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Vector Control Using Insecticides

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1. Introduction

At the end of the 19th century, it was discovered that certain species of insects, other arthropods and fresh water snails were responsible for the transmission of some diseases of pubic health importance. Since effective vaccines or drugs were not always available for the prevention or treatment of these diseases, control of transmission then had to rely mainly on control of vectors. The control programmes included among others, use of mosquito nets, drainage of gutters, filling of potholes and other water bodies used by insects for breeding. The 1940s sawed the discovery of DDT insecticide (dichlorodiphenyl tricloroethene) which was a major breakthrough in the control of vector-borne diseases. DDT also appeared to be effective and economical in the control of other biting flies (tsetse fly, simulium, and sand fly) and midges and of infestations with fleas, lice, bedbugs and triatomine bugs.

The initial large scale success achieved in the control programme was short-lived as the vectors developed resistance to the insecticides in use, thereby creating a need for new more expensive chemicals. Interest in alternatives to the use of insecticides such as environmental management (source reduction) and biological control, has been revived because of increasing resistance to the commonly used insecticides among important vector species e.g. (malaria) and also because of concerns about the effects of DDT and certain other insecticides on the environment. For many vector species, environmental sanitation[1] through source reduction and health education is the fundamental means of control; other methods should serve as a supplement, not as a substitute. Thus, in recent years, the practices of vector control have evolved, and environmental management and modification have come to the fore, both for disease control and for agricultural and other economic purposes[2], this is a complex and multi-disciplinary field[3]. Effective application of any control measure must be based on a fundamental understanding of the ecology, bionomics and behaviour of the target vector species and its relation to its host and the environment. Effective vector control also requires careful training and supervision of pest control operations and periodic evaluation of the impacts of the control measures.

In more recent years, less reliance has been placed on the use of a single method of chemical control; there is a shift towards more integrated vector control involving several types of environmental management supplemented by more than one method of chemical control and the use of drugs. More attention has been paid to community participation (a key component of primary health care (PHC) in eliminating breeding sites of vectors (including clearing of weeds/bushes near residential houses) and reducing vector densities.

Finally, there is also need to provide on continuous basis information on single, effective and acceptable methods for vector source reduction and personal protection to individuals and families in the community at a reasonable cost.
In a chapter of this nature only a few, but more important species of vectors could be discussed and even such a discussion could only be brief, emphasizing only the important features of the arthropod which serve to illustrate how the arthropod affects public health.

2. Malaria and its vectors

Human malaria is a number one public enemy and an illness caused by the bite of an infective female anopheles mosquito which transfers parasites called plasmodium from person to person. Four plasmodium parasites exists (P. falciparum, P. ovale, P. malariae and P. vivax) but only one (P. falciparum) is of vital importance in disease transmission in Nigeria. The important vectors in Nigeria are anopheles gambiae and A. funestus. These mosquitoes breed readily in ditches and collections of water in empty receptacles around the houses. The disease is endemic in Nigeria and over 90% of the population is at risk. Fifty percent of the population will have at least one attack per year, 300, 000 children and 11% of pregnant women die of malaria each year respectively and millions of dollars is lost each year in treatment of malaria.
The table below shows some of these vectors and diseases transmitted by them.

Type	Designation	Disease	Vectors	Mode of transmission
Protozoa	Plasmodium spp Trypanosome spp	Malaria African sleeping sickness	Mosquitoes Tsetse fly	Bite (sg) Bite (sg)
Filarial nematodes	Wucheria Bancrofti Onchocerca Volvula	Filariasis Onchocerciasis	Mosquitoes Black flies	Bite Bite
Viruses	YF	Yellow Fever	Aedes	Bite (sg)
Bacteria	Cholera/diarrhea Typhoid fever Bacillary dysentery	Cholera Typhoid fever Dysentery	Cockroaches	Mechanical carriers

Table 1. Pathogens and vectors of some human diseases (sg) indicates definite involvement of salivary gland.

