Dipylidium caninum: Epidemiology, Control and its Effects on Humans in Latin America

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Abstract

Dipylidium caninum is a cestode that affects the health of carnivorous animals, the ability to infect humans, dogs and cats with fleas and lice as intermediate hosts. In humans, the infection generally goes unnoticed, especially in adults, however, there are cases where symptoms such as anorexia, growth retardation, fever, anaemia, digestive disorders and diarrhoea have been reported. The control of this parasite in both humans and animals is through the control of the intermediate hosts, and in the cases reported and related to the infection, the control is based on commercially available chemical products (metronidazole, praziquantel, pyrantel pamoate, oxantel pamoate, niclosamide, among others). Knowledge about the epidemiology of the parasite in its different hosts remains highly relevant. This chapter presents evidence on the cases reported in humans in Latin America, as well as the effects on public health and some recent control strategies.

Keywords: Control, *Dipylidium caninum*, Epidemiology, Humans, Infection

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Introduction

Dipylidium caninum (*D. caninum*) is the cestode that causes dipylidiasis, a zoonotic disease affecting carnivores (dogs, cats, foxes, coyotes, and other wild carnivores) (Vieira et al., 2012; Bowman, 2014; Millán-Orozco et al., 2021; Adhikari et al., 2023), as well as humans (Cabello et al., 2011; Ayala-Rodríguez et al., 2012; Jiménez et al., 2012; González-Ramírez et al., 2019; Hogan & Schwenk, 2019; Chong et al., 2020; Benítez-Bolivar et al., 2022). The close contact of dogs and cats with humans increases the risk of infection, especially in infants (Chelkeba et al., 2020; Benítez-Bolivar et al., 2022); therefore, the control of this type of pathogens with potential zoonotic risk in companion animals is of great importance for public health worldwide (Klimpel et al., 2010; Rodríguez-Vivas et al., 2011; Chávez-Ruvalcaba et al., 2012; Cantó et al., 2013).

In its adult cestode stage, *D. caninum* measures 10-70cm in length and mm at its widest part, with about 60-175 proglottids. The intermediate hosts involved are mainly the dog flea *Ctenocephalides canis* and the cat flea *Ctenocephalides felis* (Beugnet et al., 2014); however, the human flea *Pulex irritans* and the dog louse *Trichodectes canis* occasionally serve as intermediate hosts (Bowman, 2014; Khanal et al., 2024).

The life cycle begins when a carnivore is naturally infected and harbours the adult cestode within its digestive system. The gravid proglottids are detached from the strobilus (set of proglottids), formed by the union of segments, either one at a time or in groups, passing through the anus by their own motility or together with faeces (Figure 1). Proglottids are disintegrated in the environment and release eggs, which must be ingested by intermediate hosts to continue their life cycle. Once the eggs hatch in the flea or louse gut, the embryos or oncospheres enter the coelomic cavity, where they develop into cysticercoids (infective stage). During the evolution of the intermediate hosts, the larvae maintain their infective capacity until they are consumed by the definitive hosts and hatch within the digestive system, until they reach the small intestine, where they attach to the intestinal mucosa through their suckers to become an adult cestode (Bowman, 2014; Khanal et al., 2024).

Lacking a digestive system, cestodes grow through cell proliferation in the neck area, producing several hundred segments, known as proglottids, in which semi-digested digestive material is obtained through the body wall, known as the integument (Bowman, 2014; Millán-Orozco et al., 2021). Once the cestode obtains the nutrients necessary for its growth and survival, its reproduction is quick and easy, since, being hermaphroditic, it develops gravid proglottids filled with packed eggs through continuous differentiation (Domínguez et al., 2014; Uribe et al., 2023).

Beugnet et al., (2014) obtained a total of 1,969 *Ctenocephalides felis* (*C. felis*) fleas collected from 435 cats, and 2,828 *Ctenocephalides canis* collected from 396 dogs, and 732 *C. felis* collected from 178 dogs. Upon microscopic inspection of 100 specimens, the results showed that 42% of the fleas were positive for the presence of cysticercoids, while 40% of the samples were positive for the presence of *D. caninum* DNA. Dogs and cats generally defend themselves against fleas by biting and often ingesting them. This behaviour ensures the maintenance of the parasite's biological cycle. Humans are also infected by ingesting fleas infected with *D. caninum* cysticercoids. Most cases of human infection occur in

very young children (Chelkeba et al., 2020) living in dwellings where infected dogs or cats are present. Humans eat the flea accidentally when they kiss or bite the pet, or when the flea falls on their food or sticks to a wet dummy (Bowman, 2014). Once an infected flea is ingested by a dog, cat or human, the cysticercoid is released by digestion in the small intestine, attaches to the mucosa and develops into an adult parasite in about 21 days (Beugnet et al., 2014). The longest recorded survival time of the parasite in the cat is three years. The parasite exists wherever dogs and fleas are present (Bowman, 2014).

