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The effects of managerial systems on helminth infection in free-range chickens from northern Paraná, Brazil

Os efeitos do sistema de manejo na infecção por helmintos em galinhas caipiras do norte do Paraná, Brasil

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Abstract

The effects of managerial systems on the occurrence of gastrointestinal helminths in Free-Range Chickens (FRCs) from northern Paraná, Brazil were investigated. The most predominant (23.3%; 61/262) cestode observed was *Raillietina cesticillus*; *Heterakis gallinarum* (71.4%; 187/262) and *Ascaridia galli* (45%; 118/262) were the predominant nematodes; *Postharmostomum commutatum* was the only trematode observed in 2.7% (7/262) of FRCs. The most elevated parasitic burdens were associated with *Heterakis gallinarum, Ascaridia galli*, and *Raillietina cesticillus*. Significant ($p \leq 0.05$) associations were observed when the effects of the types of bedding, soil type, and fence restriction of FRCs were considered relative to the possibility of helminthiasis. The type of bedding, the length of the sanitary break, and the presence of shading significantly ($p \leq 0.05$) influenced the possibility of FRCs being infected by *H. gallinarum*. Most parameters evaluated were significantly associated with infection of FRCs by *A. galli.* These findings suggest that FRCs from northern Paraná are infected by a wide-range of gastrointestinal helminths, but more frequently by *R. cesticillus*, *H. gallinarum,* and *A. galli*. Moreover, the type of floor bedding, the soil type, and the usage of fences in the management of FRCs is directly related to gastrointestinal helminthiasis.
Key words: Free-range chickens, helminthiasis, *Heterakis gallinarum*, *Ascaridia galli*

Resumo

Foram investigados os efeitos dos sistemas de manejo sobre a ocorrência de helmintos gastrintestinais em galinhas caipiras (GCs) do norte do Paraná, Brasil. O cestódeo predominante (23,3%; 61/262) foi *Raillietina cesticillus*; entre os nematódeos *Heterakis gallinarum* (71,4%, 187/262) e *Ascaridia galli* (45%, 118/262); *Postharmostomum commutatum* foi o único trematódeo encontrado em 2,7% (7/262) das GCs. As cargas parasitárias mais elevadas foram associadas à *Heterakis gallinarum, Ascaridia galli* e *Raillietina cesticillus*. Associações significantes ($p \leq 0,05$) quanto às helmintíases foram observadas em relação ao tipo de cama, ao tipo de solo e à presença de restrição das GCs em áreas cercadas. O tipo de cama, o tempo do vazio sanitário e a presença de sombreamento influenciaram significativamente ($p \leq 0,05$) quanto à infecção por *H. gallinarum*. A maioria dos parâmetros avaliados foram significativamente associados à infecção das CGs por *A. galli.* Estes resultados sugerem que GCs do norte do Paraná são infectadas por uma ampla variedade de helmintos gastrintestinais, porém mais frequentemente por *R. cesticillus*, *H. gallinarum* e *A. galli*. Além disso, o tipo de cama de forração, o tipo de solo e o uso de

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cercas no manejo das GCs são variáveis que estão diretamente relacionados à presença de helmintíases gastrintestinais.

Palavras-chave: Galinhas caipiras, helmintíases, *Heterakis gallinarum*, *Ascaridia galli*

Introduction

The free-range method of chicken production is a semi-intensive system of farming that aims to increase the welfare of animals. The Brazilian Ministry of Agriculture, Livestock and Supply, has stipulated that free-range chickens (FRCs) can be reared in pens for a maximum of 25 days, that these bird must have access to pastures with a stocking density of $3m^2$/bird, and be slaughtered at no less than 85 days of age (MAPA, 1999). Further, FRCs are not exposed to biologicals for the control of diseases (BERG, 2002; CARDOZO; YAMAMURA, 2004). Nevertheless, these birds are most frequently infected by parasites relative to chickens reared in pens (FOSSUM et al., 2009), and are more prone to infection by helminths than commercial layers and broilers (RABBI et al., 2006). Therefore, the control of the rearing environment is of great importance in reducing parasitic infections.

