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A Study of the Malarial Mosquitoes of Southern Illinois

II. OPERATIONS OF 1920

BY

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ERRATA

Page 44, line 1 of text, for "sludge-worms" read *midge larvae*, and for "larvae of the midges" read *sludge-worms.*

Page 188, line 4, for 3 read 23.

Page 216, last line, for "the opposite page" read *page 214.*

Page 267, delete line 13 from bottom.

Page 382, lines 3 and 5 from bottom, for "decrease" read *change.*

ARTICLE III.—*A Study of the Malarial Mosquitoes of Southern Illinois. II. Operations of 1920.* By STEWART C. CHANDLER.

INTRODUCTION

The mosquito survey of southern Illinois, which was begun by the author in the spring of 1918, has been carried forward during the season of 1920 at Herrin, Williamson county, and vicinity. The object of the work, as fully explained in a former article of the Natural History Survey Division,* is to locate the places which breed mosquitoes, to point out what types of location are especially favorable to the production of the malaria mosquitoes, and to increase our knowledge of the seasonal occurrence of all mosquito species to be found in southern Illinois. It is hoped that these articles will provide data of use to citizens of communities interested in a reduction of malarial disease through a control of the mosquitoes transmitting it. It is planned to continue the survey, each year in a different locality typical of some considerable area, so that eventually all types will be covered.

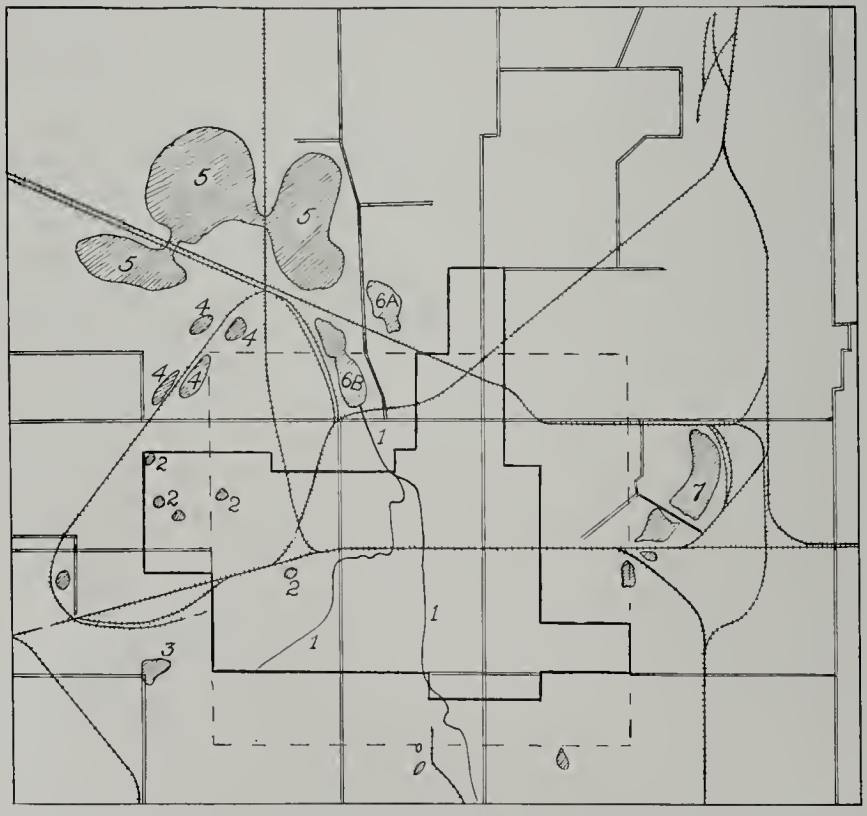
Before describing the work of the season, it is well to recall a few fundamental facts about mosquitoes and the relation between them and malaria. It is especially important to remember that some body of water, either temporary or permanent, is necessary to the development of the mosquito. Of the four stages through which this insect passes in its life cycle, egg, larva, pupa, and adult, the first three are entirely aquatic. The adult mosquito lays its eggs upon the surface of the water, or failing to find any water it may die without depositing any eggs. The common wigglers or wiggle-tails which hatch from these eggs pass their existence in the water, feeding on the minute organisms which they find there, until they emerge as adults, this entire process requiring from one to three weeks. The dependence of the malarial organism upon the mosquito needs no discussion here, except merely to state that malaria is transmitted to man only through the bite of certain species of mosquitoes belonging to the genus Anopheles. These mosquitoes are called the Anopheline or malarial mosquitoes to distinguish them from the Culicine species, which do not carry the disease.

