

Short communication

What makes a cephalopod a suitable host for parasite? The case of Galician waters

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Abstract

We analyse the cephalopod–parasite systems taking into account the abiotic and biotic factors that may affect the host risk of infection (contact) with parasites. On the basis of 2000 individuals comprising 10 cephalopod species collected at a microgeographic area (Galician waters, NW Spain), an attempt is made to find associations between parasite relative species diversity (RSD) and cephalopod life cycle characteristics. Additionally, an index of similarity and the ratios of adult/immature (A/I) and specialist/generalist (S/G) regarding the parasite condition were used to define cephalopod ecological groupings at those species with similar risk of becoming infected with a given parasite fauna. Results show the existence of three ecological groupings (coastal, intermediate, and nerito-oceanic), which suggest that the ecological niche of a cephalopod species is more important in determining its risk of parasitic infection than is phylogeny.

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1. Introduction

Parasites are an important tool in studies of ecology and fisheries biology. The examination of parasites at community level not only helps resolve the identification of potentially interacting species but also helps to increase and refine existing knowledge about the biology of both, predator and prey. Parasites represent far more than half of all animal species (Rohde, 1980) and cephalopods occur in all oceans of the world (Boyle, 1990). The occurrence of a given marine parasite in any cephalopod host species anywhere will depend

on the presence of a suitable definitive host, a suitable intermediate host and complex abiotic and biotic factors hierarchically arrayed and dynamically interactive. These impose a strict interdependency on the organisms comprising the host–parasite systems.

The economic importance of diseases caused by parasites in cephalopods (Pascual et al., 1998) argues that the ecology in exploited systems should be studied in depth. However, our understanding of the ecology of host–parasite relationships in wild cephalopod populations is poor. This is due, primarily, to logistic difficulties in collecting long-term demographic data. As an example, in Galician waters (the best studied area at a microgeographic level), it is well known that trophic transmission in almost all the common eukaryotic cephalopod parasites (Pascual et al., 1996a)

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is mainly dependent on host interaction with multiple trophic levels (e.g., Pascual et al., 1996b; Abollo et al., 1998). This also occurs at many other micro- and macrogeographic levels (see review by Hochberg (1990)). Therefore, trophic ecology might have a significant impact on the intestinal parasitic fauna of cephalopods so that continued transmission ensures a spatial and temporal connection between parasites and cephalopod host populations. However, despite a similarity in transmission pathways, parasite richness within cephalopods is highly variable at species, genus and even family levels (Hochberg, 1990). Why is this so? Because a parasite resides in another living animal, the problem is one of selection: what factors contribute to making a cephalopod a suitable host for parasites?

This paper deals with the ecology of host–parasite interactions in Galician waters. Particular emphasis is

placed on life history and ecological characteristics of cephalopods for determining how abiotic and host related factors predispose an individual to acquiring a parasite.

2. Materials and methods

Host and parasite databases were developed from published information on cephalopod parasites (see review by Pascual et al. (1996a)) and cephalopod life histories (ICES, 1994). More than 2000 cephalopod specimens were examined. These belonged to the following cephalopod species: *Loligo vulgaris*, *Allotheuthis subulata*, *Todarodes sagittatus*, *Todaropsis eblanae*, *Illex coindetii*, *Eledone cirrhosa*, *Octopus vulgaris*, *Sepia officinalis*, *Sepia orbignyana* and *Sepia elegans*. Samples were collected from 1992 to

