Original Article

Gastrointestinal and pulmonary parasites of working horses from Colombia

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A B S T R A C T

Working equids are used in different countries for numerous purposes and regularly are crucial for multiple communities' income and profit. Historically, in Bogotá D.C. they were used as animal-powered vehicles but in 2013 it was initiated a substitution and adoption program as a result of society pressure and lawful processes. Infectious diseases and mainly parasitic diseases, poses a threat in the health and productivity of these animals. Our aim was to identify, by coproparasitological methods, the gastrointestinal and pulmonary parasite species infecting working horses submitted to the mentioned substitution and adoption program. Between May and December 2013 and February and July 2014, fresh faecal samples were obtained from 1004 and 648 horses from Bogotá D.C. and other Colombian municipalities, respectively. They were processed by flotation and Baermann tests in order to visualize faecal parasitic forms (eggs, oocysts, and larvae). Prevalences were calculated for each gastrointestinal parasite at origin and one year after, at destination, and analysed by age group and coinfection. At origin (Bogotá D.C.), prevalence for at least one parasite species was 87.5% and one year later, at destination (other municipalities), was 89.5%. The most prevalent species were strongyles (86.4–89.4%) followed by *Parascaris* spp. (0.7–6.2%), cestodes (Anoplocephalidae) (3.7–4.9%) and *Oxyuris* sp. (2.8–4.3%). Other species detected were *Eimeria* sp., *Strongyloides* sp. and *Dictyocaulus* sp. Coinfection by two or more species ranged between 14.4 and 38.3% being strongyle, *Parascaris* spp., *Oxyuris* sp. and cestodes (Anoplocephalidae) the most common species involved. Some parasitic infections commonly associated with younger animals (e.g. *Parascaris* spp.) were detected in all age groups. Flow patterns of parasites linking Bogotá D.C. and other municipalities are presented. Finally, these results support the widespread distribution of most of species and the plausible health and welfare impact of this infections in working equids submitted to particular epidemiological risks.

1. Introduction

Working equids, a classification that comprises horses, donkeys and mules used in many countries for transport and traction, contribute directly and indirectly to households' livelihoods and benefit communities as a whole (OIE, 2017). In Colombia and specifically in Bogotá D.C., horses were used for decades as transport vehicles for diverse purposes like furniture shipping, demolition wasting or carry of recyclable and construction material. A national law promulgated in 2002 (Law No. 769) (Colombia, 2002) and different subsequent decrees, delineated a mandatory substitution program of animal-powered vehicles (mainly with horses) which initiated in Bogotá D.C. in 2013, with a process that included the reception, clinical examination, treatment, prophylaxis and ensuing adoption, parallel to the respective exchange by motor vehicles with the animals' owners.

Infectious diseases are an important constraint to working horses and among them, parasitic diseases and, particularly, gastrointestinal nematodes are major disorders that compromise their health and productivity (Stringer, 2014). In spite of this, in Colombia, and globally, there is a lack of information about its prevalence and epidemiological determinants.

Herein, we present the results of a cross-sectional study of gastrointestinal and pulmonary parasites in working horses from Bogotá D.C. (Colombia) included in the substitution and adoption program.

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2. Materials and methods

2.1. Animals and adoption program

All working horses included in the substitution and adoption program, which underwent parasitological exam, were mix breed animals, from both sexes and aged 1 to 22 years, based on handlers' information and confirmed by dental chronometry. In the initial phase, they were admitted at the program facility in the Faculty of Veterinary Medicine and Animal Science (Universidad Nacional de Colombia, Bogotá D.C., Colombia) between May and December 2013. In the second phase, after adoption, animals were followed at the destination locality, in diverse Colombian departments, by the program clinicians, between February and July 2014.

Once received, animals were submitted to a throughout clinical examination and blood, urine and faecal samples were taken for multiple laboratory test analysis. Healthy individuals entered the adoption process and those who presented clinical alterations were previously treated and hospitalized. Depending on the coproparasitologic results, animals received proper antiparasitic treatment with ivermectin (200 µg/kg PO) and/or praziquantel (2.5 mg/kg PO).

