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SHORT COMMUNICATION

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Helminth parasites of the Eurasian badger (*Meles meles* L.) in the Basque Country (Spain)

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Abstract The helminthological study of 26 Eurasian badgers (*Meles meles* L.) in the Basque Country (northern Spain) revealed the presence of two trematode (*Euryhelmis squamula* and *Brachylaima* sp.), three cestode (*Atriotaenia incisa*, *Mesocestoides* sp. and *Taenia* sp.) and five nematode (*Aonchotheca putorii*, *Physaloptera* sp., *Molineus patens*, *Uncinaria criniformis* and *Strongyloides* sp.) species. All 15 individuals analysed for *Trichinella* sp. were negative. The coprological analysis (flotation and migration) revealed the excretion of strongylid, capillariid and trematode eggs, and *Crenosoma* sp. and *Angiostrongylus* sp. larvae. No sex- or age-related differences were found in the parasite burden or egg and larvae excretion. *A. incisa* and *M. patens* abundances were positively correlated, both species being negatively correlated with badger weight. The presence of adults of *U. criniformis* and strongylid eggs in faeces was not independent. Badgers excreting *Angiostrongylus* larvae were in poorer condition than those not excreting.

Keywords Badger · *Meles meles* · Basque Country · Helminth · Spain

Introduction

Wild carnivores are relevant as reservoir of parasites that can affect domestic animals and humans. For example, reports of *Angiostrongylus vasorum* (Poli et al. 1991) or *Leishmania* sp. (Mancianti et al. 1994) infections in the red fox (*Vulpes vulpes*) suggest the importance of wildlife in the epidemiology of these species. Other species parasitising wild carnivores may be of economic importance because their larvae infest livestock or game species (e.g. *Taenia hydatigena*, de la Muela et al. 2001). Wild carnivores can also be carriers of zoonotic parasites such as *Toxoplasma* sp., *Echinococcus granulosus*, or *Trichinella* sp., among others (Soulsby 1982). In addition, some parasites may play a role in the population dynamics of carnivore populations, as observed with *Dirofilaria immitis* and the fox in Spain (Gortazar et al. 1994).

The Eurasian badger (*Meles meles* L.) is a medium-sized carnivore belonging to the Mustelidae and widely distributed in the northern Palaearctic, for which the Iberian Peninsula is the southwestern limit of its distribution. The parasites of the badger have been studied throughout its distribution range (Hancox 1980; Jones et al. 1980; Loos-Frank and Zeyhle 1982; Brglez 1988; Magi et al. 1999) and also in some Spanish areas (Torres et al. 2001). However, no such data are available at the moment regarding the Basque Country, whose mild and humid climate differs greatly to most of Spain. We describe in the present paper the helminth parasites retrieved from badgers in this region.

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Materials and methods

The Basque Country is an autonomous region located in northern Spain on a narrow strip of hilly country facing the sea at the Bay of Biscay, which enjoys a moderate climate thanks to a branch of the Gulf Stream. In addition, its hilly surface tends to cause formation of clouds and intense precipitation.

Twenty-six badgers were analyzed in the present work. All were road killed with the exception of two individuals, which were found dead. When possible, they were sexed, aged (juvenile/adult), weighed and measured. Each animal was necropsied in detail. The internal organs were removed and systematically analyzed with routine techniques for helminths (Soulsby 1982). All the retrieved helminths were stored in 70% alcohol. Nematodes were cleared with lactophenol and identified under a light microscope. Cestodes were stained with acetic carmine and identified under the microscope. All helminths were identified according to the keys in Anderson et al. (1983) and the descriptions in Rocamora et al.

(1978), Soulsby (1982), Guisantes et al. (1994), Miquel et al. (1994), Priemer and Lux (1994) and Cordero del Campillo and Rojo (1999). We quantified the excretion of parasite eggs by the McMaster technique and the excretion of nematode larvae by the Baermann technique ($n = 24$). *Trichinella* larvae were searched for in 10 g of diaphragm muscle samples from 15 badgers using the digestion technique. Terminology referring to parameters of parasitism is that of Bush et al. (1997). Prevalence was calculated with Quantitative Parasitology 2.0 (Rózsa et al. 2000). The residual of the regression of body weight on the cube of head and body length was taken as condition index (Andersson 1992). The data were log-transformed when needed. Kruskal-Wallis ANOVA and Mann-Whitney *U*-test were used to analyze differences in parasite abundance and excretion, depending on sex, age and condition of the badger. Prevalence relationships were tested using Fisher's exact test. All other correlations were tested using Spearman's ρ.

Results

All studied badgers were parasitized. Helminths recovered included two trematode, three cestode and five nematode species (Table 1). The commonest helminths were *Atriotaenia incisa*, *Aonchotheca putorii* and *Strongyloides* sp. The identification of the *Physaloptera* sp. specimens was not possible, since no adult parasites were found. In addition to these helminths, a huge number of immature, unidentified nematode larvae were found, whereby two of the badgers were parasitized only by these larvae. None of the studied badgers were positive to *Trichinella* sp.

