AN OVERVIEW OF ORGANIZED MOSQUITO CONTROL IN FLORIDA[1]

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ABSTRACT. Mosquitoes and the diseases they vector have wreaked havoc in Florida's history. The literature describes conditions that prevailed well into the twentieth century, thusly . . . "each summer yellow fever, malaria and dengue would sweep through the villages like a forest fire." Not until the discovery of the role of the mosquito as a vector of these pathogens did things change. Such knowledge and relentless mosquito control programs resulted in the demise of yellow fever in 1910, of dengue in 1932 and malaria in 1948. Encephalitis, on the other hand, is an annually recurring event and the threat of the historically prevalent diseases still abounds with pressure from the tropics. The control of pest mosquitoes is an ongoing necessity. To cope with the mosquito menace, Florida supports 50 organized local mosquito control districts in 48 counties. Combined state and local budgets exceed 26 million dollars annually. The state leads the nation in expenditures for mosquito control and continues to be a pioneer in the field.

HISTORICAL

One hundred years ago in the spring of 1883 Florida was a land of pestilence, largely due to mosquitoes and the diseases they vectored. According to the literature of those days . . . "Each Summer yellow fever, malaria, and dengue would sweep through the villages like a forest fire." But, ironically, and unfortunately, the role of mosquitoes was not to be known for another 17 years. The state of knowledge—or the lack of it—is well illustrated by an article which appeared in *Scientific American* in 1863 (Vol. IX. No. 18, October 31, 1863, p. 277):

> *Malaria.* This atmospheric poison has been proved to be caused by the decomposition of organic matter, and it exists to some extent everywhere. Vegetation both grows and dies, and in the soil its decomposition goes on at various rates. Soils generally are acidulous; but a rich, highly-manured, warm soil is alkaline. Where most alkali exists there is a greater facility for the escape of vapors, such as we suppose to be hurtful. The extreme condition of putrescence may be very readily produced in a soil by artificial means; the use of a little ammonia, for example, more than vegetation will bear. The substances putrefy until the whole becomes fetid in the highest degree. We have then a soil rich in organic matter and undrained. It is artificial malaria. We can, then, produce malaria from the soil by fostering some of its tendencies.
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> Cold weather tends to produce acidity of the soil, hence malaria is always diminished with a lower temperature. When a warm alkaline soil is washed with water and exposed to the air, decomposition is stopped, and it sends forth less malaria. Drainage is the most effectual method of preventing malaria arising from swampy districts.

By 1867 things began to happen in far places which were to have a profound effect on the ultimate demise of vector-borne diseases in Florida. Between 1867 and 1869, pioneers in parasitology demonstrated the development of parasitic worms in arthropods, including insects: a spiruroid in mealworms by Leuckart, *Dipylidium* in dog lice by Melnikov, and the guinea worm in *Cyclops* by Fedschenko. Prior to Leuckart's discovery, no one had even glimpsed the possible role of insects as intermediate hosts or vectors of parasites.

The impact of knowledge and its application is well illustrated by the events of the last quarter of the 19th century. In 1877, Florida experienced an epidemic of yellow fever in Fernandina Beach in which 1,146 of its 1,632 population came down with the disease; in 1887, the same disease was rampant in Key West, Tampa, Plant City, and Manatee; in 1888 yellow fever hit Jacksonville in a holocaust which by Thanksgiving of that year, had claimed more than 400 lives, sickened 5,000 people, and caused more than 10,000 persons, out of a population of 26,800 to flee the city. This epidemic resulted in the creation of the Florida State Board of Health in 1889. Even then, the role of the mosquito was unknown.

