APPLICATION OF GIS TO THE CHARACTERIZATION OF FILARIASIS TRANSMISSION IN NARATHIWAT PROVINCE

Chamnarn Apiwathnasorn[1], Kobkan Kanjanopas[2], Suwich Thammapalo[2], Sumart Loymak[2], Yudthana Samung[1], Samrerng Prummongkol[1] and David Molyneux[3]

[1]Department of Medical Entomology, Faculty of Tropical Medicine, Mahidol University, Bangkok, Thailand; [2]Filariasis Section, Department of Disease Control, Ministry of Public Health, Bangkok, Thailand; [3]Liverpool School of Tropical Medicine, Liverpool, United Kingdom

Abstract. The geographical information system (GIS) and available survey data (both from the Filariasis Annual Reports, 1985-1999 and from the published literature) for the microfilarial infection rates are used to develop the first subdistrict-level endemicity maps of lymphatic filariasis in Narathiwat Province. The maps demonstrated the subdistrict-level geographical distribution of filariasis and the subdistricts at varied degrees of infection rate. The maps also indicate that, since 1985, there was a marked decrease in endemicity at the subdistrict level and in some areas, the infection rates were zero. However, transmission remained in the subdistricts surrounding peat swamp forest (Su-ngai Padi, Paluru, Puyo, Pasemat, Bang Khunthong, and Phron subdistricts). The house locations of infected cases, as well as the vector breeding places were geo-registered and placed as symbolic dots on the base maps obtained from Landsat's Thematic Mapper (TM) 5 and the land use map of Narathiwat to display the distribution of filariasis foci. Of 102 houses mapped, there were 40 houses in primary peat swamp forest (39.22%), 26 in rice fields (25.49%), 15 in fruit orchards (14.70%), 10 in coconut fields (9.80%) and others (10.78%). All the houses were close to the larval habitats presented in the survey. A 2-km buffer zone around the conservation boundary of primary peat swamp forest was created to locate risk areas of filariasis transmission. The buffer zone covered an area of 544.11 km^2 and included 88.89% of the houses of infected cases found in 2002. It was able to identify 54 villages located in the buffer area, which might help in the determination of resource needs and resource allocation for filariasis control in Narathiwat Province.

INTRODUCTION

Filariasis is still a health problem in some rural areas of Thailand. The microfilarial positive rate was reduced from 3.16% in 1961 to less than 0.05% in 2001, owing to the success of the filariasis control program, as indicated in the annual report for the national program to eliminate lymphatic filariasis of Thailand (Ministry of Public Health, 2002). At present, the highest microfilarial rates 27.14 and 20.03 cases per 100,000 population, were found in Tak and Narathiwat for Bancroftian and brugian filariasis, respectively. Endemic foci, with microfilarial positive rates of at least 0.2%, remain in 323 villages of eight provinces, including Kanchanaburi, Krabi, Lamphun, Mae Hong Son, Nakhon Si Thammarat, Narathiwat, Surat Thani and Tak. Thailand joined the "global elimination of lymphatic filariasis" initiated by the World Health Organization (WHO) in 2001. Therefore, it requires detailed maps for initial assessment and monitoring effectiveness of the elimination programs, as recommended by WHO (2000). The maps will be utilized to display spatial variation in infection prevalences at local geographical scales and prioritization of target areas for intervention. At present, the Geographical Information System (GIS) computer software with built-in mapping tools, has made the construction of such maps considerably less complicated. The main aim of the present study is to assemble endemicity maps of brugian filariasis in Narathiwat Province at the subdistrict level using a GIS, available published and unpublished survey data, and data of the geo-registered locations of houses of infected people.

