Epidemiological and clinical characteristics of hookworm-related cutaneous larva migrans

Jörg Heukelbach, Hermann Feldmeier

Department of Community Health, School of Medicine, Federal University of Ceará, Brazil (Prof J Heukelbach MD); School of Public Health, Tropical Medicine and Rehabilitation Sciences, James Cook University, Townsville, Australia (Prof J Heukelbach); and Institute of Microbiology and Hygiene, Charité Medical School, Campus Benjamin Franklin, Berlin, Germany (Prof H Feldmeier MD)

Correspondence to:
Prof Hermann Feldmeier, Institute of Microbiology and Hygiene, Charité–University Medicine, Campus Benjamin Franklin, Hindenburgdamm 27, 12203 Berlin, Germany.
Tel +49 4181 281628;
fax +49 4181 36943;
hermann.feldmeier@charite.de

Hookworm-related cutaneous larva migrans is caused by the migration of animal hookworm larvae in the human skin. The disease mainly occurs in resource-poor communities in the developing world, but it is also reported sporadically in high-income countries and in tourists who have visited the tropics. Diagnosis is made clinically in the presence of a linear serpiginous track moving forward in the skin, associated with itching and a history of exposure. Itching is typically very intense and can prevent patients from sleeping. Bacterial superinfection occurs as a result of scratching. Treatment is based on oral drugs (albendazole or ivermectin) or the topical application of tiabendazole. To control hookworm-related cutaneous larva migrans at the community level, regular treatment of dogs and cats with anthelmintic drugs is necessary, but this is seldom feasible in resource-poor settings. Animals should be banned from beaches and playgrounds. For protection at the individual level, unprotected skin should not come into contact with possibly contaminated soil.

Introduction

In 1874, Lee[1] described for the first time a "creeping eruption" on the skin of a patient. About 50 years later, Kirby-Smith and colleagues[2] discovered a nematode larva in the skin biopsy sample of a patient with a creeping eruption. In the following years, experimental infections of volunteers with larvae of the dog and cat hookworms *Ancylostoma braziliense*, *Ancylostoma caninum*, and *Uncinaria stenocephala* consistently produced the clinical sign of a creeping eruption.[3–7]

For decades, the terms cutaneous larva migrans and creeping eruption have been used as synonyms. The first term describes a syndrome and the second a clinical sign, present in a variety of conditions.[8–10] A creeping eruption is defined clinically as a linear or serpiginous, slightly elevated, erythematous track that moves forward in an irregular pattern (figure 1).[9,11] It can be caused by animal hookworm and other nematode larvae, or by parasites such as *Gnathostoma* spp and *Loa loa*,[8,9,12–15] *Sarcoptes scabiei* (scabies mites), and larvae of parasitic flies (migratory myiasis).

A creeping eruption caused by *Strongyloides stercoralis* is called larva currens. The term reflects the fast movement of strongyloides larvae. Recently, the trematode *Fasciola gigantica* and the nematode *Spirurina* spp have been identified as rare causes for creeping eruption in Vietnam and Japan, respectively.[16,17]

Obviously, the syndrome cutaneous larva migrans excludes conditions in which the creeping eruption is caused by non-larval forms of migratory parasites, such as in dracontiasis, loiasis, or scabies, or when larvae penetrate the dermis, with or without producing the clinical picture of a creeping eruption. This is the case in cercarial dermatitis (schistosomiasis), onchocerciasis, and dirofilariasis.[8,9,18]

When animal hookworm larvae are responsible for a creeping eruption, the disease is called hookworm-related cutaneous larva migrans.[8,9] We describe the epidemiological and clinical characteristics of this condition, which causes substantial discomfort to several millions of people in developing countries every year.

Biology

Adult hookworms live in the intestine of dogs and cats. Infection may be asymptomatic in these animals, but it can cause wasting, anaemia, and death.[19] Eggs shed in faeces hatch in the superficial layer of the soil within 1 day, and develop into infective third-stage larvae after about 1 week.[5,11] When larvae are protected from direct sunlight and desiccation in a warm and humid environment, they can survive and remain infective for several months.

Third-stage *A caninum* larvae respond to soil vibration and increases in temperature with snake-like movements.[20] The characteristic movement seems to help the larvae find an animal host. This waving behaviour is also stimulated by the carbon dioxide content of the air.[20]

Similar to human hookworm larvae, host-seeking in *A caninum* larvae is driven by a temperature gradient.[20–22] After having located a host, larvae creep on the skin surface investigating a suitable penetration site.[23] Eventually, the larvae penetrate into the corneal layer of the epidermis.[19,24–27] The infective third-stage larvae excrete a protease and a hyaluronidase, enabling passage through the skin.[28]
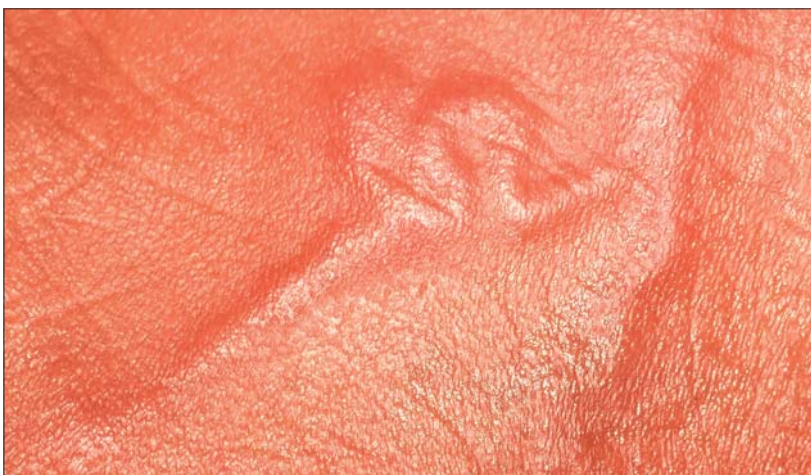

Figure 1: Characteristic creeping eruption in a child with hookworm-related cutaneous larva migrans

In the animal host, larvae penetrate into the lymphatic and venous system, eventually causing intestinal hookworm disease. However, in human beings, larvae cannot penetrate further and are confined to the skin, where they are unable to develop and complete their lifecycle, as they would do in dogs and cats.[29,30] Thus, human beings are accidental hosts and a parasitological impasse. By consequence, hookworm-related cutaneous larva migrans is a self-limiting disease that can persist for months, and rarely for years.[10,24,31–35]

Depending on the hookworm species, larvae migrate some millimetres up to a few centimetres per day. Sandground[36] observed itching within 1 h after participants were infested with a single *A braziliense* larva, whereas the creeping eruption became visible only after a few days. By contrast, in experimental infestation with *U stenocephala*, papules developed after 4–6 days, and a track appeared after 2 weeks.[7] Jackson and colleagues[37] estimated, based on the duration of infestations and the length of tracks, an average prolongation of the creeping eruption of 2·7 mm per day; however, the hookworm species was not determined in this study.

