***Toxocara canis*, *Trichinella spiralis* and *Taenia solium* helminthozoonoses: seroprevalence among selected populations in north India**

B. B. Singh · R. Sharma · J. P. S. Gill

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Abstract Helminthozoonoses are being considered as a research priority in India and many other tropical and subtropical countries. *Taenia solium* and *Trichinella spiralis* are emerging public health and food safety issues in the country and the developing world. The asymptomatic *Ta. solium* carriers act as important risk for neurocysticercosis, leading to adult onset epilepsy in the country. Human toxocariasis is another common zoonosis which occurs due to larvae of *Toxocara canis* or *T. cati*. The current study was planned to obtain baseline seropositivity data for *Ta. solium*, *To. canis* and *Tr. spiralis* antibodies among selected populations in Punjab province of northern India. In the present study, 122 human subjects belonging to selected occupations viz. farmers and veterinary practitioners were screened using the RIDASCREEN® *Ta. solium* IgG, RIDASCREEN® *Toxocara* IgG and RIDASCREEN® *Trichinella* IgG enzyme immunoassays for the qualitative determination of IgG antibodies against *Ta. solium*, *Tr. spiralis* and *To. canis*, respectively in human serum. The seropositivity of *To. canis*, *Tr. spiralis* and *Ta. solium* infections were found to be 22.13, 5.73 and 11.47 %, respectively in human serum samples. The relative risk of being infected for *To. canis*, *Tr. spiralis* and *Ta. solium* infections was found to be 1.91 (95 % CI 0.786–4.669), 2.61 (95 % CI 0.3258–20.94) and 1.596 (95 % CI 0.427–5.3893) times high respectively in farmers when compared to veterinary practitioners. The present study indicates that exposure to *To. canis* and *Ta. solium* is not uncommon among farmers and veterinary practitioners

in this part of the country. These results provided evidence of *Tr. spiralis* among selected human populations in the country and demand more research related to trichinellosis in their respective animal and human hosts.

Keywords *Toxocara canis* · *Trichinella spiralis* · *Taenia solium* · Seroprevalence · Parasitic zoonoses · North India

Introduction

Zoonotic helminths are important veterinary, public health and economic concern in India and many other tropical and subtropical countries (Singh et al. 2010, 2012, Singh et al. 2013a, b). The prevention and control of such zoonoses is a great challenge, owing to the lack of proper surveillance systems in the country (Singh et al. 2010). Helminthozoonoses are being considered among priority zoonotic research areas in the country (Sekar et al. 2011). The role of animal production is important in ensuring food security in the country.

The foodborne pathogens *Taenia solium* and *Trichinella spiralis* primarily occur due to consumption of raw or undercooked infected pork. The asymptomatic *Ta. solium* carriers act as important risk for neurocysticercosis (NCC) in the country. NCC is one of the leading causes of adult onset epilepsy in India (Singh et al. 2002; O’Neal et al. 2012). *Cysticercus cellulosae* have been reported in pigs through most parts of the country at varying rates (Singh et al. 2010). Trichinellosis is an important zoonosis and occurs across the globe. It remained a neglected zoonosis in the country but multiple outbreaks in human populations have been reported since last 5 years (Sethi et al. 2012). No surveys for *Tr. spiralis* infections have ever been carried out in the country in human and animal hosts.

B. B. Singh (✉) · R. Sharma · J. P. S. Gill
School of Public Health and Zoonoses, Guru Angad Dev
Veterinary and Animal Sciences University, Ludhiana, Punjab,
India
e-mail: bbsdhalwal@gmail.com

Human toxocariosis is a common zoonosis which occurs due to larvae of *Toxocara canis* or *T. cati* (Rubinsky-Elefant et al. 2010). Although asymptomatic in most cases, the infection could lead to visceral and ocular larva migrans in human beings. Many factors such as poor socioeconomic status, unorganized slaughtering, stray animals and lack of garbage disposal system help in persistence of these parasites in the environment. Watering of food crops with contaminated water could further enhance transmission of neurocysticercosis and toxocariasis (Singh et al. 2011). There is an urgent need for more recent parasite data to be obtained. The objectives of the current study were to obtain baseline seropositivity data for *Ta. solium* and *To. canis* infections and to document presence of *Tr. spiralis* antibodies among selected populations in Punjab province of North India.

Materials and methods

Study populations

In the present study, 122 human subjects belonging to selected occupations viz. farmers and veterinary practitioners were approached (Table 1). The persons belonging to these occupations were selected as the risk of infection is high in such populations. Each subject was informed about the objectives of the study and after their consent; the subjects were included in this study. Epidemiological data related to age were also collected (Table 2).

Table 1 Seroprevalence of *To. canis*, *Tr. spiralis* and *Ta. solium* infections in selected populations in Punjab (India)

Name of occupation	Number of samples examined	Number of samples positive		
		<i>To. canis</i>	<i>Tr. spiralis</i>	<i>Ta. solium</i> infections
Farmers	85	22	6	11
Veterinary practitioners	37	5	1	3
Total	122	27	7	14

qualitative determination of IgG antibodies against *Tr. spiralis* in human serum (Despommier 1986). For quality control purposes, the positive control and the negative control were used in duplicate every time the test was carried out. The final measurement was carried out at 450 nm on a photometer using a reference wavelength of 620 nm. The optical densities were read using ELISA Reader (Tecan Infinite 200Pro) and were analyzed.