Correspondence: Chamnarn Apiwathnasorn, Department of Medical Entomology, Faculty of Tropical Medicine, Mahidol University, 420/6 Rajvithi Road, Bangkok 10400, Thailand. Tel: 66 (0) 246 9000 ext 1575; Fax: 66 (0) 2246 8340 E-mail: tmcaw@mahidol.ac.th

MATERIALS AND METHODS

Study site

Narathiwat (Fig 1) is the southernmost Thai coastal province facing the Gulf of Thailand and borders on Pattani to the north, Kelantan State of Malaysia to the south, Yala to the east and the Indian Ocean to the west. The provincial capital is 1,437 km south of Bangkok by road, and 1,116 km by train. The province covers some 4,475 km^2, two thirds of which are forested mountains. The province is noted as a land of gold mines and boasts extensive peat swamp forests, as well

as seaside resorts along the coast of the lndian Ocean. Narathiwat is administratively divided into 13 districts: Mueang Narathiwat, Bacho, Chanae, Ra-ngae, Rueso, Si Sakhon, Sukhirin, Su-ngai Kolok, Su-ngai Padi, Tak Bai, Waeng, Yi-ngo, and Cho-airong.

It has a total population of 690,001 with a ratio of 1:1 male to female (As of 31 December 2001). The inhabitants of Narathiwat are mainly of Thai nationality (99.8%) being Muslim (88.2%) and Buddhist (17.9%). Average household size is 4.6. They are largely farmers and fishermen, with 56.3% in the agricultural sector. Migration of people in Narathiwat is uncommon. The percentage of the population who migrated within the 5 years 1995-2000 was merely 3.2%, and the population not living in the province of birth was 9.7%. 24.6% lived in municipal areas.

In 1963, Wongsathuaythong *et al* investigated elephantiasis in Narathiwat Province and reported a 7.3% infection rate among the 1,535 people examined. At present, Narathiwat remains an important endemic focus of the subperiodic form of brugian filariasis, owing to the presence of peat swamp forest as a source of reservoir hosts and breeding places.

Data sources for filariasis database

The microfilarial rate and mosquito biting density estimates derived here were mainly obtained from the filariasis investigations at village level performed by the Division of Filariasis Control and published as annual reports, during the period 1985-1999. The infection rates were presented as microfilarial slide positive rates (generally based on 20 μl samples of night blood from each investigated community). The mosquito data were presented as the number of mosquitos per 10 persons collected in many villages in epidemiological investigations. The subdistrict-level data were principally of filarial endemicity (infection rates) and biting densities and distribution of *Mansonia* vectors. All attribute data, including microfilarial infective rates, vector biting densities, population size, and number of houses, were stored in a MS Excel spreadsheet and were then transferred to the relational database management system within the GIS, for visualization of filariasis distribution and characteristics.

Fig 1- Map of Thailand showing Narathiwat Province.

In addition, data on the house locations of infected cases and the surveyed points (positive and negative sites) of the vector breeding places were geo-registered. The positions were mapped using a Garmin GPS 12XL instrument. The location data were placed into the subdistrict boundaries as scattered dots on the base maps.

Subdistrict-level digital maps of Narathiwat, created by MapInfo (scale 1:50,000), Landsat's Thematic Mapper (TM) 5 and the land use map were used as base maps for undertaking the present study. Maps of subdistrict-level endemicity, including distribution and prevalence rates of microfilaremia, were constructed, managed and visualized in shading the range of infection to display the distribution pattern of the filariasis foci.

GIS software

Maps of filariasis distribution and characteristics were made in the GIS MapInfo Professional version 7 with base maps of Narathiwat Province at subdistrict level (scale 1:50,000), a product of Lotus Consulting International Co Ltd.

RESULTS AND DISCUSSION

Maps of filariasis distribution in Narathiwat at the subdistrict level

Lymphatic filariasis in Narathiwat appears to be a particular problem of the eastern part of the province. Surveys of brugian filariasis have been conducted in 187 villages of 77 subdistricts. The population in each village is greatly varied, from 131 to 1,531 per village during the study period. Blood examinations for the parasites were determined in more than 100,000

Table 1
Record of microfilarial positive rates at village level in subdistrict with high prevalence.