Geographical distribution and seasonal variation

Hookworm-related cutaneous larva migrans is endemic in resource-poor communities in the developing world, particularly in Brazil, India, and the West Indies.[37–40] The disease occurs sporadically or in the form of small epidemics in high-income countries and is reported in tourists who have visited the tropics. The infestation is frequent in areas where stray dogs and cats are common or where pets are not treated regularly with anthelmintics.

There is a distinct seasonal variation of hookworm-related cutaneous larva migrans, with a peak incidence during the rainy season.[41,42] Embryonated eggs and larvae survive longer in wet soil than in dry soil and are dispersed over a wide area by heavy rainfalls. By consequence, the risk of desiccation of eggs and larvae is much higher in the dry season than the rainy season. Additionally, a wet climate leads also to an increase of hookworm disease in dogs and cats, which in turn will augment the dispersion of contaminated faeces and the risk of infection in human beings.

Clinical picture

Usually, itching begins shortly after larvae have started to penetrate into the epidermis. A reddish papule appears at the penetration site in immunologically naive individuals and also in individuals sensitised previously. Hence, the itchy sensation does not reflect a specific immune response, but seems to be triggered by stimulation of itching fibres, presumably by substances released from the larva. In most cases, 1–5 days after penetration the elevated track appears (figure 1). However,

Figure 2: Bullous lesions in a patient with hookworm-related cutaneous larva migrans

studies on travellers have shown that the incubation period may last a month or even longer.[10,33,43] Larvae usually migrate in the epidermis for 2–8 weeks to several months.[10,24,31,33,37] The itching is intense and described as very uncomfortable by patients.[37,39] A recent study showed that 81% of patients with hookworm-related cutaneous larva migrans were prevented from normal sleep because of the intensity of itching.[37] Pain can also be present.[37,39]

Lesions tend to become superinfected with pathogenic bacteria as a result of scratching, particularly in developing countries.[30,39,41,44] In resource-poor communities in Brazil, superinfection of lesions was observed in 8–24% of patients,[37,39] whereas superinfection in returning travellers with hookworm-related cutaneous larva migrans occurred in 0–8%.[10,24,43] *Staphylococcus aureus* and streptococci are particularly common causes of super-infection of lesions. If lesions remain infected with group A streptococci for a prolonged period of time, post-streptococcal glomerulonephritis may ensue.[45]

Vesiculobullous lesions (figure 2) occur in 9–15% of cases,[26,31] with bullae sometimes reaching an impressive size of several centimetres.[46] The pathophysiology of bulla formation in hookworm-related cutaneous larva migrans is not known. Folliculitis (the presence of a papulopustular inflammation of follicles) is an uncommon clinical manifestation of hookworm-related cutaneous larva migrans and has been described in travellers returning from tropical countries.[31,47,48] Erythema multiforme is seen sporadically, and is considered a complication in previously sensitised individuals.[49] Very rarely, animal hookworm larvae may invade the viscera and cause pulmonary eosinophilia (Loeffler's syndrome).[50–52] *A caninum* infection can cause eosinophilic enteritis,[53] characterised by abdominal pain associated with nausea and diarrhoea. The condition may mimic acute appendicitis or intestinal obstruction.[15,53]

In massive infestation, larval invasion of skeletal muscles has been described. Little and colleagues[54]

diagnosed hookworm-related cutaneous larva migrans in a man who had crawled under a house in Louisiana, USA, and developed intense itching a few hours later. The next day, multiple creeping eruptions appeared, and he developed pulmonary symptoms. Pulmonary infiltrates persisted for weeks. 3 months after infestation, an ancylostoma larva (probably *A caninum*), was detected in a biopsy sample of skeletal muscle.[54]

Most patients have only a single larval track. If several tracks are present, they may occur at different topographic sites. Lesions are usually located on the feet, buttocks, and thighs—ie, parts of unprotected skin that come into contact with contaminated soil. Tracks are also regularly found on the arms, elbows, legs, knees, and back,[24,33,37,39] and can occur on any area of the body including the face, scalp, and genitals.[24,41,55–59] Lesions have even been reported on the oral mucosa[60,61] or within sebaceous glands on the scalp.[59] These rare localisations are explained by the creeping of larvae on the skin before penetration. Alternatively, larvae may be transferred to human skin through contaminated clothes, towels, or other objects.

In endemic areas, the topographic distribution of tracks varies according to age; children have more lesions on the buttocks, genitals, and hands, whereas lesions in adults are almost exclusively found on the legs and feet.[37]

The topographic distribution of lesions in tourists differs from that found in people living in endemic communities. In a study of people living in an urban slum in an endemic area, most tracks occurred on the trunk and the legs, and not a single track was found on the feet.[39] By contrast, in tourists, the feet, buttocks, and thighs—body areas that typically come into contact with contaminated sand while walking or sitting on the beach—are affected in decreasing order of frequency.[24,26,31,33,43,62] In India, a massive infestation with innumerable lesions on the scalp, face, trunk, and arms was reported in a man sleeping on the wet floor of a bus station.[63]

Infestation through contaminated fomites is rare. In Italy a small outbreak of hookworm-related cutaneous larva migrans was reported involving six individuals with lesions on the anterior part of thighs, arms, and chest, caused by contaminated dried flowers used for decoration purposes.[64]

Diagnosis and differential diagnosis

The diagnosis of hookworm-related cutaneous larva migrans is easily made clinically and is supported by a travel history, or in an endemic setting, by possibility of exposure.[10,11,26,30,65,66] Creeping eruption as a clinical sign is diagnostic; a biopsy is not useful. The invasive procedure only rarely identifies the parasites, since the anterior end of the track does not necessarily indicate the place where the larva is located.

Eosinophilia may or may not be present and is not specific.[24,33,67] In a study in Germany on returning travellers with hookworm-related cutaneous larva migrans, only eight (20%) of 40 presented with eosinophilia, but infection status regarding other helminths was not known.[33] However, a high eosinophil count can indicate migration of helminth larvae into the viscera, a rare complication.

