Helminthological investigation of *Mustela nivalis* Linnaeus, 1766 in Spain — A mustelid broadly spread all over Western Europe and hardly studied from a parasitic viewpoint

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Abstract: The current study provides the first important data on the helminth fauna of *Mustela nivalis* Linnaeus, 1766 (Carnivora: Mustelidae) in Western Europe. The analysis of 168 specimens, originating from 29 Spanish provinces, allowed the detection of nine parasite species: *Taenia mustelae* Gmelin, 1780 (Taeniidae), *Aonchotheca putorii* (Rudolphi, 1819) (Trichuridae), *Trichinella* sp. (Trichinellidae), *Strongyloides mustelorum* Cameron et Parnell, 1933 (Strongyloidiidae), *Molineus patens* (Dujardin, 1845) (Molineidae), *Crenosoma melesi* Jancev et Genov, 1988 (Crenosomatidae), *Filaroides martis* (Werner, 1783) (Filaroididae), *Skrjabinylus nasicola* (Leuckart, 1842) (Skrjabinylidae) and *Mastophorus murs* (Gmelin, 1790) (Spirocercidae). Moreover, the influence of some ecological factors (host sex and geographical location) on the parasitic fauna have been analysed.

Key words: Helminth fauna. *Mustela nivalis*. Mustelidae. Spain.

INTRODUCTION

In Europe there are seven Mustelids belonging to the genus *Mustela* Linnaeus, 1758. These are: *M. erminea* Linnaeus, 1758; *M. eversmanni* Lesson, 1827; *M. lutreola* (Linnaeus, 1761); *M. nivalis* Linnaeus, 1766; *M. putorius*, Linnaeus, 1758; *M. sibirica* Pallas, 1773 and *M. vison* Schreber, 1777 (Honacki et al. 1982). *M. eversmanni* and *M. sibirica* have a limited European distribution and they do not inhabit the Iberian Peninsula. *M. lutreola* and *M. vison* show reduced population densities, both in the Peninsula and in the rest of the Continent. On the contrary, *M. erminea, M. nivalis* and *M. putorius*, which according to Delattre (1987) are the phylogenetically closest related species, are more widely distributed in Europe, and also in Spain.
**M. nivalis** is a Mustelid with a circumboreal distribution and it shows a rather complicated systematics (Beaucournu and Gruhlich 1968, Kratochvil 1977, Von Frank 1985). The wide away of phylogenetic studies, which have been already carried out (based on morphological, biological, ethological, physiological and genetic features; Heidt 1979, Nei 1972, Simonsen 1982, Brinck et al. 1983), contrast with the limited parasitological knowledge available at present. In the area of Helminthology, the studies known refer, in general, to very small samples, originating from Central or Eastern Europe (Prokopic 1958, Soltys 1962, Kontrimavichus 1963 and 1985, Mituch et al. 1992). The only study based on a larger sample (80 specimens) is that carried out by Prokopic (1965) in Czechoslovakia. Other studies had an ecological interest referring to some helminths, principally to *Skrjabingylus nasicola* (Leuckart, 1842) and *Trichinella spiralis* (Owen, 1835) (Kozlov and Kontrimavichus 1961, Fahmy 1964, Hansson 1968, Lancaster et al. 1973, King 1977, Lewis 1978, Fameree et al. 1981, Aymerich et al. 1983, Gerard and Barrat 1986, Vlcek 1991).

On the Iberian Peninsula there was only a preliminary study based on 10 specimens from the Montseny Massif (Miquel et al. 1992). Our study provides the first important data on the helminth fauna of *M. nivalis* in Western Europe. Furthermore, when one compares the faunistic results obtained for Iberia with those data already known for this Mustelid in the rest of Europe, the peninsular effect on the composition of the Iberian helminth fauna can be noticed. From an ecological point of view, the results obtained have provided unprecedented data in Europe, about the influence of the sex and the geographical location on the helminth fauna of a representative of *Mustela* genus.

It is obvious that the current work is a valuable help to elucidate the structure of the peninsular helminth faunas of the *Mustela* species. This objective seems rather easy if we take into account the specificity (oligoxenia) of many parasite species. This would imply a clear similarity of those parasitic faunas (Motje 1995).

