Comparative analysis of the helminth community of the common shrew, *Crocidura russula*, of three western Mediterranean enclaves and the inland of the Iberian Peninsula

Fuentes, M.V.; Sainz-Elipe, S. & Galán-Puchades, M.T.
Departament de Parasitologia, Facultat de Farmàcia, Universitat de València, Av. Vicent Andrés Estellés s/n, 46100 Burjassot-València, Spain.

Received: 20.04.05 Accepted: 18.05.05

Abstract: The community similarity and the biological characteristics of the helminth community of the common shrew, *Crocidura russula* (Insectivora: Soricidae), of three Spanish western Mediterranean enclaves relatively close to and/or related with each other –two littoral Valencian Country Natural Parks, the Serra Calderona mountains and Albufera of València, as well as the island of Eivissa (Balearic Archipelago)– were studied and compared with the inland of the Iberian Peninsula. The analysis was carried out calculating the Sorenson (S) and Jaccard (J) similarity indices and comparing the biological characteristics of the helminth community. Two of the helminth communities of *C. russula* with the greatest similarity are Serra Calderona – Albufera of València (S=75, J=60), Albufera of València – Eivissa Island (S=62, J=45), while the lowest similarity is between Eivissa Island – Iberian Peninsula (S=42, J=27). The similarity may reinforce the hypothesis that the Mediterranean axis (north Africa – Iberian Peninsula) was the route used by small mammals and their helminths to colonize the east of the Iberian Peninsula and the Balearic Archipelago. Moreover, these results together with the common biological characteristics of the helminth communities analysed, make it possible to propose the helminths of *C. russula* as biological tags to compare ecologically and/or geographically related enclaves.

Key words: Helminths, *Crocidura russula*, Insectivores, Similarity indices, Biological characteristics, Western Mediterranean, Iberian Peninsula

Resumen: La similaridad entre las comunidades helmintianas de la musaraña común, *Crocidura russula* (Insectivora: Soricidae) y sus características biológicas fueron estudiadas en tres enclaves del Mediterráneo occidental español relativamente cercanos y/o relacionados entre ellos – dos parques naturales litorales del País Valencià, la Serra Calderona y la Albufera de València, así como la isla de Eivissa (Archipiélago Balear) – y comparadas con el interior de la Península Ibérica. El análisis fue llevado a cabo calculando los índices de similaridad de Sorenson (S) y Jaccard (J) y comparando las características biológicas de dichas comunidades helmintianas. Dos de las comunidades con mayor similaridad son Serra Calderona – Albufera de València (S=75, J=60) y Albufera de València – Isla de Eivissa (S=62, J=45). La similaridad más baja se da entre Isla de Eivissa – Península Ibérica (S=42, J=27). Estos resultados pueden reforzar la hipótesis de que el eje mediterráneo (norte de África – Península Ibérica) fue la ruta usada por los pequeños mamíferos y sus helmintos para colonizar el este de la Península Ibérica y el Archipiélago Balear. El estudio de la similaridad junto con las características biológicas comunes de las comunidades helmintianas analizadas, hace posible proponer a los helmintos de *C. russula* como marcadores biológicos útiles en la comparación de enclaves relacionados ecológica y/o geográficamente.

Palabras Clave: Helmintos, *Crocidura russula*, Insectívoros, Índices de Similaridad, Mediterráneo Occidental, Península Ibérica

Corresponding author:
Dr. Màrius V. Fuentes,
Departament de Parasitologia, Facultat de Farmàcia,
Universitat de València,
Av. Vicent Andrés Estellés s/n, 46100 Burjassot-València, Spain,
Telephone 34-96-354-42-98, Fax 34-96-354-47-69.
E-mail mario.v.fuentes@uv.es

1. Introduction

This study is part of various multidisciplinary projects, which are carried out with the aim of filling the knowledge gap on the helminth community of small mammals (insectivores and rodents) present in peninsular (littoral and inland) as well as insular ecosystems of great ecological importance.

