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Abstract

This paper represents an updated review of the published and unpublished records of parasites collected from cephalopod molluscs (teuthoid squids, cuttlefish and octopods) in waters off Spain, with special mention for those inhabiting coastal and shelf waters off Galicia (NW Spain). The examination of about 1600 cephalopods in the southeastern North Atlantic Ocean revealed a new parasite species *Stellicola hochbergi*, 37 new host records for Atlanto-Iberian waters, and 18 new host records for the world Ocean (three for coccidian Aggregatidae; three and one for cestodes Phyllobothriidae and Tentaculariidae; five and one for nematodes Anisakidae and Cystidicolidae; one and four for copepods Lichomolgidae and Pennellidae). Results suggests the important role of cephalopods as intermediate or final hosts in the life cycles of ten systematic groups of parasites.

Keywords: Parasites; Cephalopod molluscs; Spain

1. Introduction

Cephalopods play an important role in the marine ecosystem and are valuable to man as food and for biomedical research (Forsythe and Hanlon, 1980; Forsythe, 1984; Hanlon and Forsythe, 1985). Although they are usually regarded as non-conventional resources, cephalopod stocks are of recent importance as international commercial fisheries (Boyle, 1990). Total world catch reached 2.56 million t in 1991 (Food and

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Agriculture Organization, 1991). Owing to the value of cephalopods as important and reliable research animals, additional interest has also been developed in their mariculture potential (Hanlon et al., 1991).

Hochberg (1990) noted that about 150 species of protistan and metazoan parasites abound on and in a total of 650 cephalopod species now recognized by science; the works of Hulet et al. (1979), Kelly (1984), Hanlon et al. (1984), Ford et al. (1986), Forsythe et al. (1987), Forsythe et al. (1990) and Forsythe and Hanlon (1991), have also investigated the disease etiology and potential treatment protocols for cephalopods maintained or reared in the laboratory. Despite this, our present knowledge on the diseases of cephalopod molluscs is still limited and characterized by an almost complete lack of information on etiologies (Kinne, 1990).

As suggested by Ford et al. (1986) it will be increasingly important to screen for parasitic disease etiology in wild cephalopod populations since actual or potential laboratory-maintained species are hatched from eggs laid in the laboratory by wild-caught females. Parasitological studies on wild cephalopods can, therefore, contribute to increasing the accuracy of disease monitoring and management in future large-scale cephalopod aquaculture industry in coming years.

This paper represents an attempt to provided a much-needed integration of avalaible information on past and current research about parasites of cephalopods collected in Spain, the second largest cephalopod consuming country in the world (Guerra, 1992). This synopsis includes scientific name and taxonomic affiliation of parasites, scientific and common name of host species according with Roper et al. (1984), localities and old references to pertinent records. It is not the aim of this paper to review all the details of each of the infectious agents. We refer readers to the volume edited by Kinne (1990) for an in-depth review of the literature on cephalopod parasites, including those host species that are not commercially-exploited.

2. Materials and methods

1576 wild cephalopods (85 cuttlefish, 1333 squids and 158 octopods) of ten species in three orders (Sepioidea, Teuthoidea, Octopoda) were examined for parasites during a large sampling programme conducted by Instituto de Investigaciones Marinas de Vigo (C.S.I.C.) and Laboratorio de Parasitología (Universidad de Vigo), between 1992 and 1995 at 42°5′–45°15′N, 7°–9°20′W. Host animals were obtaining from commercial landings by fishermen operating with otter and pair trawlers, night-lighting and traditional gear.

After necropsy, fresh animals were examined for parasites using standard diagnostic techniques, including gross observations, squash preparations, wet mounts, whole mounts, smears, histology, electron microscopy and multilocus electrophoretic studies. The survey was intended to provide as complete a summary of parasite–host records as possible.

This paper also serves as an updated assessment to both Dr. F.G. Hochberg's Diseases of Mollusca: Cephalopoda (1990), and the Indice Catálogo de Zooparásitos Ibéricos (Cordero del Campillo et al., 1994).

