

# Endemic Bancroftian Filariasis in Thailand: Detection by Og4C3 Antigen Capture ELISA and the Polymerase Chain Reaction

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## Abstract

Lymphatic filariasis, mainly caused by *Wuchereria bancrofti* and *Brugia malayi*, has been targeted for elimination by the World Health Organization by the year 2020. To achieve this goal, highly sensitive and specific diagnostic tests are necessary for close monitoring and evaluation of the control program. We employed an ELISA to detect the Og4C3 antigen and a polymerase chain reaction-based assay for diagnosis of *W. bancrofti* infection, among the Thai-Karen population in Tak province, Thailand. We found that this endemic area had a microfilarial rate of 10 per cent, while the antigen assay could detect cases about two fold as many (23%). The repeated PCR for the detection of *Ssp I* of *W. bancrofti* was positive in 12 per cent of the population under this study. Our data emphasize the need for using highly sensitive and specific assays for assessment of the real burden of the disease.

**Key word :** *Wuchereria bancrofti*, *Ssp I* repeat, Og4C3 Antigen, PCR, Antigen Detection Assay

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Lymphatic filariasis has been estimated to affect more than 120 million people in endemic countries<sup>(1)</sup>. More than 90 per cent of the disease burden is due to *Wuchereria bancrofti*. The disease has been targeted by the World Health Organization for elimination as a public health problem by the year 2020<sup>(2)</sup>. In Thailand, as assessed by using a

conventional microscopic method which has low sensitivity, the disease has been controlled to the prevalence of 0.99 per 100,000 population<sup>(3)</sup>. For bancroftian filariasis in Thailand, the active transmission areas are limited to 3 provinces (Tak, Kanchanaburi, and Mae-Hong-Son) bordering Thailand and Myanmar. To achieve the goal to eliminate the

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disease, it will be necessary for a lymphatic filariasis control program to assess the real burden of the disease. Part of the control strategies will include annual mass treatment with diethylcarbamazine and ivermectin or albendazole<sup>(4)</sup>. Therefore, evaluation of infection in communities is necessary before initiating mass treatment<sup>(5)</sup>. Close monitoring and assessment of the intervention programs require highly sensitive and specific diagnostic assays.

The routine method for diagnosis of lymphatic filariasis is to detect microfilariae in peripheral nocturnal blood by microscopic method. This time-consuming and tedious method is difficult to differentiate one filarial species from another<sup>(6)</sup>. Furthermore, conventional parasitological procedures fail to identify amicrofilaremic infections or individuals with very low microfilaria levels<sup>(7)</sup>. Assays that detect circulating *W. bancrofti* antigen can also detect nocturnal periodic infections in day blood, as well as other occult infections<sup>(8,9)</sup>. The Og4C3 monoclonal antibody has been used to diagnose microfilaremic individuals, as well as amicrofilaremic individuals, with high specificity and sensitivity<sup>(9-11)</sup>.

A polymerase chain reaction (PCR)-based assay for diagnosis of *W. bancrofti* infection using species-specific deoxyribonucleic acid (DNA) probes, has been reported by several authors<sup>(12-14)</sup>. Subsequently, a very sensitive and specific PCR, based on a highly repeated DNA sequence (*Ssp* I repeat), has been developed<sup>(15)</sup>. The PCR can detect *W. bancrofti* genomic DNA in blood samples<sup>(16)</sup>, mosquitoes<sup>(17-19)</sup>, as well as in paraffin-embedded tissues<sup>(20)</sup>, and urine samples<sup>(21)</sup>.

We describe here the assessment of bancroftian filariasis in an endemic area of Thailand by using the ELISA for Og4C3 antigen and a PCR-based assay to detect *W. bancrofti* DNA in blood samples collected from Thai-Karen population, living in the endemic area of Tak province, Thailand.

## MATERIAL AND METHOD

### Study areas and populations

Recruited for the study were 196 Thai-Karens residing in Mae Chan sub-district, Umphang district, Tak province, at the Thai-Myanmar border. The Umphang district is 60 km from Mae Sot district of Tak province. The Vector-borne Diseases Control Center is located in Mae Sot 500 km northwest of Bangkok. The study was organized in cooperation with the Filariasis Division, and the Vector-

borne Diseases Control Center 18 (Mae Sot district), Department of Communicable Disease Control, Ministry of Public Health, Thailand. As almost none of the Thai-Karens speak and read Thai or English, verbal informed consent was obtained from each individual, or parents or guardians of children recruited in the study, in the presence of two witnesses. We had a translator for Thai and Karen languages for the communication. Each individual was informed as to the purpose and scope of the study. Individuals were also educated about lymphatic filariasis and how to prevent the disease. Individuals who were microfilaremic were treated with standard treatment (diethylcarbamazine, DEC). This study was approved by the Ethics Committee of the Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand.

