteria, carbon dioxide may be produced which is then absorbed by the water while passing through the ground. He shows that the gradual increase of the carbon dioxide may therefore be due to the increased activity of the bacteria.

Gutsell states how carbon dioxide is also formed in several other ways namely; (1) photosynthesis of aquatic plants, (2) marl-forming organisms, (3) agitation of the water, (4) evaporation (monocarbonates), and (5) decomposition of plant and animal remains. Free carbon dioxide is formed to a greater extent in the winter and as the season changes in the spring, the free carbon dioxide content slowly decreases.

With the breaking up of the ice in the spring, aeration balances the gas content, the decomposition gases are disposed of, and there is a general redistribution of substances passing into solution.

5. Alkalinity

Juday (1915) found, in his studies of lakes in Central America, that alkalinity and acidity were related to free carbon dioxide content. There was a strong acid reaction when much free carbon dioxide was present. When little or no free carbon dioxide was present and the half bound carbon dioxide was lost, the water was alkaline. This water contained normal carbonates in excess.

Shelford (1925) shows that alkalinity, of stream or lake-water, occurs in the presence of carbonates, bicarbonates, or hydroxides. This alkalinity must then be governed by the shifting of the disassociated hydrogen and hydroxyl-ions.

6. Temperature

Temperature has a very important control on the distribution of aquatic populations.

Shelford and Eddy (1929) show that in very shallow ponds and streams there will be little temperature variation from top to bottom of the water over a year's time. This constancy of water temperature makes an ideal habitat for many aquatic insects. In shallow ponds a fairly strong flow of water is necessary for such a condition, otherwise, although the temperature is ideal, the water may become stagnant and uninhabitable.

Gutsell (1929) shows that the temperature of the water can control the amount of saturated oxygen present. Temperature also influences the pressure of the gases present and in this sense much be considered as an important controling factor. Two other effects of a lower temperature upon water are; "increased mobility and increased lightness and expansion".

Ide (1935), in his studies of mayfly fauna, shows that there is a definite increase in the number of species of mayflies from the source downstream, which is correlated with the greater fluctuation in the temperature downstream. Also, that the season of emergence at the source becomes shorter and shorter downstream so that it is finally restricted to the early part of the summer. The higher temperatures eliminate several species.

7. Volume and Surface Velocity

Stehr and Branson (1938) show that these two factors are especially important in the distribution of specialized forms of aquatic insects, as compared with the normal aquatic communities. Volume and surface velocity also determine the amount of available food supply. In an area with a large total volume and a slow-moving current the aquatic community is made up of those organisms that can survive in an environment of mud, sand, and debris. These are usually diggers in the bottom or free swimmers. In swift water, with a small volume and a great deal of water movement, the aquatic organisms are specialized in other ways, namely: streamlined morphology; mouth parts designed to strain food from the water as it flows by; appendages designed for the most efficient attachment on rocks and projections; and coloration, camouflaging them from enemies.

C. The Aquatic Insect Community

Stehr and Branson (1938) show in their studies the importance of the seasonal life cycle of many of the aquatic organisms in an intermittant stream. Insects are of especial importance because they themselves determine the variety and size of the animal population of a stream at various seasons of the year. The insects' food habits and other activities are important factors in determining their distribution in the stream at all times. Repopulation occurs by migration from other localities in the stream and through emergence of species from hibernation.

Morofsky (1936) found that the insect population, as a whole, increased very noticeably in a stream where dams and other improvements had been carried out as against an unimproved stream full of branches, dead wood, and other debris.

Clemens (1917) through a series of extensive experiments has shown that nymphs of the mayfly Isonychia (Chirotenetes), have a decided preference for the lower surfaces of stones and rubble, as against smooth open sheets of rock. These nymphs are also sensitive to light and may be influenced by it in choice of habitat. The form of the body is adapted for rapid movement in swift water. Clemens also shows that some mayfly nymphs living in swift water are able to strain out the suspended organic materials in the stream, for food purposes. His investigations show that the suspended plant and animal forms in the stream are sufficient in amount to supply the food requirements of the nymphs present.

Alexander (1925) in his survey of the Salt Fork of the Vermilion River (in 1921) found that, because of the heavily polluted water, many species of the aquatic insects were not present and those present evidently had adjusted themselves to the polluted conditions.

Gersbacher (1927) shows that, for lake bottom animals, the two major aspects of distribution are zonal and seasonal. This may be explained by the fact that: the distribution of aquatic insects is not uniform from deep to shallow water; the zone of insects around a lake decreases on either side; this zone of aquatic insects shifts deeper in winter and is shallowest in summer; both the densest and most scanty population were found on muddy bottoms and a complete absence of bottom animals on clean sand and polluted mud banks; finally, the nature of the physical-chemical condition determines to a great extent the number and type of aquatic inhabitants.

Dodds and Hisaw (1925) have shown in their studies of aquatic insects that caddisfly larvae have successfully invaded waters of all swiftnesses, from stagnant pools to mountain torrents. The caddisfly cases, rather than the body of the larva, exhibit the peculiarities of form which fit each species for its type of environment. The absence of portable cases usually means adaptation to swift currents.

Dodds and Hisaw have further shown that the most successful species of mayfly nymph in swift streams is not the flattened form, but one with a round body (Baetis) which can very successfully hold its place in swift water.

Gersbacher (1927) has shown that in the summer season there are more species of aquatic insects present in streams and ponds and in the spring and fall there are far greater numbers of aquatic insects as a whole. The seasonal life-cycle of many of the aquatic insects is a determining factor in the variety and size of the aquatic population. Heavy prolonged rains or long dry periods may mean that a host of insects will either die or be distributed to other localities. These conditions may be changed either, by oviposition of adult insects, or migration of the immature forms.

Quantitative study of aquatic communities is quite difficult in many ways. After each collection of samples in a stream a new group of individuals may move in; and in order to make a thorough study it would be necessary to travel downstream with the moving community. Before adequate data is compiled, it is necessary to make a long series of averages of the collections made in one given area.

Several orders of insects are represented in the aquatic environment. They vary in their structure and adaptability according to their needs and locality. Each order is composed of members that vary to all extremes.

A short summary of each of the most important orders follows, taken from the studies of Needham and Lloyd (1930).

Coleoptera

Only a few families of this group of insects are wholly aquatic. A few others are partially so. The order as a whole is predominantly terrestrial, and the aquatic families show signs of having developed from a terrestrial ancestor.

All the adults and pupae are strictly terrestrial in their respiration and nearly all the larvae get their air from above the surface of the water. The pupae of all the groups are formed either on land or in direct contact with the air.

The families that are strictly aquatic are: Dytiscidae, Haliplidae, Parnidae, and Amphizoidae. A few show an intergradation in their habits from land to water; for example, the Hydrophilidae and the Dascyllidae.

The aquatic beetles have a great diversity of habits and structures ranging from the sub-family Donacinae, which gets its air by means of a long horny spiracle stuck into the air spaces of plant stems far under water, to the giant Hydrophilus beetles, which have larvae with large rapacious jaws capable of rending to bits good sized mayflies and other organisms that come within reach.

The dominant family of water beetles is the Dytiscidae, commonly known as diving beetles. All are aquatic in both larval and adult stages but take air at the surface of the water, except in a few cases where some of the larvae are able to absorb their oxygen from the water. They vary in type from those with oar-like hind legs provided with closeset swimming fringes, to the more generalized forms which have limbs modified for walking and climbing.

The Dytiscus eggs are deposited in punctures made in the green stems of aquatic plants.

Diptera

A considerable number of this order have taken to a more or less aquatic life. It has been shown that a large majority of the families have some members that develop in the water, but only a few of the smaller families are wholly aquatic. Adaptations to living in this form of habitat are diverse and unique in many ways. The Dixa midges, which inhabit spring brooks and stream pools, have larvae that are bent double. These are found on leaves, flat stones, or debris which are continuously wet by the stream current. In some of the larger families only a small portion are adapted for aquatic life. The crane-flies are largely terrestrial but some have the larval stage living in the water. These are so equipped that they can either live out of water with the use of spiracles or under water with a set of anal gills. The net-winged midges, which live in rapid water, have a very depressed form of body structure both in the larva and pupa, and the larvae are peculiar in having a row of ventral sucking discs, which have been developed for holding fast to objects in the stream.

The black-fly larva, which also lives in rapidly running water, has a single sucking disc at the posterior end of a flask-shaped body, which hangs bent in the current with head down stream. This insect larva has a ray-shaped net around its mouth which helps to strain objects and particles of food from the water. They also spin silk-like threads that they swing on when moving from place to place. Their oxygen supply is obtained by means of "tube-gills". These are formed from a branches prolongation of the tracheal lining of the prothoracic spiracles.

Two other important aquatic Dipterous larvae are the Tabanidae and the Chironomidae. The Tabanidae are large, naked, translucent larvae, tapering at either end and ringed with fleshy tubercles. They are found in amongst the trash of most shallow waters. The midges (Chironomidae) are probably the most far-flung family of the order Diptera and are best able to live in all types of water habitats. In structure the larvae of the Chironomidae are long and slender, having only a few blood gills at the posterior end of the abdomen with which they are able to live in all waters, from springs to stagnant pools and deep lake bottoms. They usually construct some sort of shelter which they bind firmly together by means of silk-like threads secreted from the salivary glands. These shelters range from long soft tubes made from bottom silt, to cases built out of many small grains of sand. The species of Chironomidae that live in deep water and stagnant pools where the oxygen supply is limited are usually a bright red in color. This is believed to be due to haemoglobin in the blood plasma which helps gather oxygen in waters where there is such a low supply available. This family is of great importance as fish food.

Ephemeroptera

The order Ephemeroptera, a rather small group, are all aquatic in the early stages. They are found in abundance in all fresh water, both rapid and stagnant. The adults have a very short life cycle ranging from a few hours to a day or two. They are also characterized by shedding the entire outer protective coat after emerging from the aquatic nymphal skin as an adult. The adults of this order are primarily concerned with reproduction and so leave most of the struggle for existence to the nymphal or immature stage. These nymphs are highly specialized for almost every type of aquatic habitat. They breathe by means of tracheal gills which obtain the required oxygen from the water.

Some of the habitats are: in mud, where Hexagenia and Ephemera are to be found; in silt bottoms, where the more inactive types such as Caenis and Ephemerella are found; on aquatic plants, where the active climbing and swimming forms, such as Callibaetis and Blasturus may be seen; and the beds of swift flowing streams, where the much-flattened nymphs of the Heptagininae cling. Mayfly nymphs are of great importance as fish food. They are herbivorous.

Hemiptera

A small part of this large order is aquatic. Some of the families are well adapted for life in water; a few others live along the shores in the debris and drift. The adults and nymphs are very similar in habits and structure having only a slight metamorphosis from one to the other. They are characterized by having a strong, jointed, puncturing and sucking proboscis which projects posteriorly beneath the head.

The families are very diverse in structure, probably due to individual family adaptations to specialized living conditions. The Veliidae and Gerridae have adapted themselves to living on the surface of the water, and a few have acquired the ability to dive and swim. The Nepidae and Belostomatidae stay almost entirely on the surface, while the Corixidae and Notonectidae have acquired specialized mechanisms for carrying down with them an abundant air supply and swimming around freely under water. There are no tracheal gills developed in this order. One of the largest bugs of the order Hemiptera is the Benacus, which is very powerful and can easily overpower the largest of dragon fly nymphs. Their beaks are stout and capable of painfully wounding one's hand.

It is well known that Hemiptera accustomed to traveling on the surface of the water are mainly scavengers, while the species that dive and swim for long periods of time under water are mostly predatory in nature. It has been shown that the Corixidae are of especial importance as fish food.

Neuroptera

Only two families of this large order are aquatic in nature. They are the Sialidae and the Hemerobiidae. The larvae of the Sialidae are found in swift streams beneath stones where they cling tenaciously by means of their stout legs and a pair of processes, in the form of claws, at the posterior end of the abdomen. They are also provided with paired lateral fleshy projections with tufts of fine tracheal gills at the base of each. Some species probably take several years to obtain their full growth. These larvae are blackish in color. They are all carnivorous and free-ranging. There is quite a similarity between Coleopterous larvae and those of Sialidae. The Hemerobiidae are limited to two genera in this section. These are small insects, the larvae feeding upon fresh-water sponges, living in and about them. They are characterized by specialized abdominal appendages which move like a shuttle and by no anal opening of the stomach and intestine, the food probably being wholly absorbed. In turn the posterior part of the alimentary tract forms a silk-like secreting organ, which is of importance in the construction of a cocoon during the pupal stage.

Odonata

This order is comprised of insects of larger size and stronger build than are insects of most other orders. Most of the members are aquatic as nymphs and all are carnivorous, both in the adult and nymphal stages. They eat other insects and will just as readily prey upon their own kind if they are smaller or weaker.

The nymphs live in all types of fresh water. Damsel flies crawl around openly, climbing stems of aquatic plants under water in search of prey. The dragon fly nymphs are more stealthy. They hide under leaves and debris for whatever comes by that they can overpower. Among these insects are bottom sprawlers (Libellulidae) and the burrowers (Gomphidae).

The success of both damsel flies and dragon flies in capturing their prey is due to their remarkably specialized labium which is elongated, hinged in the middle, and folded back under the thorax. At its tip may also be many hooks and spines. This whole organ can be thrown forward with lightning speed and drawn in again dragging the prey into the reach of its jaws.

Dragon flies obtain oxygen by using a highly specialized group of tracheal gills in the posterior portion of the alimentary canal. By powerful abdominal muscles they inhale and exhale water, causing it to flow over these gills which remove the available oxygen. In damsel flies oxygen is obtained by three more or less leaflike gills which are borne on the posterior end of the abdomen. This gills are traversed by fine tracheae.

Plecoptera

This group of insects constitutes a small and primitive order which is characterized by its varying camouflaged coloration and its tendencies towards keeping out of sight. These insects live almost exclusively in swift tunning, well aerated water, in the immature stage.

The nymphs are streamlined in structure, lying very flat against the under side of rocks. Some appear to resemble certain species of mayflies with which they are closely associated, but one way of easily distinguishing them is by the presence of two claws on the tips of the tarsi whereas mayflies have only one, and by the lack of gills upon the dorsal side of the abdomen.

This order contains both carnivorous and herbivorous types. They are consumed readily by many fish.

Trichoptera

Nearly all the immature members of this order are aquatic and they vary greatly in size, shape and form. They secrete a substance from their salivary glands which is used in the construction of their cases. These cases range from those intricately made from small grains of sand or larger bits of stone, to those constructed of pieces of leaves, wood, and loose debris. Usually the cases are cylindrical but sometimes they are traingular, or square, in cross-section. Some species (Hydropsychidae) make no cases, but live in open troughs in the crevices of rocks. They spin webs or mesh-like nets on the up stream end which strain out small organisms or particles of food. These are carnivorous in their feeding habits. Most of the others are herbivorous, but there are gradations between these two. The caddisfly has filamentous gills which are found on various parts of the body. These furnish group recognition characters. The most typical have them placed laterally along the abdomen, and by undulating the abdomen they cause water to flow over their gills.

The pupa of caddisflies is peculiar in that it remains under water in the original larval case where it breathes by means of gills of the type found in the larva.

Lepidoptera

The aquatic forms of this order are restricted to a few in the family Pyralidae. These are divided into those living along the shore on vegetable matter and the group living under water and obtaining air from the air spaces of stems of aquatic plants. They are all similar to the terrestrial form of caterpillar in having: a brown chitinous shield over the prothoracic segment; by possessing bristle-bearing tubercles regularly placed over the body; and by the presence of fleshy grasping pro-legs beneath the abdomen.

There are three main types of Lepidopterous aquatic larvae, two found in ponds, and one in rapid streams. In ponds are found Nymphula larvae without gills living near the surface of the water in flat cases. These cases are composed of pieces of leaves bound together by a silk-like secretion. Others, such as Paraponyx, live in leaf cases and are provided with abundant branching gills which form a white fringe around the body. Elophila fulicalis is found in rapid streams having as its protection an irregular shaped shelter spun of silk-like substance. These larvae are strongly depressed in shape and have unbranched gills arranged in two longitudinal lateral rows. It has been shown that their food consists mainly of green algae.

Section III

Procedure

Section III

Procedure

A. Dates on which samples were collected, and places visited.

Physical data and quantitative samples of the aquatic insects population were taken at various times during the period between October, 1938 and May, 1939, at the following stations.

District I, Cushman Pond

Station No. 1, Oct. 10, Oct. 29, Oct. 31, Nov. 14, Nov. 23, Jan. 9, March 24, March 29, Aprill 12, Apr. 21, and May 1.
Station No. 2, Nov. 14, Nov. 23, Jan. 9, Feb. 12, Feb. 25, March 29, Apr. 12, Apr. 21 and May 1.

District II, North Amherst Stream

Station No. 1, Oct. 17, Nov. 11, Nov. 21, March 25, May 1, Apr. 1.
Station No. 2, Oct. 5, Oct. 9, Oct. 30, Nov. 6, Nov. 11, Nov. 20, Jan. 11, Jan 15, Feb. 25, March 25, Apr. 1, Apr. 5, and May 1.

District III, Pulpit Hill Stream

Station No. 1, Oct. 29, Nov. 2, Nov. 11, Nov. 20, Jan. 11, Feb. 25, March 24, March 29, Apr. 5, Apr. 21, and May 1.

Station No. 2, Nov. 11, Feb. 25, March 24, March 29, Apr. 16, Apr. 21, and May 1.

District IV, Lover's Lane Brook

Station No. 1, Oct. 26, Nov. 2, Nov. 16, Nov. 28, Feb. 20, March 3, March 18, Apr. 15, Apr. 22, and Apr. 29.

Station No. 2, Nov. 6, Nov. 16, March 3, Apr. 15, Apr. 22, and Apr. 29.

B. Physical factors involved.

1. Use of standard equipment in obtaining data.

Tests were made to determine the hydrogen ion concentration (pH), and the free carbon dioxide (CO_2) content, the oxygen (O_2) content, and the alkalinity (methyl orange), the temperature, and the volume and velocity of the water.

These determinations were made at the same time the aquatic insect samples were collected.

During the winter months weather conditions were such that the above equipment could not be taken into the field. Instead, sealed samples of the water were brought into the laboratory in pint size "Ball" jars. Fig. (8). The jars were completely immersed in the water to exclude all the air in order to eliminate any possible gaseous change of the contents which might occur during transportation. While immersed they were tightly sealed. The sealed bottles were kept in the stream water until just before going into the laboratory. Precautions were also taken that as little temperature change as possible took place in transportation to the laboratory.

A description of the various techniques used in making determinations follows.

__Hydrogen Ion Concentration__ (pH)

The test for pH was made using a "Wulff" pH kit. Fig. (7). It was necessary to compare the results obtained with this set with that obtained with a standard Coleman glass electrode pH determinator. After adjustments were made, the final readings were tabulated.

The procedure of analysis consisted of first, taking out the color chart (in this case 5.0 to 7.0) and slipping it into the examining frame. This frame, or __stage__, had a glass slide and a white reflector which aided in the contrasting of the sensitized paper slips with the color strips of the chart. The lower range of the pH on the chart was to the left of the observer. With this chart now ready for use the next step was to fill the small glass container provided, with some of the water to be examined. A strip of the number II sensitized paper was now dropped into this sample of water and the sand of the minute measurer started at the same time. During this period the sensitized strip of paper was frequently agitated. After the prescribed time of a minute was up, the strip was placed on the stage and compared with the color chart. This latter step was accomplished by holding the stage so that light was reflected up through the glass slide and by sliding the color chart back and forth until the matching strip was found. After correction with the standard, this was taken to be the pH of the particular water sample being tested.

In section IV graphs have been constructed showing the pH relationships of all the districts.

Carbon Dioxide

The carbon dioxide tests were made using the equipment shown in Fig. (8). A four litre bottle was filled with N/44 NaOH solution and a glass tube connected it with a burette. A hand bulb was so attached to the bottle of NaOH that the solution could be forced over into the burette for titration. Calcium carbonate tubes were inserted at all the air intakes in order that air drawn in would have all its moisture removed. If this were not done, the added moisture would spoil the value of the NaOH solution.

