Pathogenicity of *Lernaeocera lusci* and *L. branchialis* in bib and whiting in the North Sea

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ABSTRACT. The pathogenicity of the crustacean parasites *Lernaeocera lusci* and *L. branchialis* towards their definitive host species (bib and whiting, respectively) was studied in the Dutch and Belgian coastal area. Negative correlations between parasite intensity and haematocrit value were found for both parasite species. *L. branchialis* was the more pathogenic species: the parasite-induced reductions in haematocrit value were most significant for this species. It is assumed that parasite-induced host mortality can act as a regulatory force at high parasite densities in natural populations.

KEY WORDS: *Lernaeocera* · Pathogenicity · *Merlangius* · *Trisopterus* · North Sea

INTRODUCTION

*Lernaeocera lusci* Bassett-Smith and *L. branchialis* L. are copepod crustaceans with a heteroxenic life cycle. The intermediate host usually is a flatfish species, whereas the definitive host usually is a gadoid species. Their rather broad host specificity enables the parasites to infect different host species in different areas (Boxshall 1974, Kabeta 1979, Tirard 1991, Van Damme 1993). In the southern North Sea (0+) bib *Trisopterus luscus* L. and (0+) whiting *Merlangius merlangus* L. are the typical definitive host species of *L. lusci* and *L. branchialis*, respectively (Sproston & Hartley 1941, Potter et al. 1988, Van Damme 1993).

The effect of a number of marine parasites on the fitness of individual hosts is well documented (Kinne 1985). The impact of parasite-induced reductions in host fitness on the size and structure of host populations however is largely unknown. Though we know from ecological theory that parasite-induced host mortality can regulate parasite and host density (Anderson & May 1978, May & Anderson 1978) empirical evidence of this has hardly been given (Scott & Dobson 1989).

L. *branchialis* appears to be less pathogenic towards bib, but this may reflect the lower number of studies dealing with the biology of this species (Evans et al. 1983, Eiras 1986). The aim of this study is to compare the pathogenicity of *L. lusci* and *L. branchialis* towards their definitive hosts. We will particularly study the additive effect of different parasite intensities on the host haematocrit value.

MATERIAL AND METHODS

Fish were sampled during 2 coastal surveys. On 2 October 1991 bib and whiting were collected from a research vessel in the Belgian coastal area. The mean (± SD) total lengths of the (0+) bib and (0+) whiting exam-ined were 163 ± 18 and 200 ± 22 mm, respectively. On 21 October 1991 samples were collected from a
commercial shrimp trawler in the Oosterschelde (Roompot). The mean total lengths of bib and whiting examined were 169 ± 17 and 209 ± 21 mm.

Immediately after capture, the haematocrit value of blood sampled from the vena caudalis was determined. Heparinised microhaematocrit tubes were filled with blood, one end was sealed and samples were then centrifuged in a micro-haematocrit centrifuge for 3 min. The haematocrit value was calculated as the ratio of erythrocytes to plasma. After blood sampling, the fish were labelled and preserved in 8 % formalin. The numbers of Lernaeocera lusci and L. branchialis were counted in the laboratory. Only fish with mature parasites (X substages according to the nomenclature of Van Damme & Hamerlynck 1992) and carrying live parasites (Z substages) were included in the analysis. Fish carrying only dead parasites were attributed to a separate infection class.

The haematocrit values were examined by regression analyses. The regression equations describing the relationship between haematocrit value (H) and the number of parasites \(x_1\) and the length of the fish \(x_2\) were calculated according to

\[ H = a + b_1 x_1 + b_2 x_2 \]

where \(a = \text{intercept}\) and \(b_1, b_2 = \text{regression coefficients}\).

### RESULTS

#### Belgian coastal area

The mean total lengths of the fish in the infection classes were not significantly different (ANOVA, \(p > 0.05\)) (Table 1). The relationship between the number of parasites and the haematocrit level of the respective hosts in the North Sea is shown in Fig. 1. The linear regression equations fitted through the haematocrit values were highly significant (\(p < 0.05\) for both species). Infection of bib with 1, 2 or 3 Lernaeocera lusci resulted in a reduction in haematocrit level of 2, 13 and 29 %, respectively. In Table 1 it is shown that the presence of a Z stage of L. branchialis resulted in a decrease in haematocrit level of 9 %.

The multiple regression equations describing the relationships between haematocrit value and both total fish length and number of parasites are shown in Table 2. It can be seen that the haematocrit value was significantly affected by the number of parasites for both whiting \((b_1 = -11.8)\) and bib \((b_1 = -1.8)\). Only in bib was the haematocrit value also significantly correlated to fish length \((b_2 = 0.1)\).