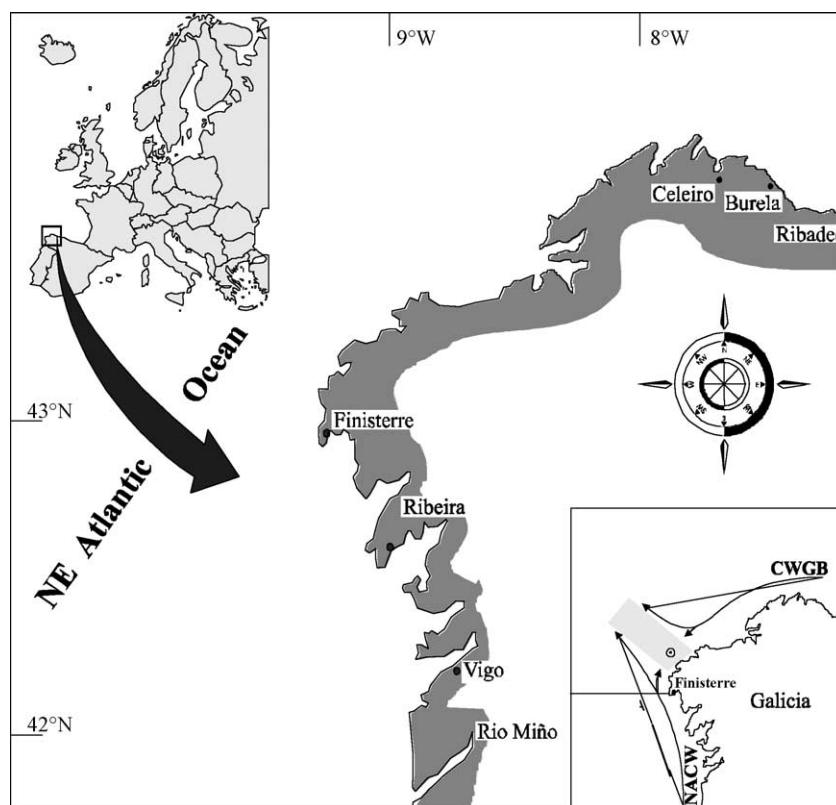


Fig. 1. Galician waters. Sampling area (top) and cephalopod species examined (bottom). CWGB: Central Water from Gulf of Biscay, NACW: North Atlantic Central Water mass.

1998 from the local fishing grounds off the Galician coast (42°05'–45°15'N, 7°–9°20'W) (Fig. 1). Parasites were identified to the species or genus level according to standard protocols (Pascual, 1996).

A number of terms are defined. Parasitic disease risk is the ecological pattern of exposure to parasites (Zuk, 1990), and this definition is expressed in terms of parasite richness and relative species diversity (RSD). Parasite richness refers to the total number of species in a given host species and RSD refers to the ratio of the number of parasite species to the number of host species. The relationship between the two values is an indirect expression of the specificity of the parasites in the group of host species under consideration (Caro et al., 1997). Additionally, adult/immature (A/I) and specialist/generalist (S/G) ratios were calculated. The term adult (A) refers to those cephalopods hosting an adult form of parasite species and immature (I) refers to cephalopods hosting a larval form of any given parasite species. Specialist (S) parasites are those with narrow host specificity, able to survive on a single host species. Generalist (G) parasites are those with wide host specificity, infecting a wide range of host species.

Eight features of cephalopod data were considered: depth (DRP: depth range of cephalopod paralarvae; DRJA: depth range of juvenile/adult cephalopods), temperature (TRJA: temperature range of juvenile/adult cephalopods), salinity (SRJA: salinity range of juvenile/adult cephalopods), exploitation level (EL), potential fecundity of a given cephalopod species (PF),

maximum mantle length at full maturity (MMLFM), bathymetry (B) and vagility (migration scale, MS). An index of similarity, [PSC = $(2C/A + B) \times 100$; A: number of parasitic species in the host species A, B: number of parasitic species in the host species B, C: number of parasitic species which occur in both the host species] (Krebs, 1978), was used to compare parasitic species overlap between the various cephalopod species (Table 1). Significant values to be considered are those with a similarity index (PSC) higher than 50%.

3. Results

Table 2 lists host and parasite taxa, indicating the cephalopod host and their parasite fauna. In addition, harbouring mature (adult, A) or immature (I) forms of a parasite species and S/G condition for each parasite species are shown.

There was no evident pattern in RSD values among the 10 different species of cephalopods sampled in relation to environmental factors (depth, temperature and salinity) (Fig. 2). However, A/I and S/G were lower in paralarvae that live between 50 and 500 m and juvenile and adult cephalopods that live between 300 and 900 m.

