HELMINTHFAUNA OF THE SHORT-FINNED SQUID
TODAROPSIS EBLANAE (BALL, 1841) (CEPHALOPODA: OMMASTREPHIDAE) OFF NW SPAIN

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ABSTRACT: A survey of parasites in 600 Short-finned squid Todaropsis eblanae (Ball, 1841) (Cephalopoda: Ommastrephidae) taken from two locations (North-South Galicia) off the northwestern Iberian Peninsula revealed the presence of many somatoxenous helminths. Two species of Tetraphyllidean plerocercoids were represented which, in decreasing order of prevalence, were Phyllobothrium sp. (32.9%) and Pelichnibothrium species (0.33%), and one Trypanorhynchidean metacestode, Nybelinia lingualis (0.16%), was also present. In addition, larval nematodes of the species Anisakis simplex (L3) were recorded (19.3%). The survey was undertaken to examine the abundance of helminth infection in relation to squid sex, standard length, maturity and locality. Analysis indicated that parasite prevalence and abundance were lower in the southern squids than in the northern squid group. Throughout the whole area, the relationship between parasite infection and host factors showed a significant positively correlated peaked pattern, often with the highest number of parasites being found in the largest and most mature individuals (>20 cm; maturity IV-V).

KEY WORDS: Helminths, squids, Todaropsis eblanae, NW Spain, host-parasite relationships.

INTRODUCTION

Despite Spain being the second largest squid-consuming country in the world (it has by far the largest harvest of squids in Europe), with an annual consumption per capita of about 4 kg (GUERRA & PEREZ-GANDARAS, 1983), almost nothing is known about the host-parasite relationships of cephalopods in Atlantic and Mediterranean waters in Spain, where only three parasite records have been previously reported (HÖCHBERG, 1990; CARBONELL, RAGA & CAMPOS, 1992).

The long-term objective of our research programme is to analyse the fishery implications of parasitism in commercially-exploited cephalopods from Atlantic waters off Spain. To this end, different aspects of the host-parasite relationships were investigated. A possible local variation in degree of infection was also assessed, in the light of clearly differing hydrographical conditions between both northern and southwestern shelf areas (FRAGA, MOURINO & MANRIQUEZ, 1982).

MATERIAL AND METHODS

Six hundred post-recruit Short-finned squid Todaropsis eblanae (Ball, 1841) (Cephalopoda: Ommastrephidae) were collected from fishing grounds off the coast of Galicia (42° 5’ - 45° 15’ N latitude to 7° - 9° 20’ W longitude) between November 1992 and November 1993. Squid samples were obtained from commercial landings and separated into two groups according to the area where they were caught, the northern group (127.42 ± 17.99 mm) comprising all squids collected from Ribadeo to Finisterre, and the southern group (121.66 ± 14.49 mm) formed by the squids caught from Finisterre to the Mino river (GONZALEZ, RASERO & GUERRA, 1992) (Fig. 1). A total of fifty individuals, 25 from each group, were examined each month. For each squid, sex, dorsal mantle length (DML) and total body weight (BW) were recorded. The range of gonad maturity was determined according to an established scale of maturity stages (LIPINSKY, 1979), but combining stages I and II for males as stage I. The squid were eviscerated immediately after capture, all organs removed and examined for helminth parasites and the worms counted using a stereo microscope. For detailed examination, larval nematodes were killed and fixed with Berland’s fluid, stored in Loos’ fluid, cleared in lactophenol and temporarily mounted in glycerine jelly. Plerocercoids were removed, relaxed in tap water, fixed in warm ethanol, stained with Mayer hematoxylin and mounted in Canada Balsam.