Fig. 1: Adult *Dipylidium caninum* cestode recovered from a naturally infected dog (Photograph taken and owned by: Jair Millán-Orozco, PhD).

In humans and animals, diagnosis is based on microscopic observation of the gravid proglottids. These cestodes are characterized by a double genital apparatus, with a genital pore on each side of the proglottid. No other human cestode has this feature. *D. caninum* in its adult stage is whitish, shaped like a melon seed when relaxed or like a cooked grain of rice when contracted; it is highly mobile and can often be observed crawling on the fur of infected animals or on the skin, nappies or stool of an infected infant (Figure 2). Each proglottid contains a large number of eggs typical of cestodes, but arranged in clusters of 5-20 in packets called ovigerous capsules. To observe proglottids or eggs, examination of material collected from the perianal area is better than examination of faecal material (Khalifa et al., 2011).

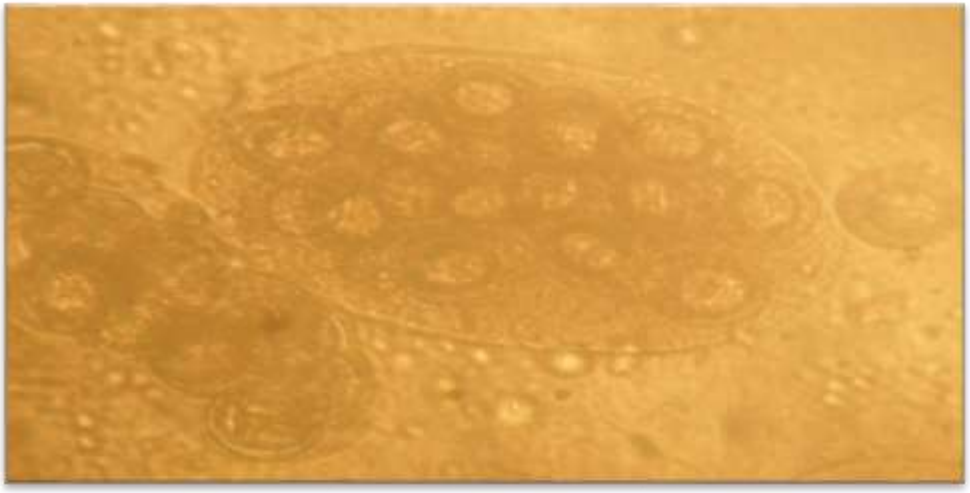

Fig. 2: Packed egg characteristic of *Dipylidium caninum,* obtained from a gravid proglottid of a naturally infected dog (Photograph taken and owned by: Jair Millán-Orozco, PhD).

Chemical and Biological Control against *D. caninum*

Prophylactic measures consist of eliminating fleas from the house and cestodes from pets. Although recommended, monitoring of young children for flea ingestion is a difficult situation to achieve. However, in animals positive to inspection during visits to private veterinary clinics, the main control strategy is through the use of commercially available anthelmintics (Peña et al., 2013; Knaus et al., 2014; Knaus et al., 2021; Millán-Orozco et al., 2021).

One of the effective strategies that has recently been implemented is biological control; however, there are very few studies on the use of this strategy against gastrointestinal parasites in dogs, especially against *D. caninum*. For this reason, some promising results on this new parasitic control strategy are mentioned below.

In Brazil, the effect of nematophagous fungi on the infectivity of *D. caninum* eggs was evaluated using the fungi *Poconia chlamydospora* (*P. chlamydospora*), *Duddingtonia flagrans* and *Monacrosporium thaumasium* seeded and grown in Petri dishes with 2% water-agar. In this study, the results obtained showed that the fungal isolate *P. chlamydospora* showed the highest *in vitro* ovicidal activity during the first fifteen days after incubation (Araujo et al., 2009).

On the other hand, one of the first works on the use and evaluation of new therapeutic options for the control of *D. caninum* was carried out by Millán-Orozco (2009), who developed a master thesis in order to evaluate the effect of *Bacillus thuringiensis* (*B. thuringiensis*) toxins against the adult cestode of *D. caninum*. The preliminary results of this study reported the first findings on the cestocidal effect of *B. thuringiensis in vitro*, since a combination of spores and crystals at a concentration of 10mg/mL reduced motility to 80% during the first 5h post-incubation, while 100% mortality was achieved from 9h post-incubation (Millán-Orozco et al., 2009a); in addition to producing a reduction in integument thickness of 22% compared to the control group (Millán-Orozco et al., 2009b).