Statistical analysis

Data were analyzed using statistical package for social sciences (SPSS 2000 for windows version 11.0.1 SPSS INC, Chicago, IL). The effect of occupation and age on seroprevalence of infection was studied. The relative risk (RR) viz. the probability for the occurrence of the disease in farmers versus veterinary practitioners was analyzed. The RR was calculated as:

$$\text{Relative Risk} = \frac{\text{Probability (Disease/Number of farmers examined)}}{\text{Probability (Disease/Number of veterinary practitioners examined)}}$$

Laboratory methods

The serum samples from each individual were collected. The serum samples were stored at -20°C till use. Screening of human sera was conducted employing IgG-ELISA for measurement of serum antibody using RIDA-SCREEN ELISA kits supplied by R—Biopharm AG, Darmstadt, Germany. The RIDASCREEN® *Ta. solium* test is an enzyme immunoassay (EIA) for the qualitative determination of IgG antibodies against *Ta. solium* and its cysticerci (bladder worms) in human serum (Flisser and Larralde 1986). The RIDASCREEN® *Toxocara* IgG test is an EIA for the qualitative determination of IgG antibodies against *To. canis* in human serum (Brunello et al. 1986). The RIDASCREEN® *Trichinella* IgG test is an EIA for the

Results

The seroprevalence of *To. canis*, *Tr. spiralis* and *Ta. solium* infections were found to be 22.13, 5.73 and 11.47 %, respectively. Among farmers, the seroprevalence of 25.88, 7.05 and 12.94 % were recorded for *To. canis*, *Tr. spiralis* and *Ta. solium* infections, respectively (Table 1). In veterinary practitioners, seroprevalence of 13.51, 2.70 and 8.10 % were recorded for *To. canis*, *Tr. spiralis* and *Ta. solium* infections, respectively (Table 1). In farmers, the RR of being infected for *To. canis*, *Tr. spiralis* and *Ta. solium* infections was found to be 1.91 (95 % CI 0.786–4.669), 2.61 (95 % CI 0.3258–20.94) and 1.596 (95 % CI 0.427–5.3893) times high respectively when compared to veterinary practitioners. For all the parasites,

Table 2 Seroprevalence of *To. canis*, *Tr. spiralis* and *Ta. solium* infections in different age groups in Punjab (India)

Age (in years)	Number of samples examined	Number of samples positive		
		<i>To. canis</i>	<i>Tr. spiralis</i>	<i>Ta. solium</i> infections
0–20 years	2	1	1	1
20–40 years	75	19	6	9
40–60 years	37	7	0	4
>60 years	8	0	0	0
Total	122	27	7	14

Fig. 1 Seroprevalence of human toxocariasis, *Trichinella* and *Ta. solium* infections among different age groups in Punjab (India)

higher sero prevalence was recorded in persons belonging to 20–40 years age groups (Fig. 1). Sero reactivity was observed for all the three parasites in three samples; two samples each reacted positively for both *Ta. solium*–*To. canis* and *Tr. spiralis*–*To. canis* antibodies. This could be due to cross reactivity or due to an association between seropositivity of these parasites.

Discussion

Three globally important zoonotic pathogens including *Tr. spiralis*, *To. canis* and *Ta. solium* were studied. This is a preliminary study indicating high seroprevalence of human toxocariasis and *Ta. solium* infections among occupational risk groups. The results indicate that exposure to *To. canis* and *Ta. solium* is not uncommon in this part of the country. Previous studies also indicate that porcine cysticercosis is prevalent in all the northern states of the country except Jammu and Kashmir. The prevalence of human ranges from 0.5 to 2 % but high prevalence's have been reported in certain pig rearing communities (Rajshekhar 2004). Neurocysticercosis accounts for 8.7–50 % of patients with recent onset of seizure (Rajshekhar 2004). But cross-reactions have been reported between antibodies against

Echinococcus species and *Ta. solium* infections. Earlier studies have also reported seroprevalence of human toxocariasis to be 6.4 and 23.3 % from clinically normal and suspected toxocariasis patients in northern India.

The results also indicate circulation of antibodies against *Tr. spiralis* among human population in the country and demand more research related to trichinellosis in animal and human hosts. Presence of antibodies specific to more than one parasite in few samples indicates either multiple infections or cross reactivity between these helminth parasites. Improved personnel hygiene and public health practices could help control these infections among occupational risk groups. This warrants epidemiological studies to determine prevalence and related risks for persistence of these parasites in the human population of the country.

Conclusions

Helminthozoonoses result in significant economic and production losses in India and many other tropical and subtropical countries. The exposure to *To. canis* and *Ta. solium* is common among farmers and veterinary practitioners in northern India. This study also provided serological evidence for the presence of *Tr. spiralis* in India and warrant extensive molecular studies on human and animal *Trichinella* infections in the country.

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