Nematodes (roundworms), cestodes (tapeworms), and trematodes (flatworms) are frequent helminth parasites of FRCs (RUFF, 1999; CARDOZO; YAMAMURA, 2004), that can result in economic losses to the poultry industry. Reports of gastrointestinal parasites in FRCs have originated predominantly from the African (SSENYONGA, 1982; ESHETU et al., 2001; MAGWISHA et al., 2002; LUKA; NDAMS, 2007; YORIYO et al., 2008; DUBE et al., 2010), Asian (RABBI et al., 2006; ESLAMI et al., 2009; RAHMAN et al., 2009), and American (MACHADO et al., 1980; REIS et al., 1980; VIERO, 1984; COSTA et al., 1986; OLIVARES et al., 2006) continents. However, most of these have only described the occurrence/frequency of helminths in FRCs. Alternatively, it was demonstrated that the rate of infections of gastrointestinal helminths in FRCs is influenced by the ecological and agricultural aspects of the habitat (ESHETU et al., 2001) and the type of birds being reared (MAGWISHA et al., 2002; RABBI et al., 2006). Nevertheless, few studies investigating the effects of managerial systems on helminthiasis in FRCs were located when major databases were accessed, and we did not identify a similar study performed in Brazil. This study evaluated the possible relationships between several managerial aspects of the production of FRCs and the risk of helminthic infection, since an understanding of this relationship may contribute to the control of helminths in free-range chickens.

Materials and Methods

Study area

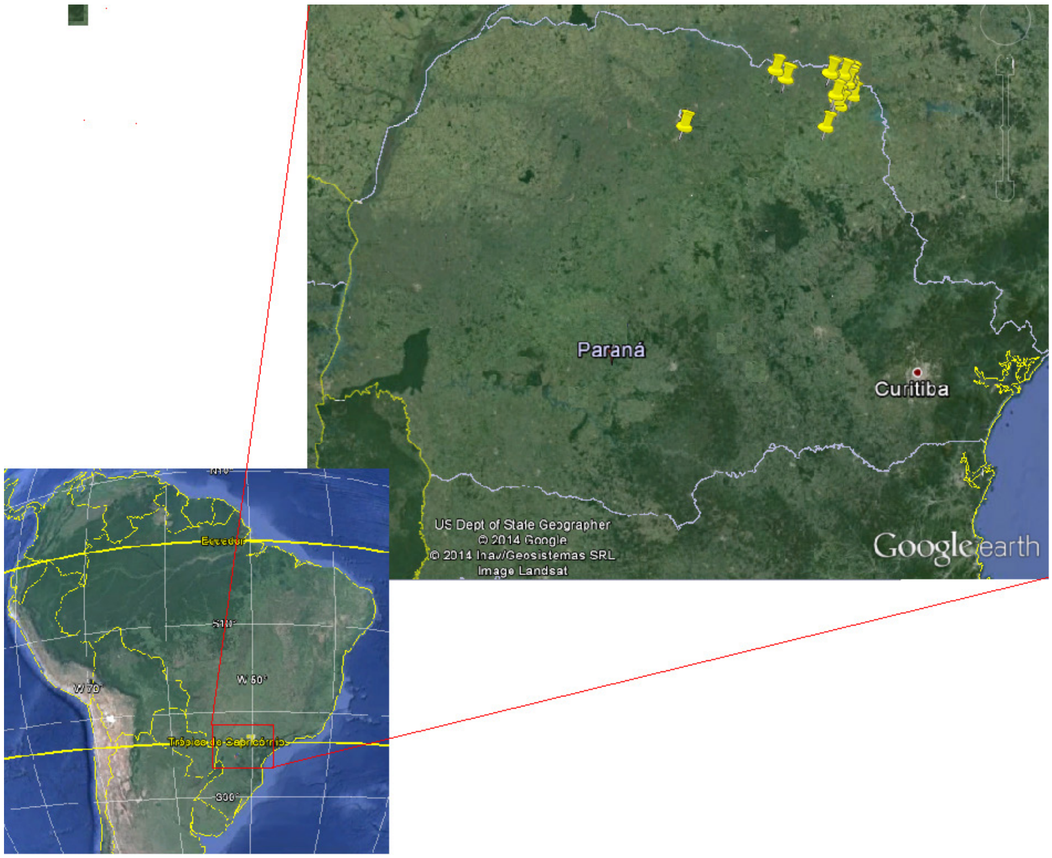
This study was done in the northern region of the state of Paraná, southern Brazil. FRCs reared in the following cities were included: Jacarezinho, Santo Antônio da Platina, Cambará, Barra do Jacaré, Cornélio Procópio, Santa Mariana, Apucarana, and Conselheiro Mairinck (Figure 1). These cities are located within latitudes 22°30’0” and 24°0’0” and between longitudes 49°30’0” and 52°30’0”(BHERING; SANTOS, 2008). This is a subtropical region, which predominantly consist of clay soil, has evenly distributed rainy seasons, and an average annual temperature of 22°C.