Village No.	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Puyo subdistrict														
4	3.46	ND	ND	3.86	ND	ND	ND	0.69	ND	1.47	0.21	0	ND	0.84
5	8.25	ND	ND	6.25	3.45	ND	ND	0	ND	0	1.96	1.02	0.88	0
Su-ngai Padi subdistrict														
1	ND	2.96	ND	1.15	ND	2.3	ND	1.61	ND	1.26	0.44	0.22	ND	0
7	ND	2.76	ND	3.03	ND	2.94	ND	1.27	ND	3.55	3.35	1.44	0.72	0
8	ND	4.41	ND	1.73	ND	0.59	ND	1.84	ND	1.04	2.42	0	0	ND
10	ND	ND	ND	ND	ND	ND	ND	ND	0	5.62	2.44	0	0	2.38
Bang Khun Thong subdistrict														
1	ND	ND	3.16	0.23	ND	0.9	ND	0.84	ND	0.79	0.72	0.42	0.41	ND
6	ND	ND	4.72	3.79	ND	0.28	ND	ND	ND	0.99	0.29	ND	0.45	ND
Kaluwo subdistrict														
4	ND	1.76	ND	1.03	0.42	ND	0.21	ND	0.23	ND	0.87	0	ND	0.21
6	ND	1.24	ND	2.37	1.22	ND	1.34	ND	0.97	0.84	0	0	ND	0
Paluru subdistrict														
5	1.61	ND	ND	0.73	ND	0.8	0.78	ND	0.78	0.69	0.19	ND	0	0
6	1.76	ND	ND	1.11	ND	0.29	0.83	ND	1.78	1.79	0	ND	ND	0
7	1.31	ND	ND	1.24	ND	0.21	0.52	ND	0.36	0.36	0	ND	0.70	0.19

ND = not determined

people, which accounted for 75.92-98.82% coverage of the total population. The maps of filariasis distribution by subdistrict over the past 10 years are presented in Fig 2. It appears that the observed pattern of endemicity was not stable until 1990, with new foci of low and high endemicity reporting each year. The number of subdistricts found to be endemic for filariasis transmission rose steadily, from 1 in 1985 to 11 subdistricts in 1988. As survey coverage increased, 9 additional subdistrict foci were discovered in 1989. As of 1985-1990, filariasis was endemic in 14 subdistricts. Since 1990, investigations were limited to areas of high endemicity in the eastern part of the province.

Filariasis was endemic in 136 villages within the 35 subdistricts investigated during the period 1985 to 1999, with average microfilarial rates ranging from 0.02 in Kaluwo Nua and Lochut subdistricts to 2.42 in Puyo subdistrict. However, microfilarial rates at village level ranged from 0.07 in Chuap to as high as 8.25 in Puyo subdistrict. The maps indicate that a marked decrease in infection rates has occurred in all filariasis foci but the distribution was confined to the eastern part where 9 subdistricts (Bang Khunthong, Kaluwo, Paluru, Pasemat, Phron, Puyo, Sala Mai, Su-ngai Padi, and Tapoyo) remained endemic foci of filariasis. In 1999, infection rate ranged from 0.08 in Sala Mai to 0.42% in Su-ngai Padi. Many villages with high prevalence were regularly investigated and control program was provided continuously by the Division of Filariasis Control so that the prevalence was decreased obviously within 5 years after the foci discovered. Nevertheless it seemed that filariasis infection would be recovered within few years after the prevalence rate was decreased to 0% as seen in some villages of Puyo (4 and 5), Su-ngai Padi (10), Kaluwo (4) and Paluru (7) where located around the primary peat swamp forest (Table 1). This would be an evidence for further confirmative study on the disease resurrection and consideration in planning surveillance program particular for the foci nearby conservative peat swamp forest.