3. Results and discussion

Results revealed that of the ten species of cephalopods studied, five carried both protozoan (coccidians, ciliates, mesozoans) and metazoan parasites (Phyllobothriidae, Tentaculariidae, Cystidicolidae, Anisakidae, Lichomolgidae, Pennellidae); the remaining host species carrying only helminths and/or crustacean parasites.

The eimeriorin apicomplexan *Aggregata* Frenzel, 1885 (gamogony and sporogony both present in the digestive tract, gills and mantle of benthic cephalopods), Mesozoan dicyemids (mature vermiform stages, vermiform embryos, infusorigen, and infusoriform larvae, all primarily in the fluid-filled renal sacs or 'kidneys' of benthic cephalopods), tetraphyllidean cestodes of Phyllobothriidae (plerocercoid larvae in the digestive tract of neritic and oceanic species of oegopsid squids, coastal loliginids, cuttlefishes and octopods), trypanorhynchidean cestodes of Tentaculariidae (metacestode larvae in the digestive tract of Ommastrephid squids), ascaridoid nematodes of *Anisakis* (third stage larvae encysted in the digestive tract and gonads of squid), spirurid nematodes of Cystidicolidae (larval stages in the stomach of common octopus *Octopus vulgaris*), lichomolgid copepods of *Octopicola* (adult forms located in the gills of *O. vulgaris*), and Pennellidae (post-embrionic stages parasitizing the gill lamellae and mantle cavity of several species), are all new parasite records for Atlanto-Iberian cephalopods. In addition, 18 new host records have been described for the world ocean: three for coccidians Aggregatidae, three for cestodes Phyllobothriidae and one for Tentaculariidae, five and one for nematodes Anisakidae and Cystidicolidae, one for crustaceans Lichomolgidae and four for Pennellidae. A new parasite species has been described for the Lichomolgidae (a female adult specimen, the holotype: Museo Nacional de Ciencias Naturales de Madrid MNCN 20.04/1334), the first report of a species of *Stellicola* in the Atlantic Ocean.

We have marked with an asterisk those parasites which have a taxonomic status now under debate (Table 1).

3.1. Some comments on specific identification of parasites

According to Dobell (1925), the species of *Aggregata* found in *O. vulgaris* from Mediterranean and eastern Atlantic waters should be assigned to *Aggregata octopiana* Schneider 1875. The sporocysts of this species are much larger than those of *Aggregata eberthi*. In addition to their large size, they contain far more than three sporozoites (normally about 16). At all stages of development, the parasites attain a considerably greater size than corresponding forms of *A. eberthi*, and they cause a characteristic and quite different reaction in the host's tissues. On the evidence at present available we think that it is probable that Moroff's *Aggregata duboscqi*, *Aggregata jacquemeti* and *Aggregata reticulosa* are synonyms of *A. octopiana* Schneider 1875. In any case there can be no doubt that the classic species of *Aggregata* occurring in *Octopus* need to be critically revised and redescribed.

With regard to Phyllobothrium, the rather plastic nature of the scolex structures (especially the bothridia configuration), and a strong phenetic similarity have made the identification of plerocercoids of *Phyllobothrium* spp. a difficult matter. The problems

Table 1
Summary of published and unpublished records of parasites encountered in cephalopod molluscs off Spain (original)