2.2. Coprology tests

Fresh faecal samples were taken direct from the rectal ampulla from each animal and immediately transported to the Veterinary Parasitology Laboratory (Universidad Nacional de Colombia), located nearby the animal reception facility. Samples were processed and analysed during the following 24 h. To detect gastrointestinal parasites, approximately, 2 g of faecal matter were sieved to separate gross particles and centrifuged (1.500 r.p.m. for 5 min) to perform a flotation test with Sheather's sugar solution (specific gravity = 1.27) as previously reported (Mariño-González et al., 2017). Additionally, for pulmonary parasites detection, 5–10 g of the sample were put in the Baermann apparatus, mixed with warm water and stood for 24 h for further examination (Rode and Jorgensen, 1989). Samples were examined under optical microscope at 10 or 40× objective to find parasitic eggs, oocyst or larvae.

2.3. Spatial and statistical analysis

Flow maps were performed to visualize movement of working horses from Bogotá D.C. to other municipalities of the country, as a result of the substitution program of animal traction vehicles in this capital city. Fig. 1 is showing the area of study. Prevalences were calculated for each gastrointestinal parasite at origin and one year after, at destination. We calculated pairwise comparisons of gastrointestinal parasites prevalence through Chi-square and Fisher tests between age categories with adjustment of type I error for multiple comparison via Holm-Bonferroni method. Statistical analysis and origin-destination flow maps were performed in the R Language and Environment for Statistical Computing (R-Core-Team, 2017).

3. Results

The main spatial location in the initial phase (1004 working horses) was the city of Bogotá D.C. and adjacent municipalities. Specifically, 17 out of the 20 city urban localities were reported as the origin of these animals. The prevalence of the evaluated gastrointestinal parasites by locality is presented as supplement material [Table S1]. Besides, after adoption, horses were transported to different municipalities in 11 distinct departments of Colombia (Antioquia, Arauca, Boyacá, Caldas, Casanare, Córdoba, Cundinamarca, Meta, Santander, Sucre and Tolima). The prevalence of the evaluated gastrointestinal parasites by department is presented as supplement material [Table S2].

At origin, faecal samples were collected from 1004 horses, and one

year later at destinations, 648 (64.5%) of these animals were collected anew. Prevalence values of gastrointestinal parasites at origin and destination are presented in Table 1.

Of the 1004 horses considered initially, 878 (87.5%) were positive for at least one gastrointestinal or pulmonary parasite. Age based on dentition was recorded for 1000 (99.6%) individuals and prevalence values of gastrointestinal parasites at origin, distributed in the different age categories, are presented in Table 2. Prevalence of strongyle eggs was significantly lower in the 11–22 years old group (p < 0.05) compared to individuals from 3 to 6 years. Interestingly, *Parascaris* spp. was found in all individuals including adult and old horses. No differences were found in the prevalences corresponding to the other gastrointestinal parasites between the age groups.

At the place of destination, of the 648 horses considered, 580 (89.5%) were positive for at least one gastrointestinal parasite. In this second evaluation, *Dictyocaulus* sp. and *Strongyloides* sp. were not found, strongyle eggs were found with a higher, but no significant, prevalence in destinations that origins, and *Parascaris* spp. were found with a significant lower prevalence in destinations (p < 0.05) as also shown in Table 1. Maintaining the same age classification, however considering the elapsed year, age based on dentition was recorded for 647 (99.8%) individuals and prevalence values of gastrointestinal parasites at destinations, in the different age categories, are presented in Table 3. The prevalence of *Parascaris* spp. eggs was significantly higher in horses < 3 years in relation to other groups (p < 0.05). No differences were found in the prevalences corresponding to the other gastrointestinal parasites between the age groups.