Parasitic species richness differed with life history characteristics of cephalopod species. Thus, A/I, S/G and RSD ratios increased with mantle length, the over-

Table 1

Percentage of similarity coefficient [PSC = $(2C/A + B) \times 100$; A: number of parasitic species in the host species A, B: number of parasitic species in the host species B, C: number of parasitic species which occur in both the host species]

(1)	(1)	<i>L. vulgaris</i>										
(2)	0.25	(2)	<i>A. subulata</i>									
(3)	0.66	0.00	(3)	<i>T. sagittatus</i>								
(4)	0.67	0.28	0.44	(4)	<i>T. eblanae</i>							
(5)	0.60	0.25	0.40	0.61	(5)	<i>I. coindetii</i>						
(6)	0.60	0.50	0.66	0.66	0.60	(6)	<i>E. cirrhosa</i>					
(7)	0.36	0.22	0.36	0.43	0.40	0.54	(7)	<i>O. vulgaris</i>				
(8)	0.66	0.28	0.44	0.50	0.46	0.67	0.43	(8)	<i>S. officinalis</i>			
(9)	0.80	0.66	0.40	0.50	0.44	0.80	0.40	0.50	(9)	<i>S. orbignyana</i>		
(10)	0.40	0.66	0.00	0.12	0.22	0.40	0.20	0.40	0.50	(10)	<i>S. elegans</i>	

Table 2

Summary of published and unpublished records of parasites encountered in cephalopod molluscs off Northwest Spain^a

Cephalopods	Habitat	Parasites
<i>Sepia officinalis</i>	Inshore	<i>Aggregata eberthi</i> (A, S) <i>Pseudicyema truncatum</i> (A, S) <i>Phyllobothrium</i> sp. (I, G) <i>Pennella</i> sp. (I, G) <i>Anisakis simplex</i> s.str. (I, G)
<i>Sepia elegans</i>	Inshore	<i>Aggregata</i> sp. (A, S) <i>Pennella</i> sp. (I, G)
<i>Sepia orbygniana</i>	Inshore	<i>Phyllobothrium</i> sp. (I, G) <i>Pennella</i> sp. (I, G)
<i>Octopus vulgaris</i>	Inshore	<i>Aggregata octopiana</i> (A, S) <i>Dicyema typus</i> (A, S) <i>Lecithochirium</i> sp. (I, G) <i>Phyllobothrium</i> sp. (I, G) <i>Scolex pleuronectis</i> (I, G) <i>Pennella</i> sp. (I, G) <i>Octopicola superbus</i> (A, S) <i>Cystidicola</i> sp. (I, G) <i>Anisakis simplex</i> s.str. (I, G)
<i>Eledone cirrhosa</i>	Mostly inshore	<i>Phyllobothrium</i> sp. (I, G) <i>Pennella</i> sp. (I, G) <i>Anisakis simplex</i> s.str. (I, G)
<i>Loligo vulgaris</i>	Coastal continental shelf; mainly inshore	<i>Phyllobothrium</i> sp. (I, G) <i>Pennella</i> sp. (I, G) <i>Anisakis simplex</i> s.str. (I, G)
<i>Alloteuthis subulata</i>	Inshore	<i>Pennella</i> sp. (I, G)
<i>Illex coindetii</i>	Offshore	<i>Phyllobothrium</i> sp. (I, G) <i>Pelichnibothrium speciosum</i> (I, G) <i>Dinobothrium</i> sp. (I, G) <i>Nybelinia yamagutii</i> (I, G) <i>Pennella</i> sp. (I, G) <i>Stellicola hochbergii</i> (A, S) <i>Anisakis simplex</i> s.str. (I, G)
<i>Todaropsis eblanae</i>	Offshore	<i>Aggregata</i> sp. (A, S) <i>Phyllobothrium</i> sp. (I, G) <i>Pelichnibothrium speciosum</i> (I, G) <i>Nybelinia lingualis</i> (I, G) <i>Pennella</i> sp. (I, G) <i>Anisakis simplex</i> s.str. (I, G)
<i>Todarodes sagittatus</i>	Offshore	<i>Aggregata sagittatus</i> (A, S) <i>Phyllobothrium</i> sp. (I, G) <i>Anisakis simplex</i> s.str. (I, G)

