TREND OF MALARIA INCIDENCE IN HIGHLY ENDEMIC PROVINCES ALONG THE THAI BORDERS, 1991-2001

Supawadee Konchom[1], Pratap Singhasivanon[2], Jaranit Kaewkungwal[2], Sirichai Chupraphawan[2], Krongthong Thimasarn[3], Chev Kidson[2,4], Chaiporn Rojanawatsirivet[1], Surapon Yimsamran[2] and Sornchai Looareesuwan[2]

[1]Bureau of Vector Borne Disease, Ministry of Public Health, Nonthaburi, Thailand; [2]Faculty of Tropical Medicine, Mahidol University, Bangkok,Thailand; [3]Roll Back Malaria Mekong, Bangkok, Thailand; [4]SEAMEO-TROPMED Network, Bangkok, Thailand

Abstract. The intercountry border areas of Thailand have high malaria receptivity and vulnerability that present numerous problems in the control of malaria transmission. This study focused on the 30 provinces of Thailand situated next to neighboring countries, which can be divided into 4 groups: the Thai-Myanmar border (10 provinces), the Thai-Cambodia border (6 provinces), the Thai-Lao border (10 provinces) and the Thai-Malaysia border (4 provinces). The purpose of the present study was to describe the pattern and trend of malaria incidence in the highly endemic provinces along the Thai borders for the 11 years from 1991 to 2001. Analysis of trends showed the distribution of malaria parasites to have shifted from a preponderance of *Plasmodium falciparum* to *Plasmodium vivax* along the western border with Myanmar, the northern border with Lao PDR and along the eastern border with Cambodia whereas the southern border with Malaysia the pattern changed from a preponderance of *P. vivax* to *P. falciparum*, since 1997. There was a significant difference in annual parasite incidence between borders and non-border districts, especially along the Thai-Myanmar and Thai-Cambodia borders. It is thus evident that all border districts should pay more attention to control of malaria transmission and the activities of the malaria surveillance system, and that monitoring and evaluation of the Thai Malaria Control Program needs to be performed consistently, including some areas where a few malaria cases were found as well as in malaria free areas.

INTRODUCTION

In Southeast Asia malaria has been a disease of major public health importance for a long time, especially in Myanmar, Indonesia, Malaysia, Philippines, Thailand, Cambodia, Lao PDR and Vietnam. During the years 1970-1979 the incidences of malaria rose considerably in many countries in the region, due to technical, administrative, social and economic factors in the individual national malaria control program (Harinasuta, 1987). A previous epidemiological information indicates that the malaria situation in the countries of Southeast Asia vary considerably from country to country (Kidson *et al*, 1999).

The perennial malaria transmission in Thailand occurs with 2 peaks in June to August and in October to November. This pattern has a direct relationship to the rainy season and the prevalence of the major vectors.

The border areas of Thailand are mostly forest-fringe foothills, especially along the western border with Myanmar, there is high malaria receptivity and vulnerability that presents numerous problems in the control of malaria transmission. Malaria among foreign laborers is a major obstacle to the control program although the number of reported cases declined significantly in 2000. The disease is localized in three main areas, *ie* the Thai-Myanmar border, the Thai-Cambodian border and the central part of the southern peninsula. In 2000 the proportion of *P. falciparum* dropped from 90% in 1994 to approximately 50% of total parasites microscopically detected. This was partly cases reported based on microscopic confirmation due to a *P. vivax* outbreak in the eastern provinces in 1986-1987. It is noteworthy that this is the first time in 5 decades that the coun-

Correspondence: Supawadee Konchom, Bureau of Vector Borne Disease, Ministry of Public Health, Nonthaburi 11000, Thailand.
Tel: 01 831 1270

try reported reverse ratios of *P. falciparum* and *P. vivax* (Malaria Division, 2000).

Since 1997, more than 60% of total cases in the country were detected from border provinces and one third of these were detected from the Tak Province on the Thai-Myanmar border. Approximately 17% of the total cases were found in the Thai-Cambodia border region and most of these cases were found in the Trat Province. The cases reported from the Thai-Lao and Thai-Malaysia borders accounted for 4.6% and 4.5% of the total cases, respectively (Malaria Division, 1997).