DESCRIPTION OF THE BREEDING PLACES AT HERRIN

The situation at Herrin is typical of much of the mining territory in southern Illinois. The town was started at a point between three coal mines and has spread in all directions up to the edges of the mine properties. Close to each mine two kinds of water are to be found, one in ponds cared for by the mining company and used for boilers and washers,

* Article XI, volume 13. A Study of the Malarial Mosquitoes of Southern Illinois. I. Operations of 1918 and 1919. By Stewart C. Chandler.

and the other the waste water from the mines which is allowed to run off where it will as long as it does not contaminate the other source. There are a few sink-holes in the west part of Herrin, also characteristic of a mining area because they are probably caused by the sinking of the ground over a part of the mine which has been worked out and abandoned. Just to the northwest of Herrin is a woods swamp, which in rainy seasons covers an area of about half a square mile. Low, swampy, wooded areas are fairly common in the mining sections of Williamson and Franklin counties; and in this case the water in the swamp is kept replenished by waste water from the mines.



In going carefully over the town and the territory immediately surrounding it I found eight breeding places, or series or types of breeding places—including those I have classed as domestic—from which the mosquitoes to be found in Herrin might be expected to come. All but the latter class are numerically indicated on the accompanying map, and a brief characterization of all of them follows:

No. 1. An open drain through town, known as the 17th St. ditch. This ditch is fed quite largely by waste water from the mines supplemented by small tributaries which carry off the rains and natural surface water.

No. 2 (Fig. 1). Sink-holes to be found in the west part of Herrin, the formation of which has already been described.

FIG. 1. Sink-hole, West Herrin; produces very few mosquitoes.

FIG 2. Woodland pool, north edge of Herrin; a prolific breeder of malarial mosquitoes.

No. 3 (Fig. 2). The mine pond at Sunnyside, in the southwest corner of Herrin.

No. 4. A series of woodland pools to the northwest along a railroad track, and partially formed by the railroad embankment. This track is a feeder to one of the mines and is much frequented by miners, especially when going to fish in the ponds of that vicinity.

No. 5. A woods swamp to the northwest of Herrin, described above.

No. 6. Mine ponds north of Herrin. The main pond, marked A on the map, is used for the boilers and washers, and the other, marked B, is a swampy area overgrown with cattails and fed by waste water from the 17th St. ditch.

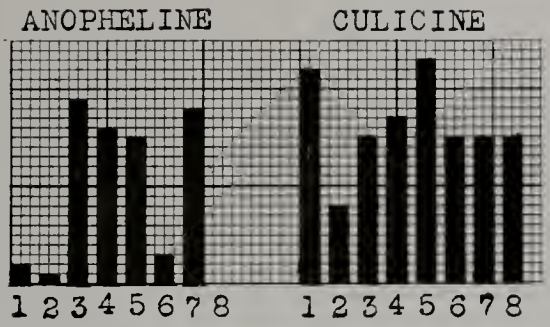
No. 7. A series of mine ponds to the east of town.

No. 8. Domestic places, such as tin cans, rain-water barrels, wells, and reservoirs.

The Production of Mosquitoes

Monthly inspections were made at each of the eight series of breeding places, and a record of the abundance of mosquito wigglers was kept. Larvae and pupae were collected and reared to the adult stage in the author's insectary at Carbondale. The species were later determined by Dr. C. P. Alexander, of the Natural History Survey. The determinations of two species supposedly foreign to this region and one new species were corroborated by Dr. Harrison G. Dyar, of the United States National Museum.