House locations of infected people investigated during 1995-2002 and larval positive collection sites of *Mansonia* mosquitos were geo-registered and overlayed on satellite image of Narathiwat taken by Landsat Thematic Mapper 5 (RGB) in the filariasis GIS system, to determine their distribution pattern. There were 113 houses, of which 11 were located in new foci around Bacho swamp forest in the northern

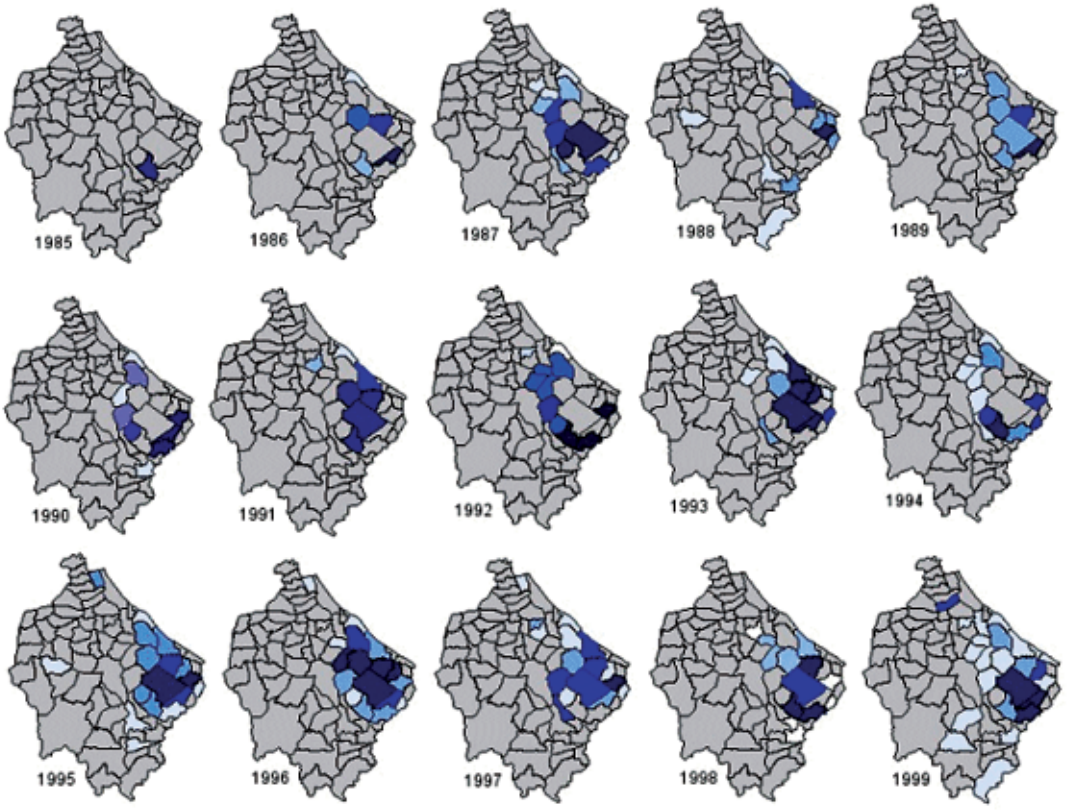

Fig 2- GIS maps showing annual investigations of brugian filariasis in Narathiwat Province 1985-1999. (blue = endemic foci; grey = no data)

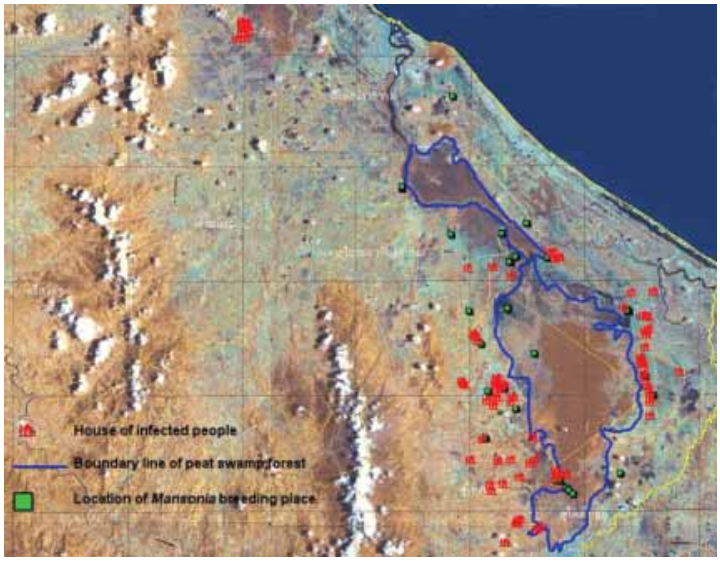

Fig 3- Distribution of houses of the filariasis-infected people and *Mansonia* breeding places overlaid on the Landsat TM 5 image of Narathiwat Province.

