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CHEMICAL INSECTICIDES FOR LYMPHATIC FILARIASIS VECTORS AND THE ROLE OF IMPREGNATED BEDNETS

by

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1. INTRODUCTION

For vector-borne diseases in general, it is important to reduce the rate of disease transmission and incidence by means of vector control. Wherever possible, this should be done in conjunction with chemotherapy for the reduction of disease prevalence. The feasibility and value of vector control as one of the components of disease control depend on the identity, ecology and behaviour of local vectors and on other epidemiological conditions.

For filariasis control, several means are now available to reduce vector density and/or man-vector contact, consisting in chemical or biological control, environmental management, individual protection or a combination of two or more of these methods. Chemical insecticides thus remain the main tool and their importance is increasing at present because they can be used for impregnating bednets.

2. CHEMICAL INSECTICIDES

In most parts of the world, the use of chemical insecticides becomes more and more problematic, when considering physiological resistance (Shidrawi, 1990), negative impact on environment, vector resting, feeding behaviour or replacement of endophilic species with exophilic ones. However, the dependence on such compounds remains important since alternatives such as biological and mechanical control methods are not fully operational.

2.1 Anopheles vectors

Anopheles vectors are endophlic mosquitos and their control is predominantly aimed at the adult stage, through application of residual insecticides inside houses. When filariasis as well as malaria depend upon the same *Anopheles* species, the disease ~~very~~ often benefits from malaria control, resulting in a satisfactory level of filariasis control even if malaria transmission continues to be a problem. No large-scale control programme directed against lymphatic filariasis transmitted by *Anopheles* has been carried out since the malaria eradication era. However, in localized areas where malaria control operations continue, i.e., in epidemic situations, urbanized areas or insular places, lymphatic filariasis transmission has been reduced by house spraying using insecticides which are still effective, such as malathion in Burundi (Barutwanayo et al., 1990) or fenitrothion in Mayotte, a neighbouring island of East Africa (El Amine, pers. comm.). Carbamates such as propoxur and bendiocarb and pyrethroids like deltamethrin, permethrin or recently lambda-cyhalothrine are effective in total indoor house-spraying huts (Darriet, 1990) but the cost of such compounds and detoxifying of esterases may limit their operational use (Deach et al., 1989) unless they impregnate mosquito nets, thus rendering their use more attractive (see section 3.).

In some epidemiological situations, it may be appropriate to attack Anopheles by larviciding when they breed for example in rice-fields adjoining villages. Organophosphates are widely used and recently new juvenoids and ecdysoids belonging to the insect growth regulators group have given promising results for such a control in the field (Darriet, 1987).

2.2 Culex vectors

Among the Culex species, only recent advances concerning Culex quinquefasciatus will be reviewed insofar as it plays a major role in the transmission of bancroftian filariasis. The preimaginal stages develop in tropical urban areas, mainly in habitats containing ~~highly polluted water, and the most~~ appropriate and classical means of control consists in larviciding and/or environmental management. Like Anopheles species, the great majority of females of C. quinquefasciatus are endophilic and feed at night, thus explaining why Culex control benefits from antimalaria campaigns during which house spraying operations or impregnated nets are applied in urban areas. On the other hand, filariasis control may benefit from antilarval or adulticidal measures directed against C. quinquefasciatus and motivated by their feeding behaviour which causes considerable nuisance to people exposed to their constant biting.

Since insecticide resistance in C. quinquefasciatus is widely observed for most of the organochlorine compounds, organophosphate larvicides such as fenthion and mainly chlorpyrifos have become the preferred means of control. However, organophosphate resistance has been reported during the last decade, particularly in urban areas where this mosquito plays a major role as a filariasis vector (Curtis et al., 1984). The present status of resistance shows clearly that C. quinquefasciatus is becoming locally resistant to other chemical groups such as carbamates or pyrethroids (Magnin et al., 1988) leading scientists to assess new insecticides and new control methods using for example expanded polystyrene beads.

In as much as Bacillus sphaericus is considered as resorting to biological control, only new pyrethroids and insect growth regulators give promising results as chemical insecticides. Ecdysoid and juvenoid compounds appear to be very promising as larvicides (Darriet et al., 1987; Doannio et al., 1986) while new pyrethroids such as cifluthrin (Rajavel et al., 1986) and bioallethrin (Yap et al., 1988) or carbamates like carbosulfan (Anonymous, 1988) have a good efficacy as adulticides but the cost of such compounds may limit the use of larvicides and encourage, as for Anopheles, the use of adulticides through impregnated netting.

2.3 Aedes vectors

Aedes sp. is one vector of Wuchereria bancrofti in South Asia and the exclusive vector in Polynesia. The insecticidal control of most adult mosquitos is very difficult due to their general exophily and day feeding behaviour. House indoor spraying as well as the use of mosquito nets, impregnated or not, is thus untargeted while fogs or aerosols could be effective but of uneconomical and short-term control for such an accumulative and nonepidemic disease. Furthermore, larval sites are not easily amenable to larvicidal control because of the many scattered and inaccessible breeding sites, even though biological control gave promising results against Aedes polynesiensis in French Polynesia (Rivière et al., 1987). Consequently, the control of Aedes sp. as vectors of bancroftian filariasis remains problematic and chemotherapy seems the most appropriate way to reduce the transmission of bancroftian filariasis.

Where vector control operations are feasible, in insular places or other particular epidemiological situations, classical insecticides such as organophosphates, carbamates or pyrethroids can be used (Wirat et al., 1982; Novack et al., 1985; Anonymous, 1986; Rajavel et al., 1986; Yap et al., 1988). Since resistance is increasing in all parts of the world, new chemical compounds have been tested under laboratory and field conditions. While insect growth regulators gave promising results (Phonchevin et al, 1985; Darriet et al., 1985), the toxin of Bacillus thuringiensis H-14, insofar as it can be included here, shows a great variability in efficacy according to the formulation used (Hougard et al., 1985; Novak et al., 1985).