In the same vein, Peña et al., (2013) evaluated the cestocidal and ovicidal effects of *B. thuringiensis* toxins against *D. caninum in vitro*. The results showed that a lethal concentration of 600µg/mL produced an 80% ovicidal effect in vitro at 3h post-incubation. As for the cestocidal effect, *B. thuringiensis* toxins achieved 100% inhibition of motility at 8h post-incubation, and reduced tegument thickness by 34%.

Several studies have reported prevalence rates of *D. caninum* in companion animals worldwide. Prevalence rates for the presence of *D. caninum* proglottids or eggs in animal faecal samples collected from public places and necropsied animals have been 0.01% in Germany (Csokai et al., 2024), 8.7% for Kenya (Njuguna et al., 2017), 3% for the UK (Abdullah et al., 2019), 5.4% (Ilic et al., 2021) and 27% (Raičević et al., 2021) for Serbia, 11.7% (Adhikari et al., 2023) and 12.5% (Khanal et al., 2024) for Nepal, 13.4% in Ghana (Johnson et al., 2015), 64.6% for Spain (Rodríguez-Ponce et al., 2016), and 70% for Iran (Nourollahi Fard et al., 2024).

On the Latin American continent, there are several reports on the prevalence rates of *D. caninum* in both cats and dogs. For felines, prevalence rates reported so far in the scientific literature are 1.1% (Lucio-Forster & Bowman, 2010) and 29% (Loftin et al., 2019) for the USA, 3.4% (Ramos et al., 2013), 7.2% (Souza et al., 2023) and 12.5% (Arruda et al., 2021) for Brazil, 4.5% for the USA (Nagamori et al., 2018) and 65.8% for China (Xhaxhiu et al., 2011), and 83.3% for Albania (Knaus et al., 2011). For canines, prevalence rates reported, have been 0.8% (Nagamori et al., 2020) and 5.6% (Little et al., 2023) for the USA, 2.6% for Chile (Luzio et al., 2015), 3% for Argentina (Soriano et al., 2010), 18.7% for Bolivia (Llanos et al., 2010), and 1.2% (Mendonça et al., 2024), 6.1% (Souza et al., 2023) and 45.7% (Klimpel et al., 2010) for Brazil.

On the other hand, prevalence rates of *D. caninum* in bundle samples obtained from public places and canine and feline collection centres in Mexico have been 0.3% in Tabasco (Torres-Chablé et al., 2015), 4% for Quintana Roo (Lyons et al., 2022), 4.7% (Lara-Reyes et al., 2021), 5.5% (Salcedo-Jiménez et al., 2024) for the State of Mexico, 4.8% for the state of Hidalgo (Olave-Leyva et al., 2023), 13.8% for Oaxaca (Vélez-Hernández et al., 2014), 16.5% for Baja California Norte (Trasviña-Muñoz et al., 2020), 30% for Zacatecas (Chávez-Ruvalcaba et al., 2012), 44.9% for Querétaro (Cantó et al., 2011), and 3% (De-La-Rosa-Arana & Tapia-Romero, 2018), 22% (Romero-Núñez et al., 2014), 29% (Cantó et al., 2013) and 63.5% (Millán-Orozco et al., 2023) for Mexico City.

The infection is so rare in humans that when individual cases occur, they are reported in almost all countries. One of the earliest available reports of *D. caninum* in humans was recorded in Canada in a 13-month-old infant who had no apparent signs of disease and no history of gastrointestinal disturbance. However, the presence of whitish coloured segments during evacuation raised suspicion of *D. caninum*, leading to the diagnosis of gravid proglottids, as well as the association with a pet (dog) in the patient's household (Wong, 1955). The patient was treated with a magnesium sulphate purge in the morning, followed by two doses of 0.2g of male fern extract (*Dryopteris filix-mas*) orally.

Subsequently, Anderson (1968) reported the case of a 9-month-old infant who arrived at the medical centre of a hospital in Seattle, USA. The child was apparently healthy, but the mother mentioned having observed the presence of worms in the infant's faeces in previous days. However, the patient was treated with Pyrvinium pamoate, which was ineffective, as the worms continued to be eliminated in the faeces, thus allowing a definitive diagnosis of *D. caninum* by inspection of the proglottids. The presence of a Siamese cat in the household allowed the source of infection to be linked, which was also treated by the veterinarians. The patient was treated with quinacrine hydrochloride at 200mg on the first day, then 100mg for three days.