While Florida suffered, Sir Patrick Manson, in 1878, was making his pioneering observation on the development of *Wuchereria bancrofti* in mosquitoes. Although this suggested to Manson the probability of mosquitoes having a comparable role in connection with malaria, we must wait yet another 15 years in the setting of 1883

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for Ross to finally furnish the proof in 1898. This followed by 5 years the ingenious work of Smith and Kilbourne who had worked out the transmission of Texas fever by ticks—the very first demonstration of an arthropod as an intermediate host and vector of a protozoan parasite. The discovery of malaria transmission by mosquitoes in 1898 was where it all began. Then, in 1900 came that important discovery by the Yellow Fever Commission of the transmission of yellow fever by *Aedes aegypti.* Finally, Dr. J. Y. Porter of the Florida Health Department, in his 1900 annual report, was able to declare in a statement concerning malaria . . . "It is seen that it is not the germ itself which rises from the soil or water, but the carrier of the germ." Consider that this was only 83 years ago—a scant 14 years before the outbreak of World War I. Things had indeed come a long way since that article on malaria in the 1863 *Scientific American,* which, by the way, drew the right conclusion, but for the wrong reason. The mosquito was not even mentioned. The benefits from the application of this new knowledge, accepted only after 1900, were rapid. In 1905, Florida suffered its last epidemic of yellow fever in Pensacola and since 1910 the disease has been absent from the state.

Florida had its last epidemic of dengue fever in 1932, and malaria was conquered in 1948. The first organized effort to control malaria came during World War I when the U.S. Army, U.S. Public Health Service and the State Board of Health set up a program of drainage and larviciding at Camp Johnson near Jacksonville. In 1919, the state, the city of Perry and the Burton-Swartz Cypress Company jointly set up a malaria control project in the city of Perry, one of the most malarious areas of the state.

Mosquito control, as we know it today, began to develop between the World Wars. In 1922 the Florida Anti-Mosquito Association was formed. In 1925 the state passed enabling legislation for the creation of mosquito control districts and by 1935, 5 districts had been formed. The U.S. Department of Agriculture laboratory was established in Orlando in 1932. In 1937 the Rockefeller Foundation, in cooperation with the Florida State Board of Health, city of Pensacola and Escambia County organized a demonstration project on ditching and filling. In the meantime, from the depression year of 1933 until 1941, many malaria control projects were performed with funding from various federal "make work" agencies including the Works Progress Administration (WPA). During this period more than 1500 miles of ditches were dug for mosquito control throughout the state.

In 1941 a Bureau of Malaria Control was created within the Florida State Board of Health and for 18 months this unit trained about 200 Army and Navy officers in malaria control for dispatch around the world. The U.S. Public Health Service set up the first Malaria Control in War Areas (MCWA) Project at Tallahassee in 1942. Projects were then established around all military bases in the State. By 1944, the senior author found himself in basic training at one of these bases—Camp Blanding, between Jacksonville and Gainesville. Two years earlier, his father had come down with a devastating case of malaria from a weekend fishing trip to "Four Holes Swamp" in coastal South Carolina—so, he knew first-hand the importance of the MCWA program in the early 1940's. Along with venereal disease, malaria claimed its share of the basic training regimen.

Between 1945 and 1949 a program of DDT residual house spraying in malarious areas of Florida was supported by Federal funds. Credit World War II and malaria for much impetus to the Florida mosquito control programs with which we are now involved. If Ross, Manson, Gorgas and Lazear and others can be credited with the birth of medical entomology as a field, then certainly the World War II entomologists working primarily in the field of malariology can be largely credited with its growth and maturity.

In 1946, the Bureau of Malaria Control was abolished and a Division of Entomology created in the Bureau of Sanitary Engineering. Entomology was growing in Florida. In 1953 the Division of Entomology became the Bureau of Entomology with a little more autonomy. The impact of Dr. John Mulrennan, Sr. was beginning to show. In 1976 the Bureau of Entomology became the Office of Entomology in the Department of Health and Rehabilitative Services.