The analyses of the carbon dioxide content of the water was carried out by first, adding 10 drops of phenolphthalein indicator to 100 c.c. of the water to be examined. The flask was then gently rotated so as to mix the contents thoroughly. Immediately following this, the water sample was titrated with the N/44 NaOH until a faint, but permanent pink color appeared. At all times great care was taken that the water to be tested was not agitated too much due to the ready loss of carbon dioxide.

The carbon dioxide, in parts per million, is equal to ten times the number of c.c. of N/44 NaOH used in titration. 100 c.c. of water was always used.

Graphs of the carbon dioxide content of the water at all the districts may be found in section IV.

Oxygen

The oxygen content of the water was determined by the use of a "modified Winkler set". Fig. (7). The solutions used were as follows: No. 1. manganous sulphate solution; No. 2. potassium hydroxide with potassium iodide solution; No. 3. concentrated hydrochloric acid; No. 4. starch solution; and No. 5. a 0.25% sodium thiosulphate solution.

Water, from the sample to be analyzed was placed in a small glass container with a stirring rod. To this was added 15 drops of each of the first three solutions. These solutions were added according to number and great care was taken to add them carefully and quickly, being sure that the pipettes were held perpendicular and close to the surface of the water. After adding each solution, the sample was stirred with the glass rod, taking care not to break the surface. The next step was to add 10 drops of the starch solution and then to titrate with the 0.25% sodium thiosulphate solution until the water became clear. The number of drops of solution No. 5 (sodium thiosulphate) was multiplied by the per cent of saturation (7.9) p.p.m. of the standard and this result divided by the number of drops it took to obtain this standard. The final result gave the per cent of oxygen in parts per million.

The standard, or saturation point, was prepared by first well-aerating for at least two to three minutes, a sample of water. This was done by rapidly agitating the water with the stirring rod. Next the sample was allowed to stand for several hours leaving it to come into equilibrium gradually. After this the same procedure of analyses as described above was carried out. This results became the standard, or, the number of drops it took to clear the solution equalled the "saturation" point (7.9) p.p.m. This standardization process was necessary at frequent intervals due to the instability of the sodium thiosulphate solution.

<u>Alkalinity</u>

The alkalinity was measured by the use of an indicator test, employing Methyl orange, and Phenolphthalein, as indicators. 0.02 Normal H_2SO_4 was used for titration. Fig. (7).

<u>Methyl orange</u> - This test was usually done last, due to the fact that the carbonates, bicarbonates, and

hydroxides, if present, would not be easily affected either by undue agitation of the water sample or any slight change in temperature.

A 125 c.c. Erlemeyer flask was used with a line marked for the 100 c.c. level. It was then filled to this level with the water to be analyzed and five drops of the Methyl orange indicator added. This gave a yellow tint to the water showing that carbonates, bicarbonates, or hydroxides were present. To obtain the amounts of these substances present, 0.02 N. sulphuric acid was titrated into the flask until the yellow color of the water was replaced by a very faint pink. Ten times the number of c.c.'s of the 0.02 N. H_2SO_4 used to produce the very faint pink color in 100 c.c. of sample water was equal to the Methyl orange (M.O.) alkalinity in parts per million.

<u>Phenolphthalein</u> - Phenolphthalein alkalinity has not been discovered in any of the streams or ponds in this study.

The procedure for measuring this alkalinity is as follows: four or five drops of phenolphthalein indicator were added to 100 c.c. of the water to be analyzed; the same Erlemeyer flask as described above was used. If the solution became colored, 0.02N, H_2SO_4 was titrated into it until the color disappeared. Ten times the number of c.c. of 0.02N, H_2SO_4, used in the titration is equal to the

Phenolphthalein alkalinity in parts per million.

Temperature

All temperatures were recorded in Fahrehheit. Only the surface temperatures of the water are included in the data collected.

Volume and Surface Velocity

Volume was recorded in cubic feet per second (c.f.s.) where the water flow was one foot per second or greater. Where the flow was less than one cubic foot per second it was described in gallons per minute. One cubic foot per second is equal to approximately 450 gallons per minute.

A distance of fifty feet was marked off on the shore next to the water's edge. A cork was then thrown into the water at the up stream point and its progress over the distance of fifty feet carefully timed. This was repeated several times and the average of all together used to get an accurate check. Besides the above data the average width and depth of each water area was measured.

"Embody's formula" (1927) was used to obtain the rate of flow and volume of the water. This formula is:

$$R = \frac{WDaL}{T}$$

In this formula R is equal to the rate of flow in cubic feet per second; W is the average width; D is the average depth; L is the length of the section measured;

a is the constant for correction of stream velocity; and T is the average time in seconds required for the cork to travel the distance L.

The constant a, represents the deterring action of the stream bed. If the bed of the stream was strewn with rocks and coarse gravel, a was taken as 0.8; if the bottom was smooth (mud, sand, or bedrock) 0.9 was used as the constant.

Surface Velocity

The actual number of feet the surface water moves in a second was obtained by timing the movement of a cork over a measured distance of fifty feet and dividing the number of feet traveled, by the number of seconds it took for the float to traverse the measured area.

Additional Data

The following data pplies to all four of the districts;

1. Turbidity - clear 2. Color - white

Tables (1-8) give the results of the physical factor determinations at each district over the winter period.

C. Biotic factors involved.

1. Quantitative collecting of organisms.

At the pond areas, namely, Cushman Pond and station No. 2 of District III, quantitative samples were taken using a longhandled open dredge. Fig. (3). This dredge measured a square foot in area and had a fine mesh screen for a bottom. It was lowered into the pond, dragged approximately a foot along the bottom, and then raised swiftly to the surface of the water. The contents were then gently washed by moving the dredge up and down several times. Care was taken not to let the edges of the dredge go below the surface of the water. The remaining material was sorted in the field and placed in a suitable bottle with a label, or if this was not feasible, due to cold weather or lack of time, the complete contents were bottled and separated later in the laboratory.

Besides the quantitative material taken with the dredge, miscellaneous samples were collected along the shore by means of a sweep net. (Fig. (3). This net was directed through the water for a given interval of time among the aquatic plants and encroaching terrestrial plants. Two minutes time was alloted for these collections; they were then compared with the contents collected in the dredge.

When ice was present, during the winter months, the dredge was lowered through a hole cut in the ice. It was not possible at this time to do any miscellaneous collecting.

At the stream localities (Districts II, III, and IV) quantitative samples were taken by the use of a collecting net fastened to a horizontal square foot frame, Fig. (3). This was placed firmly on the bottom of the stream, with the mouth of the net facing up stream. Fig. (5). The rocks and pebbles in the area of the square foot frame were then carefully picked up, examined, and washed several times in front of the net. This removed any insects present and they were washed into the net. After all large stones and pebbles were removed, the sand and silt within the square foot area were carefully stirred up to a depth of two to three inches. This removed the rest of the insects present. Several times in the process of these net collections, the square foot area examined was checked by returning the net sampler to the same place. Again the sand and pebbles were stirred up thoroughly and the contents of the net were examined. It was found that, in almost every case, all the insects present had been removed in the first sample.

As in the <u>pond areas</u>, "two minute" miscellaneous samples were made along the banks of the streams with a sweep net. Fig. (4).

2. Methods of preserving and labelling specimens.

All the insect samples collected with the above equipment were carefully separated to order. These were then preserved in vials containing five percent formalin for later more detailed identification.[1] Labels, with the appropriate data (date, station, and district number) were added to each vial.

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1. Most of the insects were determined by: Doris Colgate (Trichoptera); L.M. Bartlett (Ephemeroptera); John F. Hanson (Plecoptera); Dr. Marion Smith (Diptera, Neuroptera, Coleoptera, and Hemiptera.)

Section IV

Presentation of Data

A. Tables

1. Nature of Physical Factors

District I, Cushman Pond

Date	Surface water temp. F.		Dissolved oxygen		Methyl orange (alk.)		pH		Free CO_2	
	Sta. # 1	Sta. # 2	Sta. # 1	Sta. # 2	Sta. # 1	Sta. # 2	Sta. # 1	Sta. # 2	Sta. # 1	Sta. # 2
10/10/38	52°	---	11.2	---	12.0	---	7.3	---	---	---
10/29/38	57°	---	10.2	---	---	---	7.3	---	---	---
10/31/38	49°	---	10.7	---	11.9	---	7.3	---	---	---
11/14/38	45°	45°	9.0	8.7	11.0	12.0	6.9	6.9	---	---
11/23/38	42°	42°	8.8	9.1	13.5	11.9	6.5	6.5	---	----
1/ 9/39	34°	34°	12.7	14.0	9.0	8.0	6.5	6.5	---	---
2/25/39	---	35°	---	10.4	---	11.9	---	6.5	---	---
3/24/39	33°	---	8.8	---	15.5	---	6.9	---	15.0	---
3/29/39	34°	35°	11.3	9.8	13.0	12.0	6.5	6.5	8.0	9.0
4/12/39	45°	46°	12.3	11.7	9.5	9.0	6.5	6.5	13.0	9.0
4/21/39	56°	57°	13.6	12.5	11.0	13.0	6.5	6.5	6.0	10.0
5/ 1/39	46°	48°	10.0	10.5	14.0	15.0	6.5	6.5	14.0	12.0

Date	Volume (c.f.s.)		Velocity (f.s.)	
	Sta. # 1	Sta. # 2	Sta. # 1	Sta. # 2
4/12/39	29.2	8.0	.18	.55
5/ 1/39	21.8	6.8	.13	.47

District II, North Amherst Stream

Date	Surface water temp. F. Sta. #1	Surface water temp. F. Sta. # 2	Dissolved oxygen Sta. # 1	Dissolved oxygen Sta. # 2	Methyl orange (alk.) Sta. # 1	Methyl orange (alk.) Sta. # 2	pH Sta. # 1	pH Sta. # 2	Free CO_2 Sta. # 1	Free CO_2 Sta. # 2
10/ 5/38	---	52°	---	---	---	---	---	7.3	---	---
10/17/38	58°	---	12.0	---	18.0	---	7.3	---	---	---
10/30/38	---	53°	---	8.2	---	---	---	6.9	---	---
11/ 7/38	56°	---	11.1	---	18.1	---	6.9	---	---	---
11/11/38	---	47°	---	10.8	---	---	---	6.9	---	----
11/20/38	---	44°	~~111~~	12.0	---	---	---	6.9	---	---
11/21/38	42°	---	10.6	---	19.0	---	6.9	---	---	---
1/11/39	---	37°	---	14.3	---	---	---	6.5	---	---
1/ 15/39	---	34°	---	14.8	---	---	---	6.5	---	---
2/25/39	---	34°	---	11.7	---	18.0	---	6.5	---	---
3/25/39	35°	38°	10.5	11.2	13.0	14.0	6.9	6.9	4.0	3.0
4/ 1/39	37°	38°	11.8	11.3	14.1	14.0	6.9	6.9	1.5	2.1
4/ 5/39	---	39°	---	11.8	---	11.0	---	6.5	---	1.7
5/ 1/39	48°	48°	10.5	11.0	13.5	14.0	6.5	6.5	3.0	6.0

Date	Volume (c.f.s.) Sta. # 1	Volume (c.f.s.) Sta. # 2	Velocity (f.s.) Sta. # 1	Velocity (f.s.) Sta. # 2
4/1/39	92.7	61.7	4.5	2.9
5/1/39	85.0	55.2	4.2	2.6

District III, Pulpit Hill Stream

Date	Surface water temp. F.		Dissolved oxygen		Methyl orange (alk.)		pH		Free CO_2	
	Sta. # 1	Sta. # 2	Sta. # 1	Sta. # 2	Sta. # 1	Sta. # 2	Sta. # 1	Sta. # 2	Sta. # 1	Sta. # 2
10/29/38	55°	---	9.0	---	---	---	7.3	---	---	---
11/11/38	43°	45°	11.2	11.0	---	---	6.9	6.9	---	---
11/20/38	43°	---	11.2	---	---	---	6.9	---	---	---
1/11/39	35°	---	13.8	---	---	---	6.5	---	---	---
2/25/39	---	33°	---	10.6	---	12.0	---	6.5	---	---
3/24/39	---	33°	---	10.2	---	19.0	---	6.5	---	9.0
3/29/39	36°	34°	11.1	12.3	14.0	15.0	6.5	6.5	6.0	4.0
4/ 5/39	44°	---	11.1	---	14.0	---	6.5	---	2.5	---
4/16/39	48°	52°	11.7	11.4	12.0	13.5	6.5	6.5	4.0	4.0
4/21/39	53°	55°	10.6	10.8	14.0	16.0	6.5	6.5	3.0	4.0
5/ 1/39	49°	51°	10.7	10.5	17.0	18.5	6.5	6.5	5.0	4.0

Date	Volume (c.f.s.) Sta. # 1	Velocity (f.s.) Sta. # 1
4/21/39	1.7	2.4
5/ 1/39	1.5	2.2

District IV, Lover's Land Brook

Date	Surface water temp. F.		Dissolved oxygen		Methyl orange (alk.)		pH		Free CO_2	
	Sta. # 1	Sta. # 2	Sta. # 1	Sta. # 2	Sta. # 1	Sta. # 2	Sta. # 1	Sta. # 2	Sta. # 1	Sta. # 2
11/ 6/38	59°	---	---	---	---	---	6.9	---	---	---
11/16/38	43°	43°	---	---	---	---	6.9	6.9	---	---
2/20/39	34°	---	10.6	---	14.0	---	6.9	---	3.5	---
3/ 3/39	34°	35°	10.4	10.8	13.0	13.5	6.9	6.9	3.0	3.4
4/15/39	49°	51°	10.6	11.2	13.0	11.0	6.5	6.5	6.0	4.0
4/22/39	56°	54°	9.8	10.0	12.0	10.5	6.5	6.5	6.0	6.0
4/29/39	58°	57°	11.0	10.3	11.0	9.5	6.5	6.5	4.0	3.0

Date	Volume (c.f.s.)		Velocity (f.s.)	
	Sta. #1	Sta. # 2	Sta. # 1	Sta. # 2
4/22/39	.35	.34	2.9	2.7
4/29/39	.35	.31	2.7	2.6

3. Nature of Aquatic Insect populations

a. Stream and pond populations from bottom collections.

District I, <u>Cushman</u> <u>Pond</u>

Insects	1938 Oct 10	Oct 12	Oct. 31	Nov 14	Nov 23	1939 Jan 9	Mch 23	Mch 29	Apr 12	Apr 21	May 1
Coleoptera	9		1	6		1					
Dytiscidae							2				2
Haliplidae										1	1
Gyrinidae										1	
Diptera						5					
Tipulidae	2	1									
Chironomidae		1		7						1	
Ephemeroptera											
Baetidae											
Callibaetis	8			4	11	4	7	1		1	
Siphloplecton			8			3					
Paraleptophlebia									1		
Ephemerella		1									
Heptageniidae		11									
Hemiptera	8		2								
Corixidae											
Corixa					4					1	1
Notonectidae										1	
Neuroptera			1								
Sialidae											
Chauliodes	1										
Odonata			1	3							

St. # 1 District I Cont.

Insects	1938 Oct. 10	Oct 12	Oct 31	Nov 14	Nov 23	1939 Jan 9	Mch 23	Mch 29	Apr 12	Apr 21	May 1
Odonata											
Anisoptera											
Libellulidae											
Libellula	15								2		6
Aeschnidae											
Aeschna							1			3	2
Zygoptera		1									
Lestinae	9				2						1
Lestes											
Ischnuridae											
Ischnura	9								1		5
Trichoptera			6	2							
Phryganeidae					1			1			
Neuronia postica	7				6		1	1		1	
Limnephilidae						1	3		12		1
Totals	66	15	19	22	26	14	12	3	15	10	19

St. # 2 District I

Insects	1938 Oct 29	Nov 14	Nov 23	1939 Jan 9	Feb 25	Mch 29	Apr 12	Apr 21	May 1
Coleoptera									
Dytiscidae		6							
Haliplidae				1					
Diptera									
Chironomidae									
Chironomus				2		10		21	7
Ephemeroptera									
Baetidae									
Callibaetis	10						10		
Hemiptera									
Notonectidae	1	1							
Corixidae									
Corixa						2			
Odonata		2							
Anisoptera									
Aeschnidae									
Aeschna					1	1			4
Libellulidae									
Libellula	2								
Zygoptera									
Coenagrionidae									
Chromagrion	1								
Ischnura	2								
Trichoptera									
Limnephilidae		6		1				3	4
Phryganeidae					4	2	2		3
Neuronia								1	
Totals	21	15		4	5	15	12	25	18

St. # 1

District II, North Amherst Stream

Insects	1938 Oct 17	Nov 2	Nov 7	Nov 21	1939 Feb 25	Mch 25	Apr 1	May 1
Coleoptera			2					
Parnidae								
Psephenus		1						
Diptera	1		1	1				
Tipulidae								
Antocha	3	1						
Chironomidae		12		2		5		6
Blepheroceridae								
Blepherocera								1
Rhagionidae								
Atherix variegata							1	
Ephemeroptera				1				
Heptageniidae	19							
Stenonema		2	3	23	3		4	
Rhithrogena						1		
Iron				3		5		
Baetidae								
Ephemerella	3		5	13	17		1	14
Paraleptophlebia			9	3	2		1	3
Baetis					1	1	3	
Isonychia				9			1	5
Neuroptera				1				
Sialidae								
Corydalus	2							
Plecoptera				4				
Perlidae			1					2
Perla capitata	2							
Isoperla					1		2	2
Capniidae	2							
Nemouridae			1			2		
Taeniopteryx						1	1	
Trichoptera	2		13	5				
Odontoceridae	1							
Hydropsychidae	8		2					2
Rhyacophilidae								
Glossosoma								2
Totals	43	16	37	65	24	15	14	35

St. # 2 District II

Insects	1938 Oct 5	Oct 9	Oct 30	Nov 6	Nov 11	Nov 20	1939 Jan 11	Jan 15	Feb 25	Mch 25	Apr 1	Apr 5	May 1
Coleoptera													
Parnidae		1	2										
Diptera													
Ceratopogonidae							1						
Tipulidae													1
Eriocera near spinosa, O.S.		3	2	2		1							
Antocha													1
Chironomidae													
Chironomus			19	6	12	11	8	14		9		10	3
Rhagionidae								1		1			
Simulidae						1	1	1		2			8
Ephemeroptera													
Baetidae													
Ephemerella	1		4	15	2	15	16	10		9	1	1	5
Isonychia			1		1	2	4	1		2	3	1	1
Paralepto-phlebia			7	21	7	31	12	33		34	1	12	11
Baetis				1	2	7	5	9		4	3	2	1
Heptageniidae													
Iron				2		1					2	1	
Stenonema	1	2	12	8	6	8	2	9		2	3	1	
Rhithrogena			1	6	1	6	1	3		8	3	1	
Plecoptera													
Perlidae													
Perla capitata	2				3				2		1		
Perla			1		3								
Isoperla			2	4	3	2		3	4			5	
Nemouridae													
Taeniopteryx								5					
nivalis								2		6			
Capniidae													
Allocapnia							1	3	14			3	

St. # 2 District II Cont.