The total number of cases nationwide has been decreasing every year while the number of cases detected from border provinces has been increasing gradually. This indicates that the disease has become more localized along the international borders. During 1997-2000, the total number of Thai cases reported increased from 80,000 to some 120,000 due to epidemics of *P. falciparum* in some provinces in the south and an increase of *P. vivax* along the Thai-Cambodian border. The annual parasite incidence (API) was 1.6 per 1,000 population in 2000. Foreigner cases increased from 50,000 to 67,000. Myanmar nationals accounted for 90% of foreigner cases, mostly *P. falciparum* (more than 80%). The purpose of the present study was to describe the pattern and trend of malaria incidence in endemic provinces along the Thai borders for the past 11 years from 1991 to 2001.

MATERIALS AND METHODS

Study site

This study focused on the 30 border prov-

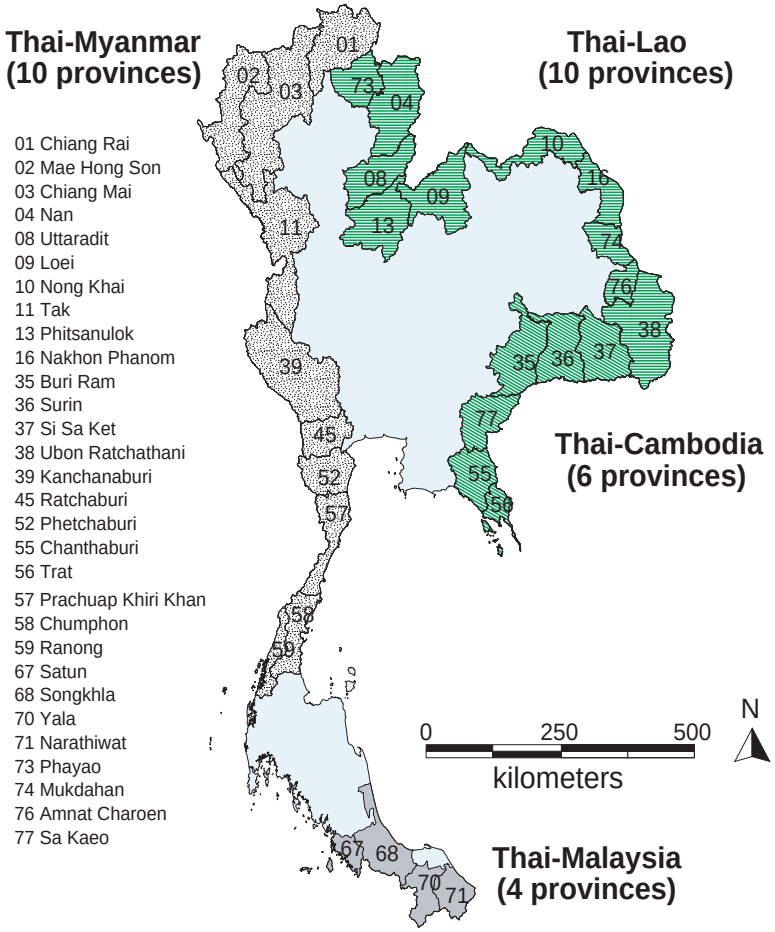

Fig 1–Map showing 30 border provinces along the Thai border.

inces of Thailand situated next to the neighboring countries: Myanmar, Lao PDR, Cambodia and Malaysia (Fig 1). These provinces have been divided into 4 groups according to their geographical locations:

1. Thai-Myanmar border group consists of 10 provinces (Chiang Rai, Mae Hong Son, Chiang Mai, Tak, Kanchanaburi, Ratchaburi, Phetchaburi, Prachuap Khiri Khan, Chumphon and Ranong).

2. Thai-Cambodia border group consists of 6 provinces (Buri Ram, Surin, Si Sa Ket, Sa Kaeo, Chanthaburi and Trat).

3. Thai-Lao border group consists of 10 provinces (Nan, Uttaradit, Loei, Nong Khai, Phitsanulok, Nakhon Phanom, Ubon Ratchathani, Phayao, Mukdahan and Amnat Charoen).

4. Thai-Malaysia border group consists of 4 provinces (Satun, Songkhla, Yala and Narathiwat).

Data collection

The secondary data were collected monthly at district level during 1991-2001 and collated at the national level by the Bureau of Vector Borne Disease, Department of Disease Control, Ministry of Public Health, Thailand. Each group of provinces in the Thai border area was divided into 2 sub-groups: border districts and non-border districts. Border district of the 30 border provinces means the district is situated next to the Thai border and non-border district means the district is not located at the Thai border. The data collected were the number of malaria cases, annual parasite incidences per 1,000 population (API), annual blood slide examination rates per 100 population (ABER), slide positive rates per 100 population (SPR) and proportions of malaria parasite species: *P. falciparum (P.f)* and *P. vivax (P.v)*.