The results of several surveys showed that the most prevalent species of malaria parasites is p. falciparum with a prevalent rate of between 80% and 100% of all positive blood films. P. vivax is conspicuously absent in West Africans who because of their Duffy negative erythrocyte membrane are immune to P. vivax[4, 5].
It is estimated that there are more than 400 species of anopheles in the world, but only 40 of these are important vectors (as transmitters or carriers) of malaria. Only the female anopheles mosquito transmits malaria to humans. Some anopheles mosquitoes can also carry other human diseases like Filariasis and some viruses. There are two other genera of mosquitoes which are important carriers of other mosquito-borne diseases: Aedes is a vector of viral diseases- Yellow fever and Dengue while culex mosquito is the vector of Filariasis

and Japanese encephalitis. For practical purposes and entomologically, it is useful to be able to differentiate between these three types of mosquitoes; so the main distinguishing features in each stage of the life cycle are shown below in the diagram

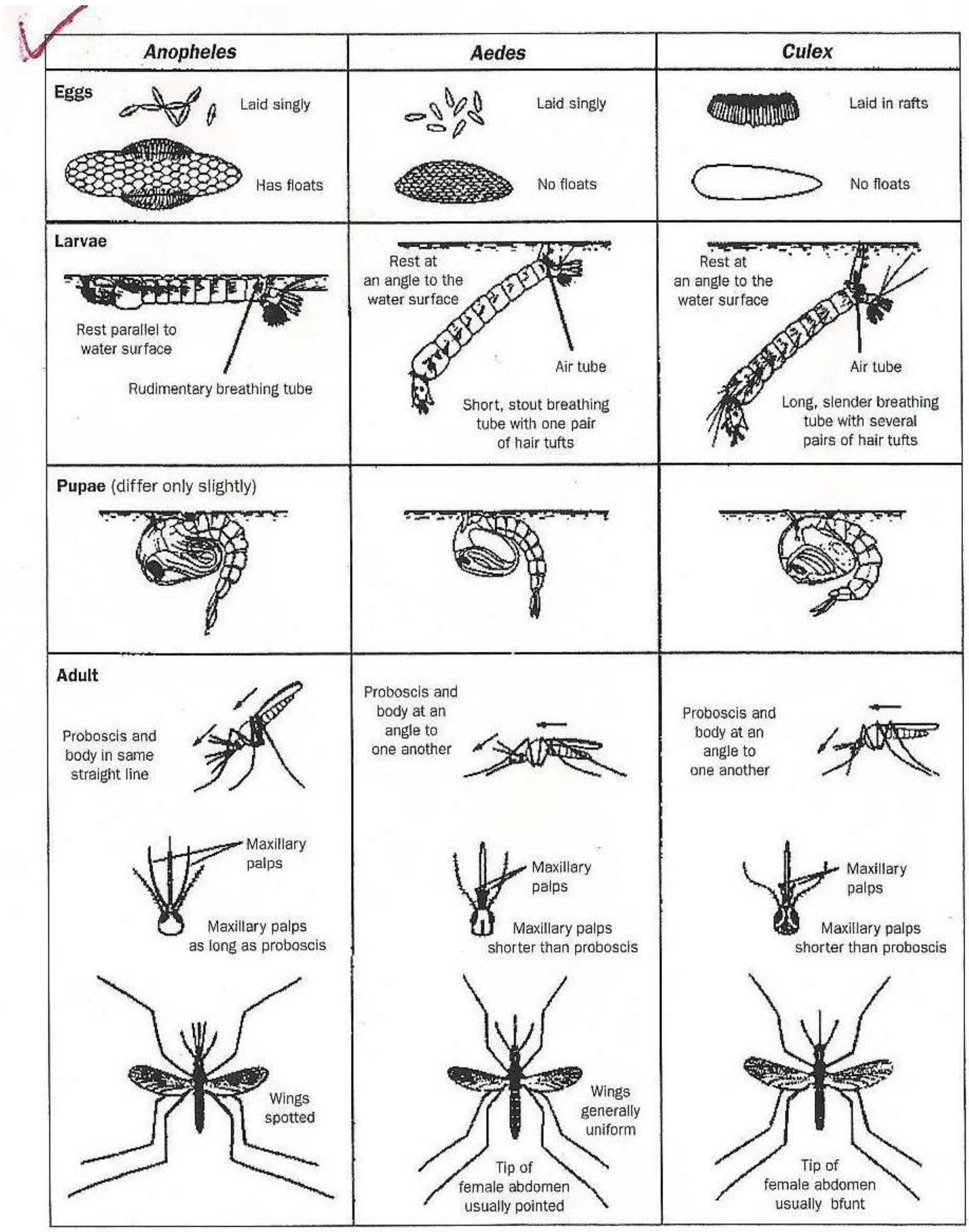


Fig. 1. Life cycles of different mosquito genera (online, 2011).

