

Risk areas for vector resistance to agricultural insecticides in Thailand and insecticide susceptibility in vectors

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Contents

- Vector-borne disease and agriculture
- Integrated Pest and Vector Management
- Mapping of insecticide resistance due to agrochemicals in Thailand
- Insecticide resistance in disease vectors
- Conclusion



Vector borne disease and agriculture

● Cropping systems / Crop selection

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● Agricultural management practices

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● Agricultural pest control

- Yadouleton et al 2009. Vegetable farming and emergence of insecticide resistance, Benin. Malar J. 14.
- Chouaïbou et al. 2008. Insecticide resistance in *Anopheles gambiae* s.l. and cotton cultivation, Cameroon. Trop Med Int Health. 2008 Apr;13.
- Overgaard et al. 2005. Mosquito resistance in fruit orchards, Thailand. Southeast Asian J Trop Med Public Hyg. 36.

IPM and IVM

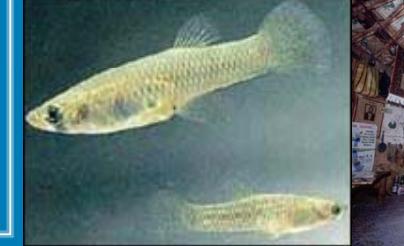
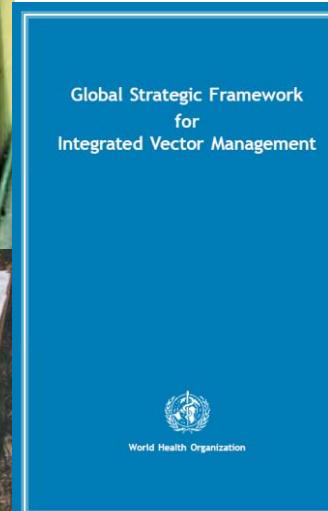
Integrated Pest Management

- Integrating control methods
Biological, mechanical, cultural, genetic, chemical
- Principles of IPM:
 1. Grow a healthy crop
 2. Conserve natural enemies
 3. Observe crops regularly
 4. Farmers become experts
- Farmer Field Schools
- Link to farmer occupation + economic incentive

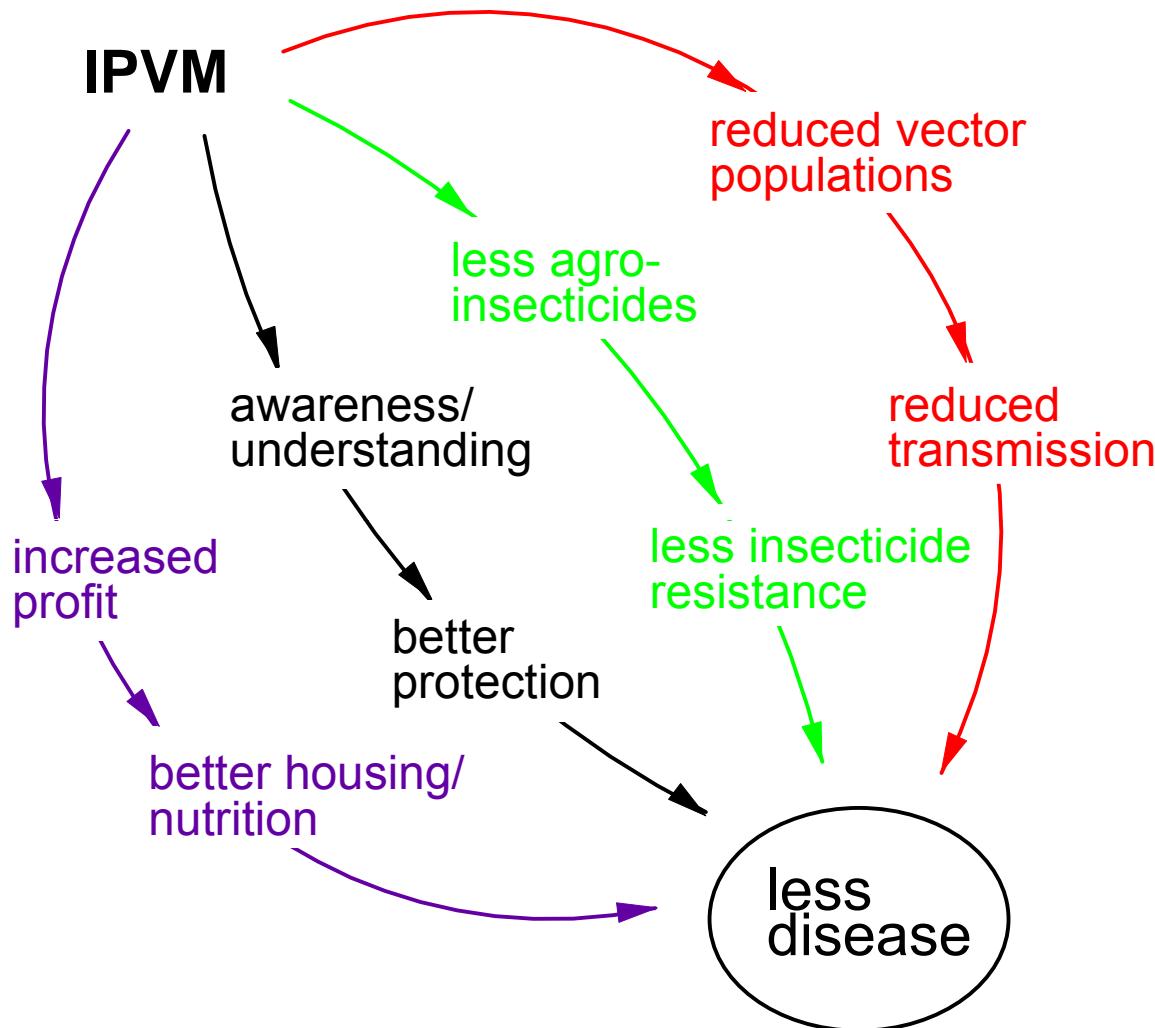


Integrated Vector Management

- Integrating control methods
Methods based on local vector biology, disease transmission, morbidity
- Intersectoral collaboration
- Engage local communities & public health framework
- No link to farmer occupation +
No economic incentive



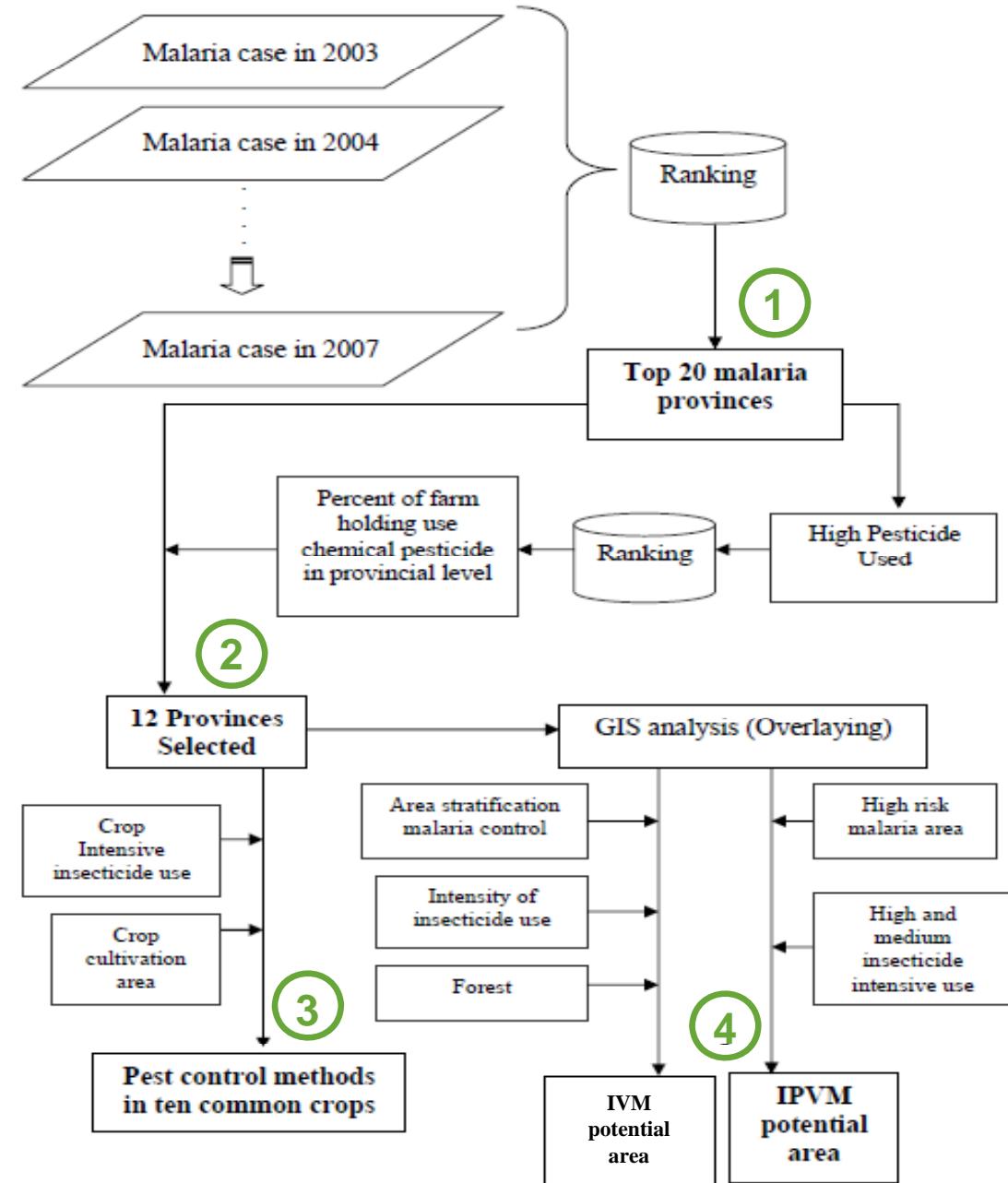
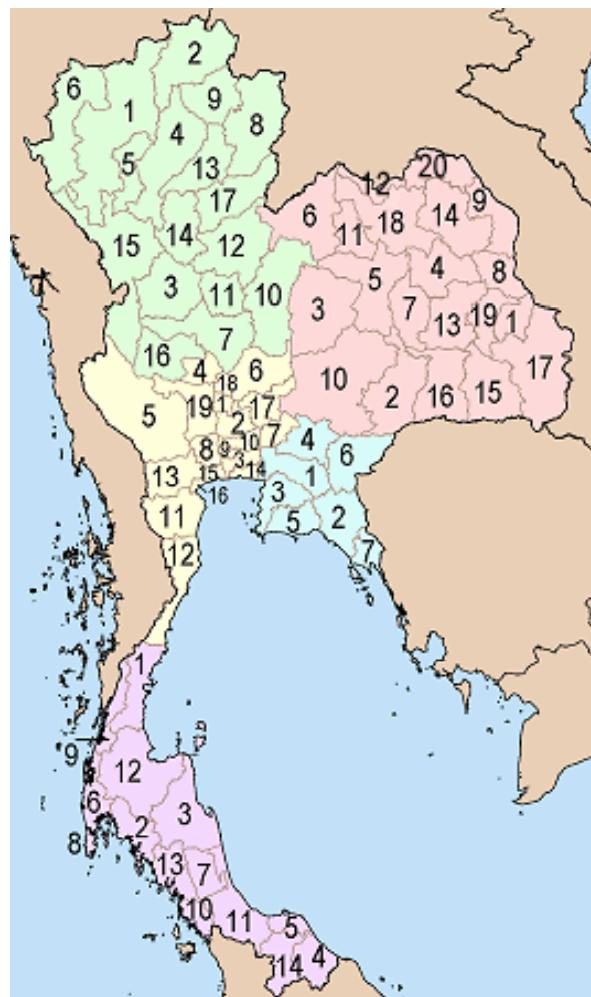
Combining IPM and IVM