### Collection of specimens

Collection of blood specimens was performed as previously described<sup>(19,22,23)</sup>. Two to five ml of blood samples were collected from each individual between 8.00-12.00 p.m. Approximately 60 µl of blood samples were smeared onto microscope slides in duplicate, air-dried and stained with Giemsa's stain. Identification of the parasite species was established. All of the microfilaria-positive specimens were the larvae of *W. bancrofti*.

### Detection of specific Og4C3 antigen

The ELISA for detecting and quantifying the *W. bancrofti*-specific Og4C3 antigen was performed according to the manufacturer's instructions (Trop-Ag *W. bancrofti*, JCU Tropical Biotechnology Pty Ltd, Townsville, Queensland, Australia). The assay was performed on the polystyrene 96-well microtiter plates coated with Og4C3 monoclonal antibody that was blocked with nitrogen casein. One hundred microliters of each serum sample was boiled with 300 µl of sample diluent (0.1 M Na<sub>2</sub>EDTA, pH 4.0) for 5 minutes. After centrifugation, the supernatant was recovered and 50 µl was added to each well, and kept in a humid container at room temperature for 90 minutes or at 4°C overnight. After washing with 0.01 M Phosphate buffered saline with Tween 20, pH 7.4 (PBS, 0.05% Tween 20), 50 µl of diluted anti-*Onchocerca* antibody were added to each well and kept at room temperature for 1 hour. After another wash, 50 µl of diluted sheep anti-rabbit immunoglobulin-horseradish peroxidase (HRP) conjugate were added to each well. The sam-

ple, hyperimmune rabbit antibody, and conjugate were each diluted with a blocking solution (PBS/T, 0.5% high nitrogen casein). Plates were kept at room temperature for one hour. After washing, 100  $\mu$ l of ABTS substrate was added to each well. The plates were kept at room temperature for 30 minutes. The reaction was stopped with 50  $\mu$ l of 2N H<sub>2</sub>SO<sub>4</sub>. The absorbance was read spectrophotometrically at 405 nm. The positive samples had antigen titers more than 100 units/ml.

#### Extraction of parasite DNA from blood samples

The DNA was extracted as previously described(24). Briefly, 100  $\mu$ l of human blood was mixed with 500  $\mu$ l of TE buffer and centrifuged. The pellet was then washed with 500  $\mu$ l of TE buffer, resuspended in 500  $\mu$ l red-cell-lysis buffer (RCLB) and incubated for 5 min to lyse red blood cells. After centrifugation, the red blood cells digestion step was repeated, then resuspended in 200  $\mu$ l of DSP buffer (20 mM Tris, pH 8.0, 50 mM KCl, 2.5 mM MgCl<sub>2</sub>, 0.15 mg/ml Proteinase K, 0.5% Tween 20). Incubation in DSP was performed at 60°C for 3 h to lyse the microfilariae and release the DNA. The proteinase K in DSP was then inactivated by incubating the samples at 90°C for 10 min. Following brief centrifugation to pellet debris, the supernatant was kept for PCR analysis.

#### The polymerase chain reaction

The PCR was performed with 1 or 2  $\mu$ l of the extracted DNA as template in a final volume of 50  $\mu$ l. The reaction included 2 units of *Taq* polymerase, 400 pM each of NV1 and NV2 primers, and 200  $\mu$ M of each deoxynucleotide triphosphate in 50 mM KCl, 10 mM Tris-HCl, pH 9.0, 0.1 per cent Triton X-100, and 1.5 mM MgCl<sub>2</sub>.

The sequences of NV1 and NV2 were 5'-CGTG ATGGCATCAAAGTAGCG- 3' and 5'-CCCTC ACTTACCAAGACAAC- 3', respectively. The DNA was denatured at 94°C for 5 min, followed by 35 cycles of 1 min at 94°C, 1 min at 55°C, 1 min at 72°C, and a final 10 min extension at 72°C. The 188 bp PCR product (*Ssp* I repeat) was resolved and visualized on a 2 per cent ethidium bromide-stained agarose gel. The positive control DNA was prepared from adult *W. bancrofti* (kindly provided by Dr. N Raghavan).

