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RELATION BETWEEN *TOXOCARA* INFECTION, ATOPY AND ASTHMATIC BRONCHITIS CHILDREN IN ZAGAZIG UNIVERSITY HOSPITALS

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Abstract

This study evaluated the relation between toxocariasis and asthmatic bronchitis children in pediatric outpatient's clinics of Zagazig University Hospitals. The sample consisted of two groups; GI included 118 asthmatic bronchitis children recruited from outpatient's clinics. GII included 100 cross-matched healthy children selected randomly from the hospital visitors. All the children were subjected to full history taken as age, residence, socioeconomic level, pet animals, playing outdoors, and mother education chest examination. All participants were subjected to stool examination to exclude other parasites, oesinophilic count and detection of ELISA-IgG anti-*Toxocara*, skin prick test and total IgE for evaluation of atopy.

The results showed that 17% of asthmatic children were seropositive for anti-*Toxocara* spp., compared to 7% of the control ones. There was significant relation between positive anti-*Toxocara* IgG and asthmatic bronchitis as well as total IgE. On the other hand, there was negative significant relation between toxocariasis and skin prick test.

Key words: Toxocariasis, Pet animals, Children, Asthmatic bronchitis, ELISA-IgG, Total IgE

Introduction

Human toxocariasis (HT) is a cosmopolitan zoonotic helminthic infection with (*Toxocara canis* and *T. cati*) the ascarid worms of dogs and cats respectively. There are other known species of *Toxocara*, but these are rarely or never infecting mans (Bowman and Hendrix, 2008). Toxocariasis was first detected in 1950s and considered as uncommon in children. Several researches detected that toxocariasis is the commonest worm worldwide (Hotez and Wilkins, 2009). Children are the most infected group as a reason of their common behaviors, like geophagia, bad personal hygienic condition and contact with animals that increase chance zoonotic transmission (Magnaval *et al*, 2001). Man is a paratenic host who get infected by accidental swallowing of the parasite's mature eggs found in feces of dog and/or cat indoors or outdoors (Despommier, 2003). Most of toxocariasis in man are asymptomatic (covert toxocariasis). However, symptomatic one gives three clinical features: visceral larva migrans (VLM), ocular larva migrans (OLM), and neurological toxocariasis (NT) (Fragoso *et al*, 2011). The pulmonary manifestation of toxocariasis is called covert. It is characterized by non-specific symptoms that are not related to the categories of classical VLM, incomplete larva migrans, OLM or NT. The clinical presentation of covert toxocariasis varies widely, with pulmonary involvement, such as asthma, acute bronchitis and pneumonia, with or without Loffler's syndrome. The diagnosis of asthma or a wheezing breath in toxocariasis patients was reported (Buijs *et al*, 1995). Frequency of both symptoms varied from 9% to more than 30% of adult patients (Carvalho and Rocha, 2011). These presentations were not so specific to *Toxocara* species but other helminthes larval stages may wander in human body causing symptoms of visceral larva migrans (Gavignet *et al*, 2008). The infection morbidity depends on parasite burden and host immune response (Macpherson, 2013). Asymptomatic human toxocariasis might be presented with impaired cognitive functions (Walsh and Haseeb, 2012) and immunomodulation (Maizels, 2013). The pulmonary toxocariasis was with asthma-like symptoms (Cooper, 2008).

In general, human helminthiasis has mark-

ed role in the regulation of allergy in the tropics (Maizels, 2013). *Trichuris trichiura* (Moncayo *et al,* 2010), *Schistosoma mansoni* (Araujo *et al,* 2000) and *Ascaris lumbricoides* (Dagoye *et al,* 2003) were associated with a decrease in incidence of skin test reactivity and asthma. But, human toxocariasis was associated with high incidence of atopy and asthmatic symptoms (Despommier, 2003). Chan *et al.* (2001) reported that toxocariasis might increase possibility of allergic diseases, especially in children. Pinelli *et al*. (2008) reported that *Toxocara* infection in experimental models paved the way to allergic diseases, like asthma which is prevalent worldwide. A common immunological feature in allergic asthma and toxocariasis was the induction of a Th2 type of immune response characterized by high levels of total IgE and eosinophilia (Gonzalez *et al,* 2006). Atopy is a heritable predisposition to produce abnormal amount of IgE due to contact with aeroallergens. One could have typical manifestations of asthma, rhino-conjunctivitis or eczema (Johansson *et al,* 1968). Total IgE (tIgE), allergen-specific IgE (sIgE), and allergen skin prick test (SPT) are common diagnostic markers of atopic disease. They can differ considerably, with important diagnostic and epidemiological implications. SPT was the best efficient test diagnose current respiratory allergic diseases while tIgE gave a lower diagnostic value than SPT and/or sIgE (Johansson *et al,* 2004)