The accompanying table (Record of Mosquito-breeding at Herrin, 1920) shows the monthly abundance of mosquitoes, both Anopheline and Culicine, in the eight different breeding places watched during the season. It will be noticed that six terms are used in this table to indicate absence or grades of abundance, namely, none, very few, few, fair numbers, many, and very many. In order to give a numerical value to these records, none is represented by a cipher (0), very few by 1, few by 2, fair numbers by 3, many by 4, and very many by 5. These figures are inserted in the table at the right of the terms to which they apply, thus making it possible to secure totals convenient for purposes of comparison. The totals for each month show the relative danger, throughout the season, of becoming infected through the bite of the Anopheline mosquitoes; and the totals for each breeding place may be useful in distinguishing the types of places which produce the most mosquitoes. The mosquito production is shown more clearly by the following diagram in which the breeding-place totals from the table are represented by the heights of the columns, the eight columns representing the eight breeding places. Both the Anopheline and the Culicine mosquito records are shown on the diagram for purposes of comparison.



A mere glance at the table (p. 28) or the diagram will show that there is a great difference in the breeding places in respect to their production of mosquitoes during the season. It is very evident that an abundance of Anopheline mosquitoes may be produced in a place in which few Culicine species are bred, and *vice versa*. It may be difficult to account for these variations in the numbers of mosquitoes produced in different situations, but a study of conditions at Herrin may help to distinguish the types of places that are most dangerous.

Comparison of Breeding Places

No. 1, an open ditch, proved to be of little importance for the production of malarial mosquitoes, but of considerable importance for the other type. In the main channels of this ditch the waste water from the mines seemed to prevent mosquito development, and (a very important fact) the edges of the ditch were clean, with little or no overhanging vegetation to furnish protection to the mosquito larvae. Those found were in the small feeders or tributaries; and in most cases contamination of the water in them by the filth of the street made conditions unfavorable for Anopheles larvae.

No. 2, a series of sink-holes, produced relatively few mosquitoes, either Anopheline or Culicine. Many of the pools dried up wholly or partially, the receding waters leaving edges exposed and unprotected, so that predaceous enemies could keep the mosquito larvae and pupae down to a minimum.

Nos. 3, 4, 5, and 7 all contained considerable water, had much grass or weeds along their margins, and appeared to contain enough suitable food for the development of malarial mosquitoes. No. 3 is an especially typical breeding place for them.

No. 6 did not seem to be favorable to the production of Anopheline mosquitoes. None of either kind were found in Part B, which contained much waste water from the mines, and but a few in Part A, which from its character might be expected to contain Anopheles larvae.

No. 8, including all sorts of domestic containers of water, produced no Anopheline mosquitoes whatever, but was responsible for some Culi-

Record of Mosquito-breeding at Herrin, 1920

Anopheline (malaria-carrying) mosquitoes

Breeding places	April		May		June		July		August		Sept.		Oct.		Nov.		Breeding place totals.
1. Open ditch	None	0	None	0	Few	2	None	0	None	0	None	0	None	0	None	0	2
2. Sink-holes	None	0	None	0	None	0	None	0	None	0	None	0	Very few	1	None	0	1
3. Mine pond	None	0	None	0	None	0	Fair Nos.	3	Very many	5	Many	4	Many	4	Fair Nos.	3	19
4. Woodland pools	None	0	None	0	Fair Nos.	3	Fair Nos.	3	Many	4	Fair Nos.	3	Fair Nos.	3	None	0	16
5. Woods swamp	None	0	None	0	Fair Nos.	3	Fair Nos.	3	Many	4	Fair Nos.	3	Few	2	None	0	15
6. Mine ponds	None	0	None	0	None	0	None	0	None	0	None	0	Fair Nos.	3	None	0	3
7. Mine ponds	None	0	None	0	Fair Nos.	3	Many	4	Fair Nos.	3	Very many	5	Fair Nos.	3	None	0	18
8. Domestic places	None	0	None	0	None	0	None	0	None	0	None	0	None	0	None	0	0
Totals for each month		0		0		11		13		16		15		16		3	74