Insects	1938 Oct 5	Oct 9	Oct 30	Nov 6	Nov 11	Nov 20	1939 Jan 11	Jan 15	Feb 25	Mch 25	Apr 1	Apr 5	Ma[illegible] 1[illegible]
Odonata													
Aeschnidae													
Aeschna		1			1								
Neuroptera													
Sialidae													
Chauliodes						1							
Trichoptera			1										
Hydropsychidae	8	6	11		15	10	7	6	25	1		1	1[illegible]
Sericostomatidae													
Helicopsyche											1		
Philopotamidae	7	1	9		19	9	1	3	6	5	1		[illegible]
Rhyacophilidae													
Glossosomatinae			6		2	1	2						
Rhyacophilinae	1		6			1							
Limnephilidae					1				2			1	[illegible]
Totals	21	15	84	65	78	107	61	103	53	85	18	40	6[illegible]

St. # 1 District III, <u>Pulpit Hill Stream</u>

Insects	1938 Oct 29	Nov 2	Nov 11	Nov 20	1939 Jan 11	Feb 25	Mch 29	Apr 5	Apr 16	Apr 21	May 1
Diptera											
Simulidae					18	170		30	24	29	44
Ceratopogonidae								3	2	4	
Chironomidae	4	10		9	4			13	23	34	14
Tipulidae											
Tipula abdominalis									2		
Antocha	1	1		1				1		1	
Rhagionidae											
Atherix variegata		1			1						
Ephemeroptera											
Heptageniidae		2		2	1						
Stenonema	3	1						1	1	1	2
Rhithrogena											1
Iron								1			
Baetidae											
Baetis	1	2						2	5	9	2
Paraleptophlebia	2						1	2	3	3	
Ephemerella	2	2		1	1		1		11	11	1
Blasturus							1				
Plecoptera											
Capniidae		2									
Allocapnia	1	3		2	5			4			
Nemouridae											
Nemoura					2				16	3	
Taeniopteryx fasciata		2			2		1	1	8	9	
Perlidae											
Isop/erla	1	4	7	1	2				4	8	7
Perla			2								
Acroneuria	1										1
Trichoptera											
Hydropsychidae	6	4		5	2			2	12	7	7
Philopotamidae	8	3		7	1			4	4	2	5
Rhyacophilidae											
Glossomatinae									2		1
Rhyacophilinae				1				2	2	2	1
Limnephilidae				2							
Totals	30	37	9	31	37	170	4	66	105	126	86

St. # 2 District III

Insects	1938 Nov 4	Nov 11	1939 Jan 11	Feb 25	Mch 23	Mch 29	Apr 16	Apr 21	May 1
Coleoptera									
Gyrinidae			1				9		
Corixa							5	3	
Hydrophilidae (larva)					1				
Diptera									
Chironomidae		5		10			5	2	12
Simulidae				1					
Empididae Hemerodromia				1					
Tipulidae Eriocera near spinosa O.S.				1					
Antocha		1							
Tabanidae							1		
Ephemeroptera									
Baetis		1							
Blasturus		1	11		8	5	11	11	11
Callibaetis	3		2				2		1
Ephemerella				2			6	3	1
Paraleptophlebia		2		11					
Siphloplecton	2					1	1		1
Caenis							1	2	
Heptageniidae									
Iron				2	3				
Rhithrogena					1				
Ephemeridae									
Hexagenia	1								
Hemiptera									

St. # 2 District III Cont.

Insects	1938 Nov 4	Nov 11	1939 Jan 11	Feb 25	Mch 23	Mch 29	Apr. 16	Apr 21	May 1
Corixidae									
Corixa			7						
Neuroptera									
Sialidae									
Sialis								1	
Odonata									
Anisoptera									
Libellulidae									
Libellula							1		
Aeschnidae									
Aeschna									
Lanthus							3		
Gomphus								1	
Zygoptera									
Ischnuridae									
Ischnura								6	
Trichoptera									
Leptoceridae		2							
Philopotaminae		1		4					
Hydropsychidae				11	1				
Rhyacophilidae									
Glossosomatinae				1					
Rhynocophilinae				1			1		
Limnephilidae			5	2		1	2		2
Totals	6	13	21	47	14	7	48	31	31

St. # 1 District IV, Lover's Lane Brook

Insects	1938 Oct 26	Nov 2	Nov 16	Nov 28	1939 Feb 20	Mch 3	Apr 15	Apr 22	Apr 29
Diptera									
Chironomidae		2	25		1	2	2	2	
Simulidae						2		1	
Dixidae									
Dixa									1
Tipulidae									
Antocha			1			1	2		
Ephemeroptera									
Baetidae									
Ephemerella		3	12		1	2	1		7
Bâetis		2	5			3	1		3
Siphloplecton	1								
Blasturus	10				1				
Ameletus							1		
Paraleptophlebia								2	
Odonata									
Anisoptera						1			
Aeschnidae									
Cordulagaster			1						
Plecoptera									
Capniidae									
Allocapnia			1		1	1			
Perlidae									
Isoperla		1	23		1		6	13	14
Perla		1	1			5			
Clioperla			4					1	
Nemouridae									
Taeniopteryx			1						
Capniidae			2						

Sta. # 1 District IV, Cont.

Insects	1938 Oct 26	Nov 2	Nov 16	Nov 28	1939 Feb 20	Mch 3	Apr 15	Apr 22	Apr 29
Trichoptera									
Hydropsychidae	1	3	17	9	2	1	3	2	
Philopotamidae			2						
Rhyacophilidae									
Glossomatinae			4					2	
Limnephilidae	7							1	
Brachycentrinae	1							1	
Totals	20	14	99	9	7	18	16	26	25

St. # 2 District IV

Insects	1938 Nov 6	Nov 16	1939 Mch 3	Apr 15	Apr 22	Apr 29
Coleoptera						
Dytiscidae						
Bidessus				1		
Diptera						
Chironomidae						
Chironomus	11		12	6	11	11
Simulidae			2	2	1	
Ephydridae						
Tipulidae Eriocera near Spinosa O.S.	1		2	11		
Ephemeroptera						
Baetidae						
Ephemerella	5		2	2	1	2
Baetis	3		2	2	1	
Paraleptophlebia	1		1	3		
Plecoptera						
Perlidae						
Isoperla	3		4	3	6	
Perla	5					
Capniidae						
Allocapnia	1		1			
Leuctra				1		
Trichoptera						
Hydropsychidae	15	1	1	4	2	1
Rhyacophilidae						
Glossomatinae				1	6	
Rhyacophilinae	1	1	2			
Totals	50	2	29	27	28	15

b. <u>Stream and Pond Populations from Shore Collections</u>

<u>District I</u>, Cushman Pond

Insects	1938 Oct 9 #1	Oct. 10 #1	Oct. 12 #1	Nov. 14 #1	Nov. 23 #1	1939 Jan. 9 #1	Mch. 24 #2	Apr. 12 #1	Apr. 12 #2	Apr. 21 #1	Apr. 21 #2	May 1 #1	May 1 #2
Coleoptera													
Dytiscidae				2		2			1				
Haliplidae				4				4					
Diptera													
Chironomidae		1					2				3		
Tipulidae						1							
Ephemeroptera													
Baetidae													
Callibaetis	5	2				3						2	1
Heptageniidae													
Arthroplea		2								5	15	1	
Hemiptera													
Corixidae													
Corixa				1					2				
Notonectidae													
Notonecta				3				3	3				
Neuroptera													
Sialidae													
Chauliodes		1				1					1		
Odonata													
Anisoptera		12											1
Aeschnidae													
Aeschna	5	3		4							1		
Libellulidae													
Libellula	6	8		6	1	2				7			
Anax					3								
Zygoptera													
Ischnuradae													
Ischnura		7								2			5
Coenagrionidae													
Chromagrion											1		
Lestinae													
Lestes		3								1			

District I, Cont.

Insects	1938 Oct. 9 #1	Oct. 10 #1	Oct. 12 #1	Nov. 14 #1	Nov. 23 #1	1939 Jan. 9 #1	Mch. 24 #2	Apr. 12 #1	Apr. 12 #2	Apr. 21 #1	Apr. 21 #2	May 1 #1	May 1 #2
Trichoptera													
Limnephilidae			1	7	2	8			2		6	1	
Phryganeidae					2	1			2				
Philopotamidae		3	33	16	2	4							
Rhyacophilidae													
Glossosomatinae			1	3		3							
Hydropsychidae		4	66	6		10							
Totals	16	46	101	52	10	35	2	7	10	15	27	4	7

<u>District II</u>, North Amherst Stream

Insects	1938 Oct. 17 #1	Oct. 30 #1	Nov. 7 #1	Nov. 11 #1	Nov. 21 #1	1939 Jan. 4 #1	Jan. 4 #2	Mch. 25 #1	Mch. 25 #2	May 1 #1	May 1 #2
Coleoptera											
Gyrinidae	2										
Diptera											
Simulidae						3					
Chironomidae						4					
Tipulidae				2							
Ephemeroptera											
Baetidae											
Isonychia	2	1					6				2
Ephemerella	5	7	4	5			6			3	15
Paraleptophlebia		4		24	7		32	5		10	14
Baetis	2	6		4	1			4		1	1
Heptageniidae											
Stenonema	1	3	2	7	1		7	1			4
Iron				2			7			5	4
Rhithrogena		3		2				6		1	1
Hemiptera											
Corixidae											
Corixa	4										
Trichoptera											
Limnephilidae			1		1		1				4
Hydropsychidae			1	2			1			2	11
Philopotamidae				15							6
Rhyacophiliade											
Glossomatinae				2						3	9
Pleocoptera											
Perlidae											
Isopterla			1	2			1			1	1
Nemouridae											
Lecutra				1							
Taeniopteryx				5							
Acroneuria				1							
Capniidae											
Capnia			1	5							
Totals	16	24	10	79	10	7	58	16		26	72

District III, Pulpit Hill Stream and Pond

Insects	1938 Nov. 4 #2	Nov. 11 #2	1939 Jan. 11 #1	Feb. 25 #2	Apr. 16 #1	Apr. 21 #1	Apr. 21 #2	May 1 #1	May 1 #2
Coleoptera									
Haliplidae	3	1							
Gyrinidae	4								
Diptera									
Chironomidae						1	2	2	
Simulidae						12		1	
Ephemeroptera									
Baetidae									
Baetis						5		23	
Ephemerella				15				3	
Paraleptophlebia				22				2	
Blasturus									
Heptageniidae									
Stenonema		6		9					
Iron				2				7	
Rhithrogena		1		9					
Hemiptera									
Corixidae									
Corixa	7	6							2
Notonectidae									
Notonecta	2	1							1
Belostomatidae									
Belostoma	1								
Neuroptera									
Sialidae									
Sialis		1							
Odonata									
Anisoptera									
Aeschinidae									
Gompus	10								
Hagenius		1							
Aeschna	1	1							
Libellulidae									1
Tetragoneuria									

<u>District</u> <u>III</u>, Cont.

Insects	1938 Nov. 4 #2	Nov. 11 #2	1939 Jan. 11 #1	Feb. 25 #2	Apr. 16 #1	Apr. 21 #1	Apr. 21 #2	May 1 #1	May 1 #2
Odonata (Cont.)									
Zygoptera									
Ischnuridae									
Ischnura	5	5							3
Agrionidae									
Agrion	1								
Coenagrionidae									
Lestes	1								
Amphiagrion	1								
Trichoptera									
Limnophilidae	7	4	2		2		1		
Phryganeidae									
Neuronia					1				
Rhyacophilidae									
Rhyacophila						1			
Hydropsychidae					1				
Philopotamidae					3				
Plecoptera									
Capniidae									
Allocapnia			2						
Nemouridae									
Taeniopteryx			11						
Totals	44	27	15	55	7	19	3	38	7

District IV, Lover's Landë Brook

Insects	1939 Feb. 20 #1	Mch 3 #1	Mch 3 #2	Apr. 15 #1	Apr. 22 #1	Apr. 29 #1	Apr. 29 #2
Coleoptera							
Dytiscidae					1		2
Hydrophilidae	1			1		2	
Tropistermus	1				1	1	
Diptera							
Tipulidae	1			2			2
Chironomidae							1
Ephemeroptera							
Baetidae							
Ameletus	1					1	
Paraleptophlebia						5	
Ephemerella						6	5
Odonata							
Agrionidae							
Agrion	1						
Trichoptera							
Hydropschidae	3		1			1	
Odonotoceridae		1	2			1	
Rhyacophilidae							
Glossosoma						1	
Plecoptera							
Perlidae							
Isoperla		2		3		3	4
Clioperla		4					5
Capniidae							
Allocapnia		2					
Totals	8	9	3	6	2	21	19

c. A Comparison of the Aquatic Insect Populations from Bottom Samples

COLEOPTERA

District I, Cushman Pond

St. #1		St. #2	
Dytiscidae	4	Dytiscidae	6
Haliplidae	2	Haliplidae	1
Gyrinidae	1		
Coleoptera	24	Coleoptera	7

District II, North Amherst Stream

St. #1		St. #2	
Parnidae			
Psephenus	1	Parnidae	3
Coleoptera	3	Coleoptera	3

District III, Pulpit Hill Stream Pond

St. #1		St. #2	
		Gryinidae	10
		Hydrophilidae (larva)	1
Coleoptera	0	Coleoptera	11

District IV, Lover's Lane Brook

St. #1		St. #2	
		Dytiscidae	
		Bidessus	1
Coleoptera	0	Coleoptera	1

DIPTERA

District I, Cushman Pond

St. #1		St. #2	
Tipulidae	3	Chironomidae	
Chironomidae	9	Chironomus	40
Diptera	17	Diptera	40

District II, North Amherst Stream

St. #1		St. #2	
Tipulidae		Ceratopogonidae	1
Antocha	4	Tipulidae	1
Chironomidae	23	Eriocera spinosa	8
Blepheroceridae		Antocha	1
Blepherocera	1	Chironomidae	
Rhagionidae		Chironumus	92
Atherix variegata	1	Rhagionidae	2
		Simulidae	13
Diptera	32	Diptera	119

District III, Pulpit Hill Stream and Pond

St. #1		St. #2	
Simulidae	315	Chironomidae	34
Ceratopogonidae	9	Simulidae	1
Chironomidae	111	Empididae	
Tipulidae		Hemerodromia	1
Tipula abdominalis	2	Tipulidae	
Antocha	5	Eriocera spinosa	1
Rhagionidae		Antocha	1
Atherix variegata	2		
Diptera	444	Diptera	38

District IV, Lover's Lane Brook

St. #1		St. #2	
Chironomidae	36	Chironomidae	
Simulidae	3	Chironomus	51
Dixidae		Simulidae	5
Dixa	1	Ephydriae	1
Tipulidae		Tipulidae	
Antocha	4	Eriocera spinosa	2
		Antocha	1
		Pilaria	1
Diptera	44	Diptera	61

EPHEMEROPTERA

District I, Cushman Pond

St. #1		St. #2	
Baetidae		Baetidae	
Callibaetis	34	Callibaetis	20
Siphloplecton	11		
Paraleptophlebia	1		
Ephemerella	1		
Heptageniidae	11		
Ephemeroptera	58	Ephemeroptera	20

District II, North Amherst Stream

St. #1		St. #2	
Heptageniidae	19	Baetidae	
Stenonema	35	Ephemerella	79
Rhithrogena	1	Isonychia	16
Iron	8	Paraleptophlebia	169
Baetidae		Baetis	34
Ephemerella	53	Heptageniidae	
Paraleptophlebia	18	Iron	6
Baetis	5	Stenonema	55
Isonychia	15	Rhithrogena	30
Ephemeroptera	155	Ephemeroptera	389

District III, Pulpit Hill Stream and Pond

St. #1		St. #2	
Heptageniidae	5	Baetidae	
Stenonema	9	Baetis	1
Rhithrogena	1	Blasturus	58
Iron	1	Callibaetis	8
Baetidae		Ephemerella	12
Baetis	21	Paraleptophlebia	13
Paraleptophlebia	11	Siphloplecton	5
Ephemerella	30	Caenis	3
Blasturus	1	Heptageniidae	
		Iron	5
		Rhithrogena	1
		Ephemereidae	
		Hexagenia	1
Ephemeroptera	79	Ephemeroptera	107

District IV, Lover's Lane Brook

St. #1		St. #2	
Baetidae		Baetidae	
Ephemerella	26	Ephemerella	12
Baetis	14	Baetis	8
Siphloplecton	1	Paraleptophlebia	5
Blasturus	11		
Ameletus	1		
Paraleptophlebia	2		
Ephemeroptera	55	Ephemeroptera	65

HEMIPTERA

St. #1		St. #2	
District I, Cushman Pond			
Corixidae		Notonectidae	2
Corixa	6	Corixidae	
Notonectidae	1	Corixa	2
Hemiptera	17	Hemiptera	4
District II, North Amherst Stream			
Hemiptera	0	Hemiptera	0
District III, Pulpit Hill Stream and Pond			
		Corixidae	15
Hemiptera	0	Hemiptera	15
District IV, Lover's Lane Brook			
Hemiptera	0	Hemiptera	0

ODONATA

St. #1 **St. #2**

District I, Cushman Pond

St. #1		St. #2	
Anisoptera		Anisoptera	
Libellulidae		Aeschnidae	
Libellula	23	Aeschna	6
Aeschnidae		Libellulidae	
Aeschna	6	Libellulidae	2
Zygoptera	1	Zygoptera	
Lestinae	12	Coenagrionidae	
Lestes		Chromagrion	1
Ischnuridae		Ischnuridae	
Ischnura	15	Ischnura	2
Odonata	61	Odonata	13

District II, North Amherst Stream

St. #1		St. #2	
		Aeschnidae	
		Aeschna	2
Odonata	0	Odonata	2

District III, Pulpit Hill Stream and Pond

St. #1		St. #2	
		Anisoptera	
		Libellulidae	
		Libellula	1
		Aeschnidae	
		Lanthus	3
		Gomphus	1
		Zygoptera	
		Ischnuridae	
		Ischnura	6
Odonata	0	Odonata	11

District IV, Lover's Lane Brook

St. #1		St. #2	
Anisoptera	1		
Aeschnidae			
Cordulagaster	1		
Odonata	2	Odonata	0

NEUROPTERA

St. #1		Sta. #2	
District I, Cushman Pond			
Sialidae			
Chauliodes	1		
Neuroptera	2	Neuroptera	0
District II, North Amherst Stream			
Sialidae		Sialidae	
Corydalus	2	Dhauliodes	1
Neuroptera	3	Neuroptera	1
District III, Pulpit Hill Stream and Pond			
		Sialidae	
		Sialis	1
Neuroptera	0	Neuroptera	1
District IV, Lover's Lane Brook			
Neuroptera	0	Neuroptera	0

TRICHOPTERA

St. #1 — **St. #2**

District I, Cushman Pond

St. #1		St. #2	
Phryganeidae	2	Limnephilidae	14
Neuronia postica	16	Phryganeidae	11
Limnephilidae	16	Neuronia postica	1
Trichoptera	42	Trichoptera	26

District II, North Amherst Stream

St. #1		St. #2	
Odontoceridae	1	Hydropsychidae	101
Hydropsychidae	12	Sericostomatidae	
Rhyacophilidae		Helicopsyche	1
Glossosoma	2	Philopotamidae	67
		Rhyacophilidae	
		Glossosomatinae	20
		Rhyacophilinae	11
		Limnephilidae	5
Trichoptera	35	Trichoptera	206

District III, Pulpit Hill Stream and Pond

St. #1		St. #2	
Hydropsychidae	45	Leptoceridae	2
Philopotamidae	34	Philopotaminae	5
Rhyacophilidae		Hydropsychidae	12
Glossomatinae	3	Rhyacophilidae	
Rhyacophilinae	2	Glossomatinae	1
Limnephilidae	8	Rhynocophilinae	2
		Limnephilidae	12
Trichoptera	92	Trichoptera	34

District IV, Lover's Lane Brook

St. #1		St. #2	
Hydropsychidae	38	Hydropsychidae	24
Philopotamidae	2	Rhyacophilidae	
Rhyacophilidae		Glossomatinae	7
Glossomatinae	6	Rhyacophilinae	4
Limnephilidae	8		
Brachycentrinae	2		
Trichoptera	56	Trichoptera	35

PLECOPTERA

District I, Cushman Pond

St. #1		St. #2	
Plecoptera	0	Plecoptera	0

District II, North Amherst Stream

St. #1		St. #2	
Perlidae	3	Perlidae	
Perla capitata	2	Perla capitata	8
Isoperla	5	Perla	4
Capniidae	2	Isoperla	23
Nemouridae	3	Nemouridae	
Taeniopteryx	2	Taeniopteryx	5
		Nivalis	8
		Capniidae	
		Allocapnia	31
Plecoptera	21	Plecoptera	69