Data analysis

Data analysis were performed using an unpaired *t*-test to determine the difference of average monthly API, *P.f* (%) and *P.v* (%) between border districts and non-border districts during 1991-2001. These data describe the difference of monthly malaria patterns between border districts and non-border districts by each group in the area.

MAPINFO Professional version 6.0 was used to create maps during 1991-2001. Each province and district has a specific ID code, which serves as the link between attributable data and corresponding spatial area. The variables for each year were displayed simultaneously on one single map, showing the trend of malaria incidence in highly endemic provinces along the Thai borders.

RESULTS

Comparison of malaria incidence in 4 groups in the Thai-border region

The comparison of average API, *P. falciparum* (*P. f*%) and *P. vivax* (*P. v*%) along the Thai border during 1991-2001 indicated that malaria incidence in the 4 groups of provinces along the Thai-border have shown a downward trend since 1993. API along the Thai-Myanmar and Thai-Cambodia borders was higher than that along the Thai-Lao and Thai-Malaysia borders (Fig 2A-2B). In some cases (*eg* Thai-Cambodia and Thai-Myanmar borders) API declined, in others (*eg* Thai-Lao border) there was no apparent change. During 1991-1998, the *P. falciparum* incidence in the Thai-Myanmar border area appeared to be higher than that of *P. vivax* and in the Thai-Cambodia border area *P. falciparum* incidence was higher than that of *P. vivax* from 1991 to 1995. However in subsequent years, the malaria parasite incidence in the Thai-Myanmar border area changed inversely, with the incidence of *P. vivax* being higher than *P. falciparum* since 1999 while *P. vivax* was higher than *P. falciparum* in the Thai-Cambodia border area since 1996. The pattern of *P. falciparum* incidence in this area has shown a decreasing trend compared with that of *P. vivax* (Fig 2E-2F). The proportion of *P. falciparum* and *P. vivax* during the past 11 years revealed that there has been a change of parasite ratio, especially in the Thai-Cambodia and Thai-Myanmar border areas. The percentage of. *P. vivax* was higher than *P. falciparum* since 1996 while the parasite ratio changed inversely in the Thai-Malaysia border area from *P. vivax* to *P. falciparum* since 1995 (Fig 2I-2L).

Comparison of malaria cases between border and non-border districts

Comparison of average monthly API, *P. falciparum* (*P.f* %) and *P. vivax* (*P.v* %) in the Thai border between border and non-border districts during 1991-2001 are presented in Fig 3. The data