Significant relation between *Toxocara* spp. prevalence and increased levels of total and aeroallergen-specific IgE (sIgE), skin prick test reactivity (SPT), and asthma incidence were reported (Kanobana *et al,* 2013). But, no relation between anti-*Toxocara* spp. IgG antibodies and allergic markers was reported (Fernando *et al,* 2009). Mendonca *et al*. (2012) reported that *Toxocara* seropositivity was associated with decreased incidence of skin prick test reactivity to common aeroallergens that might act as a modifier in the relation between sIgE and SPT.

This study aimed to evaluate the effects of *Toxocara* infection on atopy and asthma, and relation between seroprevalence of anti *Toxocara* IgG and asthma

Subjects and Methods

This study was done on asthmatic bronchitis children in outpatient's clinics of Zagazig University Hospitals from 1st January to 1st October 2017. The sample consisted of two groups. G1: 118 children with confirmed asthmatic bronchitis from Pediatric Outpatient's Clinics. GII: 100 cross-matched children selected randomly from the hospitals visitors.

The patients aged between 4 and10 years from both sexes, with different socioeconomic and educational levels. An informed written consent was obtained from parents. Patients with other medical conditions or other parasitological disease, Also presence of one of asthma risk factors like that of; family history of asthma, exposure to cigarette smoke at home, presence of low birth weight as estimated from birth records or history of recurrent respiratory infections from childhood were recorded. Those exposed to pesticides was excluded. Current asthmatic patients were recorded after Asher and Weiland (1998). The second or the standard method was physician-diagnosed asthma (Kemp *et al,* 1996).

The sociodemographic data was assessed as age, sex, pet-animals, residence either urban or rural, outdoors playing, family status and mother's education.

Fecal sample was collected from each subject in a dry cartoon container. The feces were macroscopically examined for color, consistency, mucus and presence of worms or parts of them. Then, stained direct smears and formalin-ethyl acetate concentration flotation were examined microscopically by low and high powers to detect helminthic ova, larvae, trophozoites and cysts. Positive cases with parasites other than toxocariasis were excluded to avoid cross-reactions. Individually, five ml venous blood was collected in 2 tubes, one with anticoagulant for

detection of eosinophilia corresponded to levels above 400/mm³ (Figueiredo *et al*, 2005). The second was centrifuged to separate sera which were stored at -20°C until needed for anti-*Toxocara* IgG and total IgE

Immunological investigation: Sera were tested for anti-*Toxocara* IgG by Rida-Screen *Toxocara*-IgG ELISA kit (R-Biopharm AG, Germany) purified antigens coated to a micro-well plate. Serum antibodies was bind to antigens and detected by using enzyme-labeled Protein A (conjugate) that converted colorless substrate (H2O2/ TMB) to a blue end product. Sulphuric acid stopped reaction and turned the mixture color to yellow. Measurement was at 450nm on a photometer with a reference wave length ≥ 620 nm.

Quantitative measurement of total IgE antibodies concentration was done by using ELISA kit (Immunospec corporation, CA), where levels higher than 200IU/ml were considered high.

Skin Prick test was performed using extracts of allergens used worldwide by ISAAC, as, house dust mite and cockroach (ALK Abello, Nieuwegein, The Netherlands). Both have been reported as major atopic sensitizers in developing countries Histamine (10mg/ml) and allergen diluent were used as positive and negative controls, respectively. Both extracts and controls were injected on the volar aspect of the left forearm using separate ALK lancets. Skin response was read after 15min, positive one detected as a wheal about 3 mm or larger of significant reaction without diluent control reactivity Atopy was defined as a positive SPT when positively reacted to at least one of the applied allergens. Those taking regular short acting antihistamines were asked to stop for at least 72 h prior to skin prick test.

