Mike Coleman and Janet Hemingway

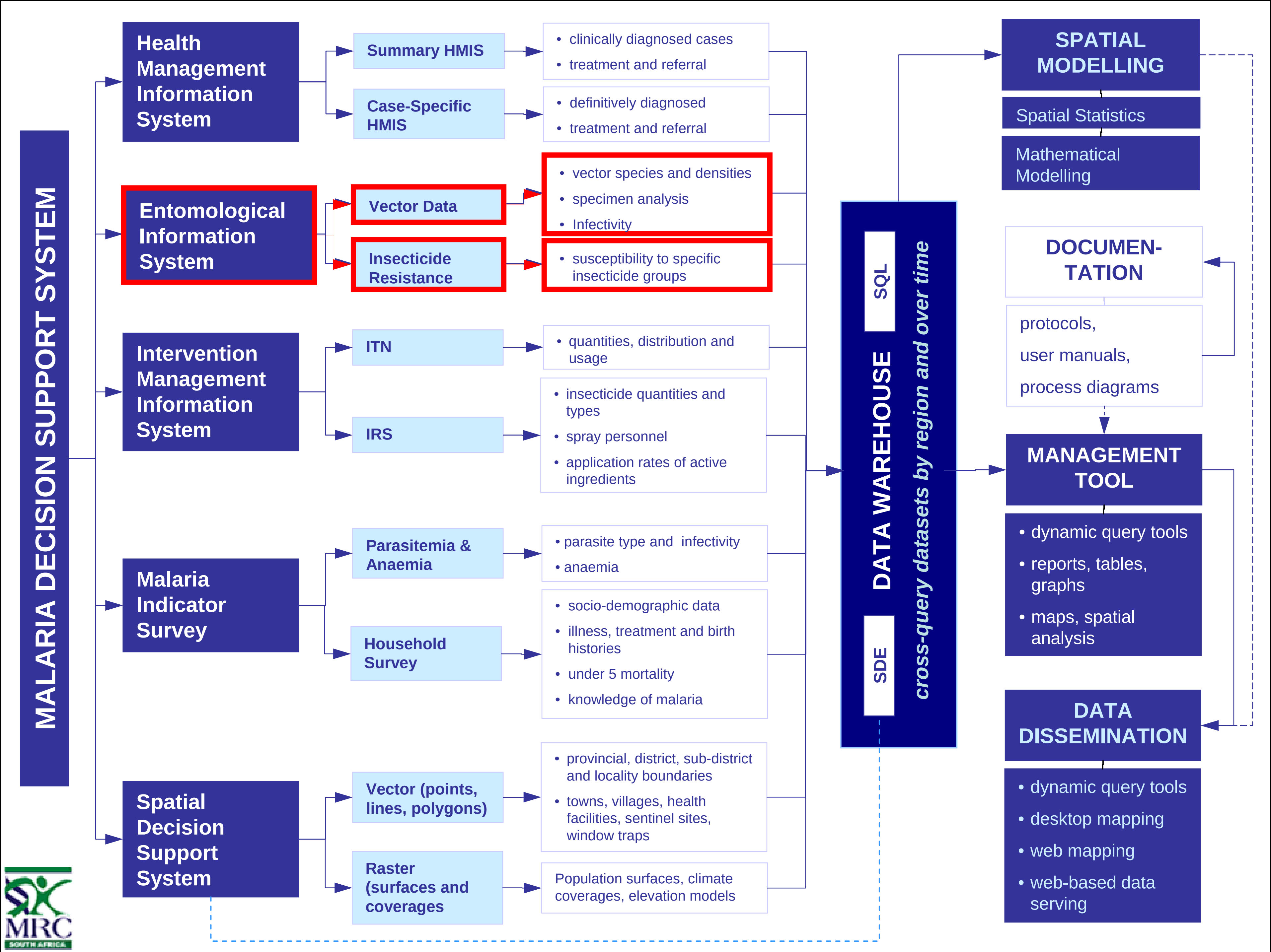
Malaria Decision Support Systems: Entomology

MDSS defined

Vector control is difficult – we all know that –DSS make it easier.

