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# MIGRATION AND DISTRIBUTION OF LEPTODORA KINDTII IN LAKES OF THE DOUGLAS LAKE REGION

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## INTRODUCTION

Leptodora kindtii (Focke) a large, rapacious cladoceran is widely distributed in Europe, Great Britain, Canada and the United States (Andrews 1948). Many aquatic investigators have given their attention to it and it has been included in numerous cladoceran faunal lists but the average plankton observer misses it due to its nocturnal habits. Little definite has been reported concerning its location during the diurnal part of its existence.

The purpose of this paper is to present the results of observations on the migration and distribution of Leptodora in lakes of the Douglas Lake region. Incidental natural history notes are also included.

The data on which this paper is based were collected during the 1949 Summer Session of the University of Michigan Biological Station at Douglas Lake, Michigan from June 26 to August 9, and directed by Dr. Frank E. Eggleton who offered helpful suggestions and constructive criticism throughout the course of the investigation.

## MATERIALS AND METHODS

Since there is no adequate quantitative collecting mechanism suitable for obtaining adult Leptodera all my collections were qualitative. My main desire in all cases was to simply show the presense of this cladoceran. Two collecting methods were utilized: (1) a Juday (43 cm. long and 7 cm. in diameter) bottle, (2) a Birge cone plankton net (constructed of India linen) 10 cm. in diameter

are notably few, large numbers could not be expected.

Field record sheets were made out for all plankton-catches. Large night plankton hauls of Leptodora were preserved in 4% formalin as well as those taken in unusual places or at unusual times. Some were also run up through the alcohols and then made into permanent slides in P. V. A.

## DISCUSSION

Leptodora have always been extremely abundant in the summer nightime plankton catches in Douglas Lake made near the shore in the surface waters. During the day these same waters have always been free of these cladocerans, so the main purpose of this investigation was to try and find where the Leptodora migrated to during the day. My first line of action, of course, was to read the available literature on this particular phase of the Leptodoran life habits. Welch 1935 stated that they migrated into deeper waters during the day and Sebastyen 1933 mentioned the same thing, so I started my investigation by taking diurnal plankton samples at regular depths in South Fish Tail Bay down to the bottom and at various distances from the shore. It was along this south shore of Douglas Lake where the Leptodora have always been so abundant at night.

The following vertical distribution results were taken from six different series of testings (20 Juday bottles concentrated from each level). Both A.M. and P.M. readings were taken. No living Leptodora were ever taken from below 15 meters and none were ever found in the bottom ooze that looked like they recently had been alive. No more than three dead Leptodora were ever taken from

the bottom ooze from a 20 Juday bottle concentration at 15 meters depth. On one occasion, at 3 P.M. in the afternoon (July 3), two very active living Leptodora were taken from the water layers just above the bottom ooze at 14 meter depth and at 12° Centigrade. Nineteen meters was the greatest depth tested and a single dead Leptodoran was found here. It was in a rather bad stage of disintegration so had probably settled down from a higher level. In fifteen separate diurnal surface plankton hauls of 15 minutes each, in off shore waters, between 9 A.M. and 4:30 P.M. only one Leptodora was found. On one dark overcast morning living Leptodora were taken in the surface water near shore until 9 A.M. In the latter part of July, the Leptodora began appearing in the shore waters around 4:30 P.M., but staying close to the bottom until 6 P.M. when they could be found in the surface water. This early in the evening, however, their numbers were always very sparse and could not be called the start of the nightly migration. It is significant that my latest morning catches and earliest evening catches were made with the sky overcast.

Other diurnal vertical distribution records were taken from the shallower parts of Douglas Lake with rather unexpected results. Testing of these areas was stimulated by the fact that I had collected Leptodora from Lake Munro where the greatest depth is only slightly less than four meters. Thus I knew that this cladoceran did not need a deep depression to migrate down into during the day. The first shallow area to be collected in Douglas Lake was in the interdepression area at the intersection of a line from Grapevine Point to Sunny Strand with a line from North Woods Camp to Camp Manitou. This area has a maximum depth of five meters with a sandy

mud bottom having a heavy carra growth. Here two active Leptodora were taken just above the bottom in the carra; and, at a depth of 2½ meters, three active Leptodora were caught in the 20 Juday bottle concentration. The surface catch on this day, July 13 P.M., was negative. August 7 this same area was checked again, but this time by a 15 minute plankton net haul. The surface waters were again negative but, at a depth of 2½ meters, three very active and three very recently dead Leptodora were taken.

