Research Note

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Use of negative binomial distribution to describe the presence of *Anisakis* in *Thyrsites atun*

Uso de distribuição binomial negativa para descrever a presença de *Anisakis* em *Thyrsites atun*

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Abstract

Nematodes of the genus *Anisakis* have marine fishes as intermediate hosts. One of these hosts is *Thyrsites atun*, an important fishery resource in Chile between 38 and 41° S. This paper describes the frequency and number of *Anisakis* nematodes in the internal organs of *Thyrsites atun*. An analysis based on spatial distribution models showed that the parasites tend to be clustered. The variation in the number of parasites per host could be described by the negative binomial distribution. The maximum observed number of parasites was nine parasites per host. The environmental and zoonotic aspects of the study are also discussed.

Keywords: Nematode, *Anisakis*, *Thyrsites atun*, negative binomial distribution.

Resumo

Nematóides do gênero *Anisakis* têm nos peixes marinhos seus hospedeiros intermediários. Um desses hospedeiros é *Thyrsites atun*, um importante recurso pesqueiro no Chile entre 38 e 41° S. Este artigo descreve a freqüência e o número de nematóides *Anisakis* nos órgãos internos de *Thyrsites atun*. Uma análise baseada em modelos de distribuição espacial demonstrou que os parasitos tendem a ficar agrupados. A variação numérica de parasitas por hospedeiro pôde ser descrita por distribuição binomial negativa. O número máximo observado de parasitas por hospedeiro foi nove. Os aspectos ambientais e zoonóticos desse estudo também serão discutidos.

Palavras-chave: Nematóide, *Anisakis*, *Thyrsites atun*, distribuição binomial negativa.

The snake mackerel (*Thyrsites atun*) is a carnivorous fish that feeds primarily on schooling marine animals, including Euphausiacea in oceanic areas and squid (*Loligo gahi*) and small fish, such as anchovies (*Engraulis ringens*), sardines (*Strangomera bentincki*), and mote sculpins (*Normanichthys crockeri*), in neritic areas (DUARTE et al., 2007). The presence of parasites can reflect past and present relationships with their hosts, such as trophic relationships, phylogenetic affinities and migrations (RODRIGUEZ; GEORGE-NASCIMENTO, 1996). Several previous studies found that the stomach and intestines of demersal fish are frequently infected by nematodes and digeneans. More species and more parasitized individuals are found in demersal fish than in species with pelagic habits (MUÑOZ; OLMOS, 2007).

The main families of fish parasites that cause zoonotic disease are Opisthorchiidae, Heterophyidae, Anisakidae, Gnathostomidae and Diphyllobothridae (LIMA DOS SANTOS; HOWGATE, 2011). Anisakid nematodes are common parasites of marine organisms worldwide. Cetaceans are the final hosts of these parasites (PODOLSKA; HORBOWY, 2003). Evidence of parasites of the genera *Contracaecum*, *Anisakis* and *Hysterothylacium* has been found in farmed fish (CARVAJAL et al., 1995; CARVAJAL; GONZALEZ, 1990; CHEN et al., 2008; DICK et al., 1987; MARTY, 2008; MUZZALL et al., 2006; PAPERNA, 1996; SHIH et al., 2010; TORRES et al., 2010).

The presence of parasite larvae in fishes is economically important due to the increased cost of packing resulting from the need for visual inspection and the manual removal of parasites (CARVAJAL; CATTAN, 1985). These larvae are also important in public health because they are involved in diseases that are transmitted to humans (ARRIAZA et al., 2010; BROGLIA; KAPEL, 2011; CABRERA, 2010; GÓMEZ et al., 2003; HOCHBERG; HAMER, 2010; HUANG, 1988; ISHIDA et al., 2007; JOFRÉ et al., 2008; MERCADO et al., 2001; SKOV et al., 2009; MYERS, 1970; DE LA TORRE MOLINA et al., 2000; PONFERRADA et al., 2005). The species of parasites involved in these disease processes include *Anisakis simplex*, *Pseudoterranova decipiens*, *Anisakis physeteris* and *Contracaecum* spp. (DORNY et al., 2009; TORRES et al., 2000; DIAS et al., 2010).