#### Data analysis

Data were recorded and analyzed by using Microsoft Excel 6.0 program. The unpaired *t*-test was used to test statistically the significant difference.

## RESULTS

#### Characteristics of the study population

Among the 196 Thai-Karens living in Mae Chan, 114 (58%) were males and 82 (42%) females. The mean age was 28  $\pm$  13 (1-69) years. The majority (53%) of the subjects were in the age group >15-30 years (Table 1). There was a total of 20 microfilaremic cases accounting for the prevalence of 10 per cent. Most microfilaremic individuals were in the age group >15-30 years (17%) and >30-45 years (17%). Women had a slightly higher microfilarial infection rate than men (11% compared to 10%, respectively).

#### Prevalence of lymphatic filariasis assessed by using Og4C3 antigenemia

The ELISA for the specific circulating antigen (Og4C3) to assess the situation of bancroftian filariasis in this population identified 44 anti-

Table 1. Microfilaremia and Og4C3 antigenemia in Thai-Karens stratified by age and sex.

Age-group (years)	Male			Female			Total					
	Total	Mf+	Ag+	Total	Mf+	Ag+	Total	%	Mf+	%	Ag+	%
≤ 15	17	1	2	4	0	1	21	11	1	5	3	14
> 15-30	56	4	11	49	4	8	105	53	8	8	19	18
> 30-45	27	5	9	20	3	6	47	24	8	17	15	32
> 45-60	12	1	3	8	2	4	20	10	3	15	7	35
> 60	2	0	0	1	0	0	3	2	0	0	0	0
Total (%)	114	11	25	82	9	19	196	100	20	10	44	23

Note: Mf+ and Ag+ indicate microfilaremic and antigenemic patients, respectively.



**Fig. 1.** Detection of 188-bp *Ssp* I repeat by a PCR assay on a 2% ethidium bromide-stained agarose gel. Lane 1: 100-bp marker, lane 2: positive control using *W. bancrofti* genomic DNA, lane 3: negative control using blood sample from non-infected healthy volunteers, lanes 5-8: five representative samples positive for *Ssp* I repeat by the PCR.

genic cases in total (Table 1). All of the microfilaremic cases were positive for Og4C3 antigenemia. The antigen detection assay was positive for 24 individuals in the amicrofilaremic group. The number accounted for a 23 per cent prevalence of antigenemia (Table 1). The antigen test could detect more positive cases than the conventional microscopic method. The majority of the antigenic cases were in the age group > 45 - 60 years (35%). Those who were in the age group < 15 years, > 15-30 years, > 30-45 years and > 60 years had antigenemic rates of 14 per cent, 18 per cent, 32 per cent and 0 per cent, respectively.

#### Polymerase chain reaction (PCR) for diagnosis of lymphatic filariasis

The molecular biology technique using PCR to detect genetic material, DNA, of infectious

organisms has been used widely. For lymphatic filariasis, the DNA region named *Ssp* I repeat was used in the polymerase chain reaction (PCR) for the detection of the filarial parasite, *Wuchereria bancrofti*. The PCR result showed the 188-bp *Ssp* I repeat as shown in Fig. 1. All blood samples from microfilaremic patients were positive when tested by the PCR. In addition, four more subjects who had been earlier classified in the amicrofilaremic group were found positive for the *Ssp* I repeat. Therefore, the PCR was positive in 12 per cent of the study population.

#### High Og4C3 antigen levels among microfilaremic individuals

To study the correlation between the Og4C3 antigen level and microfilaremic status, we analysed the data and it was tested with unpaired *t*-test. The