District III, Pulpit Hill Stream and Pond

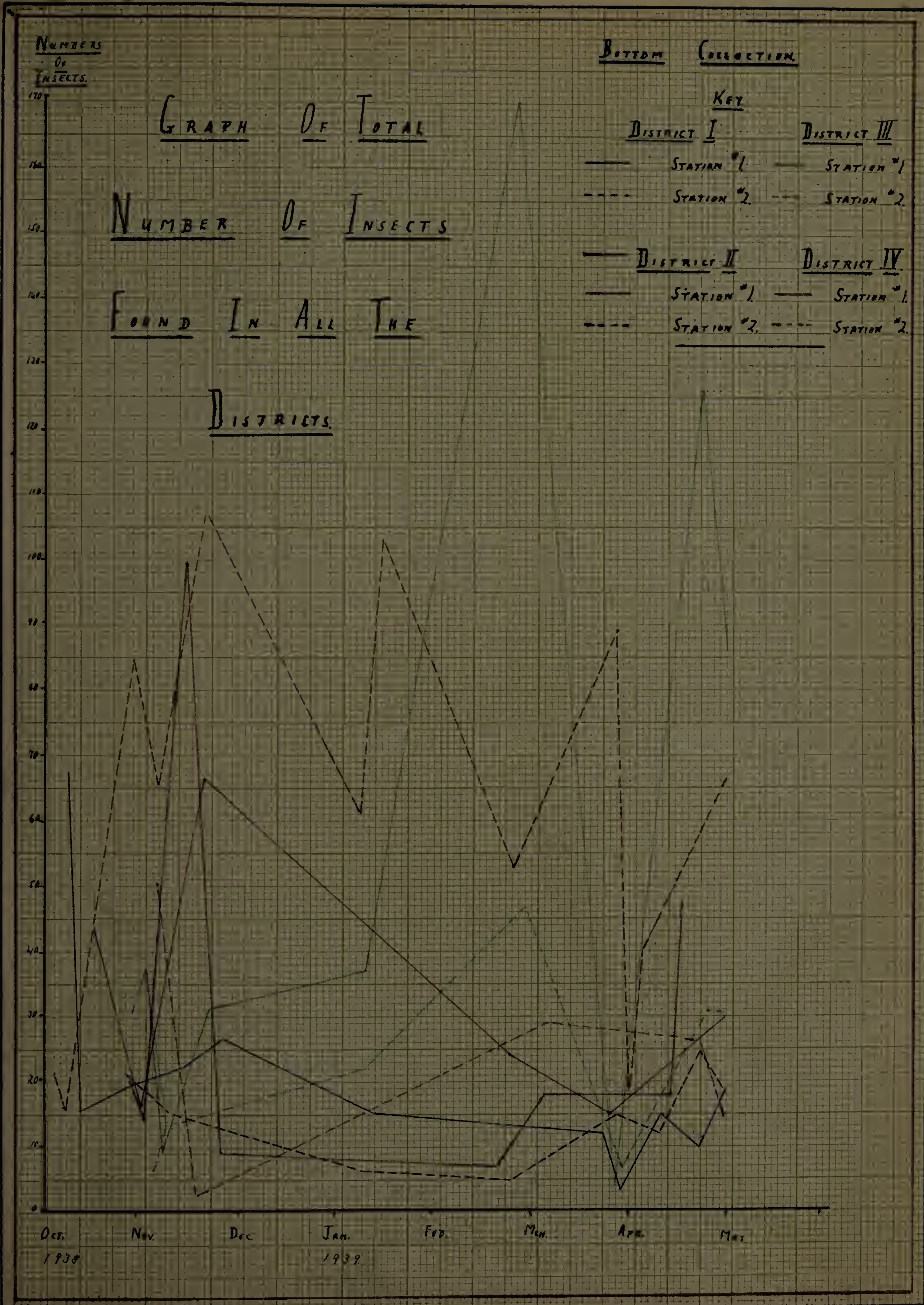
St. #1		St. #2	
Capniidae	2		
Allocapnia	15		
Perla	2		
Nemouridae			
Nemoura	21		
Taeniopteryx fasciata	23		
Perlidae			
Isoperla	34		
Acroneuria	2		
Plecoptera	99	Plecoptera	0

District IV, Lover's Lane Brook

St. #1		St. #2	
Capniidae		Perlidae	
Allocapnia	3	Isoperla	16
Perlidae		Perla	5
Isoperla	58	Capniidae	
Perla	7	Allocapnia	2
Clioperla	5	Leuctra	1
Nemouridae			
Taeniopteryx	1		
Lecutra	2		
Plecoptera	76	Plecoptera	24

B. Graphs

1. Physical Factors


Numbers Of Insects
Graph Of Total
Number Of Insects
Found In All The
Districts.
Bottom Collection.
Key
District I
Station #1
Station #2
District II
Station #1
Station #2
District III
Station #1
Station #2
District IV
Station #1
Station #2
Oct. 1938
Nov.
Dec.
Jan. 1939
Feb.
Mch.
Apr.
May

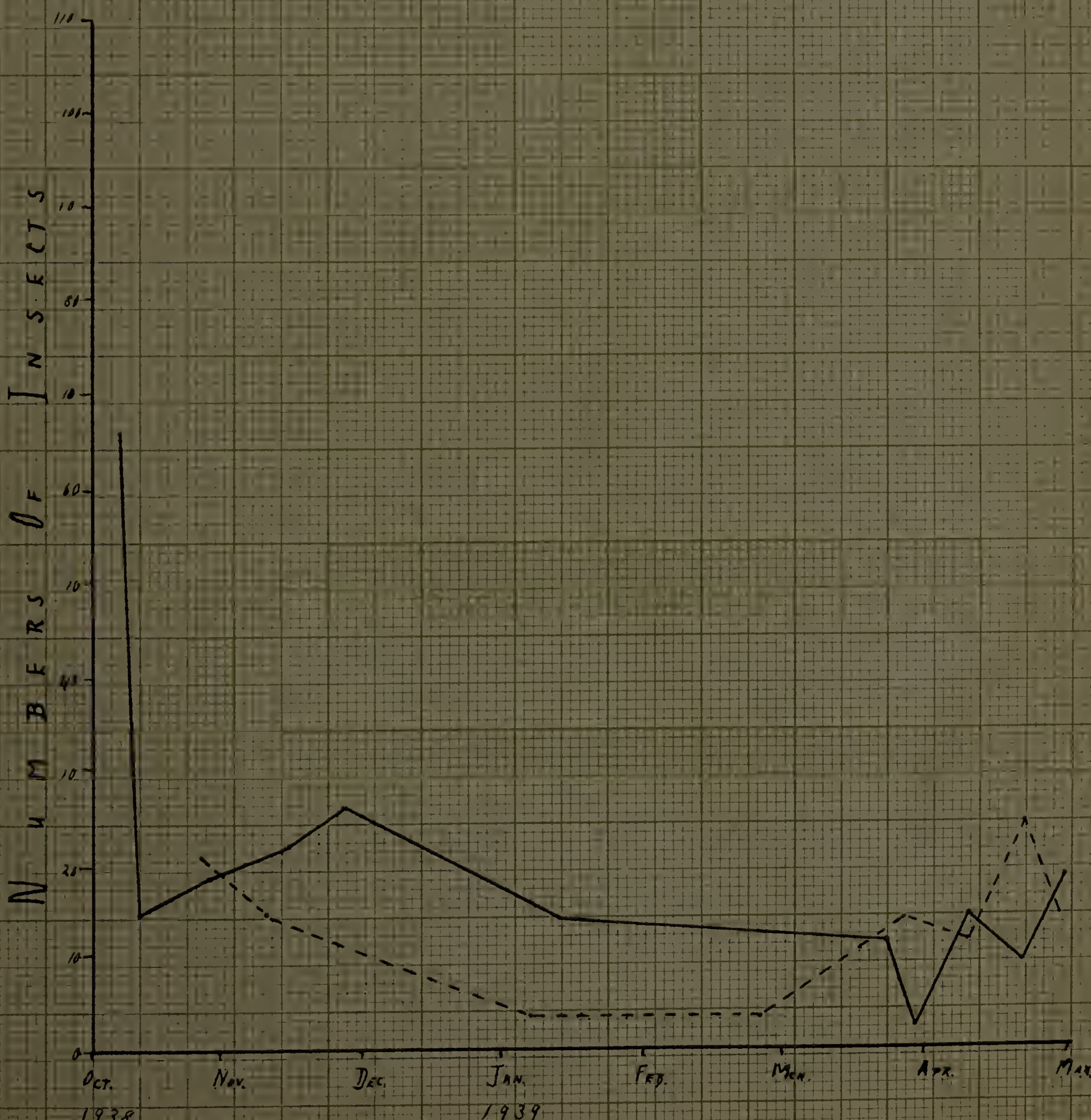
Bottom Collections

Graph Of Total Numbers Of Insects Found In District No. I

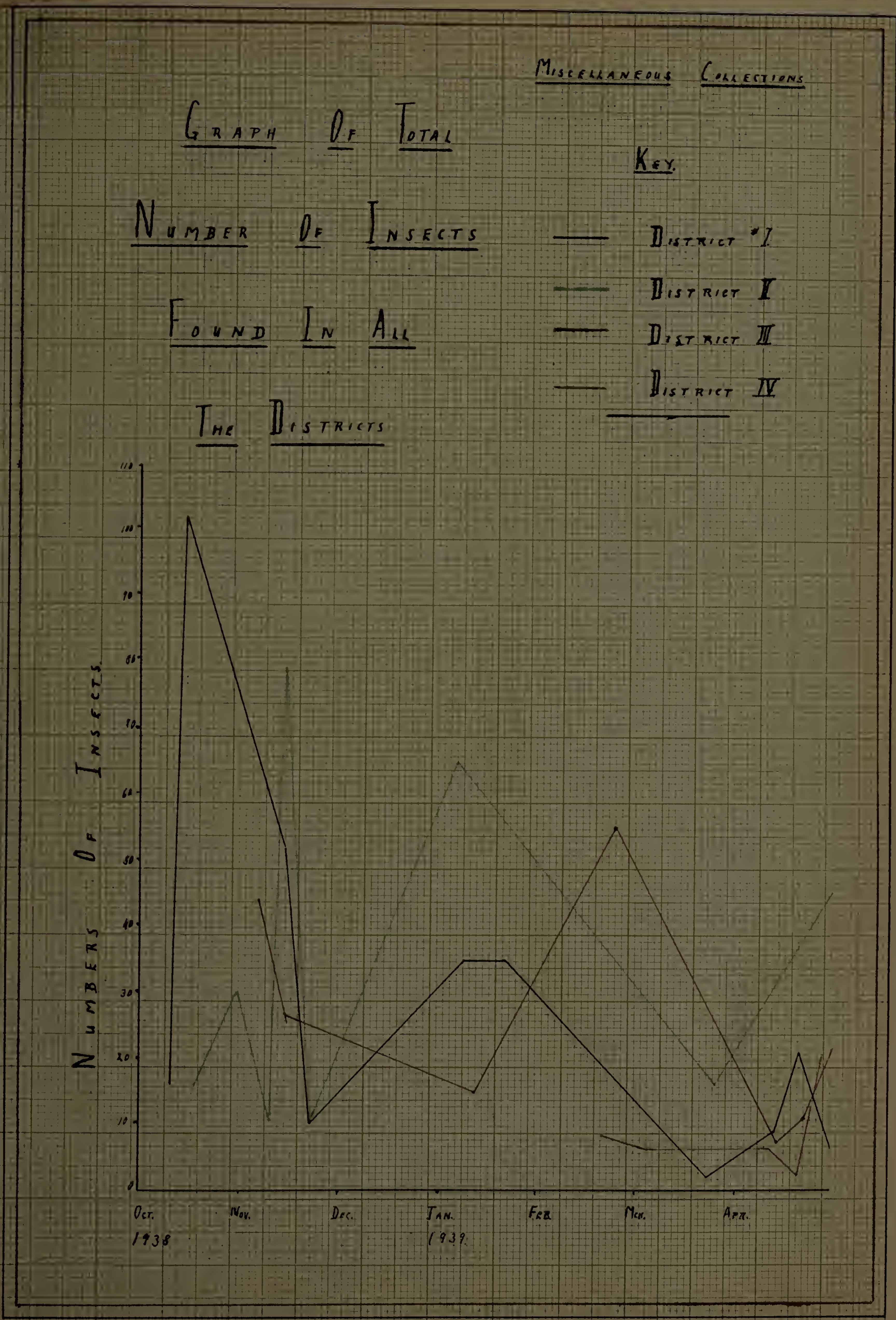
Key

——— Station #1

- - - - Station #2



No. 2 THE H. COLE CO., COLUMBUS, OHIO.



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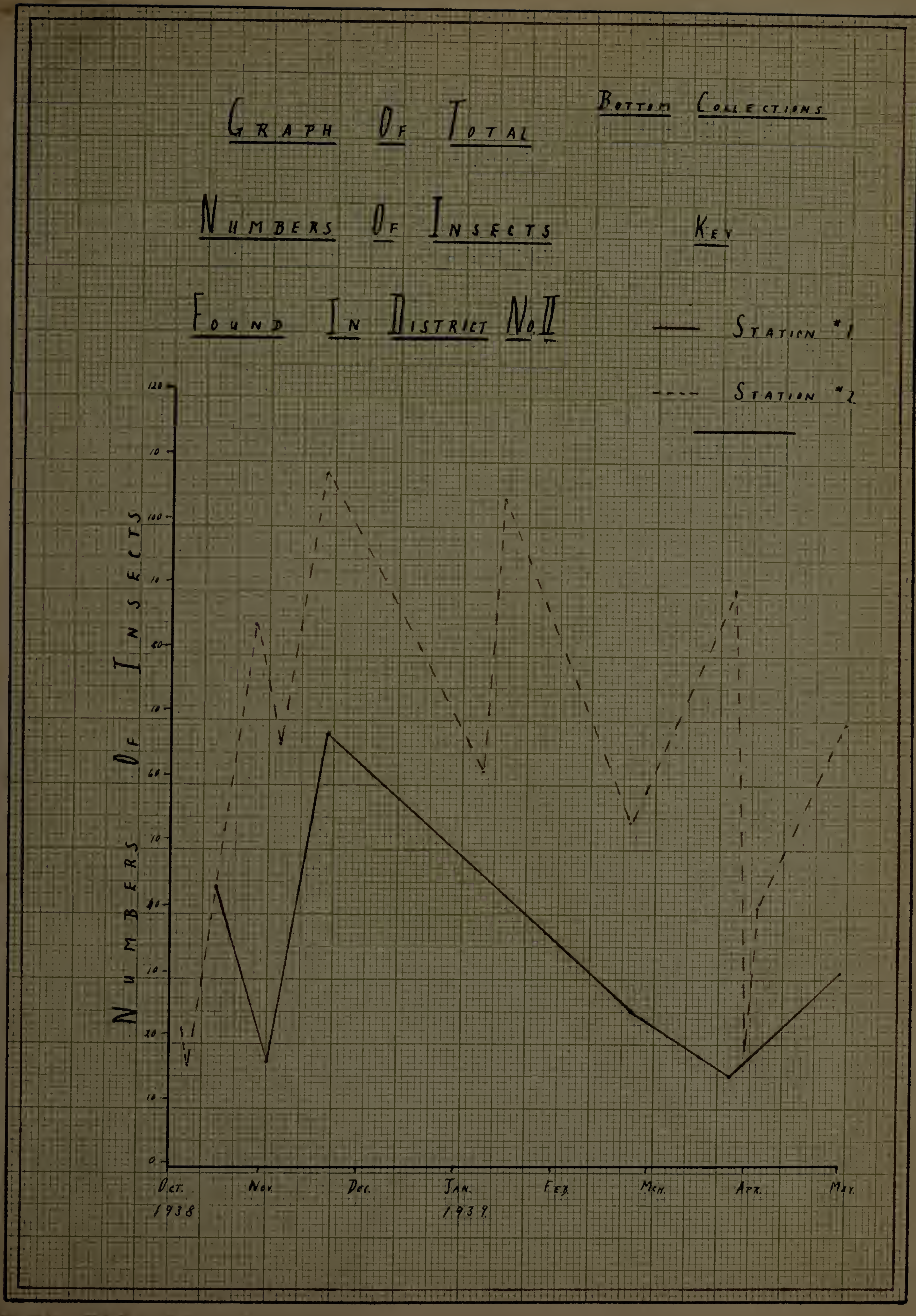
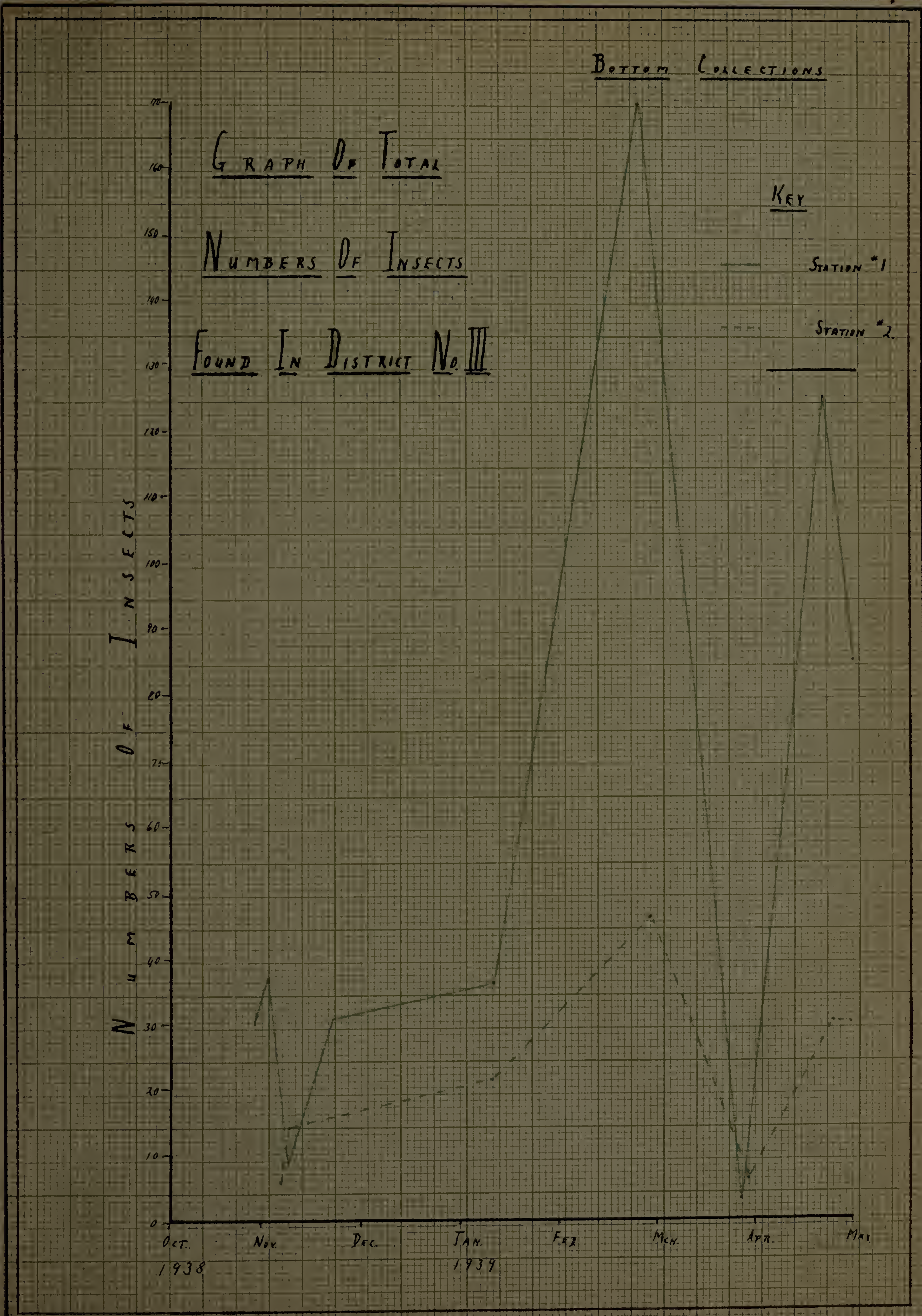


THE H. COLE CO., COLUMBUS, OHIO.



