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Resistance of Insect Vectors of Diseases to Insecticides in Malaysia and other South East Asian Countries

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VECTOR BORNE DISEASES take pride of place as among the most important communicable diseases in various countries of South East Asia including Malaysia. The recent sporadic outbreaks of haemorrhagic fever which occurred repeatedly almost every year throughout the vast areas of Asia extending from Sri Lanka to the Philippines, the resurgence of malaria transmission in the subcontinent of India, Sri Lanka and fast increasing number of incidence in other countries in South East Asia have caused great concern among public health and vector-control authorities in this region. The effective control of vectors and insects of public importance, therefore, is a matter of utmost importance, to countries of this region.

During the past quarter of a century or more, persistent insecticides have proved so successful that they are still the main weapon used against vector-borne diseases. Many species have developed resistance to these compounds, and have been criticized time and again on the ground that they contribute to the pollution of the environment, but insecticides are still responsible for the control of vector-borne diseases in many areas of the world. They remain the most economical means of fighting insects and have saved millions of lives and have elevated the suffering of many more millions of people.

Many insect vectors, however, have developed resistance to insecticides. The problem of insecticide-resistance in vectors is like a ripple, ever increasing its spread among more species of insects to most types of insecticides over larger geographical areas. Insecticide-resistance in anopheline mosquitoes has created more concern than any other problem in applied medical entomology during the last two decades. This is especially so because of the serious challenge which the problem of resistance now poses to man's attempt to eradicate vector-borne disease like malaria on a world basis.

The areas covered in this review include countries like Malaysia, Singapore, Indonesia, Thailand, Philippines, Khmer Republic, South Vietnam, and Korea.

Among the anopheline mosquitoes, the following four malaria vectors have developed resistance to insecticides:

Anopheles sundaicus has developed DDT resistance in 1954 in Java, Indonesia (Chow & Seoparma, 1956). On the south coast, dieldrin resistance was detected in Jogjakarta Province in 1959. In south Sumatra this species was found to be refractory to DDT and dieldrin in 1961. Dieldrin resistance was reported in this species in 1961 in Sabah, East Malaysia (Chow, 1963, 1970a).

A. aconitus: Resistance to dieldrin first appeared near Suban in Central Java in 1958 after six half-yearly cycles of 0.5 gr/m. In the next three years it spread rapidly over large areas of Java necessitating the replacement of dieldrin with DDT in malaria eradication project (MEP). Double resistance to DDT and dieldrin was demonstrated in this species in 1962 in Jogjakarta Province. Further intensive testing revealed that this condition was widespread especially in Central Java. Tests done in 1973 at several sites in Central Java and Jogjakarta Province revealed high resistance to DDT. Intradomicillary application of DDT however, have reduced transmission of malaria by this species (Loekman, 1973).

A. minimus flavirostris which is the major vector in Philippines has developed resistance to dieldrin in 1959 (Chow, 1959). DDT is still effective against the species. This species is also a vector of filariasis.

A. sinensis which is the main vector in the Republic of Korea has developed strong resistance to dieldrin in Western plain and hill areas of Korea (Hong, 1971). It has also showed intermediate resistance in Korea to fenitrothion and fenthion (Self et al, 1974). These are the only indication of O.P. resistance in *Anopheles* in this part of the world.

A few other species have also developed dieldrin resistance in 1962 (Chow, 1963) in Sabah, East Malaysia:

A. philippinensis has developed dieldrin resistance (Chow, 1963) in Sabah, East Malaysia.

A. barbirostris has developed intermediate DDT resistance in Thailand.

A. barbirostris, A. annularis and *A. subpictus* have developed resistance to dieldrin in Java, Indonesia.

A. vagus vagus was found to be resistant to dieldrin in Peninsular Malaysia (Chow, 1963) and highly resistant to dieldrin in Java, Indonesia (Chow, 1958). This species is resistant to dieldrin and DDT in Saigon, Vietnam in 1965 (Chow, 1965).

A. vagus limosus has developed resistance to dieldrin in Philippines in 1959 (Chow, 1959).

Among the Culine mosquitoes, the following vectors have developed resistance to insecticides:

Culex pipiens fatigans – the most important vector of urban strain of *Wuchereria bancrofti* in addition to being naturally refracting to DDT in this region, has developed a high degree of resistance to DDT, dieldrin, BHC (Reid, 1955, Wharton, 1958a & b, Thomas 1970b) and strong resistance to fenthion (Thomas, 1970a). In Singapore, this species has been found to be resistant to malathion (Chan *et al,* 1972). Some degree of resistance is also reported in *Culex pipiens complex* to malathion and fenthion in South Vietnam.

Culex tritaeniorhynchus which is a major vector of Japanese encephalitis has developed resistance to dieldrin (Hwang *et al,* 1965) and DDT (Chow, 1973) in Korea. Larvae of *C. tritaeniorhynchus* was reported to be DDT and lindane resistant (Self *et al* 1974) in Korea.

Aedes aegypti vector of dengue and haemorrhagic dengue has developed resistance to DDT, fenthion and malathion in Malaysia and to DDT, dieldrin BHC and malathion in South Vietnam, and DDT, BHC, dieldrin and fenthion in Khmer Republic (Mouchet *et al,* 1972).

Aedes albopictus has developed resistance to DDT in Malaysia, Singapore, Philippines, Khmer Republic and South Vietnam; resistance to dieldrin in Malaysia and South Vietnam, Philippines and fenthion resistance in Malaysia. (Mouchet *et al,* 1972).