The common shrew, *Crocidura russula* (Insectivora: Soricidae), is one of the most thoroughly studied small mammals in the context of the Iberian Peninsula as well as in some insular enclaves of the western Mediterranean. Moreover, the role of this insectivore and its helminth-parasites as ecological tags/markers stands out: as a fundamental marker of forest mass regeneration quality –fundamentally as regards bush species (Fuentes *et al*., 1998); as possible biological tag of the post-fire regeneration in Mediterranean ecosystems (Fuentes *et al*., 2005); as well as concerning the colonization routes taken by helminths between the continent and some islands (Mas-Coma, 1978; Galán-Puchades, 1986).

The aim of this article is to analyse the community similarity and the biological characteristics of the helminth community of the common shrew, *C. russula* (Insectivora: Soricidae), of three Spanish western Mediterranean enclaves relatively close to and/or related with each other: two littoral Valencian Country Natural Parks and the Pityusic island of Eivissa (Balearic Archipelago). Moreover, each enclave is compared with the global helminthfauna of the common shrew in the inland of the Iberian Peninsula.

2. Material and methods

The community similarity analysis was carried out by means of a study of helminthological relations between the helminth community of *C. russula* in the inland of the Iberian Peninsula –excluding aquatic ecosystems (Mas-Coma, 1977; Mallach *et al*., 1985; Galán-Puchades, 1986; Sanmartín *et al.*, 1987; Álvarez-Mascato *et al.*, 1991; Blasco *et al.*, 1991; Cordero del Campillo *et al.*, 1994; Fuentes *et al.*, 2003; Sáez Durán, 2003; Torres *et al.*, 2003), and three further helminth communities relatively close to and/or related with each other (Fig. 1): the community present in the Serra Calderona (Fuentes et al., 2000, 2005), the Albufera of València Natural Park (Portolés *et al.*, 1996) and the island of Eivissa (Balearic Archipelago) (Mas-Coma *et al.*, 2000).

Figure 1.- Geographical location of the enclaves studied in the western Mediterranean frame

The analysis was carried out calculating the similarity indices of Sorenson (S) and Jaccard (J). These qualitative indices make it possible to establish the relation between helminth communities of a host in several habitats (Cooper and Crites, 1976):

$$S = \frac{2C}{A+B}\,100 \qquad J = \frac{C}{A+B-C}\,100$$

in which A is the number of parasite species in host A; B is the number of parasite species in host B; and C is the number of common parasite species in hosts A and B. The values of S and J range from 0 to 100: if the value = 0, compared hosts do not share any species; if the value = 100, compared hosts have the same helminthfauna.

At the same time, studies concerning the biological helminth community characterisitics of *C. russula* in the four analysed ecosystems were carried out . Taking into account the importance of the invertebrates, which are part of the diet of this host, the study of the helminth biological cycles was

carried out differentiating between invertebrate-borne and free-environmental stage (FES) helminthiasis, and not the more commonly used classification between heteroxenous and monoxenous helminths. Species such as *Taenia taenuicollis* larvae (for which the common shrew acts as an intermediate host) can be considered heteroxenous although the insectivore might be infested due to the ingestion of a Taeniid egg, a FES-form.

3. Results

The helminth communities of *C. russula* in the different enclaves analysed was composed of 16 helminth species in the Serra Calderona, 16 species in Albufera of València, 13 species in the island of Eivissa, and 25 species in the Iberian Peninsula (Table 1).

Table 1.- The helminth community composition of *Crocidura russula* in three western Mediterranean enclaves and in the Iberian Peninsula. SC = Serra Calderona; AV = Albufera of València; EI = Eivissa Island; IP = Inland Iberian Peninsula.