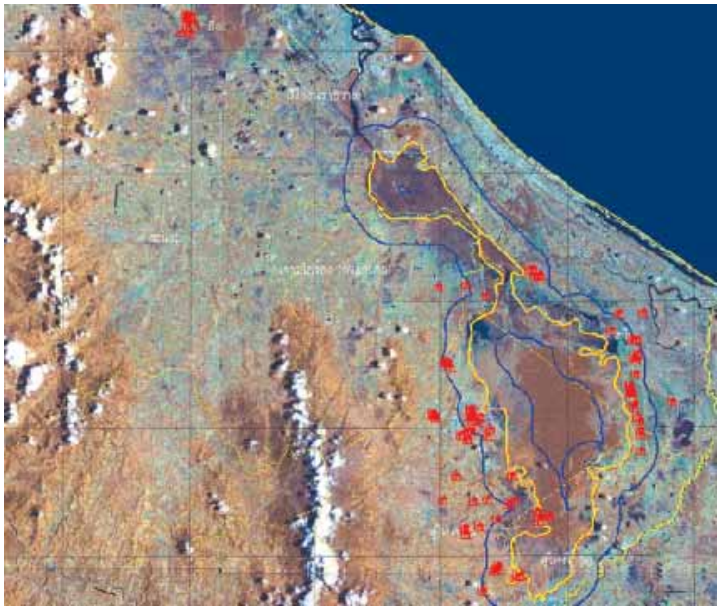

Fig 4- Risk area of brugian filariasis created by GIS.

