A HISTORY OF MOSQUITOES AND MOSQUITO-BORNE DISEASES IN MISSISSIPPI 1699–1965[1]

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Veazie (1901) aptly remarked, "Mosquitoes were never discovered by man, they discovered man many centuries ago, much to man's annoyance." This pointed statement is quite applicable to Mississippi where mosquitoes and their transmitted diseases have been a devastating blight on the people since that day in 1699 when the first Europeans stepped ashore at Biloxi. Under the French banner, D'Iberville and his party established a fort at Biloxi after which ". . . a search was made for mineral wealth and the Indians were to be taught to raise silkworms and pearl-fishing was to be established." However, he was later to refer to Biloxi as ". . . a place with sandy soil, mosquitoes, and having a poor water supply." (Duffy, 1958).

YELLOW FEVER. It is generally held that yellow fever was introduced to the Mississippi Coast sometime between 1700–1704 by way of Havana, Cuba. The fact that D'Iberville suffered a case of yellow fever at Biloxi in 1702, which forced his return to France in an attempt to recover from this debilitating disease, further supports this contention. Yellow fever, whatever its point of origin or entry, remained in the state until 1905 when the last cases were reported. Deaths resulting from yellow fever were apparently commonplace throughout the 18th century but few reliable records are available prior to 1817 (Barber, 1929a). Augustin (1909) reported that there were at least twenty-five major yellow fever epidemics during the period 1817–1905 in Mississippi with a total of nearly twenty thousand reported cases and five thousand deaths on record. A list of the major epidemic years and their pertinent statistics are tabulated in Table 1.

TABLE 1.—The major yellow fever epidemics for the 19th and 20th centuries.

	Year	Number of Cases	Number of Deaths
1.	1817	?	9
2.	1819	?	180
3.	1820	280	?
4.	1823	?	3
5.	1825	?	182
6.	1828	?	90
7.	1829	?	90
8.	1835	9	1
9.	1837	?	280
10.	1839	?	285
11.	1853	380	130
12.	1855	70	13
13.	1873	3	9
14.	1878	14,922	3,231
15.	1879	77	20
16.	1888	15	5
17.	1890	6	2
18.	1892	4	0
19.	1893	3	1
20.	1895	3	0
21.	1897	1,304	88
22.	1898	737	51
23.	1899	90	11
24.	1903	4	2
25.	1905	572	46
	TOTALS	18,479	4,729

For yellow fever, 1878 was the major epidemic year throughout the United States. National statistics record some 125,000 cases with 12,000 deaths from yellow fever; Mississippi statistics for the same period recorded nearly 15,000 cases with about 20 percent mortality. At this time, yellow fever was epidemic in at least seventy communities in Mississippi. Of the twenty-five major epidemics, 81 percent of all cases and 68 percent of all deaths occurred in 1878. The devastating effects which this epidemic must have wrought on a post-war poverty-ridden people may be gleaned from the follow-

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ing examples. In 1878, with a population of 2,250, Jackson suffered 630 cases with 82 deaths. A more poignant example is the case of Lake, Mississippi. During the epidemic (1878) Lake, with a population of 325, suffered 300 cases of yellow fever with 86 cases terminating in death.

The last epidemic of 1905, though far less catastrophic than some of the earlier ones, was just as impressive to the people. Thigpen (1964) interviewed oldtimers from Pearlington, Mississippi who had witnessed the epidemic of 1905. He says, "If there was word of an impending atomic bomb attack, there would be no more fright and terror than when the public health doctor came to Pearlington to see a sick man and pronounced his disease to be yellow fever. Entire families were bundled up and on their way to the north in less than two hours following notice of the disease. Governor Vardaman clamped on what was called a 'shotgun quarantine.' Soldiers patrolled the entire area and no one was allowed to enter or leave the area for four months. There was no mail, and the only contact with the outside world was a single phone line to Bay Saint Louis, Mississippi."

Veazie (1901) mentioned the large number of open cisterns behind every home on the Mississippi Gulf Coast which undoubtedly was a contributory factor for the hordes of *Aedes aegypti* during the 18th, 19th and early 20th centuries. It is noteworthy that from the time of the discovery that *Aedes aegypti* was in fact the vector of yellow fever (1900), the disease disappeared from the United States by 1905. The story of malaria has not been as cryptic.

Malaria. Although both malaria and yellow fever allegedly came to the Mississippi Coast with the early exporers, first mention of malaria in Mississippi may be surmised indirectly by Boyd's (1940) reference to its presence in the rich, deltaic regions of the lower Mississippi Valley during the 18th century. Likewise, cases of malaria are alleged to have been endemic to the area throughout the course of the 19th century, being noticeably higher following the Civil War (Barber, 1929a). It was fortuitous indeed that although proof of arthropod-transmitted diseases did not come until 1889, the use of window screens had taken a foothold by the beginning of the 1880's.