Basically, the mosquito has four stages in its life cycle: eggs → larva→ pupa → adult. It is useful to understand the life cycle and natural history of the anopheles mosquito not only for epidemiological reasons but most importantly for the fact that all the four stages are targets to control mosquito vector. There are several features of the behaviour of anopheles mosquitoes which are important in understanding malaria epidemiology and also for planning mosquito control.

Malaria is holo-endemic in most regions of Nigeria; ideal climatic conditions for the propagation and transmission of the infection are a temperature between 26^{o}C – 30^{o}C and relative humidity of over 60 percent.

3. Disease control

The general methods of malaria control can be grouped into three measures directed against the parasite in man, measures directed against the vector and measures designed to prevent mosquito-man contact, these are summarized in table 2

Principal goal	Interventions
Treatment	Outpatient treatment of uncomplicated malaria Inpatient treatment of severe and complicated malaria Home treatment
Prevention	
(a) Inhibit mosque ito breeding	i) Source reduction (drainage, filing in ditches) ii) Chemical larviciding iii) Management of agricultural, industrial and urban development to avoid breeding sites
(b)Kill adult mosquitoes	i) IRS (indoor residual spraying) ii) ITMs (insecticide treated materials – bed nets, curtains, etc)
(c) Prevent mosquito contact	i) ITMs ii) Repellants, sprays, coils, etc
(d) Reduce malaria infection and morbidity in humans	i) IPT (intermittent preventive treatment of pregnant women) ii) Chemoprophylaxis

Table 2. Interventions to control malaria[5].

The first involves the use of appropriate anti-malarial agents to treat clinical malaria and the use of chemoprophylaxis among the vulnerable groups. The problem facing most tropical countries is serious as majority of patients with clinical malaria are either untreated or treated inadequately by self-medication. Also, their governments cannot afford to buy sufficient anti-malarial drugs for their needs and most people cannot afford to purchase effective treatments[7]. The annual per capita expenditure on anti-malarial drugs in most of sub-Saharan Africa is still <US$10. An adult (60kg) course of Chloroquine costs US$0.08 but the new artemisinin based combinations (ACTs) cost more than five times as shown in table 3.

Drug	US$
Chloroquine	0.13
SP	0.14
Amodiaquine	0.20
Artemisinin-based combinations (ACTs)	1-3

Table 3. Average cost of a full course of adult outpatient treatment[8].

This is currently unaffordable to most patients surviving barely on less than a US$1 per day. The treatment of malaria has become quite challenging, and the emergence of resistant strains of the parasite. In Nigeria where at least 80%[9,10] of the people live in rural areas and are supperstitious illiterates, early recognition and the right treatment are not adhered to. This encourages drug resistance.

The Abuja declaration on Roll Back Malaria on 25 April 2000 and agreed to by African Heads of State sets an ambitious goals to reduce the burden of malaria (insecticide-treated nets, prompt access to treatment and prevention of malaria in pregnancy) by the year 2010[8]. Achieving high coverage in both IPT and use of ITNs among the vulnerable groups and the general population has remained elusive for many countries in sub-Saharan Africa[11]. A major barrier to net ownership is poverty as the price of a net represents a large proportion of the income of a poor household, this has been reported in various studies[12, 13, 14].

Environmental control (source reduction) offers the best practical and easy measure to control disease vector as it eliminates the breeding places. The filling of mosquito breeding sites with soil, ash or rubbish and is most suitable for reducing breeding in small depressions, water holes or pools, which does not require much filling material. On the other hand, drainage of water can be achieved by constructing open ditches; however, the drainage systems used in agriculture or for the transportation of sewage and rainwater in cities often promote breeding because of poor design and maintenance.