Work steps of this study

1. Select provinces with high malaria transmission
2. Select provinces with high pesticide use
3. Screen pesticide-intensive crop types
4. Develop maps showing vector insecticide resistance due to agrochemicals and potential areas for IPVM
5. Test insecticide susceptibility in mosquito vectors

Step 1. Provinces with high malaria transmission

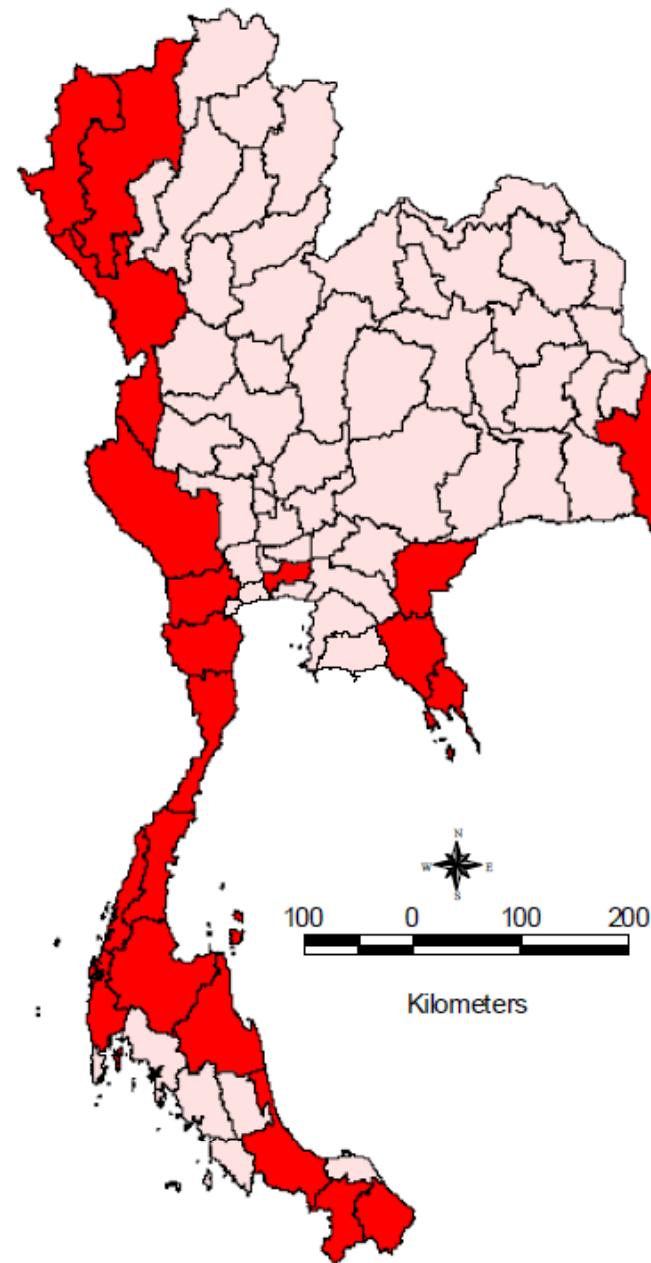


Top 20 malaria provinces

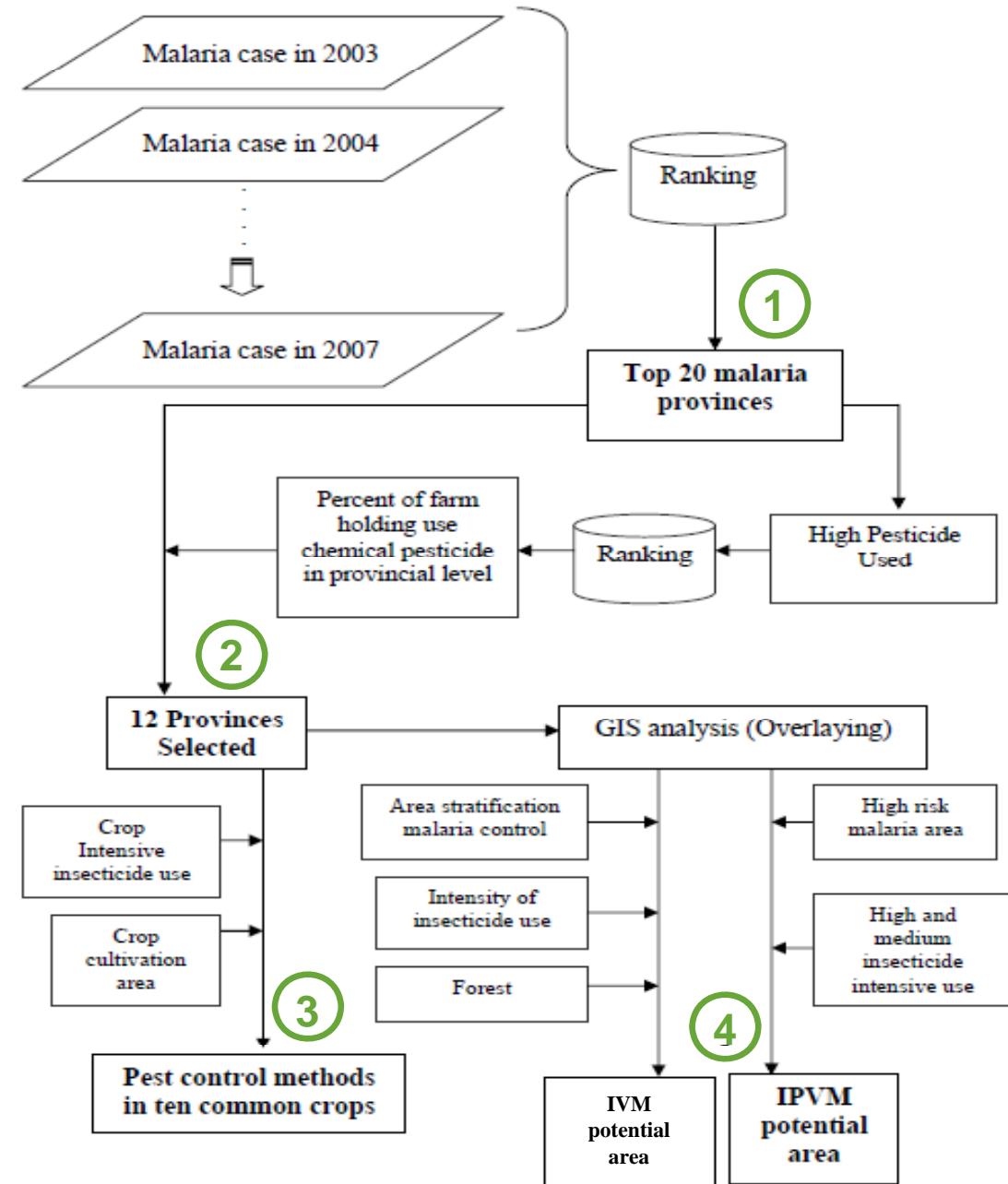
Provinces	2003	2004	2005	2006	2007	Sum	Mean
Yala	1,498	1,655	3,777	3,247	6,416	16,593	3,319
Tak	3,018	2,132	3,315	4,299	2,474	15,238	3,048
Kanchanaburi	1,327	3,417	2,645	2,452	1,957	11,798	2,360
Maehongson	1,492	2,033	2,640	3,161	1,977	11,303	2,261
Ranong	704	1,436	2,237	2,988	2,932	10,297	2,059
Prachuapkhirikhan	899	1,236	1,459	905	1,092	5,591	1,118
Chumphon	839	1,103	1,217	1,038	1,171	5,368	1,074
Songkhla	151	54	194	1,350	3,581	5,330	1,066
Narathiwat	89	226	1,574	1,562	1,352	4,803	961
Suratthani	815	931	1,816	329	642	4,533	907
Chanthaburi	1,345	915	388	1,313	530	4,491	898
Ratchaburi	409	1,034	810	299	347	2,899	580
Phangnga	403	718	803	370	471	2,765	553
Chiangmai	469	906	630	363	168	2,536	507
Trat	462	574	286	844	355	2,521	504
Ubonratchathani	715	587	206	506	429	2,443	489
Phetchaburi	320	659	376	389	260	2,004	401
Nakhonsithammarat	573	420	454	230	299	1,976	395
Bangkok	155	528	708	299	63	1,753	351
Sakaeo	469	299	142	251	224	1,385	277

Source: DDC, 2007.

