Short Communication

SEROPREVALENCE OF *TOXOPLASMA GONDII* ANTIBODIES AMONG *ATAYAL* ABORIGINAL PEOPLE AND THEIR HUNTING DOGS IN NORTHEASTERN TAIWAN

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SUMMARY: *Atayal* aborigines, living at an altitude of 1,500-1,600 m in northeastern Taiwan, still hunt for wild animals with the help of hunting dogs. In this study, the latex agglutination test (LAT) was used to detect sera anti-toxoplasma antibodies in this community as a measure of their exposure to *Toxoplasma gondii*. The positive rates for sera anti-toxoplasma antibodies were 21.8% and 19.6%, respectively, in 422 *Atayal* and 51 hunting dogs tested. Neither of the positive rates were found to be significantly different between male (22.1%) and female *Atayal* (21.4%), or between humans (21.8%) and dogs (19.6%) ($P > 0.05$) when compared by the Chi-Squared test (χ^2 -test). A significant difference was observed between the positive rates in adults (28.3%) and children (18.7%) ($P < 0.05$), and the age pattern of prevalence is consistent with an increasing duration of exposure to *Toxoplasma gondii* with age. The consumption of raw liver of wild animals or insufficiently cooked meat may be the major mode of transmission of toxoplasmosis in *Atayal*.

INTRODUCTION

Although toxoplasmosis is a cosmopolitan infection, the disease appears to be overshadowed in the tropics by other endemic diseases like malaria and enteric fever (1,2). Toxoplasmosis has not generated a great deal of attention in Taiwan, while in other parts of the world it is considered an important and, at times, devastating group of parasites (3). Humans acquire infection through the ingestion of food contaminated with oocysts or infected meat, especially pork and goat meat, containing encysted forms of the parasites (4).

It is estimated that over 50% of the United States population is seropositive (5). In parts of Europe nearly 90% (6) of the population is seropositive and in some Asian countries from 17% to 48% have serologic evidence of previous exposure to the parasite (7). Most infections are asymptomatic, however, in some people it eventually becomes symptomatic. Toxoplasmic encephalitis is a major disease in AIDS patients (8). Prenatal infection may also occur, resulting in newborns with congenital toxoplasmosis (9).

There are nine different aboriginal groups living in mountainous regions in Taiwan. The *Atayal*, who live at an altitude of 1,500-1,600 m in the northeast, still hunt for wild animals with the help of hunting dogs. Intestinal parasite infections and *P. capitis* infestations in aborigines have been studied in detail (10,11), however, there have been few seroepidemiological studies on *Toxoplasma gondii* infections among aborigines, except that of Tsai (12) who reported prevalence rates of 10% in *Ami* aborigines in Hualien county and 6% in urban Taiwanese, Wallace (13) who reported a seropositive rate of only 1% in *Pai-Wan* aborigines and Cross (5) who reported prevalence rates of 18% in *Yami* aborigines who inhabit the offshore island of Lan-Yu. To date, there have been no seroepidemiological studies on toxoplasmosis among the different aboriginal populations in Taiwan. In the present paper, we describe the first seroepidemiological findings of *T. gondii* infection among *Atayal* and their hunting dogs.

The *Atayal* population is about 5200, most of whom are laborers or farmers in Nan-ao district, Ilan county, which has a mean altitude of 1,500-1,600 m, a mean daily temperature 10-20°C and 20% and 50% relative humidity. A total of 422 serum samples were randomly collected from apparently healthy *Atayal* individuals (208 males and 214 females) as well as 51 hunting dogs. The mean ages were similar for both sexes and ranged from 7 and 75 years in males and 6 and 78 years in females.

The latex agglutination test is widely used and accepted as a satisfactory screening test for toxoplasmosis (14), and has been reported to

produce 96.6% agreement with the dye test in a qualitative comparison (15). The only disadvantage of the test is the occurrence of nonspecific reactions. In Britain, the false positive rate is 1.3% (16). In our study, all sera, including from dogs, were screened by the *Toxoplasma* latex agglutination test (TOXO Test-MT, Eiken Co. Ltd., Tokyo). The test was performed according to the manufacturer's instructions, using 96 well microtiter plates (Nunc International, Denmark) and buffer and latex solutions. Sera found positive at $\leq 1/32$ were regarded as positive. Significant differences were tested by the Chi-squared test (χ^2 -test).