Regarding multiparasitism, 145 (14.4%) horses at the origin and 44 (6.8%) horses at destination were positive for more than one gastrointestinal parasite, as described in Table 4. The triangular matrices of Fig. 2 show the number of individuals that presented each of the possible combinations of pairs of parasites evaluated at the places of origin and destination. As also shown in Fig. 2, the most frequent pairs of parasites were strongyle-*Parascaris* spp. (Origin: 35.5%; Destination: 8.0%), strongyle-cestodes (Anoplocephalidae) (Origin: 27.8%; Destination: 48.0%) and strongyle-*Oxyuris* sp. (Origin:23.7%; Destination:36.0%).

Origin-destination flow maps were plotted to visualize the movement of the working horses from Bogotá D.C. to the other municipalities (supplement material, [Supplementary Fig. S1]). The prevalence of the evaluated gastrointestinal parasites by locality is presented as supplement material [Table S1.] and The prevalence of the evaluated gastrointestinal parasites by department is presented as supplement material [Table S2].

4. Discussion

Herein, we detected, by coproparasitological methods, gastrointestinal and pulmonary parasitic infections in working horses from Bogotá D.C. who entered the substitution and adoption program. Although parasite infection in working equids could limit their performance, health and productivity, the majority of animals maintain subclinical infections in spite of high prevalence rates and parasite burden (Karanja et al., 1994; Burden et al., 2010; Valdéz-Cruz et al., 2012). In general, the horses in the program, arrived with poor corporal condition, dull hair coat and malnourished appearance; few of them presented gastrointestinal (e.g. diarrhoea) or respiratory clinical signs probably associated with parasite infection. Besides, it is difficult to assess if parasitism was the unique aetiology for this clinical state of it was a syndrome with nutritional, infectious and other causes.

Parasite infections in working horses have been reported worldwide, in countries like Egypt (Salem et al., 2017), Iran (Tavassoli et al., 2010), Lesotho (Upjohn et al., 2010), Mexico (Valdéz-Cruz et al., 2012), Nicaragua (Kyvsgaard et al., 2011), Pakistan (Haq et al., 2017), Poland (Gawor, 1995; Gawor et al., 2006; Kornaś et al., 2009) and Romania (Buzatu et al., 2014; Anutescu et al., 2016). In Colombia, a previous
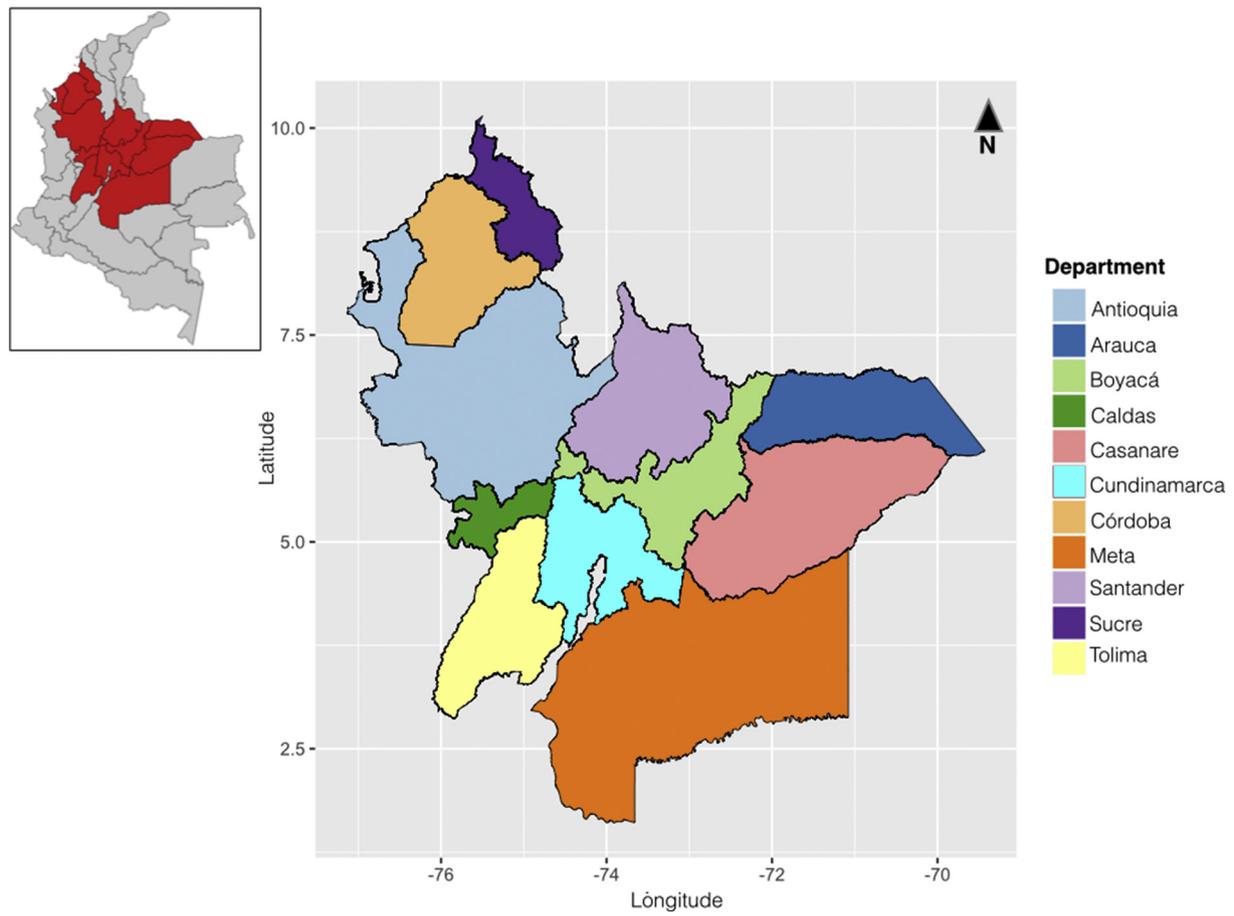
Fig. 1. Study area considering departments. The capital district is represented by the uncoloured area located within the department of Cundinamarca.