**MATERIAL AND METHODS**

168 weasels were analysed (102 males and 30 females). The sex of the 36 remaining specimens was not determined. They came from several enclaves of 29 Spanish provinces. Hosts were classified according to the geographical location of capture sites into 5 Spanish areas, according to the 38°N, 40°N and 42°N parallels of latitude and the 4° meridian (see Fig. 1). The number of individuals analysed in the areas was: NW=37; NE=24; CN=50 and CS=29. Two specimens from the more southern region (S) were added to the CS group. The individuals coming from the Montseny Massif (MON=28) were separated from the CN population, to which they geographically belong, due to the peculiar ecological conditions of the area. This area has been considered as an isolated continental ecosystem (Miquel et al. 1992, 1994 a and b).

Captured hosts were kept frozen or in 70% etanol or 10% formaldehyde until the helminthological analysis. The isolated helminths were processed according to helminthological methodology, and were microscopically determined, following the specialised literature for each species (see Miquel et al. 1994a).

The terminology, the quantitative parameters and the statistic treatment are detailed in Pence and Eason (1980), Margolis et al. (1982) and Combes (1987). *Trichinella* sp. were only treated in prevalence terms. Data referring to *Skrjabingylus nasicola* are based only on the eight examined weasel skulls. The worm burden of *Filaroides martis* refers to parasitic nodules.
Fig. 1. Map of the Iberian Peninsula showing the 29 Spanish provinces, which supplied *M. nivalis* individuals and the areas considered (NW, NE, CN, CS and S). The provinces are: Alava (A), Asturias (AST), Avila (AV), Barcelona (B), Burgos (BU), Cáceres (CC), Cantabria (CAN) Ciudad Real (CR), Girona (GI), Huesca (HU), Jaén (J), La Coruña (C), La Rioja (LR), León (LE), Lleida (L), Madrid (M), Murcia (MU), Navarra (N), Palencia (P), Pontevedra (PO), Segovia (SG), Soria (SO), Tarragona (T), Teruel (TE), Toledo (TO), Valladolid (VA), Vizcaya (VIZ), Zamora (ZA) and Zaragoza (Z). The Montseny Massif (marked with a circle) is located between Barcelona and Girona provinces in the CN area.

RESULTS

Nine helminth species have been detected: *Taenia mustelae* Gmelin, 1780 (*Taeniidae*), *Aonchotheca putorii* (Rudolphi, 1819) (*Trichuridae*), *Trichinella* sp. (*Trichinellidae*), *Strongyloides mustelorum* Cameron et Parnell, 1933 (*Strongyloidae*), *Molineus patens* (Dujardin, 1845) (*Molineidae*), *Crenosoma melesi* Janev et Genov, 1988 (*Crenosomatidae*), *Filaroides martis* (Werner, 1783) (*Filaroididae*), *Skrjabingylus nasicola* (Leuckart, 1842) (*Skrjabingyliidae*) and *Mastophorus muris* (Gmelin, 1790) (*Spirocercidae*). In total, 1 Cestode and 8 Nematodes, all of them belonging to different families.

*Taenia mustelae* Gmelin, 1780

The Taeniids detected (T. mustelae Gmelin, 1780 = T. tenuicollis Rudolph, 1819) in the intestine of several weasels were identified by the morphology and morphometry of the scolex. The most important morphometric data (n=5) are given as ranges in micrometer with the mean in parentheses: a) scolex: 268-345 (320); b) suckers: 110-141 (125); c) rostellum 55-102 (85) wide, with 2 rows of 27 hooks; d) the hooks of the inner row are little longer (20-24) than the hooks of the outer row (20-21). Our material shows a great similarity to the specimens of T. tenuicollis Rudolph, 1809 cited by Prokopic (1965) parasitizing Putorius putorius, Martes foina and Mustela erminea in Czechoslovakia. The nomenclature of T. tenuicollis has often been widely discussed (Freeman 1956, Abuladze 1964, Verster 1969, Tenora and Vanek 1969, Murai and Tenora 1973, Murai 1982, Rausch 1985). We have adopted the opinion of Freeman (1956) who concludes that T. mustelae has priority over T. tenuicollis. On the other hand, recently, Iwaki et al. (1995) have also cited T. mustelae parasitizing M. nivalis in Japan.

Aonchotheca putorii (Rudolph, 1819)


A. putorii is a gastric nematode, which mainly parasitizes Mustelids (Miquel 1993). Its systematic position is confusing and it has been discussed by several authors, both at specific and generic level (Fahmy 1964, Wakelin 1968, Butterworth and Beverley-Burton 1980, Moravec 1982, Mas-Coma 1984). We agree with the classification proposed by Moravec (1982).

