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Aggregata (Protozoa: Apicomplexa) infection in the common octopus *Octopus vulgaris* from the West Mediterranean Sea: The infection rates and possible effect of faunistic, environmental and ecological factors

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ABSTRACT

Prevalence and distribution of the coccidian parasite *Aggregata octopiana* (Protozoa: Apicomplexa) in common octopus (*Octopus vulgaris*) in the Mediterranean Spanish coasts were studied. A total of 114 octopuses were sampled from 30 geographic sectors by trawl fleet, and whitish macroscopic oocysts typical of *A. octopiana* infection were recorded in 96% of octopuses in the digestive tract and mainly in intestine and spiral caecum. The univariate analysis showed that lesion extension varied according to specific octopus, environmental and faunistic variables. A subsequent multivariable analysis indicated that the risk of macroscopic lesions in the caecum was greater in males compared to females, in octopuses living in deeper compared to shallower waters and in hauls where the crustacean *Pagurus excavatus* was present. The study provides further evidence of the abundance of *A. octopiana* in octopus ecosystems urging for further studies to evaluate its health impact. The combined abundance of infected octopuses and *P. excavatus* merits attention.

1. Introduction

Cephalopods are of increasing economic importance as evidenced by the rapid rise in their global landings over recent decades (ICES, 2011). Among them, the common octopus, *Octopus vulgaris* Cuvier 1797, is the most fished octopus species in the world. While worldwide the greatest octopus fishery takes places in the Saharan Bank (Northwest coast of Africa), other larger fisheries exist along the European Atlantic coast and the Mediterranean Sea, as well as in the waters of Japan and Venezuela (Guerra, 1997). In the Spanish Mediterranean Sea, *O. vulgaris* is the most landed cephalopod species, averaging around 4000 t per year between 2004 and 2011 (Ministerio de Agricultura Alimentación y Medio Ambiente, 2013). They are mainly fished by trawlers, but also captured by clay pots, trammel nets and other fishing gears (Tsangridis et al., 2002). Species in the Mediterranean Sea show a narrow depth distribution and most of them are found in the top 100 m; below 200 m, catches are scarce (Belcari et al., 2002). As other cephalopod species, the common octopus plays an important role in the food webs of marine ecosystems. In spite of its importance, little is known about protozoan diseases affecting octopus populations in their natural environment.

The occurrence of a given marine parasite in any cephalopod host species will depend on the presence of a suitable definitive host, a suitable intermediate host (IH) and complex abiotic and biotic factors hierarchically arrayed and dynamically interactive (González et al., 2003). One of these cephalopod parasites, the coccidian genus *Aggregata* (Protozoa: Apicomplexa), is an intracellular parasite with a two-host life cycle, transmitted through the food-web. Gamogony and sporogony mostly occur in the digestive tracts of a wide diversity of cephalopods, the definitive host, whereas merogony occurs in the digestive tract of crustaceans, the IH (Levine, 1988). Infection by parasites of this genus has been considered the most important infectious agent in wild and cultured cephalopod stocks from Spanish Atlantic waters (Estévez et al., 1996). It is responsible for a malabsorption syndrome (Gestal et al., 2002a), making the host more vulnerable to other biotic and abiotic stressors (Gestal et al., 2007). Coccidian infection has also been reported in reared *O. vulgaris* from Mediterranean Sea (Licciardo et al., 2005; Mladineo and Bocina, 2007; Mladineo and Jozić, 2005; Peñalver et al., 2008). Nevertheless, data from its prevalence and distribution in Mediterranean Sea as well as factors associated to this parasitosis are scarce. So, the aims of this work were to study the prevalence and distribution of *Aggregata octopiana* in common octopus from the Spanish Mediterranean coasts and, to identify abiotic and biotic factors related to infection.

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2. Material and methods

2.1. Study area and sample collection

This study was carried out within the framework of the Mediterranean International Trawl Survey (MEDITS financed by DG MARE and UE members Council Regulation (EC) No. 199/2008) and was conducted along the Spanish Mediterranean coast by the Spanish Institute of Oceanography (IEO). A total of 114 *O. vulgaris* were randomly taken in May 2011 from 30 geographic sectors (Fig. 1 and Table 1) with a bottom trawl (model GOC-73) with a 4 m vertical opening and a 20 mm cod end mesh size. Haul duration was 30 min and further information on the sampling design and on the characteristics of the gear is available in the MEDITS-Handbook (2012).

The following parameters were obtained from each octopus: dorsal mantle length (DML) to the nearest mm, body weight (BW) to the nearest 0.1 g, body condition score, sex and maturity stage. Body condition score (K) was calculated following Fulton's index as $K = BW / DML3 \times 100$ (Ricker, 1975). Maturity stage was determined according to the three-stage maturity scale described by Sánchez and Obarti (1993) which includes (I) immature (ovary whitish, very small and with no signs of granulation in females; spermatophoric organ transparent or whitish in males), (II) maturing (ovary yellowish with a granular structure; spermatophoric organ with white streaks of sperm) and (III) mature (ovary very large with plenty of eggs; spermatophoric sac with spermatophores).