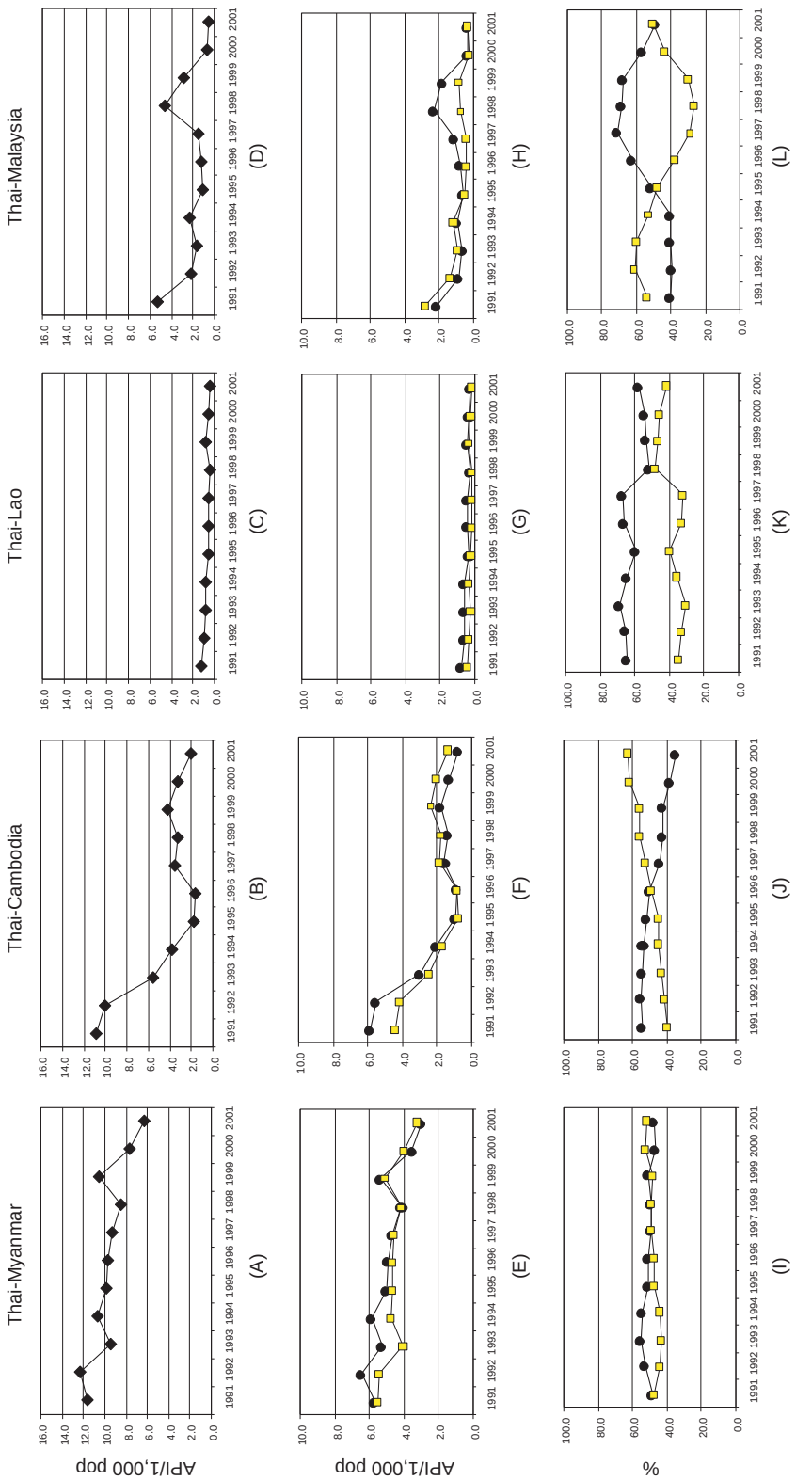

Fig 2–Comparison of average Annual Parasite Incidence per 1,000 population (API), *P. falciparum* (%) and *P. vivax* (%) along the Thai border during 1999-2001.

revealed that API in border districts was higher than non-border districts. There was a significant difference of API between border and non-border districts ($p<0.05$), especially in the Thai-Myanmar and Thai-Cambodia border areas. The data has shown that there were two seasonal peaks of malaria transmission. In the Thai-Myanmar border area, the highest peak of transmission started in June and the second peak started in December whereas in the Thai-Cambodia border area, the highest peak started in December and the other peak started in May. There was no clear peak of transmission in the Thai-Lao border area while in the Thai-Malaysia border area a peak of transmission started in June (Fig 3A-3D).

Maps: distribution of malaria

Malaria occurs persistently in the 30 provinces along the Thai border areas interfacing with Myanmar, Cambodia, Lao PDR and Malaysia. The malaria incidence was highest in the western border area with Myanmar and some provinces in the eastern border with Cambodia (Chanthaburi and Trat) over the period of 1991 to 2001 (Fig 4). The same was true at the district level, especially in the Mae Hong Son and Tak provinces.

The patterns of malaria parasite species expressed as percentage of *P. falciparum* and *P. vivax* are presented by color density as % *P. falciparum* (blue dominance), they could also be interpreted inversely (yellow-green dominance) as % *P. vivax* (Singhasivanon *et al*, 1999). The pattern showed little variability over the 5 year period 1991-1995 (Fig 5). But since 1997, the distribution of malaria parasites has changed from dominant *P. falciparum* to dominant *P. vivax* in the western border with Myanmar, the northern border with Lao PDR and in the eastern border with Cambodia while in the southern borders with and Malaysia, the pattern has changed from dominant *P. vivax* to dominant *P. falciparum*. In some border districts in provinces along the Thai border % *P. falciparum* is higher than % *P. vivax*, especially in the eastern border area with Cambodia whereas the western border with Myanmar has a higher % *P. vivax* than %*P. falciparum.*

DISCUSSION

The average monthly malaria incidence along the Thai-Myanmar and Thai-Cambodia borders during 1991-2001 shown in Fig 3 revealed that there was a seasonal pattern with two peaks, from May to July before the rainy season and October to December after the rainy season, this pattern was especially evident in the Thai-Myanmar and Thai-Cambodia border areas.