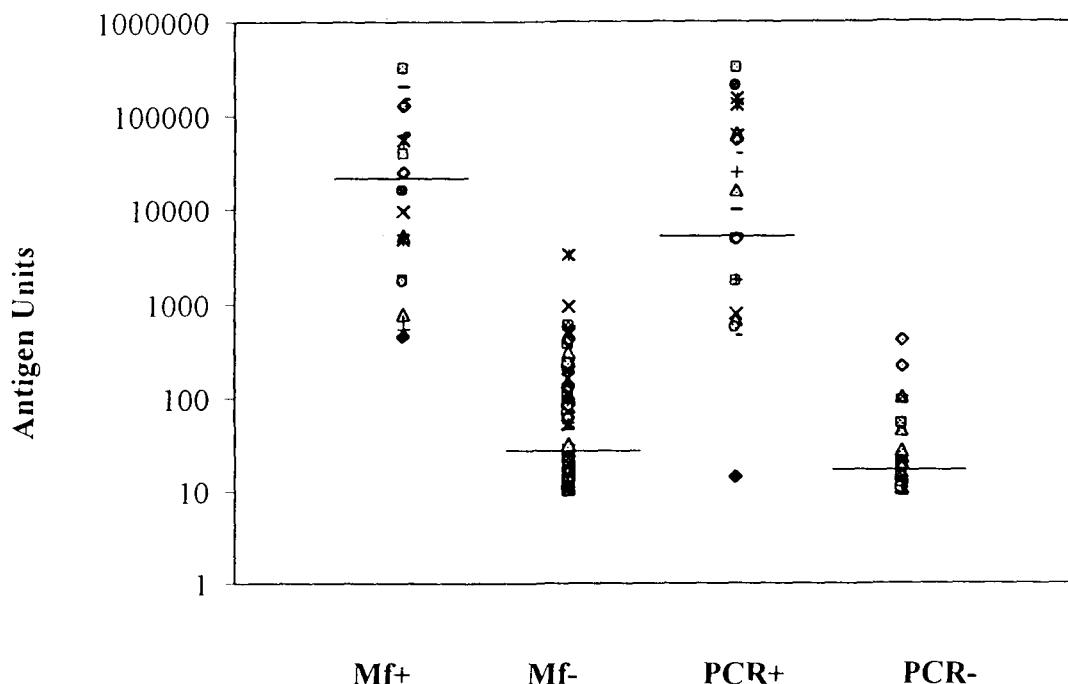


Fig. 2. The antigen units classified by microfilaremic status and detection of *Ssp* I repeat. Mf+: microfilaremic group, Mf-: amicrofilaremic group, PCR+: *Ssp* I-positive group, PCR-: *Ssp* I-negative group.

range of the antigen level was 10 - 3,156 units in the amicrofilarems, and 439- 321,907 units in the microfilarems (Fig. 2). The level of Og4C3 antigen among microfilarems (GM = 11,507 units) was higher than those in amicrofilarems (GM = 23 units) with statistic significance (unpaired *t*-test,  $p = 3.9 \times 10^{-11}$ ).

For analysis of the PCR results, we found that those who were positive for *Ssp* I repeat also had higher antigen levels (14 - 321,907 units; GM = 8,359 units) than those who were negative for the *Ssp* I repeat (10 - 389 units; GM = 13 units) (unpaired *t*-test,  $p = 3.5 \times 10^{-10}$ ).

## DISCUSSION

The data from the Filariasis Division, Department of Communicable Disease Control, Ministry of Public Health show that Thailand has controlled lymphatic filariasis to a prevalence rate of 0.99 per 100,000(3). Our study, however, showed

a much higher microfilarial rate in the endemic area of Tak province. The microfilarial rate (10%) in a Thai-Karen population living in Mae Chan sub-district, Umphang district was much higher. Therefore, this endemic area is considered a high-risk area with active transmission(25). The continuous monitoring and annual mass treatment as control strategies are necessary for the area. Advanced diagnostic techniques were found useful as indicators for assessment the real prevalence of the disease. The data also indicated that the specific Og4C3 antigen assay was a good indicator of an active infection. Although the PCR did not detect as many cases as the antigen assay, its detection of the parasite in mosquito vectors has been proved successful(19).

The PCR did not detect the *W. bancrofti*-infected cases as high as the antigen detection assay. Therefore, the PCR for detection of *Ssp* I repeat is less sensitive than the Og4C3 antigen

assay. Together with the difficulty in the application of this technique in the endemic areas, the PCR has obviously less applicability for the field study than the antigen detection assay. Another advantage of the antigen detection assay is that it directly correlated with the current active infection(26).

The high prevalence of bancroftian filariasis assessed by the detection of microfilariae, Og4C3 antigen and *Ssp* I repeat found among this population deserves considerable attention from the public heath community in Thailand. The collected data demonstrated the real burden of bancroftian filariasis as assessed by the Og4C3 antigen assay, which is an indicator of active infection. The high prevalence of the disease in the endemic area invites closer monitoring and control strategies for the disease.