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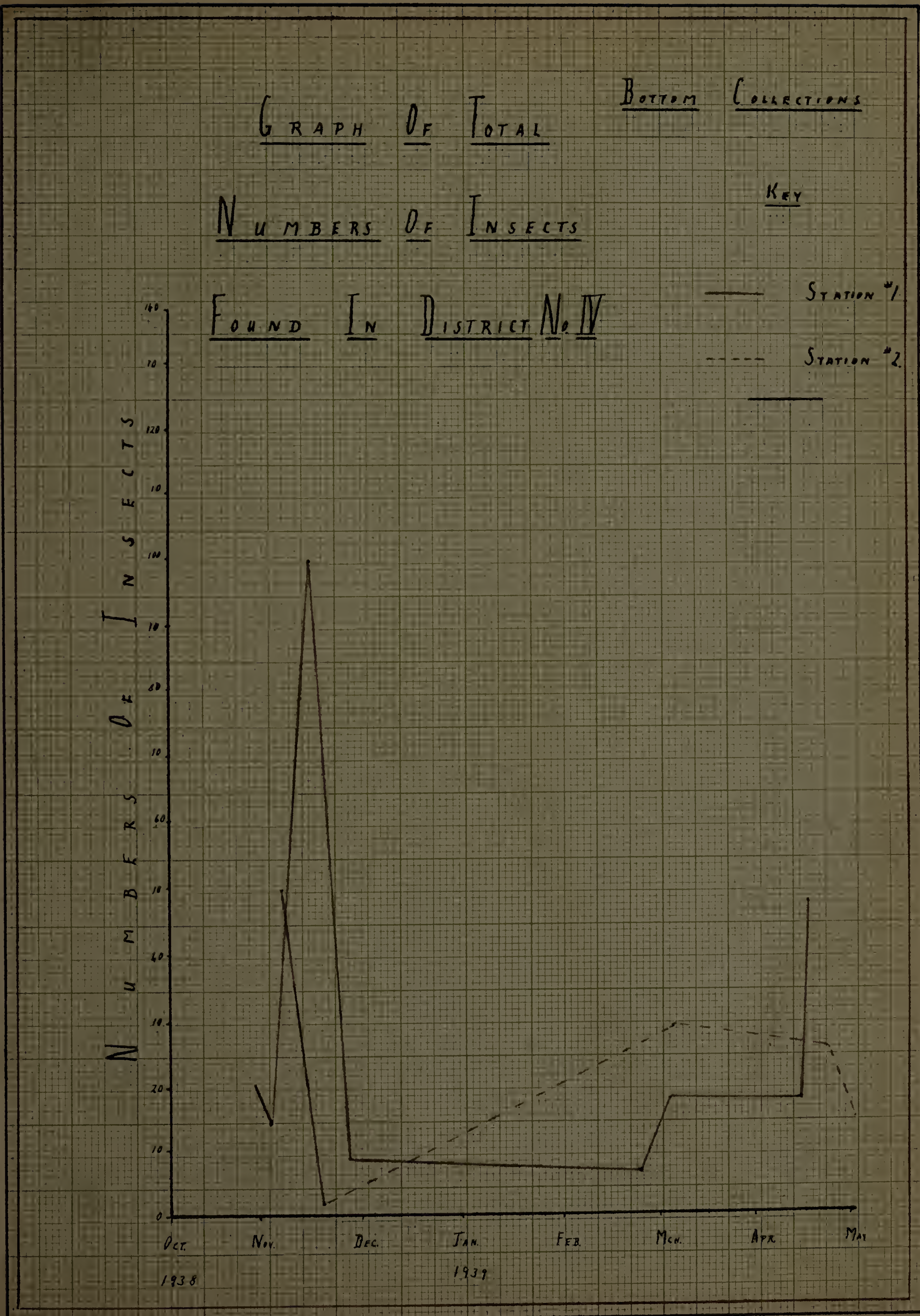
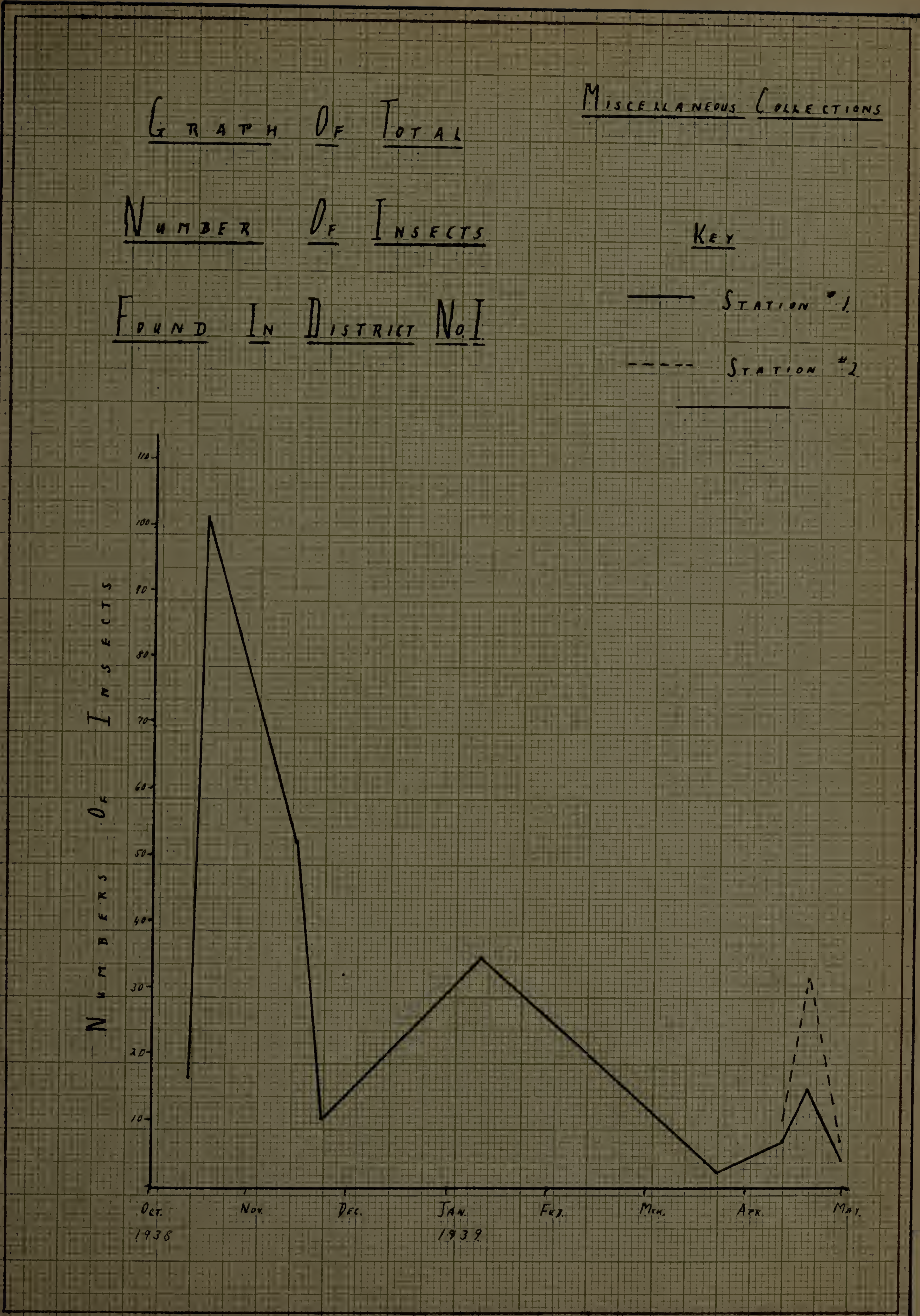

Graph Of Total
Numbers Of Insects
Found In District No. IV
Bottom Collections
Key
Station #1
Station #2
Numbers Of Insects
140
120
100
80
60
40
20
10
0
Oct.
1938
Nov.
Dec.
Jan.
1939
Feb.
Mch.
Apr.
May



Graph Of Total
Number Of Insects
Found In District No. I
Miscellaneous Collections
Key
Station #1
Station #2
Numbers Of Insects
110
100
90
80
70
60
50
40
30
20
10
Oct.
1938
Nov.
Dec.
Jan.
1939
Feb.
Mch.
Apr.
May

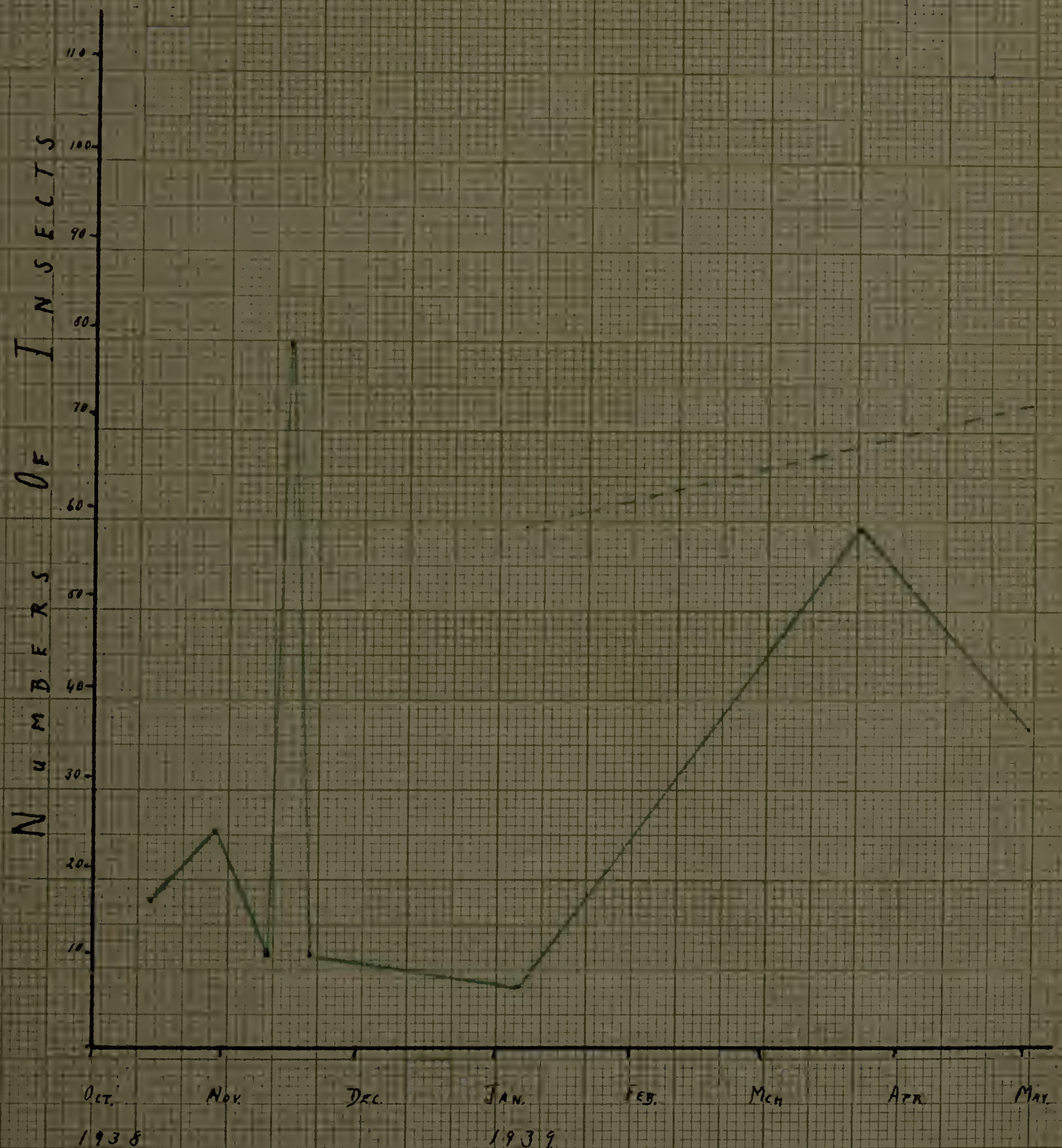
Miscellaneous Collections.

Graph Of Total Number Of Insects Found In District No. II

Key

Station #1

Station #2



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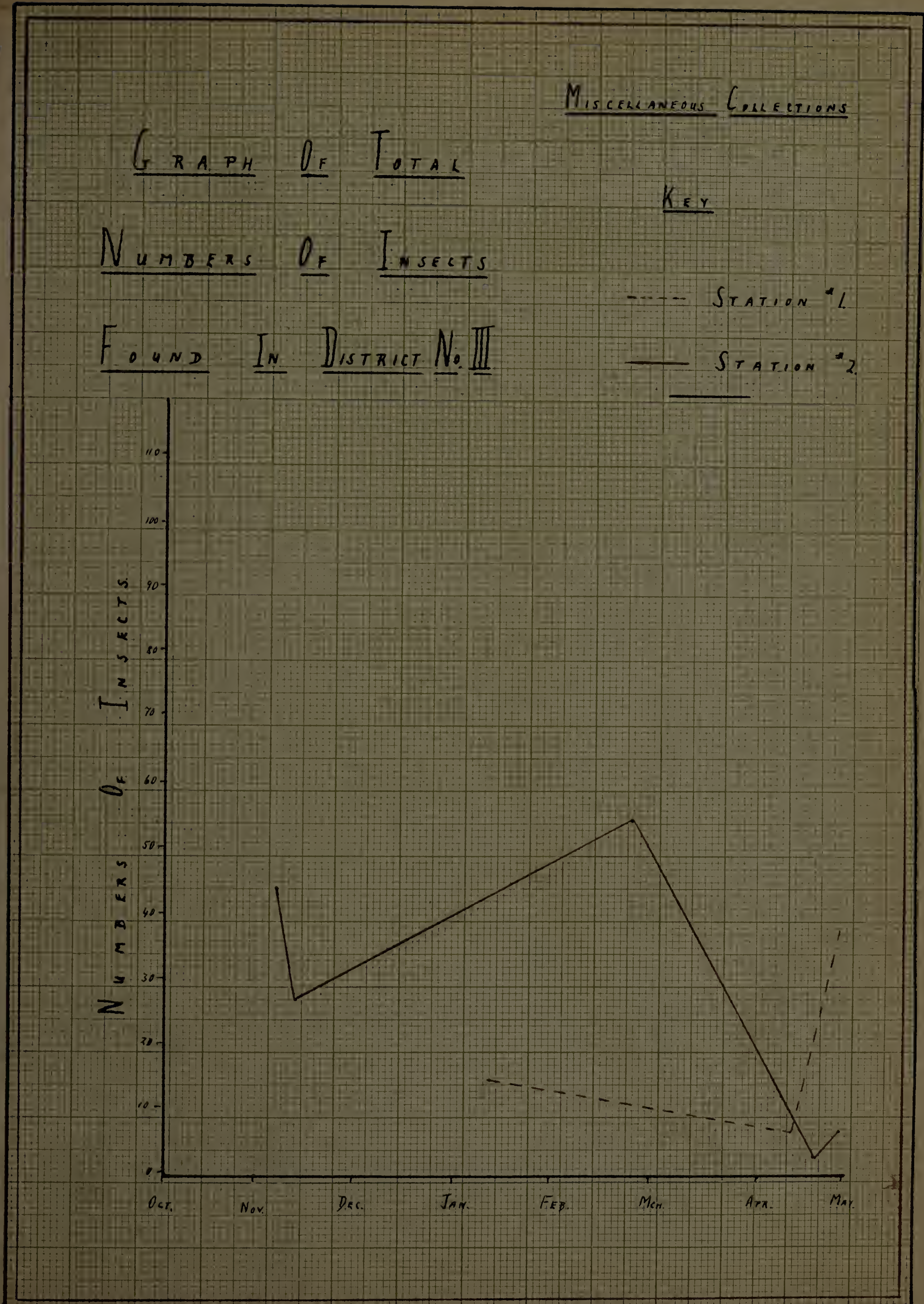


THE H. COLE CO., COLUMBUS, OHIO.

