A Preliminary Study of Mosquito Populations at Waste Lagoons in East-Central Indiana—1970[1]

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Abstract

Of 22 sites studied in July and August, 1970, 14 were producing mosquitoes. These populations were usually very large, with some lagoons producing an estimated several million mosquitoes at one time. Most of the positive sites were food processing plants. None of the five sewage lagoons observed were producing mosquitoes.

Although *Culex restuans, Culex salinarius, Aedes vexans, Anopheles punctipennis, Anopheles quadrimaculatus,* and *Culex tarsalis* were sometimes collected, *Culex pipiens* was consistently the dominant species. Eleven lagoons produced only *Culex pipiens.* Apparently little or no decrease in production potential of *C. pipiens* accompanied such environmental changes as water level fluctuation and the nature of the waste itself.

Observation of conditions at many lagoons in the study area suggested that mosquito production may be reduced by periodic removal of accumulations of solid wastes on the surfaces and bottoms of the lagoons, and by the removal of all emergent and shore vegetation.

After early observations verified that waste lagoons were production sites for mosquitoes, three study objectives were established, to determine the following: 1) the species composition of mosquito populations at these lagoons; 2) the relative abundance of different species throughout the study interval; and 3) to observe physical and ecological characteristics of the lagoons to determine the influence of these factors on the extent of species utilization.

A procedure for surveying mosquito populations at waste lagoons was also developed, though a description of this aspect of the study was considered to be beyond the scope of this paper.

Method of Investigation

Lagoons were located through local sanitarians and from a list of sites in the *Indiana Stream Pollution Control Board Annual Report of June 30, 1969—Part 2.* Each lagoon near the laboratory was then investigated to determine whether a mosquito problem existed at the site. These initial surveys helped in developing a survey procedure and a preliminary survey data form.

Following the initial surveys, those lagoons known to be mosquito producers were revisited (usually on a weekly or bi-weekly basis) to observe changes in the size and composition of the resident mosquito populations, and to note the sometimes drastic changes in the lagoons

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themselves. In addition to such in-depth observations, new lagoons were given preliminary surveys throughout the study interval.

At each lagoon, physical factors such as water temperature, lagoon dimensions, and types of aquatic and shore vegetation present were recorded. Dissolved oxygen (in ppm) was measured by the Winkler Method, in the hope that D.O. information would indicate whether fish predatory on mosquito larvae could survive waste lagoon conditions. If immature mosquitoes were present, the lagoon was quantified in the following manner: a long-handled pint dipper was used in obtaining water samples from representative points along the periphery of the lagoon. The immature mosquitoes present in each dipper were counted and retained for identification. By dividing the total number of immature mosquitoes collected by the number of dips taken, an average number of mosquitoes per dip was calculated. Then, by considering the surface area of the lagoon, the volume of water in an average dip, and by assuming that the lagoon was utilized by larvae and pupae to a depth of 6 inches, an estimated total number of immature mosquitoes was determined.

Egg rafts of the genus *Culex* were collected and quantified in a similar manner as were larvae and pupae. Calculations involved in determining the total number of egg rafts present were based on the area, and not the volume of water utilized, since, unlike larvae and pupae, egg rafts were found only on the surface of the water.

In addition to immature mosquitoes, adult mosquitoes were also collected at those lagoons selected for special study, using the CDC light trap and dry ice (CO_2). At least one adult collection was made at each major site, with a trap being set at one site each week. Light trap collections undoubtedly contained migrants from sources other than the lagoons, but it seemed desirable to assess the attractiveness of the lagoons, as well as their production potential. Thus, when possible, all life stages of a lagoon's mosquito population were collected.

Both larvae and adults were identified to species. Pupae were allowed to develop and were identified as adults, as were individual larvae which were difficult to reliably identify. While no identification key was available for the *Culex* egg rafts, some rafts were identified by allowing them to hatch and then identifying them as larvae. All rafts so identified were *Culex pipiens*.

Results

During the course of the study 22 sites were surveyed, 14 of which possessed lagoons inhabited by mosquitoes. Of the 14 mosquito-producing sites, 6 were surveyed more than once (2 to 5 separate surveys). The first survey of the study was made on July 7, and the last on September 12.

