RELATIONSHIP BETWEEN MALE HYDROCELE AND INFECTION PREVALENCES IN CLUSTERED COMMUNITIES WITH UNCERTAIN TRANSMISSION OF *WUCHERERIA BANCROFTI* ON THE THAILAND-MYANMAR BORDER

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Abstract. A cross-sectional community-based study was conducted in three clustered communities, belonging to a single small village in Mae Chan subdistrict, Umphang district, Tak Province, close to the Thailand-Myanmar border, where regular night blood survey have been discontinued since 1997 and no epidemiological study had been conducted. In order to understand prevalences of distribution of male hydrocele and infection in clinically diagnostic and epidemiologic implications in uncertain transmission of *Wuchereria bancrofti*, we analyzed the relationship between male hydrocele and community infection prevalences in 219 (90.5% coverage) subjects aged ≥1 year old, including 54.8% migratory and 45.2% local Karen inhabitants. Migratory inhabitants tended to have high prevalence of antigenemia ($p < 0.05$) and hydrocele. Overall rates of 23.7% antigenemia, 3.7% microfilaremia, and 4.6% male hydrocele were observed. Male hydrocele prevalence was significantly correlated ($r = 0.348$, $p < 0.0001$) with antigenemia prevalence, but not with microfilaremia prevalence ($r = 0.065$, $p = 0.493$). However, high antigenemia prevalence in local inhabitants was evident, particularly antigenemia prevalence in children suggesting that transmission in the village may have occurred in recent years.

INTRODUCTION

In previously cross-sectional community surveys in 1998 in Mae Chan subdistrict, Umphang district, Tak Province, Thailand, which is endemic for nocturnally subperiodic *Wuchereria bancrofti* (Bhumiratana *et al*, 1999; Bhumiratana, 2001a), microfilaremia prevalence tended to be higher than cumulative microfilaremia prevalence observed by regular night blood survey in 1997 (Filariasis Division, 1998a). Furthermore, endemic Karen carriers crossing the Thailand-Myanmar border were recognized as clinically symptomatic and microfilaremic. A cross-sectional community-based study in 1998 (Bhumiratana *et al*, 1999) showed that, among surveyed subjects, male hydrocele prevalence was correlated with microfilaremia prevalence ($r = 0.297$, $p < 0.001$) and with antigenemia prevalence ($r = 0.325$, $p < 0.001$) (unpublished data). The relationship between prevalence of infection (either antigenemic or microfilaremic) and disease (hydrocele considered as the most common pathologic manifestation in males older than 30 years) might be responsible for static transmission of rural bancroftian filariasis foci that are mostly confined to the border areas in Tak, Mae Hong Son and Kanchanaburi Provinces (Filariasis Division, 1998a; 1999). Also, in static transmission, endemic individuals might have

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regular exposure to the infectious bites (*eg* L3 doses) and gradually develop uniform pathologic manifestations as a result of continuously prolonged infection exposure. This may indicate risk of increased numbers of infective mosquitos and increased human infection *per se* (Bhumiratana *et al*, 2001b) and cumulative prevalence of antigenemia, microfilaremia is indicative of chronic bancroftian filariasis.

However, in the affected areas, such prevalence may not be a true indication of infection, or responsible for filarial endemicity due to underlying circumstances, *ie* movement of migratory Karen carriers cross the border from Myanmar, transmigration of local Karen inhabitants from one endemic area to another. On the other hand, in dynamic transmission, individuals with irregular exposure to L3 larvae should develop unlikely immunity to infection and clinical consequence is not uniform in a population (Das *et al*, 1994). Positive correlation of infection and hydrocele prevalences among surveyed subjects may be caused by selection bias that recruited high risk groups with clinical microfilaremia or antigenemia, with a few years of residency in the affected villages. Understanding the picture of current disease transmission along the border in affected areas would help to provide a logistical approach to screening sentinel populations with rapid epidemiological assessment tools applied to identify areas for targetting community-wide mass treatment under the national program for the elimination of lymphatic filariasis (PELF) (Bhumiratana, 2001a; WHO, 1999).