Statistical analysis: SPSS version 19.0 was used to construct the database and analysis. Chi-square test and Odds Ratio (OR) differentiated between groups. Significant level oselected was p value < 0.05.

Results

Among 118 asthmatic bronchitis patients 17% of subjects were seropositive for anti-*Toxocara* spp., and 7% in 100 control subjects. All details were given in tables (1, 2, 3 & 4).

Table 1: Sociodemographic and characteristic data of groups.

Variable		Patients (n=118)		Control (n=100)	
		No.	%	No.	%
Sex	Male	67	57	57	57
	Female	51	43	43	43
Age in years	7-10	66	56	62	62
	4-6	52	44	38	38
Family income	Low	69	59	15	15
	Moderate	49	41	85	85
Residence	Rural	78	66	44	44
	Urban	40	34	56	56
Education	Educated	84	71	68	68
	Ignorant	34	29	32	32
Employment	Employed	66	56	30	30
	Unemployed	52	44	70	70
Pet contact	Yes	48	41	40	40
	No	70	59	60	60
Soil contact	Yes	34	29	30	30
	No	84	71	70	70
Toxocara IgG	Positive	20	17	7	7
	Negative	98	83	93	93
eosinophilia	< 4	34	29	25	25
	> 4	84	71	75	75
Skin prick test	Negative	86	73	85	85
	Positive	32	27	15	15
Total IgE	< 0.2 mg/ml	41	35	93	93
	≥0.2 mg/ml	77	65	7	7

Table 2: Comparison of anti-*Toxocara* spp. IgG Sociodemographic data between asthmatic patients

Variable	Positive IgG (n=20)		Negative IgG (n=98)		Statistical value	
Sex	No.	%	No.	%	x	P value
Male	13	65	54	55		
Female	7	35	44	45	0.663	0.42
Age in years 7-10	14	70	52	53		
4-6	6	30	46	47	1.934	0.16
Family income Low	17	85	52	53		
Moderate	3	15	46	47	6.978	0.008
Residence Rural	13	65	65	66	0.013	0.91
Urban	7	35	33	34		
Education Educated	6	30	78	80		
ignorant	14	70	20	20	19.92	0.000
Employment Employed	11	55	55	56		
Unemployed	9	45	43	44	0.008	0.927
Pet contact Yes 48	15	75	33	36		
No 70	5	25	65	64	11.756	0.001
Soil contact Yes 34	15	75	19	19		
No 84	5	25	79	81	25.05	0.000
eosinophilia Positive >4% 8	17	85	67	68		
Negative<4% 34	3	15	31	33	2.240	0.134
Skin prick test Positive 86	4	20	82	84		
Negative 32	16	80	16	16	34.07	0.000
Total IgE < 0.2 mg/ml 41	6	30	35	34		
≥0.2 mg/ml 77	14	70	63	66	9.146	0.003

Table 3: Comparison of Anti-*Toxocara* spp. IgG data between controls

Variable	Positive IgG (n=7)		Negative IgG (n =93		Statistical value	
Sex	No.	%	No.	%	x	P. value
Male 57	6	86	51	55		
Female 43	1	14	42	45	2.532	0.111
Age in years 7-10	5	71	57	61		
4-6	2	29	36	39	0.284	0.594
Family income Low	2	29	13	14		
Moderate	5	71	80	86	2.035	0.126
Residence Rural	6	86	38	41	5.032	0.020
Urban	1	14	55	59		
Education Educated	6	86	62	67		
Ignorant	1	14	31	33	1.085	0.297
Employment Employed	2	29	28	31		
Unemployed	5	71	65	69	**0.007**	0.921
Pet contact Yes 40	5	71	35	38		
No 60	2	29	58	62	3.097	0.078
Soil contact Yes 30	4	57	26	28		
No 70	3	43	67	72	2.641	0.104
eosinophilia >4% 25	6	86	19	20		
<4% 75	1	14	74	80	14.86	0.000
Skin prick test Positive 85	2	29	83	89		
Negative 15	5	71	10	11	18.80	0.000
Total IgE < 0.2 mg/ml 93	1	14	92	99		
≥0.2 mg/ml 7	6	86	1	1	71.64	0.000