When positive for mosquitoes, waste lagoons frequently produced them in large numbers. For example, Lagoon 7 (Table 1) had an estimated total production ranging from 85.7 million to 765 million

TABLE 1. *Numbers of immature mosquitoes and species composition of populations at selected waste lagoons in East-Central Indiana, 1970.*

	Lagoon							
	7	14	3	4	6	5	1	2
No. visits	5	2	3	3	5	1	1	5
Ave. No. immatures per dip	181	23.1	78.4	71.0	109	10.8	28.5	23.5
Ave. estimated immatures present (millions)	367	174	138	116	91.2	58.3	45	[a]
Dissolved O_2 (ppm)	4.6	—	0	—	1.8	0	—	24
Species Present								
Aedes vexans	—	—	—	—	—	+	+	+
Anopheles punctipennis	—	—	—	—	—	—	+	+
Anopheles quadrimaculatus	—	—	—	—	—	+	—	—
Culex pipiens	+	+	+	+	+	+	+	+
Culex restuans	—	—	—	—	—	—	+	—
Culex salinarius	—	—	—	—	—	—	—	+
Culex tarsalis	—	—	—	—	—	—	—	+

[a] Could not be quantified

immature mosquitoes, with an average production of 367 million (181 immatures per dip). Only three of the lagoons producing mosquitoes were utilized by less than one million individuals.

Many lagoons were not exceptionally large (typically about 50 yards square), and the high potential for mosquito production evidently was a result of intensive utilization of the lagoon media for mosquito development. The mosquito-producing lagoons studied were located primarily at food processing plants producing vegetable wastes. Most related mosquito studies have been concerned with sewage lagoons only.

Those human waste lagoons surveyed (four public school lagoons and one mobile home park lagoon) were found to support no mosquito populations. While the factors which made them apparently incapable of supporting mosquito populations are unknown, the extensive treatment given human waste—chlorination for example—may be involved. However, since the human waste lagoons were visited but once, mosquito populations may have been present at other times during the year.

Culex pipiens, the northern house mosquito and a vector of Saint Louis Encephalitis, was the predominant waste lagoon mosquito in the study area. In fact, no mosquito-producing lagoon was devoid of *Culex pipiens*, which in every lagoon was far more abundant than any other species. Eleven lagoons were known to produce nothing but *Culex pipiens*. Other studies have also shown this species to be common in waste lagoon habitats (2, 3, 4, 5). In addition, *Culex restuans*, *Culex salinarius*, *Aedes vexans*, *Anopheles punctipennis*, *Anopheles quadrimaculatus*, and *Culex tarsalis* were also collected as immature forms.

Table 2 shows that, while lagoon surveys were first begun during the week of July 6, *Culex pipiens* was the only species found in any lagoon until August 4. Diversity of species tended to increase as the season progressed. The lagoon having the greatest species diversity also had the highest average D.O. reading (Table 1).

The dominance of *Culex pipiens* prevailed in both the adult and larval stages (Table 3).

The overwhelming dominance of *Culex pipiens* is an indication of its ability to exploit to the fullest the entire complex of conditions commonly present at waste lagoons, utilizing the resident bird population, the abundant emergent and shore vegetation, and the high organic content of the water in maintaining large populations. Shelter for adults was provided by tall vegetation immediately surrounding the lagoons, and an accessible blood source was available in the numerous birds attracted to the lagoons, providing females with protein for egg production. Newly-hatched larvae found shelter in the partially submerged vegetation often present, and a food source in the lagoon waste water, allowing many of them to complete their development to adulthood.

TABLE 2. *Species composition of larval mosquito collections at waste lagoons in East-Central Indiana, 1970. (Numbers in the table are projections based upon estimated numbers in dip samples and species breakdown of sub-samples identified.)*

Species	Week of: July 6	July 13	July 20	July 27	Aug. 3	Aug. 10	Aug. 17	Aug. 24	Total
Aedes vexans	—	—	—	—	—	—	25	17	42
Anopheles punctipennis	—	—	—	—	—	—	43	6	49
Anopheles quadrimaculatus	—	—	—	—	—	—	8	—	8
Culex pipiens	2,980	1,585	952	5,199	5,780	3,446	1,329	6,616	27,887
Culex restuans	—	—	—	—	11	—	17	137	165
Culex salinarius	—	—	—	—	2	—	50	6	58
Culex tarsalis	—	—	—	—	—	—	—	6	6
Approx. % of collection examined	1.2	1.2	5.4	0.8	2.4	1.6	8.4	2.1	—

TABLE 3. *Species composition of adult mosquito collections at waste lagoons in East-Central Indiana, 1970. (Numbers in the table are projections based upon estimated numbers in trap samples and species breakdown of sub-samples identified.)*

Species	July 29	Aug. 4	Aug. 11	Aug. 18	Aug. 25	Sept. 12	Total
Aedes trivittatus	—	3	—	2	—	—	5
Aedes vexans	2	16	10	5	1	—	34
Anopheles punctipennis	—	2	—	—	—	—	2
Culex erraticus	—	1	—	—	—	—	1
Culex pipiens	287	96	35	—	10	230	658
Culex salinarius	—	—	52	1	—	7	60
Culiseta inornata	—	—	—	—	—	4	4
Psorophora confinnis	1	—	1	—	—	—	2