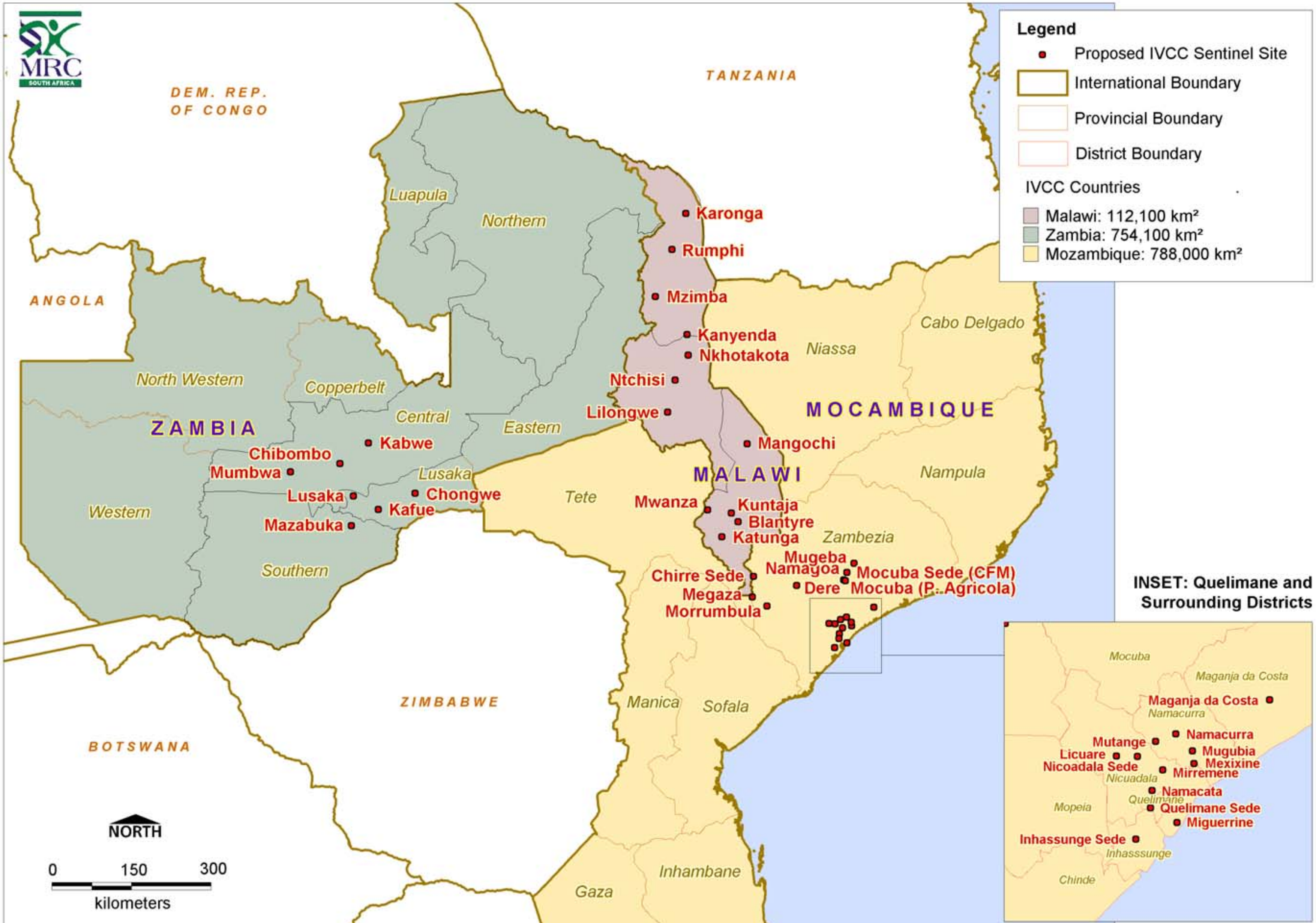
Not that running an DSS is easy.

This is,
Quality control
Informed decisions
Informed policy



MALARIA DECISION SUPPORT SYSTEM
Health Management Information System
Summary HMIS
clinically diagnosed cases
treatment and referral
Case-Specific HMIS
definitively diagnosed
treatment and referral
Entomological Information System
Vector Data
vector species and densities
specimen analysis
Infectivity
Insecticide Resistance
susceptibility to specific insecticide groups
Intervention Management Information System
ITN
quantities, distribution and usage
IRS
insecticide quantities and types
spray personnel
application rates of active ingredients
Malaria Indicator Survey
Parasitemia & Anaemia
parasite type and infectivity
anaemia
Household Survey
socio-demographic data
illness, treatment and birth histories
under 5 mortality
knowledge of malaria
Spatial Decision Support System
Vector (points, lines, polygons)
provincial, district, sub-district and locality boundaries
towns, villages, health facilities, sentinel sites, window traps
Raster (surfaces and coverages)
Population surfaces, climate coverages, elevation models
SQL
DATA WAREHOUSE
SDE
cross-query datasets by region and over time
SPATIAL MODELLING
Spatial Statistics
Mathematical Modelling
DOCUMEN-TATION
protocols,
user manuals,
process diagrams
MANAGEMENT TOOL
dynamic query tools
reports, tables, graphs
maps, spatial analysis
DATA DISSEMINATION
dynamic query tools
desktop mapping
web mapping
web-based data serving
MRC
SOUTH AFRICA

