MANSONIA VECTOR CONTROL: PROBLEMS AND POSSIBILITIES

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INTRODUCTION

FILARIASIS is a dreaded disease of mankind in the tropical and subtropical regions of Africa, Asia and America (Yap 1985). In the Southeast Asia region, *Mansonia* mosquitoes are the main vectors involved in the transmission of lymphatic filariasis which is caused by *Brugia malayi*. In 1991, *Brugian filariasis* accounted for 92% of the total filariasis cases (871) detected in Malaysia (Marzhuki *et al.* 1993).

The biology of *Mansonia* mosquitoes in relation to the transmission of filariasis has been well-reviewed by Wharton (1962). More recently, further studies on the ecological aspects and bionomics of *Mansonia* have also been reported (Chiang 1987, 1993; Chiang et al. 1984, 1988). In comparison with other common genera of mosquitoes of public health importance, information on the control of *Mansonia* has been scanty and scattered. This is reflected in the two reviews on *Mansonia* biology and control by Yap (1985) and Sucharit (1993).

This paper is a review of all the literature pertaining to the control of *Mansonia* vector mosquitoes and problems faced in control approaches, especially in the Southeast Asia region. For ease of discussion, control approaches against the immature and adult stages are subdivided into five sections: insecticides, biological control, environmental modifications, personal protection and physical measures. A summary is presented in Table 1. Future prospects for the integration of *Mansonia* vector control in the overall approach to the control of *Brugian filariasis* are also discussed.

PROBLEMS ENCOUNTERED IN *MANSONIA* VECTOR CONTROL

Several aspects in the biology of *Mansonia* mosquitoes have contributed to difficulties and possibilities in *Mansonia* control. These aspects include: (1) The attachment of *Mansonia* immatures to the roots of diverse species of aquatic plants (Wharton 1962) in habitats of high organic pollution associated with vegetation cover. This condition would make the larvae less accessible to larvicides. However, a behavioural study conducted in Florida on *Mansonia dyari* and *Mansonia titillans* indicated that there was a daily periodic detachment of the larvae from its aquatic host (Bailey 1984). Such a phenomenon in *Mansonia* vectors such as *Mansonia uniformis*, *Mansonia bonneae* and *Mansonia dives* in this region have yet to be studied. Information on this phenomenon in local vectors will facilitate the proper usage of larvicides for *Mansonia* vector control (Yap 1985). (2) The exophilic and exophagic feeding habits of most *Mansonia* adults (Gass *et al.* 1982, Chiang et al. 1984). Because of such a behaviour, residual insecticide wall spraying in endemic areas would be less effective. (3) The long flight ranges of *Mansonia* adults of up to several kilometers (Wharton 1962; Gass et al. 1983, Chiang et al. 1988, MacDonald *et al.* 1990). This tends to increase exposure of humans over a

wider area and also decrease the effectiveness of localized space spray with adulticides due to the migration of infected mosquitoes, and (4) The relatively long development period of *Mansonia* immatures of around 25 - 30 days (Wharton 1962, Foo 1985, Chiang 1987) may be advantageous when using larvicide.

CONTROL APPROACHES FOR *MANSONIA* VECTOR

Insecticides

Generally, insecticides used for the control of *Mansonia* vectors can be subdivided into larvicides and adulticides. Studies on the use of larvicides for *Mansonia* control began when Chapman (1955) conducted a laboratory test on 15 insecticides against field collected *Mansonia dubitans*. From this study, two organophosphates insecticides, ie parathion and EPN were found to be most effective. However, the above insecticides are not environmentally acceptable at present when sprayed in an open aquatic ecosystem due to their high toxicity to non-target organisms. Further laboratory bioassay using field collected immatures indicated that temephos (Abate^{R}) and chlorpyrifos (Dursban^{R}) were found to provide good results against *Mansonia pertubans* (Yap *et al.* 1968) and *Mansonia uniformis* (Yap & Hanapi 1976). Field studies further confirmed the efficacy of temephos against *Mansonia* larvae (Gass *et al.* 1985). In addition, laboratory and field evaluation of fenthion and cyfluthrin also showed adequate efficacy against *Mansonia uniformis* (Yap *et al.* 1994). More recently, etofenprox, a relatively new insecticide with exceedingly low mammalian toxicity was found to possess good larvicidal effect in the laboratory (Yap *et al.* 1995).

A novel method of controlling *Mansonia* larvae was recently suggested by Lee & Inder Singh (1992) and Lee & Chiang (1995). When chemical insecticides were introduced onto the leaves of water hyacinth, they were shown to be absorbed and transported by the leaves to the roots where they killed *Mansonia* larvae. However, this method of larval control has yet been proven in the field and the use of the chemical compounds is limited only to those with low toxicity to non-target organisms.