Therefore, in order to understand infection and disease profiles in a dynamic Karen population, we conducted a cross-sectional community-based study in a single small village with uncertain transmission in Mae Chan subdistrict, where night blood survey and selective treatment with diethylcarbamazine citrate (DEC) had been discontinued since 1997 and no epidemiological study had been conducted. Using physical examination of males for hydroceles, hydrocele prevalence was analyzed to ascertain whether or not it was associated with microfilaremia and antigenemia prevalence at the individual level, using blood examinations for circulating microfilariae (with conventional thick blood film) and circulating antigen (with ICT Filariasis) of *W. bancrofti*.

MATERIALS AND METHODS

Study area and population recruitment

The study was carried out in June 1999 in a village, Kuiloeto, in Mae Chan subdistrict, 72 km southwest of Umphang district, Tak Province, Thailand. The district (of 4,325 km^2 area), 249 km southwest of Tak or 668 km northwest of Bangkok, is located at above 460 msl, at latitude 16°22′N to 15°13′N and longitude 99°3′E to 98°37′E; and the west is bound by the border (180 km long). The subdistrict, where a very high level of seasonal malaria transmission is known to occur regularly, is co-endemic for nocturnally subperiodic *W. bancrofti*. Three clustered communities (namely TM6A, TM6B, TM6C) belonging to Kuiloeto village where microfilaremia rate was reported to be ≥ 0.6% (Filariasis Division, 1998a) were selected as study sites (2 km^2 area). Active case detection for every single family was performed with assistance of a multidisciplinary survey team from the Filariasis Division and Vector Borne Disease Control Center 18 (Mae Sot), Tak Province.

The total population was 290 excluding persons aged < 1 year (n = 11), those aged ≥ 1 year who did not consent to participate (n = 23) or those who stayed outside the village (n = 37). Of the 242 aged ≥ 1 year who resided in the village during the study, 219 (90.5% coverage) including 113 males and 106 females were recruited. Information on sex, age, years of residency and history of microfilaremic infection, DEC treatment or clinical illness due to bancroftian filariasis, was collected by a local well-trained Karen field worker, using a standard performa which was used to record data from physical examination. Also an informal filarial survey of key informants (including community leaders, tra-

ditional healers, heads (husbands or wives) of families and village health and/or malaria volunteers) was performed using direct questionnaire (WHO, 1998). All were physically examined in the day time for clinical filariasis (WHO, 1992a;b), and followed-up at night for blood microfilariae and antigen. Only male subjects were further examined for the presence of swelling of the external genitalia so as to analyze association between infection and disease. Informed consent was obtained from all study subjects; for children this was obtained from their parents. All microfilaremic subjects were subsequently given by two rounds of a single oral dose of 6 mg/kg DEC per annum, a regimen used for transmission control in the area (Filariasis Division, 1998b). Ethical clearance was approved by the Filariasis Division, Department of Communicable Disease Control, Ministry of Public Health.

According to movement of Karen populations in the area, residency was defined as years of stay at the time of data collection of study subjects residing in their domicile communities at the study sites without travel history outside the subdistrict for the past 3 years. Study subjects with years of residency fell into 4 categories: 1) local inhabitants who traveled within the study boundary had residency as years of ages, 2) local inhabitants who traveled during the past 3 years outside the study boundary had residency defined as years of age minus years of stay elsewhere, 3) migratory inhabitants who traveled into the study boundary had residency defined as years of age minus years of age at the time of immigration into the community, and 4) migratory inhabitants who traveled over a period of past 3 years outside the study boundary had residency defined as years of age minus years of age at the time of immigration into the community and years of stay elsewhere.

Physical examination for male hydrocele

Physical examination and comprehensive history of male hydrocele, based on experience gained from previous study during cross-sectional community surveys (Bhumiratana *et al*, 1999) were used for diagnosis of a scrotal mass (Goodson, 1981; WHO, 1992b). Reliability of physical examination of the male external genitalia was based on the judgement of intra-observer variations for each study site. It was based on palpation of an abnormal mass within the scrotal cavity. Hydroceles as scrotal nodules (both unilateral and bilateral) in the child or the adult were examined for their mass, size (grades 1 to 3), location (ventral, superior or anterior to the testicle) and consistency, in both supine and erect positions. Illness history was recorded as well as duration of the mass discovered by self-examination and prior medical management. Finally, all male subjects positive for hydroceles were tested as to whether or not the mass could be transilluminated. Torsion of the testicle and testicular appendix, tumors and mumps orchitis were among the masses considered for further exploration if the index of suspicion was high.