The next case of dipylidiasis in humans was reported by Currier et al., (1973). In this report, white segments were observed in the faeces of a 14-month-old infant in Alabama, USA. As in the previous cases, the infant showed signs of being healthy, however, she had a history of frequent play with a puppy and on some occasions had consumed puppy faeces. The infant was successfully treated with 4g of quinacrine hydrochloride as a single dose.

Near the end of the 20th century, a double infection was reported in Brazil. The initial report was carried out in a three-year-old boy who had been shedding white parasites for three weeks; however, on clinical and epidemiological investigation the mother of the child, a thirty-year-old woman, was also found to be positive for the infection. However, the presence of the definitive host dog and/or cat as a possible transmitter of the disease was not known (Devera & Campos, 1998). Unfortunately, the authors made no mention of any established treatment after the definitive diagnosis had been made.

At the beginning of the 21st century, another case was reported in a six-month-old baby girl in Texas, USA, who, according to her parents' report, had been shedding small white structures resembling rice grains for three months, and was thought to be vegetable seeds. Despite the above, the mother decided to refer her to the pediatrician for consultation without any other apparent symptoms. The hospital pathologist confirmed that these were segments compatible with *D. caninum*, thus establishing the diagnosis and subsequent treatment. It should be noted that the source of infection may have been a pet dog in the nursery where the parents kept their baby (Molina et al., 2003). It should be noted that as in the study mentioned above, the authors did not present information available on the treatment of the infant.

Neira et al., (2008) reported a clinical case in a two-year-old preschooler aged two years eight months with no history of illness in Chile. At the time of physical examination, a lack of personal cleanliness on the part of the mother was observed in the child. The mother mentioned that her home consisted of a wooden floor, a dirt yard, available drinking water and sewage, as well as the presence of three dogs (one of them adult), and a cat, which were not under veterinary monitoring, as she reported the presence of abundant fleas and the child frequently played with the pets. For this reason, a copro-parasitological study was carried out, which was positive for the presence of eggs grouped in an ovigerous membrane or capsule, characteristic of the cestode *D. caninum*. The established treatment was Niclosamide, at a rate of 500mg as a single dose.

In Mexico, one of the few cases available in the literature was reported by Cabello et al., (2011) in the state of Sinaloa, in an 18-month-old girl, who had no clinical manifestations of disease; however, the mother mentioned that the child had removed small white structures on

different occasions, which caught her attention. At the time of inspection, the little girl showed no gastrointestinal symptoms related to any disease, so these whitish structures were analyzed at the time of defecation, coinciding with gravid proglottids of *D. caninum*, and a definitive diagnosis was made. Apparently, the patient had no history of contact with animals. The treatment established by the doctors was Albendazole at a single dose of 500mg.

The most recent report on the presence of *D. caninum* in humans in Mexico was carried out by Jiménez et al., (2012), in which they analyzed coprolites from the Cueva de los Muertos Chiquitos, in the state of Durango. They analyzed 36 coprolites, two of which were positive for *D. caninum*, according to the morphology of the eggs found in the samples. It should be noted that these coprolites date back approximately 1,400 years.

On the other hand, on the island of Cuba, Ayala-Rodríguez et al., (2012) reported a case of Dipylidiasis in a 15-year-old female patient who presented with abdominal pain, flatulence and occasional diarrhoea, in addition to passing cucumber seed-like structures in her stool. As an important antecedent, the patient mentioned owning a dog with which she frequently lived and sometimes slept with her. Visualization of the proglottids and the ovigerous capsules inside them allowed the diagnosis of *D. caninum*, and treatment with Praziquantel at a single dose of 10 mg/kg was established.

The first report of human dipylidiasis in Venezuela was made by González-Ramírez et al., (2019), which was presented in an 11-month-old baby, who was taken to the pediatrician as she had been presenting gastrointestinal problems for two months, without a diagnosis. The infant presented with small white structures around the anus, while on physical inspection he was in normal condition with loss of appetite, abdominal pain, low weight and height for age. Laboratory studies were performed, which showed a slight hypoalbuminemia and an increase in electrolytes (sodium and calcium), while the other parameters (total proteins, globulins, urea, creatinine, potassium, aspartate aminotransferase and alanine transferase) were normal, in addition, when immunological and hematological studies were performed, it was observed that total Immunoglobulin-E (Ig-E) was increased; The patient had a slight decrease in hemoglobin, hematocrit and eosinophils, and the white blood cell count was normal. The patient was treated with a single dose of 10mg/kg Praziquantel, which allowed full recovery.