Study area



Legend
Proposed IVCC Sentinel Site
International Boundary
Provincial Boundary
District Boundary
IVCC Countries
Malawi: 112,100 km²
Zambia: 754,100 km²
Mozambique: 788,000 km²
DEM. REP. OF CONGO
TANZANIA
ANGOLA
ZAMBIA
MALAWI
MOCAMBIQUE
ZIMBABWE
BOTSWANA
Luapula
Northern
North Western
Copperbelt
Central
Eastern
Lusaka
Western
Southern
Karonga
Rumphi
Mzimba
Kanyenda
Nkhotakota
Ntchisi
Lilongwe
Mangochi
Mwanza
Kuntaja
Blantyre
Katunga
Kabwe
Chibombo
Mumbwa
Lusaka
Chongwe
Kafue
Mazabuka
Niassa
Cabo Delgado
Nampula
Tete
Zambezia
Mugeba
Namagoa
Mocuba Sede (CFM)
Dere
Mocuba (P. Agricola)
Chirre Sede
Megaza
Morrumbula
Manica
Sofala
Inhambane
Gaza
NORTH
0 150 300
kilometers
INSET: Quelimane and Surrounding Districts
Mocuba
Maganja da Costa
Maganja da Costa
Namacurra
Namacurra
Mutange
Mugubia
Licuare
Mexixine
Nicoadala Sede
Mirremene
Nicuadala
Namacata
Quelimane
Quelimane Sede
Mopeia
Miguerrine
Inhassunge Sede
Inhasssunge
Chinde

Insecticide resistance

The emergence of Anopheles species resistant to insecticides widely used in vector control has the potential to impact severely on the control of these disease vectors. This may have a dramatic effect in Africa, as few affordable alternative insecticides are available for vector control. The extensive use and misuse of insecticides for agriculture and vector control has contributed to this problem.

Monitoring resistance

Collection Blood fed females from houses.

F1 generation reared.

Species identification.

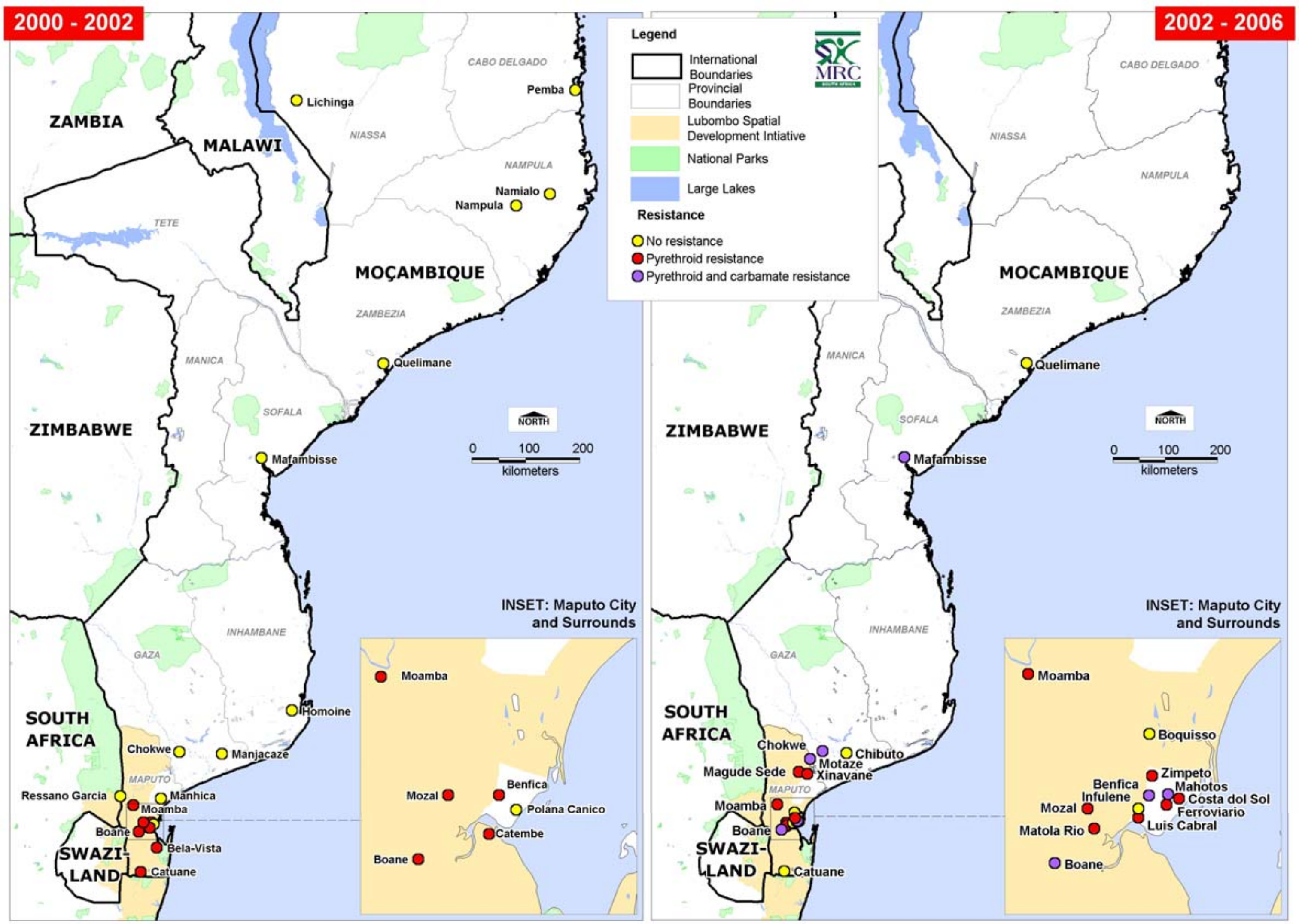
WHO susceptibility assay.