Earlier work on the control of adult *Mansonia* through the use of residual spraying of organochlorine insecticides such as DDT, dieldrin and BHC had been reported in the 1950s (Wharton 1955, Reid & Wharton 1956, Wharton & Santa Maria 1958, Wharton *et al.* 1958). However, the use of the above chlorinated hydrocarbon insecticides is considered to be environmentally unacceptable at present. Following a lapse of about two decades, Chang (1980) reported a preliminary field study on malathion thermal fogging for the control of *Mansonia bonneae* and *Mansonia dives* as a short-term control measure. However, Lee & Salleh (1990) were not able to reduce the *Mansonia* adult population in an open swamp area by thermal fogging using lambda-cyhalothrin. The laboratory efficacy of cyfluthrin against *Mansonia* and other mosquitoes of public health importance thorough the use of WHO standard adult residual test had also been reported (Vythilingam *et al.* 1992). More recently, Chang *et al.* (1993) reported that the incorporation of malathion ULV spray and pirimiphos-methyl residual spray against mosquitoes in an integrated control program which included drug treatment of patients with diethylcarbamazine citrate resulted in partial interruption of *Brugia malayi* transmission.

Biological control

A review concerning the use of microbial agents (microbial insecticides) for *Mansonia* vector control has been published recently (Foo 1994). The potential of using microbial agents such as *Bacillus thuringiensis* H-14 (B t H-14) against *Mansonia* larvae in both laboratory and field conditions was first reported by Foo & Yap (1982, 1983). Subsequently, Chang *et al.* (1990a, 1990b) also conducted field studies using different formulations of *Bacillus thuringiensis* H-14 against larvae of *Mansonia bonneae*. In addition to *Bacillus thuringiensis* H-14, *Bacillus sphaericus* have been reported to give good larvicidal effect under laboratory condition (Cheong & Yap 1985, Lee 1988, Yap et al. 1988). Field studies further confirmed the larvicidal properties of *Bacillus sphaericus* (Foo 1985, Pradeep Kumar *et al.* 1988, Chang *et al.* 1990a, Yap *et al.* 1991). Besides bacteria, the fungus *Tolypocladium cylindrosporum* was also found to have potential as a biological control agent against *Mansonia* larvae (Serit & Yap 1984). Studies on turbellarian worms (*Dugesia* sp. and *Mesostoma* sp.) and fish as predators for *Mansonia* larvae have also been conducted (Burton 1960, Ridzuan 1988, Loh *et al.* 1992, Lounibos *et al.* 1992, Yap *et al.* 1993). Laboratory efficacy of mermithid nematodes (*Romanomermis culicivorax* and *Romanomermis iyengari*) against *Mansonia* immatures has also been reported (Daim 1988).

Environmental modification

With the knowledge that *Mansonia* larvae attach themselves to the roots of aquatic plants for respiration, the killing of host plants by the use of herbicides has been attempted with satisfactory results in control of the vectors (Chow 1953, Chow *et al.* 1955). However, the negative environmental impact from the use of herbicides in an open aquatic ecosystem precludes the acceptance of this approach.

In India, in the Shertallai part of Kerala State, aquatic plant species in the genera *Eichhornia, Pistia* and *Salvinia* were periodically removed from ponds and canals, and used as manure for coconut trees. In addition, an incentive in the form of composite fish culture was given to the people who remove these plants from their ponds. This further reduced the host plants for the breeding of *Mansonia* (Rajagopalan *et al.* 1990).

In addition, Hoedojo & Oemijati (1972) reported the absence of *Brugian filariasis* and its main vector, *Mansonia indiana* in West Java and attributed this to urbanization and environmental changes resulting from land use.

Personal protection

Repellent soap formulated with DEET (N, N-diethyl-3-methylbenzamide) and permethrin has been reported to give satisfactory personal protection against *Mansonia* bites in the field for up to eight hours (Yap 1986, Abu Hassan & Narayanan 1992). In addition, repellent bars (Mosbar^{R}) and DEET impregnated anklets and wristbands have also been reported to confer good protection in the field (Chiang *et al.* 1990, Chiang & Eng 1991). Besides repellents, mosquito coils had also been shown to give adequate protection against adult *Mansonia* mosquitoes in the laboratory (Yap & Chung 1987). More recently, a field study conducted in Penaga, Penang using cattle bait further confirmed the potential of mosquito coils for protection against *Mansonia* mosquitoes (H H Yap, unpublished). Other household insecticide products (eg aerosol, mosquito mats and electric liquid vaporizers) have also been shown to give good control against *Mansonia* mosquitoes in the laboratory (H H Yap, unpublished data).

Physical measures

The use of acoustical traps against *Mansonia* adult male mosquitoes was studied by Kanda and a group of scientists from the Institute for Medical Research, Kuala Lumpur, Malaysia in the late 1980s. Kanda *et al.* (1987, 1988) reported that sound frequency of 330 and 350 Hz together with dry ice and a hamster attracted and trapped large numbers of *Mansonia* in two experimental areas in Malaysia.

