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Stopping Breeding of Dengue Virus Spreader Aedes Mosquitoes (Diptera: Culicidae) with Environmental Modifications

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Abstract

Dengue virus spreader Aedes mosquitoes are now present globally in tropical and sub-tropical regions, and spread to more temperate areas during the summer. Mosquitoes *Aedes albopictus* Skuse and *Aedes aegypti* (Linnaeus) have adapted to breed around human dwellings and prefer to lay eggs in clean water, and since the virus can be passed from adult to egg, the dengue virus is guaranteed to survive until the next summer and heavy rains. Modern mosquito control in wetlands integrates chemical, biological and physical techniques. However, environment modifications, using breeding reduction methods, provide permanent and effective mosquito control with some apparent impacts. For the reason that of this, the present study is aimed to assess impacts of environmental modifications for mosquito control. Environment modification, or also known as physical or permanent control, is typically one part of a mosquito control. This can be as simple as properly discarding old containers which hold water capable of producing mosquitoes such as tires, which severe as *A. aegypti* or *A. albopictus* mosquitoes producing habitat can be managed by proper disposal of them. Otherwise, it can be as complex as implementing of rotational impoundment management or open marsh water management techniques which control salt marsh mosquitoes at the same time as significant habitat restoration is occurring. Source reduction is important in that its use can virtually eliminate the need for pesticide usage in and adjacent to the affected habitat. Mosquito control by environment modification efforts is a management initiative when ditching of high marshes by hand or with explosives occurs. Other environment modification concerted efforts include the filling of salt marshes and the creation of impoundments. While all of these techniques have mosquito control benefits, some environmental impacts may occur from their implementation. Environment modifications in freshwater habitats like flood plains, swamps, marshes typically involve constructing and maintaining channels or ditches, which can serve the dual functions of dewatering an area before mosquito emergence can occur and also as harborage for larvivorous fishes. Mosquito production from storm water or waste water habitats also can be a problem, but typically can be managed by keeping such areas free of weeds through an aquatic plant management program and maintaining water quality that can support larvivorous fishes. The implications of environment modifications for future studies and impact assessment for mosquito control are appropriately touted for their effectiveness and economic benefits to incorporate in an integrated vector management program.

Keywords

Disease Vector, Vector Survey, Arboviruses, Public Health, Environmental Management

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1. Introduction

Proper surface and subsurface drainage to remove excess water in a safe and timely manner plays an important role in controlling water related diseases. Careful control and appropriate reuse of drainage water can help to protect the

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environment and optimize the use of water resources. The health issues related to water management can be in the categories of water related vector-borne diseases, faecal or orally transmitted diseases and chronic health issues related to exposure to residues of agrochemicals. Vector-borne diseases are caused by bacteria, viruses and parasites transmitted by water related disease transmitting agents called vectors. A vector is often an insect, which transmits an infection from one person to another person or from infected animals to humans. Most infections can only be transmitted by a particular, disease-specific vector e.g., dengue virus spreader Aedes mosquitos (Diptera: Culicidae) are now present globally in tropical and sub-tropical areas, and spread to more temperate regions during the summer. However, with the growth of ecological consciousness, peoples began to realize the environmental damage that accompanied by the use of broad spectrum chemicals, especially those that does not break down and get in the food chain. Many mosquito populations have become resistant (immune) to the chemicals used commonly (Sarwar, 2014 a; 2014 b).

Mosquito species differ in their breeding habitats, biting behavior, flight range and in many other ways. Therefore, different strategies are needed to control different species of mosquitoes. For the reason that there is no drug, protection treatment or preventive vaccine available against dengue viruses, the reduction of infection risk is best achieved by reducing risk of breeding of the vector mosquitoes. This can be done through government authorities, to reduce pest nuisance and lower risk of infection in the communities by managing the mosquito populations in the wetlands with appropriate methodologies. Yearly town clean-up campaigns, for example, are very effective in reducing populations of Asian tiger mosquitoes that breed predominately in artificial or natural containers (Sarwar, 2015 a; 2015 b; 2015 c).

2. Environmental Considerations

Like other habitations, the saltmarsh environment also supports breeding of pest and vector mosquitoes. Modern mosquito control programs utilize chemical larvicides and a range of integrated approaches to reduce mosquito breeding potential in saltmarsh habitats. Increased public awareness of ecological risks and the ecological importance of intertidal wetlands have resulted in the development of management systems that have minimal environmental impacts and complement integrated control programs (Harley et al., 2001). A system of habitat modification has been developed and implemented over the last two decades, with a focus on minimal impact to the saltmarsh ecosystem and saltmarsh biota that are influenced by specific ecological conditions (Breitfuss, 2001).