Culicine (non-malaria-carrying) mosquitoes

1. Open ditch	None	0	None	0	Few	2	Very many	5	Very many	5	Very many	5	Very many	5	None	0	22
2. Sink-holes	None	0	None	0	None	0	Few	2	Few	2	Few	2	Few	2	None	0	8
3. Mine pond	None	0	None	0	None	0	Many	4	Very many	5	Fair Nos.	3	Fair Nos.	3	None	0	15
4. Woodland pools	Many	4	Fair Nos.	3	Few	2	Fair Nos.	3	Fair Nos.	3	Few	2	None	0	None	0	17
5. Woods swamp	None	0	Very many	5	Fair Nos.	3	Fair Nos.	3	Fair Nos.	3	Very many	5	Many	4	None	0	23
6. Mine ponds	None	0	None	0	Many	4	Fair Nos.	3	Fair Nos.	3	Fair Nos.	3	Few	2	None	0	15
7. Mine ponds	None	0	None	0	Fair Nos.	3	Very many	5	Many	4	Fair Nos.	3	None	0	None	0	15
8. Domestic places	None	0	None	0	None	0	None	0	Very many	5	Very many	5	Very many	5	None	0	15
Totals for each month		4		8		14		25		30		28		21		0	130

cines. This corroborates statements made by many observers of mosquito life, that the malaria-carrying mosquitoes do not by choice breed in water found about the habitations of man.

Malaria in Herrin

In order to secure a monthly record of the number of cases of malaria in Herrin, the physicians were asked to record their cases on blanks furnished them for that purpose. The monthly summary of their reports is given in the following table.

Number of Cases of Malaria in Herrin, 1920

Physician	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Totals.
W. R. Gardiner	0	0	0	0	0	0	0	1	0	1
E. M. Sanders	0	0	0	0	1	0	0	0	1	2
G. C. Chamness	3	5	6	6	9	9	9	4	0	51
D. S. Boles*	4	3	4	13	12	10	12	0	0	58
Carl Baker	0	0	0		0	0	0	0	0	0
L. W. Brown and F. C. Murrah	0	0	0	0	20	27	25	24	18	114
J. S. Waldman	0	2	2	2	0	2	1	4	0	13
R. E. Ransmeyer	0	2	1	0	1	1	1	0	2	8
Totals.....	7	12	13	21	43	49	48	33	21	247

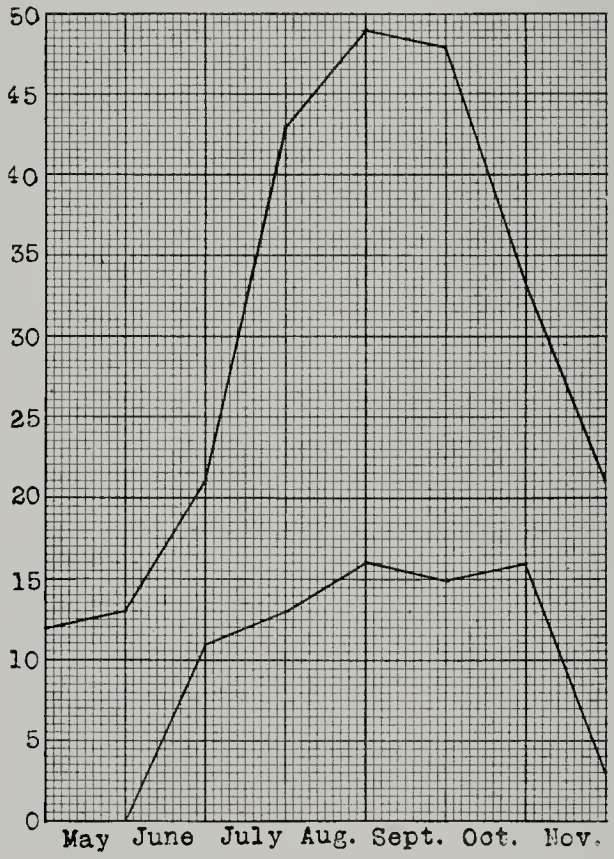
*Dr. Boles' practice was taken over on October 1, by Dr. R. L. Kane.

It should be said, in connection with these malaria records, that diagnosis was very often made by symptoms of disease and not by the blood test, a lack which may cause some inaccuracies in the foregoing records. However, even if a physician does not make blood tests, his records are probably as accurate in one month as in another.

Relation between Malaria and the Malarial Mosquitoes

Since malaria can be transmitted to man only through the bite of certain species of Anopheles, there should be some correspondence between the amount of malaria and the abundance of Anopheles in a given place. To bring out this relationship at Herrin, I have plotted the following curves, comparing the monthly totals of the number of cases of malaria reported by physicians with the monthly totals of numerical values taken from the Anopheline mosquito breeding-record. These curves clearly follow each other in a general way; and the fact that there were cases of malaria reported before any Anopheles were found is prob-

ably due to hold-over cases, which reappeared as the weather warmed up in spring.