Biochemical and molecular assays.

Management / policy change

Coleman and Hemingway (2007) Pest. Sci. Insecticide resistance monitoring and evaluation in disease transmitting mosquitoes.

Mozambique an example



Casimiro S, Coleman M, Mohloai P, Hemingway J and Sharp B. Insecticide resistance in *Anopheles funestus* (Diptera: Culicidae) from Mozambique. J Med Entomol. 2006 43(2):267-75

Impact of insecticide resistance.

Short history of insecticide choice in southern Mozambique

1946 - 1988 DDT
1993 - lambda cyhalothrin became insecticide of choice
2000 – LSDI baseline carried out and pyrethroid resistance found
2000 – Bendiocarb become the insecticide choice
2000 – low level of bendiocarb resistance had been detected
2003 – Bendiocarb resistance spreading
2006 – DDT reintroduced

Resistance mechanisms

Metabolic: Most common mechanism. Insect relies on already existing detoxification pathways to overcome insecticide.

Target site: Insecticides generally act at a specific site, typically in the nervous system. The site of action may alter so that insects are not or less affected.

Reduced penetration: Modifications of the insect cuticle or stomach lining slowing or preventing absorption.

Behavioral changes: Modification in insect behavior, resulting in avoidance of insecticide.

Resistance mechanisms

	OP	Car	Pyr	DDT	Cyc	Fib
Change in target site sensitivity						
Acetylcholinesterase	√	√√				
Sodium Channels			√ √	√ √		
GABA receptors					√√	√
Changes in metabolism						
Glutathione *S*-transferase			√	√ √		
Monooxygenase		√	√ √	√		
Esterase	√ √	√	√			

Vector control

Vector control is a key component of a malaria control program.

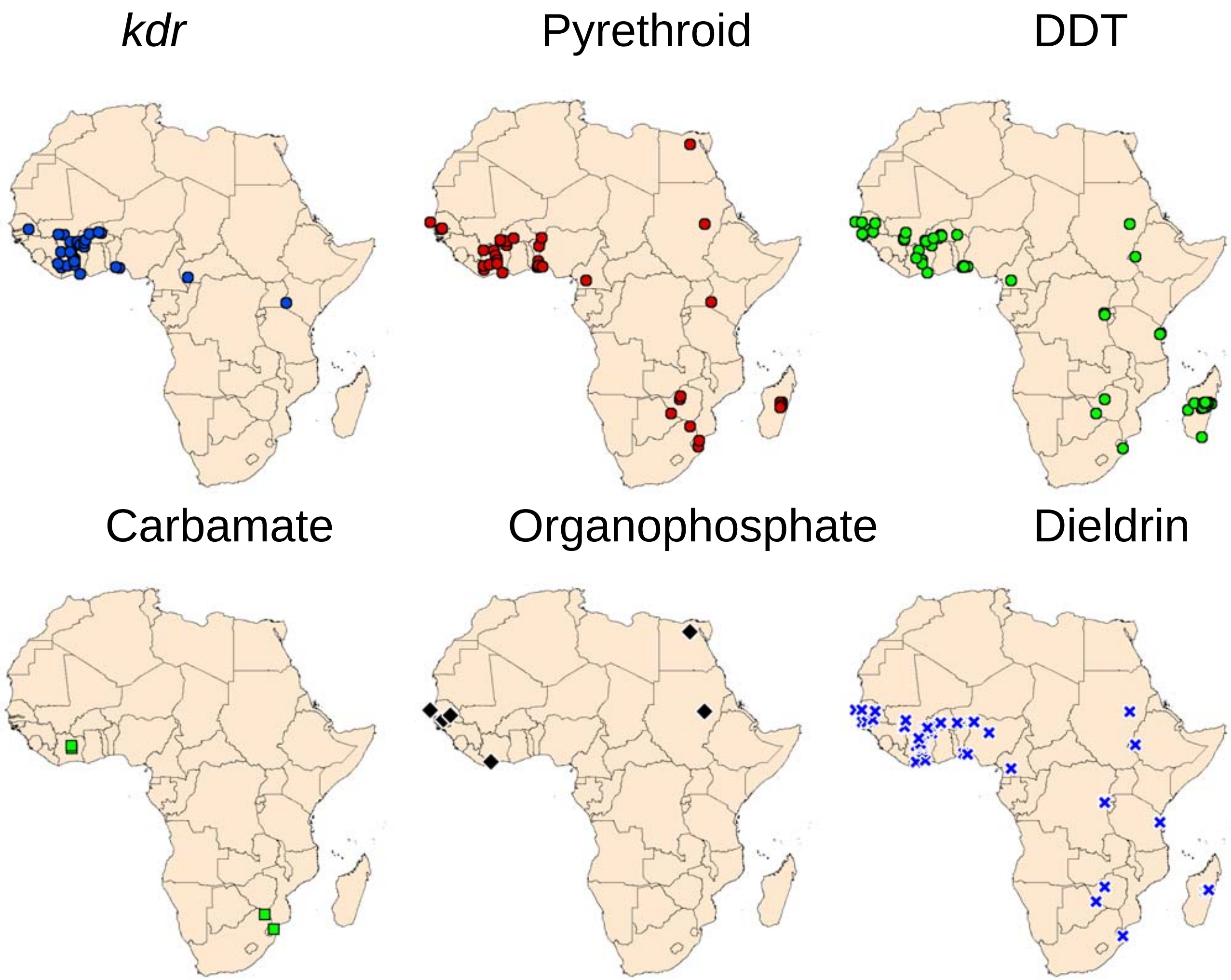
Insecticides play a crucial role as through, IRS, ITNs and larvacides.