Our results showed that the highest seropositive rate was 29.7% observed in *AOHUA* village, followed by 27.2% in *PEEHO* village, 24.6% in *KINGYAN* village, 24.3% in *WUTA* village, 14.9% in *NANAO* village, and 13.7% in *KINGYO* village. The lowest seropositive rate was 12.5% in *TUNGAO* village (Table I). The distribution of seroprevalence by village shows that the rates for *AOHUA* (29.7%) and *PEEHO* (27.2%), which are near the *Central Mountains* and convenient for hunting, were significantly higher than that of the other four villages ($P < 0.05$) (Fig. 1).

The overall seropositive rate was 21.8% (92/422) in *Atayal* and 19.6% (10/51) in their dogs, respectively. No significant difference in the seropositive rate between humans and dogs was observed ($P > 0.05$) by the Chi-squared test (Table II). Also, the prevalence in males (22.1%) was

Table I. Seroprevalence of toxoplasmosis among *Atayal* aborines in mountainous villages in northeastern Taiwan, 1997

	Village											
	AOHUA			PEEHO			KINGYAN			WUTA		
	No. of Exam.	No. of Positive	Positive Rate (%)	No. of Exam.	No. of Positive	Positive Rate (%)	No. of Exam.	No. of Positive	Positive Rate (%)	No. of Exam.	No. of Positive	Positive Rate (%)
Male	64	18	28.1	16	4	25.0	34	7	23.5	20	4	20.0
Female	47	15	31.9	17	5	29.4	35	9	25.7	17	5	29.4
Total	111	33	29.7	33	9	27.2	69	16	24.6	37	9	24.3

	Village								
	NANAO			KINKYO			TUNGAO		
	No. of Exam.	No. of Positive	Positive Rate (%)	No. of Exam.	No. of Positive	Positive Rate (%)	No. of Exam.	No. of Positive	Positive Rate (%)
Male	34	7	20.6	28	4	14.2	12	1	8.3
Female	33	3	9.1	45	6	13.3	20	3	15.0
Total	67	10	14.9	73	10	13.7	32	4	12.5

*Symbols illustrated. Number and village name (seroprevalence).

1. KINGYANG (24.6%)	2. PEEHO (27.2%)	3. WUTA (24.3%)
4. AOHUA (29.7%)	5. KINGYO (13.7%)	6. TUNGAO (12.5%)
7. NANAQ (14.9%)	▲. Central mountains.	

Fig. 1. A map of seven *Atayal* aborigines villages in the mountainous areas of the northeastern Taiwan and the positive rate in each village (1997).

Table II. Seroprevalence of *Toxoplasma* antibodies among *Atayal* aborigines and hunting dogs in northeastern Taiwan, 1997

	No. of Exam.	No. of Positive	Positive Rate(%)
Humans	422	92	21.8
Dogs	51	10	19.6

* No significant difference was observed between humans and hunting dogs ($P>0.05$).

Table III. Seroprevalence of *Toxoplasma* antibodies among *Atayal* aborigines, according to sex and age, in northeastern Taiwan, 1997

Age group (years)	Male			Female			Average Positive Rate (%)
	No. of Exam.	No. of Positive	Positive Rate (%)	No. of Exam.	No. of Positive	Rate (%)	
<i>Children</i>							
A. 1 ~ 9	23	1	4.3	16	2	12.5	7.7
B. 10 ~ 19	126	29	23.0	119	21	17.6	20.4
<i>Adults</i>							
C. 20 ~ 29	10	1	10.0	11	3	27.2	19.0
D. 30 ~ 39	16	3	18.7	14	5	35.7	26.6
E. 40 ~ 49	11	1	9.1	15	4	26.7	19.2
F. 50 ~ 59	8	5	62.5	13	3	23.0	38.0
G. 60 ~ 69	6	3	50.0	14	4	28.6	35.0
H. ≥ 70	8	3	37.5	12	4	33.3	35.0
Total	208	46	22.1	214	46	21.4	21.8