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We studied twenty specimens of *Thyrsites atun* collected in the locality of Queule (39° 23' 57" S and 73° 12' 44" W), located in the coastal area of the Araucania region. All of the viscera were extracted, fixed in 96% ethyl alcohol and stored in properly labeled containers until analysis. The samples were examined, and the number of nematodes per individual was counted at the School of Veterinary Medicine, Universidad Católica de Temuco, Chile. Parasites were found in the mesentery and serosa of the gastrointestinal tract of the fish. The pattern of randomness in the distribution of the number of parasites per host was investigated (ZAR, 1999). We used the variance/average ratio to characterize the data as randomly patterned, uniform or clustered. A second test, based on the Morisita index, was also applied for the same purpose. If both tests have values less than 1, the data are uniformly distributed. If these values are equal to 1, the data are random. If these values are higher than 1, the data have a grouped distribution (ZAR, 1999; FERNANDES et al., 2003). Data shown to be random by these tests tend to fit a Poisson distribution, data shown to have a grouped distribution tend to fit a negative binomial distribution, and data shown to be uniformly distributed tend to fit a binomial distribution (ZAR, 1999; FERNANDES et al., 2003).

The analysis of the data included two steps. In the first step, the pattern of the data was verified using the variance/average ratio and the Morisita index (ZAR, 1999; FERNANDES et al., 2003). In the second step, we applied the Poisson distribution, the negative binomial distribution or the binomial distribution according to the data pattern observed. We used a χ^2 test to evaluate the fit of the data to the expected distribution (FERNANDES et al., 2003). All analyses were performed with the XLSTAT 5.0 program (Addinsoft, New York, USA).

The values of the variance/average ratio and the Morisita index were 4.30 and 37.80, respectively. These results showed that the data followed a grouped distribution. We therefore used the negative binomial distribution to model the data. The data fit this distribution (χ^2 Observed = 4.722 < χ^2 table = 28.336; $p > 0.05$). Many individuals were found not to contain nematodes. The maximum observed number of parasites was nine per host (Table 1, Figure 1).

A previous study of the nematode *Anisakis* in *Merluccius gayi* showed no correlation between the number of parasites and the size of the host. However, that study found a correlation between the prevalence and the size of the host. This correlation is consistent with the observation that euphausiids are an intermediate host for the parasite (ANDERSON, 2000). Seasonal variation in the prevalence of *A. simplex* was not observed in *Merluccius gayi*. Seasonal variation in the intensity of infection with anisakids was observed in hake. This pattern was related to the behavior of the hake and the presence of alternative hosts (CARVAJAL; CATTAN, 1985). This parasite has many species as intermediate hosts, including herring, sardines and cod. This parasite can also affect humans because undercooked fish may contain the third larval stage of *A. simplex* (CHOU et al., 2011). The negative binomial distribution furnishes a robust model that allows an informative interpretation of the patterns of the number of parasites per host (SHAW et al., 1998). This conclusion is consistent with the results of this work.

Table 1. Number of parasites of the genus *Anisakis* observed in the mesentery and serosa of the gastrointestinal tract in *Thyrsites atun* (Queule, Araucania region, Chile).

Number of parasites observed	Number of *T. atun* with parasites
0	12
1	4
2	1
3	2
4	0
5	0
6	0
7	0
8	0
9	1
10	0

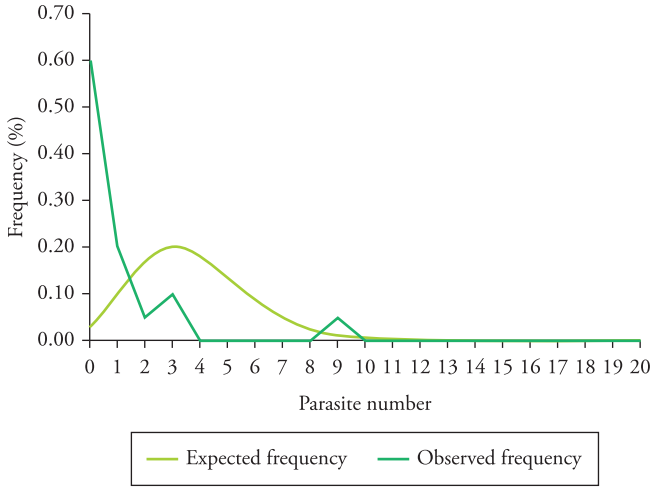

Figure 1. Expected and observed frequencies for the negative binomial distribution model of the presence of *Anisakis* in the mesentery and serosa of the gastrointestinal tract in *Thyrsites atun* (Queule, Araucania region, Chile).

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