Table 4: Seroprevalence between Patients and Control Group

Variable	Positive IgG		Negative IgG		X Score	P value
	No.	%	No.	%		
Patients group	20	17	98	83	4.938	0.026
Control group	7	7	93	93		

Discussion

In Egypt, zoonotic toxocariasis as one of the widely distributed geoparasites was reported (Khalil, 1977; Morsy *et al*, 1981; Nada *et al*, 1996; Antonios *et al*, 2008; Haridy *et al*, 2009; El-Tras *et al*, 2011: Etewa *et al*, 2014). Generally speaking, asthma increased in the industrialized countries (Eder *et al*, 2006). Incidence of asthma was 20.8% corresponded to those recorded in Latin American countries and in some developed countries worldwide (Mallol *et al*, 2000; Pitrez and Stein, 2008 Vereecken *et al*, 2012).

Almost 21% of the population was infected with one or more intestinal helminthes. Geohelminthes infection was considered as a potential risk factor for asthma (Cooper 2004; VanRiet *et al*, 2007). The association between asthma and toxocariasis has not been well documented. But, there were some studies showing positive association in human (Buijs *et al*, 1997; Ferreira *et al*, 2007) and in animal model (Pinelli *et al*, 2008), but shown no relation was reported (Sharghi *et al*, 2001).

In the present study, the IgG positive children were 17 % & 10% among asthmatic patients and controls respectively. But, Fernando *et al.* (2009) in Sri Lanka reported 29% of toxocariasis in hospitalized children with bronchial asthma recorded. Mendonca *et al*. (2013) in Brazil reported high rates of toxocariasis (63.6%) in elementary school children in urban and semi-rural areas. Also, Kanobana *et al.* (2013) reported that antibodies of *Toxocara* spp. in 40.1% of the children. Nyan *et al.* (2001) in Banjul reported that toxocariasis was more common in urban 17% versus 8.2% rural one. Mendona *et al*. (2013) in Salvador found that 48.4% of children aged 4-11 years in urban suffered from helminthic infections.

The present study found no significant difference between toxocariasis and family income. But, Souza et al. (2011) in Salvador recorded a positivity rate of 59.9% with a higher incidence among lower social classes. Also, Alvarado-Esquivel (2013) reported that socioeconomic status was an important factor in positive rate of toxocariasis. However, Silva *et al.* (2016) did not accept such an effect using family income and maternal schooling as a monitor for social classes.

The present study found highly significant difference between toxocariasis and pet contact. Many studies suggested that dog contact was the main risk factor of *T. canis*, as a direct source of infection, but cat exposure was less frequently as the cats cover feces under sand (Loukas *et al*, 2000; Schnieder *et al*, 2011; Strube *et al*, 2013).

In the present study, there was a significant relation between toxocariasis and soil contract. Buijs *et al.* (1994), Kerr-Muir *et al*, (1994) and El Tantawey *et al.* (2013) found that eating soil (pica) was a risk factor for infection. In the present study, there was no significant difference between toxocariasis and sexes. Nyan *et al.* (2001) in Banjul reported no significant difference among sexes regarding intestinal helminthic infections. However, Silva *et al.* (2016) found a two-fold increase in risk of toxocariasis in boys compared to girls. This might be due to the fact that boys always plays outdoors (Roldán *et al*, 2010), and more exposure to contaminated environments (Wi´sniewska-Ligier *et al*, 2012; Romero Nú˜nez *et al*, 2013).

In the present study, there was highly significant difference between toxocariasis and mother ignorance. This made the ignorant mother had no knowledge about primary the hygienic items (Kanobana *et al*, 2013).