not significantly different from the prevalence of 21.4% in females ($P > 0.05$) (Table I). However, the prevalence was significantly higher in females in the three age groups 1-9 years, 30-39 years and 40-49 years ($P < 0.05$), and significantly higher in 50-59 year old and 60-69 year old males ($P < 0.05$) (Table III). Due to the lack of seroepidemiological studies on *Toxoplasma gondii* infection among different aboriginal groups in Taiwan in recent years, we merely compared the seropositive rate with that of the *Ames* (10%) (12), *Pai-Wan* (1 %) (13) and *Ya-mi* aboriginal groups (18%) (4) tested about 10 years ago in different parts of Taiwan, discovering that the seroprevalence of our cohort was the highest. Several workers have reported sex differences in the prevalence of toxoplasmosis. In some instances, the prevalence was found to be higher in females (17); while in others, it was higher in males (18). Griffin (19) found no sex difference. Sex differences in most studies have been attributed to greater exposure to infected meat by either females (20) or males (21), depending on food habits and culture. In the present study, the higher prevalence in *Atayal* females can be explained by higher exposure to *Toxoplasma* cysts in cooked meat during food preparation. In Japan, the ingestion of oocysts contaminating the soil seems to be the main mode of transmission of toxoplasmosis (22). In a previous study, we found there was no evidence to suggest that the ingestion of oocysts was an important means of transmission of the disease because the prevalence of toxoplasmosis in local cats was low (23). In fact, dogs and not cats are popular pets in this

mountain-dwelling *Atayal* community, most of whom are laborers or farmers who still hunt for wild pigs or goats with hunting dogs. The hunting dogs have the same food source as their masters, which is why they have the same high seroprevalence of anti-toxoplasma antibodies. Thus, the evidence refutes the possibility of transmission of the disease via the soil.

The seroprevalence of toxoplasmosis among *Atayal* according to age revealed that the highest seropositive rate was 38.0% observed in the 50-59 age group followed by 35.0% in the ≥ 60 age group, 20.4% in the 10-19 age group and 19.2% in the 40-49 age group. The lowest seropositive rate was 7.7% in the 1-9 age group. The results indicate an increase in prevalence with an increase in duration of exposure to *Toxoplasma* with age (Table III). The seropositive rates in *Atayal* adults (≥ 20 years) and *Atayal* children (≤ 13 years) were 28.2% and 18.9%, respectively. A significant difference in the seropositive rates between the adult and children populations was observed ($P < 0.05$) by Chi-squared test (Table III). A similar correlation with age has been found in France (24).

Fan (25) reported that *Taenia saginata asiatica* (*Taiwan taenia*) infection through the consumption of raw wild pig or goat, especially livers, was common in many aboriginal communities in Taiwan, and that taeniasis caused gastrointestinal and neurological symptoms which resulted in serious economic loss in the communities (26). The reason for the high prevalence of sera anti-toxoplasma antibodies observed in this study is believed to be because the *Atayal* also consume raw wild pig and goat meat and organs (25). Kundin (27) reported that the prevalence of *Toxoplasma gondii* from infection among wild pigs was low (1.0%; 2/203) in east Taiwan (27), however, further study to isolate *T. gondii* meats or visceral organs of wild animals is necessary. It is interesting to note that aboriginal people deny that they still hunt for wild animals due to the implementation in recent years of laws protecting wild animals in Taiwan. Thus, it has become difficult to obtain samples for isolating *T. gondii*.

In summary, raw or insufficiently cooked meat may be the major mode of transmission of toxoplasmosis in *Atayal*. Raw liver in particular is still a very common food source (25), and most likely plays a significant role in the transmission of toxoplasmosis among the *Atayal* in northeastern Taiwan. Although the prevalence of antibodies to *Toxoplasma* in our study indicates a high level of transmission among the *Atayal*, there are no records of cases with congenital or postnatal toxoplasmosis in this community. This may be explained by the lack of serologic tests for toxoplasmosis in the past and/or by a low degree of suspicion of this disease among clinicians.

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