Parasite	Host	Locality	Source
PROTOZOA			
Apicomplexa—Aggregatidae			
Aggregata eberthi	*Sepia oficcinalis* (common cuttlefish) [–]	Catalonian Sea (WM)	Vivares, 1970; Vivares, 1973a; Vivares, 1973b; Vivares and Rubio, 1969
	[33/38]	Ria de Vigo (IA)	Present work
Aggregata octopiana [a]	*Octopus vulgaris* (common octopus) [70/70]	Ria de Vigo (IA)	Present work
	[13/13]	Ribadeo (CS)	Present work
	[8/8]	Burela (CS)	Present work
Aggregata sp.	*Sepia elegans* [b] (elegant cuttlefish) [12/12]	Ria de Vigo (IA)	Present work
	Todaropsis eblanae [b] (lesser flying squid) [3/300]	Burela (CS)	Present work
	Todarodes sagittatus [b] (European flying squid) [1/30]	Burela (CS)	Present work
Ciliophora—Chromidinidae			
Chromidina elegans	*Spirula spirula* (spirula) [–]	Canary Islands (NEA)	Jepps, 1931; Clarke, 1970
Mesozoa—Dicyemidae [a]			
Pseudicyema truncatum	*Sepia officinalis* (common cuttlefish) [–]	Catalonian Sea (WM)	Whitman, 1883; Nouvel, 1933; Nouvel, 1947
	[38/38]	Ria de Vigo (IA)	Present work
Dicyemennea gracile	*Sepia orbignyana* (pink cuttlefish) [–]	Catalonian Sea (WM)	Nouvel, 1933; Nouvel, 1938; Nouvel, 1947
Pleodicyema delamarei	*Bathypolypus sponsalis* (deep Mediterranean octopus) [2/2]	Catalonian Sea (WM)	Nouvel, 1961
Dicyema spp.	*Octopus vulgaris* (common octopus) [70/70]	Ria de Vigo (IA)	Present work
	[13/13]	Ribadeo (CS)	Present work

Table 1 (continued)

Parasite	Host	Locality	Source
METAZOA			
Cestoda—Phyllobothriidae			
Phyllobothrium sp. [a]	*Octopus vulgaris* (common octopus) [3/70]	Ria de Vigo (IA)	Present work
	Eledone cirrhosa (lesser octopus) [7/67]	Burela (CS)	Present work
	Sepia officinalis (common cuttlefish) [1/38]	Ria de Vigo (IA)	Present work
	Sepia orbignyana [b] (pink cuttlefish) [2/22]	Ria de Vigo (IA)	Present work
	Loligo vulgaris (European squid) [5/8]	Riveira (IA)	Present work
	Illex coindetii (broadtailed short-finned squid) [84/300]	Riveira (IA)	Present work
	[204/300]	Burela (CS)	Present work
	Todaropsis eblanae (lesser flying squid) [53/300]	Riveira (IA)	Present work
	[134/300]	Burela (CS)	Present work
	Todarodes sagittatus (European flying squid) [7/35]	Riveira (IA)	Present work
	[6/30]	Burela (CS)	Present work
Pelichnibothrium speciosum	*Illex coindetii* [b] (lesser flying squid) [1/300]	Burela (CS)	Present work
	Todaropsis eblanae [b] (broadtailed short-finned squid) [2/300]	Burela (CS)	Present work
Dinobothrium sp.	*Illex coindetii* (lesser flying squid) [3/300]	Riveira (IA)	Present work
	[3/300]	Burela (CS)	Present work
Cestoda—Tentaculariidae			
Nybelinia yamagutii	*Illex coindetii* (lesser flying squid) [2/300]	Burela (CS)	Present work
Nybelinia lingualis	*Todaropsis eblanae* [b] (broadtailed short-finned squid) [1/300]	Burela (CS)	Present work

Table 1 (continued)

Parasite	Host	Locality	Source
Nematoda—Anisakidae			
Anisakis simplex B	*Eledone cirrhosa* (lesser octopus) [1/67]	Burela (CS)	Present work
	Loligo vulgaris [b] (European squid) [5/8]	Burela (CS)	Present work
	Illex coindetii [b] (lesser flying squid) [8/300]	Riveira (IA)	Present work
	[58/300]	Burela (CS)	Present work
	Todaropsis eblanae (broadtailed short-finned squid) [37/300]	Riveira (IA)	Present work
	[75/300]	Burela (CS)	Present work
	Todarodes sagittatus [b] (European flying squid) [12/35]	Riveira (IA)	Present work
	[10/30]	Burela (CS)	Present work
Nematoda—Cystidicolidae			
Cystidicola sp.	*Octopus vulgaris* [b] (common octopus) [8/70]	Ria de Vigo (IA)	Present work
Copepoda—Lichomolgidae			
Stellicola hochbergi n. sp.	*Illex coindetii* [b] (lesser flying squid) [1/300]	Burela (CS)	Present work
Doridicola cf. *agilis*	*Todarodes sagittatus* (European flying squid) [1/3]	Golf de Roses (WM)	Stock, 1960
Octopicola spp.	*Octopus vulgaris* (common octopus) [24/70]	Ria de Vigo (IA)	Present work
	[5/13]	Ribadeo (CS)	Present work
Copepoda—Pennellidae [a]			
Pennella spp.	*Octopus vulgaris* [b] (common octopus) [2/70]	Ria de Vigo (IA)	Present work
	[3/13]	Ribadeo (CS)	Present work
	Eledone cirrhosa [b] (lesser octopus) [1/67]	Burela (CS)	Present work
	Sepia officinalis (common cuttlefish) [35/38]	Ria de Vigo (IA)	Present work