Part of the reason for such a high prevalence of lymphatic filariasis is that this remote area is difficult to access by health personnel. Furthermore, the local villagers are not well educated; being unaware of its danger and prone to infection. Poverty is another major hindrance preventing this population from access to health care services.

To eliminate the disease successfully, health personnel need to have access to the remote areas as well as to provide health education.

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## REFERENCES

1. Michael E, Bundy DAP. Global mapping of lymphatic filariasis. *Parasitol Today* 1997; 13: 472-6.
2. Behbehani K. Candidate parasitic diseases. *Bull World Health Organ* 1998; 76 (Suppl 2): 64-7.
3. Filariasis Division. Annual Report, Filariasis Division, CDC Department, Ministry of Public Health, Bangkok, Thailand. 1999 (in Thai).
4. Ottesen EA, Duke BOL, Karam M, Behbehani K. Strategies and tools for the control/elimination of lymphatic filariasis. *Bull World Health Organ* 1997; 75: 491-503.
5. Ottesen EA, Ramachandran CP. Lymphatic filariasis infection and disease: Control strategies. *Parasitol Today* 1995; 11: 129-31.
6. Poole CB, Williams SA. A rapid DNA assay for the species-specific detection and quantification of *Brugia* in blood samples. *Mol Biochem Parasitol* 1990; 40: 129-36.
7. Chanteau S, Plichart R, Spiegel A, Martin PM, Cartel JL. Diagnostic values of ELISA-IgG4 as compared to ELISA-IgG and indirect immunofluorescence, for the routine diagnosis of bancroftian filariasis in the South Pacific. Application on capillary blood collected on filter paper. *Trop Med Parasitol* 1991; 42: 339-42.
8. Weil GJ, Jain DC, Santhanam S, et al. A monoclonal antibody-based enzyme immunoassay for detecting parasite antigenemia in bancroftian filariasis. *J Infect Dis* 1987; 156: 350-5.
9. Turner P, Copeman B, Gerisi D, Speare R. A comparison of the Og4C3 antigen capture ELISA, the Knott test, an IgG4 assay and clinical signs, in the diagnosis of bancroftian filariasis. *Trop Med Parasitol* 1993; 44: 45-8.
10. More SJ, Copeman DB. A highly specific and sensitive monoclonal antibody-based ELISA for the detection of circulating antigen in bancroftian filariasis. *Trop Med Parasitol* 1990; 41: 403-6.
11. Triteeraprapab S, Thumpanyawat B, Sangprakarn S. *Wuchereria bancrofti*-specific circulating antigen for diagnosis of bancroftian filariasis. *Chula Med J* 1998; 42: 267-77.