Top 20 malaria provinces

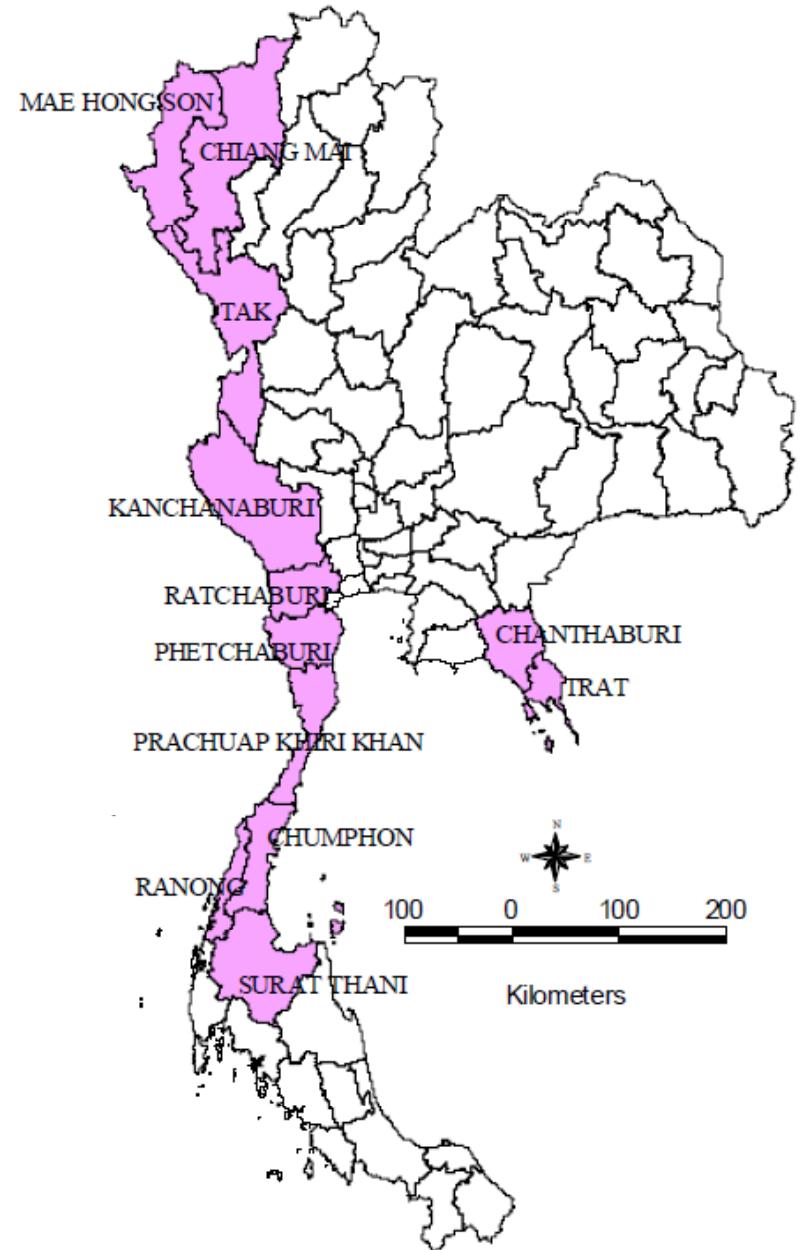


Step 2. Provinces with high pesticide use

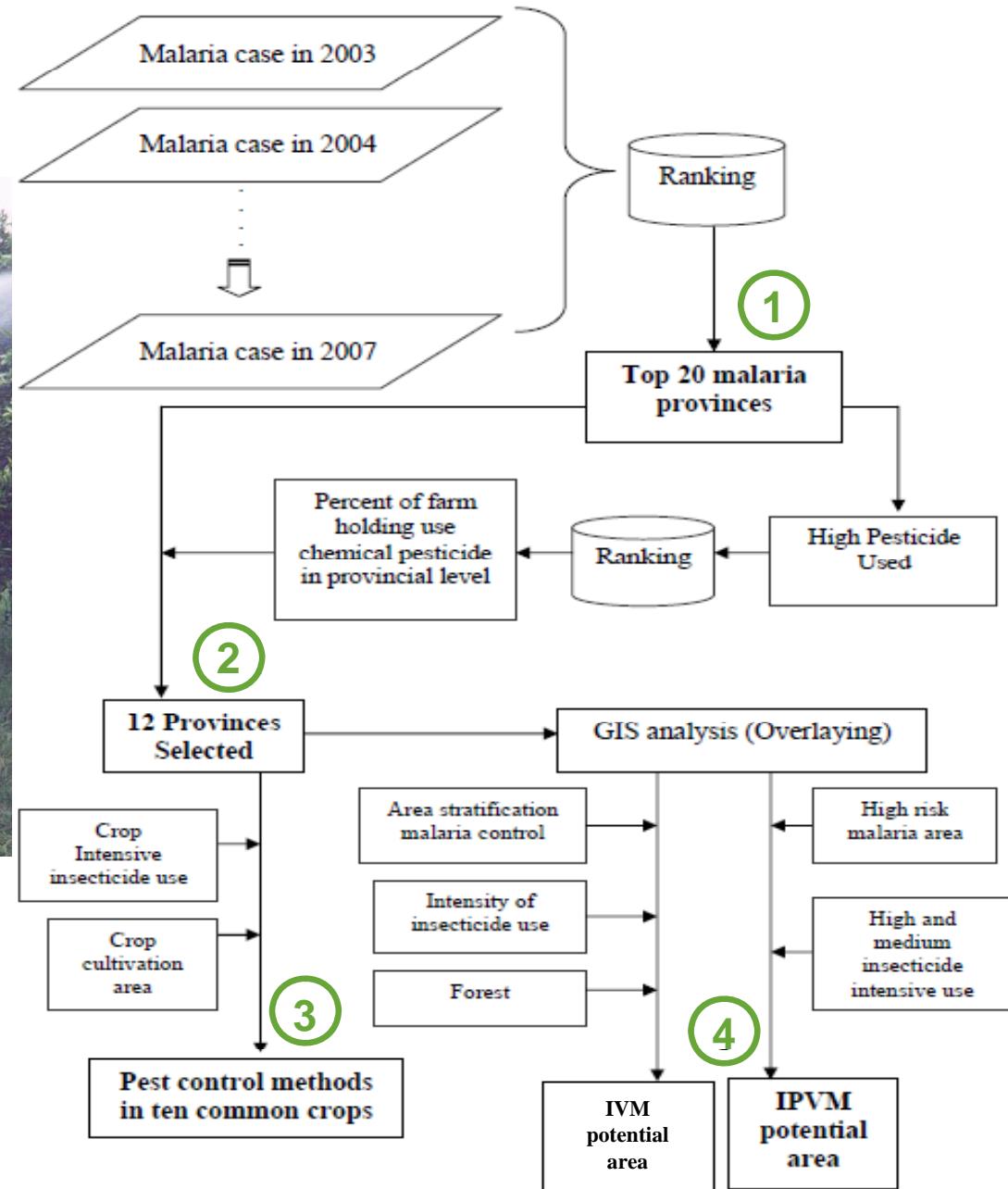


12 selected provinces

- Selection based on number of pesticide-using land holders in top 20 malaria provinces



Step 3. Screening of pesticide-intensive crops

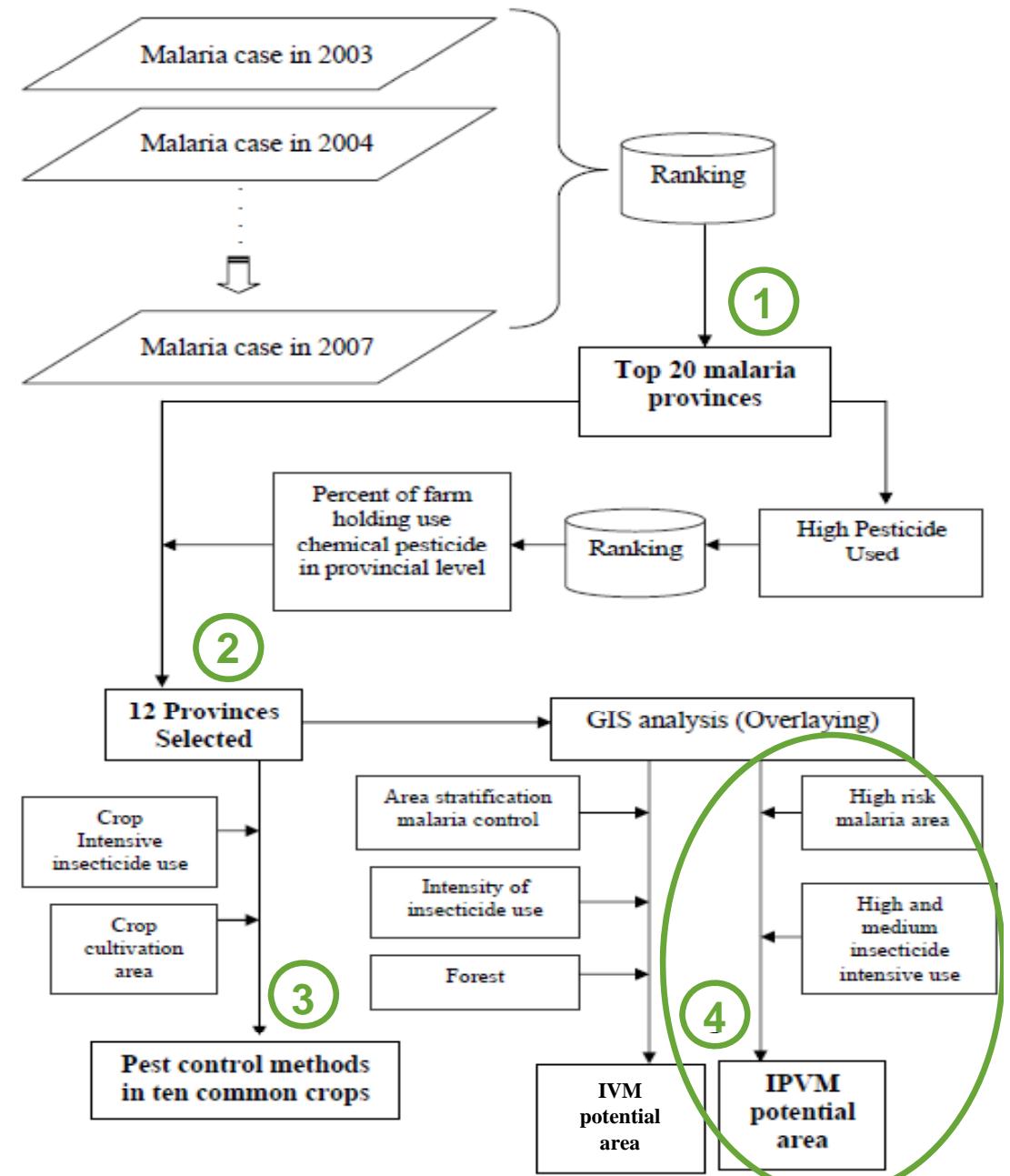
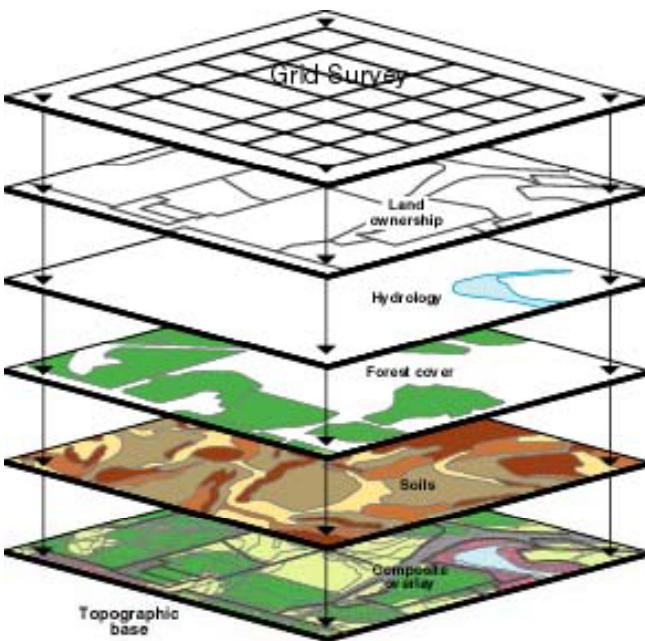