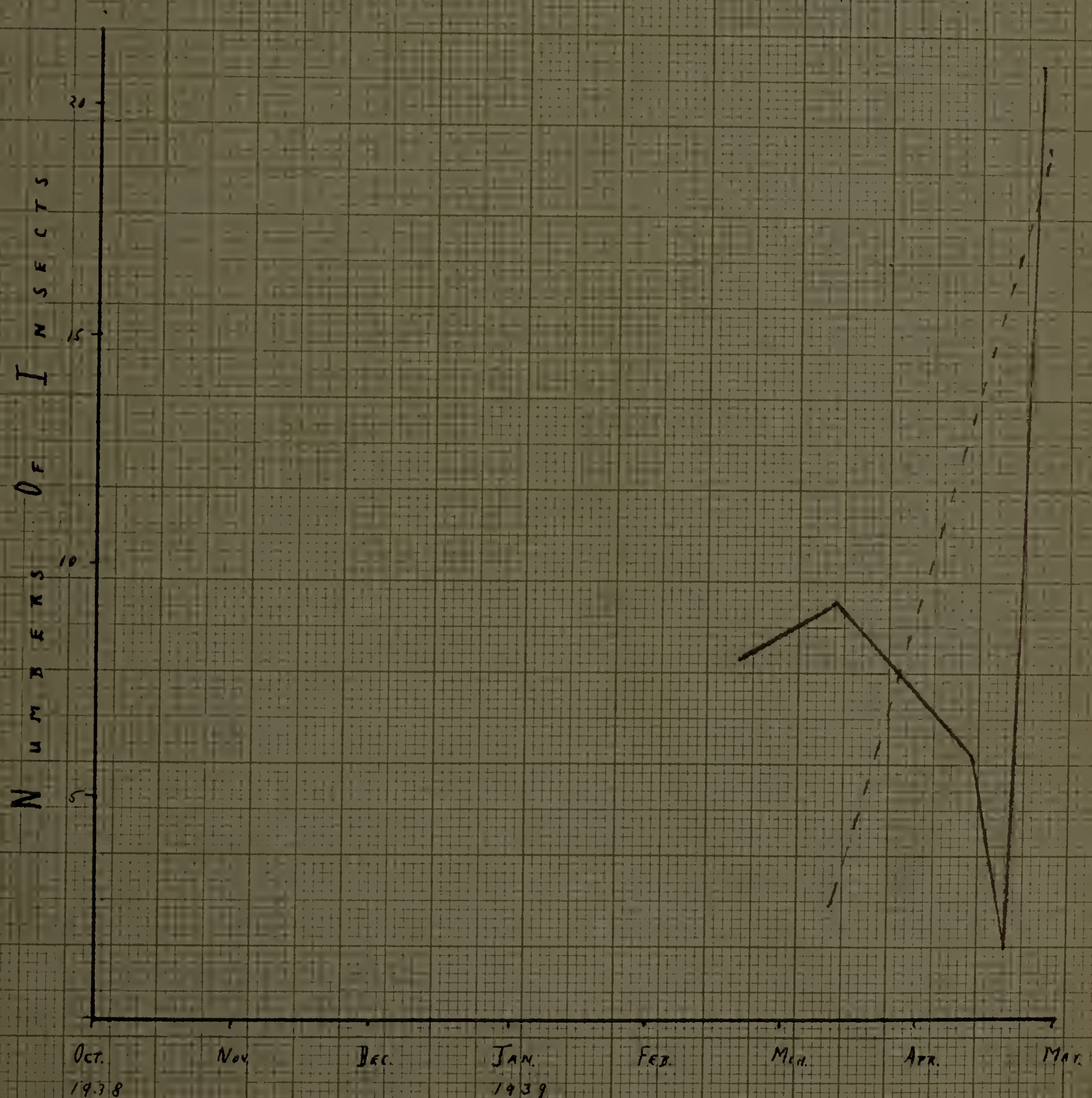
Miscellaneous Collections

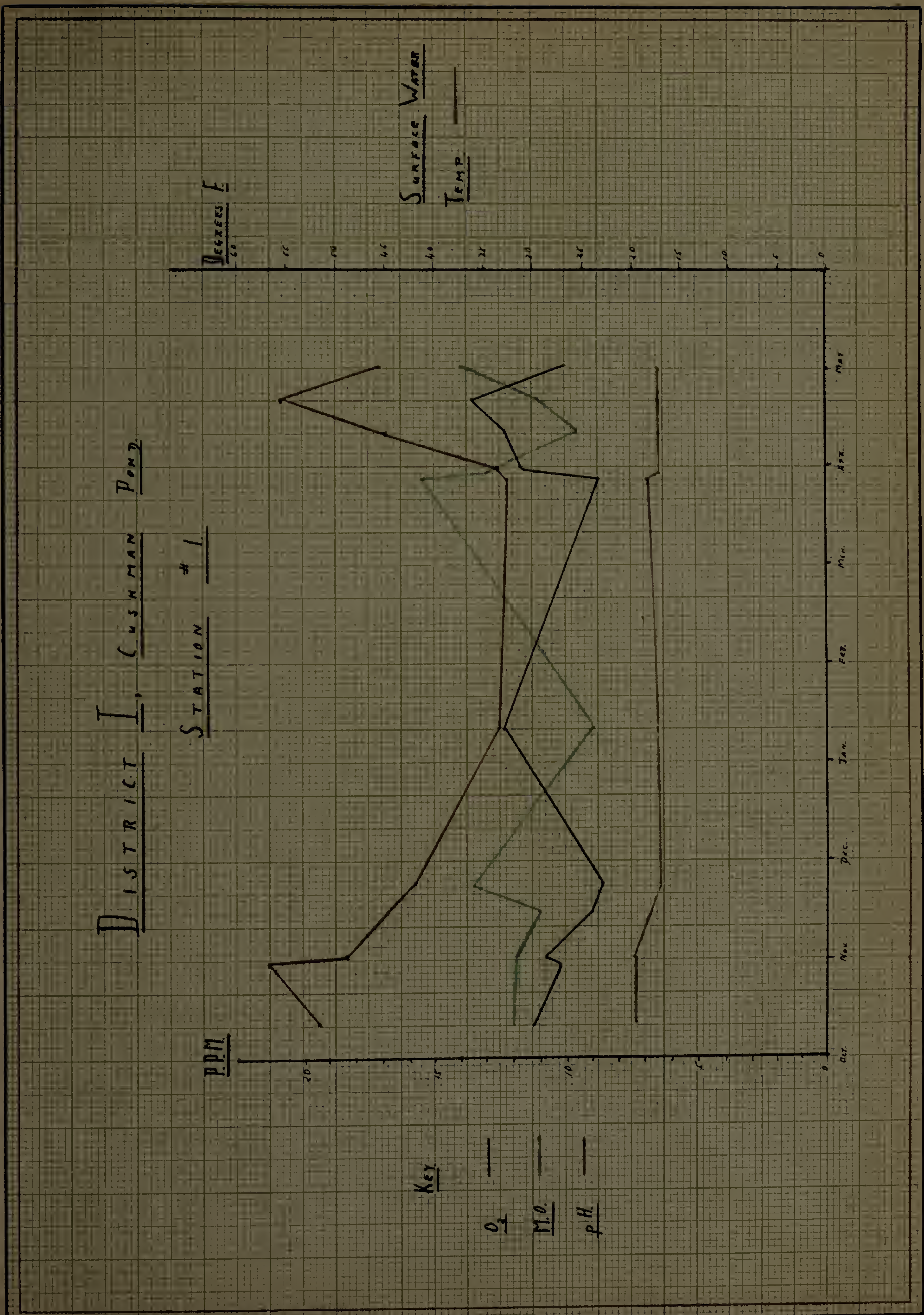
Graph Of Total Number Of Insects Found In District No. IV

Key.

——— Station #1.

- - - - Station #2.





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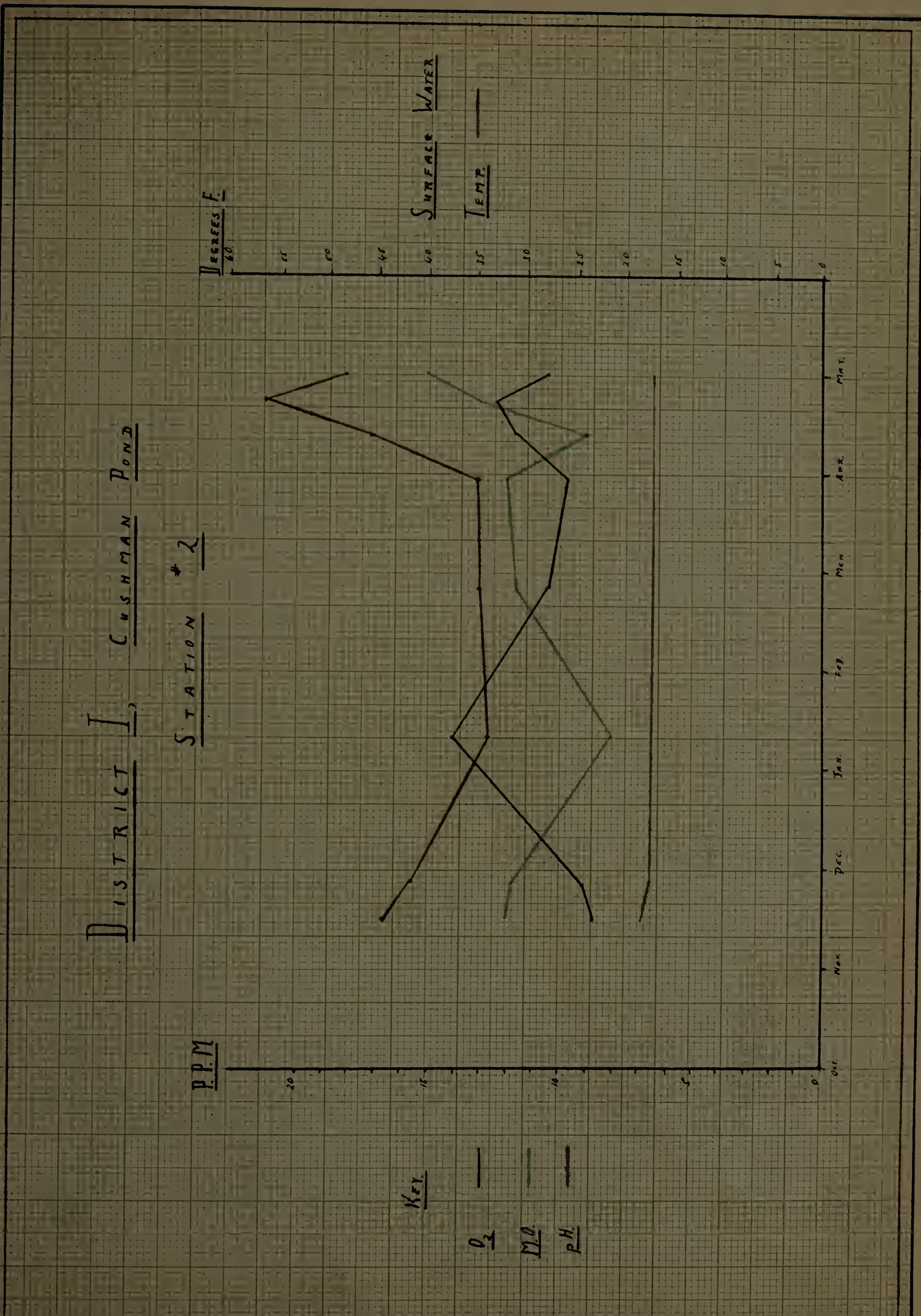
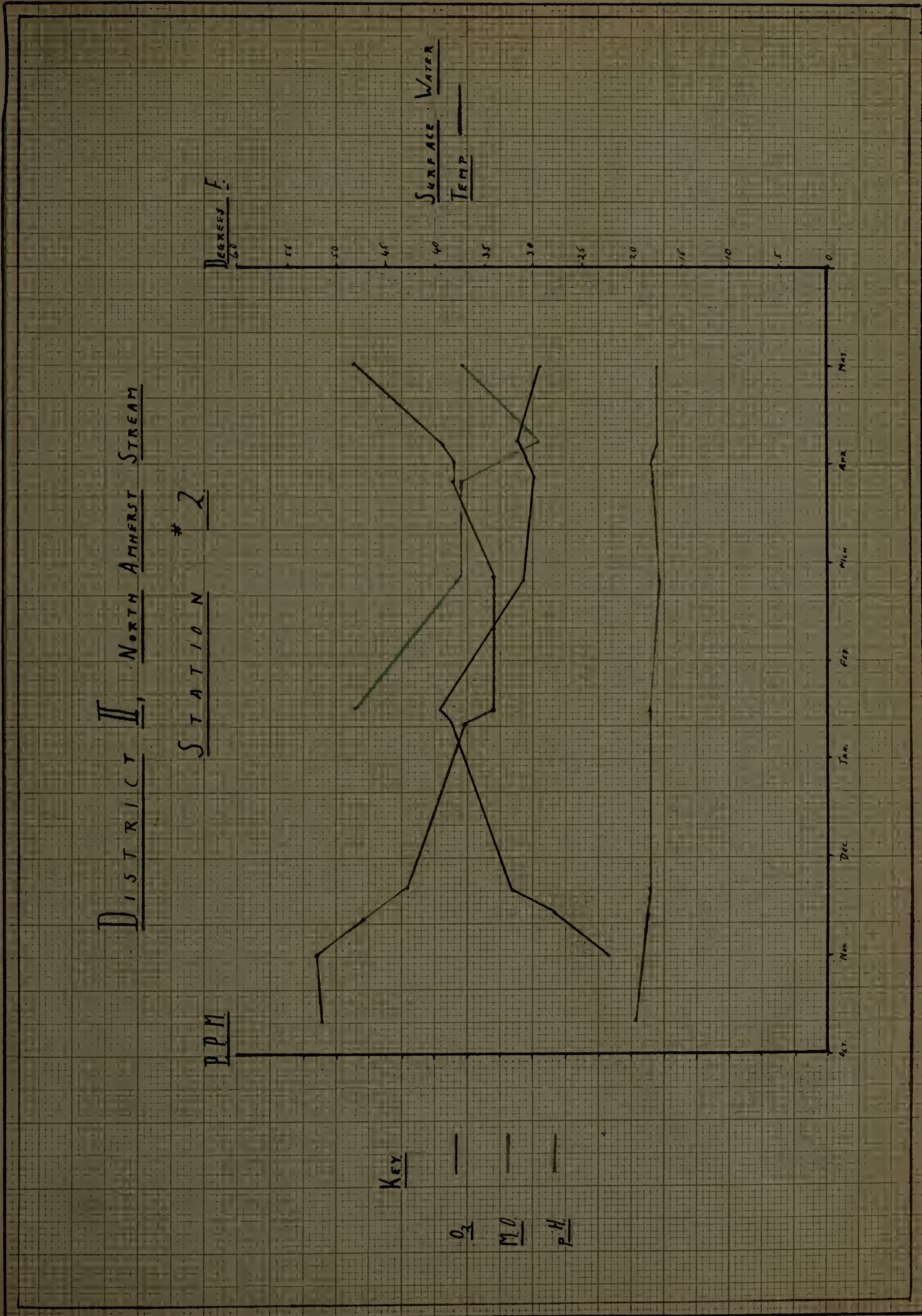


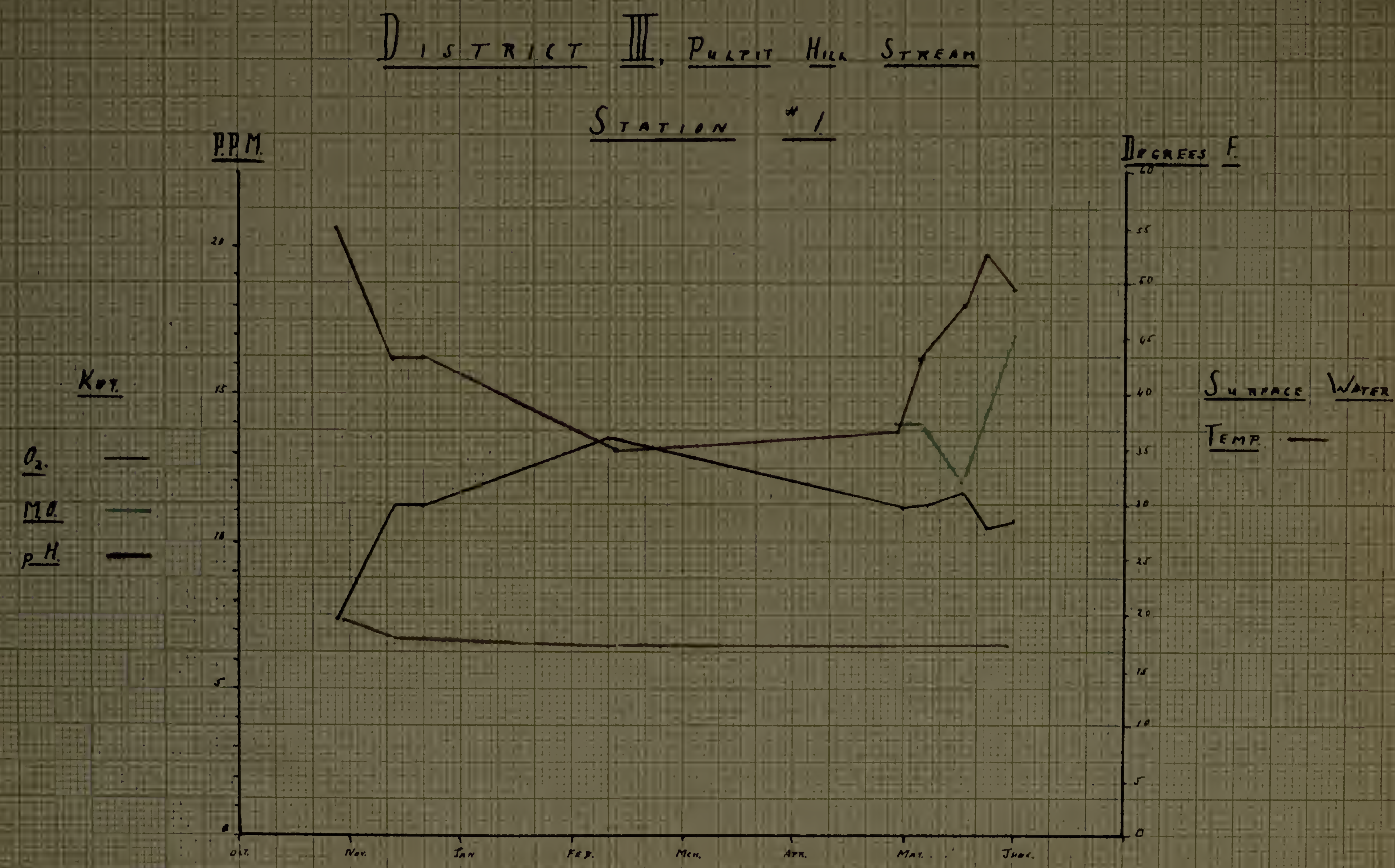
... 2?0-F THE H COLE CO., COLUMBUS, OHIO.

District II, North Amherst Stream

Station # 1



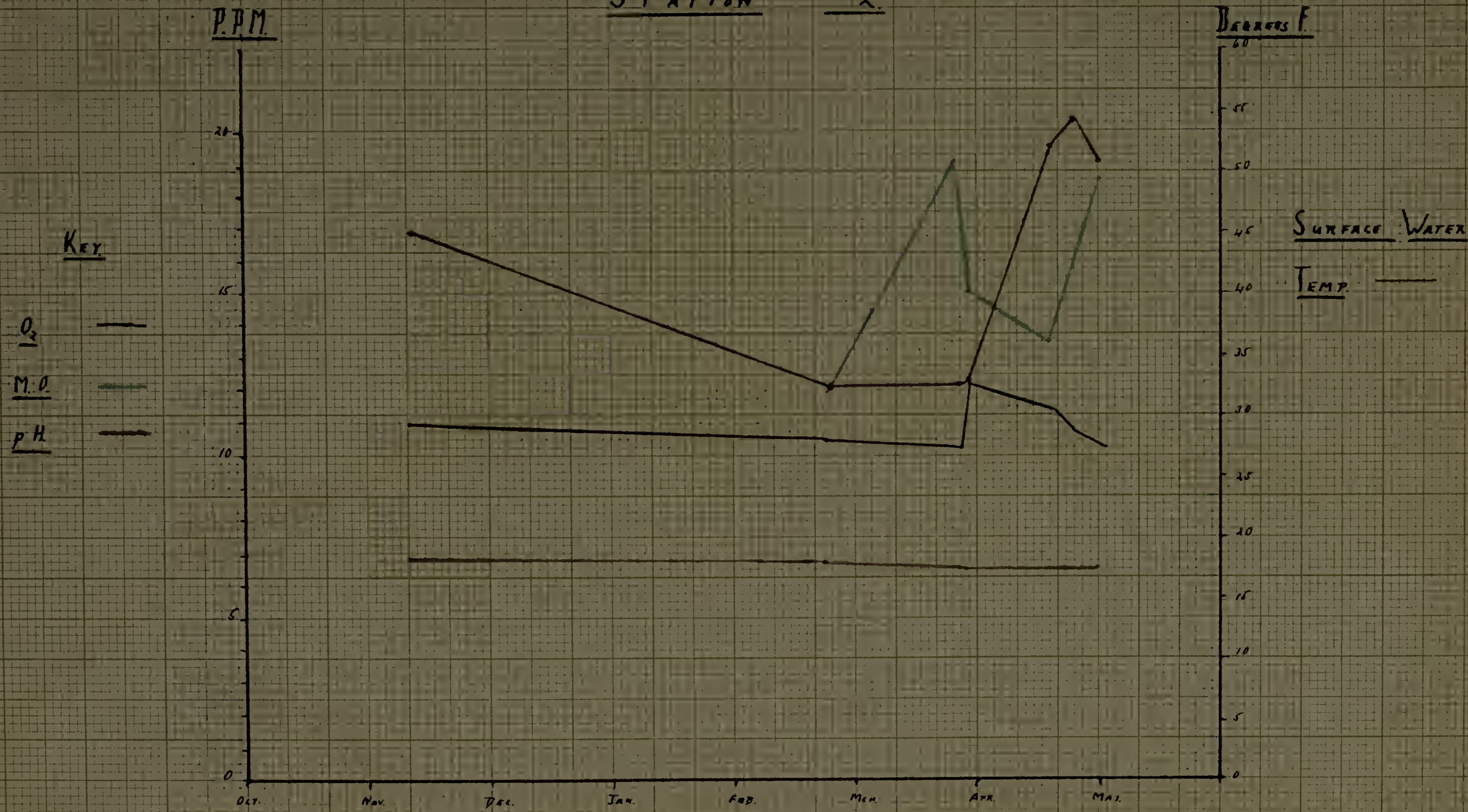
THE H. COLE CO., COLUMBUS, OHIO.