Blood examinations of *W. bancrofti* circulating microfilariae and antigen

Examination of night finger-prick blood samples taken from each individual between 19.00 and 24.00 hours, was performed double-blind. For thick smear, a 60-μl blood was smeared on a microscopic slide, air-dried, stained with Giemsa's stain in the field, and transferred afterwards to the laboratory. The result was read only after examination of the whole blood smear for microfilariae by an expert microscopist. For ICT Filariasis (AMRAD ICT, French's Forest NSW, Australia), qualitative detection of circulating antigen of *W. bancrofti* adult worm was performed according to the manufacturer's instruction. Briefly, a 100-μl blood was added to the white area of the pad which allowed the blood to clot and the serum diffused to the pink area of the pad, where specific polyclonal antibody (PAb) gold conjugate was immobilized. When closing the card test, the serum sample and PAb gold conjugate on the pink area of the pad were transferred to come in contact with the end of the membrane and then migrated along the membrane, crossing the immobilized monoclonal antibody line (referred to as test), which specifically

captured the antigen complexed with PAb gold conjugate. Clear-cut results were read within 45 minutes of closing the card by an experienced team familiar with the test.

Data analysis and statistical methods

Results for principal outcomes, characteristics of the 219 study subjects from the three clustered communities and prevalences of infection and disease, were presented as the proportion of the study subjects, *ie* with antigenemia, microfilaremia and hydrocele, and in analysis of infection and hydrocele prevalence and characteristics, mean ± SD and range were also presented. Differences between percentages were tested by chi-square test or Fisher's exact test as appropriate ($p < 0.05$). Correlation between prevalences of infection and hydrocele in individual males was estimated by Spearman rank correlation coefficient *r* (Munro, 1997), for two-sided tests at significant level ($\alpha = 0.01$).

RESULTS

General description

The 219 recruited subjects were 1 to 80 years of age (mean ± SD = 24.1 ± 17.7 years); had 1 to 80 years of residency (mean ± SD = 13.2 ± l6.3 years); had 1 to 12 family members (mean ± SD = 5.2 ± 2.0 persons); being 42 (19.2%) with history of DEC treatment; being 11 (50%) with history of bancroftian filariasis (Table 1). The study subjects tended to have residency longer than 3 years (χ^2 =

Table 1
Principle characteristics of the 219 study subjects from the three clustered communities.

Characteristics	Total subjects (n = 219)	Study village			p-value
		TM6A (n = 136) (%)	TM6B (n = 32) (%)	TM6C (n = 51) (%)	
Sex					
Male	113	71 (62.8)	15 (13.3)	27 (23.9)	0.84
Female	106	65 (61.3)	17 (16.1)	24 (22.6)	
Age (years)					
1 - 15	88	55 (62.5)	11 (12.5)	22 (25.0)	0.727
> 15	131	81 (61.8)	21 (16.0)	29 (22.2)	
Mean ± SD	24.1 ± 17.7	23.9 ± 17.6	26.1 ± 18.2	23.3 ± 17.8	
Min-Max	1 - 80	1 - 80	2 - 72	1.4 - 75	
Residency (years)					
≤ 3	51	24 (47.1)	12 (23.5)	15 (29.4)	0.029[a]
> 3	168	112 (66.7)	20 (11.9)	36 (21.4)	
Mean ± SD	13.2 ± 16.3	14.8 ± 16.3	13.1 ± 18.0	9.2 ± 14.8	
Min-Max	1 - 80	1 - 80	1 - 72	1.4 - 65	
Family members (persons)					
< 5	75	54 (72.0)	10 (13.3)	11 (14.7)	0.062
≥ 5	114	82 (71.9)	22 (19.3)	40 (35.1)	
Mean ± SD	5.2 ± 2.0	4.8 ± 1.5	5.9 ± 3.2	5.9 ± 2.3	
Min-Max	1 - 12	1 - 7	2 - 12	1 - 10	
History of DEC treatment					
Yes	42	39 (92.9)	1 (2.4)	2 (4.8)	<0.001[a]
No	177	97 (54.8)	31 (17.5)	49 (27.7)	
History of bancrofitian filariasis					
Yes	11	10 (90.9)	1 (9.1)	0	-
No	208	126 (60.6)	31 (14.9)	51 (24.5)	

[a]Significant difference for χ^2 test ($p < 0.05$).