^a Data on ecological habitat is also shown for each cephalopod species. I: hosting of an immature form of a parasite species, A: hosting of a mature form of a parasite species, S: specialist, G: generalist.

all in cephalopods ranging from 200 to 400 mm size at full maturity. Moreover, those cephalopods living between 200 and 300 m, and with lower potential fecundity showed lower A/I, S/G and RSD values. Finally, cephalopods with lower vagility harbour higher immature specialist parasites and RSD than those with higher migration activity.

Otherwise, PSC values (Table 1) showed that overlaps in parasitic species largely occurred among cephalopod species that inhabit common ecological niches. Three ecological groupings for cephalopods (A, B, C) could be defined based on their parasitocoenoses: coastal (A), nerito-oceanic (C) and intermediate (B).

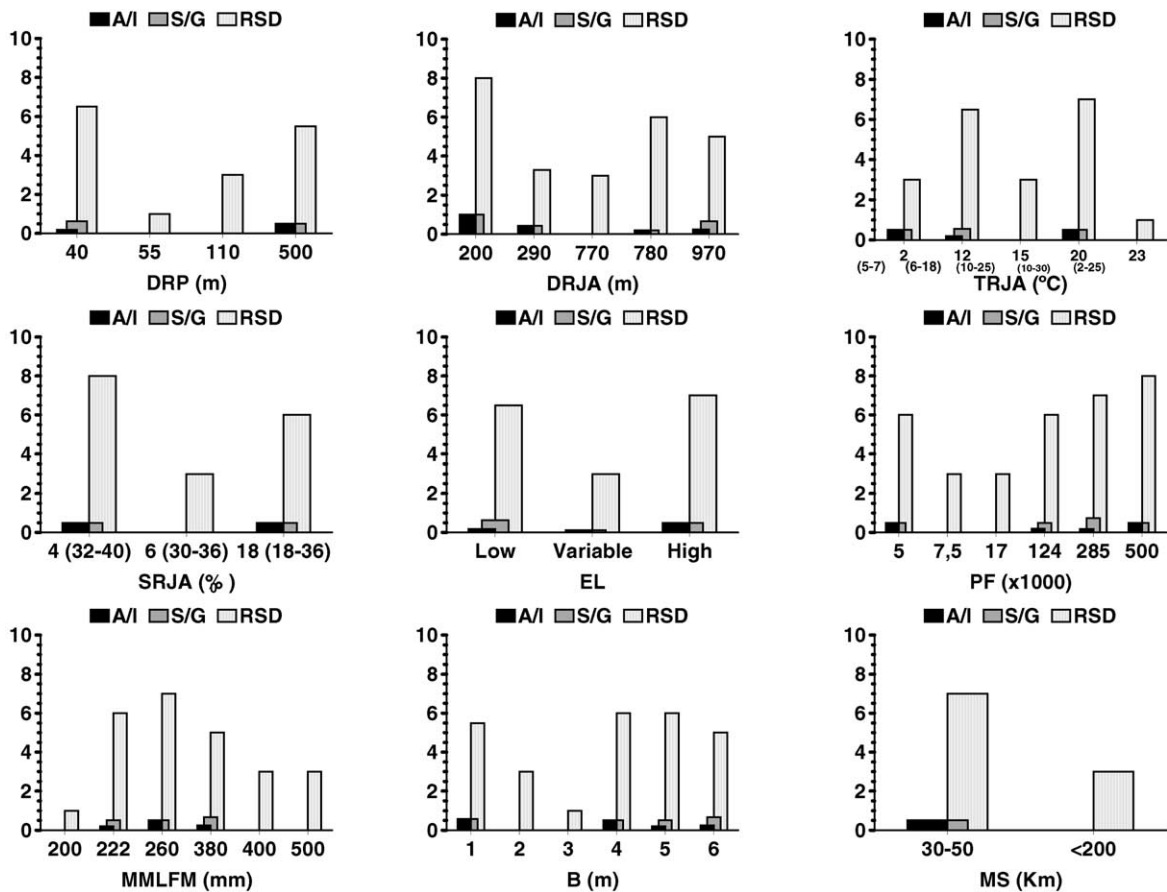


Fig. 2. Relationships between parasitic richness (A/I, S/G and RSD) and ICES-data on environmental factors, fisheries and life-history characteristics of cephalopods at the sampling area. DRP: depth range of paralarvae, DRJA: depth range of juvenile/adults, PF: potential fecundity, TRJA: temperature range of juvenile/adults, SRJA: salinity range of adults, EL: exploitation level, MMLFM: maximum mantle length at full maturity, B: bathymetry, MS: migration scale. Y-axis represents the values for A/I, S/G and RSD, respectively.

4. Discussion

The results presented in this paper suggest that environmental factors (i.e. host external factors) are not important determinants of eukaryotic parasitic disease risk in terms of parasitic species diversity. However, ecological and behavioural features of the cephalopod life cycle (namely, sdeep range, bathymetry, mantle size, potential fecundity and vagility) appear to be extremely important as determinants of RSD. Moreover, the fact that A/I and S/G ratios are relatively low for all sample cephalopod species and that they change according to the above biotic factors suggest