12. Dissanayake S, Min X, Piessens WF. Detection of amplified *Wuchereria bancrofti* DNA in mosquitoes with a nonradioactive probe. *Mol Biochem Parasitol* 1991; 45: 49-51.
13. Theodore JG, Kaliraj P, Jayachandran S, Jayaraman K. Cloning, over-expression and evaluation of a recombinant fusion protein of *Wuchereria bancrofti* towards its application as a diagnostic agent for bancroftian filariasis. *Parasitology* 1993; 106: 413-20.
14. Siridewa K, Karunananayake EH, Chandrasekharan NV, et al. Cloning and characterization of a repetitive DNA sequence specific for *Wuchereria bancrofti*. *Am J Trop Med Hyg* 1994; 51: 495-500.
15. Zhong M, McCarthy J, Bierwert L, et al. A polymerase chain reaction assay for detection of the parasite *Wuchereria bancrofti* in human blood samples. *Am J Trop Med Hyg* 1996; 54: 357-63.
16. Williams SA, Nicolas L, Lizotte-Waniewski M, et al. A polymerase chain reaction assay for the detection of *Wuchereria bancrofti* in blood samples from French Polynesia. *Trans R Soc Trop Med Hyg* 1996; 90: 384-7.
17. Chanteau S, Luquiaud P, Failloux AB, Williams SA. Detection of *Wuchereria bancrofti* larvae in pools of mosquitoes by the polymerase chain reaction. *Trans R Soc Trop Med Hyg* 1994; 88: 665-6.
18. Nicolas L, Luquiaud P, Lardeux F, Mercer DR. A polymerase chain reaction assay to determine infection of *Aedes polynesiensis* by *Wuchereria bancrofti*. *Trans R Soc Trop Med Hyg* 1996; 90: 136-9.
19. Triteeraprapab S, Kanjanopas K, Suwannadabba S, Sangprakarn S, Poovorawan Y, Scott AL. Transmission of the nocturnal periodic strain of *Wuchereria bancrofti* by *Culex quinquefasciatus*: establishing the potential for urban filariasis in Thailand. *Epidemiol Infect* 2000; 125: 207-12.
20. McCarthy JS, Zhong M, Gopinath R, Ottesen EA, Williams SA, Nutman TB. Evaluation of a polymerase chain reaction-based assay for diagnosis of *Wuchereria bancrofti* infection. *J Infect Dis* 1996; 173: 1510-4.
21. Lucena WA, Dhalia R, Abath FG, Nicolas L, Regis LN, Furtado AF. Diagnosis of *Wuchereria bancrofti* infection by the polymerase chain reaction using urine and day blood samples from amicrofilaraemic patients. *Trans R Soc Trop Med Hyg* 1998; 92: 290-3.
22. Triteeraprapab S, Songtrus J. High prevalence of bancroftian filariasis in Myanmar-migrant workers: A study in Mae Sot District, Tak Province, Thailand. *J Med Assoc Thai* 1999; 82: 734-9.
23. Triteeraprapab S, Nuchprayoon I. Eosinophilia, anemia, and parasitism in a rural region of northwest Thailand. *Southeast Asian J Trop Med Public Health* 1998; 29: 584-90.
24. Williams SA, Nicolas L, Lizotte-Waniewski M, et al. A polymerase chain reaction assay for the detection of *Wuchereria bancrofti* in blood samples from French Polynesia. *Trans R Soc Trop Med Hyg* 1996; 90: 384-7.
25. Filariasis Division. Elimination program for lymphatic filariasis. Filariasis Division, CDC Department, Ministry of Public Health, Thailand 2000 (in Thai).
26. Chanteau S, Glaziou P, Luquiaud P, Plichart C, Moulia-Pelat JP, Cartel JL. Og4C3 circulating antigen, anti-*Brugia malayi* IgG and IgG4 titers in *Wuchereria bancrofti* infected patients, according to their parasitological status. *Trop Med Parasitol* 1994; 45: 255-7.

## โรคเท้าข้างในแหล่งโรคภูมิของประเทศไทย: การวินิจฉัยโดยวิธีอิเล็กทรอนิกส์ Og4C3 และปฏิกริยาลูกโซ่พลีเมอร์เรส

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โรคแท้ห้ามีสาเหตุหลักมาจากพยาธิโรคแท้ห้าม *Wuchereria bancrofti* และ *Brugia malayi* ซึ่งมีการแพร่ระบาด องค์กรอนามัยโลกมีนโยบายที่จะกำจัดให้หมดไปภายในปี พ.ศ. 2563 ในการที่จะบรรลุเป้าหมายนี้มีความจำเป็นที่จะ ต้องอาศัยการวินิจฉัยที่มีความไวและความจำเพาะสูงในการติดตามและประเมินโครงการควบคุมโรค ผู้จัดได้ใช้วิธีอิเล็กทรอนิกส์ในการตรวจแอนติเจน *Og4C3* และใช้ปฏิกิริยาลูกลิซโซ-polymersesในการวินิจฉัยโรคติดเชื้อพยาธิโรคแท้ห้าม *W. bancrofti* ในประชากรที่อาศัยอยู่ในพื้นที่ที่มีโรคคุกคามของจังหวัดต่างๆ ของประเทศไทย พบว่ามีอัตราการตรวจพบเชื้อในโรคพิลารีย์ 10% ในขณะที่การตรวจแอนติเจนสามารถตรวจการติดเชื้อได้เพิ่มขึ้นประมาณ 2 เท่า (23%) และวิธีปฏิกิริยาลูกลิซโซ-polymerses ตรวจส่วน *Ssp 1 repeat* พบร้อยละ 12% ข้อมูลดังกล่าวเน้นให้เห็นความจำเป็นที่จะต้องใช้วิธีวินิจฉัยที่มีความไวและความจำเพาะ สูงในการประเมินสถานการณ์โดยตามความเป็นจริง

คำสำคัญ : วิเชชรเรย์ แพนครอฟต์, Ssp | repeat, แอนดี้เจน Og4C3, ปฏิกิริยาลักโçaพลเมอร์เรล, การตรวจแอนดี้เจน

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