Mosquito vector distribution

The transmission of malaria in any given region depends in large measure on what mosquito vectors are available. A great deal of research has been devoted to defining the species of the genus Anopheles of Asia and to 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 significant role in species prevalence in particular geographical areas.

This is a summary overview only. A comprehensive review of the pertinent literature relevant the South-East Asian and Western Pacific Regions of WHO has been published (Zahar, 1996). A summary of the major mosquito vectors in the Greater Mekong Subregion is given in the map in Figure 26. While this is greatly simplified it serves the purpose to show that a relatively small group of vectors is responsible for much of the transmission of malaria in the region.

An. dirus, favoring a forest habitat and *An. minimus*, favoring a forest fringe habitat, are ubiquitous in many parts the region, whereas *An. sinensis* is common in China and *An. maculatus* occurs in some other countries of the region, while *An. sundaicus* is prevalent in the Mekong delta area. Thus it is interesting to suggest that the virtual absence of malaria transmission in northeastern Thailand is in large measure the result of extensive deforestation and the consequent destruction of the breeding sites of *An. dirus* and *An. minimus*. If so, the continuing deforestation through much of the region 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 (Singhasivanon *et al*, 1999).

Given the simplistic picture in Figure 26 it might be imagined that the region is somewhat uniform in terms of vector activity, but that is not necessarily so. What are listed as species are in reality species complexes. Recognition thereof depends on the method of identification other than simple morphology. Thus Panyim *et al* (1988a,b) demonstrated, using DNA probes, that *An. dirus* is in reality a species complex. Indeed many vectors or potential vectors are actually species complexes: Table 2 lists the species complexes of Anopheles and the number of sibling species known to exist in each of the six Mekong countries at the present time. Many have little or no role as vectors but where they do so act, the true picture requires that each species of the respective complex be treated as a separate entity. This is illustrated by the distribution pattern within a single country. Thus in