Number of cases of malaria (upper line), and abundance of Anopheline mosquitoes (lower line).

Species of Mosquitoes at Herrin, 1920

The following table gives the species of mosquitoes reared from collections at Herrin, the months when collected, and the numbers of the breeding places in which they were found. For example, the first species listed *(Anopheles guttulatus)* was bred from larvae or pupae collected in August from breeding places Nos. 4 and 5, in September from Nos. 4 and 7, and in October from Nos. 5 and 6.

Of these eleven species, three are worthy of special notice, namely, *Anopheles crucians, Aëdes sollicitans,* and *Culex degustator.* The first two are distinctly salt-marsh species, very rarely found more than fifty miles from salt water. Dr. Harrison G. Dyar, who confirmed the determinations of these species, expressed great surprise that they were found

so far inland, and suggested that there might be some salt deposits or salt springs in the vicinity, creating conditions approximating those of the seacoast. This is entirely possible, as those familiar with the history and geology of southern Illinois are well aware. There is certainly much salt under the surface, from Murphysboro east to the Ohio River, as witnessed by the salt springs, salt wells, and old salt works which were at one time of commercial importance, and it is possible that the waste water from the mines is a factor in the production of salt-marsh conditions at Herrin. The last of the three species has been taken before in the Mississippi Valley. It is a new species, and is to be called *Culex degustator* by Dr. Dyar.

SPECIES OF MOSQUITOES REARED FROM IMMATURE STAGES,* HERRIN, 1920

Species.	Breeding place and month collected.†						
	Apr.	May	June	July	Aug.	Sept.	Oct.
Anopheles guttulatus Harris	.....	.....	.....	.....	4, 5	4, 7	5, 6
A. punctipennis (Say) Say	.....	.....	4, 7	4, 7	.....	5, 8	
A. crucians Wied.	.....	.....	.....	.....	.....	3	
Culiseta inornata (Williston) Dyar	.....	.....	.....	.....	.....	.....	6
Culex apicalis Adams (*saxatilis* Gross.)	.....	.....	.....	.....	.....	.....	7
Culex territans Walker (*restuans* Theob.)	.....	5	.....	5	1, 5		
C. pipiens Linn.	.....	.....	1	.....	8	5, 8	1, 6
C. salinarius Coquillett	.....	.....	.....	.....	.....	1, 3, 5	1, 7, 8
C. degustator Dyar, sp. n.	.....	.....	6	4	3, 4, 7		
Aëdes canadensis (Theob.), D. & K.	4						
A. sollicitans (Walker) D. & K.	.....	4, 5					

* The last species listed in this table was not reared, but taken as an adult. All the others were reared; not taken in the adult stage.

† Breeding places numbered 1 to 8 are described below, and 1 to 7 are indicated on the map, p. 24.

Description of Breeding Places referred to in the Table by Number

1. Open drain, with small feeders, running through town of Herrin.
2. Sink-holes, or hollows, filled with water.
3. Mine pond (Sunnyside Mine) from which water for boilers and washers is drawn.
4. Series of woodland pools in low-lying lands.
5. Large woods-swamp.
6. Mine ponds (C. W. & F. Mining Co. Mine A).
7. Mine ponds (Big Muddy Coal Co. Mine 7).
8. Domestic breeding-places in Herrin: tin cans, wells, cisterns, etc.

Further data were obtained this season on the relative abundance of *Anopheles guttulatus* and *A. punctipennis*. The fact was brought out in the survey work at Carbondale, reported by the author in the operations of 1918 and 1919, that the former species, considered the more effective carrier of malaria, was outnumbered 12 to 1 by the latter; but at Herrin during the season of 1920, there were exactly as many *guttulatus* reared from the monthly collections as *punctipennis*.

Conclusion

Control measures were discussed in full in the report of the operations of 1918 and 1919, mentioned in the introduction to this article. At Herrin, owing to the necessity of maintaining ponds, drainage—one of the best methods of control—can not be employed. It is quite likely that cleaning the edges, stocking the pond with fish (especially with top-minnow), or applying oil in some way, will be found to be the most practical methods.