The coprological analysis revealed the excretion of capillariid (prevalence: 0.25 [0.10–0.47]; abundance: 130.2 ± 486.0; intensity: 521.1 ± 917.8), strongylid (0.42 [0.22–0.64]; 447.9 ± 1053.8; $1075.0 \pm 1{,}445.3$) and trematode (0.08 [0.01–0.27]; 139.6 ± 613.4; $1{,}675.0 \pm 1873.8$) eggs. *Crenosoma* sp. and *Angiostrongylus* sp. larvae were also observed (Table 1).

No sex- or age-related differences were found in the parasite burden or egg and larvae excretion. We found a negative correlation between badger weight and *Molineus patens* (Spearman's, $r = -0.74$, $n = 21$, $P < 0.001$,) and *A. incisa* burden (Spearman's, $r = -0.44$, $n = 21$, $P < 0.05$). In fact, *A. incisa* and *M. patens* abundances were positively correlated (Spearman's, $r = 0.42$, $n = 26$, $P < 0.05$). Badgers in worst body condition excreted more *Angiostrongylus* larvae than those in best condition (*U*-test: $z = 1.96$, $P < 0.05$).

The presence of adults of *Uncinaria criniformis* and strongylid eggs in faeces was not independent ($\chi^2 = 5.54$, $P < 0.05$). No such relation was found between *A. putorii* adults and capillariid eggs.

Discussion

With the exception of *Taenia* sp., all the species found were previously reported in badgers in the Iberian Peninsula (Feliú et al. 1991). Torres et al. (2001) stated that the helminthfauna of mustelids in the Iberian Peninsula is weak regarding parasitic intensities. However, the prevalences and intensities reported here are, as a rule, higher than those reported in previous studies on badger helminths (Loos-Frank and Zeyhle 1982; Brglez 1988; Torres et al. 2001).

Brachylaima sp. was found in one badger, and *Euryhelmis squamula* was identified in three animals, one of them heavily infested. Both species were found by Torres et al. (2001) in badgers in Spain, but not in the northern area of the peninsula, where, according to Torres et al. (1996), *E. squamula* is very frequent in polecats (*Mustela putorius*). In concordance with the study by Feliú et al. (1996), which examined other carnivore mammals in the Iberian peninsula, the prevalence of *Brachylaima* sp. reported here is low. However, the burden hosted by the only parasitized badger (1,642 individuals) is very high when compared with that reported by Torres et al. (2001) or by studies on other Carnivora species (e.g. Guisantes et al. 1994; Feliú et al. 1996; Torres et al. 1998). Terrestrial snails (second intermediate hosts of *Brachylaima*) were found in the gastric content of this badger, confirming that this badger's generalist diet may be involved in the diverse helminthfauna of this species.

One *Taenia* sp. individual was found in one badger. As mentioned above, this is the first report of this genus parasitizing badgers in the Iberian Peninsula. However,

Table 1 Prevalence (95% confidence intervals in parentheses), mean abundance (± standard deviation), mean intensity (± standard deviation) and range of helminth adults and larvae detected in badgers (*Meles metes*) in the Basque Country (northern Spain)

	n	Prevalence	Abundance	Intensity	Range
Trematoda					
Euryhelmis squamula	26	0.12 (0.02–0.30)	197.08 ± 877.18	1,708.00 ± 2,397.30	8–4,450
Brachylaima sp.	26	0.04 (0.00–0.20)	63.15 ± 322.02	1,642.00	1,642
Cestoda					
Atriotaenia incisa	26	0.69 (0.48–0.86)	2,778.10 ± 6,562.50	3,484.10 ± 7,926.30	11–33,000
Mesocestoides sp.	26	0.04 (0.00–0.20)	19.23 ± 98.06	500.00	500
Taenia sp.	26	0.04 (0.00–0.20)	0.04 ± 0.19	1.00	1
Nematoda					
Aonchotheca putorii	26	0.46 (0.27–0.67)	103.69 ± 277.94	224.67 ± 382.00	2–1,316
Physaloptera sp.	26	0.19 (0.07–0.39)	12.23 ± 43.12	63.60 ± 86.80	8–217
Molineus patens	26	0.39 (0.20–0.59)	102.12 ± 272.35	265.50 ± 397.29	8–1,300
Uncinaria criniformis	26	0.35 (0.17–0.56)	21.31 ± 40.89	55.40 ± 50.45	13–151
Strongyloides sp.	26	0.61 (0.41–0.78)	1,272.70 ± 2,544.90	2,068.10 ± 3,006.60	25–9,898
Crenosoma sp.	24	0.04 (0.00–0.21)	2.08 ± 10.20[a]	50.00[a]	50[a]
Angiostrongylus sp.	24	0.42 (0.20–0.66)	27.68 ± 55.24[a]	65.75 ± 70.61[a]	5–200[a]