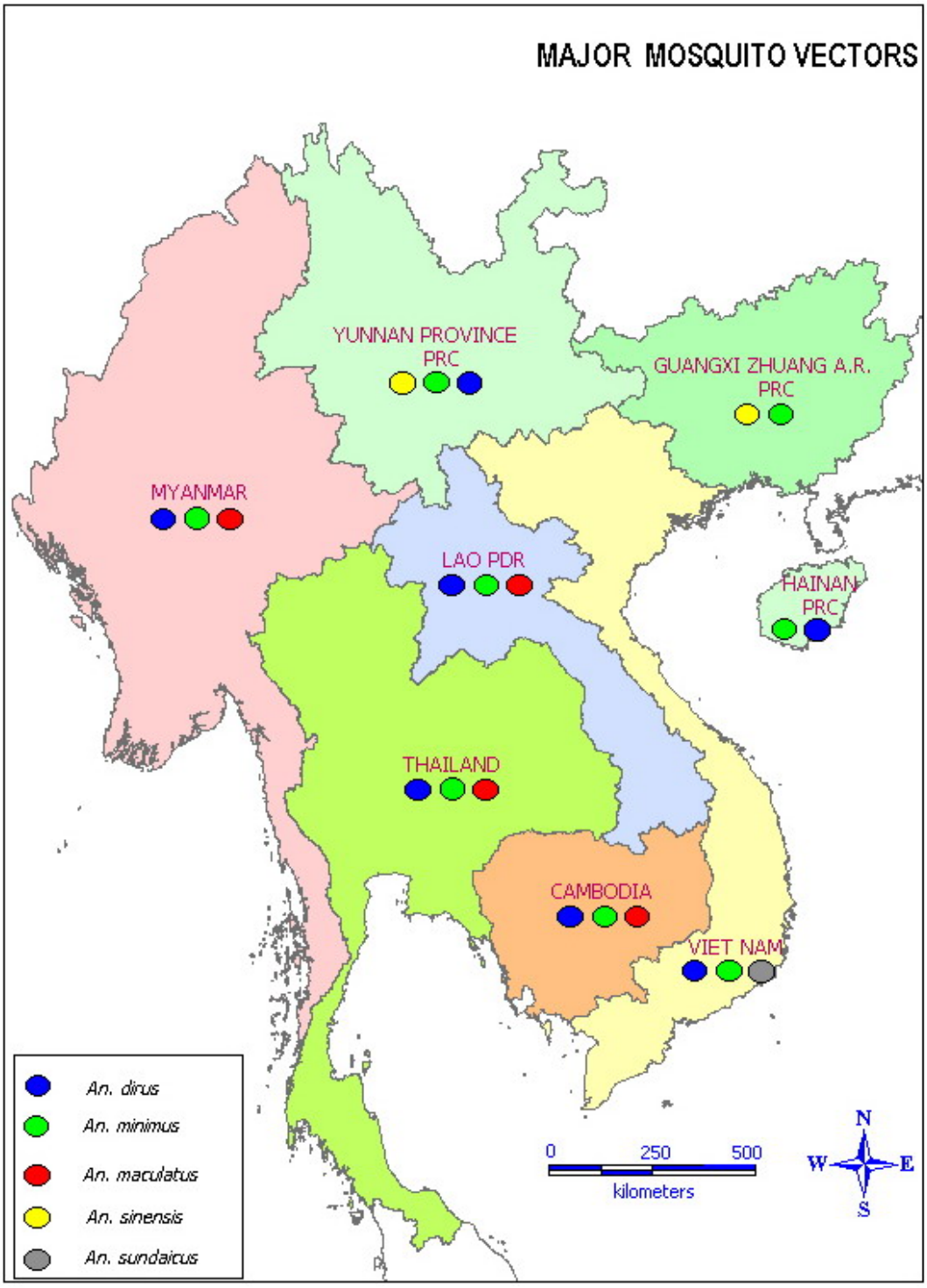
MAJOR MOSQUITO VECTORS
YUNNAN PROVINCE
PRC
GUANGXI ZHUANG A.R.
PRC
MYANMAR
LAO PDR
HAINAN
PRC
THAILAND
CAMBODIA
VIET NAM
An. dirus
An. minimus
An. maculatus
An. sinensis
An. sundaicus
0
250
500
kilometers
N
W
E
S

Figure 26.

Thailand the 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, still others three. They have different biting times and other behavioral modes and thus will be more or less efficient as malaria vectors, so that epidemiological evaluation requires molecular delineation of species as well as detailed analysis of human ecology.

Table 2
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,C	+
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.

Armed with this knowledge we can now look back at some of the databases already presented and reflect on some issues concerning malaria transmission patterns and parasite distribution patterns: are they related to the differing geographic distribution of species within the *An. dirus, An. minimus* or *An. sinensis* complexes? It is a research question with potentially important practical consequences. Certainly the role of *An. dirus* species in relation to forest cover and deforestation patterns is important. So many adult males who travel into the deep forest for work become infected there by bites from this group of vector mosquitoes, then return to their villages on the forest fringe where they become reservoirs for transmission by *An. minimus* to their young children. *An. sundaicus*, on the other hand, breeds in brackish water as is found in esturaries, e.g. in the Mekong delta.

Thus there is a tortuous relationship between malaria parasite species, vector species and the physical environment. This complex

relationship is not stable, changing due to multiple human activities in the course of economic development, environmental shifts, population movement and urbanization. It is not easy to maintain sufficient flexibility in malaria control programs to cope with this rapid change, nor is it easy for national planners to cope with the need for continual modification of demands. Vector behavior is just one example: malaria control programs in the region generally have spent a substantial portion of their budgets on vector control by residual spraying of insecticide and more recently oninsecticide-impregnated bed nets. But if the vector is exophagic and exophilic spraying the walls of houses will be a dubious use of resources. So too will 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.

This brief commentary is a somewhat simplistic overview of what is in itself an extensive, critical activity in malaria control. A great deal of expert effort has been invested in vector analysis in the region and deserves a much more detailed assessment in the future from a GIS perspective.

Data sources: Summary data were provided by Visut Baimai.