Helminth species	Enclaves	References
TREMATODA		
Brachylaima spp.	IP	Galán-Puchades, 1986
	SC	Fuentes *et al.*, 2000, 2005
	AV	Portolés, Granel & Esteban, 1996
	EI	Mas-Coma *et al.*, 2000
Pseudoleucochloridium soricis	IP	Mas-Coma, 1977; Galán-Puchades, 1986
Platynosomum soricis	IP	Mas-Coma, 1977
Dicrocelidae gen sp.	IP	Sáez Durán, 2003
Nephrotrema truncatum	IP	Mas-Coma, 1977; Galán-Puchades, 1986
Digenea gen. sp.	SC	Fuentes *et al.*, 2000, 2005
CESTODA		
Taenia taenuicollis larvae	IP	Galán-Puchades, 1986
Mesocestoides sp. larvae	IP	Galán-Puchades, 1986
	SC	Fuentes *et al.*, 2005
Joyeuxiella pasqualei larvae	EI	Mas-Coma *et al.*, 2000
Staphylocistis pistillum	IP	Mas-Coma, 1977; Galán-Puchades, 1986; Fuentes *et al.*, 2003
	SC	Fuentes *et al.*, 2000, 2005
	AV	Portolés, Granel & Esteban, 1996
	EI	Mas-Coma *et al.*, 2000
Staphylocistis scalaris	IP	Mas-Coma, 1977; Galán-Puchades, 1986; Fuentes *et al.*, 2003; Torres *et al.*, 2003
	AV	Portolés, Granel & Esteban, 1996
Staphylocistis tiara	IP	Mas-Coma, 1977; Galán-Puchades, 1986; Alvarez Mascato *et al.*, 1991; Blasco *et al.*, 1991; Torres *et al.*, 2003; Fuentes *et al.*, 2003
	SC	Fuentes *et al.*, 2000, 2005
	AV	Portolés, Granel & Esteban, 1996
	EI	Mas-Coma *et al.*, 2000
Staphylocistis biliarius	IP	Mas-Coma, 1977 (*Hymenolepis* sp. *sensu* Jourdane,1972); Galán-Puchades, 1986
	SC	Fuentes *et al.*, 2000, 2005
Staphylocistis prolifer	IP	Alvarez Mascato *et al.*, 1991
Staphylocistis sp. (new sp.)	EI	Mas-Coma *et al.*, 2000
Pseudhymenolepis redonica	IP	Mas-Coma, 1977; Galán-Puchades, 1986; Alvarez Mascato *et al.*, 1991; Fuentes *et al.*, 2003; Torres *et al.*, 2003
	SC	Fuentes *et al.*, 2000, 2005
	AV	Portolés, Granel & Esteban, 1996
	EI	Mas-Coma *et al.*, 2000