Table 1
Salinity, temperature and depth of the geographical sectors of octopus capture.

Geographical sector	Salinity	Temperature	Depth
1	37,838	16,176	46
2	38,038	13,009	75
3	38,084	12,920	154
4	37,997	13,578	60
5	38,041	13,033	88
6	38,022	13,082	113
7	37,940	14,267	55
8	37,972	13,701	66
9	38,121	13,008	128
10	38,027	12,922	110
11	38,024	12,953	88
12	37,991	13,161	85
13	38,049	13,017	115
14	38,061	13,048	115
15	37,935	14,460	58
16	38,065	13,016	80
17	37,868	15,618	46
18	38,032	12,981	75
19	38,047	13,106	82
20	38,046	13,043	95
21	38,066	13,225	92
22	37,899	15,536	36
23	38,010	13,232	77
24	38,001	13,931	68
25	37,949	15,332	57
26	37,872	16,467	41
27	38,059	13,447	143
28	38,061	13,450	101
29	38,044	13,467	77
30	37,948	16,705	59

2.2. Analysis of coccidial infection in octopuses

Mesenteries of digestive gland and gonad, gills and mantle musculature were visually inspected to detect extra-intestinal macroscopic whitish oocysts. Intestine samples of 8 octopuses were fixed in 10% buffered formalin. Octopus gastrointestinal organs were dissected on board and stored at −20 °C.

To estimate infection intensity, the presence of macroscopic whitish oocysts in the oesophagus, crop, digestive gland, caecum and intestine was semiquantitatively evaluated on a 6-degree scale with grade 0 corresponding to absence of oocysts and grade 6 to heavy infection

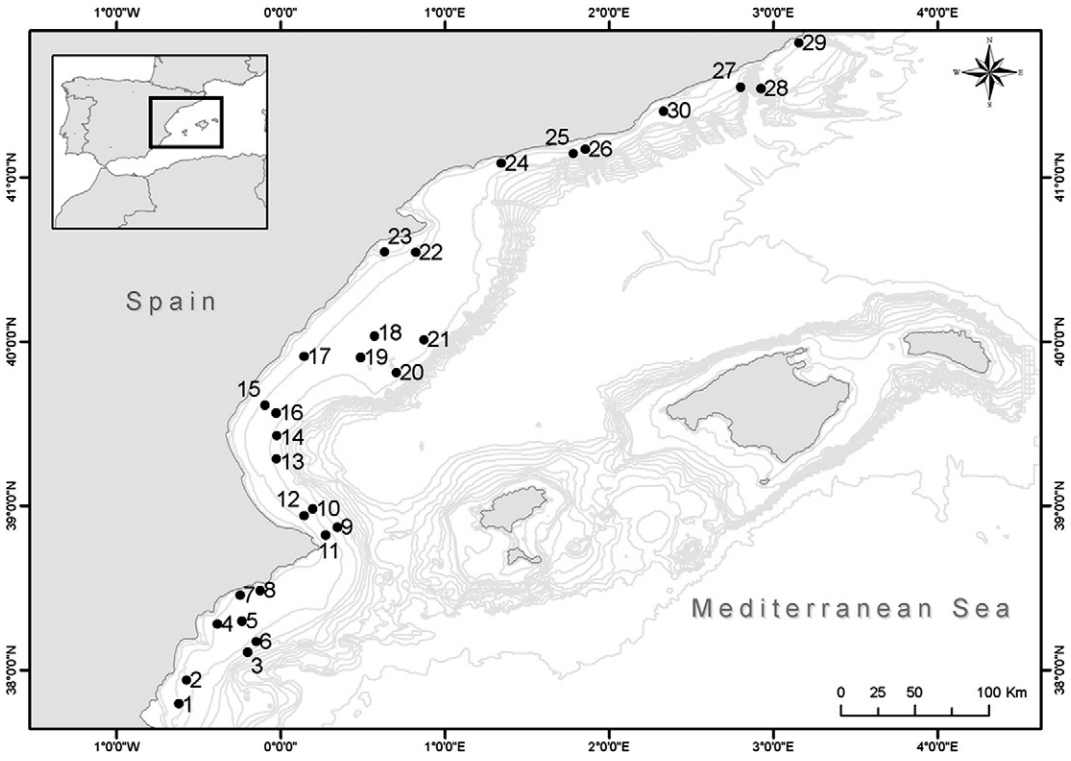

Fig. 1. Map of the studied area (Northwest Mediterranean) showing the position of each geographic sector.

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