Musca domestica

Housefly *Musca domestica* has developed resistance to many insecticides in Cameron Highlands, Malaysia. It has developed very high heterogenous resistance to lindane and to DDT in about 80% of the population, high resistance to contact effect to trichlorfon, quite high resistance to dichlorvos (DDVP). In addition, this species has developed intermediate or moderate resistance to diazinon, dimethoate and fenthion (Keiding 1968).

Bedbugs

Bedbugs *Climex hemipterus* was found to be resistant to dieldrin and DDT in Malaysia (Reid, 1960; Cheong, 1964). Thevasagayam (unpublished data 1969) found DDT and dieldrin resistance in this species in houses sprayed during malaria eradication programme. *Climex lecturalius* was found to be resistant to DDT and dieldrin in Korea (Cha *et al,* 1970).

Lice

Body lice was found to be resistant to DDT in Korea in 1951 (Hurlbut *et al,* 1952).

Fleas

Strong resistance to DDT and dieldrin was noticed in *Xenopsylla cheopis* in South Vietnam (Chow, 1970b).

Implications of Resistance in Vector Control

The resistance problem of arthropods to insecticides have been thoroughly reviewed by the Expert Committee on Insecticides (1970) and later by Brown and Pal (1971). The implications of resistance in vectors have been reviewed by Hammon

Table I

Resistance of Insect Vectors to Insecticides in Malaysia and Other South East Asian Countries

Species	Resistance to DDT Group	Resistance to Dieldrin/BHC Group	Resistance to Organophosphorus Group
Anopheles aconitus	Indonesia	Indonesia Sabah	—
A. sundaicus	Indonesia	Indonesia	—
A. minimus flavirostris	—	Indonesia	—
A. sinensis	—	Korea	Korea
A. barbirostris	Thailand	Indonesia	—
A. annularis	—	Indonesia	—
A. subpictus	—	Indonesia	—
A. vagus vagus	S. Vietnam	Indonesia S. Vietnam Malaysia	—
A. vagus limosus	—	Philippines	—
A. filipinae	—	Philippines	—
Culex pipiens fatigans	Malaysia	Malaysia	Malaysia Singapore S. Vietnam
Culex tritaeniorhynchus	Korea	Korea	—
Aedes aegypti	Malaysia S. Vietnam Khmer Rep.	S. Vietnam Khmer Rep.	Malaysia S. Vietnam Khmer Rep.
Ae. albopictus	Malaysia Singapore Philippines S. Vietnam	Malaysia Philippines S. Vietnam	Malaysia
Musca domestica	Malaysia	Malaysia	—
Cimex hemipterus	Malaysia	Malaysia	—
Cimex lectularius	Korea	Korea	—
Pediculus humanus	Korea	—	—
Xenopsylla cheopis	S. Vietnam	S. Vietnam	—
Cockroaches – German	Malaysia	—	—

and Garrett-Jones (1963); Busvine and Pal (1969); and Pal (1974). The implications of insecticides resistance in vectors in Malaysia and other countries in Southeast Asia are very similar to that which has already been described by these authors.

Although resistance has been found in various vectors, it does not exist in all insects throughout the geographical range of the species, but the problem is limited to certain pockets only and their distribution is patchy. So far, none of the important vectors of malaria in Malaysia has been proven to have developed resistance to insecticides. As shown in the table, the majority of these have developed resistance to dieldrin and/or DDT only. Dieldrin resistance when it occurs, appears rapidly and reaches a high level, whereas DDT resistance appears more slowly and has not prevented malaria control and/or eradication programmes. Where there is double resistance to these compounds as present in the same major vectors of malaria in Java, the control of malaria becomes extremely difficult. It is then necessary to look for substitute insecticides among organophosphorous groups or carbamates. However, these are considerably more expensive and may be beyond the economic reach of many developing countries in South East Asia. It is calculated that malathion is at least 5 times the price of DDT and propoxur 20 times, making spraying operations with them at least 3 and 8 times more expensive, respectively (Pal, 1974).

Culex pipiens fatigans which is refractory to DDT and *Aedes aegypti* vector of haemorrhagic dengue as well as *Aedes albopictus* have developed high levels of resistance to chlorinated hydrocarbons. However, these species are still susceptible to many O.P. compounds although resistance to a few others has been reported. Its effect does not seem to be far reaching and the great majority of species are still susceptible to these compounds. However, in some insects, a low level resistance to the O.P. compounds is sufficient to prevent their effective use in the field. Moreover, they are more expensive.

In the Cameron Highlands, Malaysia, control of houseflies poses a real problem as the resistance in this species is multivalent. This probably is as in some other cases, due to the great number of insecticides used against agricultural pests in the farms where the houseflies breed. It is difficult however, to assess with accuracy the effect of pesticides/insecticides which are used in agriculture on the development of insecticide-resistance in vectors. Insecticides-resistance in other vectors also causes considerable difficulties in their effective control in S.E. Asia.

The extensive use of a wide range of chemically diverse pesticides in agriculture for crop protection most probably exerts a strong insecticidal selection pressure on many vectors. Therefore, a mutual consultation between agricultural and public health authorities in the use of various types of insecticides against agricultural pests and/or against insects of medical importance would be of immense benefit. An integrated method that includes appropriate combinations of control measures such as the introduction of new insecticides, mechanical, biological and genetical methods designed for local suitability and needs must be considered for use in vector control programmes. However, these involves financial educational, organizational and operational implications.

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