NEMATODA		
Calodium splenaecum	IP	Mas-Coma, 1977
	AV	Portolés, Granel & Esteban, 1996
Calodium soricicola	IP	Mas-Coma, 1977
	AV	Portolés, Granel & Esteban, 1996
Liniscus incrassatus	IP	Mas-Coma, 1977; Mallach *et al.*, 1985; Alvarez Mascato *et al.*, 1991
	SC	Fuentes *et al.*, 2000, 2005
	AV	Portolés, Granel & Esteban, 1996
	EI	Mas-Coma *et al.*, 2000
Aonchotheca europaea	IP	Mas-Coma, 1977 (*Capillaria* sp. aff. *exigua*); Mallach *et al.*, 1985; Alvarez Mascato *et al.*, 1991; Torres *et al.*, 2003
	SC	Fuentes *et al.*, 2000, 2005
	AV	Portolés, Granel & Esteban, 1996
	EI	Mas-Coma *et al.*, 2000
Baruscapillaria sp. aff. *kutori*	IP	Alvarez Mascato *et al.*, 1991
Capillariinae gem. sp.	SC	Fuentes *et al.*, 2000, 2005
Trichosomoides sp.	EI	Mas-Coma *et al.*, 2000
Parastrongyloides winchesi	IP	Mas-Coma, 1977; Mallach *et al.*, 1985; Fuentes *et al.*, 2003
	SC	Fuentes *et al.*, 2000, 2005
	AV	Portolés, Granel & Esteban, 1996
	EI	Mas-Coma *et al.*, 2000
Paracrenosoma combesi	IP	Mas-Coma, 1977
	SC	Fuentes *et al.*, 2000, 2005
	AV	Portolés, Granel & Esteban, 1996
Longistriata confusa	IP	Mas-Coma, 1977; Torres *et al.*, 2003
Longistriata sp. aff. *baeri*	IP	Sanmartín *et al.*, 1987; Alvarez Mascato *et al.*, 1991
Longistriata sp.	IP	Mallach *et al.*, 1985; Torres *et al.*, 2003
	SC	Fuentes *et al.*, 2000, 2005
	AV	Portolés, Granel & Esteban, 1996
Gongylonema sp. aff. *soricis*	AV	Portolés, Granel & Esteban, 1996
	EI	Mas-Coma *et al.*, 2000
Pseudophysaoptera sp.	SC	Fuentes *et al.*, 2000, 2005
	AV	Portolés, Granel & Esteban, 1996
Porrocaecum sp. larvae	IP	Alvarez Mascato *et al.*, 1991; Torres *et al.*, 2003
	SC	new record
	AV	Portolés, Granel & Esteban, 1996
Stammerinema rhopalocephala larvae	AV	Portolés, Granel & Esteban, 1996
Acuaria sp. larvae	EI	Mas-Coma *et al.*, 2000
Acuariinae gen. sp. larvae	IP	Mallach *et al.*, 1985
	SC	Fuentes *et al.*, 2000, 2005
ACANTHOCEPHALA		
Centrorhynchus appendiculatus larvae	EI	Mas-Coma *et al.*, 2000

Two of the helminth communities of *C. russula* with the greatest similarity (i.e. which have the greatest number of helminth species in common) are the Serra Calderona – Albufera of València (S=75, J=60), Albufera of València – island of Eivissa (S=62, J=45), while the lowest similarity are island of Eivissa – Iberian Peninsula (S=42, J=27) (Figure 2).

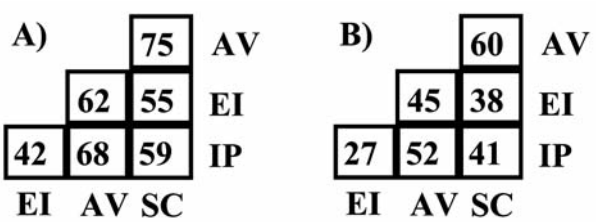

Figure 2.- Community similarity of the helminth communities of *Crocidura russula* of Serra Calderona (SC), Albufera of València (AV), Eivissa Island (EI) and Inland Iberian Peninsula (IP) expressed by Sorenson (A) and Jaccard (B) similarity index values

The analysis of the biological characteristics of the helminth communities reveals the absence of statistically significant differences between the four enclaves studied (Table 2). The predominance of invertebrate-borne against free-environmental-stage helminthiasis is common to the four ecosystems. The presence of one aquatic cycle species, *Nephrotrema truncatum*, and one FES species, for which *C. russula* acts as an intermediate host, *Taenia taenuicollis* larvae, in the inland of the Iberian Peninsula, as well as the presence of one species for which *C. russula* acts as a paratenic host, *Joyeuxiella pasqualei* larvae, and one ageohelminth species, *Trichosomoides* sp. on the island of Eivissa, stand out.

Table 2.- Bioecological characterisitics of the helminth community of *Crocidura russula* in three western Mediterranean enclaves and in the Iberian Peninsula. PI= Inland Iberian Península; SC = Serra Calderona Mountains; AV = Albufera of València; EI = Island of Eivissa; i.h.= intermediate host; p.h.= paratenic host; FES = Free-Environmental Stages.