4. The use of insecticides

The first house-spraying campaigns after the Second World War, showed the capacity of this interventions to produce profound reductions in malaria transmission in a wide variety of circumstances. In Africa, the intervention was used in 1960s and 1970s but later abandoned except in some countries in southern and eastern Africa where residual insecticide spraying (IRS) remained the cornerstone of malaria control strategy. Since 2005, however, there has been renewed interest in large scale IRS programmes. To date, 25 out of the 42 malaria endemic countries in the WHO Africa region have included IRS in their control strategy for malaria control. Of these, 17 countries routinely implement IRS as a major malaria control intervention, six including Nigeria are piloting the IRS in a few districts while 2 are planning to pilot. At the end of 2006, the National Malaria Control Programme (NMCP) and its partners initiated a pilot IRS project in 3 local government areas/districts in 3 states (Lagos, Plateau, Borno states) using the WHOPES approved insecticides:

a. Lambdacyhalothrin CS 10% (0.030g/m^2)
b. Alphacypermethrin WP10% (0.030g/m^2)
c. Bifenthrin WP 10% (0.050g/m^2)

The evaluation of the local context of the 3 chemicals confirmed that residual effectiveness of the insecticides lasted for at least 4 months.

Residual spraying of houses involves the treating of interior walls and ceilings using a handheld compression spraying and is effective against mosquitoes that favour indoor resting before or after feeding. For a more detailed discourse of notable insecticide formulations, spray pumps, spraying techniques and maintenance of equipment, see Jan A. Rozendaal[15].
The figure 2, below summarizes and describes the IRS management principles;