Planted area and farm value

Plant	Planted area (hectares)	Farm value (million baht)
1. Paddy	10,737.44	196,775
2. Rubber	2,294.72	205,013
3. Cassava	1,196.64	29,581
4. Maize	973.12	20,143
5. Sugarcane	965.28	32,789
6. Oil Palm	379.84	14,915
7. Coconut	225.76	7,230
8. Longan	161.28	5,285
9. Soybean	147.04	2,431
10. Vegetable(all)	100.64	n.d.
11. Pineapple	100.64	6,365
12. Durian	126.88	9,359
13. Rambutan	Mango	5,648
14. Pepper	Tangerine	896
15. Orchid		n.d.

Remark: n.d.= no data

Source: OAE, 2006



Step 4a. Stratification of malaria areas

A. Control area with transmission

1. Perennial transmission areas: transmission occurs >6 months per year
2. Periodic transmission areas: transmission occurs <6 months per year

B. Control area without transmission

1. High-risk non-transmission areas: no transmission for at least 3 years, primary malaria vectors present
2. Low-risk non-transmission areas: no transmission for at least 3 consecutive years; only suspected vectors present

C. Pre-integration areas (PA)

D. Integration areas (IA)

4b. Classification of insecticide-intensive land uses

Land use name (assigned code)	Insecticide Use ¹ Kg/rai ⁴	Insecticide market share ²		Insecticide use Class ³ 1-5 scale	Classification Insecticide Use from Overgaard		New classification Insecticide Use	
		baht/rai ⁴	relative to rice		1-4 scale	Name	1-4 scale	Name
Grapes (n. p.)	24.63	4,800.00	377.66	4.00	-	-	4	High
Citrus/Tangerine (incl. in 13)	4.92	1,023.39	80.52	2.00	-	-	4	High
Mango (incl. in 13)	0.27	133.06	10.47	2.00	-	-	4	High
Durian (incl. in 13)	0.73	135.66	10.67	n. d.	-	-	4	High
Fruit orchard (13)	1.973	n. d.	n. d.	2.00	4	High	4	High
Chili, pepper (incl. in 7)	1.18	n. d.	n. d.	4.00	-	-	4	High
Onion, garlic (incl. in 7)	0.77	n. d.	n. d.	n. d.	-	-	4	High
Vegetables (7)	4.73	n. d.	n. d.	5.00	4	High	4	High
Floriculture (10)	n. d.	n. d.	n. d.	4.00	4	High	4	High
Cotton	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.	4	High
Soybean (incl. in 2)	0.12	n. d.	n. d.	3.67	-	-	3	Medium
Peanut (incl. in 2)	0.098	n. d.	n. d.	3.67	-	-	3	Medium
Green beans (n. p.)	0.04	n. d.	n. d.	n. d.	-	-	3	Medium
Legumes (2)	0.086	27.95	2.20	n. d.	3	Medium	3	Medium
Paddy rice (1)	0.14	12.71	1.00	4.67	3	Medium	3	Medium
Tobacco	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.	2	low
Kenaf	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.	2	Low
Maize (incl. in 3)	0.011	0.58	0.05	3.33	-	-	2	Low
Cereals (3)	n. d.	n. d.	n. d.	n. d.	2	Low	2	Low
Mixed crops (8)	n. d.	n. d.	n. d.	n. d.	2	Low	2	Low
Tea (9)	n. d.	n. d.	n. d.	n. d.	2	Low	2	Low
Pineapple (6)	n. d.	9.6	0.76	2.00	2	Low	2	Low

Overgaard, H.J. 2006. Malaria mosquito resistance to agricultural insecticides: Risk area mapping in Thailand. Colombo, Sri Lanka: IWM Research Report 103.

GIS overlay

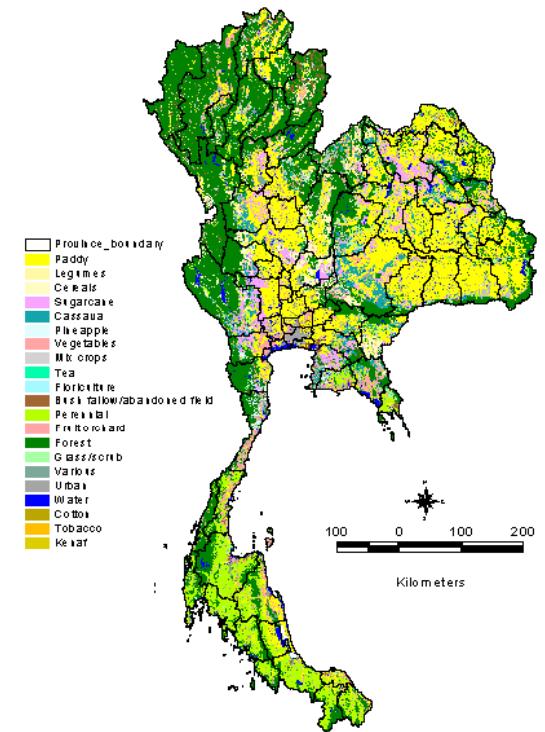
Malaria transmission areas

A1 and A2

Insecticide-intensive land uses

High and Medium

- Risk areas for vector insecticide resistance due to agrochemicals
- Potential area for implementing IPVM



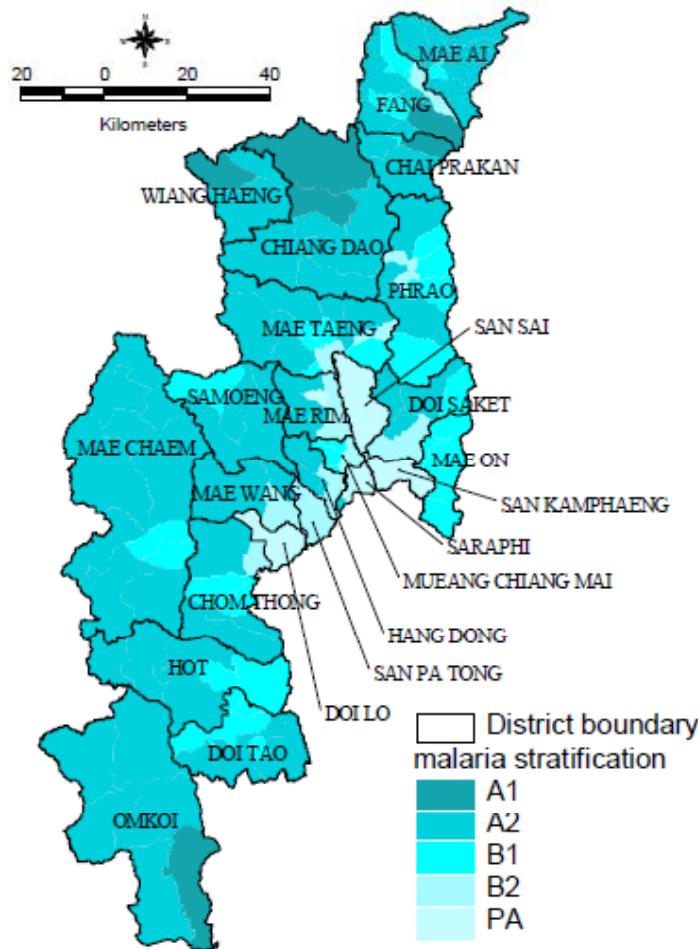
Land use map

Results from GIS overlay

Province	Province area	IPVM potential area	
		ha	%
Chanthaburi (F)	635,091	121,673	19.1
Prachuab khirikhan (G)	642,416	77,764	13.0
Chumphon (H)	598,243	81,254	12.6
Trat (I)	286,409	24,184	8.4
Ranong (J)	314,001	26,451	8.4
Chiangmai (K)	2,202,781	127,339	5.7
Maehongson (L)	1,272,529	44,046	3.4
Phetchaburi (M)	615,439	16,217	2.6
Ratchaburi (N)	517,834	13,448	2.6
Tak (O)	1,726,865	38,373	2.2
Suratani (P)	1,312,804	24,653	1.8
Kanchanaburi (Q)	1,940,760	19,694	1.0