Mosquitoes and the diseases they carry have played an important role in our history. If these disease agents become reintroduced into populations, they can be transmitted by the yellow fever mosquito (*Aedes aegypti*) and the Asian tiger mosquito (*Aedes albopictus*). The increased use of non-degradable plastic, glass and aluminium containers, and non-recapable radial tires have increased populations of these containers breeding mosquitoes. The Aedes mosquitoes are most active during daylight, for approximately two hours after sunrise and several hours before sunset. Indoors, the mosquitos rest in closets and other dark places, while, outside, they rest where it is cool and shade, and mainly attack at the feet and ankles. The mosquitos breed around human dwellings and prefer to lay eggs in clean water which contains no other living species. These eggs become adult in about one and a half to two weeks. The mosquitos have greatly reduced the `humming' sound that these make with their wings. Humans nearly hear Aedes sound, unlike the other species whose humming is extremely irritating and awakens the deepest sleeping persons. The insect is very fast in flight unless gorged with blood than other types of mosquito that even fly onto face and can be easily caught or killed. Expanding international trade has increased the chance of introducing new mosquito species into our areas, as has recently happened with the Asian tiger mosquito *A. albopictus* (Carlson et al., 1992; 1997).

Mosquito control strategies have changed considerably over the past few decades. Environment modification is an established method of effective long-term mosquito management particularly in salt-marsh environments. It is especially pertinent when mosquitoes are known vectors of life-threatening diseases and their larval breeding habitat is in close proximity to residential areas. Wet season rainfall, often followed by effluent discharges to the swamp from the adjacent sewage treatment plant, creates ideal sites for the immature stages of the common mosquitos. Subsequent to increase in effort, a drainage system can be established and a significant reduction in mosquito numbers following habitat modification is possible. Environment modification has successfully reduced mosquito numbers and minimized the risk for mosquito-borne disease to residents in urban and surrounding areas (Sarwar, 2014 c; 2014 d).

Environment reduction involves eliminating the habitat or modifying the aquatic habitat to prevent mosquitoes from breeding. This measure includes sanitation measures where artificial containers, including discarded automobile tires, which can become mosquito habitats, are collected and properly disposed. Environment modification may also involve management of impounded water or open marshes to reduce production and survival of the flood water mosquitoes.

If habitat modification is not feasible, biological control using fishes may be possible. Mosquito control officials often apply biological or chemical larvicides with selective action and moderate residual activity to the aquatic habitats. To have the maximum impact on the mosquito population, larvicides are applied during those periods when immature stages are concentrated in the breeding sites and before the adult forms emerge and disperse. The underlying philosophy of mosquito control is based on the fact that the greatest control impact on mosquito populations will occur when these are concentrated, immobile and accessible. This emphasis focusing on habitat management and controlling the immature stages before the mosquitoes emerge as adults. This policy reduces the need for widespread pesticide applications in urban areas (Jacups et al., 2011). The primary objective of mosquito and vector control is to preserve or create an environment favorable to humans and animals by lessening the effects that mosquitoes and other vectors have upon our lives.

3. Mosquito Production and Management

Of the Aedes mosquitoes, *A. aegypti* comes in three polytypic forms, domestic (breeds in urban habitat often around or inside houses), sylvan (sylvan form is a more rural form and breeds in tree holes generally in forests) and peridomestic (peridomestic form thrives in environmentally modified areas such as coconut groves and farms). Mosquitoes in well drained saline wetlands are principally found in the areas behind the mangrove communities, which is called the high marsh, where pools of water in mudflats or saltmarsh vegetation are left by the highest tides (spring tides) of each month, or are filled by rainfall / runoff, and are not flushed by the daily tide movements during the weeks thereafter. In wetlands that are not well drained, mosquitoes are also able to exploit impounded stagnant pools retained within stands of mangroves, and other vegetation on the low marsh, caused by siltation or other blockage of the normal tidal channels and thus not subjected to the normal daily flushing. Mangrove swamps and saltmarshes are often perceived to present a mosquito problem, and to be the source of pest populations plaguing nearby residential areas. It is true that there are often vector mosquitoes in and near the various parts of saline wetlands, but the problem is rarely simple and can reflect a very complex situation, with a number of mosquito species involved (Dale et al., 2002).