Insecticides are made up from a small group of compounds with discreet mode of action. Some of these groups share similar modes of action that allows for cross resistance.

Cross resistance explains why some populations can rapidly develop resistance to a new insecticide.

Resistance can also develop due to historical exposure.

Resistance in Africa 1950 to 2006



Coleman M, Sharp B, Seocharan I, Hemingway J. Developing an evidence based decision support system for rational insecticide choice to control African malaria vectors. 2006 J. Med. Ent.

Insecticide resistance database.

There are several databases developed in the area of entomology, AnoBase, Vectorbase, **ANVR (WHO)** and **MRC.**

Partners met in Durban, to look at possibilities of combining insecticide resistance data sets.

A way forward has been proposed that would result in a single format of databases allowing anyone to access and combine all data.

WHO and the MRC agreed to the concept of single data base.

Ontology and Schema.

Outputs: Ontology, Schema, joint insecticide resistance database with WHO.

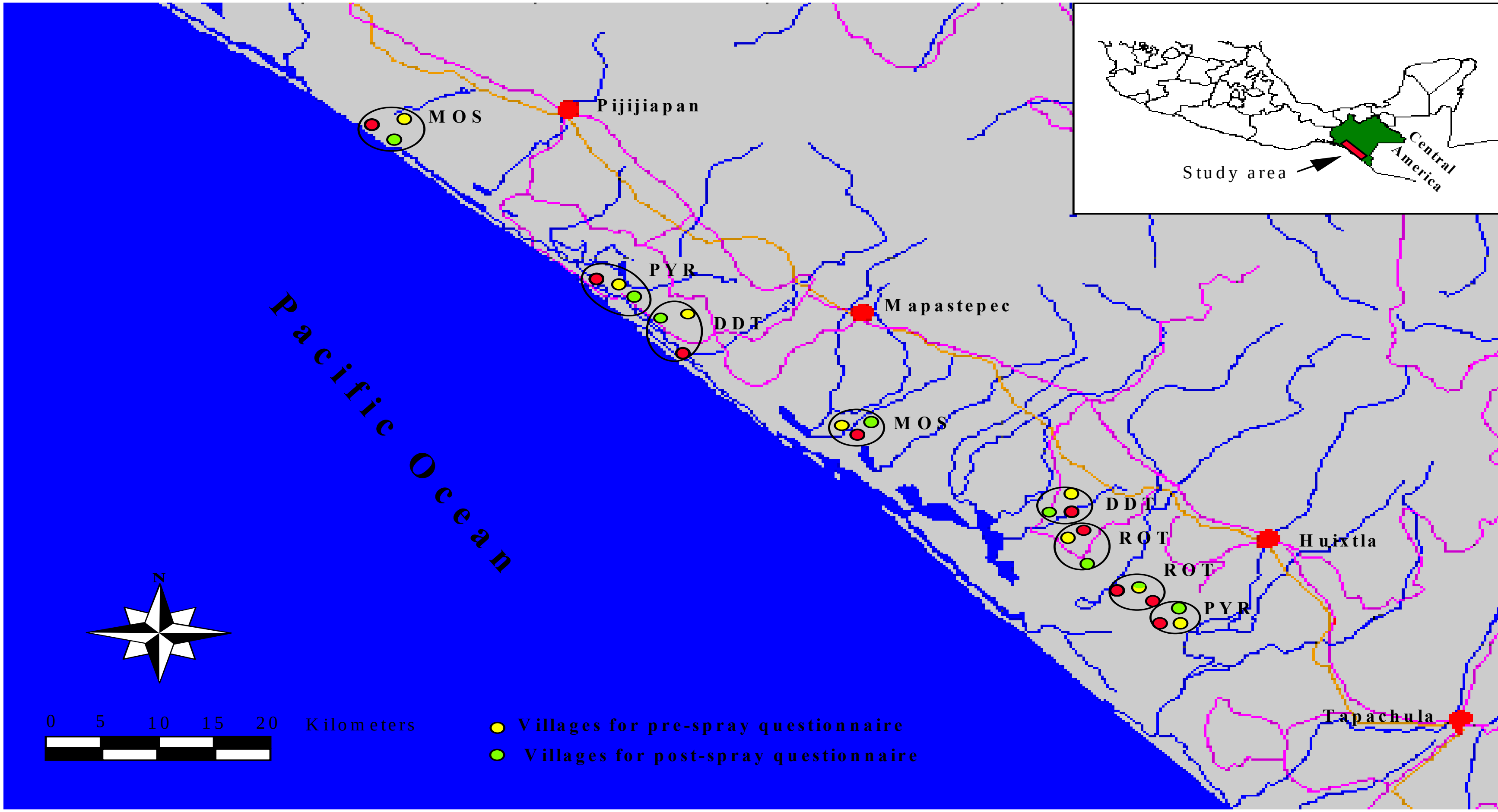
Resistance management in Mexican Anopheles; a large scale field trial.