[a]Larvae per gram of faeces

the absence of gravid proglottides and the poor preservation of the scolex made it impossible to identify the species. In badgers in other European areas, *T. martis* (Loos-Frank and Zeyhle 1982), *T. intermedia* and *T. secunda* (Stubbe 1965) have been reported. On the other hand, our results confirm previous reports regarding *A. incisa* and *Mesocestoides* sp. as common cestodes of *M. meles* in Spain (Torres et al. 2001). Remains of small rodents were found in the stomach of a badger harbouring *Mesocestoides* sp. The second larval stage of this species has been found in small rodents in the Iberian Peninsula (Cordero del Campillo et al. 1994), which, as mentioned above, indicates that their feeding habits are related to the badger's helminthfauna. *Mesocestoides* sp. is relevant because it can infect the dog (Cordero del Campillo and Rojo 1999). Attempts to control this cestode should take into account the role of wildlife in its ecology.

A. putorii was the most prevalent helminth detected. This could indicate that earthworms are an important component of the badgers' diet, as observed in northeastern Spain (Torres et al. 2001). However, no studies on the badger's diet in the Basque Country are available, and no evidence of the presence of earthworms in the gastric content was observed during necropsy. However, *A. putorii* cycle may be also direct (Anderson 2000).

We found also a high prevalence of *Strongyloides* sp. Since *S. stercoralis* has been cited parasitising dogs and humans in Spain (Cordero del Campillo et al. 1994), further studies should be performed in order to identify the *Strongyloides* species harboured by wild carnivores.

M. patens and *A. incisa* abundances were positively correlated. This is difficult to explain, since *A. incisa* may have an indirect life cycle, and *M. patens* is monoxenous. This could be due to individual differences in exposure and susceptibility, parasite interactions or sampling artefacts, as observed by Holmstad and Skosping (1998).

Many unidentified larvae were found parasitizing 20 badgers. It was not possible to identify them due to including specimens of different size and morphology, which did not fit with described mammal helminth larvae. These might include larvae of free-living nematodes, or pseudoparasites, but this was not further investigated.

Crenosoma sp. larvae were detected in only one individual. *C. vulpis* is cited as a badger parasite by Boch and Schneidawind (1988), and *C. melesi* has been reported in Spanish badgers by Torres et al. (2001). However, these authors did not find this species in badgers from northern Spain, in contrast to Álvarez et al. (1991), who reported a prevalence of 0.25 in badgers in Galicia (northwestern Spain).

In contrast, the prevalences observed for *Angiostrongylus* sp. larvae were high. *A. vasorum* was reported parasitizing badgers in Spain, but not in the northern peninsula (Torres et al. 2001). Gastropods were found in the gastric content of two badgers excreting *Angiostrongylus* larvae. *A. vasorum* is a worm of veterinary relevance since it may cause death in parasitized dogs (Soulsby 1982) and is frequent in the Basque Country (Juste et al. 1993). As almost half of the examined individuals were infected, not only foxes (which were considered the main host), but also badger, and probably other mustelids should be considered as relevant hosts in the maintenance of the *A. vasorum* life cycle. Surprisingly, we did not find any adults during the necropsies, although heart and lung vessels were carefully examined. The reasons for this are not clear. Interestingly, Gortazar et al. (1998) also found 21% of *Angiostrongylus* larvae-positive red foxes by histological examination of the lung, despite the absence of adults from heart and pulmonary vessels. On the other hand, since *A. dujardini* has frequently been observed in Spanish rodents also in the Basque Country (Cordero del Campillo et al. 1994), the possibility of a pseudoparazitation may not be discarded.

The absence of *Trichinella* sp. in the analyzed badgers is in agreement with the low prevalences reported by Rossi et al. (1992) in badgers in Italy (1.1%) or Torres et al. (2001) in Spain (2.1%).

The presence of strongylid eggs in faeces was related to the presence of *U. criniformis* adults, suggesting that these eggs belong to this species more probably than to *M. patens*. This may indicate that the coprological analysis may be a useful tool for detecting the presence of *Uncinaria*. In contrast, *A. putorii* and the capillariid eggs did not show this relation. Although other members of the Capillariidae family have been reported in Spanish badgers (Feliú et al. 1996), none of them were recovered from the badgers examined in this study.

Thin badgers harboured higher *A. incisa* and *M. patens* burdens. A relationship was also found between badgers' body conditions and *Angiostrongylus* larvae prevalence. Since parasites have recently been found to be involved in the regulation of some wildlife populations (e.g. Hudson et al. 1992), these findings may be interesting for future research.

No zoonotic parasites were found in the present study. However, badgers in the Basque Country host a diverse parasitofauna and may be involved in the epidemiology of parasites of veterinary importance.

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