	PI	SC	AV	EI
Helminth species	25	16	16	13
Invertebrate-borne helminthiasis	16	12	11	10*
Poliheteroxenous	5	2	1	1
Terrestrial cycle	4	2	1	1
Aquatic cycle	1	----	----	----
Diheteroxenous	8	7	8	8
Terrestrial cycle	8	7	8	8
Acting as i.h. or p.h.	3	3	2	1*
FES-borne helminthiasis	9	4	5	3
Ageohelminths	----	----	----	1
Pseudogeohelminths	4	2	3	1
Geohelminths	4	2	2	1
Acting as i.h.	1	----	----	----

* The infection with *J. pasqualei* larvae is the only case which is acquired after ingestion of a reptile, no invertebrate.

4. Discussion

The great similarity detected between the helminth communities of *C. russula* originating from the three enclaves situated in the western Mediterranean frame is based on the presence of *Pseudophysaloptera* sp. in Serra Calderona and in the Albufera of València as well *Gongylonema* sp. aff. *soricis* present in the Albufera of València and on the island of Eivissa. The similarity between these three enclaves may reinforce the hypothesis that the Mediterranean axis (north Africa – Iberian Peninsula) was the route used by small mammals and their helminths to colonize the east of the Iberian Peninsula and the Balearic Archipelago (Mas-Coma, 1978).

The absence of differences between the biological characteristics of the helminth communities confirms the fact that the difference between the analysed enclaves is solely qualitative but does not concern the helminth community structure. This can easily be understood as these ecosystems are similar to a certain extent, i.e. water ecosystems (rivers, deltas, lakes etc.) are excluded. The only exception being the Albufera of València where *C. russula* was hardly ever captured close to irrigation channels or near the lake itself (Portolés *et al.*, 1996).

Furthermore, the predominance of invertebrate-borne against free-environmental stage helminthiasis reaffirms (yet again in all study areas) that the diet of this insectivore consists primarily of arthropods, snails and other invertebrates, typical intermediate hosts of heteroxenous helminth species present in its helminth community, as reported by Fuentes *et al*. (1998, 2005).

Fuentes *et al*. (2005) conclude that the common shrew may not be an adequate biological tag of the post-fire regeneration or other environmental interference in Mediterranean ecosystems. However, the preservation of a great part of the helminth species found in smaller enclaves, compared with the inland of the Iberian Peninsula as a whole, and taking into account their biological requirements (in particular those species of an indirect cycle) make it possible to propose the composition and structure of the helminth community of *C. russula* as a biological tag of the preservation conditions of ecologically valuable enclaves and to consider this as a common feature of geographically and ecologically related enclaves.

5. Acknowledgements

Supported by Projects No. PB87- 0135 and No. PB92-0517-C02-01 of the Ministerio de Educación y Ciencia and project BOS 2000-0570-C02-02 of the Ministerio de Ciencia y Tecnología, Madrid, Spain; project No. CPE/073 of the Institució Valenciana d'Estudis i Investigació, València,. Spain; and Project UV97-2216 of the Universitat de València.

6. References

Álvarez Mascato, F.; Núñez, A.; Bos J.; Quinteiro, P.; Tojo, J. and Sanmartín Durán, M.L. 1991. Datos sobre la Helmintofauna de varias especies de insectívoros (Soricidae, Erinaceidae, Talpidae) en Galicia In: *I Congreso Internacional de las Asociaciones Sudoccidental-Europeas de Patrasitología*. Valencia. Spain, 50.

Blasco, S.; Escera, M.; Feliu, C.; Torres, J.; Arrizabalaga, A. and Montagud E. 1991. Repercusiones ecológicas del fuego sobre las helmintofaunas parásitas de pequeños mamíferos en un ecosistema mediterráneo de Cataluña (España). In: *I Congreso Internacional de las Asociaciones Sudoccidental-Europeas de Patrasitología*. Valencia. Spain, 300.

Cooper, C.L. and Crites, J. 1976. Community ecology of helminth parasitism in an insular passerine avifauna. *J Parasitol*, 62, 105-110.

Cordero del Campillo, M.; Castañón Ordóñez, L. and Reguera Feo, A. 1994. Indice-catálogo de zooparásitos ibéricos. Universidad de León, Secretariado de Publicaciones. León. Spain.