Along with the growth of entomological activity came the establishment of research centers. In 1953 the legislature appropriated money to establish the Entomological Research Center at Vero Beach. The Center was dedicated in 1956 and has become renowned for the excellence of its facilities and research. In 1973, the name was changed to the Florida Medical Entomology Laboratory (FMEL) and the FMEL was transferred to the administration of the University of Florida in 1979. The West Florida Arthropod Research Laboratory (WFARL) was established in Panama City during 1963 for applied research on stable flies (dog flies) and other arthropods of medical importance, including mosquitoes. In that same year, 1963, the Encephalitis Research Center was established in Tampa following the disastrous out-

break of St. Louis encephalitis (SLE) in 1962. Its name was changed to the Epidemiological Research Center in 1968. So, by 1963, Florida mosquito control was organized as it is today, *viz.;* 50 districts, 3 research centers and an Office of Entomology. Also, in that year the U.S. Department of Agriculture laboratory was moved from Orlando to Gainesville.

Having detailed some of the rationale, emphasizing health aspects, on which the Florida mosquito control program is based and the history from when it derived, we now turn to the larger question of how we go about the business of mosquito control in the state.

TODAY'S CHALLENGE

While mainly public health examples have been used, it is evident that mosquito control is as much for relief from distress as from disease. The present state of mosquito control would have been reached for either reason, but has probably received equal impetus from both. It is evident that people and mosquitoes must coexist in Florida—neither element is going away. Consider that this very county (Orange)—now the leading tourist area in the world and one of the most rapidly growing areas of the state—was once in an area known as "Mosquito County." While the historically notable mosquito-borne diseases (malaria, yellow fever and dengue) are largely absent from the State, the flicker that could ignite future epidemics remains. Encephalitis, on the other hand, is an annually recurring threat.

Florida still has one of the largest and most diversified mosquito faunas in the nation, 67 species, 11 of which are unique to the state. Not only does Florida have its own native species with descriptive names signifying horror, vexation, torment, perturbation, etc., but a number of species in the tropical islands to the south are constantly spearheading new assaults on the state. Their quest for new territory is enhanced by a geometric proliferation of man-made vehicles to transport them frequently and rapidly to a new territory which contains favorable niches for them to occupy without competition from an organism's fiercest competitor—its own kind. Such is the case with *Anopheles albimanus,* the principal malaria vector of the Caribbean. This species has time-and-again invaded Florida, but thus far it has failed to establish itself.

Posing an even greater threat than new, infiltrating mosquitoes, might well be the already established presence of vector species which, in Florida, have lain dormant as vectors, but still have all of the attributes to once again transmit the viruses of dengue and yellow fever, the protozoans of malaria, or the worms of filariasis. These mosquitoes, "flying hypodermic needles," if you will, await only the opportunity to become active vectors of pathogenic organisms.

So long as humans come to Florida for the first time, pass through, or return from jaunts to the Caribbean, multiple opportunities abound to transport the pathogens in the perfect package, human blood, to our established mosquito species which have already proven their mettle as vectors in Florida's history. Florida not only has a set of native mosquito species and disease systems, mainly various encephalitides, but it also has the constant threat of new invasions including various combinations of vectors and disease systems.

In the late spring and early summer of 1975, the Vietnamese refugee movement brought thousands of medically unscreened persons from Southeast Asia to Eglin Air Force Base in Florida. These people had come from an area where malaria and dengue were rampant. Florida's natural mosquito vectors of these diseases, *Anopheles quadrimaculatus* and *Aedes aegypti,* respectively, potentially had the opportunity to get "off the bench" and into the game. A similar situation was repeated in 1980 with an influx of thousands of Cubans and Haitians into tropical and subtropical Florida. Again, the vectors not only were present, but the pathogens of dengue fever and filariasis could have easily entered with the people.

The 1962 epidemic of St. Louis encephalitis in the Tampa Bay area resulted in 222 cases and 43 deaths. Another came in 1977, with 110 cases involving 23 counties of central and south Florida with 8 deaths. In 1983, the ingredients for epidemics of all of these past-occurring diseases still abound.