![Fig. 1. The location of sampling zones off Galician waters (NW Spain).](image-url)
The concepts denoted by the terms prevalence, mean intensity, and abundance of infection were defined in accordance with the recommendations by Margolis et al. (1982). To eliminate possible geographic effects, the relationship between host factors and helminth infection was investigated using pooled data from both areas. «Rare» species (i.e., those with prevalence <10%—see Bush, Aho & Kennedy, 1990) were not used for meaningful analysis. The abundance of infection was transformed as log (n+1) to reduce the variance (which helped normalize the data—see Elliot, 1979) and was compared with intrinsic host factors, using the correlation coefficient (r), simple linear regression, analysis of variance (one-way ANOVA) and analysis of covariance (ANCOVA). Probability values <0.05 were defined as significant. We have followed Weldon & Slaugom (1986) in recognizing one important aspect of regression, the relative importance of the relationship (the proportion of variation associated with the relationship, as measured by R²). The data analysis was performed using the SYSTAT package software (version 5.0).

RESULTS

Parasite species belonging to four genera were found (Table 1). The total prevalence of helminth larvae in Galician waters was 33.4% (53.5% in the north and 18.6% in the south, the ratio of number of helminths from the northern group being 2.87 greater than those in the south group). Tetraphyllidean plerocercoids of Phyllobothrium sp. (Cestoda: Tetraphyllidea) were the most widespread and abundant helminth, with an overall combined prevalence of 31.4%. There were 1 to 94 specimens per squid. Larvae were localized in the organs of the digestive tract (Fig. 2), being most commonly found in the lumen of the stomach and caecum. «Rare» plerocercoids have also occasionally been found parasitizing under the integument of the external wall of the stomach and on the coelomic membrane. In the Northern area, two squids had a total of 3 worms belonging to Pelichnibothrium speciosum (Cestoda: Tetraphyllidea), whereas infection by Nybelinia lingualis (Cestoda: Trypanorhynchida) appeared even lower, with only one specimen parasitizing a single squid. All the nematodes were Anisakis simplex (Nematoda: Anisakidae) at stage III of development and had the morphological features of that stage (Berland, 1961; Grabda, 1976; Orecchia et al., 1986; Pippy & Van Banning, 1975; Smith, 1983). They measured 16.76 ± 3.29 mm long by 0.4 ± 0.07 mm in width. Overall prevalence was 18.45%, with a mean intensity of 2.62 (range: 1-89) specimens per squid. They were found encysted on the wall of the stomach and several free individuals were found in the mantle cavity and gonads.

There was no significant relationship between larval abundance and squid sex, treated either as an independent factor (ANOVA: F=0.98; P > 0.05 for Phyllobothrium sp.; ANOVA: F=1.18; P > 0.1 for A. simplex) or

<table>
<thead>
<tr>
<th>Species</th>
<th>Locality</th>
<th>P (%)</th>
<th>I</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phyllobothrium sp</td>
<td>North</td>
<td>44.57</td>
<td>3.97±1.12</td>
<td>2.28±0.82</td>
</tr>
<tr>
<td></td>
<td>South</td>
<td>17.72</td>
<td>1.62±0.37</td>
<td>0.37±0.09</td>
</tr>
<tr>
<td>Pelichnibothrium speciosum</td>
<td>North</td>
<td>0.66</td>
<td>1.5±-</td>
<td>0.01±-</td>
</tr>
<tr>
<td></td>
<td>South</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Nybelinia lingualis</td>
<td>North</td>
<td>0.33</td>
<td>1±-</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>South</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Anisakis simplex</td>
<td>North</td>
<td>24.8</td>
<td>3.88±1.12</td>
<td>1.74±0.89</td>
</tr>
<tr>
<td></td>
<td>South</td>
<td>12.1</td>
<td>1.37±0.5</td>
<td>0.41±0.25</td>
</tr>
</tbody>
</table>

Table 1.– Prevalence (P), mean intensity (I) and abundance (A) of infection by helminths in Todaropsis eblanae caught in NW Spain (± standard deviation).

Fig. 2.– Percentage of organs parasitized by Phyllobothrium sp. and Anisakis simplex in Todaropsis eblanae from Galician waters.