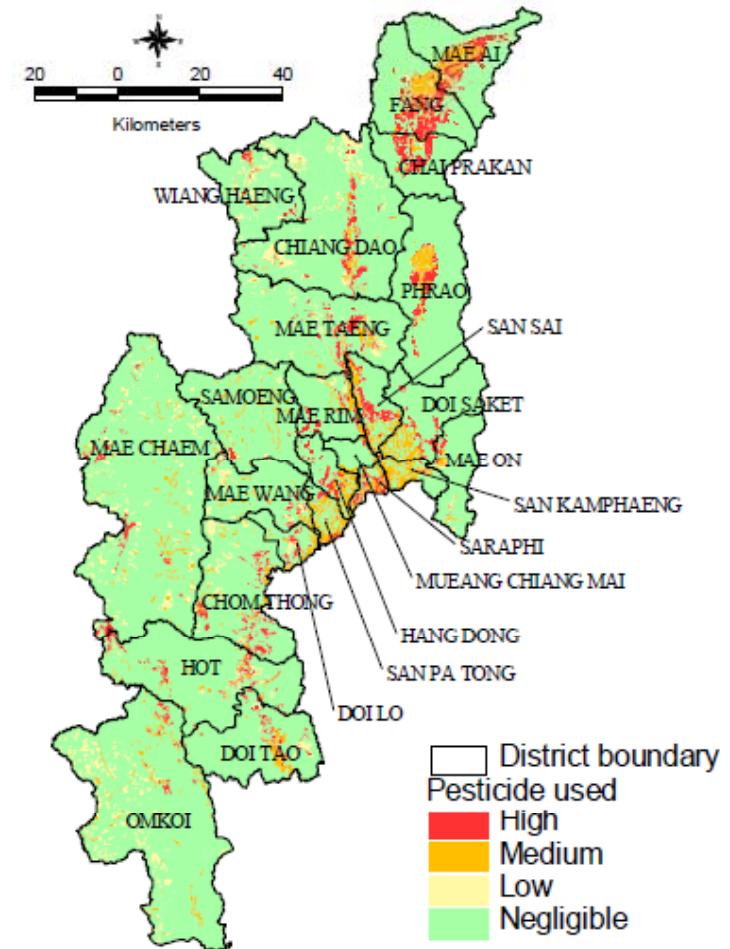
Chiang Mai

Malaria area stratification



76% in A1 and A2

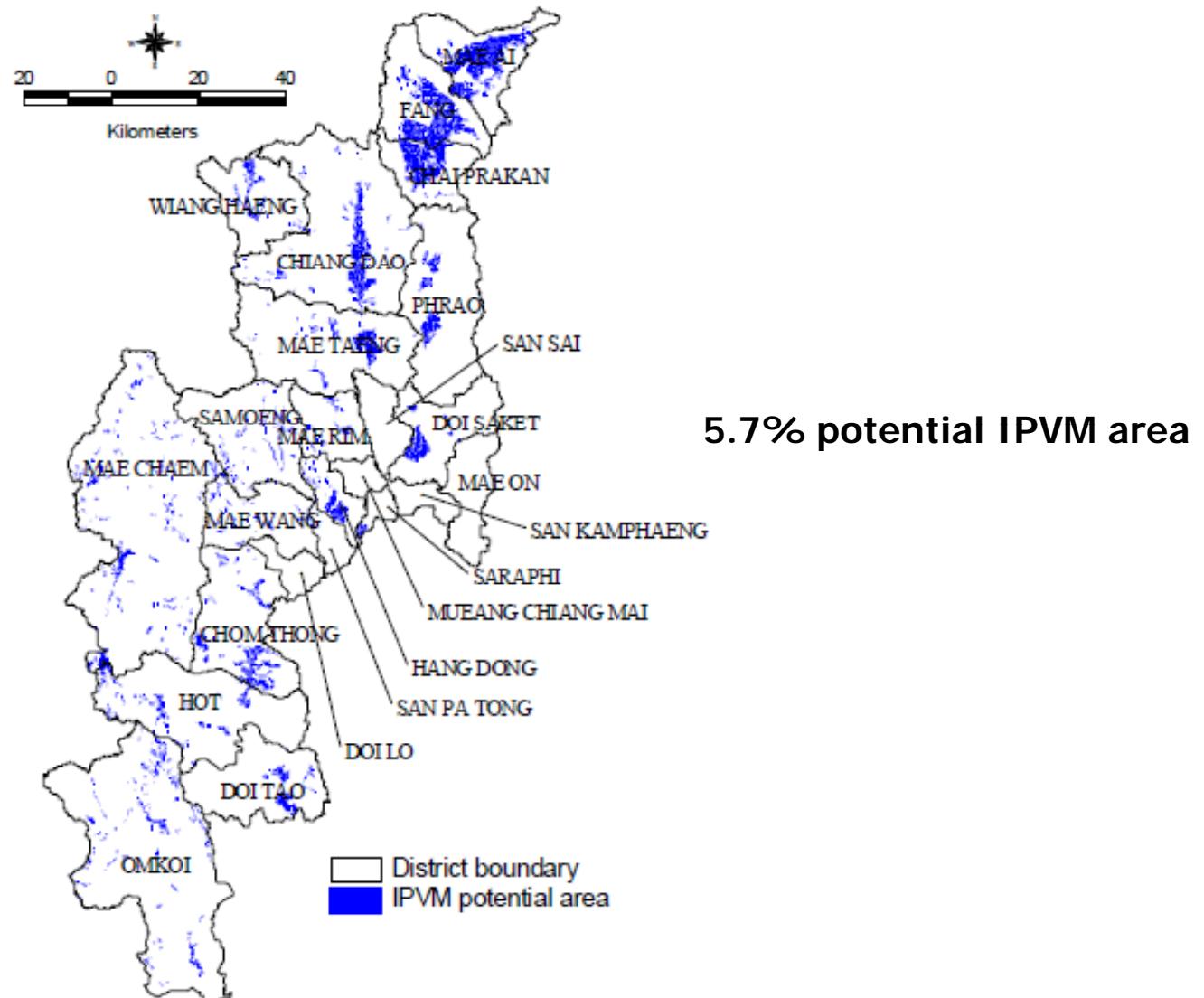
Insecticide-intensive land use



12% in High and Medium

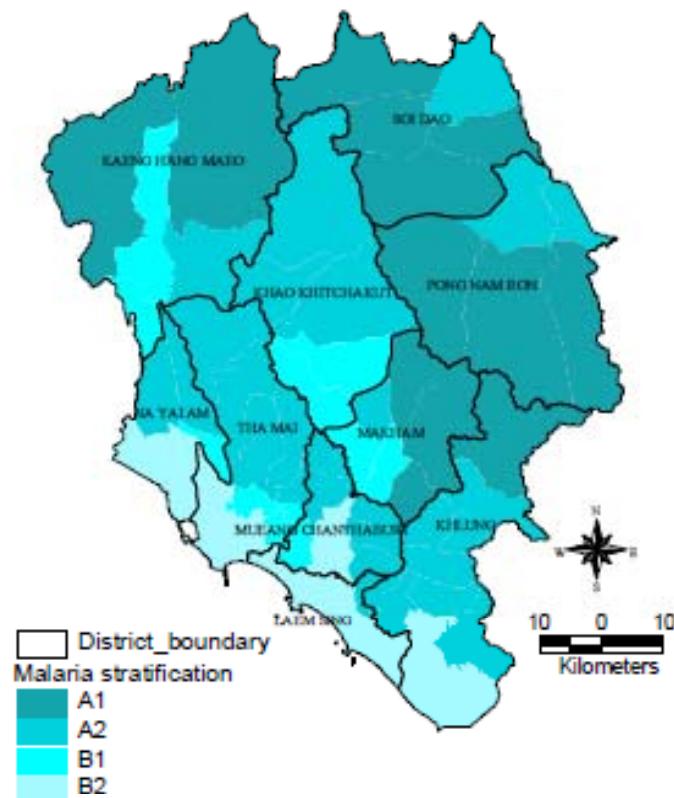
Chiang Mai

Potential area for implementing IPVM



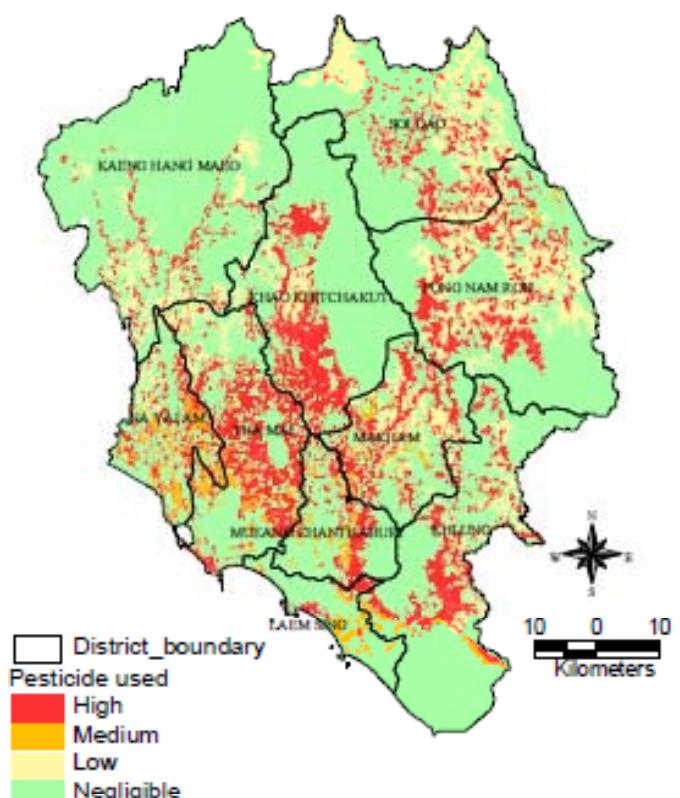
Chantaburi

Malaria area stratification



81% in A1 and A2

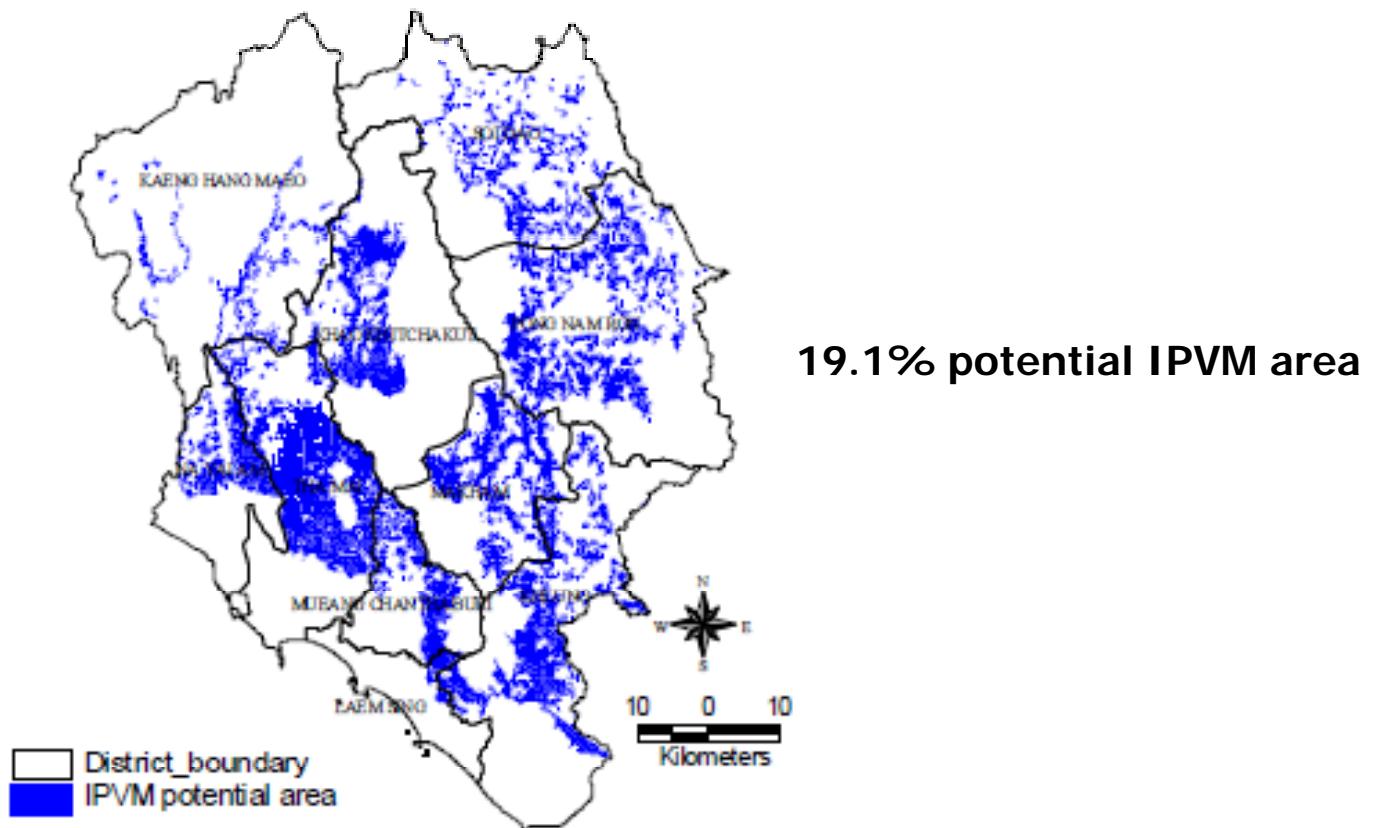
Insecticide-intensive land use



26% in High and Medium