North Fishtail Bay was the next area selected and samples were taken eighty meters from the west shore in about five meters of water. Heavy beds of Anarchis were growing on the bottom. Twenty Juday bottle concentrations were taken. One Leptodora was taken from the water just above the Anarchis and one was taken 2½ meters from the surface. Surface testings were negative. These were P.M. testings. Next I selected a very shallow area over the sand bar east of Grapevine Point, having a very sparse emergent Scirpus growth and an average depth of less than two meters. Most of my samples were taken in an area 1 2/3 meters deep. On July 23 eleven Leptodora were taken at a depth of 1½ meters, just over the light sandy bottom, from a 15 minute plankton haul. This was at 4:30 P.M. with bright sunshine over the water. July 24 sand bottom testings were made in the same area but no Leptodora were found. July 27 I rechecked the sand bar both in the late morning and early afternoon. In the morning 20 dead Leptodora were taken, some of which looked like they had been dead for several hours. However at 2:05 P.M., in bright sunshine, I took 38 Leptodora (15 minute plankton haul) in the same area just above the bottom, ten of which were very actively living and a majority of the rest

looking like they had just been killed by the heavy flocculent material present in the sample. A surface haul at this same time was negative. August 7, a 10 P.M. plankton haul was made over this area again, one just above the bottom and one on the surface. The 15 minute surface haul netted 10 living Leptodora while the haul just above the bottom resulted in only three Leptodora, one of which was dead. This nocturnal haul gave exactly opposite results to the diurnal hauls, as far as the presence of the Leptodora in the over bottom areas and surface areas was concerned.

The above findings are not in harmony with previously published material, on this cladoceran, in regard to their diurnal distribution. Welch 1935 states that there is evidence, where bodies of water are clear and shallow, the Leptodora bury themselves in the mud during the day. Perhaps the fact that the bottom is sandy off Grapevine Point accounts for the fact that they are not in the bottom, but above it.

Another interesting fact about their diurnal distribution has been brought out by this investigation. Every diurnal plankton haul, of 15 minute duration, that I have made in Douglas Lake off shore waters, at a depth of between $1\frac{1}{2}$ to $2\frac{1}{2}$ meters, has resulted in a catch of from two to six active Leptodora. The larger catches were always made over the shallower areas. Diurnal surface samplings over this same area will nearly always be negative. Readings at night, in the $1\frac{1}{2}$ to $2\frac{1}{2}$ meter layer below the surface, have been essentially negative while the nocturnal plankton surface haul, over the same areas, show positive results. This nocturnal-diurnal shift in Leptodora is exactly like that in the shallow waters, over the sand bar, east of Grapevine Point. This may indicate a vertical

migration. Notably, the shore surface waters contain many more Leptodora at night than do the surface waters over the depressions and other off shore areas. Plankton, as a whole, is more numerous near shore so perhaps the more abundant food draws them to the surface shore waters in greater numbers.

Another one of the objectives of this work was to investigate the distribution of Leptodera in various parts of Douglas Lake and in certain nearby lakes, in Cheboygan County, exemplifying different physical and chemical conditions. The parts of Douglas Lake, in which the presence of this cladoceran has been verified, include the east, west and south shores of South Fishtail Bay as well as its depression, the west shore of North Fishtail Bay and the sand bar east of Grapevine Point between the two afore mentioned bays. The waters of Grapevine Point and the interdepression area have also been found positive. June 29 the presence of Leptodora in Burt Lake was officially confirmed for the first time. July 11, the east shore, and July 18, the very shallow west shore of Munro Lake were found officially positive for Leptodora. Finding these cladocerans in the shallow ~~west~~ south end of Munro Lake meant that, either these Leptodora could live permanently in very shallow water or else could migrate close to a mile to get into water four meters deep, Munro's maximum depth. These results, as mentioned before, led to my taking diurnal plankton hauls over the shallow sand bar east of Grapevine Point. Except for the depth, Munro Lake is much like Douglas Lake. Chemical and oxygen contents are almost identical. It is a Third Order Lake with an epilimnion about like Douglas Lake. Getting Leptodora from Munro definitely proved they do not need a deep depression to migrate down into during the day. Leptodora were

as plentiful in Munro as in Douglas.

July 20 the east shore of Lancaster Lake was found very sparsely positive, for the first time, officially. Only four small Leptodora, with seemingly segmented eyes, were collected; they were all dead but only recently so. Finding these cladocerans here indicated that they can survive a shallow epilimnion and sharp thermocline with an abrupt temperature drop. Lancaster Lake has a deep hypolimnion, like that of Douglas Lake, with low oxygen content and low temperature. It is 17 meters deep, in the deepest part, and has a more acid Ph (8.1) than Douglas Lake. July 20 I also made a plankton haul in Vincent Lake, an acid bog lake, but collected no Leptodora. Evidently conditions here are unfavorable for their existence. Vincent's Ph never gets above 7. and may go down to 5.4. At its deepest, this lake is only $6\frac{1}{2}$ to 7 meters deep and has a very thick layer of flocculent material over the bottom. The south and west shore surface waters of South Fishtail Bay seem to have about the same number of Leptodora in them at night, but the east shore is extremely shallow for some distance and has been sparsely populated when collected.