Cutaneous larva migrans caused by *A caninum* may be detected by ELISA. The test has been applied in a single case, and there are no data on sensitivity and specificity.[68] Recently, epiluminescence microscopy has been used to visualise migrating larvae.[69,70] The sensitivity of this method is not known.

For clinicians not familiar with hookworm-related cutaneous larva migrans, the disease may mimic scabies, loiasis, myiasis, cercarial dermatitis (schistosomiasis), tinea corporis, and contact dermatitis, but considering the characteristic features of hookworm-related cutaneous larva migrans, these conditions are ruled out easily.[10,11] Larva currens has to be excluded. *S stercoralis* larvae migrate several centimetres per hour, considerably faster than those of animal hookworms and the track moves forward in a haphazard manner; lesions persist for only a few hours and occur in the perianal area, on the thighs, and on the trunk.[30,71]

Hookworm-related cutaneous larva migrans can mimic herpes zoster;[72] however, the latter follows the anatomic path of a peripheral nerve and does not progress in the manner that the creeping eruption in hookworm-related cutaneous larva migrans does. A serpiginous ganglion cyst has also to be considered as a differential diagnosis.[73] Another condition of non-parasitic origin resembling creeping eruption has been a hair growing horizontally in the skin.[74]

Case management

Oral treatment

Three drugs are available for systemic treatment, all of which are powerful anthelmintics.[75–78] The drug of choice is ivermectin. A single dose (200 μg per kg bodyweight) kills the migrating larvae effectively and relieves itching quickly.[75,79–81] Cure rates after a single dose range from 77% to 100%.[31,43,79,82] In the event of treatment failure, a second dose usually provides a definitive cure.[43,75,82] Repeated treatment may be necessary in hookworm folliculitis.[48] Ivermectin is contraindicated in children who weigh less than 15 kg (or are less than 5 years of age) and in pregnant or breastfeeding women. However, off-label treatment of children and inadvertent treatment of pregnant women have occurred without reports of significant adverse events.[83,84] Ivermectin has an excellent safety profile, and has been used in millions of individuals in the developing world during onchocerciasis and filariasis control operations without any notable adverse events.[85]

A single dose of ivermectin is more effective than a single dose of albendazole,[24,75,79] but repeated treatments with albendazole are a good alternative in countries where ivermectin is not available. Oral albendazole (400 mg daily), given for 5–7 days, showed excellent cure rates of

92–100%, and the drug is well-tolerated by patients.[75,77,78,86,87] Because a single dose of albendazole has a lower efficacy,[75] a 3-day regimen of albendazole is usually recommended.[10] An alternative approach is to start with a first dose of albendazole and to repeat the treatment if necessary.

Tiabendazole (50 mg per kg bodyweight for 2–4 days) was widely used after the first report of its efficacy in 1963.[88–94] However, given orally the substance is poorly tolerated, and frequently causes dizziness, nausea, vomiting, and intestinal cramps.[24,75,89,92] Since ivermectin and albendazole perform better and cause fewer adverse events, the use of oral tiabendazole is not recommended.

Topical treatment

Topical tiabendazole has been used for more than 40 years.[93,95–98] Topical application on lesions in a concentration of 10–15% three times daily for 5–7 days is as effective as oral treatment with ivermectin.[26,33,99] The topical treatment is without adverse events, but requires good compliance from the patient. Topical tiabendazole is of limited value in the presence of multiple or widespread lesions, and is not effective in hookworm folliculitis.[75]

Ivermectin and albendazole are promising compounds for topical use, especially in children, but efficacy data on this form of administration are limited.[100]

Freezing the edge of the track with liquid nitrogen or carbon dioxide is obsolete, since it is ineffective, painful, and may cause ulcerations.[26,75,101] Secondary infections should be treated with a topical antibiotic.

Hookworm-related cutaneous larva migrans in low-income settings

In rural areas in South Africa, China, and Argentina, and also in urban areas in Uruguay and Netherlands Antilles, the prevalence of *Ancylostoma* spp in dogs ranges from 66% to 96%.[102–107] Backyards, streets, public parks, and playgrounds are frequently contaminated by dog and cat faeces, and hookworm larvae are commonly found in soil samples from such places.[108–111] Sand samples from a Caribbean beach have contained hookworm larvae of animal origin.[112] As a result, outbreaks have been reported in kindergartens, schools, public parks, and in children playing in sand boxes.[44,110,113–115]

In many resource-poor communities in the tropics, people walk barefooted, children crawl or sit naked on the ground, and pet animals are frequently infected with hookworms; therefore, the prevalence of hookworm-related cutaneous larva migrans is expected to be high. For instance, in urban slums and rural communities in Brazil up to 4% of the general population and 15% of children can be infested.[41,42] A low socioeconomic status and certain behaviour, such as walking barefoot, were identified as risk factors for the presence of hookworm-related cutaneous larva migrans in this setting.[42]

Figure 3: Sign prohibiting dogs to be taken to the beach in Mallorca, Spain

In low-income settings, people regard hookworm-related cutaneous larva migrans as a nuisance, and many are affected by the parasitic skin disease.[37,116] Treatment is often not available at local health-care centres and needs to be purchased at the pharmacy.

Hookworm-related cutaneous larva migrans in high-income countries

Sporadic cases of autochthonous hookworm-related cutaneous larva migrans acquired in high-income countries of temperate climate are usually associated with untypical climatic conditions, such as prolonged periods of warm weather and rainfall. Such cases have been reported in Germany, France, UK, New Zealand, and northern Australia.[117–127] When people live in close contact with their pets, infestations can also occur in winter time.[122]

In high-income countries with hot climates, such as in the southern USA, hookworm-related cutaneous larva migrans occurs sporadically or in small epidemics.[117,128–133] A study in Florida between 1998 and 2000 found that 20 (33%) of 60 feral cats were infected with *A braziliense*.[134] In Italy, an outbreak has been reported, and autochthonous cases have occurred, in beach volley ball and beach soccer players.[65,135,136]

If the global temperature increases further during the next decades, the occurrence of hookworm-related cutaneous larva migrans in high-income countries is expected to increase.