Sample size and sampling methodology

The size of the conglomerate sample (262 chickens) was determined by the software Epi Info 3.5.4 (DEAN et al., 1996). To calculate the minimum sample size, an expected frequency of 50%, a worst acceptable of 6%, and a confidence level of 95% were used. During October 2008 and

December 2009, 262 FRCs submitted for slaughter from 14 rural districts of the eight selected cities from northern Paraná were evaluated; 40 sample collections were done during this period, each sample contained five to ten organs. The collections were determined by the necessity to slaughter the chickens by farmers for consumption or marketing. The size of the sample obtained from each farm was proportional to the number of birds slaughtered during the period. The weight of the birds at slaughter varied between 2 to 2.4 kg; all birds demonstrated good body condition. Therefore, it was not possible to determine performance losses caused by helminths.

Figure 1. Google Earth image demonstrating the geographical locations of the cities (yellow pins) in northern Paraná where this study was done.



Parasitological examinations

The trachea, the gastrointestinal tract, and bursa of Fabricius of all FRCs were collected and transported refrigerated to the Laboratory of Veterinary Parasitology, Universidade Estadual de Londrina, where they were opened and examined. The luminal surfaces of all organs were scraped and the contents filtered by three sieves of different diameters (150 µm, 425 µm, and 600 µm) to separate the helminths by category (PAVANELLI, 1981). The contents were then examined under a stereomicroscope; all helminths collected were immersed in Railliet-Henry fluid, fixed, and identified. Identification was based on the morphological characteristics of helminths (YAMAGUTI, 1959, 1961; TRAVASSOS et al., 1969; SOULSBY, 1982; SCHMIDT, 1986). The frequencies of the helminths identified during this study were then compared with similar investigations done in Brazil.

Epidemiological survey

An epidemiological survey was designed to investigate whether the characteristics associated with the production systems used at the 14 farms investigated have any influence of infection by helminths. The chicken farmers who consented to the study were interviewed at each farm during which one questionnaire was applied, using the closed question format (THRUSFIELD, 2005). The possible relationship between data from each farm was then related with the results of parasitological exams of each chicken by the Epi Info 3.5.4 (DEAN et al., 1996). All farmers indicated that anthelmintic therapy was not used during the period of this survey. The parameters evaluated included: type of bedding; age at slaughter; age released from cages; soil type; stocking capacity; rearing systems; water source; rearing of other avian species; presence of shading, and sanitary break. The feed administered to all chickens was similar at all farms (pasture and cereal), and thus not used as a variable. The possible association between these parameters relative to the occurrence of infection was determined by using the odds ratio (OR) with a confidence interval (CI) of 95%.

Statistical analyses

The frequency of an individual helminth species was determined by calculating the percentage of the host population infected (THRUSFIELD, 2005). The Miettinen formula was used to calculate the confidence interval (CI). The ratio of the birds exposed to the variables relative to the ratio of birds not exposed (Ratio of Cross-product) was used to determine the OR of the variables investigated (RUMEL, 1986); $p \leq 0.05$ was considered as significant. All statistical analyses were done by using the software Epi Info 3.5.4 (DEAN et al., 1996).

Results

Distribution of helminths

The age of the FRCs evaluated varied between 85 and 120 days. The distribution of helminths in FRCs within the regions evaluated is given in Table 1. Chickens from all farms evaluated were infected by gastrointestinal parasites. However, not all FRCs examined were parasitized; the frequency of parasitism varied between 8 - 100%, with an overall average parasitism of 76.3%. No seasonal effect on infection was observed.