The present study showed no significant difference between toxocariasis and eosinophilia level in asthmatic patients, but a highly significant difference between *Toxocara* spp. Infection and eosinophilia among controls. Mendonca *et al.* (2013) reported that eosinophilia was 4% more in students positive for anti-*Toxocara* spp. than in controls. Dattoli *et al.* (2011) recorded higher of eosinophils levels in pure toxocariasis patients. Martin *et al.* (2008) reported that 87% of toxocariasis patients had elevated eosinophilia. Fernando *et al.* (2009) reported sig-

nificant higher eosinophilia in non-asthmatic toxocariasis children.. In the present study there was significant relation between *Toxocara* spositivity and total IgE positivity. This agreed with the results of Mendonca *et al.* (2012) and El-Tantawey *et al. (*2013).

Alcântara-Neves *et al.* (2014) found strong positive association between helminthiasis and both total IgE and eosinophilia. Saporito *et al.* (2008) and Bahnea *et al.* (2008) reported that eosinophilia and high IgE level in asthmatic patients suggested toxocariasis. The present study, found significant negative relation between toxocariasis seropositivity and skin prick test. This went with with the reports of Mendonca *et al.* (2012) and Silva *et al.* (2016).

The present study showed high significant relation between *Toxocara* spp. and asthma, which agreed with others (Buijs *et al,* 1997; Kanobana *et al,* 2013; El Tantawey *et al,* 2013). Ferreira *et al*. (2007) found that 21.5% children had *Toxocara* antibodies and independent association between asthma and positivity But, Sharghi *et al.* (2001) and Taylor (1993) did not find relation between toxocariasis and asthma.

Conclusion

The outcome data showed *Toxocara* positivity was associated with pets contact and/or soil contact, and low family income and ignorant mothers. No association was between *Toxocara* spp. rate and blood eosinophilia level in asthmatic patients. There was highly significant association between toxocariasis and eosinophilia among controls. Significant prevalence of anti *Toxocara* IgG in asthmatic patient also significant relation between toxocariasis and total IgE while significant negative relation between toxocariasis and skin prick test

References

Alcântara-Neves, NM, Britto, G, Veiga, RV, Figueiredo, CA, Fiaccone, RL, *et al*, 2014: Effects of helminth co-infections on atopy, asthma andcytokine production in children living in a poor urban area in Latin America. BMC Res. Notes 7, 8:17-24.

Alvarado-Esquivel, C, 2013: Toxocariasis in waste pickers: A case control seroprevalence study. PLoS One 8, e54897

Antonios, SN, Eid, MM, Khalifa, EA, Othman, AA, 2008: Seroprevalence study of *Toxocara canis* in selected Egyptian patients. J. Egypt. Soc. Parasitol. 38, 1:313-8.

Araujo, MI, Lopes, AA, Medeiros, M, Cruz, AA, Sousa-Atta, L, *et al*, 2000: Inverse association between skin response to aeroallergens and *Schistosoma mansoni* infection. Int. Arch. Allergy Immunol. 123:145-8.

Asher, MI, Weiland, SK, 1998: The International Study of Asthma and Allergies in Childhood (ISAAC) Steering Committee. Clin. Exp. Allergy 28, 5:S52-66.

Bahnea, RG, Ivan, A, Cârdei, E, Luca, MC, Stoica, O, 2008: Retrospective clinical and laboratory study of the toxocariasis cases hospitalized between 2005 and 2008. Rev. Med. Chir. Soc. Med. Nat. Iasi. 112:938-41

Bowman, DG, Hendrix, DS, 2008: Feline Clinical Parasitology, 1st ed. Iowa State University Press A Blachwell Science Company (281,286).

Buijs, J, Borsboom, G, van Gemund, JJ, Hazebroek, A, van Dongen, PA, 1994: *Toxocara* seroprevalence in 5-year-old elementary schoolchildren: Relation with allergic asthma. Am. J. Epidemiol. 140:839-47.

Buijs, J, Borsboom, G, Renting, M, Hilgersom, WJ, van Wieringen, JC, *et al*, 1997: Relationship between allergic manifestations and *Toxocara* seropositivity: a cross-sectional study among elementary school children. Eur. Respir. J. 10:1467-75

Buijs, J, Egbers, MW, Nijkamp, FP, 1995: *Toxocara canis*-induced airway eosinophilia and tracheal hyporeactivity in guinea pigs and mice. Euro. J. Pharmacol. 293:207-15.