Hookworm-related cutaneous larva migrans in travellers

Most patients with hookworm-related cutaneous larva migrans seen by health-care professionals in high-income countries are travellers returning from the tropics and

subtropics.[11,26,31,33,43,137–142] A study based on 30 GeoSentinel sites including more than 17 000 travellers who returned ill showed that hookworm-related cutaneous larva migrans occurred in 2–3% of them, with the highest prevalence of the condition in those returning from Caribbean destinations, followed by southeast Asia, and Central America.[140] Similarly, in French travellers returning from tropical destinations who presented at a tropical diseases unit in Paris, hookworm-related cutaneous larva migrans was diagnosed in eight (1·3%) of 622 patients.[138]

At specialised units, the occurrence of hookworm-related cutaneous larva migrans is even higher. In three Italian dermatology clinics, 78 (70%) of 111 diagnosed parasitic conditions in travellers were hookworm-related cutaneous larva migrans,[139] and the disease was confirmed in 25% of 269 patients presenting with dermatoses during a 2-year period in a tropical disease unit in France.[31] Of 1010 returning travellers diagnosed with a parasitic condition at a tropical disease unit in Toronto (ON, Canada), 105 (10·4%) were diagnosed with hookworm-related cutaneous larva migrans, 92% of whom were tourists.[142] The high frequency of hookworm-related cutaneous larva migrans in tourists compared with other travellers (such as business travellers and people visiting friends and relatives) was confirmed in studies from France and Canada.[142,143] The Canadian study found that the disease in tourists was mainly acquired from beach destinations in Jamaica, Barbados, Brazil, Thailand, and Mexico.[142] An outbreak of hookworm-related cutaneous larva migrans in military personnel has been reported in Belize.[144]

Tourists are often not aware of the risk for acquiring hookworm-related cutaneous larva migrans when walking barefoot on beaches, or when sunbathing on the beach. Thus, the fact that most cases in tourists are acquired on tropical beach destinations reflects a typical risk behaviour of tourists rather than the true distribution of hookworm larvae in the endemic area. A recent airport-based study on international travellers leaving northeast Brazil showed that all travellers who acquired hookworm-related cutaneous larva migrans during their stay had visited beaches.[145] Protective footwear—eg, wearing sandals to the beach and on the beach—has shown to be effective in reducing infestation.[62]

Prevention and control

Human beings have kept domesticated dogs and cats since prehistoric times, and the close bond between human beings and domestic animals has facilitated the spread of zoonotic infections throughout the world.[146] Still today, human attitudes towards dogs and cats have a crucial role in the spread of zoonotic diseases. The dog population in areas endemic for hookworm-related cutaneous larva migrans is diverse and includes owned dogs (pet dogs) with restricted movement, free-ranging dogs that may receive some shelter or food from human beings but that are not owned, and feral dogs.[146] Free-ranging and feral dogs account for about half of the dog population in developing countries.[146] The situation is similar for cats.

To control hookworm-related cutaneous larva migrans at the community level, dogs and cats have to be treated regularly with anthelmintic drugs. However, in resource-poor communities, control is made difficult by financial constraints, the high number of stray dogs and cats, a deficient public veterinary health system, and unawareness of health risks by pet holders.[27] It is clear that in these settings, control can only be achieved by an integrated approach, based on cooperation between public-health professionals, medical anthropologists, veterinarians, and the community.[27]

Control based on health education and community participation in treatment of the animal reservoir have been effective and efficient in an endemic area in South Africa, where the number of cases decreased from 15 per month to none after applying these strategies.[147] Health education should be focused on mothers and teenage girls who take care of their younger siblings, since most cases in low-income communities occur in infants, toddlers, and small children.[42]

In high-income countries, pets should be dewormed regularly. In urban areas animals should be banned from beaches and playgrounds, and faeces should be collected by the pet owner immediately after defecation.

Sand pits should be covered with clear plastic covers to prevent animals defecating in them at night.[148] It has also been postulated that this control measure would result in high soil temperature during daily sunlight, preventing survival of larvae.[148]

The only means of prevention at the individual level in endemic areas is to avoid unprotected skin coming into contact with possibly contaminated soil. However, such behavioural changes are difficult to encourage, since they are deeply rooted in a societal context. Besides, families in low-income endemic areas are often too poor to afford shoes for all children.

Tourists should be advised to use sandals when walking on the beach, to avoid beaches where dogs and cats stroll around, and to use a sun chair on tropical beaches.[11,62] Lying on towels does not protect sufficiently. Areas on the beach where the sand has been humidified by the tide can be considered as safe. Additionally, animals should be banned from beaches (figure 3). Towels and clothes should not touch the ground when hung up for drying. In general, tourists should avoid direct soil contact in places where dogs and cats are observed.

Conclusion

Hookworm-related cutaneous larva migrans occurs in endemic areas mainly in low-income communities, but also in tourists visiting beach destinations in tropical and

subtropical areas. The disease causes discomfort and substantial morbidity. Adequate prevention measures using an integrative approach need to be implemented to reduce the occurrence of hookworm-related cutaneous larva migrans.

Conflicts of interest
We declare that we have no conflicts of interest.

References

1 Lee RJ. Case of creeping eruption. *Trans Clin Soc London* 1874; **8:** 44–45.

2 Kirby-Smith JL, Dove WE, White GF. Creeping eruption. *Arch Dermatol* 1926; **13:** 137–73.

3 White GF, Dove WE. A dermatitis caused by larvae of *Ancyolostoma caninum*. *Arch Dermatol* 1929; **20:** 191–200.

4 Shelmire B. Experimental creeping eruption from a dog and cat hookworm (*A braziliense*). *JAMA* 1928; **91:** 938–44.

5 Beaver PC. Larva migrans. *Exp Parasitol* 1956; **5:** 587–621.

6 Hunter GW, Worth CB. Variations in response to filariform larvae of *Ancylostoma caninum* in the skin of man. *J Parasitol* 1945; **31:** 366–72.

7 Fülleborn F. Experimentally generated "creeping eruption". *Dermatol Wochenschr* 1926; **83:** 1474–75 (in German).

8 Caumes E. It's time to distinguish the sign "creeping eruption" from the syndrome "cutaneous larva migrans". *Dermatology* 2006; **213:** 179–81.

9 Caumes E, Danis M. From creeping eruption to hookworm-related cutaneous larva migrans. *Lancet Infect Dis* 2004; **4:** 659–60.

10 Hochedez P, Caumes E. Hookworm-related cutaneous larva migrans. *J Travel Med* 2007; **14:** 326–33.

11 Heukelbach J, Feldmeier H. Creeping eruption (cutaneous larva migrans). In: Faber WR, Hay RJ, Naafs B, eds. Imported skin diseases, 1st edn. Maarssen: Elsevier, 2006: 243–50.

12 Menard A, Dos SG, Dekumyoy P, et al. Imported cutaneous gnathostomiasis: report of five cases. *Trans R Soc Trop Med Hyg* 2003; **97:** 200–02.

13 Magana M, Messina M, Bustamante F, Cazarin J. Gnathostomiasis: clinicopathologic study. *Am J Dermatopathol* 2004; **26:** 91–95.