Hemingway, J., R. P. Penilla, A. D. Rodriguez, B. M. James, W. Edge, H. Rogers, and M. H. Rodrigez 1997. Resistance management strategies in malaria vector mosquito control. A large-scale field trial in Southern Mexico. Pestic Sci 51:375-382.

Penilla RP, Rodriguez AD, Hemingway J, Torres JL, Arredondo-Jimenez JI, Rodriguez MH. Resistance management strategies in malaria vector mosquito control. Baseline data for a large-scale field trial against Anopheles albimanus in Mexico.Med Vet Entomol. 1998 Jul;12(3):217-33.

Sponsored by the Insecticide Resistance Action Committee (IRAC; Public Health Section), with further contributions from Agrevo, Bayer, Cheminova, FMC, Mitsui Toatsu, Rhône Poulenc, Sumitomo and Zeneca**.**

Parasites and vectors in Mexico



Selection Insecticide resistance

Combined agricultural and public health use of DDT resulted in widespread DDT -R in the 1970s

OP, carbamate and pyrethroid-R were selected in the late 1970s by agricultural insecticides in many areas.

Experimental design

	Year 1	Year 2	Year 3	
Traditional	A	A	A	Single insecticide
Rotation	A	B	C	Unrelated insecticides
Mosaic	A B A B A B A B A	A B A B A B A B A	A B A B A B A B A	Two unrelated insecticides

MRC SOUTH AFRICA

Mortality of *An. albimanus* to WHO diagnostic adult doses of insecticide

		Mortality (%)			
Insecticide	**Concentration (%)**	**1982**	**1983**	**1990**	**1997**
DDT	4	38	39	47	40
Malathion	5	84	93	99	100
Fenitrothion	1	44	57	99	100
Fenthion	2.5	97	100		99
Chlorphoxim	4	98	99	100	100
Propoxur	0.1	89	95		100
Deltamethrin	0.025	64	57	86	99
Cypermethrin	0.1		82		100
Bendiocarb	0.1		87		100
Pirimiphos methyl	4		99		100

Resistance seen by bioassay is an under estimate of actual R gene frequencies

E.g. 100% mortality with 0.1% propoxur, but 8% of the same population carried an altered acetylcholinesterase resistance gene.