Fig. 3.– Regression analysis illustrating the pattern of infection attained by component helminths according to squid length.
interactively with host maturity (ANCOVA: F=2.34; P > 0.1 for *Phyllobothrium* sp.; ANCOVA: F=0.44; P > 0.1 for *A. simplex*). Hence, squid sex was not considered in subsequent analyses and samples from male and female squid were pooled. The results of the correlation and regression analyses of the abundance data in wild squid showed an increase in the abundance of worms with the length of the host: for *Phyllobothrium* sp.: r=0.66; P < 0.001; R²=0.98; ANOVA: F=225.17; P < 0.001; for *A. simplex*: r=0.84; P < 0.001; R²=0.95; ANOVA: F=101.16; P < 0.001. Both worm counts increased significantly with host length in all length groups, but the *A. simplex* increase was slightly less pronounced than that shown for *Phyllobothrium* sp. (Fig. 3). The abundance of helminth infection also increased as the gonads matured (r=0.96; P < 0.001; R²=0.99; ANOVA: F=105.84; P < 0.005 for *Phyllobothrium* sp.; r=0.94; P < 0.001; R²=0.84; ANOVA: F=21.35; P < 0.05 for *A. simplex*), peaking in ripe and spawning squid (Fig. 4). Nevertheless, for each size or maturity squid class, southern squids were always less parasitized than those from the Northern area.

**DISCUSSION**

Analysis of the species composition of helminth parasites from *T. eblanae* revealed a similarity between this material and the helminthfauna of Atlantic squids of the family Ommastrephidae, previously described by GAEVSKAYA & NIGMATULLIN (1975). Moreover, it is noted that all cosmopolitan parasites found in Ommastrephid squids (i.e., those broad generalist species: *Phyllobothrium* sp., *A. simplex*) are also «component» species (sensu BUSH, AHO & KENNEDY, 1990) in squids off the northwestern Iberian Peninsula.

Increasing parasite infection with size and maturity of marine fish hosts is widespread. Cephalopods closely resemble fish in much of their way of life (PACBERG, 1990). Similarly, several aspects of biological interest emerged from the examination of the relationship between squid factors and parasite infection. In intermediate host-parasite systems, such as Ommastrephid squid-cosmopolitan helminths, the parasites usually survive the whole host-life cycle (HOCHBERG, 1990). Accordingly, the number of parasites has been observed to increase with increasing host size. As the size-maturity and age of squid are interrelated (GONZALEZ, 1994), a similar trend could be expected between helminth infection and squid age. At least in the case of long-lived parasites, differences in infection values between various size-maturity groups of squid may simply be due to an accumulation of worms over time as a result of the predatory behaviour of squid (NAIDENOVA, NIGMATULLIN & GAEVSKAYA, 1985). The increase in host size-dependent infection values suggests that the various size-maturity groups of squid take part in different ways in the life cycle of the parasites, being the second and/or third intermediate hosts. Similar patterns have frequently been observed in other surveys (NIGMATULLIN & SHUKHGALTER, 1990) and could be explained by behavioural or dietary shifts, increasing host transfer of parasites through predation. There were, therefore, no differences in the infection rates between the different sexes, since preferences for one of the two sexes were for hosts of a certain size class.

A clearly-expressed local variability of infection was also observed in squids from different ecological sampling areas. The results suggest that infection was related less closely to host size at a site of low infection (southern area) than at a site with heavier infection (northern area). Samples from the southern area appeared to have a lower level of helminth infection, but this variability is probably not only due to a younger mean size of the hosts in these samples. The length or maturity of squid explains much, but not all, of the variability observed in the abundances (in all cases >90% of the variation in the respective data for *Phyllobothrium* sp. and *A. simplex*). In fact, differences in life-history characteristics, including age at maturity, growth rate and feeding ecology, were also noted among both squid groups along the Galician coast (GONZALEZ, RASEÑO & GUERRA, 1992). In addition, it is also difficult to say whether these differences are real, since different maturity groups of squids within a single sampling area can also have different parasite infection values.
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