The incidence pattern of *P. falciparum* compared with *P. vivax* (Fig 5) has increased in all provinces and districts along the Thai-Myanmar and Thai-Cambodia border since 1997. This finding suggests that population movement in both directions across the international borders provides a regular importation of malaria infections that present a high potential to spread malaria within the border areas and extend the transmission area. Population movement has been suggested as a major factor in malaria transmission along the border (Stern, 1998).

The southern border provinces have shown a change in parasite ratio from *P. vivax* to *P. falciparum*, whereas on the western border with Myanmar, the northern border with Lao PDR and the eastern border with Cambodia, the trend was from *P. falciparum* to *P. vivax*. It has been reported that there was an increasing total number of malaria cases during 1997 to 1998 (Malaria Division, 2000). Malaria epidemics were observed in the Sa Kaeo Province along the Thai-Cambodia border. There were 613 malaria cases reported in 1995, some 900 in 1996, 4,800 cases in 1997, and 4,189 in 1998. It is to be noted that *P. falciparum* accounted for 16% of these cases whereas it had been over 60% prior to the outbreak, when *P. vivax* became the dominant species. The changing of parasite ratio was considered possibly to be due to the impact of the artemisinin derivatives that were launched in 1995 for treatment of *P. f* cases (Thimasarn, 1999). It is not clear what caused the explosion of *P. v* cases overall: possibly population influx following reopening of the Thai-Cambodia border.

The results from this study revealed that the malaria situation along the Thai borders is still a serious problem especially in the Thai-Myanmar and Thai-Cambodia border areas over the period 1991 to 2001. A major problem derived from the population movement across the border as well as geographical characteristics of the border ar-