14 Diaz Camacho SP, Willms K, de la Cruz Otero Mdel, et al. Acute outbreak of gnathostomiasis in a fishing community in Sinaloa, Mexico. *Parasitol Int* 2003; **52:** 133–40.

15 Gillespie SH. Cutaneous larva migrans. *Curr Infect Dis Rep* 2004; **6:** 50–53.

16 Hattori S, Niimi Y, Kawana S. Creeping eruption caused by a larva of the suborder Spirurina type X. *Eur J Dermatol* 2003; **13:** 87–89.

17 Xuan lT, Hung NT, Waikagul J. Cutaneous fascioliasis: a case report in Vietnam. *Am J Trop Med Hyg* 2005; **72:** 508–09.

18 Kourilova P, Hogg KG, Kolarova L, Mountford AP. Cercarial dermatitis caused by bird schistosomes comprises both immediate and late phase cutaneous hypersensitivity reactions. *J Immunol* 2004; **172:** 3766–74.

19 Kahrs RF, Holmes DN, Poppensiek GC. Diseases transmitted from pets to man: an evolving concern for veterinarians. *Cornell Vet* 1978; **68:** 442–59.

20 Granzer M, Haas W. Host-finding and host recognition of infective *Ancylostoma caninum* larvae. *Int J Parasitol* 1991; **21:** 429–40.

21 Khalil M. Thermotropism in ancylostome larvae. *Proc R Soc Med* 1922; **15:** 16–18.

22 Haas W, Haberl B, Syafruddin, Idris I, Kersten S. Infective larvae of the human hookworms *Necator americanus* and *Ancylostoma duodenale* differ in their orientation behaviour when crawling on surfaces. *Parasitol Res* 2005; **95:** 25–29.

23 Haas W, Haberl B, Syafruddin, et al. Behavioural strategies used by the hookworms *Necator americanus* and *Ancylostoma duodenale* to find, recognize and invade the human host. *Parasitol Res* 2005; **95:** 30–39.

24 Blackwell V, Vega-Lopez F. Cutaneous larva migrans: clinical features and management of 44 cases presenting in the returning traveller. *Br J Dermatol* 2001; **145:** 434–37.

25 Albanese G, di Cintio R, Beneggi M, et al. Larva migrans in Italy. *Int J Dermatol* 1995; **34:** 464–65.

26 Davies HD, Sakuls P, Keystone JS. Creeping eruption. A review of clinical presentation and management of 60 cases presenting to a tropical disease unit. *Arch Dermatol* 1993; **129:** 588–91.

27 Heukelbach J, Mencke N, Feldmeier H. Cutaneous larva migrans and tungiasis: the challenge to control zoonotic ectoparasitoses associated with poverty. *Trop Med Int Health* 2002; **7:** 907–10.

28 Hotez PJ, Narasimhan S, Haggerty J, et al. Hyaluronidase from infective Ancylostoma hookworm larvae and its possible function as a virulence factor in tissue invasion and in cutaneous larva migrans. *Infect Immun* 1992; **60:** 1018–23.

29 Elliot DL, Tolle SW, Goldberg L, Miller JB. Pet-associated illness. *N Engl J Med* 1985; **313:** 985–95.

30 Gilles HM. Soil-transmitted helminths (geohelminths). In: Cook GC, Zumla A, eds. Manson's Tropical Diseases, 21st edn. London: Saunders, 2004: 1527–60.

31 Caumes E, Carriere J, Guermonprez G, Bricaire F, Danis M, Gentilini M. Dermatoses associated with travel to tropical countries: a prospective study of the diagnosis and management of 269 patients presenting to a tropical disease unit. *Clin Infect Dis* 1995; **20:** 542–48.

32 Stone OJ, Willis CJ. Cutaneous hookworm reservoir. *J Invest Dermatol* 1967; **49:** 237–39.

33 Jelinek T, Maiwald H, Nothdurft HD, Loscher T. Cutaneous larva migrans in travelers: synopsis of histories, symptoms, and treatment of 98 patients. *Clin Infect Dis* 1994; **19:** 1062–66.

34 Richey TK, Gentry RH, Fitzpatrick JE, Morgan AM. Persistent cutaneous larva migrans due to *Ancylostoma* species. *South Med J* 1996; **89:** 609–11.

35 Katz R, Ziegler J, Blank H. The natural course of creeping eruption and treatment with thiabendazole. *Arch Dermatol* 1965; **91:** 420–24.

36 Sandground JH. Creeping eruption in the Netherland East Indies caused by the invasion of the larvae of *Ancylostoma braziliense*. *Geneesk Tijdschr Ned Indië* 1939; **13:** 805–10.

37 Jackson A, Heukelbach J, Calheiros CM, Soares VL, Harms G, Feldmeier H. A study in a community in Brazil in which cutaneous larva migrans is endemic. *Clin Infect Dis* 2006; **43:** e13–18.

38 Chetty GN, Janaki VR, Thambiah AS. Cutaneous larva migrans (report of five cases). *J Assoc Physicians India* 1981; **29:** 403–06.

39 Heukelbach J, Wilcke T, Feldmeier H. Cutaneous larva migrans (creeping eruption) in an urban slum in Brazil. *Int J Dermatol* 2004; **43:** 511–15.

40 Lee CP, Bishop LJ. The incidence of cutaneous larva migrans in Montserrat, Leeward Islands, West Indies. *West Indian Med J* 1988; **37:** 22–24.

41 Heukelbach J, Wilcke T, Meier A, Saboia Moura RC, Feldmeier H. A longitudinal study on cutaneous larva migrans in an impoverished Brazilian township. *Travel Med Infect Dis* 2003; **1:** 213–18.

42 Heukelbach J, Jackson A, Ariza L, Feldmeier H. Prevalence and risk factors of hookworm-related cutaneous larva migrans in a rural community in Brazil. *Ann Trop Med Parasitol* 2008; **102:** 53–61.

43 Bouchaud O, Houze S, Schiemann R, et al. Cutaneous larva migrans in travelers: a prospective study, with assessment of therapy with ivermectin. *Clin Infect Dis* 2000; **31:** 493–98.

44 Lima W, de Camargo MC, Guimaraes MP. Outbreak of cutaneous larva migrans in a nursery school in Belo Horizonte, Minas Gerais (Brazil). *Rev Inst Med Trop Sao Paulo* 1984; **26:** 122–24 (in Portuguese).

45   Feldmeier H, Singh CG, Guerra H. Pyoderma, group A streptococci and parasitic skin diseases—a dangerous relationship. *Trop Med Int Health* 2005; **10:** 713–16.