Chantaburi

Potential area for implementing IPVM



Step 5. Insecticide susceptibility in mosquito vectors

Question

- Do agricultural pesticides affect mosquito vectors?

Aim

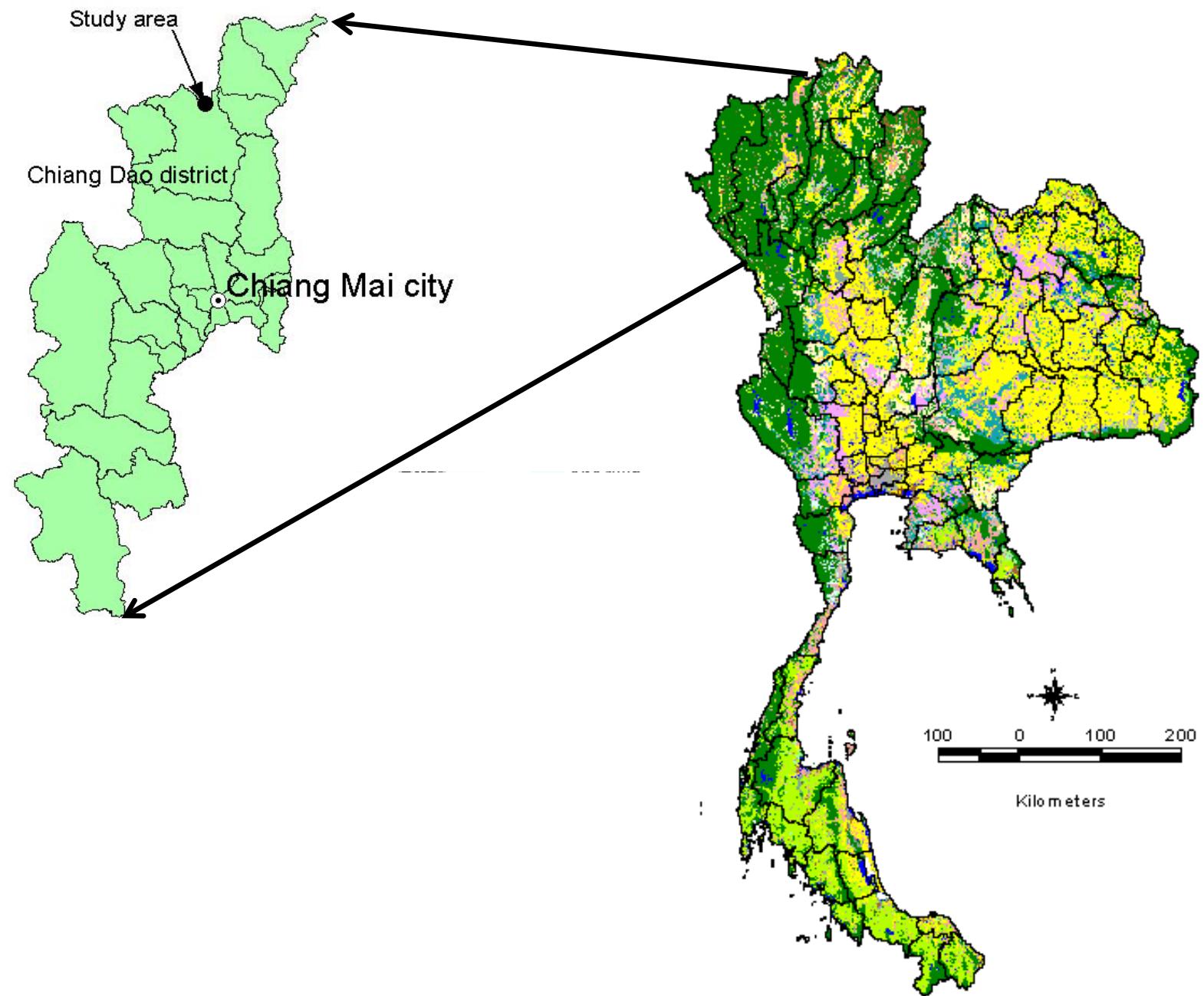
- Test mosquito resistance in insecticide-intensive land use systems

Locations

- Chiang Mai and Chantaburi



Insecticide susceptibility study in Chiang Mai



Sites and mosquito collections

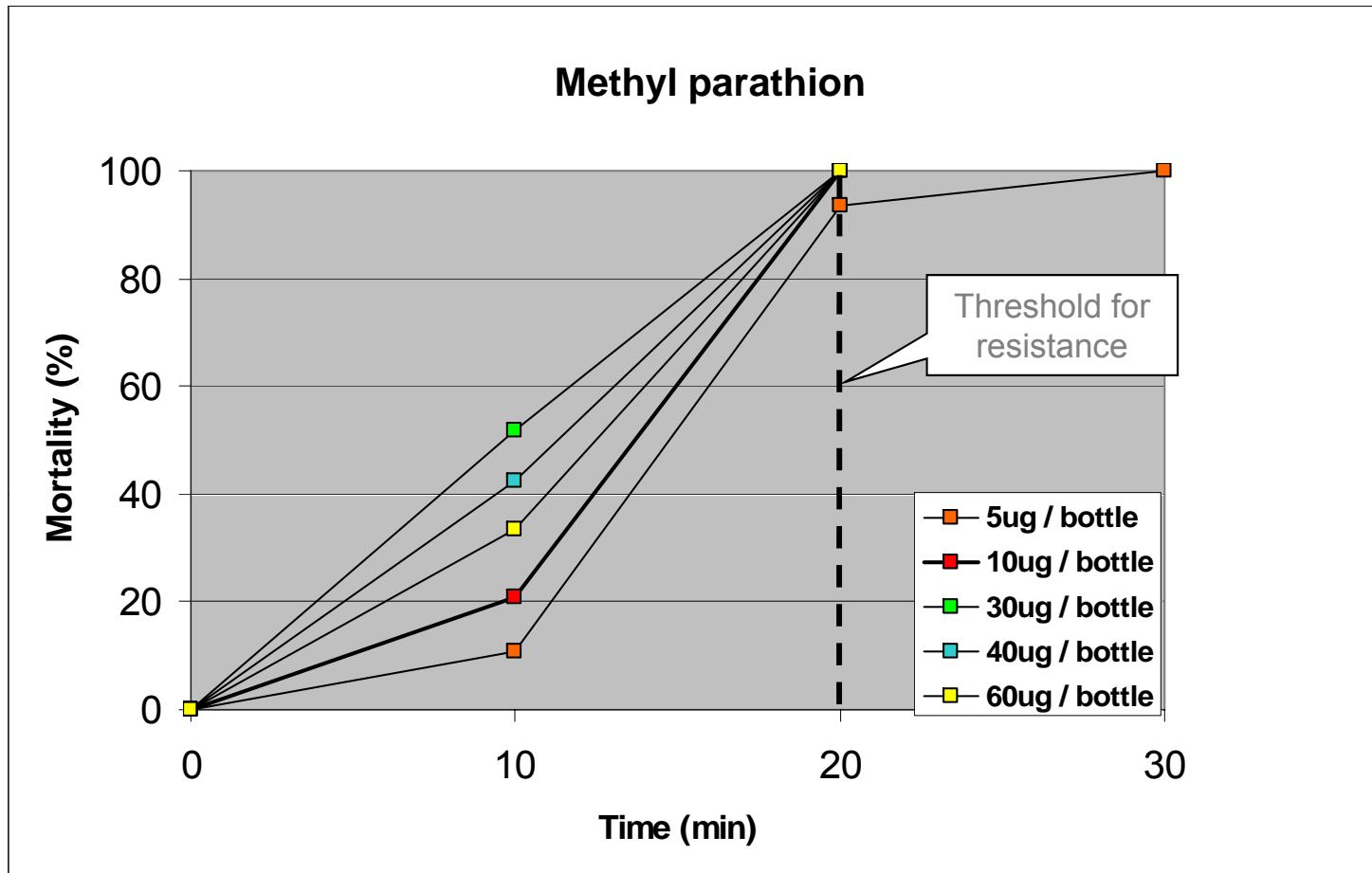
Fruit orchard with high pesticide use (HIGH)