7.11, p = 0.029) and no history of DEC treatment (χ^2 = 20.9, p < 0.001). Among the 219 subjects, most (61.2%) resided in the community, TM6A. Of the 219, there were 120 migratory inhabitants of 4 to 75 years of age (mean ± SD = 29.4 ± 11.7 years) and with 1 to 35 years of residency (mean ± SD = 8.9 ± 18.6 years); there were 99 local inhabitants with 1 to 80 years (mean ± SD = 24.7 ± 16.2 years), with 1 to 80 years of residency (mean ± SD = 19.8 ± 16.7 years).

Infection and hydrocele prevalence

Of the 219 subjects who were parasitologically, serologically and physically examined, there were 8 (3.7%) microfilaremic subjects, 52 (23.7%) antigenemic subjects and 10 (4.6%) hydrocele subjects (Table 2). Of the 120 migratory subjects, there were 39 (32.5%) antigenemic subjects, 7 (5.8%) microfilaremic subjects and 10 (8.3%) hydrocele subjects. Of the 99 local inhabitants, there were 13 (13.1%) antigenemic subjects and only one microfilaremic subject (1%). Migratory inhabitants tended to have high prevalence of antigenemia (χ^2 = 8.76, p = 0.003) and hydrocele, whereas microfilaremia was similar in both groups (Fisher's exact test, p = 0.075).

Table 2
Infection and hydrocele prevalences in relation to age and sex distrubution in the 219 subjects from the three clustered communities.

Study village	Sex	Study subjects examined	Antigenemia prevalence (%)			Microfilaremia prevalence (%)			Hydrocele prevalence (%)		
			≤15 yrs	>15 yrs	Total	≤15 yrs	>15 yrs	Total	≤15 yrs	>15 yrs	Total
All	Male	113	2	24	26 (23.0)[b]	0	6	6 (5.3)[b]	0	10	10 (8.9)
	Female	106	5	21	26 (24.5)[b]	0	2	2 (1.9)[b]	0	0	0
	Total	219	7 (3.2)[a]	45 (20.6)[a]	52 (23.7)	0	8 (3.7)	8 (3.7)	0	10 (4.6)	10 (4.6)
TM6A	Male	71	2	13	15 (21.1)	0	4	4 (5.6)	0	6	6 (8.5)
	Female	65	3	6	9 (13.9)	0	1	1 (1.5)	0	0	0
	Total	136	5 (3.7)	19 (14.0)	24 (17.7)	0	5 (3.7)	5 (3.7)	0	6 (4.4)	6 (4.4)
TM6B	Male	15	0	6	6 (40.0)	0	1	1 (96.7)	0	2	2 (13.3)
	Female	17	1	6	7 (41.2)	0	0	0	0	0	0
	Total	32	1 (3.1)	12 (37.5)	13 (40.6)	0	1 (3.1)	1 (3.1)	0	2 (6.3)	2 (6.3)
TM6C	Male	27	0	5	5 (18.5)	0	1	1 (3.7)	0	2	2 (7.4)
	Female	24	1	9	10 (41.7)	0	1	1 (4.2)	0	0	0
	Total	51	1 (2.0)	14 (27.5)	15 (29.4)	0	2 (3.9)	2 (3.9)	0	2 (3.9)	2 (3.9)

[a]Significant difference for χ^2 test (p < 0.05).
[b]No significant difference for neither χ^2 test nor Fisher's exact test (p < 0.05).