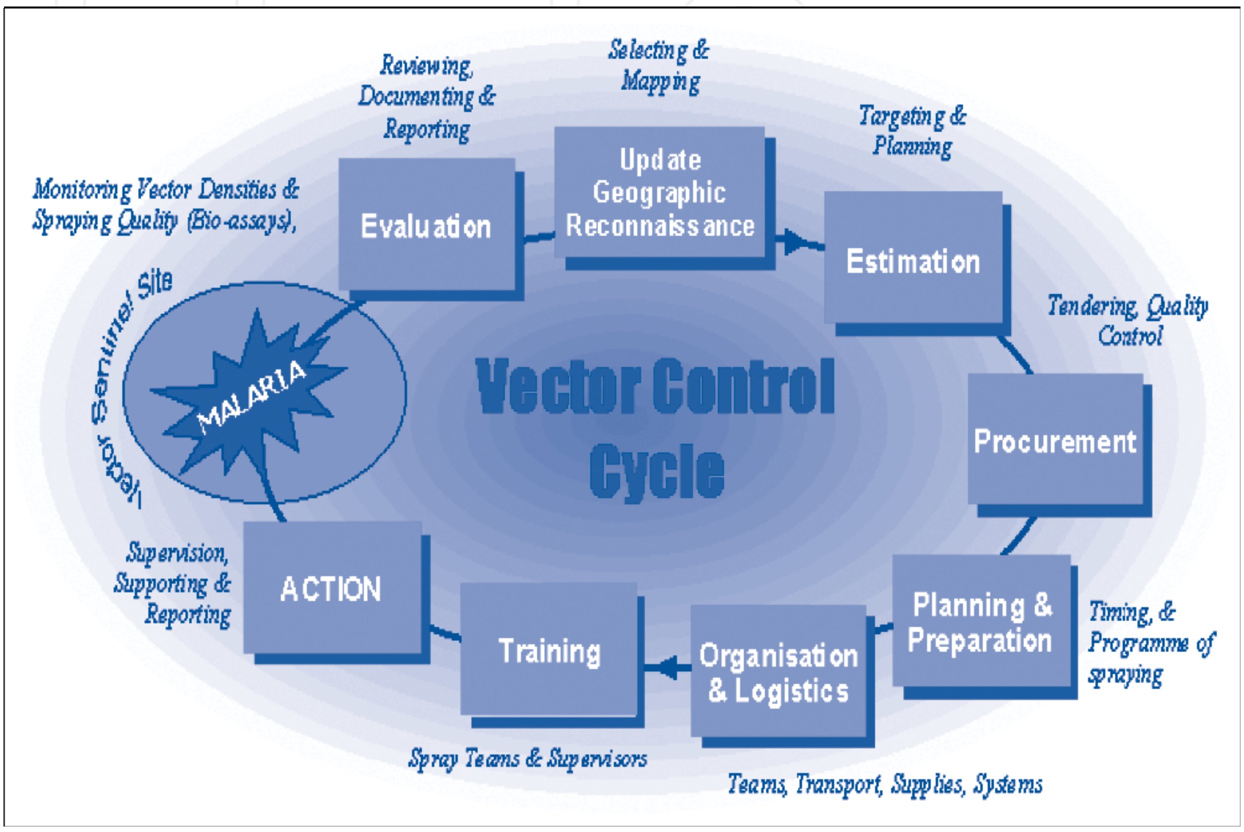


Fig. 2. IRS Management cycle.

Mosquito nets are an old technology and most people in sub-Saharan Africa are aware of the existence of nets. In some countries such as Nigeria and the Gambia nets have been in regular use for over hundred years. Similarly, in some parts of Africa, net ownership is a well established social norm and nets are widely available. For instance, recently, it was found that 70% of households (HHs) in Dar es Salaam (Tanzania) owned a mosquito net[16] and around 35% of HHs were found to own a net in urban Burkina Faso[17].
Insecticide treated mosquito nets have had significant impact in reducing morbidity and mortality among children under-five years old and pregnant women where ITNs have been appropriately and extensively used in malaria endemic areas. The potential epidemiological advantages and public health benefits of treating nets with insecticide for protection against malaria were recognized in the mid-1980s. Specifically, the efficacy of insecticide treated nets (ITNs) for the control of malaria in children under-5 years of age has recently been demonstrated by several large scale studies[18, 19, 20, 21] which find reductions in all cause – mortality, ranging from 16% to 63%. These insecticides which have been approved by WHOPES (World Health Organization Pesticides Evaluation Scheme) are safe. They have the following properties; provide personal protection from mosquito bites, effective against

other insects: bedbugs, flies and cockroaches, community and household mass effective which may be more important in some contexts[22] and mosquito nuisance effect. There have been reports also of dead insects on the nets and on the floor, less mosquito noise and that ITNs providing a better night's sleep than a net alone[16].

Most nets (and other materials) need to be treated and retreated with insecticides to increase their effectiveness. There are several insecticides that can be used which have proved to be safe. The insecticides recommended by the National Malaria and Vector Control Programme for treatment/retreatment of nets are those approved by WHOPES and registered by NAFDAC (National Foods and Drugs Administration Commission) are shown in table 4 below:

Generic name	Trade name	Dose per 1 net	Manufacturer
Alphacypermethrin 10%.SC[a]	Fendona	6ml	BASF
Deltamelthrin 1%.SC	K-Othrine, Ko-Tab	40ml	Aventis
Etofenprox 10%.EW[b]	Vectron	30ml	Mitsui
Permethrin 10%.EC[c]	Peripel, Imperator	75ml	Aventis
Cyfluthrin 5% EW	Solfac EW	15ml	Bayer
Lambdacyhalothrin 2.5% CS[d]	Icon	10ml	Syngenta

Key:
SC[a] = Suspension concentrate
EW[b] = Emulsion oil in water
EC[c] = Emulsifiable concentrate
CS[d] = Capsule suspension

Table 4.

For a detailed description of preparation of insecticide mixtures and treatment methods, the reader should consult guidelines on the use of insecticide-treated mosquito nets[23].

A single impregnation of a cotton or nylon mosquito net will provide protection for 1 year[24,25]. Nylon tends to retain permethrin and deltamethrin better than cotton. The impregnated nets can be washed and can tolerate small tears/holes without markedly reducing the protective effect. Recently, long lasting nets (LLNs) have been developed and have the advantage of retaining insecticidal activity for years (so the nets will not lose its potency with repeated washings). Despite various government policies, cost of the nets remains a significant barrier and a long obstacle to the Roll Back Malaria goal of universal coverage – defined as one long lasting insecticide-treated nets for every two people in the household with 80% usage. ITN development is a public good. The development of insecticide resistance in the 1950s and recently by vectors has been a cause for concern. There have been reports of resistance to DDT in a wide range of sub-Saharan African countries[26], but this has not reached an operationally significant level. With the exception of the Gezira region of Sudan[27], widespread loss of vector susceptibility is not yet a big problem in Nigeria. A worrying new development is the emergence of knockdown resistance to pyrethroid insecticides in natural populations of anopheles mosquitoes in Cote d'Ivoire and Burkina Faso[28, 29, 30] where insecticides are widely used in cotton production.