Fruit orchard with low pesticide use (LOW)



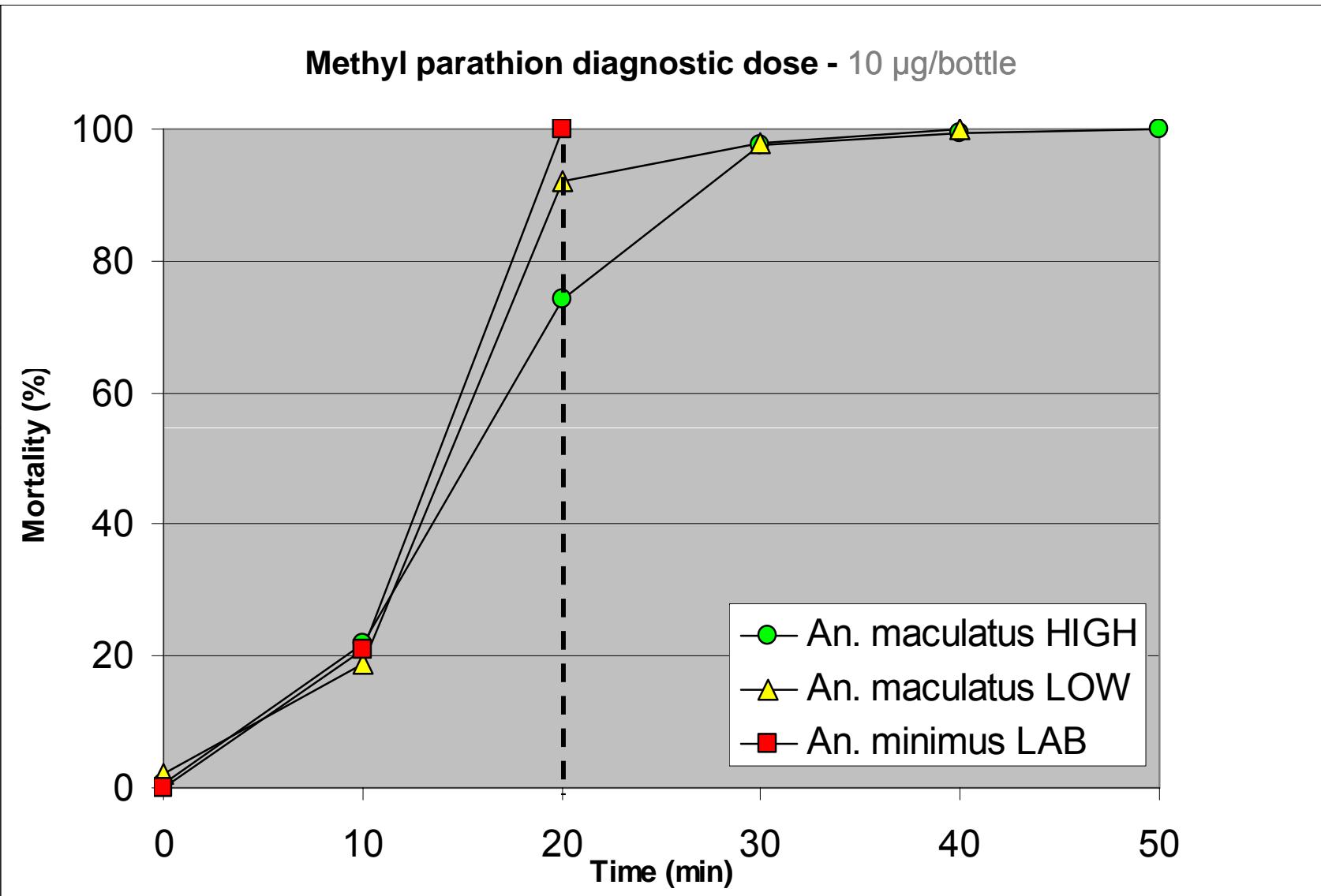
Diagnostic dose and threshold for resistance



Diagnostic dose:
The lowest concentration that kills 100% of susceptible mosquitoes in shortest time

Threshold for resistance:
The time interval where 100% mortality occurs in a susceptible population

Susceptibility in wild-caught mosquitoes



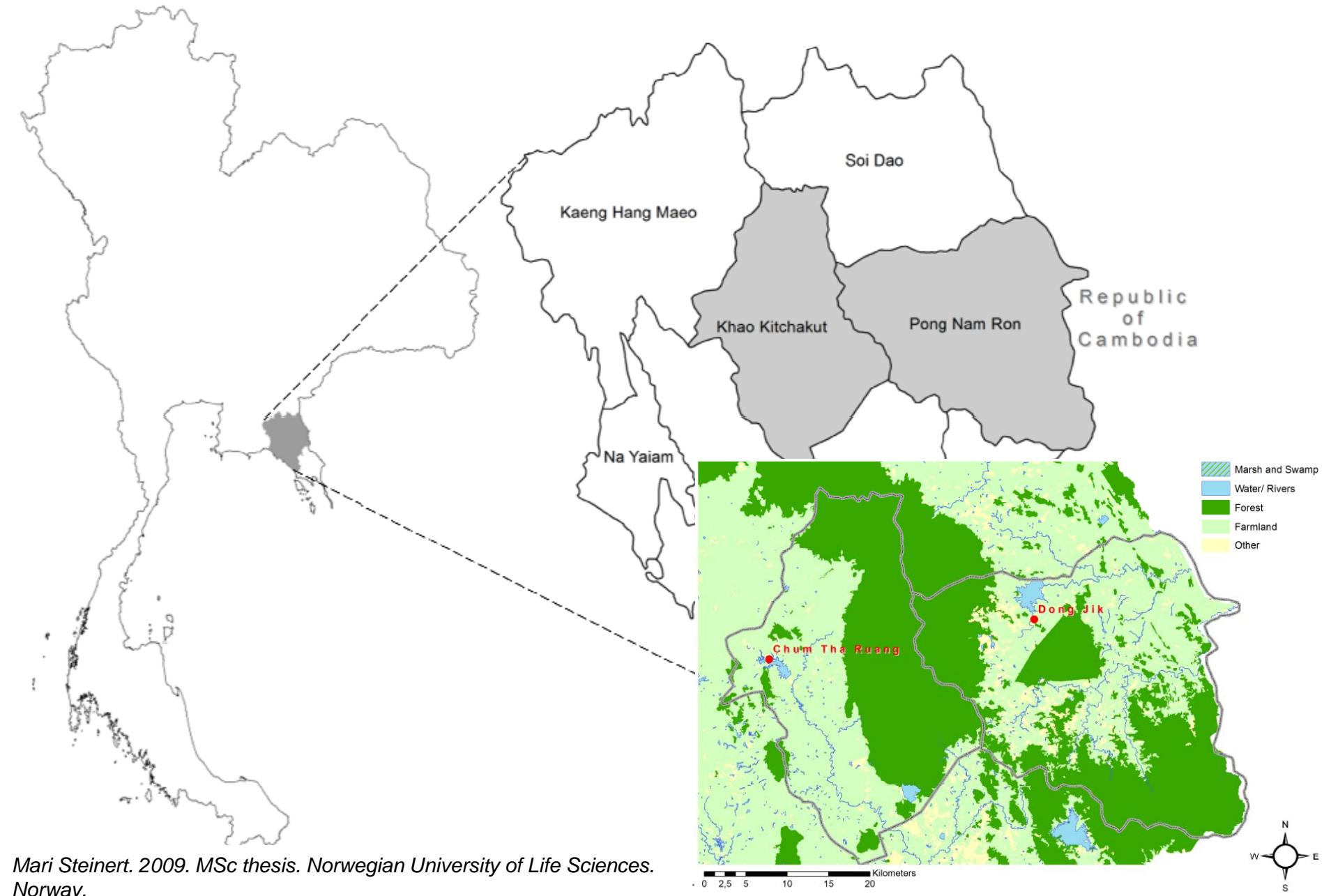
Overgaard, H.J., Sandve, S.R., Suwonkerd, W. 2005. Evidence of anopheline mosquito resistance to agrochemicals in northern Thailand. *Southeast Asian Journal of Tropical Medicine and Public Health* 36 (suppl 4): 148-153.