Carvalho, E, Rocha, R, 2011: Toxocariasis: visceral larva migrans in children. J. Pediatr. (Rio J.) 87:100-10.

Chan, PW, Anuar, AK, Fong, MY, Debruyne, JA, Ibrahim, J, 2001: *Toxocara* seroprevalence and childhood asthma among Malaysian children. Pediatr. Int. 43:350-3.

Cooper, PJ, 2004: Intestinal worms and human allergy. Parasite Immunol.; 26: 455-467

Cooper, PJ, 2008: *Toxocara canis infection*: an important and neglected environmental risk factor for asthma? Clin. Exp. Allergy 38:551-3.

Dagoye, D, Bekele, Z, Woldemichael, K, Nida,

H, Yimam M, *et al*, 2003: Wheezing, allergy, and parasite infection in children in urban and rural Ethiopia. Am. J. Respir. Crit. Care Med. 167:1369-73.

Dattoli, VCC, Freire, SM, Mendonca, LR, Santos, PC, Meyer, R, A *et al*, 2011: *Toxocara canis* infection is associated with eosinophilia and total IgE. Trop. Med. Int. Hlth. 16:514-7.

Despommier, D, 2003: Toxocariasis: clinical aspects, epidemiology, medical ecology and molecular aspects. Clin. Microbiol. Rev. 16:265-72.

Eder, W, Ege, MJ, von Mutius, E, 2006: The asthma epidemic. N. Engl. J. Med. 355:2226-35

El-Tantawy, NL, El-Nahas, HA, El-Assmy, M M, Alsalem, AM, 201): Clinico-sero-epidemiological evaluation of toxocariasis in asthmatic pediatric children in Mansoura city in Egypt. Arch. Clin. Microbiol. 4, 4:3-8.

El-Tras, WF, Holt, HR, Tayel, AA, 2011: Risk of *Toxocara canis* eggs in stray and domestic dog hair in Egypt. Vet. Parasitol. 178, 3/4:319-23

Etewa, SE, Abdel-Rahman, SA, Abd El-Aal, NF, Fathy, GM, El-Shafey, MA, *et al*, 2014: Geohelminths distribution as affected by soil properties, physicochemical factors and climate in Sharkyia Governorate, Egypt. J. Parasit. Dis. 10.1007/s12639-014-053

Fernando, D, Wickramasinghe, P, Kapilanand, G, Dewasurendra, RL, Amarasooriya, M, Dayaratne, A, 2009: *Toxocara* seropositivity in Sri Lankan children with asthma. Pediatr. Int. 51:241-5

Ferreira, MU, Rubinsky-Elefant, G, de Castro, T, Hoffmann, EH, da Silva, M. *et al*, 2007: Bottle feeding and exposure to *Toxocara* as risk factors for wheezing illness among under-five Amazonian children: A population based cross-sectional study. J. Trop. Pediatr. 53:119-24.

Figueiredo, SD, Taddei, JA, Menezes, JJ, Novo, NF, Silva, EO, *et al*, 2005: Clinical-epidemiological study of toxocariasis in a pediatric population. J. Pediatr. 81:126-32

Fragoso, RP, Monteiro, MB, Lemos, EM, Pereira FE, 2011: Anti-*Toxocara* antibodies detected in children attending elementary school in Vitoria, State of Espírito Santo, Brazil: prevalence and associated factors. Rev. Soc. Bras. Med. Trop. 44:461-6.

Gavignet, B, Piarroux, R, Aubin, F, Millon, L, Humbert, P, 2008: Cutaneous manifestations of human toxocariasis. J. Am. Acad. Dermatol. 59:1031-42.