Most (85.9%; 225/262) of the FRCs examined contained at least one example of a helminth species. These represented 16 genera and 23 species of helminths that were distributed in cestodes (*n*=6), nematodes (*n*=16), and trematode (*n*=1). The prevalence of helminths identified and their habitats are given in Table 2. *Raillietina cesticillus* was the most prevalent cestode, and was identified in 23.3% (61/262) of the FRCs evaluated; *Heterakis gallinarum* and *Ascaridia galli* were the predominant nematodes observed, and occurred in 71.4% (187/262) and 45% (118/262) of all FRCs, respectively. The only trematode identified, *Postharmostomum commutatum*, was observed in 2.7% (7/262) of the FRCs evaluated. The most elevated parasitic burdens were associated with *Heterakis gallinarum* (21.1 helminths/infected bird), *Ascaridia galli* (12.2 helminths/infected bird) and *Raillietina cesticillus* (8.7 helminths/infected bird), which corresponded to 3,939; 1,435 and 531 examples respectively. Additionally, this study might represent the first description of helminthiasis due to *Physaloptera truncata* and *Subulura brumpti* in FRCs from southern Brazil.

Table 1. Distribution and parasitism frequency in free-range chickens from rural areas of southern Brazil.

Study locations	Rural areas	Free-range chickens evaluated		
		Total	Positive	%
Santo Antonio da Platina	A	9	9	100
	B	12	12	100
	C	9	9	100
	D	5	5	100
Cambará	E	25	6	24
Barra do Jacaré	F	64	60	93.3
Santa Mariana	G	25	4	16
	H	7	7	100
	I	6	6	100
Conselheiro Mairink	J	50	46	92
Apucarana	K	25	2	8
Jacarezinho	L	5	5	100
	M	12	12	100
Cornélio Procópio	N	8	7	87.5
Total		262	200	76.3

Table 2. The frequency of gastrointestinal helminths in free-rage chickens from southern Brazil.

Helminths	Anatomical location	Chickens infected	
		Number	%
Cestodes			
Choanotaenia infundibulum	Small Intestine	2	0.8
Hymenolepis carioca	Small Intestine	10	3.8
Raillietina cesticillus	Small Intestine	61	23.3
Raillietina echinobothrida	Small Intestine	20	7.6
Raillietina tetragona	Small Intestine	14	5.3
Raillietina sp.	Small Intestine	16	6.1
Nematodes			
Ascaridia galli	Small Intestine	118	45
Capillaria annatis	Cecum; Small Intestine	16	6.1
Capillaria annulata	Crop	2	0.8
Capillaria collaris	Cecum; Small intestine	2	0.8
Capillaria contorta	Crop	3	1.2
Capillaria obsignata	Small Intestine	5	1.9
Capillaria sp.	Cecum; Small Intestine	6	2.3
Dispharynx spiralis	Proventriculus	6	2.3
Heterakis gallinarum	Cecum	187	71.4
Oxyspirura mansoni	Small Intestine	1	0.4
Physaloptera truncata	Crop	1	0.4
Strongyloides oswaldoi	Small Intestine	6	2.3
Subulura brumpti	Cecum	3	1.2
Syngamus trachea	Trachea	1	0.4
Tetrameres americanus	Proventriculus	3	1.2
Tetrameres fissispina	Proventriculus	1	0.4
Trematodes			
Postharmostomum commutatum	Cecum	7	2.7

Epidemiological findings

Significant ($p \leq 0.05$) associations were observed when the effects of the types of bedding, soil type, and fence restriction of FRCs were considered relative to the occurrence of helminthic infection in FRCs (Tables 3). The type of bedding, the length of the sanitary break (time without birds in production area), and the presence of shading significantly ($p \leq 0.05$) influenced the occurrence of *H. gallinarum* infections (Table 4). Most parameters evaluated were significantly associated with infection of FRCs by *A. galli* (Table 5); these included the type of bedding, age when released from cages, age at slaughter, length of the sanitary break, the rearing of other birds, type of soil, and the presence of shading. The relationship between management variables and the occurrence of *H. gallinarum* and *A. galli* infection were evaluated because these were the most prevalent helminthes in this survey.