Table 1 (continued)

Parasite	Host	Locality	Source
Copepoda—Pennellidae [a]			
Pennella spp.			
	Sepia elegans (elegant cuttlefish) [4/12]	Ria de Vigo (IA)	Present work
	Sepia orbignyana [b] (pink cuttlefish) [5/22]	Ria de Vigo (IA)	Present work
	[3/13]	Celeiro (CS)	Present work
	Alloteuthis subulata (European common squid) [23/60]	Ria de Vigo (IA)	Present work
	Loligo vulgaris (European squid) [8/8]	Ria de Vigo (IA)	Present work
	Illex coindetii [b] (lesser flying squid) [225/300]	Riveira (IA)	Present work
	[285/300]	Burela (CS)	Present work
	Todaropsis eblanae (broadtailed short-finned squid) [-]	Golf de Roses (WM)	Stock, 1960
	[287/300]	Riveira (IA)	Present work
	[292/300]	Burela (CS)	Present work
Malacostraca—Edriophthalma			
Ceratothoa parallela	*Sepia officinalis* (common cuttlefish) [-]	Valencia (WM)	Carbonell et al., 1992

[a] See text.
[b] New host records for the World Ocean.
Numbers in brackets are number parasitized/number examined.
WM, western Mediterranean; IA, Ibero-Atlantic waters; CS, Cantabric Sea; NEA, north east Atlantic.

of defining natural affinities between larval types for specific identification are perplexing, mainly because our knowledge concerning larval development, life histories and host specificity are inadequate.

Despite larval stages of the pennellid *Pennella varians* being repeatedly noted on the gills of *Eledone moschata, Sepia officinalis, Sepia elegans, Loligo vulgaris* and *Todaropsis eblanae* (Wierzejski, 1877; Rose and Hamon, 1953; Rose and Vaissière, 1953), relationships between the larval and the adult forms are also frequently a matter for conjecture. This is due to the fact that very few of the diagnostic characters used for identifying adults are present in the earlier post-embryonic stages within the life cycle. Nevertheless, since all published reports indicate that only cephalopods from the

Mediterranean are infected with this copepod, our material represents the first record of the genus in cephalopods from the north Atlantic Ocean.

The name Mesozoa was proposed by Van Beneden (1876) to indicate his belief that the simple structure of these parasites represents an evolutionary stage between the protozoans and metazoans. Nevertheless, there has been considerable controversy regarding their taxonomic position. The Dicyemids have usually been considered to form, together with the Orthonectids (parasites of various invertebrates), the phylum Mesozoa (e.g. Hyman, 1940). Stunkard (1954), however, has argued that the Mesozoans should be included as a class in the phylum Platyhelminthes. Furthermore, because of differences between the dicyemids and orthonectids in internal structure and the lack of homologies in their life-cycle stages, other workers (e.g. Kozloff, 1969; Hochberg, 1983) have considered them not to be closely related. Hochberg (1983) suggested that "it is best to treat these two assemblages as separate phyla (Dicyemida and Orthonectida) and to use the term Mesozoa to refer to their grade of organization only". However, recent studies on the base compositions and sequences of their nucleic acids have suggested that dicyemids are somewhat closer to ciliate protozoans than to flatworms (Hori and Osawa, 1987). Finally, Cavalier-Smith (1993) in his revision of the Kingdom Protozoa and its 18 Phyla considered the dicyemids as protozoans belonging to the phylum Mesozoa class Rhombozoa.

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