Fuentes, M.V.; Cerezuela, A.M. and Galán-Puchades, M.T. 1998. Insectívoros y roedores de la Serra Calderona (Comunitat Valenciana). Dinámicas de recolonización y estudio helmintoecológico postincendio. *Galemys*, 10, 37-58.

Fuentes, M.V.; Cerezuela, A.M. and Galán-Puchades, M.T. 2000. A helminthological survey of small mammals (insectivores and rodents) in the Serra Calderona mountains (Valencian Community, Spain). *Res Rev Parasitol*, 60, 25-35.

Fuentes, M.V.; Saez, S.; Trelis, M.; Cruz, J.; Sarmento, P.; Casanova, J.C.; Torres, J.; Feliu, C. and Esteban, J.G. 2003. Helminthfauna of small mammals (Insectivora, Rodentia) collected in the Serra da Malcata (Portugal). *Res Rev Parasitol*, 63, 89-92.

Fuentes, M.V.; Sainz-Elipe, S. and Galán-Puchades, M.T. 2005. The helminth community of the common shrew in a postfire regenerated Mediterranean ecosystem. *Helminthologia*, 42, 31-34.

Galán-Puchades, M.T. 1986. Contribución al conocimiento de la fauna de Plathelmintos parásitos de Crocidurinae (Insectivora: Soricidae) en el marco europeo continental e insular del Mediterráneo Occidental. Tesis Doctoral, Universitat de València. Spain.

Mallach, M.P.; Galán-Puchades, M.T.; Antunez, A; Vargas, J.M. and Mas-Coma, S. 1985. Primeros datos helmintológicos sobre la musaraña *Crocidura russula* (Hermann, 1780) (Insectívora: Soricidae) en el sur de España. In: *IV Congreso Nacional de Parasitología*. Tenerife. Spain, 211.

Mas-Coma, S. 1977. Contribución al conocimiento de la helmintofauna de micromamíferos. III. Parásitos de *Crocidura russula* (Hermann, 1780) (Insectivora: Soricidae). *Säugetierkdl Mitt*, 25, 67-78.

Mas-Coma, S. 1978. La Parasitología, auxiliar de la Paleontología y de la Mamalogía en la dilucidación de las vías de poblamiento insular. *Circ Farm*, 36, 29-34.

Mas-Coma, S.; Esteban, J.G.; Fuentes, M.V.; Bargues; M. D.; Valero, M. A. and Galán-Puchades, M. T. 2000. Helminth parasites of small mammals (Insectivores and Rodents) on the Pityusic Island of Eivissa (Balearic Archipelago). *Res Rev Parasitol*, 60, 41-49.

Portolés, E.; Granel, P. and Esteban, J. G. 1996. Helminthfaunistic analysis of *Crocidura russula* (Hermann, 1780) (Insectivora: Soricidae) from the Albufera Natural Park (Valencia, Spain). *Res Rev Parasitol*, 56, 203-211.

Sáez Durán, S. 2003. Helmintofauna de micromamíferos (Insectivora, Rodentia) de la zona meridional de la Península Ibérica: Sierra Espuña (Murcia), Sierra de gredos (Ávila) y Serra da Malcata (Beira Baixa). Trabajo de Investigación, Universitat de València. Spain.

Sanmartín-Durán, M.L.; Álvarez-Mascato, F.; García-Estévez, J. and Outeda-Macias, M. 1987. Trichostrongiloideos parásitos de múridos y sorícidos en Galicia. *Rev Ibér Parasitol*, Vol. Extra., 97-104.

Torres, J.; Trelis, M.; Espert, A.; Ribas, A.I.; Toledo, R.; Casanova, J.C.; Roman, J.; Arrizabalaga, A.; Esteban, J.G. and Feliu, C. 2003. Helminth fauna of small mammals (insectivores and rodents) in Doñana (southeastern Iberian Peninsula). *Res Rev Parasitol*, 63, 23-29.