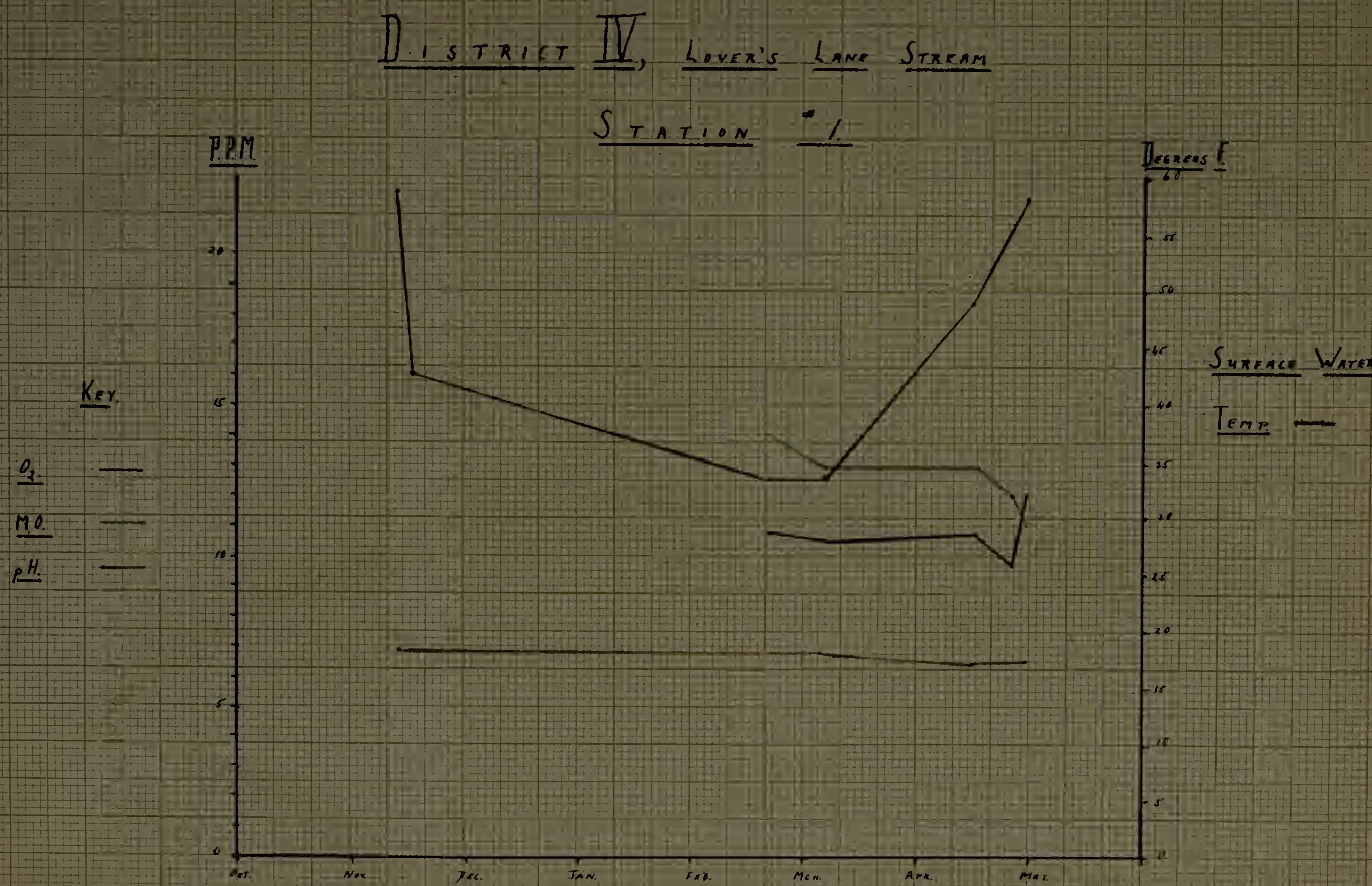
THE B. COLE CO., COLUMBUS, OHIO.

District III, Pulpit Hill Stream

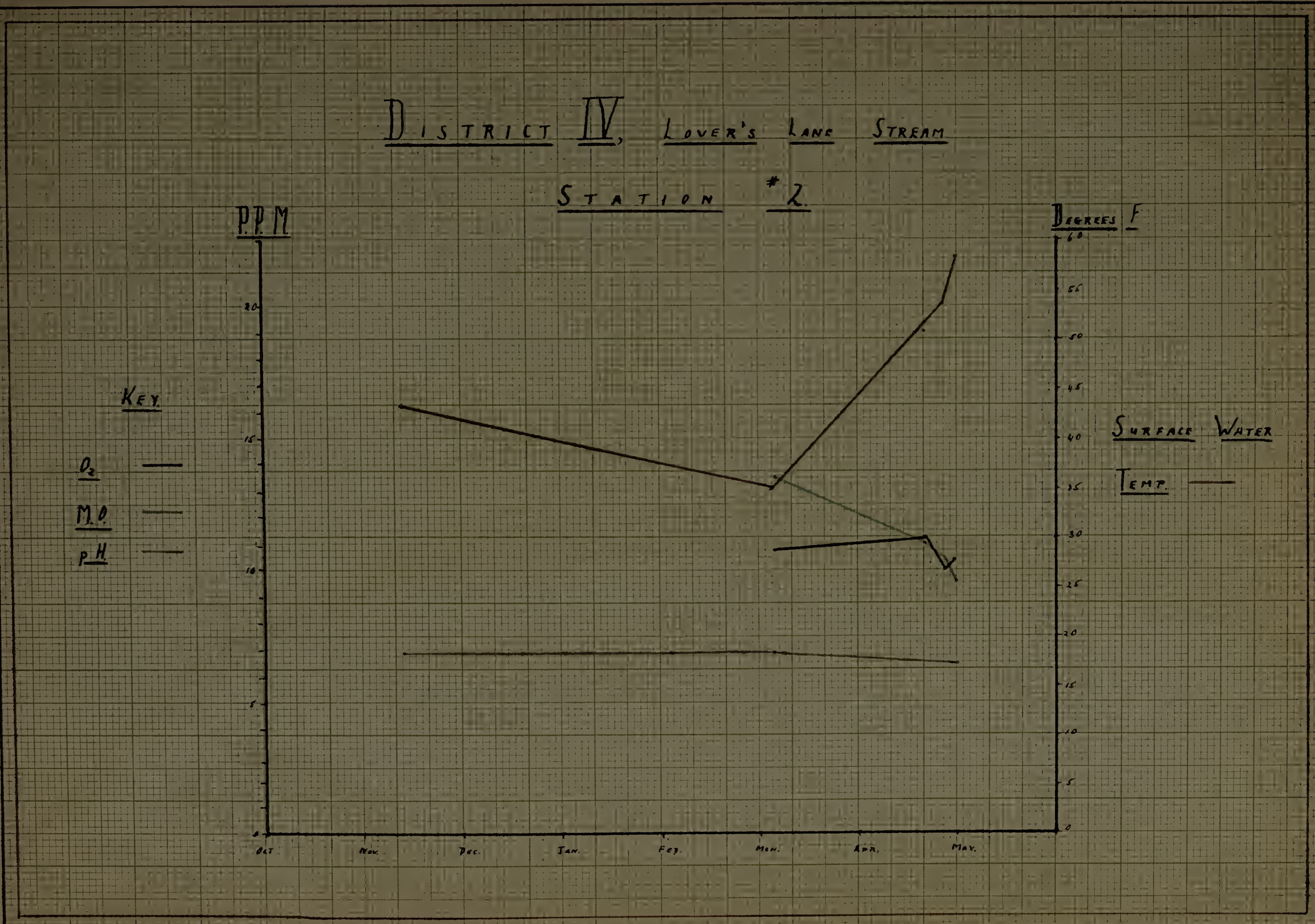
Station # 2

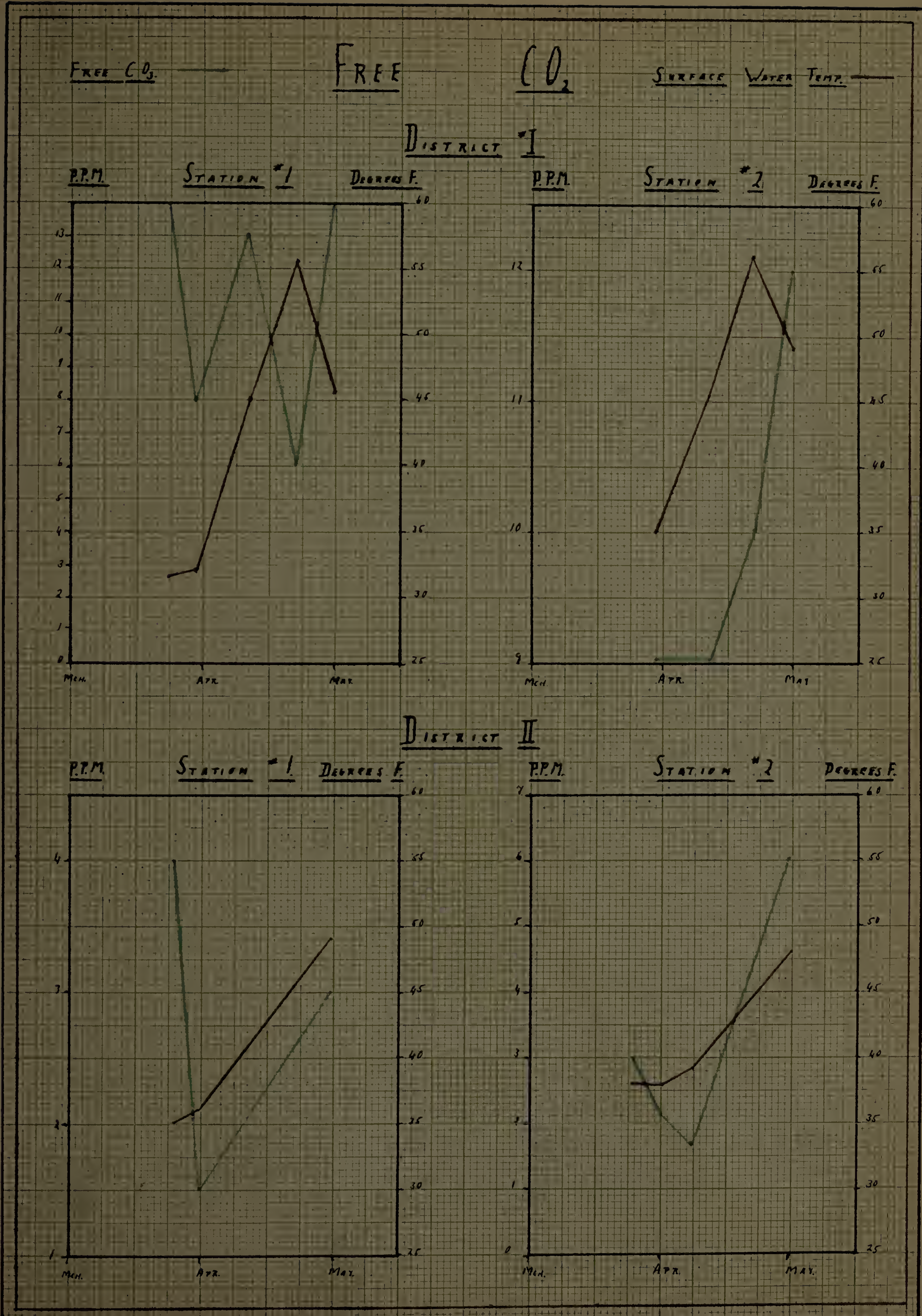


No. 350-S THE H. COLE CO., COLUMBUS, OHIO.

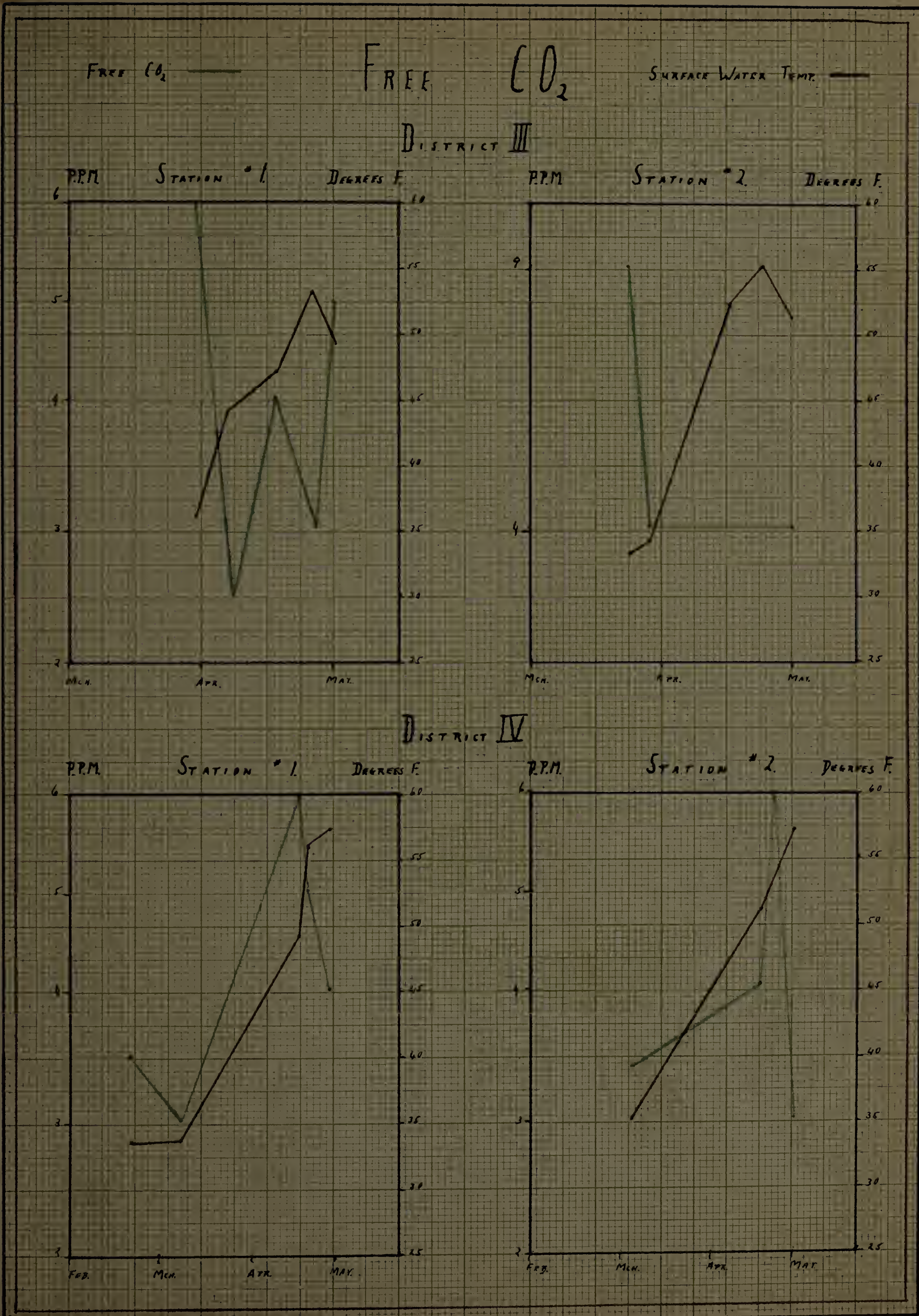


THE H. COLE CO., COLUMBUS, OHIO.


District IV, Lover's Lane Stream
Station #2
P.P.M.
Degrees F
Key
O_2
M.O.
pH
Surface Water
Temp.
20
15
10
5
0
60
55
50
45
40
35
30
25
20
15
10
5
0
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May.



No. 2... THE H. COLE CO., COLUMBUS, OHIO.



No. 2?0 F. THE H. COLE CO., COLUMBUS, OHIO.

D. Discussion of Data

I. Discussion of Physical Factors.

A. General statements

a. Temperature

The temperature of the water varied at the different stations from one to two degrees, and sometimes more, on a given date. Occasionally, it was the same. The water temperature did not fluctuate quite as rapidly at the pond areas as it did at the stream areas. This was probably due to the fact that the water in the ponds moved more slowly and was not stirred up as much as the water in the streams. The air camecin contact with more of the fast moving and turbulent stream water and had a better chance to cause more temperature fluctuation. During the winter months the pond areas were covered with a layer of ice which helped to keep the water temperature rather stable. The streams were more nearly subject to every change in the air temperature because they very seldom froze over entirely. The surface water temperature of the four Districts seemed to follow a normal curve from a high temperature in the fall down to within a degree or two of freezing (32°) in the winter and then gradually moving back up to a high temperature in the spring.

b. Dissolved oxygen content.

When the pond areas (i.e. Cushman Pond and Pulpit Hill Pond) were frozen over during the winter the dissolved oxygen content was at its lowest point. This could be due to the ice shutting off the water from direct contact with the air or, as in Cushman Pond, the presence of decomposing plant remains producing a great amount of carbon dioxide which replaced the oxygen in the water. The dissolved oxygen content was lower at Cushman Pond than at Pulpit Hill Pond at this time.

At the pond areas the water moves slowly and does not have as much chance for good contact with the air as in the stream areas where the turbulent, swift moving water obtains a good deal of oxygen from the air. At Cushman Pond this handicap is taken care of in the fall and late spring by the oxygen given off by luxuriant aquatic plants.

c. Methyl orange alkalinity.

The methyl orange alkalinity was fairly high at all the stream and pond areas and it fluctuated somewhat over the winter period. This showed the presence of carbonates and bicarbonates in all the stream and pond areas.

d. Hydrogen - ion concentration

The hydrogen - ion concentration (pH) was almost neutral in all the stream and pond areas. It ranged from alkaline,--in the fall, to slightly acid in the winter and early spring.

e. Carbon Dioxide content.

The carbon dioxide content was highest at Cushman

Pond where there is much decomposing aquatic plant material and especially so during the period when it is frozen over. At Pulpit Hill Pond the carbon dioxide content was not as high as at Cushman Pond but at its highest when frozen over. North Amherst Stream and Lover's Lane Brook were very low in carbon dioxide content. This was due probably to the lack of much aquatic plant growth and the fact that they do not freeze over in the winter for any length of time.

f. Volume and Velocity of the water.

The volume and velocity of the water was obtained only twice at the four districts, and then only when the streams and ponds were at a normal stage. From this data it was found: that Cushman Pond had a fairly large volume of water flowing through it in the main channel at a very slow rate of speed; North Amherst Stream had a very large volume of water flowing at a fairly fast rate of spped; Pulpit Hill Stream had a small volume of water flowing at a fairly fast rate of speed; and Lover's Lane Brook had a very small volume of water flowing at a fairly fast rate of speed.

During heavy rains and in the winter when the snow and ice would thaw, Lover's Lane Brook was noticed to have a very large volume of water flowing through it at a very fast rate of speed. This probably served to scour the leaves and stream bottom and remove many of the aquatic insects.

B. As applied to districts.

a. District I, Cushman Pond.

At Cushman Pond the physical factors coincided in every case at both stations. In October when the surface water temperature was fairly nigh the dissolved oxygen content was fairly high, the methyl orange alkalinity was a little higher then the oxygen content and the pH was on the alkaline side of the range. Towards the last of November the surface water temperature began to go down and at this time the oxygen content went down too. The alkalinity, however, went up and the pH lowered to a slightly acid concentration. Then as the water temperature continued to fall down near freezing, the oxygen content rose to a rather high peak and the alkalinity fell to a low level. The pH remained on the slightly acid side. As the surface water temperature remained close to freezing and an ice layer covered the pond area, the oxygen content fell gradually to a low level again. At the same time the alkalinity gradually rose to its highest point. In April, when the ice and snow melted, the oxygen content began to rise until in May it dropped again. The alkalinity dropped in April and in May rose again. At the time when the carbon dioxide content was measured in the spring, it showed a rather high content, before the ice and snow melted and than as the temperature rose in April and the ice and snow thawed out, the carbon dioxide content dropped lower and then rose again in May.

b. District II, North Amherst Stream

At this stream area the surface water temperature began to fall in November and it reached its lowest point the last of March at station # 1, but remained lowest at station # 2 from January to the last of February. From March to May the temperature began to rise at both stations. In the fall, the methyl orange alkalinity was very high while the oxygen content was rather low, and the pH concentration was slightly alkaline. As the temperature of the water dropped to near the freezing point; the alkalinity dropped very slightly, the oxygen content rose; and the pH fell to a slightly acid concentration. As the water temperature rose in the spring, at first, the alkalinity dropped still lower, the oxygen content rose slightly, and the pH rose a little then, as the temperature reached its height in May; the alkalinity remained low while the oxygen content and pH fell. In the spring the carbon dioxide was high before the water temperature began to rise, dropped as the snow and ice melted and as the temperature went up the carbon dioxide content also rose.

c. District III, Pulpit Hill Stream

This area is divided into station # 1 located below a dam on the stream proper while station #2 is located on a pond just above station # 1.