Migration of Leptodora was another angle that I worked on. As mentioned above, from my finding them diurnally, most consistently, just over the bottom of the shallow sand bar east of Grapevine Point and at a level below the surface of $1\frac{1}{2}$ to $2\frac{1}{2}$ meters, in deeper off shore waters, indications seem to point out that these serve partially, at least, as diurnal locations. This is strengthened by the fact that these two areas are essentially negative during the nocturnal hours. I have had little luck finding them diurnally in very deep water or in bottom ooze. My collecting methods left

much to be desired so these locations are certainly not ruled out. My investigations indicate that as they migrate in towards shore they don't migrate along the surface but at a deeper level; at least as deep as 1½ meters. July 11 I made a complete evening of surface sampling with no indication of migrating Leptodora. Since they are present in the 1½ to 2½ meter layer during the day it is suggestive that they might migrate in this layer. My results also indicate that as the Leptodora migrate back out in the early morning that they use this 1½ to 2½ meter layer to leave by. Deeper layers were not tested at these times so these results need additional work.

Migration does not appear to be too greatly influenced by wind. This would lend credance to the theory that they migrate in some distance below the surface. Light does play an important part in the migration time of this cladoceran. As the days became shorter migration into the surface shore waters became increasingly earlier. In the early part of July migration time (based on getting 20 Leptodora per 15 Birge Cone Plankton hauls) was around 9:30 P.M. while on August 7 it had advanced to 8:10 P.M. Migration from shore outward in the early A.M. shows a definite reaction to light. July 18 all the Leptodora had left the surface shore waters by 4:20 A.M.; at least an hour before sunrise. August 7 it was 5:35 A.M. before the last Leptodora left the surface shore waters. Earliest P.M. and latest A.M. catches, as before mentioned, were made under overcast conditions. Heavy wave action does seem to push the Leptodora around a little. July 3 plankton hauls, in the shore surface water, were made during a heavy storm condition, high on-shore wind and huge waves. From 6:45 P.M. to 7:20 P.M. Lep-

todora were found in the surface shore waters but, with a quieting of the wind and waves and a light increase, they disappeared. Light could have been a factor here but the waves were high enough to have caused a disturbance down in the $1\frac{1}{2}$ to $2\frac{1}{2}$ meter water layer below the surface. Temperature seems to have little influence on migration, although, on the night of July 24, when there was an early and very numerous migration, the water temperature was 22° C. This temperature was not reached again so no comparison could be made. Migration occurs rapidly; within a 15 minute period numbers can increase from a negative catch upwards to 50 Leptodora.

Responses to ecological factors were recorded as noticed. Leptodora appear able to withstand quite a variation in temperature and pressure, being found active in surface water at $25\frac{1}{2}$° C. and active 15 meters down in Douglas Lake at 12° C. They seemingly cannot stand conditions as those present and described for Vincent Lake. I have seen Leptodora eating copepods, amplipods and gleotrichium. Thus they eat both plant and animal material. Evidently they can live in a very low oxygen concentration since I have kept Leptodora alive, in a petrie dish, as long as six days and noticed them eating on the fifth day. Drying up of the water could have caused their death, too, since the level was very low. No water was added because this would have also added more oxygen. These cladocerans are definitely attracted by artificial light. Lumer (1932) has previously reported this. My investigations seem to show that they are not overly repulsed by natural light, i.e. finding them just over the bottom of a shallow sand bar in bright sunshine.

Further investigations with Leptodora could be done with a Juday plankton trap so that quantitative results could be gotten.

Since these cladocerans are predacious plankton feeders it would be interesting to find if this $1\frac{1}{2}$ to $2\frac{1}{2}$ meter layer, that they are found in during the day, correlates with the layer their food plankters are in. Investigations of the food plankters in the shore surface water at night and in the off shore surface water might also help explain the greater numbers of Leptodora found nocturnally in the shore surface waters.

## SUMMARY

(1) Leptodora kindtii can be found, diurnally, in Douglas Lake in the offshore waters of North and South Fishtail Bays and in the interdepression area at a depth of $1\frac{1}{2}$ to $2\frac{1}{2}$ meters. They are most numerous, diurnally, just above the bottom of the shallow (2 meters) sand bar just east of Grapevine Point.

(2) Leptodora kindtii does not need a deep depression to migrate into during the day as is proven by the findings in (1) and its presence in shallow Munro Lake.

(3) First official records of the presence of Leptodora kindtii in North Fishtail Bay and the interdepression area of Douglas Lake as well as for Burt Lake, Munro Lake and Lake Lancaster were made.

(4) Migration of Leptodora kindtii occurs later in the morning and earlier in the evening as the days become shorter.

(5) Leptodora kindtii are much more frequent at night in the shore surface waters than in the surface waters over the depressions of Douglas Lake.

(6) Leptodora kindtii can live actively at a depth of 15 meters and a temperature of $12^{\circ}$ C.

(7) An acid bog lake having a Ph ranging from 5.4 up to 7., with

heavy flocculent material over its bottom, is an unfavorable habitat for Leptodora kindtii.