Table 1

Prevalence of gastrointestinal parasites at origin and destination of faecal samples collected from 1004 and 648 horses, respectively.

Parasite	Origin		Destination	
	Prevalence (%)	95% IC	Prevalence (%)	95% IC
Strongyles	86.4	84.0–88.4	89.4	86.7–91.6
Parascaris sp.	6.2	4.8–7.9	0.7	0.3–1.9
Cestodes (Anoplocephalidae)	4.9	3.7–6.6	3.7	2.4–5.5
Oxyuris sp.	4.3	3.2–5.8	2.8	1.7–4.4
Dictyocaulus sp.	0.8	0.4–1.6	0	–
Eimeria sp.	0.3	0.08–0.9	0.2	0.008–0.9
Strongyloides sp.	0.2	0.03–0.8	0	–

Table 2

Prevalence (95% CI) of gastrointestinal parasites collected from 1000* horses at the place of origin in the different age categories.

Age Group (Years)	Strongyles	*Parascaris* spp.	Cestodes (Anoplocephalidae)	*Oxyuris* sp.	*Dictyocaulus* sp.	*Eimeria* sp.	*Strongyloides* sp.	N
< 3	88.3 (79.3–93.7)	16.9 (10.1–26.8)	10.4 (5.4–19.2)	1.3 (0.2–7.0)	0	1.3 (0.2–7.0)	0	77
3–6	91.5 (87.0–94.6)	8.0 (5.0–12.4)	7.9 (5.0–12.4)	4.2 (2.2–7.8)	0.5 (0.08–2.6)	0	0.5 (0.08–2.6)	213
7–10	87.7 (84.0–90.7)	4.3 (2.6–6.8)	3.4 (2.0–5.8)	4.3 (2.6–6.8)	0.3 (0.04–1.5)	0.3 (0.05–1.5)	0	374
11–22	80.9 (76.4–84.8)	4.8 (2.9–7.6)	3.3 (1.8–5.8)	5.1 (3.2–7.9)	1.8 (0.8–3.8)	0.3 (0.05–1.7)	0.3 (0.05–1.7)	336

* Number of horses with age estimated by dentition.

study by Cardona-Álvarez et al. (2015) registered, by necropsy, gastric parasite infections in working horses from Córdoba department.