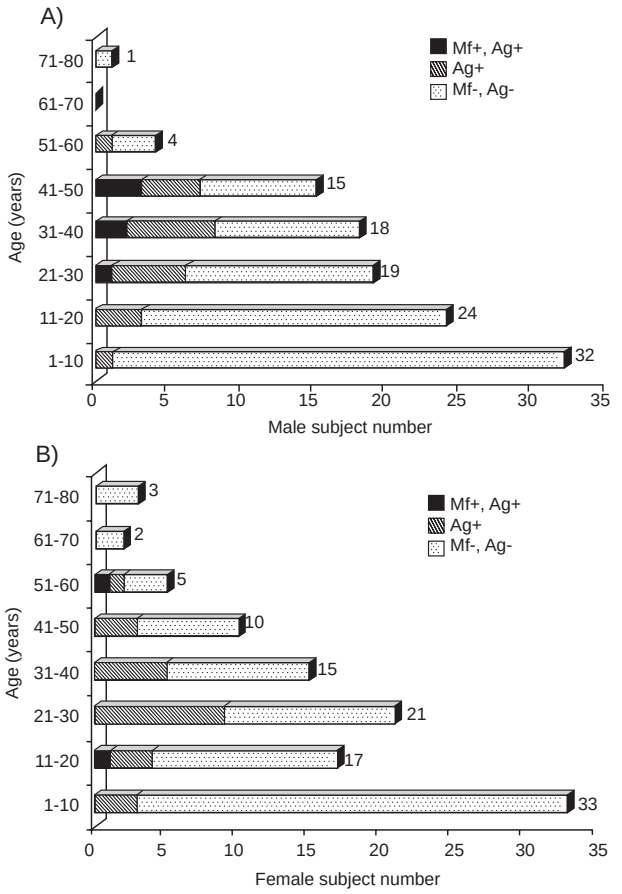

Fig 1–Prevalences of antigenemia and microfilaremia in relation to age- and sex- distribution in the 219 study subjects (A and B). The legends showed 3 groups of the study subjects: l) amicrofilaremic (Mf-), non-antigenemic (Ag-) subjects (▨); 2) antigenemic (Ag+) subjects (▧); 3) microfilaremic (Mf+), antigenemic (Ag+) subjects (■).

Microfilaremia prevalence was age-dependent: 18 to 60 years, mean ± SD = 39.5 ± 13.7 years, and sex-dependent: 6 (5.3%) males and 2 (1.9%) females (Table 2 and Fig 1). In all surveyed communities, microfilaremic subjects tended to be older than 15 years of age but were, however, similar for both sexes (Fisher's exact test, p = 0.282) (Table 2). Antigenemia prevalence was age-dependent: 1.5 to 60 years, mean ± SD = 31.4 ± 13.9 years, but similar for both sexes: 26 (23.0%) males and 26 (24.5%) females (Table 2 and Fig l). In all surveyed communities, antigenemic subjects tended to be older than 15 years of age (χ^2 = 18.23, p < 0.001) but were, however, similar for both sexes (χ^2 = 0.01, p = 0.916) (Table 2).

Hydrocele prevalence was age-dependent: 27 to 50 years, mean ± SD = 39.3 ± 6.2 years and specific for migratory adult males with residency of 1 to 25 years, mean ± SD = 6.2 ± 7.4 years (Tables 2, 3). In order to estimate correlation between hydrocele and infection prevalence in individual males, significant differences in either antigenemia or microfilaremia prevalence between male groups were analyzed. Of the 113 male subjects, there was significant difference in antigenemia prevalence between hydrocele males [7 (70%) of 10 males] and non hydrocele males [19 (15.4%) of 103 males] (Fisher's exact test, p = 0.001) (Table 4). There was no significant difference in microfilaremia prevalence between two groups; 1(10%) of 10 hydrocele males and 5 (4.8%) of 103 non hydrocele males (Fisher's exact test, p = 0.434) (Table 4). Similarly, male hydrocele prevalence was significantly correlated with antigenemia prevalence (r = 0.348, p = 0.001), whereas it was not correlated with microfilaremia prevalence (r = 0.065, p = 0.493) (Table 4).

Hydroceles of varying size (5 to 10 cm, mean ± SD = 6.3 ± 1.4 cm) in the adult males mostly were unilateral scrotal nodules (90%), 10% were bilateral, and were nontender, transilluminated (Table 3). Of these, 3 (of grade 2 and grade 1 hydroceles) were neither antigenemic nor microfilaremic. None had a known history of microfilarial infection and/or DEC treatment, of acute inflammation of the testicles, of sexually transmitted diseases except one, 42 years old male with grade 1 hydrocele had a past history of chyluria for years and an abnormal penis with nodules (Fig 2).

DISCUSSION

In prior community surveys in endemic villages in Mae Chan subdistrict, microfilare-

Table 3
Demographic and physical findings of the male hydrocele subjects (n = 10).