(8) Leptodora kindtii can be kept alive in the laboratory for six days, remaining all this time in the water it was collected in.

(9) Leptodora kindtii does not use the surface waters for its night and morning migrations into and away from the surface shore waters.

(10) Copepods, amplipods and gleotrichium were definitely s een ingested by Leptodora kindtii.

## LITERATURE CITED

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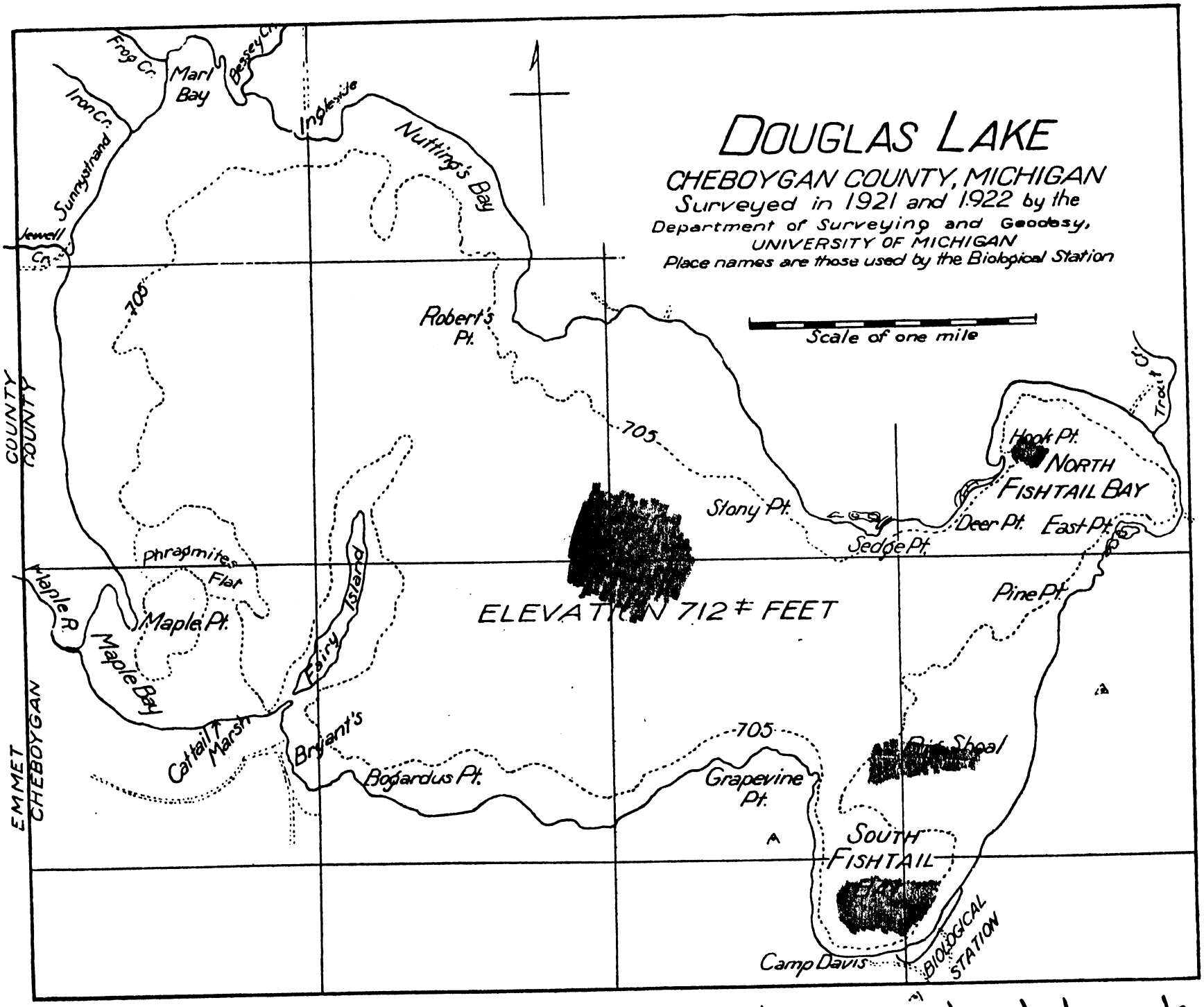
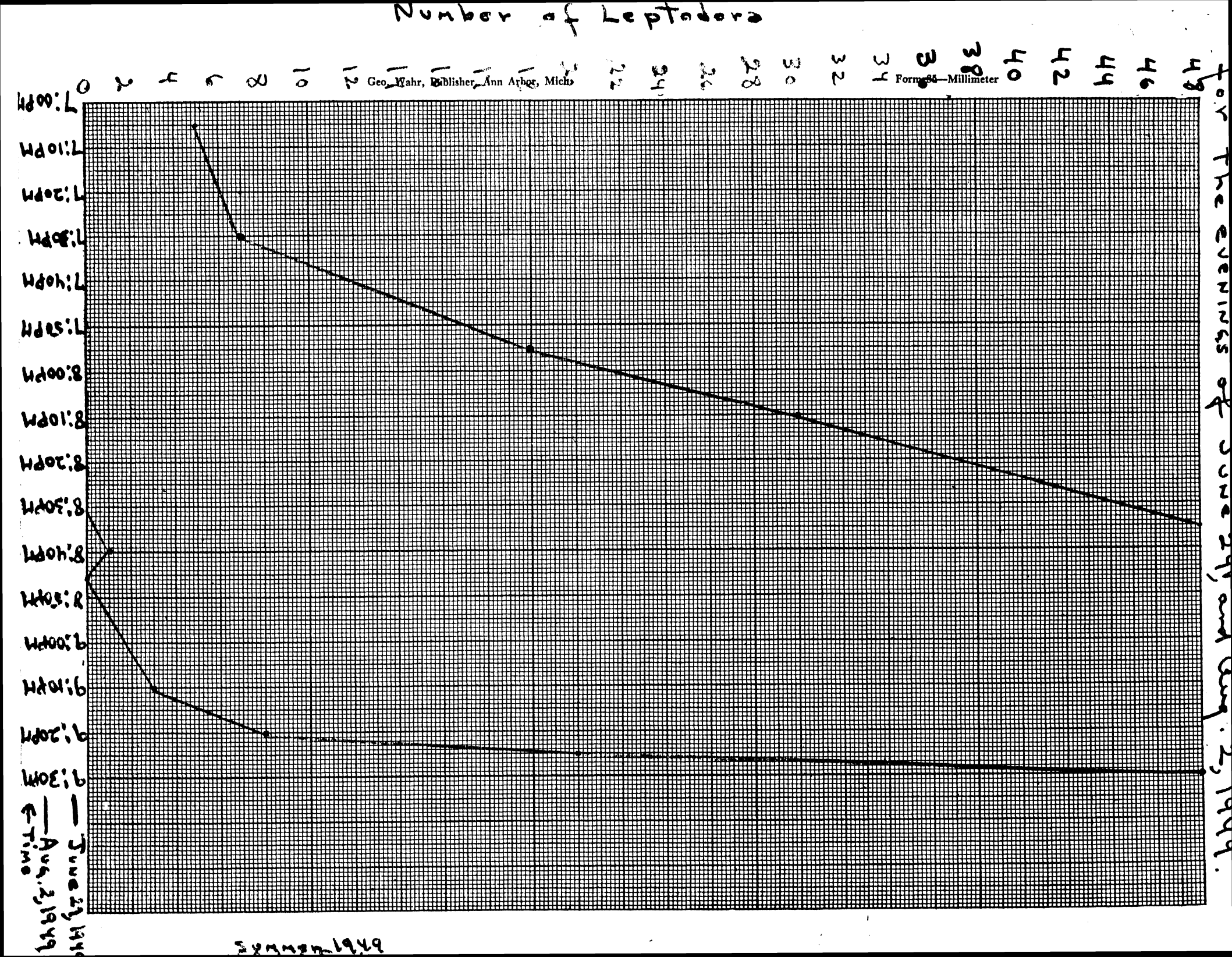