The general prevalence for gastrointestinal or pulmonary parasites (i.e. at least one parasite species) for the sampled working horses ranged between 87.5 and 89.5%; which is lower to previous registers in Romania (100%) (Anutescu et al., 2016), but similar to reports from Iran (79.2%) (Tavassoli et al., 2010) and México (91.3%) (Valdéz-Cruz et al., 2012). This high proportion of infected animals could be

Table 3

Prevalence (95% CI) of gastrointestinal parasites collected from 647* horses at the place of destination in the different age categories.

Age Group (Years)	Strongyles	*Parascaris* spp.	Cestodes (Anoplocephalidae)	*Oxyuris* sp.	*Eimeria* sp.	N
< 3	80.0 (49.0–94.3)	20.0 (5.7–50.9)	0	0	0	10
3–6	90.5 (84.7–94.3)	0.6 (0.2–3.7)	4.7 (2.3–9.4)	0.6 (0.1–3.7)	0	148
7–10	91.2 (86.7–94.3)	0.9 (0.2–3.3)	4.6 (2.5–8.3)	4.6 (2.5–8.3)	0.5 (0.08–2.6)	217
11–22	87.5 (83.0–90.9)	0	2.6 (1.3–5.2)	2.6 (1.2–5.2)	0	272

* Number of horses with age estimated by dentition.

Table 4

Frequency and proportion of the number of parasites at origin and destination.

Number of parasite species*	Origin (%)	Destination (%)
0	126 (12.5)	68 (10.5)
1	733 (73.0)	536 (82.7)
2	133 (13.2)	41 (6.3)
3	12 (1.2)	3 (0.5)
Total	1004 (100)	648(100)

* Number of parasites identified in faecal samples by genus or taxonomic group (strongyles or cestodes).

explained by different and particular epidemiological determinants, like the absence of proper anthelminthic control programs (i.e. not received or were rarely treated with any anthelmintic product during his life or, in contrast, treated with the same drug class for a long period of time), frequent exposure to contaminated sources, ubiquity of some parasite species, lack of regular veterinary checks and low risk perception from the owners.

Prevalence of strongyle eggs was 86.4 and 89.4% in Bogotá D.C. and in the different destination departments in the country, respectively, corroborating its wide distribution in spite of geographic, climatic and ecological differences. Previous studies registered similar or higher prevalences for these parasites, like those registered by Gawor (1995) in Poland (96%); Tavassoli et al. (2010) in Iran (72.9%); Upjohn et al. (2010) in Lesotho (88.2%); Kyvsgaard et al. (2011) in Nicaragua (94%) and Buzatu et al. (2014) and Anutescu et al. (2016) in Romania with 69.0 and 92.9%, respectively. Some studies highlighted the predominance of small strongyles in nearly all the infections (Gawor, 1995;

Gawor et al., 2006; Anutescu et al., 2016). In the present study, we did not perform coproculture in order to identify the larvae and species composition, nonetheless, we can infer the predominance of cyathostomes in infected animals. Further, unless cyathostome infections commonly has not be considered a notable cause of disease, we cannot discard its role in weight loss and diarrhoea in some animals, as previously reported (Reilly et al., 1993; Murphy et al., 1997; Love et al., 1999).