Table 3. The relationship between the management systems of free-range chickens from southern Brazil and the susceptibility to infection by helminths.

Variables evaluated	Possible responses	Helminths present/ total (%)	P	OR (95% CI)
Type of bedding	Straw	127/160 (79)	0.0003	0.16 (0.05-0.49)
	Without bedding	98/102 (96)		
Age released from cages	Less than 30 days	166/193 (86)	0.9216	1.04 (0.44-2.44)
	More than 30 days	59/69 (85)		
Slaughter age	Less than 100 days	180/205 (87)	0.1379	1.92 (0.83-4.40)
	More than 100 days	45/57 (78)		
Water source	Water basin	129/149 (86)	0.8560	1.14 (0.53-2.44)
	Artesian well	96/113 (84)		
Sanitary break	Less than 60 days	173/193 (89)	0.0876	2.03 (0.91-2.45)
	More than 60 days	52/66 (79)		
Rearing of other birds	Yes	48/52 (79)	0.2059	2.24 (0.70-7.93)
	No	177/210 (84)		
Fence restriction	Yes	162/195 (83)	0.0436	0.31 (0.09-0.98)
	No	63/67 (94)		
Soil type	Clay	153/186 (82)	0.0148	0.26 (0.07-0.80)
	Sandy/Mixed	72/76 (94)		
Stocking capacity	Below 3m²/bird	9/9 (100)	0.3674	1.17 (1.11-1.23)
	Above 3m²/bird	216/253 (85)		
Presence of shading	Yes	177/210 (84)	0.2059	0.45 (0.13-1.42)
	No	48/52 (92)		

Table 4. The relationship between the management systems of free-range chickens from southern Brazil and the susceptibility to infection by *Heterakis gallinarum*.

Variables evaluated	Possible responses	Helminths present/total (%)	P	OR (95% CI)
Type of bedding	Straw	105/160 (65)	0.014	0.47 (0.25-0.87)
	Without bedding	82/102 (80)		
Age released from cages	Less than 30 days	136/193 (70)	0.6976	0.84 (0.43-1.64)
	More than 30 days	51/69 (73)		
Slaughter age	Less than 100 days	142/205 (70)	0.7867	0.86 (0.42-1.76)
	More than 100 days	42/57 (73)		
Water source	Water basin	109/149 (73)	0.5524	1.22 (0.68-2.18)
	Artesian well	78/113 (69)		
Sanitary break	Less than 60 days	149/193 (76)	0.0067	2.34 (1.24-4.41)
	More than 60 days	38/66 (57)		
Rearing of other birds	Yes	45/52 (86)	0.0133	3.08 (1.24-7.98)
	No	142/210 (71)		
Fence restriction	Yes	139/195 (71)	0.9199	0.98 (0.50-1.91)
	No	48/67 (71)		
Soil type	Clay	130/186 (69)	0.049	0.77 (0.40-1.48)
	Sandy/Mixed	57/76 (75)		
Stocking capacity	Below 3m²/bird	9/9 (100)	0.0636	1.42 (1.31-1.54)
	Above 3m²/bird	178/253 (70)		
Presence of shading	Yes	141/210 (67)	0.0040	0.27 (0.10-0.70)
	No	46/52 (88)		

Table 5. The relationship between the management systems of free-range chickens from southern Brazil and the susceptibility to infection by *Ascaridia galli*.