I.D. code	Age (years)	Residency (years)	Infection intensity per family (% antigenemia rate)[a]	Blood examination		Duration of the hydrocele discovered (years)	Size (cm in Y axis)	Past history of *W. bancrofti* infection
				Mf	Ag			
TM6A99119	45	1	2/4 (50)	Neg	Pos	5	6	No
TM6A99128	42	13	1/7 (14)	Neg	Neg	8	6	Chyluria
TM6A99136	37	4	3/5 (60)	Pos	Pos	20	6	Microfilaremia[b]
TM6A99140	40	4	3/5 (60)	Neg	Pos	Unknown	6	No
TM6A99168	36	2	2/4 (50)	Neg	Pos	2	10	No
TM6A991130	35	25	0/1 (0)	Neg	Neg	5	7	No
TM6B991139	50	2	2/4 (50)	Neg	Pos	Unknown	5	No
TM6B991143	41	3	2/4 (50)	Neg	Pos	3	6	No
TM6C991168	27	3	0/4 (0)	Neg	Neg	3	5	No
TM6C991177	40	3	3/5 (60)	Neg	Pos	22	6	No

Abbreviation: Ag = antigen, Mf = microfilaria, Neg = negative, Pos = positive.
[a]Antigenemia rate (%) in parentheses was derived from hydrocele subjects and their family members examined (antigen positive subject number/ total family members).
[b]DEC-treated over past one year.

Table 4
Relationship between male hydrocele and infection prevalences in the male subjects (n = 113).

Male hydrocele	Antigenemia			Microfilaremia		
	Present	Absent	Total	Present	Absent	Total
Present	7	3	10	1	9	10
Absent	19	84	103	5	98	103
Total	26	87	113	6	107	113

Table 5
Rapid assessment of community burden with bancroftian filariasis by key informants in the village.

Key informants	Subject no. (n = 51)	Villagers with hydroceles	
		Do not know	Know (Range of affected persons)[a]
Community leaders	6	2	4 (1 to 2)
Traditional healer	1	1	0
Heads of families	42	32	10 (1 to 2)
Village health and/or malaria volunteers	2	0	2 (2 to 3)

[a]One local inhabitant with hydrocele was not recruited into the study, whereas the others judged by key informants were hydrocele and recruited.