The frequency of coinfection by two or more parasites was 14.4 and 38.3% in Bogotá D.C. and destination departments, respectively, being strongyle, *Parascaris* spp., *Oxyuris* sp. and cestodes (Anoplocephalidae) the most common species involved; which agrees with previous reports (Gawor, 1995; Tavassoli et al., 2010; Upjohn et al., 2010). Prevalence for *Parascaris* spp. infection ranged from 0.7 to 6.2%, a lower frequency compared with that reported by Anutescu et al. (2016) (10%), Tavassoli et al. (2010) (12.2%) and Upjohn et al. (2010) (21.6%); besides, despite the higher proportions were registered in the youngest individuals (i.e. < 3 years), it is noteworthy that infection by this species was detected in all age groups. Similarly, *Oxyuris* sp. prevalences (2.8–4.3%) were comparable with those registered by Upjohn et al. (2010) (6.2%) but lower in comparison with Tavassoli et al. (2010) (22.6%); an equivalent result was noted for cestode frequency (3.7–4.9%) and the previous report of Tavassoli et al. (2010) (3.2%). Finally, a small proportion of animals presented infection (mostly coinfections with strongyles) with other gastrointestinal (i.e. *Eimeria* sp., *Strongyloides* sp.) species, which is comparable with previous studies in working horses (Gawor, 1995; Tavassoli et al., 2010; Anutescu et al., 2016; Haq et al., 2017). For lungworm (i.e. *Dictyocaulus* sp.), it was also detected in

Fig. 2. Quantity of individuals for each possible combination of gastrointestinal parasites at origin (left) and destination (right). Str. Strongyle; Par. *Parascaris* spp.; Ces. Cestodes (Anoplocephalidae); Oxy. *Oxyuris* sp.; Dic. *Dictyocaulus* sp.; Eim. *Eimeria* sp.; Std. *Strongyloides* sp.
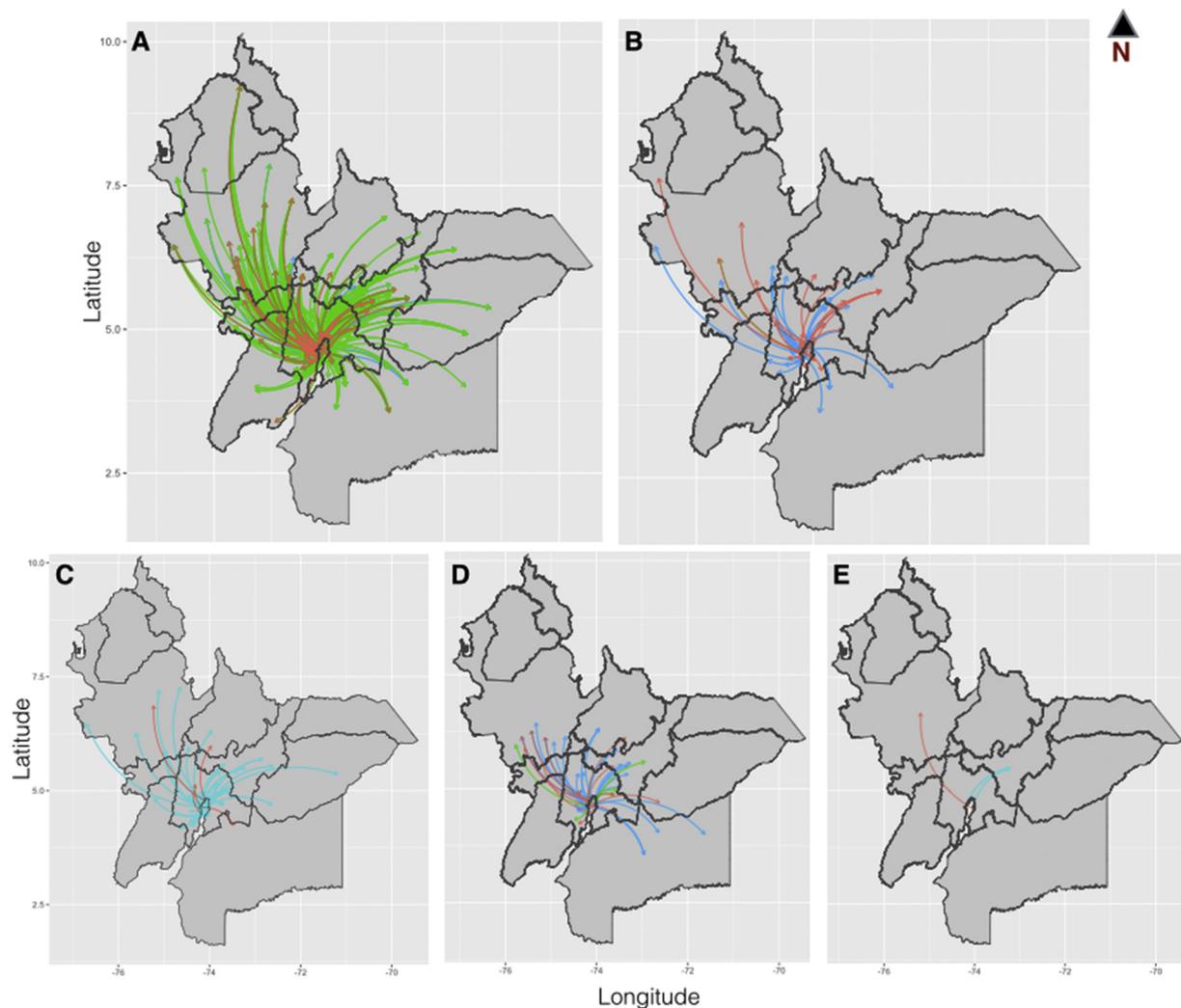
Fig. 3. Origin-destination flow maps of the movement of the working horses from Bogotá D.C. to the other municipalities of the country discriminated by the gastrointestinal parasites evaluated. A. Strongyle; B. *Parascaris* spp.; C. Cestodes (Anoplocephalidae); D. *Oxyuris* sp.; E. *Eimeria* sp. Blue lines represent those animals positive in the locality of origin and negative at destination, green lines horses positive in the locality of origin and positive at destination, and red lines horses negative in the locality of origin and positive at destination. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