In any discussion of malaria, it must at once be noted that the accuracy of morbidity and mortality statistics is at best questionable, this being particularly true of Mississippi's malarial history (Andrews, 1950; Barber, 1929a; Thayer, 1897 and Hoffman, 1932). Estimates of the number of cases resulting in deaths are quite tenuous; the vastness of the range being readily apparent in the following: estimates of deaths per cases vary from 1 death in 50 cases to 1 death in 470 cases; in 1946 over 17,000 cases were reported to the State Board of Health, but when in the next year (the state required identification of the pathogen as well as posted a $5.00 bounty per *confirmed* case), according to Walker, the number dropped to just under a thousand cases (unpublished report, 1956). The primitive diagnostic techniques that must have been employed by physicians (trained in a time prior to the known epidemiology of arthropod-transmitted diseases) in the last century and the early part of this century unquestionably accounted for a great deal of inaccurate statistics.

In spite of the fact that quinine was isolated from cinchona by 1823 and was employed in the general practice of Dr. Henry Perrine of Natchez by 1826 (supposedly the first American physician to use the prepared drug—Boyd, 1941), its use must have been very limited. The high cost of quinine shortly after the Civil War must have been prohibitive to extended use since the price ranged from $4.00 to $4.50 an ounce, a price hardly within range of a war-broken and poverty-ridden society (Barber, 1929a). The price gradually declined and by the second decade of this century was being sold for about 25 cents an ounce. It is curious that the people now refer to typhoid inoculations as "malaria shots."

Malaria has been incriminated for much

illness of which it was innocent during the last 150 years (Barber, 1929a). With the incidence of malaria presumably evident in every county in Mississippi by 1914 (von Ezdorf, 1913), the first recorded suggestion to eradicate this disease did not come for another two years, being attributed to F. L. Hoffman (1916) whose pleas finally bore fruit with the formation of the National Malaria Society and the formation of an anti-malarial program by the Mississippi State Board of Health.

The next thirty years evidenced a great deal of anti-malarial work in Mississippi. Chronologically, the emphasis gradually changed with new accomplishments and newer ideas. The 1916–1921 period was characterized by the effective use and promulgation of draining, ditching, filling, impounding, larviciding, and experimental biological control measures employing top-minnows (Clarke, 1922; Bass, 1919). The thoughts behind these early efforts must have been preventive in intent with an emphasis on eliminating breeding areas.

The use of and emphasis upon window screens became a subject of interest throughout the 1920's. The earlier techniques of ditching, impounding and the like did, of course, continue and increase during this period as well. Educating the public through pamphlets, brochures, and indoctrinating the school children was also heavily stressed at this time (Barber, 1929a & b; Maxcy, 1923; Underwood, 1929).

By 1930, the realization of the socio-economic influences of malaria prompted redoubled efforts, in all directions, of the anti-malarial campaign. The advent of the WPA saw many anti-malaria tasks being intensified in the state. The combined efforts of the State Board of Health and the WPA projects endured through the 1930's (Bradley, 1940; Underwood, *et al.*, 1950).

In 1942 the federal government inaugurated the MCWA (Malaria Control in War Areas) which performed the most extensive surveys ever made on the endemicity of mosquitoes in Mississippi. The MCWA contributed much to existing larviciding, ditching, draining, and adulticiding programs for the duration of the war period (Anon., 1946; Underwood, *et al.*, 1950).

Unlike yellow fever, which was widespread throughout the state, malaria has always found its highest level of incidence in the Delta region followed by, in order of incidence, the Bluff, Northeastern, Southeastern, and Coastal regions (von Ezdorf, 1914; Barber, 1927; Dauer, 1936; Hoffman, 1932). Morbidity statistics for this last area, the Coastal region, readily demonstrate that malaria was uncommon compared to the rest of the state, in many years there being no reported cases.

In some retrospective studies, Brierly (1945) and Rector (unpublished report, 1936) investigated the importance of the socio-economic pressures on the incidence of malaria. Both recognized essentially the same things, that while the anti-malarial campaign was steadily decreasing the incidence of the disease, the cyclical occurrence of the disease seemed unaffected by all efforts. Although the actual number of cases steadily declined, the proportional incidence still evidenced a five-to-six year cycle (Fig. 1).

