This report contains the collective views of an international group of experts and does not necessarily represent the decisions or the stated policy of the World Health Organization

WHO Technical Report Series

818

VECTOR RESISTANCE TO PESTICIDES

Fifteenth Report of the WHO Expert Committee on Vector Biology and Control



World Health Organization

Geneva 1992

WHO Library Cataloguing in Publication Data

WHO Expert Committee on Vector Biology and Control

Vector resistance to pesticides : fifteenth report of the WHO Expert Committee on Vector Biology and Control.

(WHO technical report series; 818)

1. Disease vectors 2. Insecticide resistance 1. Title 11. Series

ISBN 92 4 120818 X ISSN 0512-3054 (NLM Classification: WA 240)

© World Health Organization 1992

Publications of the World Health Organization enjoy copyright protection in accordance with the provisions of Protocol 2 of the Universal Copyright Convention. For rights of reproduction or translation of WHO publications, in part or *in toto*, application should be made to the Office of Publications, World Health Organization, Geneva, Switzerland. The World Health Organization welcomes such applications.

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Where the designation "country or area" appears in the headings of tables, it covers countries, territories, cities or areas.

The mention of specific companies or of certain manufacturers' products does not imply that they are endorsed or recommended by the World Health Organization in preference to others of a similar nature that are not mentioned. Errors and omissions excepted, the names of proprietary products are distinguished by initial capital letters.

Printed in Switzerland

Contents

1.	Introduction	1
2.	Present status of pesticide resistance	2
	Impact of pesticide resistance on the control of vectors and reservoirs of disease 3.1 African Region 3.1.1 Malaria vectors 3.1.2 Vectors of filariasis (including onchocerciasis) 3.1.3 Trypanosomiasis vectors 3.1.4 Other vectors 3.2 Region of the Americas 3.2.1 Malaria vectors 3.2.2 Dengue vectors 3.2.3 Vectors of Chagas disease 3.3 Eastern Mediterranean Region 3.3.1 Malaria vectors 3.3.2 Leishmaniasis vectors 3.3.3 Filariasis vectors 3.4.4 European Region 3.4.1 Leishmaniasis vectors 3.4.2 Malaria vectors 3.4.3 Other vectors and nuisance insects 3.5 South-East Asia Region 3.5.1 Malaria vectors 3.5.2 Arbovirus vectors 3.5.3 Filariasis vectors 3.6 Western Pacific Region 3.6.1 Malaria vectors 3.6.2 Arbovirus vectors 3.6.3 Flies	17 17 18 18 19 19 20 20 20 21 21 21 21 21 22 22 23 23 23 24 24 24
	Socioeconomic impact of resistance 4.1 Administrative implications 4.2 Operational implications 4.3 Financial implications 4.4 Social implications 4.5 Agricultural implications	24 24 25 25 26 26
	Detection and monitoring of vector resistance 5.1 Principles 5.2 Review of WHO bioassay test procedures 5.2.1 Standard methods 5.2.2 Tentative methods 5.2.3 New methods 5.2.4 Diagnostic dosages (concentrations) for monitoring vector resistance 5.2.5 Supply of test kits, testing materials and instructions 5.2.6 Recommendations	27 27 28 28 29 29 29

5	5.3	Review of biochemical tests for resistance 5.3.1 Progress in research on resistance mechanisms	31 31 32	
5	5.4	5.3.2 Available biochemical assays Molecular biological methods of detecting vector resistance	34	
s. Resistance management				
		Selection and sequence of pesticide use	36	
		Selective application of pesticides	37	
		6.2.1 Focal application	37	
		6.2.2 Seasonal application	37	
		6.2.3 Partial application of pesticides to selected resting sites	37	
		6.2.4 Partial application of pesticides to bed-nets, curtains and traps	38	
(3.3	Rotation of pesticides	38	
(6.4	Mixtures of pesticides	39	
(3.5	Use of synergists	39	
(6.6	Use of low or high dosages	40	
(6.7	0	40	
(6.6	Biopesticides	40	
1	6.9	Environmental management	41	
•	6.10	Integrated vector control	42	
		semination of information and training	43	
	7.1	Documentation and dissemination of information	43	
	7.2	Training	43	
8.	Red	commendations	44	
Acknowledgements			46	
References			47	
	nne: aar	x 1 nostic dosages (concentrations) and exposure times for use in		
		foring resistance	53	
Ar	nne	x 2	58	
M	Modified WHO forms for recording susceptibility test results			

WHO Expert Committee on Vector Biology and Control

Geneva, 5-12 March 1991

Members

- Dr R. Garms, Bernard-Nocht Institut für Schiffs- und Tropenkrankheiten, Hamburg, Germany
- Professor G.P. Georghiou, Department of Entomology, University of California, Riverside, CA, USA (*Chairman*)
- Dr J. Hemingway, Royal Society Junior Fellow, London School of Hygiene and Tropical Medicine, London, England (*Rapporteur*)
- Professor Liu Wi-teh, Head, WHO Collaborating Centre, Shanghai Institute of Entomology, Academia Sinica, Shanghai, China
- Dr M. Rodriguez, Centre for the Study of Malaria, General Directorate of Epidemiology, Secretariat of Health, Tapachula, Chiapas, Mexico
- Dr T. Shono, Associate Professor of Applied Entomology, Institute of Agriculture and Forestry, University of Tsukuba, Tsukuba, Ibaraki, Japan
- Dr S.K. Subbarao, Assistant Director, Malaria Research Centre, Indian Council of Medical Research, Delhi, India (*Vice-Chairman*)
- Dr M. Sudomo, Health Ecology Research Centre, National Institute of Health Research and Development, Jakarta, Indonesia
- Professor M. Zaim, School of Public Health and Institute of Public Health Research, University of Teheran, Teheran, Islamic Republic of Iran