Station # 1 -- at this station the water temperature oxygen content, alkalinity and pH all progressed nearly exactly as in the North Amherst Stream area. (station #2).

Station # 2 -- at this station the temperature of the water showed the same regular curve of fall and rise, alkalinity lowest in mid-April after which it rose gradually, oxygen content gradually decreased until the last of March when the ice and snow melted, and then there was a sharp rise. After this it slowly decreased again. The pH reacted the same way as at the other districts.

The carbon dioxide content was the same at station # 1 as at the other districts but at station # 2 it was high in mid-March, fell rapidly in late March, and instead of rising when the ice and snow thawed, it remained at a low level.

d. District IV, Lover's Lane Stream

At this area the water temperature and pH concentration showed curves approximating the other stream areas. Although insufficient alkalinity tests were taken to make a comparison with the other districts; there was a slight difference which should be mentioned. Just after the spring thaw the oxygen content and alkalinity both dropped for awhile then the oxygen content rose while the alkalinity continued to fall.

The carbon dioxide content differed from the other areas, in that, after rising awhile following the spring thaw, it began to drop again to a lower level.

II. Discussion of aquatic insect populations.

A. Distribution in terms of taxonomic groups.

a. Stream and pond populations from bottom samples.

In the pond areas at Cushman and Pulpit Hill, bottom collections were made with a square foot dredge. At Cushman Pond heavy, luxuriant aquatic plant growth extended from the shore throughout the entire pond area. At Pulpit Hill Pond there was very little aquatic vegetation in the pond or along the shore line.

There was a complete absence of the aquatic insect order Plecoptera in these pond areas. Only a small number of the order Neuroptera were found present. The most conspicuous orders of aquatic insects in numbers were the following: Coleoptera, Diptera, Ephemeroptera, Hemiptera, Odonata, and Trichoptera. Among the aquatic insect orders found present in the pond areas there were certain families and species which were found to be present in only one area. The following is a list of these families and species: Cushman Pond, Odonata-(Zygoptera) Lestes; Pulpit Hill Pond, Coleoptera-Hydrophilidae, Diptera-Empididae, Ephemeroptera-Ephemeridae, Hexagenia; Baetidae, Caenis, Hemiptera-Belostomidae, Belostoma, Odonata-(Anisoptera) Lanthus, Gomphus, Neuroptera-Sialis.

In the stream areas of North Amherst, Pulpit Hill, and Lover's Lane, bottom collections were made with a square foot sampler. At North Amherst Stream and Lover's Lane Brook there was very little aquatic plant growth found present on the stream bottom or shore line. At Pulpit Hill Stream there was some aquatic plant growth on the stream bottom.

The order Hemiptera was found to be absent in all three of the stream areas. Only a few of the order Coleoptera were found present. There were none found at Pulpit Hill Stream. The order Odonata was also very scarce in numbers, there being none found at Pulpit Hill Stream, station # 1 of North Amherst Stream, and station # 2 of Lover's Lane Brook. The Neuroptera were conspicuous also in their fewness of numbers, there being none found at Pulpit Hill Stream and Lover's Lane Brook. The following insect orders were found to be abundant in numbers: Diptera, Ephemeroptera, Plecoptera and Trichoptera.

As in the pond environments there were certain families and species of aquatic insects which were found to occur only in one stream area. They were found to be as follows: North Amherst Stream, Coleoptera-Psephemus,

<u>Diptera</u>-Blepherocera, <u>Ephemeroptera</u>-Isonychia, <u>Neuroptera</u>-Corydalus, <u>Trichoptera</u>-Odontoceridae, Helicopsyche; Pulpit Hill Stream, <u>Diptera</u>-Tipula, <u>Plecoptera</u>, Acroneuria, Nemoura; Lover's Lane Brook, <u>Diptera</u>-Dixa, <u>Ephemeroptera</u>-Ameletus, <u>Odonata</u>-Cordulagaster, <u>Plecoptera</u>-Clioperla, Leuctra.

b. Stream and pond aquatic insect populations, from shore samples.

A hand net was used to make the aquatic insect collections along the shore of all four areas. These aquatic insect collections from along the shore line were compared with those obtained in the bottom samples.

At the pond areas of Cushman and Pulpit Hill the following aquatic insect orders were found to differ in numbers. At Cushman Pond the orders Trichoptera and Odonata were found to be more numerous along the shore line than in the bottom samples. At Pulpit Hill Stream and shore collections showed that the orders Ephemeroptera and Diptera were more numerous in comparison to the bottom samples. In these pond areas the same aquatic insect families and species were found present in both shore and bottom samples.

In the order <u>Trichoptera</u> the families Philopotamidae, Rhyacophilidae and Hydropsychidae were found present at Cushman Pond, along the shore line, while none of these families were found present in the bottom samples. In the order <u>Ephemeroptera</u> the species Callibaetis was found present along the shore line while in the bottom samples Siphloplecton, Paraleptophlebia and Ephemerella were found present in addition to Callibaetis. In the Order Odonata the species Anax was found present only in the shore samples. At Pulpit Hill Pond the order Odonata was found to have species Agrion, Lestes, Amphiagrion, Tetragoneuria, and Hagenius along the shore while only Lanthus was found in the bottom samples. In the order Hemiptera the species Notonecta and Belostoma were found only in the shore samples. In the order Coleoptera the family Haliplidae was found only in the shore samples.

At the stream areas the shore and bottom samples compared very well in numbers but there were several differences in the occurrence of families and species. At North Amherst Stream, the following families and species occured only along the shore: Coleoptera-Gyrinidae, Plecoptera-Leuctra, Acroneuria, Trichoptera-Limnephilidae, and Philopotamidae. These occured only in bottom samples; Coleoptera-Psephenus, Diptera-Blepherocera, Atherix, Neuroptera-Chauliodes, Corydalus, Plecoptera-Perla, Trichoptera-Odontoceridae. Pulpit Hill Stream, those peculiar to the shore samples; Trichoptera-Neuronia,. These occurred only in the bottom samples; Diptera-Ceratopogonidae, Tipula, Antocha, Atherix, Plecoptera-Nemoura, Perla, Isoperla, Acroneuria, Trichoptera-Glossomatinae. Lover's Lane Brook, along the shore line the following families and species were found; Odonata-Agrion, Trichoptera-Odonataceridae, Coleoptera, Tropistermus, These were found only in the bottom samples; Diptera-Simulidae, Dixa, Ephydridae, Ephemeroptera-Baetis, Siphloplecton, Blasturus, Odonata-Cordulagaster, Plecoptera-Perla, Taeniopteryx, Leuctra, Trichoptera-Philopotamidae, Brachycentrinae, Coleoptera-Bidessus.

B. Districtuion in terms of numbers of individuals collected.

a. Populations from bottom samples.

District I, Cushman Pond

Station # 1 -- At this station the aquatic insect population was high in early October, dropped low in number during the next few days and, after rising somewhat in late November, gradually tapered lower until the last of March when there was a sharp drop to the lowest point. From there the population showed a slight rise in numbers in early April, a slight decline in late April and another upturn in early May.

Station # 2 -- (located in the inlet of the pond). This area showed a more gradual descent in numbers but went considerably lower over the period between the middle of January and the middle of Bebruary. There was then a gradual rise in population numbers until May when again it fell, slightly.

District II, North Amherst Stream

Station # 1 - In November the aquatic insect population fell very low in numbers then rose rather high in late November and from there tapered off gradually to the lowest point in late March. From April to May there was a gradual rise.

Station # 2 - In October the aquatic insect population dropped low then rose to a rather high point in November. Then in December, January and March the population fluctuated from fairly low to a very high number until, in April, it fell quite low. From April to May the aquatic insect population rose somewhat higher.

District III, Cushman Pond and Stream

Station # 1 - In November the population numbers dropped very low then gradually rose to a very large total in February. In March the numbers fell very low increased again in April and then decreased slightly in early May.

Station # 2 - (pond area). In this station the population numbers were not as great as at station # 1 but they followed the same pattern of fluctuation.

District IV, Lover's Lane Brook

Station # 1 - In this area the aquatic insect population fell low in numbers in early November then rose to a high total in the middle of the month. In late November the total fell to a very low point at which it stayed until the first of March when it rose somewhat. There was no increase until the last of April when the total rose again slightly.

Station # 2 - At this station the population fell lowest in numbers in mid-November and then rose somewhat. In late April the population fell slightly.

b. Population from miscellaneous shore collections.

District I, Cushman Pond

Along the shore line in this area, the aquatic insect population dropped low in the early part of October then rose to a large total about the middle of the month. In late November the total dropped very low again then rose somewhat in January from where it tapered off to a very low point the last of March. In April there was a gradual rise, and in early May another low.

District II, North Amherst Stream

The shore collections dropped low in numbers in early November then rose very high in mid-November and fell low again the last part of the month. In January there was a marked increase, a decrease the last of March, when again a slow increase in numbers in early May.

District III, Pulpit Hill Stream

The aquatic insect population fell somewhat in November and then gradually rose to a rather high total in February. The total numbers gradually dropped to a low point in mid-April, and then a gradually increase in early May.

District IV, Lover's Lane Brook

Collections in this area were made only from late February to late April. Lowest numbers of insect were taken from early March to April 22, after which date a sharp increase occurred.

III. Comparison between date on insect population and on physical factors.

The data obtained from the aquatic insect collections was compared with that of the physical factors. There were certain periods when the aquatic insect populations reached a very high total of numbers and other times when they dropped to a very low total. A careful check was made of the physical factors at these periods of highs and lows to find out whether there might be any significant variables present.

1. Cushman Pond

Station # 1 - The surface water temperature was 18° lower at the time of least numbers of aquatic insects. There was an increase of 1.0 in the alkalinity and the pH was 0.8

lower on the low date. The oxygen content was 0.1 higher on the low date.

Station # 2 - The surface water temperature was 22° lower on the low date. The oxygen content was higher on one date that a low occurred but considerably lower on the other date. There was a difference of 3.6 between the two low dates, greater then between the lows and highs. The alkalinity varied from lower to higher than the high at the two low dates with a variation between the two lows of 3.9.

At Station #1 the variables were temperature, alkalinity and pH. The oxygen content was slightly higher on the low date. The alkalinity was higher, but the temperature and pH were lower. At station # 2 the oxygen content and alkalinity varied so much on the two low dates that no comparison can be made between lows and highs, the temperature was lower on the low dates and there was no variation in the pH.

2. <u>North Amherst Stream</u>

Station # 1 - The surface water temperature was respectively 5° and 7° lower at the time of the two spring (no physical tests taken on date of fall low) lows. The oxygen content was lower on these lows from 1.2 to 0.4 but as noted there was considerable difference between the lows. The alkalinity was from 6.0 to 4.9 lower than at the time of highs, and there was no variation in the pH.

Station # 2 - No physical tests were made on the dates of two of the lows. On the date of the third low, the temperature was 8^{o} and 18^{o} respectively higher than on the dates of the two highs; pH 0.4 and 0.8 higher respectively; no data taken on oxygen and alkalinity.

At station # 1 three factors were variable; the oxygen content lower on lows; the alkalinity lower on lows; the temperature lower on lows. At station # 2 the temperature was distinctly higher on the one low for which physical data was taken; pH likewise higher.

3. Pulpit Hill Stream

Station # 1 - No physical data recorded for date on which greatest number of insects were taken. On date of second highest number, the surface water temperature was 10^{o} to 17^{o} lower on lows, the oxygen content was 0.5 to 0.6 higher on lows, there was no variation in the alkalinity, and the pH was higher at the time of one low but similar to the high on the other low.

Station # 2 - No physical data recorded on date of one of the lows. The temperature was 1^{o} lower during one high but 18^{o} lower on another at the low period. The oxygen content was higher on the one low but there was more variation between the two high periods. The alkalinity was higher on the one low, but variable on the two highs. There was no variation in the pH.

At station # 1 the variables were: temperature, oxygen and pH. The temperature was lower on low dates. The oxygen was higher on low dates, the pH higher on one low only and there was no variation in the alkalinity. At station # 2 the variables were: temperature, oxygen, and alkalinity. The temperature was lower on low dates. The oxygen and alkalinity were both higher on low dates and there was no variation in the pH.

4. Lover's Lane Brook

There was insufficient data at this area for an adequate comparison. This district is characterized by a quick flooding action of the brook water at the time of heavy rains or melting snow and ice. The bottom area is then scoured by the force of these floods and this helps to keep the brook continually changing its aquatic insect population. At several periods during the winter the brook is entirely frozen so that no water flows through it.

In comparing the occurrence of highs and lows in aquatic insect populations at the four districts the following data was found true: at Cushman Pond the lows occurred in the winter and the highs occurred in the fall and spring; at North Amherst Stream the lows occurred in the fall and spring and the highs in the late winter and spring; and at Lover's Lane Brook the lows occurred in the fall and late winter and the highs in the fall.

In all the districts there were as many lows in the fall as in the spring with actually fewer insects in the fall. There were about half as many lows over the winter period. There were twice as many highs in the fall as in the winter or spring.

From these comparisons it seems that no definite correlations can be drawn between the increase or decrease of the insect population and the physical factors measured. The temperature and pH did not seem to have much effect upon the periods of greatest or least numbers of insects present. Oxygen and alkalinity were extremely variable in relation to one another, but there is no evidence from the available data to show any correlation between this variability and the highs and lows of the insect population. Perhaps the aquatic insect populations are not affected to much by any extreme of any one physical factor but by all the factors together; it seems that the increase in insect populations might be due to an optimum condition in the environment where possibly many of the physical factors are involved, not just one single factor.

C. Photographs

Fig. (2) Some of the most important orders of aquatic insects found at the different environments in this study.

Top row, left to right: Trichoptera; Plecoptera; Ephemeroptera and Diptera.

Bottom row, left to right: Neuroptera; Odonata; Hemiptera and Coleoptera.

Fig. (3) Dredge, net for miscellaneous collecting, and square-foot sampler.

Fig. (4) Method used to take Misc. Samples.

Fig. (5) Method used to take Bottom Samples.

Fig. (6) Material from field (preserved with 37% formalin), equipment used to separate it, and in vials (5% formalin) ready for identification.

Fig. (7) Oxygen, Alkalinity and pH determination equipment.

Fig. (8)"Ball" jars for water samples and free Carbon Dioxide determination equipment.

District I

Fig. (9) Cushman Pond in the fall.

Fig. (10) Cushman Pond in the winter.

District I

Fig. (11) Cushman Pond, station #1.

Fig. (12) Cushman Pond, station #2.

District II

Fig. (13) North Amherst Stream in the fall.

Fig. (14) North Amherst Stream in the winter.

District III

Fig. (15) Pulpit Hill Stream in the fall, station #1.

Fig. (16) Pulpit Hill Stream in the winter, station #1.

District III

Fig. (17) Pulpit Hill Pond in late fall,
station #2.

Fig. (18) Pulpit Hill Pond in the winter,
station #2.

District IV

Fig. (19) Lover's Lane Brook in the fall.

Fig. (20) Lover's Lane Brook in the winter.

Section V

Summary

Section V

Summary

1. An attempt was made to correlate variations in insect populations of aquatic habitats with the nature of the physical factors of their environment.

2. To this end, the following physical factors were analyzed: hydrogen-ion concentration; free oxygen content; free carbon dioxide content (only in the spring), alkalinity (Methyl orange), surface water temperature, and the volume and velocity (twice in the spring). Stream bottom and shore samples were collected in the different areas under study to determine the number and types of aquatic insects present. The above data was taken at various times during the period October, 1938 and May, 1939.

3. A progressive record was kept during the above period and at the close of the study appropriate tables and graphs were made, and the data on each discussed.

4. The general characteristics of each aquatic area were tabulated.

5. Photographs were taken of the methods and equipment used in this study, and also of each area studied. The latter photographs were taken at different seasons of the year (i.e., fall and winter.).

6. A survey was made of certain literature pertaining to this problem, and the material which seemed most valuable and informative was included in the review section, Section II.

7. It was found that the aquatic insects studied could be divided into three groups:

a. Those living in swift stream;s

b. Those living in ponds and comparatively quiet water;

c. Those able to adapt themselves to either condition of aquatic environment.

Examples of the first group include:
Coleoptera- Parnidae; Diptera- Blepheroceridae, Rhagionidae, Ceratopogonidae, Ephyridae; Ephemeroptera- the genera Isonychia, Ameletus and Stenonema; Neuroptera- the genus Corydalus; Trichoptera- Odontoceridae, Seriocostomalidae, Philopotamidae; Plecoptera- Perlidae, Capniidae, Nemouridae.

Examples of the second group include:
Coleoptera- Haliplidae, Gyrinidae; Diptera- Empididae; Ephemeroptera- the genera Callibaetis, Caenis and Hexagenia; Hemiptera- Corixidae, Notonectidae; Odonata- Libellulidae, Coenagrionidae, Ischnuridae; Trichoptera- Leptoceridae, Phryganeidae.

Examplesoof the third group include:
Coleoptera- Dytiscidae; Diptera- Tipulidae, Chironomidae,

Simulidae; Ephemeroptera- The genera Siphloplecton, Paraleptophlebia, Ephemerella, Rhithrogena, Iron; Odonata- the genus Aeschna; Neuroptera- the genus Chauliodes; Trichoptera- Hydropsychidae, Limnephilidae, Rhyacophilidae.

8. In the bottom collections of aquatic insects, certain families and species were found present in one area and not in the others. A list of such forms is given on pgs.

9. In the miscellaneous shore collections of aquatic insects certain families and species were found present in these shore samples and not in the bottom collections. These differences are noted on pages to .

10. It was found that the aquatic insect populations occurred in large numbers at certain periods while at other periods they occurred only in very small numbers. The low periods of aquatic insect populations occurred as frequently in the fall as in the spring with actually a fewer numbers of insects in the fall lows. There were twice as many highs in the fall as in the winter.

11. Among the physical factors the following things were noted: the surface water temperature was lower for a longer period of time during the winter at the pond areas then at the stream areas, because the pond areas were covered with ice keeping the temperature more stable while at the stream areas, where the surface water very seldom froze over entirely, the continuous fast flowing water made for a more

fluctuating temperature; the pH concentration remaind close to neutral in all the districts, either beginning on the alkaline side in the fall in some cases and then dropping to slightly acid by spring or, continuing slightlyacid throughout the whole period from fall to spring; the oxygen content and alkalinity fluctuated on both sides of a normal point of mean; the carbon dioxide content was only taken in the spring so could not be used for comparison; the volume and velocity of the water at the four districts was taken only at normal flow.

12. One of the important influences which had a great effect upon the stream areas was the rapid arise in the stream volume, especially in District IV (Lover's Lane Brook), with the consequent shifting of bottom gravel and destruction of the aquatic insect population. This takes place when heavy rains or melting snows swell the streams to overflowing.

13. There was insufficient data on the physical factors at District IV to make possible any adequate comparisons with the other districts. In some other cases there was inadequate data for any complete comparisons.

Section VI

Conclusions

Conclusions

1. Comparisons of the high and low periods of insect population with data obtained by the measurement of certain physical factors at these same periods, fail to show any correlation between the factors measured and the numbers of insects present. It is probable that certain optimum conditions of the environment are necessary for the occurrence of an optimum number of insects, and that these conditions are the result of the interaction of several physical factors rather than merely the variability of one or even two of the factors involved. Furthermore, the data presented on the physical factors is inadequate in many cases for purposes of comparison.

2. Increased volume and flow of streams at the time of heavy rains or the melting of snow and ice in the spring porbably cause a considerable destruction of the aquatic insect population. This may be an additional factor in the case of the spring lows.

Section VII

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