### Oosterschelde

There was a similar decrease in haematocrit value of both bib and whiting with increasing infection levels of...
Table 2. Multiple regression equations describing the relationship between haematocrit (H) number of Lernaeocera spp. (X1) and fish length (X2), according to $y = a + b_1 x_1 + b_2 x_2$ (see text) for whiting and bib in the Belgian coastal area and in the Oosterschelde. ns: not significant ($p > 0.05$), *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>a</th>
<th>b1</th>
<th>b2</th>
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<tbody>
<tr>
<td>Belgian coastal area</td>
<td></td>
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</tr>
<tr>
<td>Bib</td>
<td>39</td>
<td>16.8</td>
<td>-1.8*</td>
<td>0.1*</td>
</tr>
<tr>
<td>Whiting</td>
<td>40</td>
<td>42.2</td>
<td>-11.8***</td>
<td>0.0 ns</td>
</tr>
<tr>
<td>Oosterschelde</td>
<td></td>
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</tr>
<tr>
<td>Bib</td>
<td>151</td>
<td>31.9</td>
<td>-2.4*</td>
<td>0.1*</td>
</tr>
<tr>
<td>Whiting</td>
<td>33</td>
<td>26.7</td>
<td>-7.7***</td>
<td>0.0 ns</td>
</tr>
</tbody>
</table>

$Lernaeocera lusci$ and $L. branchialis$, respectively (Fig. 1). Infection with $L. lusci$ and $L. branchialis$ had a stronger effect on the haematocrit value of whiting (25% and 65% reduction after infection with 1 and 2 parasites, respectively) than of bib (6% and 11% reduction, respectively). The Z substages caused a decrease of 15% in whiting (Table 3).

Table 3. Mean fish length (TL, ± SD) and haematocrit value ($H$, ± SD) of bib Trisopterus luscus and whiting Merlangius merlangus with 0, 1, 2, >2 or $Z$ parasites ($Lernaeocera lusci$ and $L. branchialis$, respectively) in the Oosterschelde

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>TL (mm)</th>
<th>$H$</th>
<th>%H</th>
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<tr>
<td>Trisopterus luscus</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>0</td>
<td>46</td>
<td>166 ± 15</td>
<td>42 ± 7</td>
<td>100</td>
</tr>
<tr>
<td>1</td>
<td>48</td>
<td>177 ± 14</td>
<td>40 ± 6</td>
<td>94</td>
</tr>
<tr>
<td>2</td>
<td>34</td>
<td>174 ± 20</td>
<td>38 ± 5</td>
<td>89</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>176 ± 14</td>
<td>36 ± 6</td>
<td>85</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>161</td>
<td>33</td>
<td>77</td>
</tr>
<tr>
<td>Merlangius merlangus</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>28</td>
<td>207 ± 17</td>
<td>43 ± 9</td>
<td>100</td>
</tr>
<tr>
<td>1</td>
<td>11</td>
<td>212 ± 29</td>
<td>32 ± 6</td>
<td>75</td>
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<tr>
<td>2</td>
<td>2</td>
<td>220</td>
<td>15</td>
<td>35</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>204 ± 23</td>
<td>36 ± 10</td>
<td>85</td>
</tr>
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</table>

The multiple regression equations are shown in Table 2. As observed for the Belgian coast there was an effect of bib length on the haematocrit value ($b_2 = 0.1$). The effect of parasitic infection on the haematocrit value was significant for both species ($p < 0.05$). It was stronger in whiting ($b_1 = -7.7$) than in bib ($b_1 = -2.4$).

DISCUSSION

A wide range of factors may influence the abundance of copepod parasites on either intermediate or definitive hosts. Recently, interest has focused on the role of density-dependent factors because of their potential to regulate parasite populations (Scott & Dobson 1989). However, it can be assumed that density-dependent factors are of little importance in determining the infection level of $Lernaeocera$ species in the intermediate hosts. Intrasppecific competition for resources, the effect of host immune responses, and parasite-induced host mortality probably do not constrain the number of larval stages in the flatfish hosts: it was indeed found by several authors that the number of parasites per intermediate host individual can accumulate to seemingly unconstrained numbers (630 $L. lusci$ on 1 flounder, 580 $L. branchialis$ on 1 lemon sole, 2670 $L. branchialis$ on 1 lumpfish; Kabata 1958, Templeman et al. 1976, Van Damme 1993).

At least one density-dependent factor may partly determine the abundance of parasites on the definitive host: whereas the role of host immunity and inrasppecific competition is considered to be negligible (Van Damme 1993), the probability of survival of the definitive host (and hence of the parasite) may be affected by the presence of the parasite. It was found in the present study that $Lernaeocera branchialis$ is more pathogenic towards its definitive hosts than $L. lusci$: the reduction in haematocrit is more significant in the former species than in the latter species. The differences in pathogenicity between the 2 species are also reflected in the literature on this subject. Mann (1953), Kabata (1958) and Khan & Lee (1989) all recorded significant effects of $L. branchialis$ on the condition of its host, whereas Evans et al. (1983) and Eiras (1986) failed to find evidence for pathogenic effects of $L. lusci$.

It has been suggested by several authors that the decrease in haematocrit value is an indication for a lower metabolic rate, which in its turn may result in reduced swimming speed, increased susceptibility to predators and lower efficiency in prey uptake (Blaxhall 1972, Hille 1982, Boon et al. 1990). Pathogenic parasites such as $Lernaeocera branchialis$, which induce a decrease in haematocrit value of their host, may significantly affect host fitness. As a consequence, infected fish may suffer from higher mortality rates than parasite-free fish. Hence the assumption that heavily infected fish may be eliminated from the population, which may result in a decrease in overall parasite abundance. This hypothesis, that present-day regulation of parasite abundance may occur through the action of parasite-induced host mortality, cannot be tested in field studies. There are only some scarce indications that the higher pathogenicity of $L. branchialis$ (in comparison with $L. lusci$) is negatively correlated with the overall abundance of the species. In the Dutch Delta the abundance of $L. branchialis$ is generally lower than the abundance of $L. lusci$, and fish with more than 2 parasites of the former species are rarely found in the area.

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