In 1980, (provisional data) the Health Program Office of the Florida Department of Health and Rehabilitative Services reported 49 cases of malaria, 13 cases of dengue and 1 case of Eastern encephalitis in the state. A recent survey showed a 6.7% infection rate for microfilariae of *W. bancrofti* among Haitian refugees in South Florida (Yangco et al. 1983). The implications are apparent.

Long after the major mosquito-borne diseases were contained, pest mosquitoes continued to defy abatement. Except for a relentless mosquito control effort, there is no reason to believe that pest mosquitoes pose any less of a problem today than at any time during Florida's history. For example, on the night of June 29, 1982, 4 CDC light traps operated near Clewiston in Hendry County, yielded 1.1 million mosquito specimens. The majority were *Psorophora columbiae,* but *Mansonia dyari, Ma. titillans* and

Culex nigripalpus were also amply represented. The latter species is the local vector of SLE.

As elsewhere, there is no *one* mosquito problem in Florida. For this reason, mosquito control is essentially a local matter and has evolved along lines of local needs and responses.

It is evident that the mosquito control problem in Florida is not that different today than in yesteryear. But, today's environmental concerns, insecticide resistance and a declining mosquito control dollar have resulted in the need for a much more prudent and knowledgeable effort than ever before. No longer can we dig a ditch simply because it will lower the mosquito breeding potential of a swamp or marsh; no longer can we apply an effective chemical simply because it works; no longer can we select tools without regard to cost. Although we have many new challenges to old problems, we believe that Florida has the resources and the will to continue to meet and manage the mosquito menace.

ORGANIZED MOSQUITO CONTROL IN FLORIDA

It is clear that mosquito control in Florida is not a choice, it is a necessity that cannot be haphazard and left to chance. It must be organized and programmed to do the job.

While operational mosquito control is a local problem—it is indeed a statewide responsibility. From the very beginning of organized mosquito control at the local level, the state has recognized the benefits accruing to the populace at large. Any effort against *Aedes taeniorhynchus* in Brevard or Lee counties benefits the state of Florida. Any effort in controlling *Aedes aegypti* in Key West, Miami, Sarasota, Tampa or Jacksonville benefits the state. Any effort to control encephalitis anywhere in the state benefits all of us. In this spirit, the Office of Entomology administers a "matching funds" program whereby the 50 participating districts receive State funds.

Indian River County in 1925 was the first Florida county to vote for a mosquito control district and the taxes necessary for the control operations. St. Lucie County was next to establish a district in 1926, followed by Pinellas County in the early 1930's. Dade and Broward counties formed districts in 1935. But even so, by 1948 there were only 10 districts—but then in 1949 and 1953 came two state aid mosquito control laws, thanks to legislative action inspired by Dr. John Mulrennan, Sr.

In 1949 the first state aid mosquito control law was passed by the Florida legislature which provided up to $15,000 of full matching funds for mosquito control in any county of the state. In 1953, a second state aid bill was passed which provided for matching funds for counties to be prorated on the basis of local funding. The first bill (State I Funds) placed major emphasis on chemical control. However, salt marsh mosquitoes soon became resistant to DDT and environmental problems associated with the use of chemicals became apparent. Consequently, the second bill provided matching funds (State II Funds) for so-called permanent control measures. These laws prompted a proliferation of new districts. By 1950 there were 16 districts, by 1958 there were 45 districts, and by 1963 the count had reached its present level of 50 districts in 48 counties.