2.4 Mansonia vectors

For the control of Mansonia species, predominantly involved in the transmission of Brugia malayi in South Asia, the variability in feeding behaviour and resting places contributes to some difficulties in the use of adulticides. For those which are more exophagous and found to be biting predominantly at dusk, aerial application can be conducted with chlorinated or organophosphate insecticides. For endophagous ones which bite throughout the night, indoor house spraying and/or prevention of man-vector contacts, through residual formulations, household insecticides, repellents or impregnated mosquito nets can be applied with success all the more so as compounds and application methods for antimalaria vector control can be used. The breeding of the vectors is closely associated with weeds and their control is mainly possible through environmental management, i.e. weeding or fish culture. Many compounds present a high toxicity against immature stages under laboratory conditions but their application in the field is very difficult; the long immature stage and the periodic detachment phenomenon from weeds may have serious implications in the use of larvicides.

The success of mass drug treatment for the control of B. malayi and a few factors in the basic biology of the vector have contributed to the lack of interest in the control of this mosquito (Yap, 1985). This explains why Mansonia sp. appear to be more susceptible than other vector mosquitos to insecticides. However, for environmental considerations, the use of chlorinated compounds is actually unacceptable but organophosphates like malathion (Chang, 1980), carbamates like carbosulfan (Klein & Darriet, 1989), pyrethroids like lambda-cyhalothrine (Darriet, 1990), insect growth regulators like methoprene (Anonymous, 1987) and the toxins of Bacillus sphaericus (Pradeepkumar et al., 1988) and B. thuringiensis H-14 (Foo & Yap et al., 1983) have given promising results under laboratory and field conditions.

3. IMPREGNATED BEDNETS

The most economical way to use pyrethroids consists in impregnated bednets or curtains. Their effects, studied under laboratory and field conditions, and their possible improvements as well as the socioeconomic and cultural aspects linked to their use have been abundantly described in many reviews concerning malaria control (Lines et. al., 1987; Hossain & Curtis, 1989; Zuzi et al., 1988; Jinjiang et al., 1988; Rozendaal & Curtis, 1989). Consequently, and given a few data available for filariasis control, special attention will be paid to the potentialities of this method and its role for such diseases.

The goal of impregnated bednets consists in reducing the transmission efficiency as well as protecting the individuals. Such a method is directed against endophilic and endophagous mosquitos which bite when most people are asleep, thus excluding all of subperiodic bancroftian filariasis exclusively transmitted by the Aedes species and part of malayan filariasis when transmitted by exophagous Mansonia sp.

Reducing the vector's life expectancy or feeding success or diverting it from biting humans is likely to reduce the incidence of the disease. Given the fact that, contrary to malaria, a cumulative parasitosis is concerned, impregnated netting does not act immediately on the symptoms but results, within a period of time, in a decrease of the prevalence and the level of endemicity. Insofar as this method does not prevent all infective bites, such control measures have to be maintained as long as the adult worms are present in the population where the disease is endemic. Consequently, impregnated bednets can play an important role in lymphatic filariasis control but have to be combined, according to the epidemiological and economical conditions, with other weapons such as chemical insecticides or chemotherapy.

Given the few data available on the role of impregnated bednets in lymphatic filariasis control, some large-scale field trials would need to be carried out in some places selected for their epidemiological importance:

- The first trial could be located in a rural area where Anopheles sp. are both vectors of malaria and bancroftian filariasis, where the impact of impregnated bednets could be assessed for both diseases.

- The second trial could be located in an urban area where C. quinquefasciatus and Anopheles sp. are both vectors of bancroftian filariasis; while the first one constitutes an important nuisance, the latter is a vector of malaria. The impact of impregnated nets could be evaluated for both vectors and both diseases as well as in terms of nuisance reduction.

- The third trial could be located in a place where Mansonia sp. is a vector of malayan filariasis and bites throughout the night inside houses, causing considerable nuisance to people exposed to its constant biting. Evaluation of such a trial could be assessed in terms of malayan transmission as well as in terms of nuisance reduction.

These trials could be carried out first without any other means of filariasis control and then associated with antivectorial measures combined or not with chemotherapy.

Research could also be intensified in the screening of new compounds in order to select alternatives to permethrin and deltamethrin since they are used on a large scale for malaria control.

4. CONCLUSIONS

Despite insecticide resistance, the present status of chemical insecticides against lymphatic filariasis shows clearly that they continue to play an important role in vector control especially for Anopheles and Culex species. New compounds belonging to pyrethroids and carbamates as well as new families like insect growth regulators are now of operational use but the number of new active molecules synthesized by the pesticide industry is decreasing and alternatives or complementary means of control have to be improved or perfected.

Where feeding behaviours of mosquitos allow the use of impregnated mosquito netting, this method has to be employed insofar as it provides considerable advantages from a cost/effectiveness and environmental point of view. However, further studies have to be carried out to improve the efficacy of the tool and especially to specify its role in the context of filariasis transmission as proposed previously under the three epidemiological situations. At least, priority will consist in determining if this method could be integrated into the primary health care system and if it is acceptable to the community.

In case of success of such a method, three weapons will be available in the fight against lymphatic filariasis and a strategy could be defined, as for onchocerciasis control (Hougard & Quillévéré, 1991), to find a correct combination between chemical insecticides, impregnated mosquito net and chemotherapy, with diethylcarbamazine or ivermectin while waiting for a macrofilaricide.

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