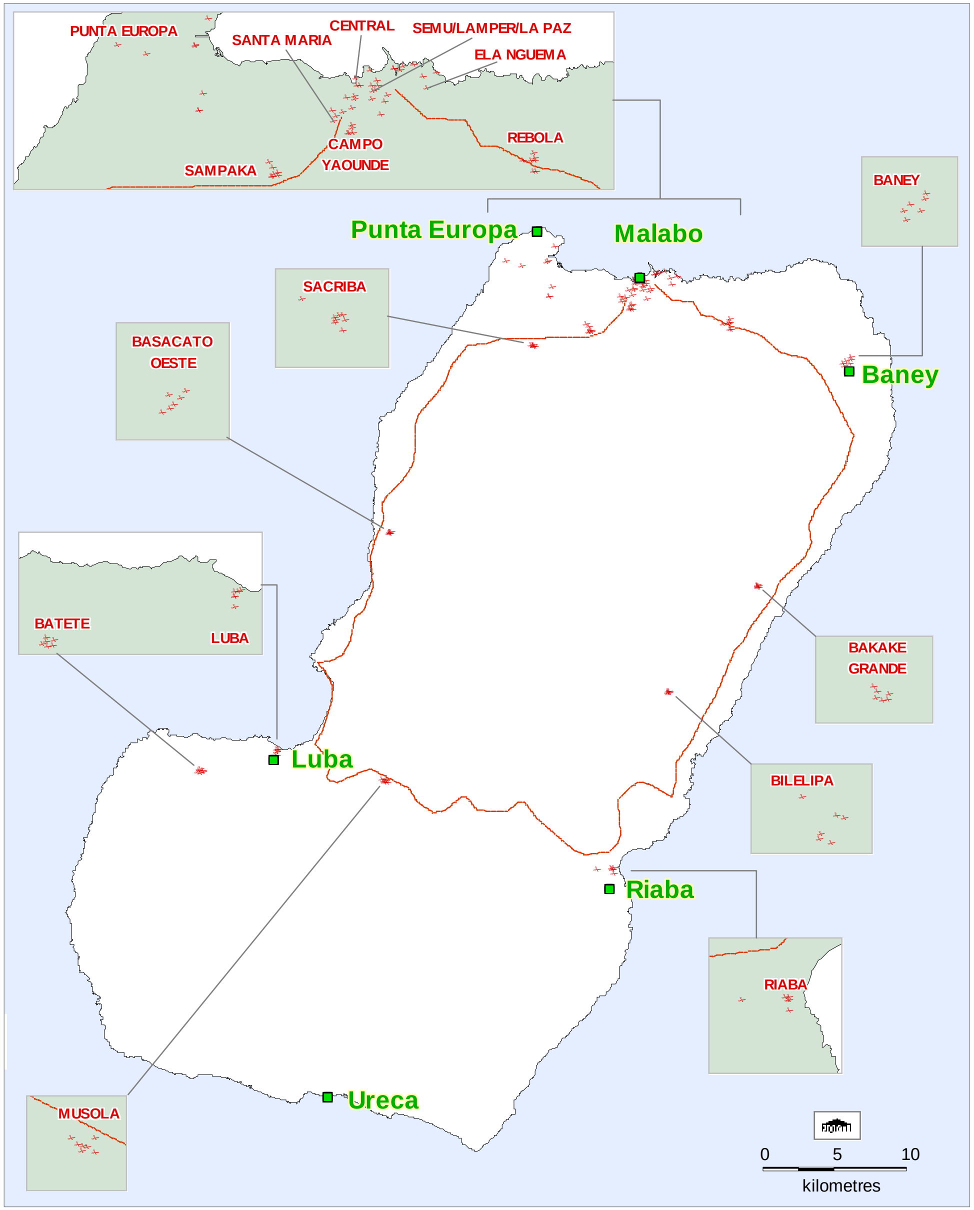
The type of resistance mechanism selected is very important in determining what effect the resistance will have on the efficacy of insecticide treatment.

Summary

Removal of the relevant insecticide selection pressure sees a reduction in the resistant gene frequency in the mosquito population.

However the impact on malaria and infectivity was not measured as there is very low malaria risk in the region.