Trichinella sp.

Locality: province of Avila (AV). Prevalence: 0.6%. Invasion intensity: indeterminate.

In the first intestinal portion of a weasel we detected some small nematodes (ingravid females) classified as belonging to the genus Trichinella Railliet, 1985. Following Pozio et al. (1992) the helminths could only be classified at a genus level.

Strongyloides mustelorum Cameron et Parnell, 1933


S. mustelorum is a nematode, which is frequently detected in the small intestine. Its determination could be easily carried out on the basis of the original description (Cameron and Parnell 1933) and its recent redescription (Kharchenko and Tkach 1992).

Molineus patens (Dujardin, 1845)


In our study the most frequent parasitic species was M. patens. This intestinal nematode could be determined according to the paper of Durette-Desset and Pesson (1987). The suprageneric systematic position of this species has recently been established by Durette-Desset and Chabaud (1993).
**Crenosoma melesi** Jancev et Genov, 1988

Localities: provinces of B, BU and L. Prevalence: 3.0%. Invasion intensity: 1 – 10

*C. melesi* was recovered from the respiratory system. Its determination was based on the original report (Jancev and Genov 1988). These authors, apart from describing the new species, did clearly specify their distinctive characters with respect to *Crenosoma* spp., which are also parasitizing Mustelids.

**Filaroides martis** (Werner, 1783)

Localities: provinces of AV, B, C, CR and PO. Prevalence: 3.0%. Invasion intensity: 1 – 2 (nodules)

Some nematodes living inside of parasitic nodules in the bronchi belonged to the species *Filaroides martis*. Their determination was mainly based on the morphology and morphometry of some males and on the already existing references (Lopez-Neyra 1947, Anderson 1962 and 1963).

**Skrjabingylus nasicola** (Leuckart, 1842)

Locality: province of Barcelona (B). Prevalence: 37.5% (n=8). Invasion intensity: 1 – 14.

The helminths isolated from the frontal sinus of three weasels, coming from the Montseny Massif, were identified as *Skrjabingylus nasicola*. Its particular habitat and the morphological descriptions of the species (Lankester 1983, Gerard and Barrât 1986) were helpful in the identification.

**Mastophorus muris** (Gmelin, 1790)

Localities: provinces of B and Z. Prevalence: 2.4%. Invasion intensity: 1 – 2.

The stomach nematode *M. muris* appeared sporadically. Its identification was based on the papers of Wertheim (1962) and Quentin (1970). Based on our results, *M. nivalis* has to be added to the Iberian Carnivores (*Vulpes vulpes, Meles meles, Mustela erminea, M. putorius, Martes foina, Genetta genetta* and *Felis silvestris*), which slightly but constantly are parasitized by the Spirocercid in Iberia (Feliu et al. 1991, Motje 1995, Torres et al. unpublished data).

The ecological results obtained from the whole sample and from the different subpopulations are detailed in the Table 1.