Representatives of other organizations

- International Group of National Associations of Manufacturers of Agrochemical Products (GIFAP)
- Dr G. Hessa, Bayer, Leverkusen, Germany
- Mr R. Slatter, Wellcome Environmental Health, Berkhamstead, Herts., England
- Dr G. White, ICI Public Health, Haselmere, Surrey, England
- United Nations Environment Programme
- Dr G.B. Waiyaki, Programme Officer, Division of Environmental Management, Nairobi, Kenya

Secretariat

- Professor G. Davidson, London School of Hygiene and Tropical Medicine, London, England (*Temporary Adviser*)
- Dr L. Molineaux, Chief, Operational Research, Division of Control of Tropical Diseases, WHO, Geneva, Switzerland
- Dr D.A. Muir, Genolier, Switzerland (Temporary Adviser)
- Dr J.A. Najera, Director, Division of Control of Tropical Diseases, WHO, Geneva, Switzerland
- Dr M. Raymond, Institute of the Sciences of Evolution, University of Montpellier II, Montpellier, France (*Temporary Adviser*)
- Mr G.R. Shidrawi, Operational Research, Division of Control of Tropical Diseases, WHO, Geneva, Switzerland (*Secretary*)



1. Introduction

The WHO Expert Committee on Vector Biology and Control met in Geneva from 5 to 12 March 1991. Dr J.A. Najera, Director, Division of Control of Tropical Diseases, opened the meeting on behalf of the Director-General, and pointed out that the Organization was fully aware of the serious impact of pesticide resistance on vector-borne¹ diseases and had constantly sought expert assistance in the assessment of the problem and advice on its management. Since the first meeting of an Expert Committee to consider pesticide resistance in 1956, there had been nine meetings at which the evolving status of resistance, its consequences and appropriate action to counter it had been discussed.

The last time that an Expert Committee considered the problem of pesticide resistance was in 1985 (1). Since then, the numbers and geographical range of pesticide-resistant species have continued to expand. In addition to pesticide resistance, operational and managerial problems, together with environmental change and population movements, have contributed to the deteriorating trends in disease transmission. Today, over 250 million people are infected with malaria. Certain other vector-borne diseases such as dengue are also increasing in significance both geographically and in terms of the numbers of people infected.

Pesticides have been the cornerstone of the control of the vectors of tropical diseases for nearly half a century. The global malaria strategy currently proposed by WHO includes the selective application of vector-control measures. Decisions on such control must take account of different components of resistance management, particularly since sustained control rather than eradication is envisaged. The sustainability of control programmes depends heavily on the "tools" being used and the risk of resistance inherent in each of them.

The Expert Committee was therefore requested to:

- update information on the status of vector resistance to pesticides;
- evaluate current, new and tentative methodologies for detecting and monitoring resistance; and
- discuss the essential components of resistance management as they apply to programmes for the control of vector-borne diseases.

Matters of particular technical concern include recommendations on discriminating dosages for the field detection and monitoring of pesticide resistance and advice on appropriate resistance-management practices to be applied in long-term vector-control programmes.

The Committee noted that the new Division of Control of Tropical Diseases at WHO headquarters was designed to facilitate the transfer of

¹ The term "vector" is used in a broad sense and includes primary and intermediate vertebrate and invertebrate hosts and animal reservoirs of human and animal diseases.

new practical disease-control developments to Member States. This is especially important in the economic and efficient use of pesticides because of:

- the large proportion of available resources being used for pesticides in programmes for the control of vector-borne diseases; and
- the traditional role of WHO in serving as the global coordinator for information on vector resistance and on the methodology and materials (test kits) for the standardization of pesticide-resistance measurements.

2 Present status of pesticide resistance

The present status of pesticide resistance in mosquitos, other insects and arthropod vectors is presented in Tables 1-3 as in previous reports. An additional table (Table 4) on the status of resistance in rodent reservoirs of disease has also been included. No table for snail resistance to molluscicides is given as there is insufficient evidence of field resistance to warrant it. The new reports of resistance added to Tables 1-3 are based either on data on the results of discriminating-dosage bioassays transmitted to WHO, or on reports in published papers. All four tables list the species that have shown some evidence of resistance to particular groups of chemicals in one or more populations in the countries specified. The data should not be taken as reflecting the all-encompassing worldwide, or even country-wide, occurrence of insecticide resistance since, in many countries, surveys and tests of resistance have not been carried out for several species of public health importance or only a few compounds have been investigated (2).

The operational criterion of resistance has usually been taken as the survival of 20% or more of individuals tested at the currently known diagnostic concentrations of commonly available pesticides, using WHO test kits in the field. However, the tables also include records of resistance determined in laboratory populations (established from field populations) on which many other pesticides have been tested. Resistance is defined as an inherited characteristic that imparts an increased tolerance to a pesticide, or group of pesticides, such that the resistant individuals survive a concentration of the compound(s) that would normally be lethal to the species. On the basis of this definition, the proportion of survivors (heterozygotes in the first place, but including homozygotes as selection progresses) can be looked upon as reflecting the frequency of the gene or genes that code for particular resistance mechanisms and thus confer resistance.

The inclusion of species and countries in the lists does not imply that:

• A certain type of resistance in a given species is at an operationally



CONTRACT