46   Veraldi S, Arancio L. Giant bullous cutaneous larva migrans. *Clin Exp Dermatol* 2006; **31:** 613–14.

47   Veraldi S, Bottini S, Carrera C, Gianotti R. Cutaneous larva migrans with folliculitis: a new clinical presentation of this infestation. *J Eur Acad Dermatol Venereol* 2005; **19:** 628–30.

48   Caumes E, Ly F, Bricaire F. Cutaneous larva migrans with folliculitis: report of seven cases and review of the literature. *Br J Dermatol* 2002; **146:** 314–16.

49   Vaughan TK, English JC. Cutaneous larva migrans complicated by erythema multiforme. *Cutis* 1998; **62:** 33–35.

50   Schaub NA, Perruchoud AP, Buechner SA. Cutaneous larva migrans associated with Loffler's syndrome. *Dermatology* 2002; **205:** 207–09.

51   del Giudice P, Desalvador F, Bernard E, et al. Loeffler's syndrome and cutaneous larva migrans: a rare association. *Br J Dermatol* 2002; **147:** 386–88.

52   Chitkara RK, Krishna G. Parasitic pulmonary eosinophilia. *Semin Respir Crit Care Med* 2006; **27:** 171–84.

53   Croese J, Fairley S, Loukas A, Hack J, Stronach P. A distinctive aphthous ileitis linked to *Ancylostoma caninum*. *J Gastroenterol Hepatol* 1996; **11:** 524–31.

54   Little MD, Halsey NA, Cline BL, Katz SP. Ancylostoma larva in a muscle fiber of man following cutaneous larva migrans. *Am J Trop Med Hyg* 1983; **32:** 1285–88.

55   Grassi A, Angelo C, Grosso MG, Paradisi M. Perianal cutaneous larva migrans in a child. *Pediatr Dermatol* 1998; **15:** 367–69.

56   French SJ, Lindo JF. Severe cutaneous larva migrans in a traveler to Jamaica, West Indies. *J Travel Med* 2003; **10:** 249–50.

57   Sherman SC, Radford N. Severe infestation of cutaneous larva migrans. *J Emerg Med* 2004; **26:** 347–49.

58   Karthikeyan K, Thappa DM, Jeevankumar B. Cutaneous larva migrans of the penis. *Sex Transm Infect* 2003; **79:** 500.

59   Guimarães LC, Silva JH, Saad K, Lopes ER, Oliveira Meneses AC. Larva migrans within scalp sebaceous gland. *Rev Soc Bras Med Trop* 1999; **32:** 187–89.

60   André J, Bernard M, Ledoux M, Achten G. Larva migrans in the oral mucosa. *Dermatologica* 1988; **176:** 296–98.

61   Thome Capuano AC, Catanhede Orsini Machado de Sousa, Aburad de Carvalhosa A, dos Santos Pinto JD. Larva migrans in the oral mucosa: report of a case. *Quintessence Int* 2006; **37:** 721–23.

62   Tremblay A, MacLean JD, Gyorkos T, Macpherson DW. Outbreak of cutaneous larva migrans in a group of travellers. *Trop Med Int Health* 2000; **5:** 330–34.

63   Sugathan P. Massive infestation of cutanea larva migrans. *Dermatol Online J* 2002; **8:** 21.

64   Galanti B, Fusco FM, Nardiello S. Outbreak of cutaneous larva migrans in Naples, southern Italy. *Trans R Soc Trop Med Hyg* 2002; **96:** 491–92.

65   dos Santos Lima W. Larva migrans. In: Neves, DP, ed. Parasitologia Humana, 10th edn. São Paulo: Editora Atheneu, 2002: 243–46 (in Portuguese).

66   Pessôa SB, Martins AV. Infecção com larvas de nematóides (Larva migrans). In: Pessôa SB, ed. Parasitologia médica (Medical parasitology). 11th edn. Rio de Janeiro: Guanabara Koogan, 1982: 586–93 (in Portuguese).

67   Heukelbach J, Poggensee G, Winter B, Wilcke T, Kerr-Pontes LR, Feldmeier H. Leukocytosis and blood eosinophilia in a polyparasitised population in north-eastern Brazil. *Trans R Soc Trop Med Hyg* 2006; **100:** 32–40.

68   Kwon IH, Kim HS, Lee JH, et al. A serologically diagnosed human case of cutaneous larva migrans caused by *Ancylostoma caninum*. *Korean J Parasitol* 2003; **41:** 233–37.

69   Elsner E, Thewes M, Worret WI. Cutaneous larva migrans detected by epiluminescent microscopy. *Acta Derm Venereol* 1997; **77:** 487–88.

70   Veraldi S, Schianchi R, Carrera C. Epiluminescence microscopy in cutaneous larva migrans. *Acta Derm Venereol* 2000; **80:** 233.

71   Gill GV, Welch E, Bailey JW, Bell DR, Beeching NJ. Chronic *Strongyloides stercoralis* infection in former British Far East prisoners of war. *Q JM* 2004; **97:** 789–95.

72   Malvy D, Ezzedine K, Pistone T, Receveur MC, Longy-Boursier M. Extensive cutaneous larva migrans with folliculitis mimicking multimetameric herpes zoster presentation in an adult traveler returning from Thailand. *J Travel Med* 2006; **13:** 244–47.

73   Friedli A, Saurat JH, Harms M. Serpiginous ganglion cyst of the foot mimicking cutaneous larva migrans. *J Am Acad Dermatol* 2002; **47:** S266–67.

74   Sakai R, Higashi K, Ohta M, Sugimoto Y, Ikoma Y, Horiguchi Y. Creeping hair: an isolated hair burrowing in the uppermost dermis resembling larva migrans. *Dermatology* 2006; **213:** 242–44.

75   Caumes E. Treatment of cutaneous larva migrans and toxocara infection. *Fundam Clin Pharmacol* 2003; **17:** 213–16.

76   Heukelbach J, Wilcke T, Winter B, et al. Efficacy of ivermectin in a patient population concomitantly infected with intestinal helminths and ectoparasites. *Arzneimittelforschung* 2004; **54:** 416–21.

77   Veraldi S, Rizzitelli G. Effectiveness of a new therapeutic regimen with albendazole in cutaneous larva migrans. *Eur J Dermatol* 1999; **9:** 352–53.

78   Rizzitelli G, Scarabelli G, Veraldi S. Albendazole: a new therapeutic regimen in cutaneous larva migrans. *Int J Dermatol* 1997; **36:** 700–03.