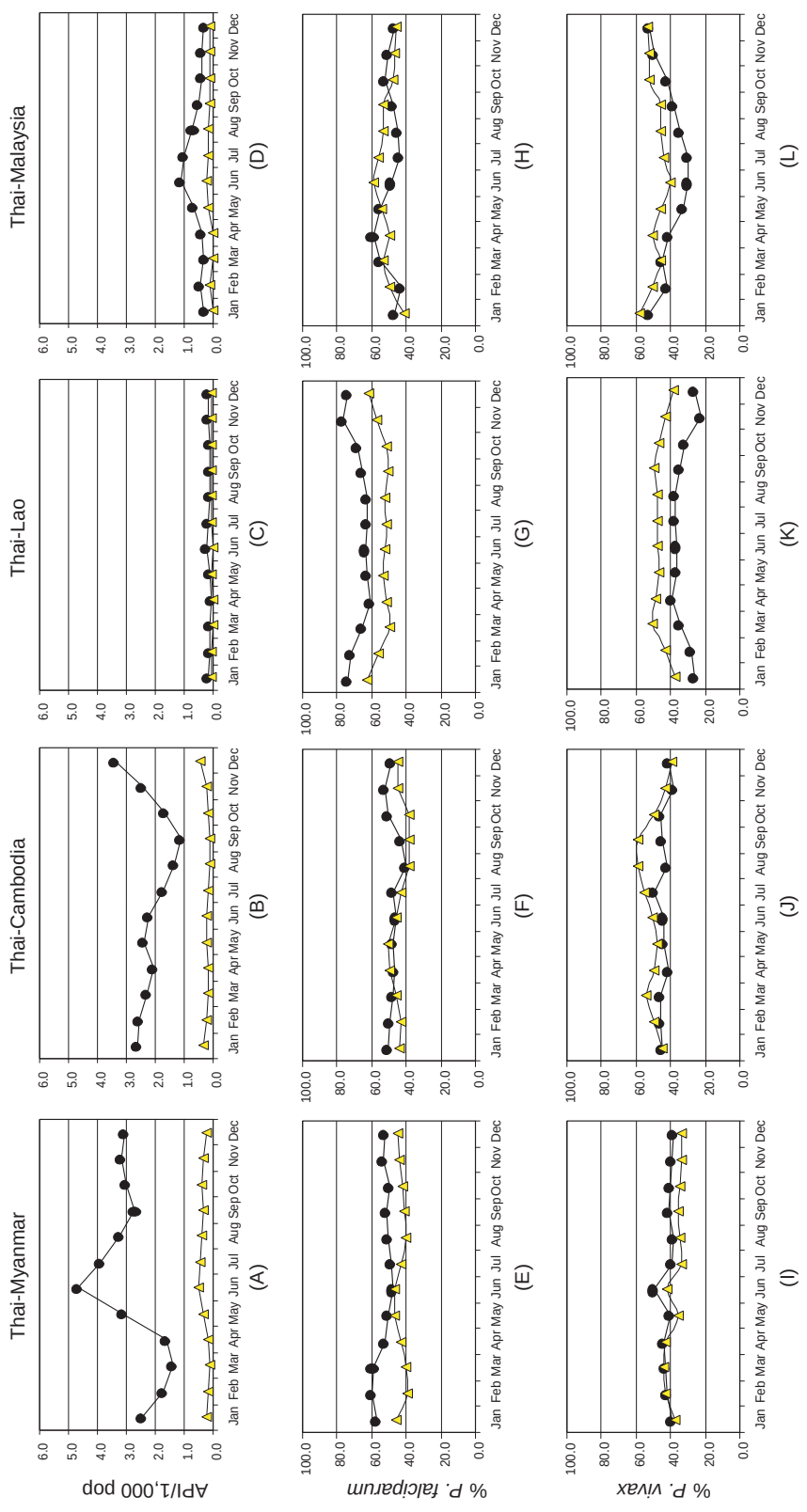

Fig 3–Comparison of average monthly Annual Parasite Incidence per 1,000 population (API), *P. falciparum* (%) and *P. vivax* (%) of the Thai boder between border and non-border districts during 1991-2001.