CONCLUSION

The success of mass drug treatment for the control of *Brugian filariasis* in many areas may have contributed to the lack of interest and impetus in research activities in the control of *Mansonia* vector (Mak & Yong 1986; World Health Organization 1992) when compared to those for the control of other vector mosquitoes including *Aedes, Anopheles* and *Culex* species. Nevertheless, the information accumulated thus far on *Mansonia* vector control points to the feasibility of including the vector control component into the overall integrated approach of using both drug treatment and vector control for *Brugian filariasis* control. This approach is obviously suitable for locations with *Brugian filariasis* transmission which have large numbers of animal reservoirs and *Mansonia* vectors, and where chemotherapeutic control alone has been proven ineffective (Lim & Mak 1983).

The biology of the *Mansonia* mosquitoes further indicates that larviciding may be a better approaches because of their longer immature stage. The use of adulticide (residual and space sprays) should only be considered in epidemic situation where rapid reduction of the infective mosquito population is required. Moreover, household insecticide products especially mosquito coils should be incorporated in the overall *Mansonia* vector control program.

In conclusion, a coordinated and intensified effort in the research activities on *Mansonia* vector control utilizing various control approaches (chemical and bio-control agents, reduction of man-vector contact source reduction) should be conducted. The ultimate aim is to incorporate *Mansonia* vector control as a viable and important component of the overall strategy for *Brugian filariasis* control.

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Table 1: Summary of literatures concerning the control of *Mansonia* mosquitoes.

	Control approaches	Method	References
a.	Insecticides	*Immature stage*	
		Laboratory bioassay and field evaluation (15 insecticides)	Chapman (1955)
		Laboratory bioassay (several insecticides including DDT, temophos & chlorpyrifos)	Yap *et al.* (1968)
		Laboratory bioassay (several insecticides including DDT, temophos & chlorpyrifos)	Yap & Hanapi (1976)
		Field evaluation (temophos)	Gass *et al.* (1985)
		Laboratory bioassay (fenthion & cyfluthrin)	Yap *et al.* (1994)
		Laboratory bioassay (etofenprox)	Yap *et al.* (1995)
		Adult stage	
		Laboratory evaluation (chlorinated hydrocarbons)	Wharton (1955)
		Field evaluation (chlorinated hydrocarbon)	Reid & Wharton (1956)
		Field evaluation (chlorinated hydrocarbon)	Wharton & Santa Maria (1958)
		Field evaluation-space spray (chlorinated hydrocarbon)	Wharton *et al.* (1958)
		Field thermal fogging (malathion)	Chang (1980)
		Laboratory evaluation (DDT, decamethrin & chlorpyrifos)	Lee *et al.* (1986)
		Field thermal fogging (lambdacy holothrin)	Lee & Salleh (1990)
		Laboratory evaluation (cyfluthrin)	Vythilingam *et al.* (1992)
		Filed ULV (malathion) & residual spray (pirimiphos-methyl)	Chang *et al* (1993)

b.	Biological control		
	i. Microbial agents	*Bacillus thuringiensis* H-14 (laboratory evaluation)	Foo & Yap (1982)
		Bacillus thuringiensis (field evaluation)	Foo & Yap (1983)
		Bacillus sphaericus strain 1593 (laboratory evaluation)	Cheong & Yap (1985)
		Bacillus sphaericus (laboratory evaluation)	Lee (1988)
		Bacillus sphaericus (field evaluation)	Pradeep Kumar *et al.* (1988)
		Bacillus sphaericus strain 1593, 2297 and 2362 (laboratory evaluation)	Yap *et al.* (1988)
		Bacillus sphaericus (review paper)	Yap (1990)
		Bacillus sphaericus strain 2362 (field evaluation)	Yap *et al.* (1991)
		Bacillus thuringiensis and *Bacillus sphaericus* (simulated field)	Chang *et al.* (1990a)
		Bacillus thuringiensis (H-14) (field studies)	Chang *et al.* (1990b)
		Clostridium bifermentans (laboratory evaluation)	Lee & Seleena (1990)
		Bacillus thuringiensis and *Bacillus sphaericus* (Review paper)	Foo (1994)
	ii. Fungi	*Tolypocladium cylindrosporum* (laboratory evaluation)	Serit & Yap (1984)
	iii. Predators	Fish (laboratory evaluation)	Ridzuan (1988)
		Fish (simulated field evaluation)	Lounibos (1992)
		Turbellarian *Dugesia* sp.	Loh *et al.* (1992)
		Turbellarian *Mesostoma* sp.	Yap *et al.* (1993)
		General predators	Parsons & Wilson (1982)

	Control approaches	Method	References
c.	Environmental modifications	Herbicides against host plant	Chow (1953)
		Herbicides against host plant	Chow *et al.* (1955)
		Urbanization & land use	Hoedojo &Oemijati (1972)
		Manual removal of host plants	Rajagopalan *et al.* (1989)
d.	Personal Protection	Repellent soap containing DEET & permethrin (field evaluation)	Yao (1986)
		Repellent soap containing DEET & permethrin (field evaluation)	Abu Hassan & Narayanan (1992)
		Repellent bar & DEET impregnated anklets & head bands	Chiang *et al.* (1990, 1991)
		Mosquito coil (laboratory evaluation)	Yap & Chung (1987)
e.	Physical measures	Acoustical trap (sound trapping)	Kanda *et al.* (1987, 1988)

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