Gonzalez-Quintela, A, Gude, F, Campos, J, Garea, MT, Romero, PA, *et al*, 2006: *Toxocara* infection seroprevalence and its relationship with atopic features in a general adult population. Int. Arch. Allergy Immunol. 139:317-24

Hotez, PJ, Wilkins, PP, 2009: Toxocariasis: America's most common neglectedinfection of poverty and a helminthiasis of global importance? PLoS Negl. Trop. Dis. 3:e400

Johansson, SGO, Mellbin, T, Vahlquist, B, 1968: Immunoglobin levels in Ethiopian preschool children with special reference to high concentrations of IgE (IgND). Lancet 1:1118-21.

Johansson, S, Bieber, T, Dahl, R, *et al*, 2004: Revised nomenclature for allergy for global use: Report of the Nomenclature Review Committee of the World Allergy Organization, October 2003. J. Allergy Clin. Immunol. 113:832-6.

Haridy, FM, Hassan, AA, Hafe, AO, El-Sherbini, GT, Morsy, TA, 2009: External and intestinal parasites of pet dogs with reference to zoonotic toxocariasis. J. Egypt. Soc. Parasitol. 39, 1:321-6.

Kanobana, K, Vereecken, K, Diaz, R, Sariego, I, Rojas, L, *et al*, 2013: *Toxocara* seropositivity, atopy and asthma: a study in Cuban schoolchildren. Trop. Med. Int. Hlth. 18: 403-6.

Kemp, T, Pearce, N, Crane, J, Beasley, R, 1996: Problems of measuring asthma prevalence. Respirology 1:183-8.

Kerr-Muir, MG, 1994: *Toxocara canis* and human health. BMJ. 309:5-6.

Khalil, HM, 1977: Toxocariasis in Egypt. J. Egypt. Publ. Hlth. Assoc. 52, 5:330-43

Loukas, A, Hintz, M, Linder, D, Mullin, NP, Parkinson, J, *et al*, 2000: A family of secreted mucins from the parasitic nematode *Toxocara canis* bears diverse mucin domains but shares similar flanking six-cysteine repeat motifs. J. Biol. Chem. 275:39600-7

Macpherson, CN, 2013: The epidemiology and public health importance of toxocariasis: a zoonosis of global importance. Int. J. Parasitol. 43: 999-1008

Magnaval, JF, Glickman, LT, Dorchies, P, Morassin, B, 2001: Highlights of human toxocariasis. Korean J. Parasitol. 39:1-11

Maizels, RM, 2013: *Toxocara canis*: molecular basis of immune recognition and evasion. Vet. Parasitol. 193, 4:365-74.

Mallol, J, Sole, D, Asher, I, *et al*, 2000: Prevalence of asthma symptoms in Latin America: Int-

ernational Study of Asthma and Allergies in Childhood (ISAAC). Pediatr. Pulmonol. 30:439-44.

Martin, UO, Machuca, PB, Demonte, MA, Contini, L, 2008: Analysis of children with a presumptive diagnosis of toxocariasis in Santa Fe, Argentina. Med. (B Aires) 68:353-7

Mendonca, LR, Veiga, RV, Dattoli, VC, Figueiredo, CA, Fiaccone, R, *et al*, 2012: *Toxocara* seropositivity, atopy and wheezing inchildren living in poor neighborhoods in urban Latin American. PLoS Negl.Trop. Dis. 6:e1886.

Mendonca, LR, Figueiredo, CA, Esquivel, R, Fiaccone, RL, Carvalho, L, *et al*, 2013: Seroprevalence and risk factors for *Toxocara* infection in children from an urban large setting in Northeast Brazil. Acta Trop. 128, 90–95

Moncayo, A, Vaca, M, Oviedo, G, Erazo, S, Quinzo, I, *et al*, 2010: Risk factors for atopic and non-atopic asthma in a rural area of Ecuador. Thorax 65:409-16.

Morsy, TA, Sadek, MS, Abdel Hamid, MY, 1981: Intestinal parasites of stray cats in Cairo, Egypt. J. Egypt. Soc. Parasitol. 11, 2:331-45.

Nada, SM, Abazza, BE, Mahmoud, LA, Habeeb, YS, Hussein, HF, *et al*, 1996: Toxocariasis as a cause of renal disease in children in Sharkia Governorate, Egypt. J. Egypt. Soc. Parasitol. 26, 3:709-17.