■ - Indicates areas where diurnal catches of Leptodora kindtii were made during the SUMMER of 1949.


Number of Leptodora
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Geo. Wahr, Publisher, Ann Arbor, Mich.
Form 86—Millimeter
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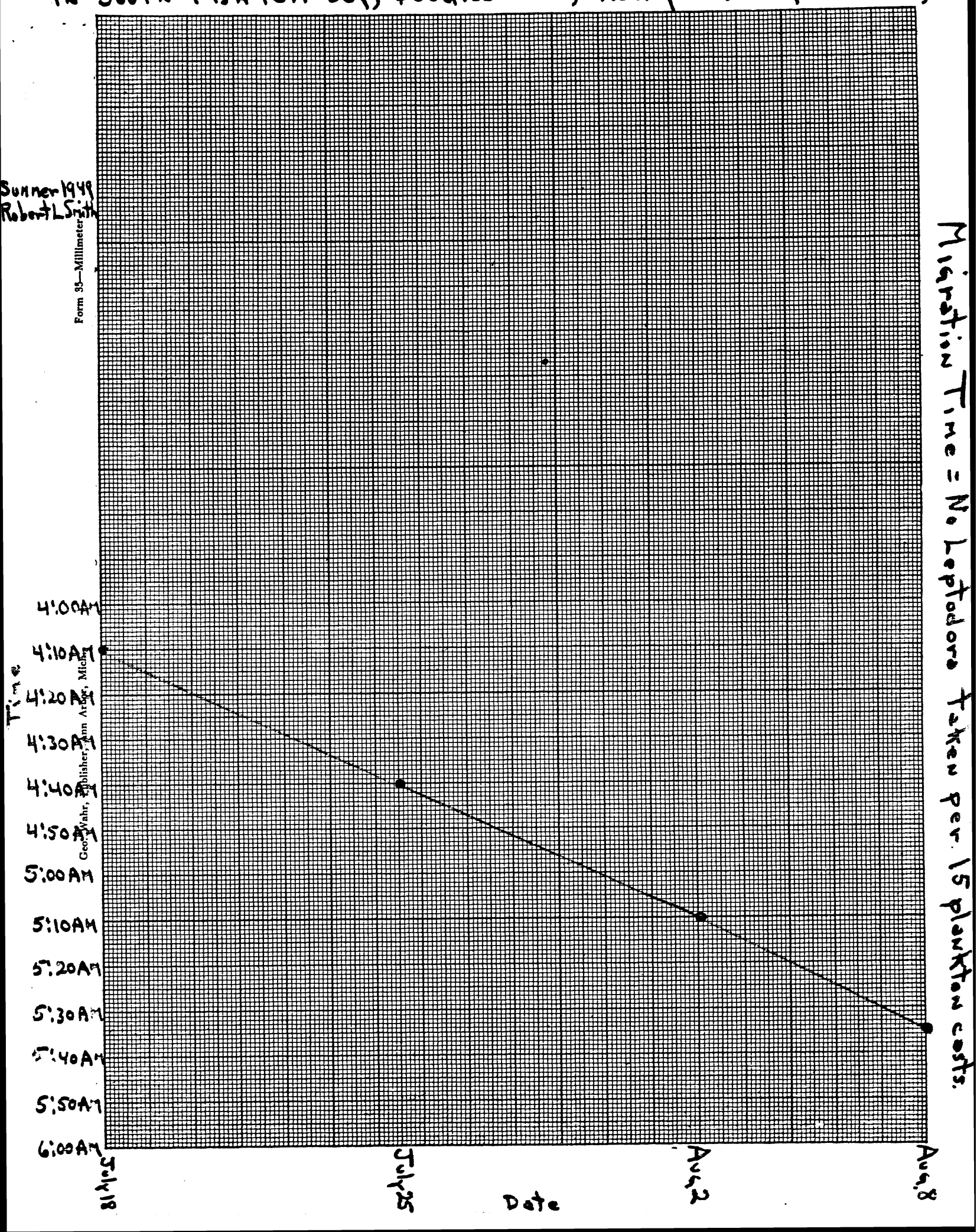
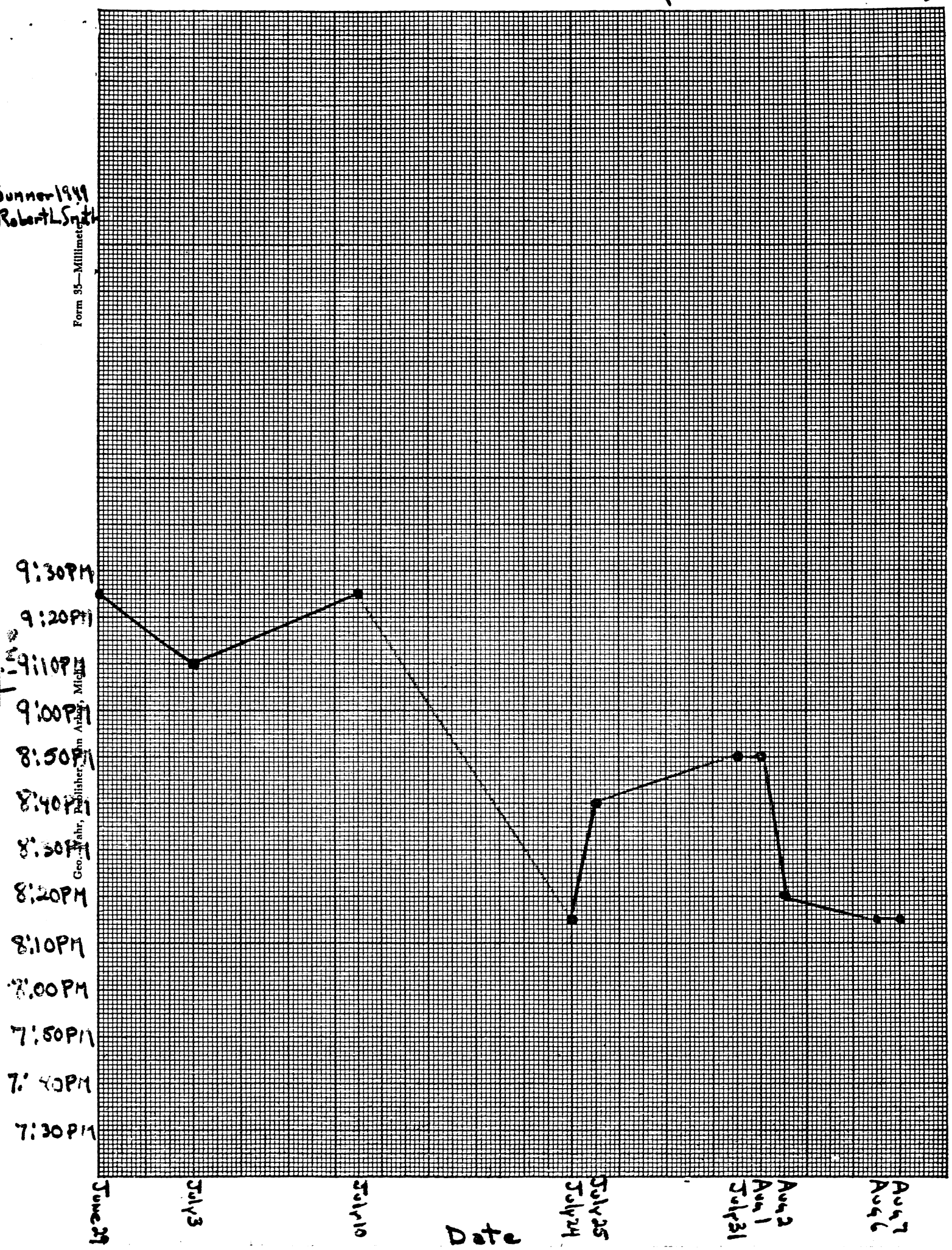
Time
June 29, 1949
Aug. 2, 1949
for the evenings of June 29, and Aug. 2, 1949.
Summer 1949