79   Caumes E, Carriere J, Datry A, Gaxotte P, Danis M, Gentilini M. A randomized trial of ivermectin versus albendazole for the treatment of cutaneous larva migrans. *Am J Trop Med Hyg* 1993; **49:** 641–44.

80   Caumes E, Datry A, Paris L, Danis M, Gentillini M, Gaxotte P. Efficacy of ivermectin in the therapy of cutaneous larva migrans. *Arch Dermatol* 1992; **128:** 994–95.

81   Dourmishev AL, Dourmishev LA, Schwartz RA. Ivermectin: pharmacology and application in dermatology. *Int J Dermatol* 2005; **44:** 981–88.

82   Van den Enden E, Stevens A, Van Gompel A. Treatment of cutaneous larva migrans. *N Engl J Med* 1998; **339:** 1246–47.

83   Sáez-de-Ocariz MM, McKinster CD, Orozco-Covarrubias L, Tamayo-Sánchez L, Ruiz-Maldonado R. Treatment of 18 children with scabies or cutaneous larva migrans using ivermectin. *Clin Dermatol* 2002; **27:** 264–67.

84   Gyapong JO, Chinbuah MA, Gyapong M. Inadvertent exposure of pregnant women to ivermectin and albendazole during mass drug administration for lymphatic filariasis. *Trop Med Int Health* 2003; **8:** 1093–101.

85   del Giudice P, Chosidow O, Caumes E. Ivermectin in dermatology. *J Drugs Dermatol* 2003; **2:** 13–21.

86   Albanese G, Venturi C. Albendazole: a new drug for human parasitoses. *Dermatol Clin* 2003; **21:** 283–90.

87   Sanguigni S, Marangi M, Teggi A, De Rosa F. Albendazole in the therapy of cutaneous larva migrans. *Trans R Soc Trop Med Hyg* 1990; **84:** 831.

88   Katz R, Ziegler J, Blank H. Creeping eruption treated with thiabendazole. *Arch Dermatol* 1965; **91:** 425–26.

89   Katz R, Ziegler J, Blank H. The natural course of creeping eruption and treatment with thiabendazole. *Arch Dermatol* 1965; **91:** 420–24.

90   Stone OJ, Mullins F. Thiabendazole effectiveness in creeping eruption. *Arch Dermatol* 1965; **91:** 427–29.

91   Stone OJ, Mullins F. First use of thiabendazole in creeping eruption. *Tex Rep Biol Med* 1963; **21:** 422–24.

92   Leeming JA. Cutaneous larva migrans. *S Afr Med J* 1966; **40:** 403–05.

93   Stromberg BE, Christie AD. Creeping eruption and thiabendazole. *Int J Dermatol* 1976; **15:** 355–56.

94   Hardin TF. Management of cutaneous larva migrans in pediatric practice: report on 200 cases. *J Am Osteopath Assoc* 1969; **68:** 970–72.

95   Eyster WH. Local thiabendazole in the treatment of creeping eruption. *Arch Dermatol* 1967; **95:** 620–21.

96   Davis CM, Israel RM. Treatment of creeping eruption with topical thiabendazole. *Arch Dermatol* 1968; **97:** 325–26.

97   Harland PS, Meakins RH, Harland RH. Treatment of cutaneous larva migrans with local thiabendazole. *BMJ* 1977; **2:** 772.

98   Whiting DA. The successful treatment of creeping eruption with topical thiabendazole. *S Afr Med J* 1976; **50:** 253–55.

99   Esser AC, Kantor I, Sapadin AN. Souvenir from the Hamptons— a case of cutaneous larva migrans of six months' duration. *Mt Sinai J Med* 1999; **66:** 334–35.

100 Caumes E. Efficacy of albendazole ointment on cutaneous larva migrans in 2 young children. *Clin Infect Dis* 2004; **38**: 1647–48.

101 Caumes E. Treatment of cutaneous larva migrans. *Clin Infect Dis* 2000; **30**: 811–14.

102 Saleh FC, Kirkpatrick CE, De Haseth O, Lok JB. Occurrence of some blood and intestinal parasites in dogs in Curaçao, Netherlands Antilles. *Trop Geogr Med* 1988; **40**: 318–21.

103 Minnaar WN, Krecek RC, Rajput JI. Helminth parasites of dogs from two resource-limited communities in South Africa. *J S Afr Vet Assoc* 1999; **70**: 92–94.

104 Taranto NJ, Passamonte L, Marinconz R, de Marzi MC, Cajal SP, Malchiodi EL. Zoonotic parasitosis transmitted by dogs in the Chaco Salteño, Argentina. *Medicina (B Aires)* 2000; **60**: 217–20 (in Spanish).

105 Malgor R, Oku Y, Gallardo R, Yarzabal I. High prevalence of *Ancylostoma* spp infection in dogs, associated with endemic focus of human cutaneous larva migrans, in Tacuarembo, Uruguay. *Parasite* 1996; **3**: 131–34.

106 Minnaar WN, Krecek RC. Veterinary needs of dogs in two resource-limited communities in the Gauteng and North West provinces of South Africa. *J S Afr Vet Assoc* 2001; **72**: 209–13.

107 Wang CR, Qiu JH, Zhao JP, Xu LM, Yu WC, Zhu XQ. Prevalence of helminthes in adult dogs in Heilongjiang Province, the People's Republic of China. *Parasitol Res* 2006; **99**: 627–30.

108 Castillo D, Paredes C, Zanartu C, et al. Environmental contamination with *Toxocara* sp eggs in public squares and parks from Santiago, Chile, 1999. *Bol Chil Parasitol* 2000; **55**: 86–91 (in Spanish).

109 Mercado R, Ueta MT, Castillo D, Munoz V, Schenone H. Exposure to larva migrans syndromes in squares and public parks of cities in Chile. *Rev Saude Publica* 2004; **38**: 729–31.

110 Santarem VA, Giuffrida R, Zanin GA. Cutaneous larva migrans: reports of pediatric cases and contamination by *Ancylostoma* spp larvae in public parks in Taciba, Sao Paulo State. *Rev Soc Bras Med Trop* 2004; **37**: 179–81 (in Portuguese).

111 Guimarães AM, Alves EG, de Rezende GF, Rodrigues MC. *Toxocara* sp eggs and *Ancylostoma* sp larva in public parks, Brazil. *Rev Saude Publica* 2005; **39**: 293–95 (in Portuguese).

112 Esterre P, Agis F. Beach sand nematodes in Guadeloupe: associated public health problems. *Bull Soc Pathol Exot Filiales* 1985; **78**: 71–78 (in French).