4. Environmental Options

Saline wetlands can be modified by restoring full tidal flushing to the mangroves and enabling natural dewatering of the saltmarshes following tidal and rainfall inundations. The former can be achieved by renovating tidal channels and maintaining them in a condition which allows full tidal exchange and precludes the formation of impounded pools within the mangroves. The latter can be most simply achieved through managing whereby marsh pools that hold water after highest tides or rainfall are connected for tidal influence using various sized channels and with persisting ponds to support predatory fishes, or through runnelling (shallow channels to enhance flushing of the marsh) whereby narrow shallow ditches provide tidal influence to the pools. Runnelling modifications generally act against all mosquito species exploiting the marsh pools and modifications are suitable for reduction of Aedes species, because they eliminate ground surfaces which are alternately wet and dry (which is required for Aedes egg deposition, conditioning and hatching), but they do provide habitat for Culex and Anopheles species unless they support significant numbers of predatory fishes (Breitfuss et al., 2004).

Mosquito control with runnelling is realized through the tidal circulation providing a flushing of the breeding depressions, and also by providing access to the marsh for larvivorous fish. Runnelling can raise rather than lower the water table as occurs and can better maintain the integrity of high marsh (although it may become wetter and more characteristic of low marsh). The implementation of either of these habitat modifications will require expert advice on site suitability and construction strategy. Permits from relevant authorities (such as State Departments of Fisheries, Environment, and Planning) will also be required, and these will vary between states. One important consideration for environment modification proposals is the possible presence of acid sulphate water / soils in the habitat. These conditions often support mosquito populations in coastal regions and can also produce additional saline habitats for these coastal species in non-tidal areas. Runnelling and channelling (controllable course through a body of water) in areas likely to have acid sulphate influences should not be undertaken without consulting appropriate experts (Florida Mosquito Control, 1998; Breitfuss et al., 2003).

5. Mosquito Control Through Environmental Management

Although wetland values have been recognized for many years, efforts to preserve freshwater wetlands through regulation are relatively important. Ongoing information would hopefully provide continuing insights into wetland functions which can assist in the development of a better understanding to address wetland mosquito problems

(O'Bryan et al., 1997; Corzine and Jackson, 1997; Florida Mosquito Control, 1998; Dale, 2001).

5.1. Containers

Containers such as flowerpots, cans and tires are excellent habitats for several Aedes and Culex species. Container inhabiting mosquitoes of particular concern are *A. albopictus* and *A. aegypti*, which have become the primary mosquito problem over the past several years in some parts of the world. A container-breeding mosquito problem can be solved by properly disposing of such materials, covering them, or tipping them over to ensure that they do not collect water. Several mosquito control agencies have extensive programs to address urban container-breeding mosquito problems through house-to-house surveillance and formalized education programs.

5.2. Freshwater Lakes, Ponds and Retention Areas

While it can be possible to fill small artificial ponds that produce mosquitoes, it is usually impossible to do so in natural areas (however small); large permanent water bodies, or in areas set aside for storm water or waste water retention. In such situations, other options that are effective in controlling mosquitoes include periodic drainage, providing deep water sanctuary for larvivorous fish, minimizing emergent and standing vegetation, and maintaining steep banks. The Culex, Coquillettidia, Mansonia and Anopheles mosquitoes are frequently produced in these habitats.

5.3. Fresh water Swamps and Marshes

Environmental laws greatly restrict habitat manipulations in these areas which can produce Culex, Anopheles and Culiseta species, thus making permanent control there difficult.

5.4. Temporarily Flooded Locations

Pastures and agricultural lands are enormous mosquito producers, frequently generating huge broods of Aedes, Psorophora and Culex mosquitoes. Improved drainage is one effective tool for source reduction in such habitats. The second is the use of microjet irrigation practices for those agricultural areas that require artificial watering.

5.5. Salt Marshes

Not so distant past, the extensive coastal salt marshes produced enormous Aedes broods, thus making coastal human habitation virtually impossible. Several of the source reduction efforts have greatly reduced salt-marsh mosquito production in these marshes through high to mid intensity management that relies upon artificial manipulation of the frequency and duration of inundation.

5.6. Salt Water Wetlands

Mosquito control management activities in salt water wetlands must satisfy these criteria like proper planning, which includes documentation of both the necessity and desirability of wetland management for mosquito control, is a key factor of the best management practices. Mosquito control in saline wetlands (mangroves and saltmarshes) can be complex and is usually beyond the capacity of an individual. Notwithstanding the difficulties associated with persuading the various levels of government to undertake mosquito management in these sensitive habitats, the general principles for mosquito control in mangrove and saltmarsh areas can be listed as:-

i. Tidal flushing within stands of mangroves should be maintained so that stagnant impounded water does not provide mosquito habitat.

ii. Natural dewatering of the surface of the saltmarsh should be maintained so that water does not persist in depressions filled by the highest monthly tides.

iii. Structural management (channeling or runnelling) of water flow through the mangroves and onto and off the marsh, providing for natural flushing and dewatering, and access for predators, can be effective in reducing mosquito populations and can be environmentally acceptable.

iv. Use of biorational control agents, such as bacterial products and growth regulators, to reduce mosquito populations can be effective and environmentally acceptable.