Partly because of their great size, many lagoon mosquito populations tolerated extreme changes in environmental conditions, and former population levels were rapidly re-established when conditions at the lagoon were stabilized. For example, Lagoon 7 underwent a drop in water level of about 10 feet in 1 week, making it very shallow and reduced in area. The drop in water level resulted in an initial decrease in the number of *Culex pipiens* larvae present (from 340 to 134 immatures per dip), followed by an increase in numbers as the water level was gradually raised again.

Higher water levels also resulted in the submergence of heavy growths of weeds and grasses at most lagoons, apparently enhancing the lagoon medium for mosquito production by providing shelter and an additional food supply. Vegetation overhanging the lagoon edge provided shelter and shade as well. Intentional water level fluctuation would be ineffectual in the control of mosquitoes in these lagoons.

Four lagoons at one collecting site contained a chalky-white waste produced in the manufacture of insulating material, and superficially appeared to be incapable of supporting life. However, *Culex pipiens* larvae, pupae, and egg rafts were able to thrive in the medium. *Culex pipiens* was capable of tolerating other water conditions ranging from a relatively clear and clean state to one in which the waste water was dark and foul-smelling, a range of water conditions sometimes exhibited by a single lagoon during the summer. While other species of mosquito may also be capable of tolerating such water conditions, evidently they were either incapable of doing so as effectively as *Culex pipiens*, or they could simply not compete with the predominant *Culex pipiens* population itself, and so were not abundant in any lagoon.

Fluctuation in water level was the rule, rather than the exception, partly because of the seasonal nature of the vegetables processed at many collecting sites. Some lagoons visited in early August were completely dry, while water, and possibly mosquitoes, might have been found later in the season when tomato processing, for example, was in progress.

Discussion

Effective methods of mosquito control at waste lagoons in central Indiana are not presently known. While insecticides would serve to limit population sizes, a more permanent solution would be to make the lagoon itself unattractive to mosquitoes, possibly by completely denuding the shoreline and the surrounding area of all vegetation, a procedure suggested by other studies (1, 2, 5). Periodic removal of heavy accumulations of solid wastes on lagoon surfaces and bottoms might also be helpful, since this would reduce the larval food supply. Better still, installation of screens which would prevent solid materials from entering the lagoon would decrease the biochemical oxygen demand and possibly provide conditions which would permit survival of natural predators of immature mosquitoes.

While it was initially hoped that fish predatory on mosquito larvae could be introduced into lagoons as a control measure, most lagoons underwent changes in dissolved oxygen content and water level which are probably too great to permit the survival of any species of fish.

The occurrence of *Anopheles quadrimaculatus* and *Culex tarsalis* is cause for some concern, since they are known vectors, respectively, for malaria and Western Equine Encephalitis.

Future studies of the ability of mosquito populations to become established in newly-filled tomato waste lagoons would be enlightening, and a study of the relationship of invertebrate predators to larval mosquito populations could provide information applicable to a biological control program. Since flies were numerous at lagoon sites, a detailed study of these populations would be informative.

Summary and Conclusions

1) Approximately ⅔ of the waste lagoons observed in east-central Indiana during July and August, 1970, were mosquito production sites.
2) Although six other species were present, *Culex pipiens* (the northern house mosquito) was the dominant species at the lagoons studied.
3) Immature mosquito populations were very large, averaging as high as an estimated 367 million.
4) Changes in the level and nature of the liquid waste appeared to have little or no effect in decreasing the production potential of the lagoons which were revisited.
5) Of the five human waste lagoons studied, none was found to support a mosquito population.
6) Diversity of species utilizing lagoons tended to increase as the summer progressed.
7) Further basic studies should be made, extending through spring, summer, and fall, to better evaluate seasonal effects on species composition at waste lagoon sites.

8) Since egg raft populations could sometimes be quantified, that is, rough estimations could be made of the number of rafts present in a given lagoon, an identification key to the eggs of *Culex* species would be helpful in making a rapid assessment of species present.

9) Lagoons might be utilized to a lesser degree by maintaining clean shore lines, by periodic removal of accumulated solid wastes, and by removal of all emergent vegetation. Aeration might be of indirect benefit in controlling mosquitoes by creating conditions more optimal for predators (aquatic beetles, dragonfly larvae, etc.). In most cases, however, certain basic improvements in design and function of these lagoons appeared paramount in source elimination of mosquito populations.

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