113 Araujo FR, Araujo CP, Werneck MR, Gorski A. Cutaneous larva migrans in children in a school of center-western Brazil. *Rev Saude Publica* 2000; **34**: 84–85 (in Portuguese).

114 Nunes CM, Pena FC, Negrelli GB, Anjo CG, Nakano MM, Stobbe NS. Presence of larva migrans in sand boxes of public elementary schools, Araçatuba, Brazil. *Rev Saude Publica* 2000; **34**: 656–58 (in Portuguese).

115 Gutierrez de la Solana Dumas, Alvarez MM, Manzur KJ. An outbreak of cutaneous larva migrans. *Rev Cubana Med Trop* 1983; **35**: 303–16.

116 Heukelbach J, van HE, Rump B, Wilcke T, Moura RC, Feldmeier H. Parasitic skin diseases: health care-seeking in a slum in north-east Brazil. *Trop Med Int Health* 2003; **8**: 368–73.

117 Boland TW, Agger WA. Cutaneous larva migrans; recent experience in the La Crossa area. *Wis Med J* 1980; **79**: 32–34.

118 Klose C, Mravak S, Geb M, Bienzle U, Meyer CG. Autochthonous cutaneous larva migrans in Germany. *Trop Med Int Health* 1996; **1**: 503–04.

119 Roest MA, Ratnavel R. Cutaneous larva migrans contracted in England: a reminder. *Clin Exp Dermatol* 2001; **26**: 389–90.

120 Zimmermann R, Combemale P, Piens MA, Dupin M, Le Coz C. Cutaneous larva migrans, autochthonous in France. Apropos of a case. *Ann Dermatol Venereol* 1995; **122**: 711–14 (in French).

121 Diba VC, Whitty CJ, Green T. Cutaneous larva migrans acquired in Britain. *Clin Exp Dermatol* 2004; **29**: 555–56.

122 Patterson CR, Kersey PJ. Cutaneous larva migrans acquired in England. *Clin Exp Dermatol* 2003; **28**: 671–72.

123 Kienast A, Bialek R, Hoeger PH. Cutaneous larva migrans in northern Germany. *Eur J Pediatr* 2007; **116**: 1183–85.

124 Herrmann A, Christoph T, Sebastian G. Larva migrans "saxoniae": larva migrans infection in Saxony. *J Dtsch Dermatol Ges* 2004; **2**: 46–48 (in German).

125 Manning L, Chambers S, Paltridge G, Maurice P. Cutaneous larva migrans (hookworm) acquired in Christchurch, New Zealand. *N Z Med J* 2006; **119**: U1910.

126 Bradley J. Home-grown cutaneous larva migrans. *N Z Med J* 1999; **112**: 241–42.

127 Beattie PE, Fleming CJ. Cutaneous larva migrans in the west coast of Scotland. *Clin Exp Dermatol* 2002; **27**: 248–49.

128 Fuller CE. A common source outbreak of cutaneous larva migrans. *Public Health Rep* 1966; **81**: 186–90.

129 Belsole R, Fenske N. Cutaneous larva migrans in the upper extremity. *J Hand Surg [Am]* 1980; **5**: 178–80.

130 Simon MW, Simon NP. Cutaneous larva migrans. *Pediatr Emerg Care* 2003; **19**: 350–52.

131 Meinking TL, Burkhart CN, Burkhart CG. Changing paradigms in parasitic infections: common dermatological helminthic infections and cutaneous myiasis. *Clin Dermatol* 2003; **21**: 407–16.

132 Jones WB. Cutaneous larva migrans. *South Med J* 1993; **86**: 1311–13.

133 O'Quinn JC, Dushin R. Cutaneous larva migrans: case report with current recommendations for treatment. *J Am Podiatr Med Assoc* 2005; **95**: 291–94.

134 Anderson TC, Foster GW, Forrester DJ. Hookworms of feral cats in Florida. *Vet Parasitol* 2003; **115**: 19–24.

135 Veraldi S, Persico MC. Cutaneous larva migrans in a beach soccer player. *Clin J Sport Med* 2006; **16**: 430–31.

136 Biolcati G, Alabiso A. Creeping eruption of larva migrans—a case report in a beach volley athlete. *Int J Sports Med* 1997; **18**: 612–13.

137 Wilson ME, Chen LH. Dermatologic infectious diseases in international travelers. *Curr Infect Dis Rep* 2004; **6**: 54–62.

138 Ansart S, Perez L, Vergely O, Danis M, Bricaire F, Caumes E. Illnesses in travelers returning from the tropics: a prospective study of 622 patients. *J Travel Med* 2005; **12**: 312–18.

139 Romano C, Albanese G, Gianni C. Emerging imported parasitoses in Italy. *Eur J Dermatol* 2004; **14**: 58–60.

140 Freedman DO, Weld LH, Kozarsky PE, et al. Spectrum of disease and relation to place of exposure among ill returned travelers. *N Engl J Med* 2006; **354**: 119–30.

141 Diaz JH. The epidemiology, diagnosis, management, and prevention of ectoparasitic diseases in travelers. *J Travel Med* 2006; **13**: 100–11.

142 Boggild AK, Yohanna S, Keystone JS, Kain KC. Prospective analysis of parasitic infections in Canadian travelers and immigrants. *J Travel Med* 2006; **13**: 138–44.

143 Ansart S, Perez L, Jaureguiberry S, Danis M, Bricaire F, Caumes E. Spectrum of dermatoses in 165 travellers returning from the tropics with skin diseases. *Am J Trop Med Hyg* 2007; **76**: 184–86.

144 Green AD, Mason C, Spragg PM. Outbreak of cutaneous larva migrans among British military personnel in Belize. *J Travel Med* 2001; **8**: 267–69.

145 Heukelbach J, Gomide M, Araújo F, et al. Cutaneous larva migrans and tungiasis in international travelers exiting Brazil: an airport survey. *J Travel Med* 2007; **14**: 374–80.

146 Macpherson CN. Human behaviour and the epidemiology of parasitic zoonoses. *Int J Parasitol* 2005; **35**: 1319–31.

147 McCrindle CM, Hay IT, Kirkpatrick RD, Odendaal JS, Calitz EM. A primary health care approach to an outbreak of cutaneous larva migrans. *J S Afr Vet Assoc* 1996; **67**: 133–36.

148 Uga S, Kataoka N. Measures to control Toxocara egg contamination in sandpits of public parks. *Am J Trop Med Hyg* 1995; **52**: 21–24.