that similarity of spatial and trophic aspects of the ecological niches of cephalopods (i.e., their ecological valence) has a predominant and greater influence on the eukaryotic parasitic patterns than does multiple local abiotic factors in promoting distinctiveness (Fraga et al., 1982). It follows that differences in parasite richness are due, primarily, to fluctuations in the ecological conditions of the biotopes, which means the vertical and horizontal structure of ecosystems that the different cephalopod species inhabit. The present results are in agreement with Russian authors who discussed the ecological relationships of the host–parasite systems for various Atlantic ommas-

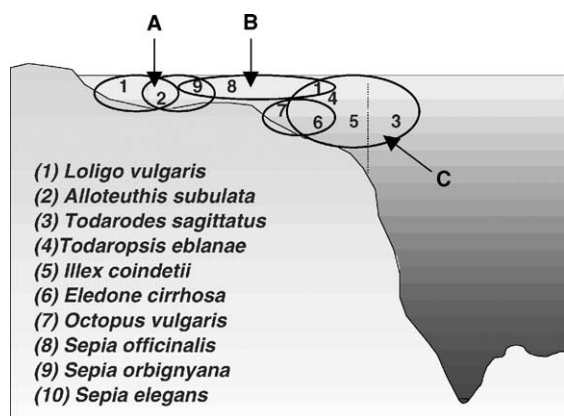


Fig. 3. Grouping of cephalopod species with similar parasitic disease risk.

trephids squid species (Gaevskaia, 1977; Gaevskaia and Nigmatullin, 1978; Nigmatullin and Shukhgalter, 1990; Bagrov, 1982). These papers suggest the existence of two helminthocoenoses (coastal and oceanic) with different parasitic species composition and with cosmopolitan forms within both parasitocoenoses.

If we consider the macroenvironment in terms of external environment as the habitat for parasites and their hosts (Pavlosky, 1934), we must look at the endemiotope (the environment where the parasite prevalence is higher than 10%) as a whole, with the multiplicity of on-going processes within. If it is so, our results confirm the link between cephalopod ecological segregation (i.e. ecological groupings A, B and C) and parasite composition. Partial overlaps in parasitic species among cephalopod species (group C) could indicate temporary breakdowns in food/habitat segregation. This also reflects that segregation is less pronounced between the same size–age host classes than between ontogenetic intraspecific groups.

If we accept that cephalopod species that are ecological equivalents are subjected to the same degree of parasitic disease risk, we could extrapolate the parasitic infection results on a single cephalopod species at any geographic locality to each ecologically characterised cephalopod–parasite system (Fig. 3). On the whole, since the ecosystem structure where any given cephalopod species lives is more important in determining its parasitic community richness than is cephalopod phylogeny, single epidemiological evaluation models could be developed without laborious and

time-consuming studies on the different host–parasite systems at the community level (Bush et al., 1997).

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