Variables evaluated	Possible responses	Helminths present/total (%)	P	OR (95% CI)
Type of bedding	Straw	55/160 (34)	0.000024	0.32 (0.19-0.56)
	Without bedding	63/102 (62))		
Age released from cages	Less than 30 days	95/193 (49)	0.0326	1.94 (1.05-3.61)
	More than 30 days	23/69 (33)		
Slaughter age	Less than 100 days	104/205 (50)	0.0007	3.16 (1.55-6.53)
	More than 100 days	14/57 (24)		
Water source	Water basin	70/149 (46)	0.5484	1.20 (0.71-2.03)
	Artesian well	48/113 (42)		
Sanitary break	Less than 60 days	104/193 (53)	0.0001	4.20 (2.08-8.58)
	More than 60 days	14/66 (21)		
Rearing of other birds	Yes	12/52 (23)	0.0004	0.35 (0.19-0.65)
	No	106/210 (50)		
Fence restriction	Yes	139/195 (71)	0.9199	0.98 (0.50-1.91)
	No	48/67 (71)		
Soil type	Clay	68/186 (36)	0.000029	0.30 (0.16-0.54)
	Sandy/Mixed	50/76 (65)		
Stocking capacity	Below 3m²/bird	7/9 (77)	0.0953	4.48 (0.82-32.29)
	Above 3m²/bird	111/253 (43)		
Presence of shading	Yes	105/210 (50)	0.0020	3.0 (1.44-6.35)
	No	13/52 (25)		

Discussion

This study represents a novelty in the understanding of helminths in FRCs from Brazil since it allowed for the detection of management variables associated with the risk of helminthic infection within a subtropical region. Alternatively, questionnaires were used to evaluate the association between variables and helminthic infection in free-land laying hens from England and Wales (SHERWIN et al., 2013); and blackhead disease in turkeys from France (CALLAIT-CARDINAL et al., 2010). Factors such as hygiene and density were associated with parasite infection.

The results from this study suggest that the type of floor bedding, the soil type, and the usage of fences in the management of FRCs were directly related to gastrointestinal helminthiasis in FRCs, while the stocking density and the source of water had no significant effect on the development of gastrointestinal parasitism in FRCs.

It has been suggested that the depth of straw is associated with a reduced infection by *A. galli* (SHERWIN et al., 2013). In addition, protection of up to eight weeks due to the introduction of new straw in layer houses has been described (MAURER et al., 2009). Similar results were observed during this study where the usage of straw as floor bedding compared without any floor bedding reduced the possibility of FRCs being infected by *H. gallinarum* and *A. galli* probably due to restricted contact with the infectious stages of these parasites. Furthermore, in the current study the stocking density (3m² per bird) was not associated with parasitism, while the stocking density of the hens (5-10m² per bird) reared outdoors seemed not to influence the transmission patterns of *A. galli* and *H. gallinarum* (HECKENDORN et al., 2009). Moreover, the providing of sand within the litter area was associated with an increase in fecal egg counts for *Ascaridia*, *Heterakis* and *Trichostrongylus* (SHERWIN et al., 2013); these findings are in agreement with the association between sandy soil, helminth infection (P=0.0148) and *A. galli* infection (P=0.000029) seen in this research.

An important finding was that FRCs reared in management systems that used sanitary breaks for less than 60 days have a more elevated risk of being infected by *H. gallinarum* (p=0.0067; OR, 2.34; CI 1.24-4.41) and *A. galli* (p=0.0001; OR, 4.20; CI, 2.08-8.58). This can be associated with the fact that the infective capacity of the ovum of *H. gallinarum and A. galli* is progressively reduced when exposed to the adverse effects of environmental conditions (SMITH, 1998; MERCADO et al., 2004). Moreover, elevated soil temperatures have been associated with reduced infectivity of the eggs of *H. gallinarum* and *A. galli* (CHRISTENSON et al., 1942; TARBIAT, 2012), while desiccation was considered as detrimental to the viability of the eggs of *A. galli* (CARDOZO; YAMAMURA, 2004; TARBIAT, 2012).

This study has demonstrated that the average frequency of parasitism in FRCs from all rural regions evaluated was 76.3%. Prevalence levels in FRCs has been described as 62% in Zaria, Nigeria (LUKA; NDAMS, 2007), 89.9% in Morocco (HASSOUNI; BELGHYTI, 2006), 89.5% in the Shewa Zone (HUSSEN et al., 2012) and 91% in the Amhara region (ESHETU et al., 2001) of Ethiopia, 92.7% in Lages, Santa Catarina, southern Brazil (VIERO, 1984), 97% in Kampala, Uganda (SSENYONGA, 1982), and 100% in Tanzania (MAGWISHA et al., 2002). These results suggest that gastrointestinal parasitism is a major problem for FRCs worldwide, and reinforces the theory that all FRCs are probably subclinically infected by intestinal helminths (MAGWISHA et al., 2002).