Entomological Monitoring, Bioko



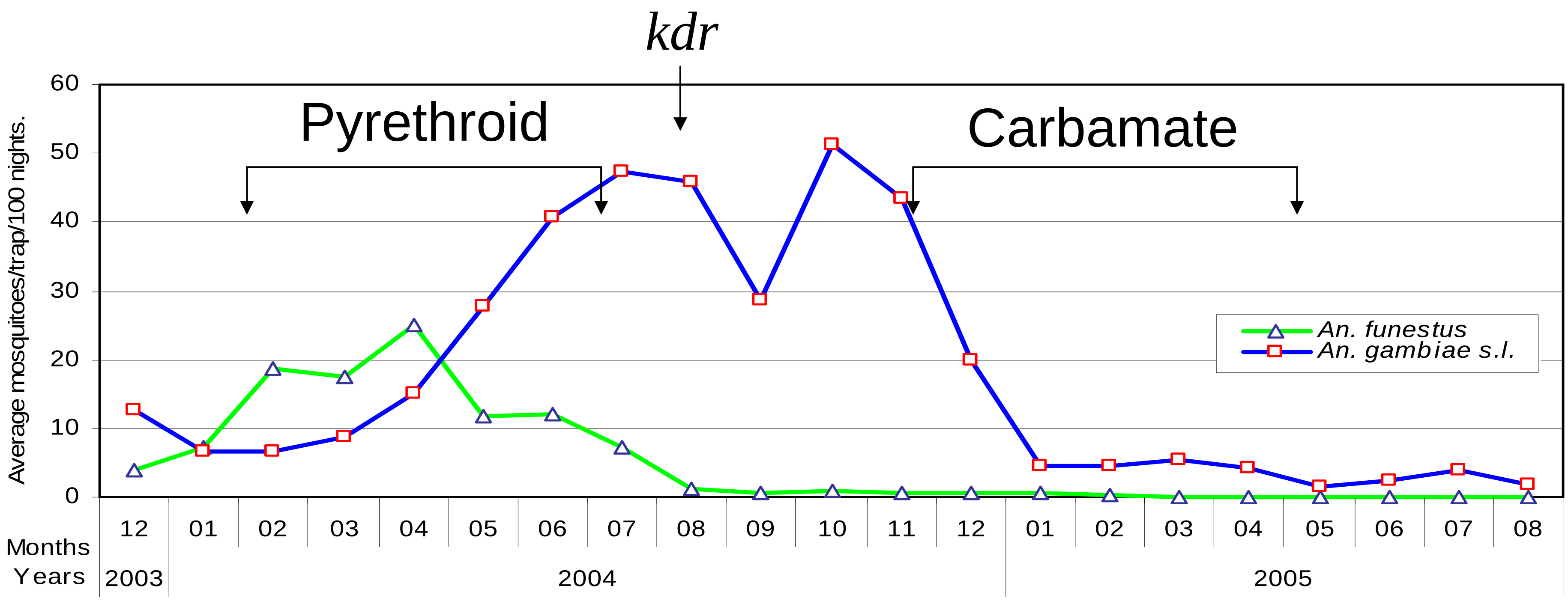
- Window traps fitted to 6 houses at each of 16 sentinel sites in December 2003

- Collections done on a daily basis by the homeowner

Sharp BL, Ridl FC, Govender D, Kuklinski J, Kleinschmidt I. Malaria vector control by indoor residual insecticide spraying on the tropical island of Bioko, Equatorial Guinea. Malar J. 2007 May 2;6:52

Species density - Bioko

Temporal information on changes in species composition.

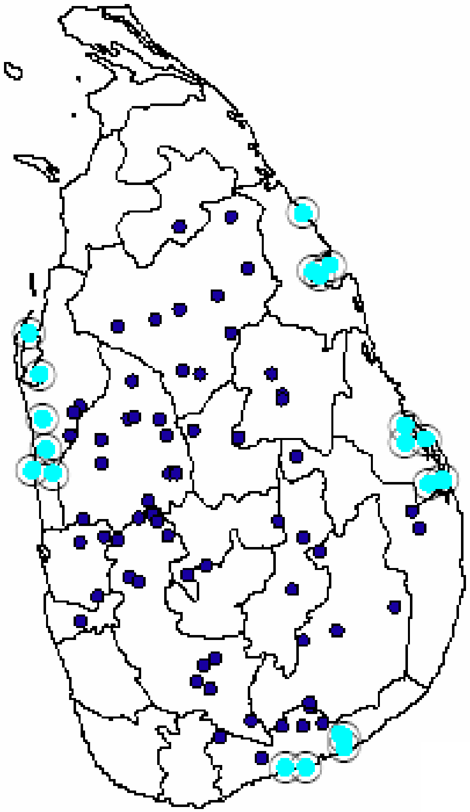


Sporozoite Rates

	An. gambiae s.s.	*An. melas*	*An. funestus*
Pre spray	6.0 (n=581)	8.3 (n=133)	4.0 (n=372)
Post spray 1	1.8 (n=790)	3.1 (n=32)	2.3 (n=215)

Resistance in sub-species – Sri-Lanka

An. subpictus - coastal v's inland locations



	Coastal (10km)	Inland
1991	86.7%	57.9%
	100%	61.4%
	97.5%	
1992	95.5%	68.4%
	100%	7.5%
	100%	75.0%
	100%	14.3%
	100%	
1995	100%	41.0%
	100%	
	100%	
1996	100%	92.7%
	100%	
	64.7%	
1997		2.3%
2000	50.7%	
	55.3%	
2001	80.0%	
2003	100%	
	100%	

An. subpictus – four sibling species in Sri Lanka.

A, C & D – Inland
B – Costal, brackish water breeder and shown to be very susceptible to insecticides.

Kelly-Hope *et al* Spatiotemporal distribution of insecticide resistance in *Anopheles culicifacies* and *Anopheles subpictus* in Sri Lanka 2005 Trans R Soc Trop Med Hyg *;99(10):751-61.*

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