Another major factor in maintaining the cyclical incidence of malaria was agriculture. Agriculture in Mississippi had always meant one crop—cotton. The relationship between the crop and the itinerant nature of its field planters and harvesters has a direct bearing on the cycle. In those years when the price of and profit on cotton turned for the worse, the natural consequences of a pinched income inevitably proscribed the purchase of expensive drugs, window screens, much less a substantive diet (Carter, 1913; Barber, 1929a). The itineracy of the workers meant not investing hard-earned cash in temporary living quarters. Brierly (1945) presented some interesting graphs on the cyclical occurrence of malaria and correlates the peaks with personal income (measured by collected revenues). Although this itinerant worker class was, for the most part, not paying income

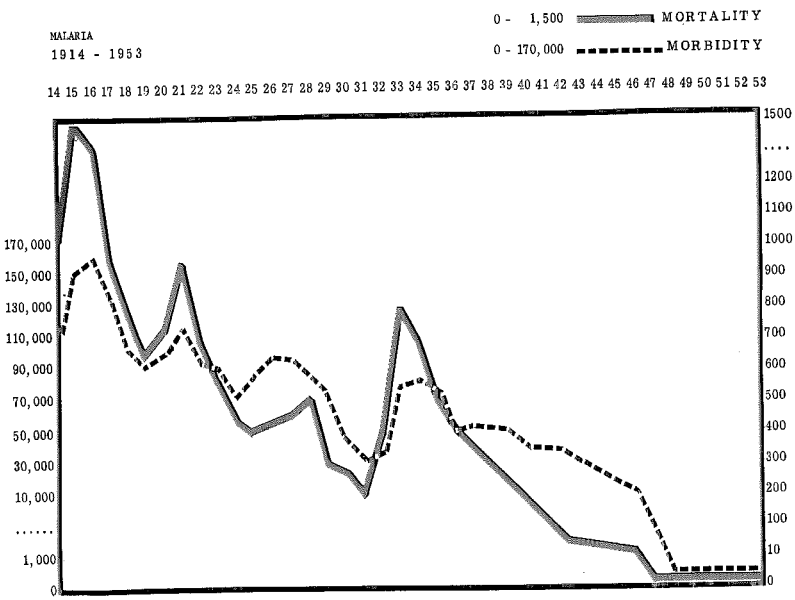

FIG. 1.—Incidence of malaria in period 1914–1953.

taxes, the increase or decrease in collected revenues are assumed to be reliable indices of the state's general economic condition.

Forty years of intensive anti-malarial campaigns running the full gamut of every possible method of prevention and control finally eliminated this pestilence from Mississippi—the last case on record being one in 1955, the last death in 1953. Yellow fever and malaria having been permanently erased from the state, new directions were taken and the mosquitoes of annoyance value received the impact of Mississippi's campaigners.

The new directions turned towards the practical control of pest mosquitoes and may be conveniently discussed in two units—salt-marsh and inland (rice field) mosquitoes.

Invasions of salt-marsh mosquitoes along the Coast probably began many millennia ago. Past ravages probably included the same six species (*A. sollicitans, A. taeniorhynchus, C. salinarius, C. inornata, A. atropos,* and *A. crucians*) that have constituted the major invasions of the Coast during 1915, 1925, 1927, 1929, 1938, 1962 and 1963.

The invasions of 1925 (extending as far inland as Wiggins, Mississippi, some 36 miles from the coast) were so severe that the federal government appropriated $50,000.00 for a preliminary survey of the marsh mosquitoes. T. H. D. Griffitts observed flights of salt-marsh forms in every month of the year during 1927–1928 (unpublished report, 1929). He collected larvae in concentrations of 2,650 per dipper. Under an enabling act of the Mississippi legislature, unsuccessful attempts were made to initiate control programs along the coast; but, as often occurs on the Coast, an invasion year is frequently followed by extremely light years and no money was appropriated (White, 1940). Following the severe invasion of 1963, the next year saw the establishment of a three county (Hancock, Harrison, and Jackson) control program, Gulf Coast Mosquito Control Commission, and another program under the auspices of the National Aeronautics Space Administration in Han-

TABLE 2.—List of mosquito species by physiographic region. An "X" indicates the presence of a species; a dash(—) indicates its absence according to available records.