Although cestodes, nematodes and trematodes were identified in the present study from all regions evaluated, parasitism was predominantly due to cestodes and nematodes, with most infections being associated primarily with *H. gallinarum* and *A. galli*. Additionally, a comparative analysis of published data from Brazil suggests that *H. gallinarum, A. galli,* *Raillietina* spp. are probably the most frequently occurring helminths in FRCs (Table 6). Similar results have been described in FRCs from other regions of Brazil (VIERO, 1984; GOMES et al., 2009), as well as from other countries such as Iran (ESLAMI et al., 2009), Bangladesh (RABBI et al., 2006), Zimbabwe (DUBE et al., 2010), and Ethiopia (ESHETU et al., 2001). These findings suggest that *H. gallinarum* and *A. galli* are probably the principal intestinal helminths of FRCs worldwide, represent an ongoing problem, and contribute to the elevated rates of mortality in FRCs (GOMES et al., 2009). This is probably due to the scavenging habits of FRCs which favor the ingestion of earthworms (RABBI et al., 2006), the paratenic hosts of *H. gallinarum* and *A. galli*, as well as the infectious stages of these parasites.

Table 6. Distribution of gastrointestinal helminths in free-range chickens from different geographical regions of Brazil.

Helminths	**References consulted**							
	This study	Costa et al., 1975	Albuquerque, 1977	Carneiro et al., 1979	Machado et al., 1980	Reis et al., 1980	Pavanelli et al., 1981	Viero, 1984
n/Region	262/S	30/SE	203/S	33/MW	31/SE	36/NE	121/S	205/S
	%	%	%	%	%	%	%	%
Cestodes								
Choanotaenia infundibulum	0.8			3			19	
Hymenolepis carioca	3.8						2.5	5.36
Raillietina cesticillus	23.3	26.6		30	6.5	5.6	32.2	11.7
Raillietina echinobothrida	7.6	23.3		33	45.2	2.8	2.5	
Raillietina tetragona	5.3	70		36	41.9	2.8	62	13.7
Raillietina sp.	6.1		59					
Nematodes								
Ascaridia galli	45	60	58	27	41.9	44.5	43.8	32.7
Capillaria annatis	6.1				3.2			
Capillaria annulata	0.8	36.6			3.2		4.9	0.9
Capillaria collaris	0.8						12.4	52.2
Capillaria contorta	1.2				9.7	5.6		
Capillaria obsignata	1.9	56.6			12.9	2.8	0.8	27.3
Capillaria sp.	2.3		86	12				
Dispharynx spiralis	2.3		1		12.9		24.8	
Heterakis gallinarum	71.4	63.3	81	75	87.1	22.5	85.9	75.6
Oxyspirura mansoni	0.4	60			59.1			
Physaloptera truncata	0.4							
Strongyloides oswaldoi	2.3			6				
Subulura brumpti	1.2							
Syngamus trachea	0.4				6.5	5.6		
Tetrameres americanus	1.2		40					
Tetrameres fissispina	0.4						9.9	
Trematodes								
Postharmostomum commutatum	2.7	3,3			9.7			0.5

Legend: S, southern; SE, southeastern; MW, Midwest; NE, northeastern.

An adult *Oxyspirura mansoni* was found in the small intestine, probably due to contamination in the slaughterhouse or during transport to the laboratory. Its natural habitat is the eye and lachrymal duct of their hosts (VICENTE et al., 1995; PERMIN; HANSEN, 1998).

In conclusion, the high prevalence and worm burden found indicate favorable environmental conditions for helminth infection in free-range system on the Brazilian subtropical region. Thus, preventive techniques are necessary and should be implemented during the rearing of FRCs. These include decreased shading, use of adequate floor beddings, and greater sanitary breaks, which might avoid contamination and reduce the viability of the parasitic infectious forms within the soil thereby resulting in increased efficiency and productivity. However, we believe that additional epidemiological studies should be done to investigate the associations between the variables evaluated and to better identify the factors that may affect the occurrence of helminths, thereby contributing to the establishment of new husbandry techniques.

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