Today the Office of Entomology supports local mosquito control districts by administering the state matching funds and by providing technical support and consultation services. The legal guidelines under which the Office operates are (1) those laws and regulations initiated by mosquito control or public health interests (F.S. 388, F.A.C. 10D-54, F.S. 381, and 386); (2) those laws and regulations drafted by other agencies, federal, state or local that impact on mosquito control programs; and (3) pesticide-related laws (F.S. 487—The Florida Pesticide Act and P.L. 92-516, the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) and its several amendments). Administratively, the Office is also guided by F.S. 120, the Administrative Procedure Act. Obtaining permits for source reduction projects involves a complex of laws and regulations and a bevy of other agencies including the Florida Department of Environmental Resources (DER), the Florida Department of Natural Resources (DNR), the Florida Game and Fresh Water Fish Commission, the Florida Archeological Commission, and the Water Management Districts. The various local government agencies include engineering or planning departments, port authorities, pollution control departments, etc. Federal agencies include the Environmental Protection Agency (EPA), Fish and Wildlife Service, National Marine Fisheries, and the Army Corps of Engineers.

The most recent available national data (1981) show Florida ranking first among all the states in expenditures for organized mosquito control ($19,705,448) with California a close second ($16,123,347). Together, these two states accounted for 44% of the total for the United States ($81,679,378). Other states with large expenditures were New Jersey ($6,458,234), Louisiana ($4,446,519), Texas ($3,367,627), South Carolina ($3,026,435), Virginia ($2,680,662), Illinois ($2,414,224), Massachusetts ($2,371,789), Minnesota ($2,205,300),

New York ($1,998,886), Ohio ($1,911,627) and Utah ($1,685,391).

There are 7 districts in Florida with 1981 budgets exceeding $1,000,000. Five more budgets exceed $750,000, four more exceed $500,000 and 12 more exceed $250,000. There are nearly 1,000 permanent and seasonal employees, including 40 biologists or entomologists, not counting a number of directors who are professionally trained in these fields. Most of the districts have active survey programs and 16 participate in a statewide seasonal surveillance program for SLE activity. For ground operation, there are 272 vehicle-mounted ultralow volume (ULV) units, 18 thermal foggers and 202 larvicidal units among the 50 districts. For aerial applications of insecticidal chemicals or oils, there are 31 helicopters, 6 single-engine aircraft and 25 multi-engine aircraft owned by 13 different districts and an additional 10 districts contract for aerial application services. Twenty-one districts have some type of permanent control activity and 12 others have some capability in this area. Several counties have biological control operations and others (Collier and Lee) are conducting research in biological control. Collectively, 14 districts conduct applied research at the district level.

TRENDS

Mosquito control in Florida is evolving into highly sophisticated programs. The state has taken a lead role in the recent proliferation of field trials involving the I.G.R. compounds, various formulations of *B.t.i. (Bacillus thuringiensis H-14)* and the "monomolecular film" (ISA-20E). In application equipment, the speed regulated flow devices now used on many ground ULV machines and advances in rotary ditching exemplify developmental trends in the State.

Much of the impetus for this work has come from mosquito control districts along with the state's West Florida Arthropod Research Laboratory and the commercial companies. This trend of local involvement in developmental work is an economic and environmental necessity. Mosquito control in Florida, as elsewhere, is rapidly becoming almost "prescription" control to satisfy specific environmental requirements.

The principles of Integrated Pest Management (IPM) are adhered to by most mosquito control districts as they move away from total reliance on chemicals to a more balanced effort, including source reduction, which once was the hallmark of Florida mosquito control.

Great strides have been made to lessen the adversary relationship between mosquito control and environmental agencies. Governor Graham has established a Mosquito Control Working Group in the state, a group composed of federal and state agencies representing both mosquito control and environmental interests. This group has worked diligently to address the many environmental problems associated with source reduction in natural marshes and the effect of mosquitocides on non-target species. These efforts have resulted in the development of a basic IPM document, management plans for mosquito control impoundments, and numerous studies on the effects of mosquitocides on fish and other non-target organisms.

SUMMARY

We have looked at the rationale for Florida mosquito control efforts; past developments as they relate to the present and future; the basic structure and resources of operational programs and current trends. Florida mosquito control workers have reason to be optimistic, for who can deny that even with all of the problems, current knowledge and resources give us an advantage over our antecedents.

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