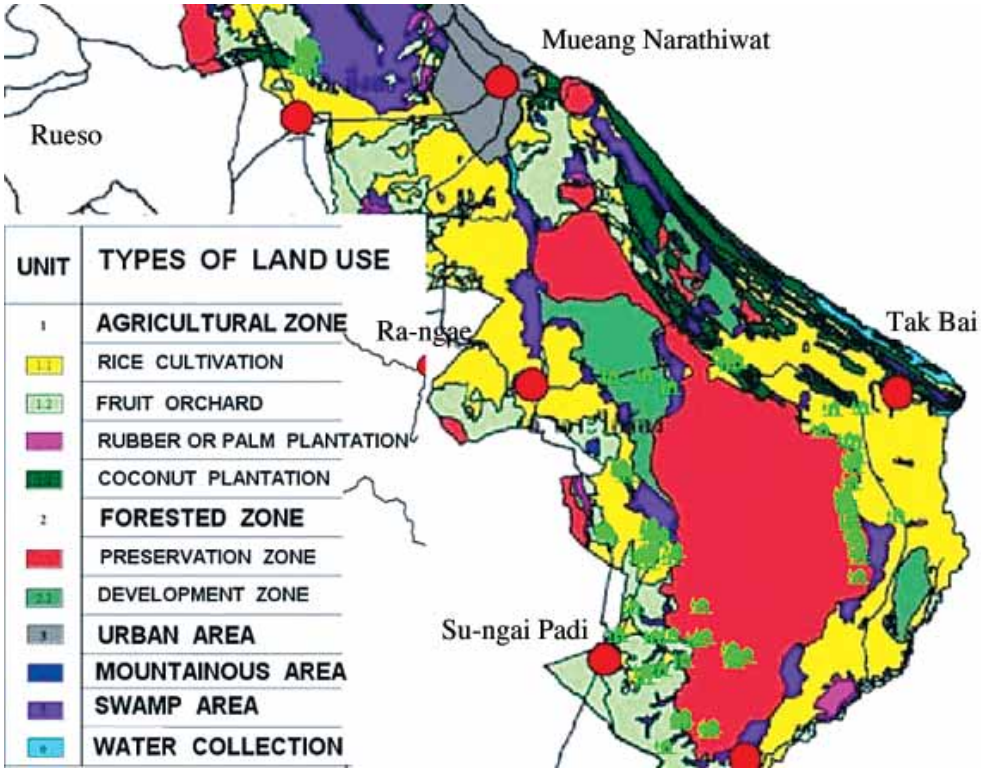

Fig 5- Distribution of houses of infected people over land-use map.

part of the province. The map revealed that the houses were distributed around forest conservation area of Toh Daeng peat swamp forest and close to *Mansonia* breeding places as shown in Fig 3. By adding the border boundary of the peat swamp forest, and using the Mapinfo ruler tool, the distance from the houses to the peat swamp forest was found to vary from 0-4.5 km.

The risk area was then constructed by using the boundary of the conservation forest area of peat swamp forest and the flight range of *Mansonia* (2 km) as the distance parameter (Fig 4). The risk area was 386.06 km^2 and covered 15 subdistricts, Lam Phu, Bang Po, Chuap, Marubo Tawanok, Phraiwan, Bang Khunthong, Su-ngai Padi, Phron, Kosit, Pu Yo, Paluru, Pasemat, Kawa and Su-ngai Kolok. It was found that 79 of 102 houses (77.45%) were within this risk area. In addition, 54 villages of 11 subdistricts were located in the risk area. Among the 15 subdistricts within the risk area, 4 subdistricts (Lam Phu, Chuap, Marubo Tawanok and Su-ngai Kolok) had no villages. The population at risk was calculated by multiplying the population density with the risk area of each subdistrict. Excluding the four subdistricts mentioned above, the total population at risk was estimated to be 43,370. The Division of Filariasis Control reported, in 2001, that there were 108 villages of six provinces (Narathiwat, Pattani, Nakhon Si Thammarat, Krabi and Surat Thani) with approximately 81,000 population living in the risk area. Hence, our estimated figure represents half of the total population at risk of brugian filariasis for the whole country. The map of the risk area might help in the determination of budget, resource needs and allocation for filariasis control in this risk area of Narathiwat Province.

When the land use map was used instead of Landsat TM 5, it revealed that people who became infected lived either in swamp forest or agricultural areas at the ratio 1:1.1 (Fig 5). Of 102 houses mapped, 40 were located in primary swamp forest (39.22%), 26 in rice fields (25.49%), 15 in fruit orchards (14.70%), 10 in coconut plantations (9.80%), and others (10.78%). The Division of Filariasis Control reported that fishing in the peat swamp forest and in rubber plantations were occupations at risk among people living in and around the swamp forest.

In conclusion, GIS for filariasis transmission in Narathiwat demonstrated : annual investigation of brugian filariasis, 1985-1999; success in filariasis control, 1985-1999; evidence of re-emergence of filariasis infection in some endemic foci; distribution of endemic foci around primary peat swamp forest; land use and filariasis endemic foci; risk area constructed by GIS system; estimated population at risk; number of villages within the risk area; and distribution and biting density of mosquito vectors.

Summary of GIS structure for mapping filariasis

Attribute data

Database: Microfilarial positive rate (MPR) at subdistrict level.

Locations: Total houses with filariasis cases (1990-2002); data of 2002 includes age and sex of cases. *Mansonia* breeding places from survey collections.

Census: Total population: male, female, total houses.

Base map

Vector type: Narathiwat Province at subdistrict level, scale 1:50,000. Border boundary of conservation forest area of peat swamp forest.

Raster type: Satellite images of Narathiwat Province and primary peat swamp forest by Landsat 5 Thematic Mapper (RGB) in May, 1997. Land-use map of the Land Development Department, Ministry of Agriculture and Cooperatives, Thailand, scale 1:290,000.

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