Later in Massachusetts, USA, another case was reported in a 2-year-old girl referred to a pediatrician, who presented with visible white worms in the stool and perianal pruritus. There was a history of having cats in the household, which shed worms similar to those of the patient. Microscopic examination of these worms (proglottids) led to confirmation of *D. caninum* by identification of eggs packed within the proglottids. Once the diagnosis was made the patient was treated with a single dose of praziquantel, and perianal pruritus resulted 3 weeks later (Hogan & Schwenk, 2019).

Subsequently, a two-year-old infant in Texas presented for consultation who had been passing visible white worms in her stool daily for 6 months. The infant had anal itching but no symptoms of fever, diarrhoea, vomiting, or weight loss. Family members reported no history of fleas on pets or in the home, and no history of consumption of raw or undercooked meat or seafood. The physical inspection was normal; however, they presented a slight perianal dermatitis with the presence of linear scoriations. Based on the above, the baby was treated with a single dose of Praziquantel at 10 mg/kg to combat *D. caninum* (Chong et al., 2020).

Finally, the most recent case of dipylidiasis in Latin America was reported by Benítez-Bolívar et al., (2022) in Colombia, in an 11-month-old patient who had been passing white motile forms in his faeces for 15 days. The patient had no symptoms of disease, and at the time of physical examination he was normal, with weight and height appropriate for his age. The parents mentioned that they had a pet dog and that the infant regularly played with the dog in the garden, and that the infant was constantly putting grass debris in his mouth. Despite this, there were no symptoms of malnutrition, iron deficiency or anaemia, and normal liver function was confirmed. Initial treatment was with Pyrantel Pamoate; however, as there was no improvement, it was decided to administer Metronidazole for 7 days. Summary of reported cases of *D. caninum* from Latin America have been presented in Table 1.

Table 1: Reported cases of *Dipylidium caninum* in humans in Latin America

Report	Country	Age	Sex	Pet	Symtoms/Sings	Diagnostic	Treatment
Wong, 1955	Canada	13 months	Female	Dog	No	Proglottides in faeces	0.2 g of male fern by mouth
Anderson, 1968	USA	9 months	Male	Cat	No	Proglottides in faeces	200 mg Quinacrine hydrochloride
Currier et al., 1973	USA	14 months	Female	Dog	No	Proglottides in faeces	4 g Quinacrine hydrochloride
Devera & Campos, 1998	Brazil	3 and 30 years	Male and female	Not established	No	Proglottides in faeces	Not established
Molina et al., 2003	USA	6 months	Female	Dog	Not established	Proglottides in faeces	Not established
Neira et al., 2008	Chile	2 years and 8 months	Male	Dog and cat	Not established	Eggs in faeces	500 mg Niclosamide
Cabello et al., 2011	Mexico	18 months	Female	Not established	Not established	Proglottides in faeces	500 mg Albendazole
Jiménez et al., 2012	Mexico	Any age	Indistinct	Not applicable	Not applicable	Proglottides in coprolites	Not applicable
Ayala-Rodríguez et al., 2012	Cuba	15 years	Female	Dog	Abdominal pain, flatulence and diarrhoea	Proglottides in faeces	10 mg/kg Praziquantel

González-Ramírez et al., 2019	Venezuela	11 months	Male	Dog	Loss of appetite, abdominal pain, low weight and height	Proglottides around the anus	10 mg/kg Praziquantel
Hogan & Schwenk, 2019	USA	2 years	Female	Cat	Perianal itching	Proglottides in faeces	Praziquantel (dose not established)
Chong et al., 2020	USA	6 months	Female	Not established	Mild perianal dermatitis with linear abrasions	Proglottides in faeces	10 mg/kg Praziquantel
Benítez-Bolívar et al., 2022	Colombia	11 months	Male	Dog	No	Proglottides in faeces	Metronidazole (dose not established)

Conclusions

Since the first report of dipylidiasis in humans in Latin America seventy years ago, reports of this disease have generally been higher in female patients, however, the time between reports has averaged seven years, probably due to lack of interest and/or absence of symptoms in most patients. In addition, the presence of pets in households and the lack of attention by pet owners to the health of their pets and the few visits to the veterinarian makes the transmission of the parasite latent. On the other hand, epidemiological studies are highly necessary, as the recorded prevalence rates and the presence of *D. caninum* are evident in both first world and developing countries.

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