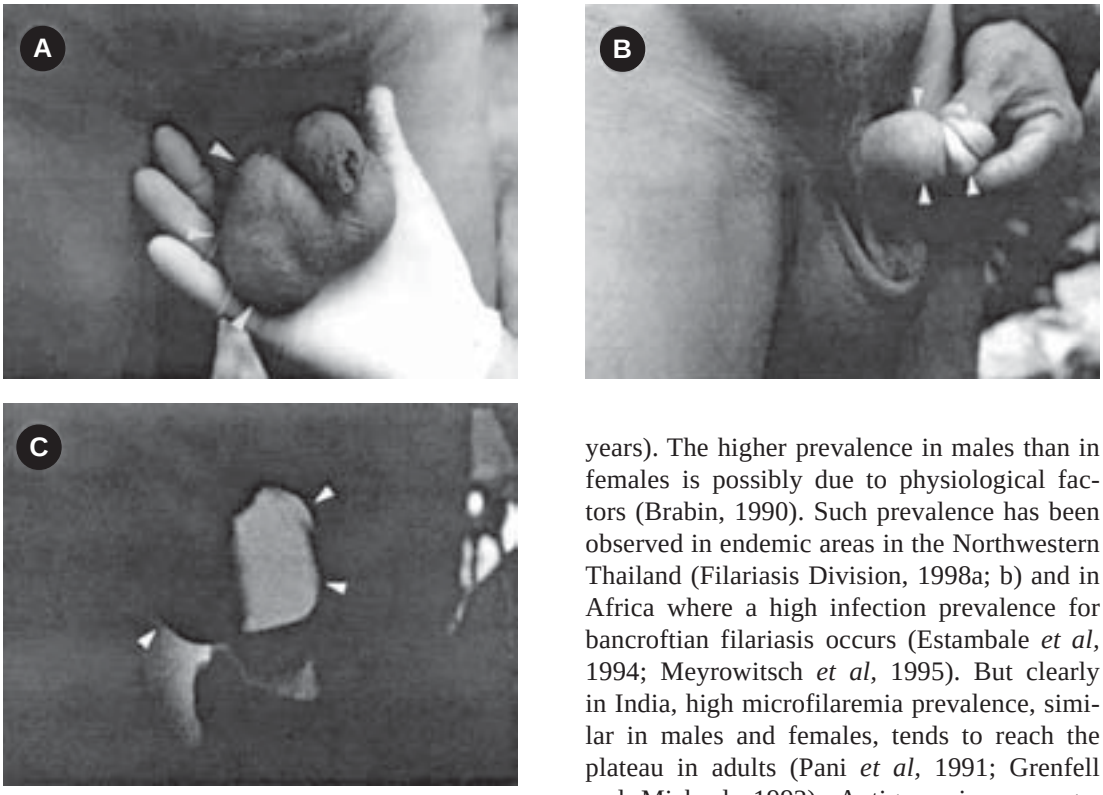

Fig 2–Acquired hydroceles in migratory male subjects. The typically unshaped, nontender and transilluminated hydroceles were considered as acquired to the *W. bancrofti* adult worm infection. The 37 years old subject (TM6A99136; A) of grade 1 unilateral hydrocele (dart) was microfilaremic, antigenemic and himself discovered the hydrocele for 20 years despite living in the village for 4 years. The 42 years old subject (TM6A99128; B) of grade 1 unilateral hydrocele with experience of chyluria was negative of circulating microfilariae and antigen of *W. bancrofti*. The abnormal penis with nontender nodules (dart) was evident. The 36 years old subject (TM6A99168; C) of grade 2 bilateral hydrocele (dart) was amicrofilaremic, antigenemic and, as long as he lived in the village, hydrocele was discovered by himself for 2 years.

mia was age- and sex-specific and was found in both asymptomatic and symptomatic cases (Bhumiratana *et al*, 1999). In the present study, microfilaremia prevalence did not change age-specific infection profile, *ie* increasing microfilaremia prevalence with increasing age (> 15 years). The higher prevalence in males than in females is possibly due to physiological factors (Brabin, 1990). Such prevalence has been observed in endemic areas in the Northwestern Thailand (Filariasis Division, 1998a; b) and in Africa where a high infection prevalence for bancroftian filariasis occurs (Estambale *et al*, 1994; Meyrowitsch *et al*, 1995). But clearly in India, high microfilaremia prevalence, similar in males and females, tends to reach the plateau in adults (Pani *et al*, 1991; Grenfell and Micheal, 1992). Antigenemia was age-dependent, but similar for both sexes, and was found in subjects with a broad spectrum of clinical manifestations (Bhumiratana *et al*, 1999). As well as microfilaremia prevalence observed in the village, antigenemia was responsible for the adulthood infection (≥ 15 years), even as early as 1 year old local children was recognized as antigenemic. However, antigenemia in children (amicrofilaremic) was considered to be a primary infection and may be responsible for transmission in the village. Antigenemia prevalence was also seen in adults older than 50 years of being tended to be low level. The evidents may be caused by low frequency of infection exposure in their previous lifetime resulting in low adult worm burden harboring in individuals. In other words, high antigenemia prevalence in adults, both males and females, than in children suggested that the adults possibly acquire repeated infection (Grenfell and Micheal, 1992). That is, antigenemic infection tends to be more dynamic for age-specific infection pattern, similar to microfilaremia prevalence in general (Grenfell and Micheal, 1992; Ramzy

et al, 1994). Therefore, epidemiological study of *W. bancrofti* infection in the area should focus on dynamic explanations for age-specific infection patterns.

Hydrocele in adult males is considered to be a common sign in bancroftian filariasis foci in endemic areas of the world (Pani *et al,* 1994; Meyrowitsch *et al,* 1995; Norões *et al,* 1996). It was a common chronic manifestation observed in the study village and other highly endemic villages in Mae Chan subdistrict (Bhumiratana *et al,* 1999). Hydrocele prevalence in males older than 30 years was age-dependent and particularly common in migratory subjects. Thus, most antigenemic (75%) and microfilaremic (87.5%) subjects were migratory inhabitants, rather than local inhabitants residing in the village. This vulnerable group seemed to affect overall prevalences of infection and disease in the village. Low microfilaremia prevalence (1%) and no hydrocele subjects were observed among local inhabitants in the study village, whereas only a high antigenemia prevalence was observed among local inhabitants, particularly children aged ≤15 years. A relationship between antigenemic infection, rather than microfilaremic infection, and hydrocele prevalence in individual males was shown. Therefore, it is suggested that cumulative antigenemia prevalence may be responsible for dynamic transmission in the area. Taken together, dynamic population and recrudescence of transmission possibly occurred in childhood in the village.