**DISCUSSION**

*M. nivalis* is a representative of the *Mustela* genus, which shows a high population density and a wide distribution all over Spain. In contrast with other mammals, the Iberian Peninsula does not constitute the southern border of its Palearctic distribution. The helminth fauna of *M. nivalis* mainly consists of the members of parasitic community occurring in all the representatives of the genus in Iberia (Motje 1995). In some *Mustela* hosts the parasitic community structure appears to be modified by helminths with specific ecology. That would be the case of the Digenean *Euryhelmis squamula* (Rudolphi, 1819), which parasitizes semiaquatic hosts, such as *M. putorius* and *M. lutreola* (Feliu et al. 1992, Motje 1995). In some other cases, as in the case of the stoat, a parasitic impoverishment occurs as a consequence of the population isolation found in the north-west area. Moreover, the Peninsula is the southern border of the European distribution of *M. erminea* (Feliu et al. 1991).
<table>
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<tr>
<th></th>
<th>males (n=102)</th>
<th>females (n=30)</th>
<th>NW (n=37)</th>
<th>NE (n=24)</th>
<th>CN (n=50)</th>
<th>MON (n=28)</th>
<th>CS (n=29)</th>
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<td>13.5</td>
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<td>7.6</td>
<td>16.6</td>
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<td>5.9</td>
<td>1.27</td>
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<td>F. martis</td>
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<td><strong>TOTAL</strong></td>
<td>69.3</td>
<td>73.3</td>
<td>67.6</td>
<td>66.7</td>
<td>60.0</td>
<td>92.8</td>
<td>40.7</td>
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P = prevalence; MI = mean intensity; IA = index of abundance, according to Pence and Eason (1980)
The helminth fauna of *M. nivalis* in Iberia is formed mainly by oligoxenic species, such as *T. mustelae*, *A. putorii*, *M. patens*, *S. mustelorum* and *F. martis*. However, this parasitic fauna shows certain peculiarities as shown by the Mustelids in Central and Eastern Europe. One of these peculiarities is the absence of Trematodes and Acanthocephales. On the contrary, in the Peninsula a greater richness of parasites transmitted by Invertebrates as intermediate hosts (Molluscs and Arthropods) is observed. The absence of species such as *E. squamula* or *Euparyphium melis* (Schrank, 1788), among the Trematoda, or *Centrorhynchus* spp., among the Acanthocephala, parasitizing *M. nivalis* in Iberia can be considered as surprising. In fact, the helminths were reported in Iberia parasitizing other Mustelids (Feliu et al. 1989, Miquel 1993, Motje 1995). Among the Nematodes, the most evident absences in the Trichuridae and Ascarididae families. As far as the Metastrongyloidea is concerned, the occurrence of *C. melesi* parasitizing *M. nivalis* has not been detected outside the Iberian Peninsula.

From a quantitative point of view, the helminth showing a higher prevalence and parasitic load is *M. patens*. In fact, it is the helminth best adapted to all the Iberian Mustelids (Feliu et al. 1991, Motje 1995). Furthermore, taking into account the abundance indexes, *M. patens* is the species most dominant in the helminth community of the weasel, in all the subpopulations. Among the rest of species of the community, only *T. mustelae*, *A. putorii*, and *S. mustelorum* can be considered as well-adapted species, because they have been found in all the subpopulations. These species are, in general, codominant in the general analysis and among the helminthfaunas of the samples. Except for *S. nasicola* (non representative data), the rest of parasitic species show in Iberia a prevalence always lower than 5% and are immigrant species. Therefore, the chorology of the majority of species is rather peculiar. Thus, *Crenosoma melesi* and *Mastophorus muris* show a marked preference for the population of the Montseny Massif, where they appear as codominant species. This is the principal reason for the fact that the Montseny appears as the area where *M. nivalis* shows the most diversified parasite fauna.

The parasitic communities of the two host subpopulations established as regards to sex do not differ markedly from each other. At a qualitative level, the absence of *Trichinella* sp. in males and *C. melesi* and *M. muris* in females are accidental. When comparing both samples, statistically significant differences were not detected either for the prevalences or for the intensities. However, the prevalences of *M. patens* and of the other geohelminth (*S. mustelorum*) are uneven. In the case of males a predominance of one species over the other does not exist. On the other hand, for the females the higher prevalence of *M. patens* (50%) over *S. mustelorum* (13.3%) is statistically significant (chi square test; p<0.01).

The geographical location of the host seems to influence the helminth fauna of *M. nivalis* more markedly than sex does. This is obvious both at a qualitative (number of species) and at a quantitative level (prevalences and parasitic burden). At a qualitative level, as we have already mentioned, it stands out that the community from the Montseny Massif is the most diverse. From a quantitative point of view significant differences are observed, for the nematodes prevalence (NP) and for the total parasitation (TP), between the Montseny Massif and the other four areas considered. From the chi square tests the differences are: MON-NW (NP and TP p<0.01); MON-NE (NP p<0.01 and TP p<0.05); MON-CN (NP and TP p<0.01); MON-CS (NP and TP p<0.01). Differences between the populations NW-CS (NP and TP p<0.05) have also been found.
The study of each subpopulation has shown that significant differences referring to prevalences (chi square test) do always refer to two geohelminths (M. patens and S. mustelorum). These differences are the main reason for the differences mentioned above (NP and TP). For M. patens these are: MON-NW, MON-NE, MON-CN and MON-CS (p<0.01). For S. mustelorum these are: MON-NW and NW-CS (p<0.05). In both nematodes significant differences have also been found (Mann-Whitney “U” test) in parasite intensity level. For M. patens these are: MON-NE (p<0.05); MON-NW, MON-CN and MON-CS (p<0.01). For S. mustelorum these are: NW-CN and NW-CS (p<0.05). These results seem to indicate that the ecological conditions in the Montseny are very favourable for the development of the free life forms of both helminths. However, the heterogeneity of the analysed sample (different altitudes and several seasons of capture) not allowed to establish any kind of correlation of infection rates of helminths with available climate data.