coinfection with a low (0.8%) prevalence compared with that recently recorded in Iran (15.7%) for working horses (Saadi et al., 2018). These multiparasitism infection patterns reflects a common condition in working equid populations, frequently submitted to risk factors like contaminated pastures and water, inappropriate (or null) anthelminthic programs, inadequate husbandry conditions and lack of awareness of parasite infection threat.

Environment conditions for both localities were diverse. At origin, animals had a roaming lifestyle with mixed habitats for resting and feeding due to its working activities around Bogotá D.C. They were composed mainly by urban paddocks and pastures, commonly with high animal density and grazing pressures and usually shared by horses (and often with cattle) from different owners and age groups. After adoption, animals were relocated in variable urban, semi-urban and rural territories, mostly in pastures and/or stables. In spite of probable high-risk habitats for infection, mainly at origin, is difficult to identify a pattern due to the miscellaneous conditions here exposed.

As visualized in Fig. 3, the parasite flow patterns suggest different behaviours for parasite groups or species. For strongyles (Fig. 3-A), it is notable a predominance of positive animals at origin and destination (green lines) and in the locations after adoption (red lines). This is related with higher prevalences for these species in both localities and a

probable widespread phenomenon of anthelminthic resistance, as already described in different settings and countries (Boersema et al., 1991; Chapman et al., 1996; Peregrine et al., 2014), due to the sustained strongyle infection in adopted animals. Conversely, for tapeworms (Fig. 3-C), predominated animals positive at origin but negative at destination, suggesting an effective anticestodal treatment during the reception and adoption process and an absent anthelminthic resistance, as reported elsewhere (Nielsen, 2016). Lastly, a heterogeneous behaviour was observed for *Parascaris* spp. (Fig. 3-B) and *Oxyuris* sp. (Fig. 3-D) which make difficult to infer a probable cause, even though resistance has been recorded for both species (Wolf et al., 2014; Nielsen, 2016).

In conclusion, this study confirms the importance and diversity of parasite species that could infect working horses in Bogotá D.C. and other municipalities from different departments in Colombia. The results are comparable with other reports around the globe and must create a global consciousness about the relevance of this parasite infections in the health and welfare of working equids.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vprsr.2019.100296.

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Conflict of interest

There are no conflicts of interest.

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