Mortality in wild-caught Anophelines

Insecticide	Species	HIGH		LOW	
		Mortality	n	Mortality	n
Methyl parathion	<i>An. maculatus</i> s.s.	74 %	214	92 %	244
	<i>An. sawadwongporni</i>	94 %	237	99 %	244
Cyper methrin	<i>An. maculatus</i> s.s.	99 %	171	100 %	166
	<i>An. sawadwongporni</i>	100 %	166	100 %	154
	<i>An. minimus</i> A	100 %	56	-	-

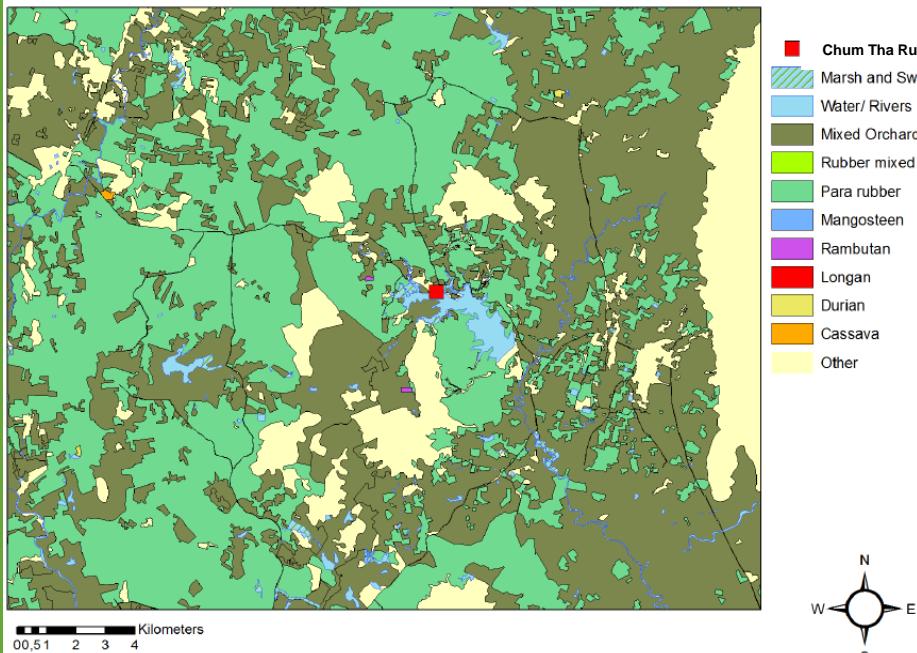


Insecticide susceptibility study in Chantaburi

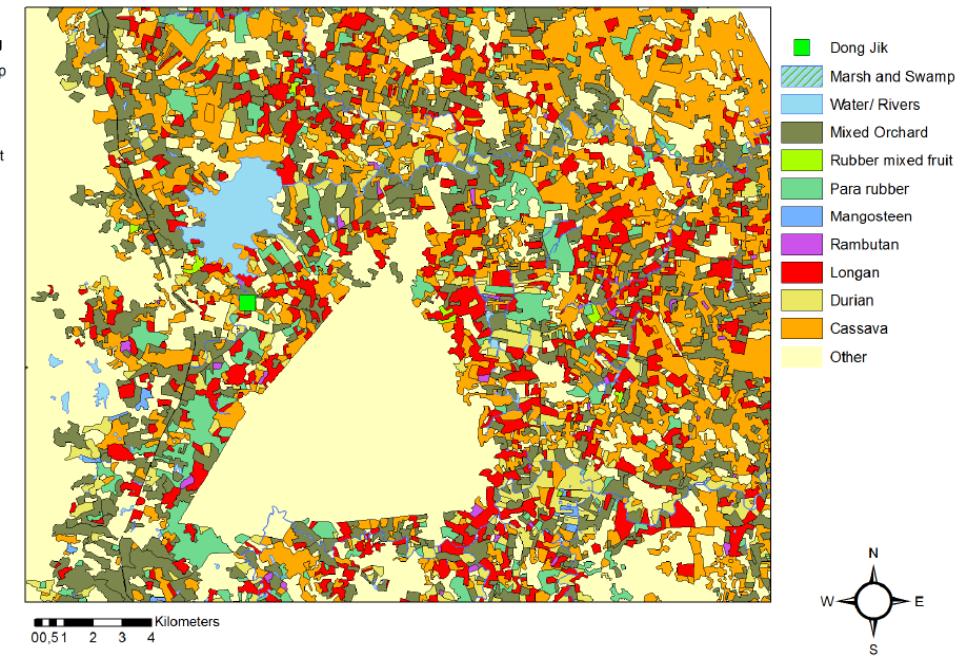


Sites and land use

Chum Tha Ruang



Dong Jik



- Widespread settlement
- Fruit orchards far from dwellings
- Mixed fruit orchards: Mangosteen, rambutan, durian

- Densely populated village
- Fruit orchards close to village
- Mixed fruit orchards, but mainly longan

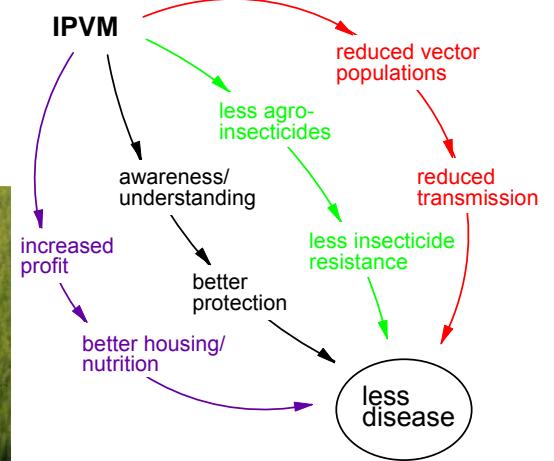
Mosquito mortality in Chantaburi

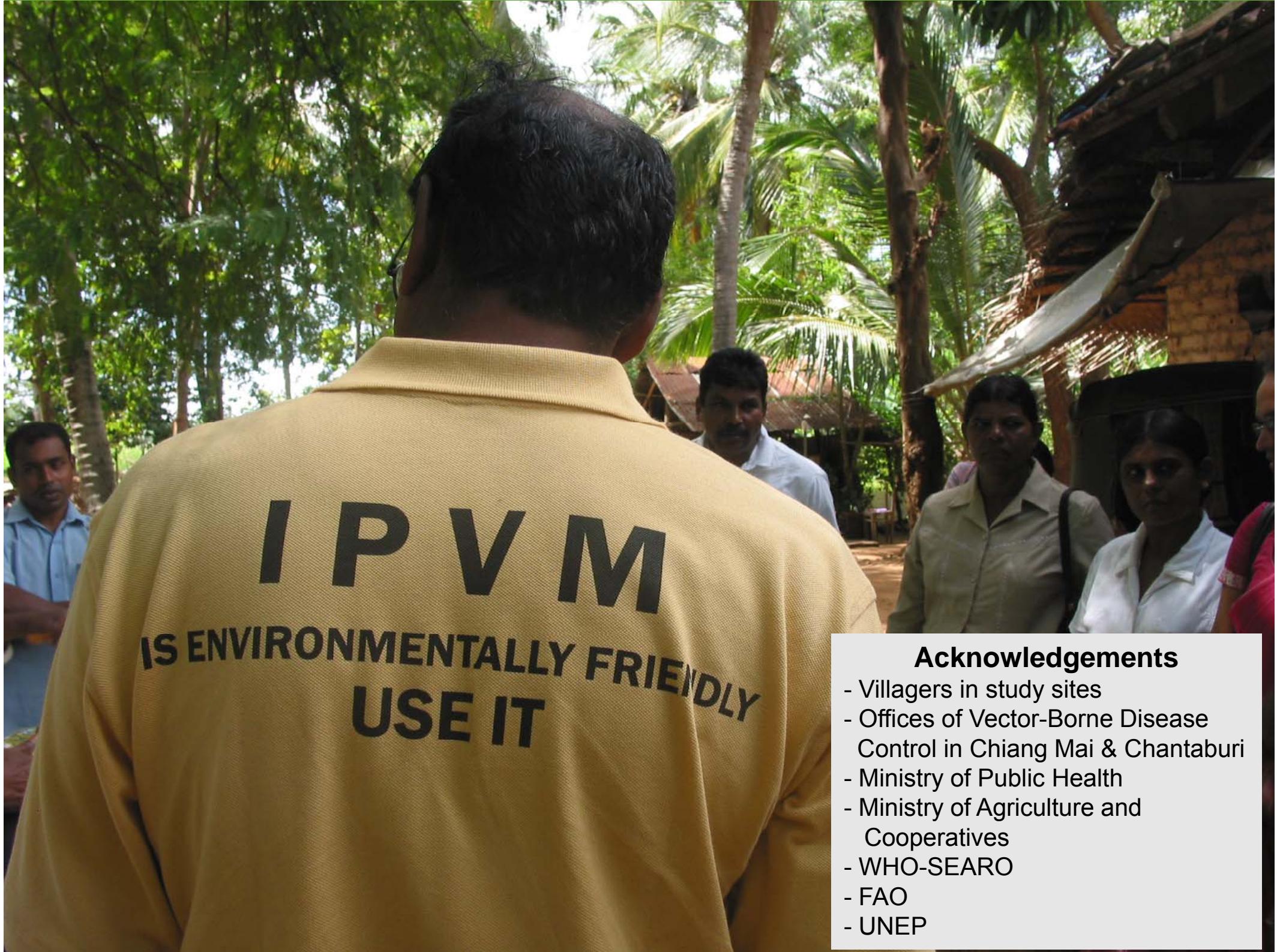
		Public health insecticide		Agricultural insecticides			
Village	Species	Deltamethrin % Mortality		Cypermethrin % Mortality		Chlorpyriphos % Mortality	
		Control	Replicates	Control	Replicates	Control	Replicates
Chum Tha Ruang	<i>Ae. aegypti</i>	0	97.50	15	98.50	0	68.75
Chum Tha Ruang	<i>Ae. albopictus</i>	5	98.75	-	-	-	-
Dong Jik	<i>Ae. aegypti</i>	0	90.00	0	87.50	0	75.00
Dong Jik	<i>An. jamesii</i>	5	100.00	25	100.00	15	100.00
Dong Jik	<i>An. barbumbrosus</i>	-	-	-	-	25	53.40

Mortality adjusted with Abbott's formula if control mortality exceeded 4%.

Conclusions

- Agricultural crop protection affects insecticide resistance in anophelines
- Potentially also in dengue vectors
- Currently no direct threat to vector control
- Beware of...
 - Increased use of pyrethroids in agriculture
 - Development of cross-resistance
- IPVM can be a valuable vector control option in areas with insecticide-intensive agriculture





Acknowledgements

- Villagers in study sites
- Offices of Vector-Borne Disease Control in Chiang Mai & Chantaburi
- Ministry of Public Health
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