Mosquito vectors and their regional distribution

The transmission of malaria in any given region depends in large measure on what mosquito vectors are available. A great deal of effort has been devoted to defining *Anopheles* species in Asia and their distribution, behavioral patterns and vectorial capacity. Different species have differing habitat preferences, *e.g.* rice fields, plantations, forests, forest fringes, foothills, plains, so that the physical environment plays a substantial role in species prevalence in particular geographical areas.

What follows is a summary overview only, taken in large measure from the first Mekong Malaria monograph. A review of the pertinent literature from WHO South-East Asian and Western Pacific Regions published by Zahar (1996) remains a relevant compendium of information.

A relatively small group of vectors is responsible for much of the transmission of malaria in the region. *Anopheles dirus*, favoring a forest habitat and *An. minimus*, favoring a forest fringe habitat, are ubiquitous in many parts of the region, whereas *An. sinensis* is common in China and *An. maculatus* occurs in some other countries in the region, while *An. sundaicus* is prevalent in the Mekong delta area. Thus it may be postulated that the virtual absence of malaria transmission in northeastern Thailand is in large measure the outcome of extensive deforestation with consequent destruction of the breeding sites of *An. dirus* and *An. minimus*. If so, it may be surmised that the continuing deforestation might be expected to have an impact on malaria patterns in future years. However, forest breeding sites can, in some cases, be substituted by plantations (Kidson *et al*, 1999).

Although only a few vector species have been recorded, the situation is somewhat less simple. What are listed as species are in reality species complexes, identified using molecular probes. Definition of *An. dirus* as a species complex was reported by Panyim *et al* (1988) using DNA probes. Subsequently it has become apparent that many vectors are species complexes. Table 3 lists the species complexes of Anopheles and the number of sibling species known to exist in each of the 6 Mekong countries at this time. Many have little or no known role as vectors but where they do, as such each member of the respective complex must be treated as a separate entity. Thus in Thailand members of the *An. dirus* complex have independent geographical patterns (Baimai *et al*, 1988); in some areas a single species is present, in others two, in still others three. They have different biting times and other behavioral modes and so will be more or less efficient as vectors. Thus epidemiological assessment requires molecular definition of vector species as well as analysis of human ecology.

So, for example, men who travel into the deep forest for work become infected there by bites from *An. dirus* return to their home villages on the forest fringe where they become reservoirs for transmission of the parasites by An. minimus to their young children. *An. sundaicus*, on the other hand, breeds in brackish water as is found in estuaries, such as the Mekong delta.

This ecological complexity involving human populations, vector diversity and environmental characteristics makes it difficult for malaria control programs to have adequate flexibility to cope with rapid change in demands. Malaria programs in the region generally have spent a substantial portion of their budgets on vector control by residual spraying of insecticide and more recently by insecticide-impregnated mosquito nets. So much depends on the behavioral mode of a particular vector species in a particular area and on the local human ecology, but to tailor policy to small differing geographical areas is very demanding and costly despite its sound scientific basis.

Table 3

Species complexes recognized and number of sibling species identified in the 6 Mekong countries.

Species/Countries	Cambodia	China	Lao PDR	Myanmar	Thailand	Viet Nam
An. annularis (2)				+	+	
An. culicifacies (4)				+	A,B	
An. dirus (6)	A	A	A	A,D	A,B,C,D,F	A
An. leucosphyrus (2)					A	
An. maculatus (9)	+	+	+	A,B,C	A,B,C,G,H,I,K	+
An. minimus (4)	+	A,B	+	+	A,B	+
An. nivipes (2)	+				A,B	
An. philippinensis	+			+	+	
An. sinensis (2)	+	?	?	A,B	+	
An.subpictus (4)	+			+	+	+
An.sundaicus (3)				+	A	+

(___) No. of sibling species

A, B etc Sibling species nomenclature

\+ Species present, sibling species composition not known

? Not known but expected to occur