Currently, pyrethroids are the only insecticides used for net treatment and are also increasingly used for spraying, so there is threat that if widespread resistance develops, the interventions will gradually become less cost-effective over time.

Finally, there is need to describe importantly the WHO integrated vector management (IVM) concept. Vector control is well suited for integrated approaches because vectors are responsible for multiple diseases and since interventions are effective against several vectors (use of insecticides) the concept of IVM was developed as a result of lessons learnt from integrated pest management which was used in Agriculture.

Integrated vector management (IVM) is a major component of the global campaign against malaria. The revised strategic plan for RBM recommended that from 2006 – 2010, 80% of the population at risk need to be protected using effective vector control measures. IVM creates synergies between various vector-borne disease control programmes. Utilization of single method could be optimized to control more than one vector-borne disease, eg ITNs can control malaria, lymphatic filariasis and to some extend leishmaniasis. IVM operates in the context of inter-sectoral collaboration. The application of IVM principles to vector control will contribute to the judicious use of insecticides and extend their useful life.

5. References

[1] World Health Organization. Chemical methods for the control of arthropod vectors and pests of Public Health importance. WHO, Geneva; 1984.

[2] Najera J A. Malaria control: achievements, problems and strategies. Parasitologica 2001, 43:1-89

[3] Molineaux I, Grammiccia G: The Garki project; WHO 1980

[4] Garnham P.c.C. (1971).Progress in parasitology. The Atlone Press, London

[5] Kara Hanson, Catherine Goodman, Jolines, Sylvia Meek, David Bradley and Anne Mills. Global Forum for health Research: The Economics of Malaria Control Interventions, 2004.

[6] Stages of life cycle of vector parasites, available at www.who.int/docstore/water_control_htlm (cited 11/05/2011)

[7] Miller, L.H., Mason, S J, Clyde, DF and McGinnis M H. Resistance factors to plasmodium vivax: Duffy genotype Fyfy. New England Journal of Medicine: 1976; 255:302-304

[8] Denis MB, Tsuyuoka R, Poravuth Y et al. Surveillance of the efficacy artersunate and mefloquine combination for the treatment of uncomplicated malaria in Cambodia. Tropical Medicine International health 2006; 11:1160-1366

[9] WHO. The Africa Malaria Report 2003, WHO/CDS/MAL/2003/1903:31-37

[10] Salako A A. Environmental health education in schools and communities in Nigeria: The essence. The Nigerian Clinical Review Journal (2008): 14; 12:17-25

[11] The Challenges of Malaria Infection in Nigeria: The Nigerian clinical Review. March/April 2011; 89:3-6.

[12] Anna Maria van Eijk, Jenny Hill, Victor A. Alegana et al. Coverage of Malaria protection in pregnant women in sub-Saharan Africa: A synthesis and analysis of National survey data. Medi-Link Journal. April 2011: 12:4:20-42

[13] Aliyu A A, Alti-Mu'azu M, Insecticide-treated net usage and malaria episodes among boarding students in Zaria, Northern Nigeria. Annals of African Medicine, 2009; 8:2:85-89.

[14] Aniefiok M. Acceptance and use of insecticide treated bed nets (ITN in the Roll Back Malaria Programme in Kuje Area Council, Abuja. Journal of Environmental health 2005; 2:26-33

[15] Insecticide-treated nets. New findings from Kenya, published by Centers for Disease Control and Prevention (CDC), Atlanta, USA, Confirm effectiveness in areas of intense transmission. Africa Health (Mera) July 2003; Issue 6

[16] Jan A. Rozendaal: Vector control (Methods used by individuals and communities) 1997.

[17] Jones C. Bed nets and malaria. Postgraduate Doctor. May 2002; vol. 24 No. 2:23-25.