In South Fishtail Bay, Douglas Lake, Mich. from July 18 to Aug 8, 1949



IN South Fishtail Bay, Douglas Lake, Mich. from June 29 to Aug. 8, 1949




Migration Time = 20 Leptodora per 15 plankton net casts.

VICINITY OF

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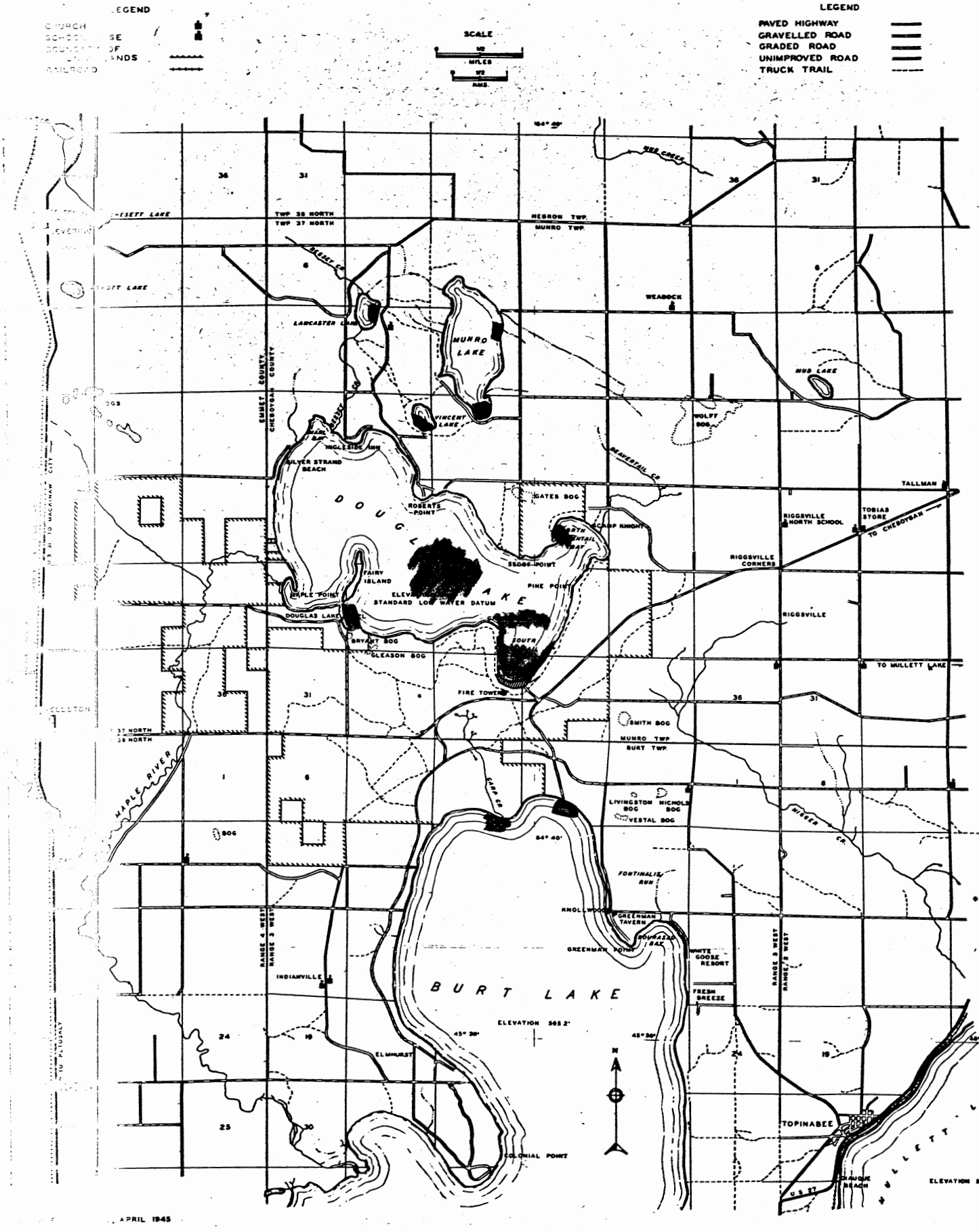
# AND DEMONSTRATION FOREST