Species	Coastal	Central	Delta	North
1. *Aedes aegypti*	X	X	X	X
2. *atlanticus*	X	X	X	X
3. *atlanticus-tormentor*	X	X	X	X
4. *canadensis canadensis*	X	X	X	X
5. *cinereus*	X	X	X	—
6. *dorsalis*	—	—	—	X
7. *dupreei*	X	X	X	X
8. *fulvus pallens*	X	X	X	X
9. *grossbecki*	—	—	X	—
10. *infirmatus*	X	X	X	X
11. *mitchellae*	X	X	X	X
12. *sollicitans*	X	X	X	—
13. *sticticus*	X	X	X	X
14. *stimulans*	—	X	—	—
15. *taeniorhynchus*	X	X	—	—
16. *thibaulti*	X	X	X	X
17. *triseriatus*	X	X	—	X
18. *vexans*	X	X	X	X
19. *Anopheles atropos*	X	—	—	—
20. *barberi*	X	X	—	X
21. *bradleyi*	X	—	—	—
22. *crucians*	X	X	X	X
23. *georgianus*	X	X	—	—
24. *pseudopunctipennis*	X	X	—	—
25. *punctipennis*	X	X	X	X
26. *quadrimaculatus*	X	X	X	X
27. *walkeri*	X	X	—	—
28. *Culex erraticus*	X	X	X	X
29. *nigripalpus*	X	X	—	—
30. *peccator*	X	X	X	X
31. *pilosus*	X	X	X	X
32. *pipiens*	—	—	—	X
33. *quinquefasciatus*	X	X	X	X
34. *restuans*	X	X	X	X
35. *salinarius*	X	X	X	X
36. *tarsalis*	X	X	X	X
37. *territans*	X	X	X	X
38. *Culiseta inornata*	X	X	X	X
39. *melanura*	X	X	X	X
40. *Mansonia perturbans*	X	X	—	—
41. *Orthopodomyia alba*	X	X	—	—
42. *signifera*	X	X	—	—
43. *Psorophora ciliata*	X	X	X	X
44. *confinnis*	X	X	X	X
45. *cyanescens*	—	X	—	X
46. *discolor*	X	X	X	X
47. *ferox*	X	X	X	X
48. *horrida*	X	X	—	—
49. *howardii*	X	X	X	—
50. *varipes*	X	X	—	—
51. *pygmaea*	X	X	X	—
52. *Uranotaenia lowii*	X	X	X	X
53. *sapphirina*	X	X	X	X
54. *Toxorhynchites rutilus septentrionalis*	X	X	—	—
TOTAL	49	48	35	36
	Coastal	Central	Delta	North

cock County for control on their Mississippi Test Facility. Recently, a cooperative effort between the two agencies has been in effect (Harden, 1965).

The inland mosquito problem exists primarily in the rice-growing Delta. In the early 1950's, rice-growing was introduced into the Delta region whereupon it very quickly created a pest problem (Mathis, *et al.*, 1954), *P. confinnis* being the dominant form. Successful control is now being maintained by titrating ethyl parathion directly into the irrigation canals (Ouzts, 1965).

At present many communities throughout the state have established some type of mosquito control program employing the usual techniques of adulticiding and larviciding. It is, however, unfortunate that after the eradication of malaria and the dissolution of the WPA and MCWA projects, the state turned its attention elsewhere. Today, in Mississippi, there is a need for an active centralized agency which provides recommendations and safeguards the public interest with regard to mosquito control programs such as commonly prevail in other states, notably Florida.

Considering forty years of extensive anti-malarial work in this state, it is rather surprising that a complete list of the species which occur here was not available until 1960. Most of the work entailing surveying, collecting and identifying species of Mississippi was done by the MCWA and the U. S. Army. During the war, many papers on the taxonomy and biology of mosquitoes appeared in the journals. The list of these papers is quite extensive and for that reason, we cite only the more important papers (King *et al.*, 1960; Peterson *et al.*, 1945; Carpenter *et al.*, 1955). These papers contain extensive bibliographies on the taxonomy of Mississippi mosquitoes. The distribution of mosquito species by physiographic regions is given in Table 2.

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THE EFFECT OF ILLUMINATION AND POOL BRIGHTNESS ON OVIPOSITION BY *CULEX RESTUANS* (THEO.) IN THE FIELD

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INTRODUCTION. In the field many mosquitoes lay their eggs in dark pools and shaded situations, even at night. Investigations of egg laying behaviour have, however, been carried out largely in the laboratory (reviewed by Clements, 1963).

Previous investigations at this Institute (Laing, 1964) have shown that the mosquito, *Culex restuans* Theo., among others, breeds readily in artificial pools in a woodland environment. The following tests were done to determine the effect of pool linings with different brightness and of artificial illumination during the night on the oviposition behaviour of this species.

METHODS AND MATERIALS. Four artificial pools one meter square, similar to those described by Briand (1964), were set out at the corners of an approximate square with a side of 10 meters in fairly dense mixed woodland at the Institute field station near Chatterton, Ontario. Two (east) were lined with translucent and two (west) with black polyethylene film. Their exact position was determined by adjacent trees which were not disturbed. Each pool was filled to the top with approximately 250 liters of water from a nearby stream. As it was expected that larvae or contamination from larvae would occur during some of the tests, approximately 100 mixed *Aedes stimulans* and *A. trichurus* were added to each pool from a snowmelt pool some 200 m to the south, which contained final instar larvae and pupae.

Fixtures with white reflectors fitted with two 40-watt cool white fluorescent lamps were set 70 cm. above the southeast and northwest pools and controlled by a time-switch set to illuminate the pools between 6:00 p.m. and 7:00 a.m. eastern daylight time. Starting on May 9, 1966 the surface of the pools was illuminated with an intensity of 1,600–2,700 lux which is about 1/25 to 1/50 as intense as open sunlight.