[18] Guiguemde T R et al. Household expenditure on Malaria prevention and treatment of families in the town of Bobo-Diolasso, Burkina Faso. Trans. of the Royal Society of Tropical Medicine and Hygiene 1994: 88: (3)285- 287

[19] Alonso P L, Lindsay SW, Schellenberg J. et al. A malaria control net trial using insecticide-treated bed nets and targeted chemoprophylaxis in a rural area of the Gambia, West Africa. The impact of the interventions on mortality and morbidity from malaria. Transactions of the Royal Society of Tropical Medicine and Hygiene, 1993; 87(S):37-44.

[20] D'Alessandro U, Olaleye BO, McGuire W et al. Mortality and Morbidity from malaria in Gambian children after introduction of an impregnated bed net programme. Lancet 1995:345 (8948).479-83

[21] Binka F N, Kubaje A, Adjuik M et al. Impact of permethrin impregnated bed nets on child mortality in Kassena-Nankana district, Ghana: A randomized controlled trial. Tropical Medicine and International health 1996; 1(2):147-54.

[22] Nevill CG, Same ES, Mung'ala VO et al. Insecticide-treated bed nets reduce mortality and severe morbidity from malaria among children on the Kenyan Coast. Tropical Medicine and International Health 1996: 1(2) 139-46

[23] Nicholas J. White. Malaria Gordon C. Cook and Alimuddin I Zumla (Eds). Manson's Tropical Diseases! 22nd edition, China, Saunders Elsevier: 2009; 1201-1300

[24] WHO Guidelines on the use of insecticide-treated nets for the prevention and control of malaria in Africa.

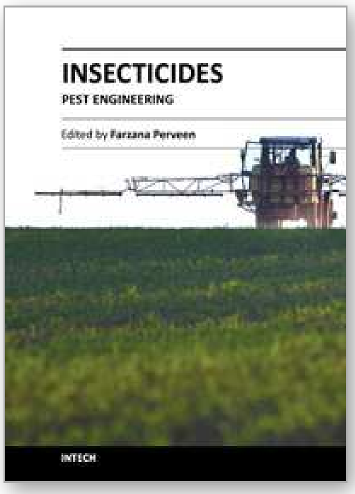
[25] Lindsay SW, Gibson MF. Bed nets revisited – old idea, new angle. Parasitology Today 1988:4:270-272

[26] Alonso PI, Lindsay SW, Armstrong IRM, et al. The effects of insecticide-treated bed nets on mortality of Gambian children. Lancet 1991;337:1499-1502

[27] WHO Vector resistance to pesticides, Fifteenth Report of the WHO Expert Committee of Vector Biology and Control, Geneva; 1992

[28] El Gaddal A A, Haridi A A M, Hassan F T, Hussein H. Malaria Control in Gezira-Managil Irrigated Scheme of the Sudan. Journal of Tropical Medicine and Hygiene 1985; 88:153-157

[29] Martinez Torres D, Chandre F, Willamson M S et al. Molecular characterization of pyrethroid knockdown resistance (kdr) in the major malaria vector anopheles Gambiae SS. Insect Molecular Biology 1998; 7(2):174-184
[30] Elissa N, Morchet J, Riviere F, Mevnier J-Y, Yaok. Resistance of Anopheles gambiae SS to pyrethroids in Cote d'Ivoire. Annales de la Societe Belge de Medecine Tropicale 1993; 73:291-294.



Insecticides - Pest Engineering

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This book is compiled of 24 Chapters divided into 4 Sections. Section A focuses on toxicity of organic and inorganic insecticides, organophosphorus insecticides, toxicity of fenitrothion and permethrin, and dichlorodiphenyltrichloroethane (DDT). Section B is dedicated to vector control using insecticides, biological control of mosquito larvae by Bacillus thuringiensis, metabolism of pyrethroids by mosquito cytochrome P40 susceptibility status of Aedes aegypti, etc. Section C describes bioactive natural products from sapindacea, management of potato pests, flower thrips, mango mealy bug, pear psylla, grapes pests, small fruit production, boll weevil and tsetse fly using insecticides. Section D provides information on insecticide resistance in natural population of malaria vector, role of Anopheles gambiae P450 cytochrome, genetic toxicological profile of carbofuran and pirimicarp carbamic insecticides, etc. The subject matter in this book should attract the reader's concern to support rational decisions regarding the use of pesticides.

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