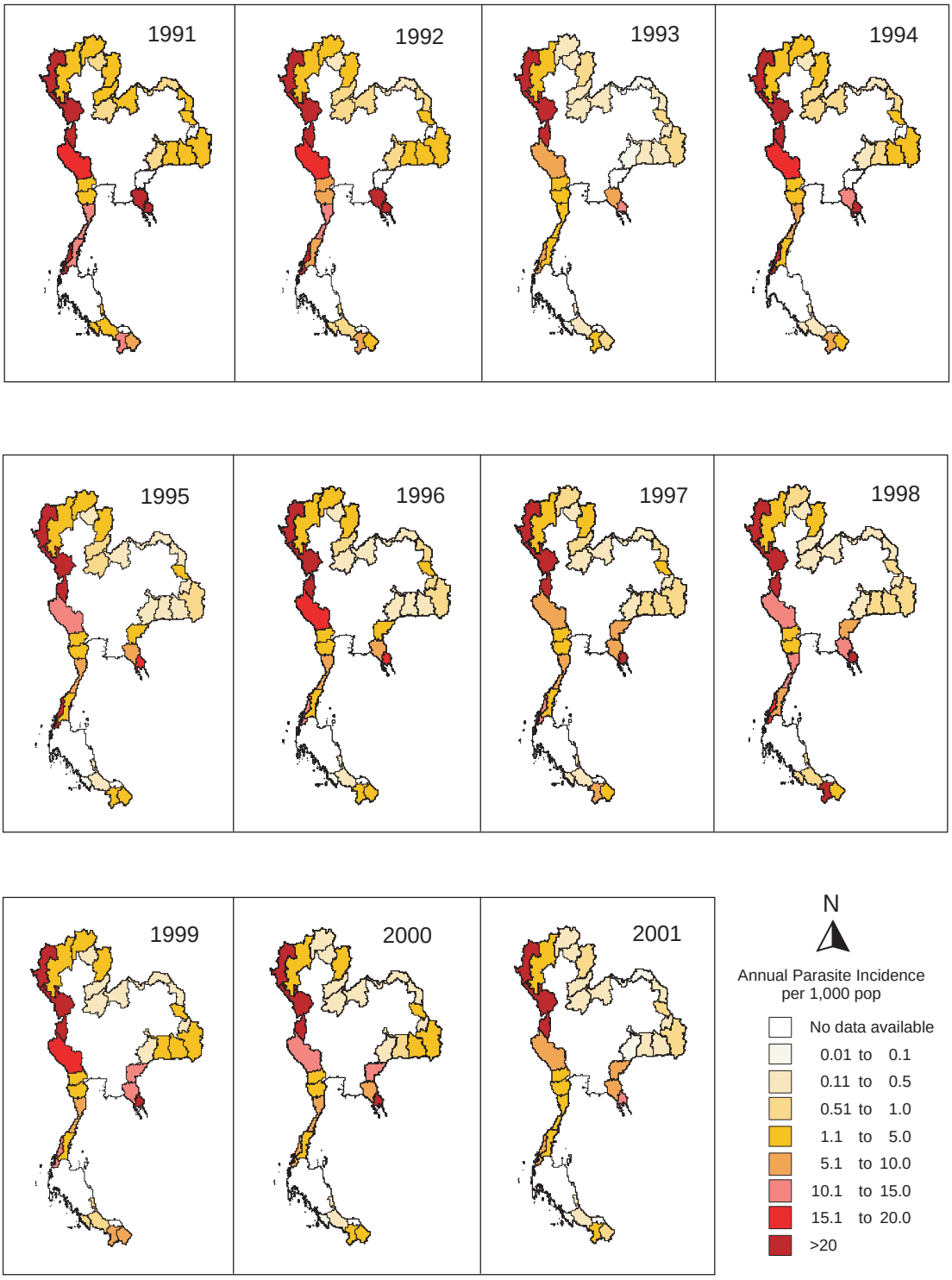

Fig 4–Annual Parasite Incidence (API), 1991-2001.