5.7. Stream Corridor Wetlands

Sediment choked channels artificially elevate floodplain water levels, reduce the flood storage capacity of the floodplain, contribute to road flooding and often generate extensive mosquito habitat. The stream corridor management practices and guidelines are to be applied with sensitivity and creativity toward that objective that are minimum vegetative disturbance, sediment containment screens, channel restoration and floodplain for proper mosquito habitat management.

5.8. Agricultural and Industrial Waste Water

Many commercial operations have on-site treatment facilities for decreasing nutrient loads from their waste water and generally they use techniques similar to those applied to domestic waste water. The quantity of waste water produced at some commercial locations, such as those processing certain crops, may be highly variable during the year. Therefore, the amount of surface water in the holding ponds or spray fields used in the wastewater treatment may fluctuate considerably, thereby contributing to the production of certain species of flood-water mosquitoes. Wastewater from feed lots and dairy barns is often placed in holding or settling ponds without any prior treatment. Several mosquito species of the genus Culex can become extremely abundant in these ponds, especially in the absence of aquatic plant control.

Hence, for the prevention and control of dengue and other diseases transmitted through the bites of Aedes mosquitoes should mainly be aimed at environment modification practices which are possible with the active involvement of the community**.**

6. Integrated Mosquito Control

The best mosquito control program is an integrated program that includes point source reduction of breeding areas, routine larviciding in those breeding areas that cannot be eliminated and adulticiding only when necessary (Sarwar, 2015 d; 2015 e; 2015 f). In this present day of environmental consciousness, municipal leaders must try to use integrated methods of mosquito control and not just routine spraying with a fogging truck. The first phase in any mosquito control program is to sponsor a spring clean-up campaign. Picking up and hauling away all rubbish piles, broken down washing machines, junk cars, bottles and cans from and around houses will eliminate many domestic mosquitoes that breed right in our backyard. Activities such as cleaning out clogged street drains and culverts, cleaning up illegal dump sites, and mowing around sewage treatment lagoons will also eliminate many mosquito breeding sites. These efforts can save time and money that would otherwise have to be spent in controlling mosquitoes breeding in these sites. The use of biological control agents such as the mosquito fish *Gambusia affinis* is also encouraged, but, the *G. affinis* should never be placed in any natural habitat, such as lakes, streams, creeks, or rivers. If the breeding source cannot support *G. affinis*, then resort to the use of chemicals to control mosquitoes before they emerge as adults. The preferred method of control in sources such as ponds, swimming pools, or barrels, is to treat sources with either *Bacillus thuringiensis* or methoprene as these chemicals are very safe to the environment and target specific. The reduction of infection risk is best achieved by reducing risk of contact with the vector mosquitoes. This can be done through personal protection measures such as use of protective clothing and topical repellents, and avoidance of saline wetlands during dusk, evening and dawn hours. And an even greater benefit can result if this is done not only on personal basis, but by all the close neighbors as well (Sarwar, 2015 g; 2015 h).

7. Conclusion

This paper evaluates the drainage intervention effects for the prevention and control of dengue and other diseases transmitting Aedes mosquitoes. Aside from being itchy and annoying, the bite of an infected females *A. aegypti* or *A. albopictus* mosquitoes can spread a viral infection called dengue. Accordingly, to protect family and community, eliminate standing water in and around home by drain and dump of standing water found inside and outside of domestic areas. Buckets, bowls, animal dishes, bird baths, flower pots, vases, tires and cans make great places for mosquitoes to lay eggs, consequently, weekly empty and wash out containers with a brush or sponge to remove mosquito eggs, and throw away, turn over, or store under a roof any containers that could collect water. Standing water in fountains or ponds is not easily drained, accordingly, at least weekly empty ornamental fountains and non-chlorinated swimming pools. Control of mosquitoes involves integrated management by governments and researchers. A number of programs are presently in place that involve minor landform modifications to saltmarsh areas with minimal disturbance to associated vegetation to create shallow, spoon shaped drains or runnels to enhance tidal flushing of ponds isolated from main tributaries. Runnels also provide increased access to mosquito habitat for fishes that prey on mosquito larvae. However, in conclusion, the issue of mosquito production from saline wetlands must be considered on a case by case basis. Relevant expert's advice on the relative nuisance values and health risks, and the acceptable and effective options appropriate for particular sites should be sought from specialists and consider carefully.

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