Nyan, OA, Walraven, GE, Banya, WA, *et al*, 2001: Atopy, intestinal helminth infection and total serum IgE in rural and urban adult Gambian communities. Clin. Exp. Allergy 31:1672-8.

Pinelli, E, Brandes, S, Dormans, J, Gremmer, E, van Loveren, H, 2008: Infection with the roundworm *Toxocara canis* leads to exacerbation of experimental allergic airway inflammation. Clin. Exp. Aller. 38:649-58.

Pitrez, PM, Stein, RT, 2008: Asthma in Latin America: the dawn of a new epidemic. Curr. Opin. Aller. Clin. Immunol. 8:378-83.

Roldán, WH, Cavero, YA, Espinoza, YA, Jiménez, S, Gutiérrez, CA, 2010: Human toxocariasis: A sero-epidemiological survey in the Amazonian City of Yurimaguas, Peru. Rev. Inst. Med. Trop. Sao Paulo 52, 1:37-42.

Romero Nú˜nez, C, Mendoza, GD, Ya˜nez, S, Ponce, M, Bustamante, P, *et al*, 2013: Prevalence and risk factors associated with *Toxocara canis* infection in children. Sci. World J. 5:72-89

Saporito, L, Scarlata, F, Colomba, C, Infurnari, L, Giordano, S, *et al*, 2008: Human toxocariasis: A report of nine cases. Acta Paediatr. 97: 1301-2.

Schnieder, T, Laabs, EM, Welz, C, 2011: Larval development of *Toxocara canis* in dogs. Vet. Parasitol. 175:193-206.

Sharghi, N, Schantz, PM, Caramico, L, Ballas, K, Teague, BA, *et al*, 2001: Environmental exposure to *Toxocara* as a possible risk factor for asthma: A clinic-based case-control study. Clin. Infect. Dis. 32:111-6.

Silva, MB, **Amor, AL, Santos, LN, Galvão, A A, OviedoVera, AV, *et al*, 2016:** Risk factors for *Toxocara* spp. seroprevalence and its association with atopy & asthma phenotypes in school age children in a small town and semi-rural areas of Northeast Brazil. Acta Trop. 17, 9:425-8.

Souza, RF, Dattoli, VC, Mendonca, LR, Jesus, JR, Baqueiro, T, *et al*, 2011: Prevalence and risk factors of human infection by *Toxocara canis* in Salvador, State of Bahia, Brazil. Rev. Soc. Bras. Med. Trop. 44:516-9.

Strube, C, Heuer, L, Janecek, E, 2013: *Toxocara* spp. infections in paratenic hosts. Vet. Parasitol. 193:375-89.

Taylor, MRH, 1993: Toxocariasis in Ireland. In: *Toxocara* and Toxocariasis: Lewis, JW, Maizels, RM, eds.; London Institute of Biology and the British Society for Parasitology, London.

Tschopp, JM, Sistek, D, Schindler, C, *et al*, 1998: Current allergic asthma and rhinitis: diagnostic efficiency of three commonly used atopic markers (IgE, skin prick tests, and Phadiatop). Results from 8329 randomized adults from the SAPALDIA Study. Swiss study on air pollution and lung diseases in adults. Allergy 53:608-13.

Van Riet, E, Hartgers, FC, Yazdanbakhsh, M, 2007: Chronic helminth infections induce immunomodulation: consequences and mechanisms. Immunobiol. 212:475-90

Vereecken, K, Kanobana, K, Wordemann, M, et al, 2012: Associations between atopic markers in asthma and intestinal helminth infections in Cuban schoolchildren. Pediat. Aller. Immunol. 23:332-8

Walsh, MG, Haseeb, MA, 2012: Reduced cognitive function in children with toxocariasis in a nationally representative sample of the United States. Int. J. Parasitol. 42, 13/14:1159-63.

Wi´sniewska-Ligier, M, Wo´zniakowska-Gesicka, T, Sobolewska, J, Markiewicz-Jó´zwi ak, A, Wieczorek, M, 2012: Analysis of the co-urse and treatment of toxocariasis in children-a long-term observation. Parasitol. Res. 110:2363- 71.