The results, above all those referring to heteroxenous species, might be explained with the diet and ethology of M. nivalis in Iberia. It is known that the weasel’s diet is fundamentally based on rodents as its main prey. According to the different studies carried out in European countries, those preys constitute approximately 60-90% of its diet. The diet is completed with secondary preys (birds, insectivores and lagomorphes), which represent from 5 to 35%, depending on the areas and the season. A remarkable aspect is the almost complete absence of invertebrate ingestions (Delattre 1987). However, those have to be often consumed as numerous species transmitted by Invertebrates, such as S. nasicola (Fahmy 1964, Hansson 1968, King 1977, Lewis 1978, Aymerich et al. 1983, Gerard and Barrat 1986), were found in M. nivalis. Therefore, in Iberia, the occurrence of helminths transmitted by Invertebrates (C. melesi, F. martis and M. muris) is more important in the northern half, becoming specially evident in the Montseny Massif area. In the Montseny area there was a weasel in which all of the helminths transmitted by Invertebrates in Iberia were present. A fact that has to be marked, which is also helpful to corroborate this tendency, is the high prevalence detected for S. nasicola in this area (37.5%; n=8 analysed skulls). The environmental characteristics of the Iberian Peninsula, namely higher rainfall and milder temperatures in the northern half, could explain the south-north gradient for the helminths transmitted by Gastropods (C. melesi, F. martis and S. nasicola). This trend, evidenced in the case of M. nivalis, is also demonstrated in other Iberian Mustelids (Motje 1995).

The only helminths that require in order to close their cycle that the weasel eats another Vertebrate are T. mustelae and Trichinella sp. The prevalence of both helminths is rather disparate. Trichinella sp. has only been detected in a female from Avila (CN area). As it is an immigrant species for M. nivalis it can be concluded that the Mustelid does not decisively contribute to the maintenance of the life-cycle of this parasite in Iberia. On the contrary, T. mustelae has been detected with a general prevalence of 13.1%, and with an average parasitic intensity of 1.7 individuals, which means that it is a codominant species (IA=0.21). It is, moreover, a Taenid which accompanies M. nivalis uniformly all over Iberia. In fact, it has been detected in more than half of the prospected provinces, and it occurs in the five subpopulations. These data fit in properly with the chorology of the larval stage of the Taenid parasitizing different Iberian Rodents (Feliu et al. 1991). If we take into account the helminth faunas of all the Iberian Mustelids (Motje 1995), ecological data referring T. mustelae are more normal in M. nivalis than in M. erminea, which surprisingly enough shows a low prevalence for the Taeniid (Feliu et al. 1991). In the concrete case of the M. nivalis population in the NW area, which
presents almost the same Iberian distribution area of the stoat, the prevalence in the weasel has been more than five times higher than in the stoat (10.8% in front of 2%). Due to the fact that the predator behaviour of those two Carnivores is quite similar, it is probable that this difference is caused by the smaller size of the vital territory and the higher population density of the weasel, and by the selective usage of different preys so as to reduce the interspecific competition (Delattre 1987).

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A szerzők 168 menyét (Mustela nivalis) helmintológiai vizsgálata alapján 1 galandféreg és 8 fonálféreg faj jelenlétét mutatták ki, amelyek a következők voltak: Taenia mustelae Gmelin, 1780 (Taeniidae), Aonchotheca putorii (Rudolphi, 1819) (Trichuridae), Trichinella sp. (Trichinellidae), Strongyloides mustelorum Cameron et Parnell, 1933 (Strongylidae), Molineus patens (Dujardin, 1845) (Molineidae), Crenosoma melesi Jancev et Genov, 1988 (Crenosomatidae), Filaroides maris (Werner, 1783) (Filaroididae), Skrjabingylus nasicola (Leuckart, 1842) (Skrjabingylidae) és Mastophorus muris (Gmelin, 1790) (Spirocercidae).

REFERENCES