We suggest that, in transmission foci with low levels of microfilaria positive rate or MPR along the border, available selective or mass treatment with DEC can suppress the loading and mating patterns of the adult worms in individual infected persons or the populations at risk. Very low density of microfilariae was generally observed in all local microfilaremic subjects (Bhumiratana *et al,* 1999). Cryptic forms of *W. bancrofti* could not be elicited. Development of hydroceles in individual predisposed adult males could result from amicrofilaremic, antigenemic infection, rather than microfilaremic, antigenemic infection. There was evidence for a negative relationship between male hydrocele and microfilaremia prevalences. Therefore, in villages with low levels of microfilaremia prevalence but with high antigenemia prevalence, the loading and mating patterns of the adult worms in individuals may be responsible for hydrocele. It could be explained by a model of dynamic nature of immunity to infection and disease (Grenfell *et al,* 1991; Maizels and Lawrence, 1991; Ottesen, 1992; Grenfell and Micheal, 1992; Das *et al,* 1994). The early stages of infection are defined by hypo-immune responsiveness (resulting in immunotolerance) and asymptomatic microfilaremia, whereas the later stages are defined by hyper-immune responsiveness and amicrofilaremia with or without chronic pathology. Such hydroceles that develop in adult males with *W. bancrofti* may result either from a direct adult worm-mediated mechanism causing local damages, both function and anatomy, of the lymphatic vessel's insufficiency of the spermatic cord (Norões *et al,* 1996), or from the inflammatory process. It may finally result in decreased absorption of the tunica vaginalis.

Apart from dynamic transmission, in rapid geographical assessment of bancroftian filariasis epidemiology (RAGFIL), screening adult males for hydroceles has been used as a surrogate measure of microfilaremia prevalence in Ghana and India (WHO, 1998). In Ghana, male hydrocele prevalence in communities with high levels of transmission correlated ($r = 0.84$) with microfilaremia prevalence at community level (Gyapong *et al,* 1998; Gyapong, 1998). Furthermore, informal survey of knowledgeable community leaders also gave a good approximation of the level of infection, as well as clinical examination of filarial cases (Gyapong *et al,* 1996). However, hydrocele prevalence in communities with low levels of transmission (<5% microfilaremia rate) may not be a good measure of *W. bancrofti* infection since the manifestations unrecognized by the communities were considered to be negative (WHO, 1999). Our observations in the study village agreed with this when hydrocele occurrence within communities was not focused on by

knowledgeable community leaders or village health and/or malaria volunteers (Table 5). Also, hydrocele was considered to be either misdiagnosed or underestimated by peripheral health workers or field workers as night blood surveys for the control program in the areas was primarily done to identify endemic foci (with levels of MPR) (Bhumiratana *et al*, 2000; 2001b). Hydroceles in individual males were likely to be confused with their residency in the village. All acquired hydrocele subjects were considered to have readily morbid hydroceles before they immigrated into the village, as shown in Fig 2. In other words, all examined by our team were considered to have acquired the infection in their villages in Myanmar (~80 km west and northwest of Kuiloeto village; data collected by interviewing), which may be endemic for *W. bancrofti*. This may be a case, since their family members were antigenemic as shown in Table 3. Therefore, information on years of residency, as well as duration of hydroceles discovered in the subjects may be confounding factors that influence epidemiological study of risks of hydrocele-positive adult males in the uncertain transmission areas.

In conclusion, hydrocele prevalence may not be used as a diagnostic index for rapid assessment of the community burden with bancroftian filariasis and thereby it was likely to be poor estimate of the infection rate in the border areas where transmission is considered to be possible but not certain. The prevalence of distribution of infection in those Karen communities in uncertain transmission areas may not reflect actual filarial endemicity. However, antigenemia prevalence in the border areas may permit estimation of the population at risk for the infection so as to determine the presence and distribution of the disease (Ramzy *et al*, 1994; WHO, 1999; Bhumiratana *et al*, 2001b). Further evaluation of antigenemia rate within the affected communities with, or at risk of, infection needs to be carried out to identify the areas for targetting implementation unit responsible for the community-wide mass treatment (WHO, 1999; Bhumiratana, 2001a). Also, hydrocele prevalence in those communities along the border should be considered in relation to level of large-scale transmission control of *W. bancrofti* under the PELF. For a mass morbidity control program, hydrocele can be screened early by well-trained community health workers or village health and/or malaria volunteers.

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