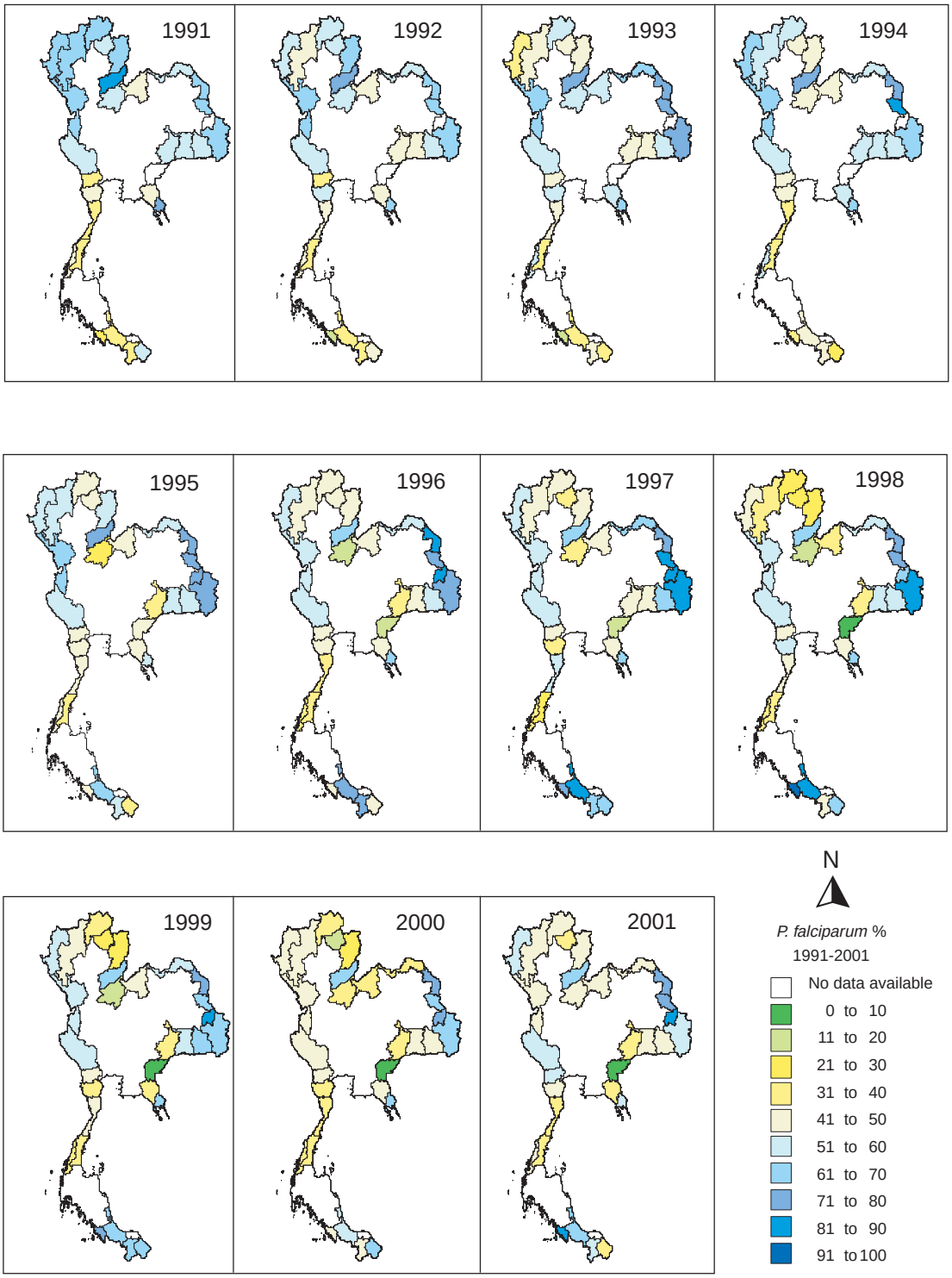

Fig 5–Malaria parasite species, 1991-2001 *P. falciparum* : *P. vivax*, distribution by provinces.

eas: mostly these forested and mountainous areas give rise to high malaria transmission (Thimasarn *et al*, 1995). The parasite ratio has changed from *P. falciparum* to *P. vivax* mostly in the western border with Myanmar, the northern border with Lao PDR and the eastern border with Cambodia. The malaria incidence of border districts with Myanmar and Cambodia was higher than border districts with Lao PDR and Malaysia.

The data shown in Figs 2 and 3 indicated that the malaria situation in border districts was a more serious problem than in non border districts. This arose from such factors as high internal migration of the people due to socio-economic conditions, especially temporary migrant labor moving from malarious areas and movement of population across national boundaries through hills, mountains and forested areas, in some cases involving refugees entering Thailand from neighboring countries (Singhasivanon *et al*, 1999). All such factors have to be taken into account in the epidemiological analysis of malaria and the application of appropriate measures for effective control. All border districts along the Thai border should pay more attention to control of malaria transmission. There should be adequate surveillance within the control services. The activities of the existing malaria surveillance system and monitoring and evaluation of the Thai Malaria Control Program need to be performed consistently, even in areas where a few malaria cases are found and in malaria free areas. An early detection model of malaria epidemics is needed to solve the malaria problem along the Thai border; such a model is now in the development process.

ACKNOWLEDGEMENTS

The authors would like to thank the Information Technology Center team, Disease Control Department, Ministry of Public Health, Thailand who kindly gave specific database and technical support. Thanks are also expressed to the staff of the Sub-Division of Epidemiology, Bureau of Vector Borne Disease, Department of Disease Control, Ministry of Public Health, Thailand for their devoted contributions.

This paper is supported in part by the Ministry of University Affairs and Faculty of Graduate Studies, Mahidol University in the academic year of 2002-2003.

REFERENCES

Harinasuta C. Endemic tropical disease in Southeast Asia, with special reference to Thailand. *Ann Trop Med Parasitol* 1987; 81: 657-69.

Malaria Division. Report of the Task Force Malaria Border Meeting, Myanmar and Thailand, Mae Sai, Thailand. 12-13 June, 1997.

Malaria Division, CDC Department, Ministry of Public Health. Annual report 2000. Bangkok: Publishing House of Agricultural Cooperative Society of Thailand, 2000 (in Thai).

Kidson C, Singhasivanon P, Supavej S, eds. Mekong malaria, malaria, multi-drug resistance and economic development in the Greater Mekong Sub region of Southeast Asia, incorporating geographical information system databases. *Southeast Asian J Trop Med Public Health*, 1999; 30 (suppl 4): 1-101.

Singhasivanon P, Thimasarn K, Yimsamran S, *et al.* Malaria in tree crop plantations in southeastern and western provinces of Thailand. *Southeast Asian J Trop Med Public Health* 1999; 30: 399-404.

Stern A. International population movements and public health in the Mekong Region: an overview of some issues concerning mapping, *Southeast Asian J Trop Med Public Health* 1998; 29: 201-12.

Thimasarn K, Sirichaisinthop J, Vijaykadga S, *et al. In vivo* study of the response of *Plasmodium falciparum* to standard mefloquine/sulfadoxine/pyrimethamine (MSP) treatment among gem miners returning from Cambodia. *Southeast Asian J Trop Med Public Health* 1995; 26: 204-12.

Thimasarn K. Financial crisis, its impact on malaria control approaches to enhance cost effectiveness of interventions. Pattaya, Thailand: International Meeting of National Malaria Control Programme Managers. 1999.