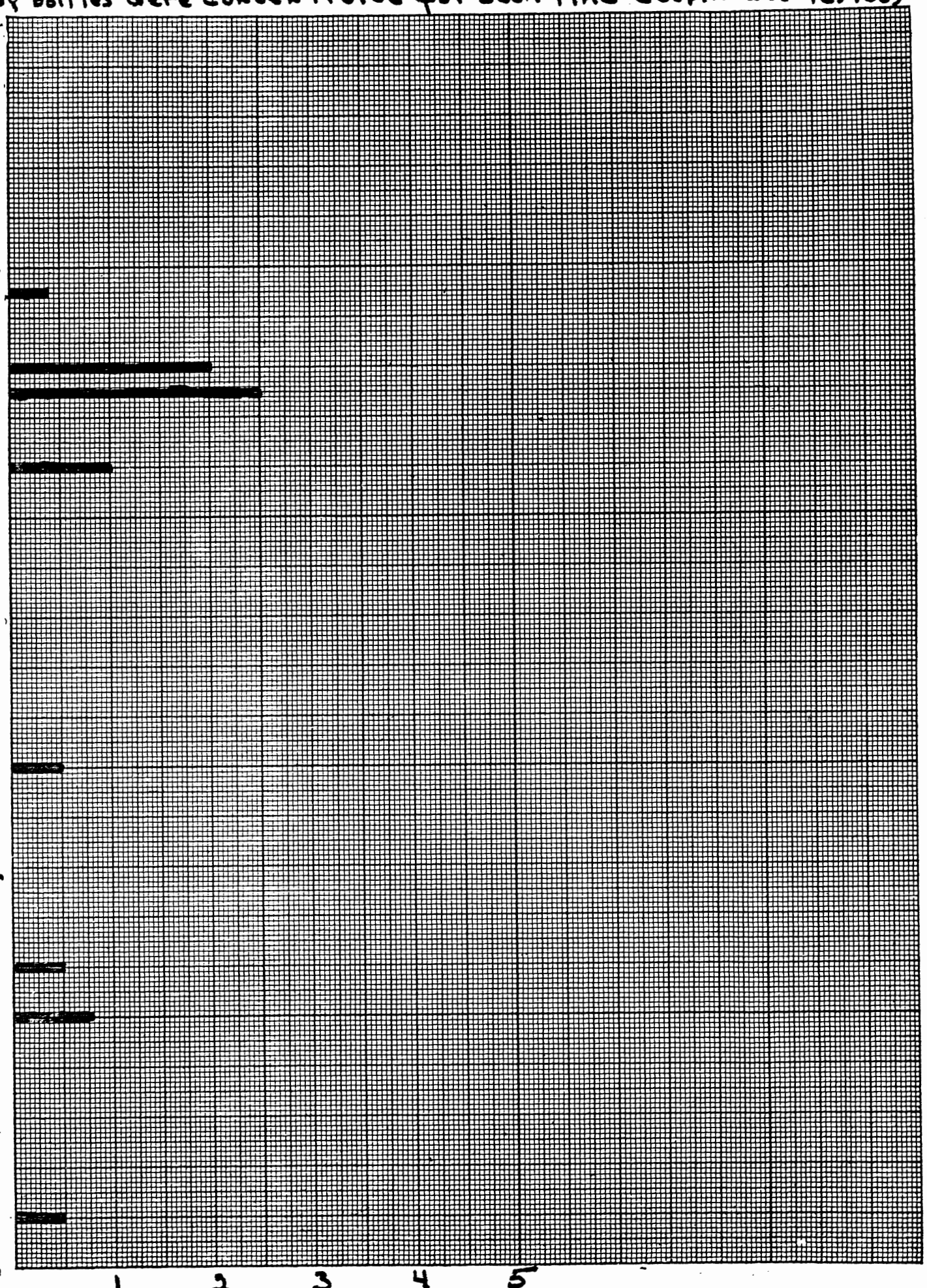
CHEBOYGAN AND EMMET COUNTIES, MICH.




Gates recorded presence of Leptodora Kindti.
Gates recorded absence of Leptodora Kindti.

Summer 1949

Various depths in the [illegible] Judday bottles were concentrated for each time a depth was tested.



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