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INFESTATION BY *PSEUDIONE HUMBOLDTENSIS* (BOPYRIDAE) IN THE SQUAT LOBSTERS *CERVIMUNIDA JOHNI* AND *PLEURONCODES MONODON* (GALATHEIDAE) OFF NORTHERN CHILE

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ABSTRACT

The relationships between mean intensity and prevalence of infestation of *Pseudione humboldtensis* and the size and sex of the hosts, the squat lobsters *Cervimunidia johni* and *Pleuroncodes monodon*, from three fishing grounds in northern Chile are described. The prevalences were 13.6% and 6.8% for *C. johni* in Coquimbo and Huasco, respectively, while in *P. monodon* they were 18.2% and 0.6% in Coquimbo and Caldera, respectively. Between fishing grounds, no significant differences were found in the prevalence of infestation between male and female *C. johni*, but in Coquimbo, the prevalence of infestation in *P. monodon* was significantly higher in females. The sizes of infested squat lobsters were significantly lower than those of uninfested hosts. Males and females parasitized by *P. monodon* showed significantly lower body weights than uninfested hosts. Parasitized males of *C. johni* showed lower body weight than uninfested males. Only 0.6% of ovigerous females of *C. johni* and none of *P. monodon* were infested. The near absence of infested ovigerous females suggests castration process in females. A nonlinear relationship was detected between host size and parasite size for both females and males. Multiple infestations of *P. humboldtensis* were found in both host species, but they were more common in *P. monodon*. Given the high prevalence of multiple infestations (50%) and the significantly lower body weights of infested *P. monodon*, we suggest that this host is more vulnerable to *P. humboldtensis* than is *C. johni*.

Pseudione humboldentis Pardo, Guisado, and Acuña, 1998 (Isopoda: Bopyridae) is found in the branchial chamber of two galatheids: *Cervimunida johni* Porter, 1903, and *Pleuroncodes monodon* (Milne-Edwards, 1837). Both host species support an important benthodemersal fishery, exploiting, annually, about 6000 tons in the northern-central Chilean coast (Sernapesca, 2001). Both species live on the continental shelf between 100 m and 350 m. The squat lobster *C. johni* is found between Taltal (25°19′S) and Mocha Island (38°20′S), and *P. monodon* is found from the northern Chilean border (18°25′S), to Ancud (40°30′S) (Acuña *et al.*, 2000).

Bopyrid isopods are ectoparasites that require calanoid copepods as intermediate hosts and a decapod for the definitive host. Normally, the definitive host bears a female and from one to a few dwarf males (O'Brien and Van Wyk, 1985). Evidence shows that the first cryptoniscus larva infecting the definitive host develops as a female, while the next larva arriving develops as a dwarf male, which remains attached to the female (Anderson, 1990). Bopyrid isopods can affect the reproduction of their definitive hosts, partially or totally inhibiting gonadic development, modifying secondary sexual characters in males, inhibiting growth, and producing nutritional deficiency in their hosts (Reinhard, 1956; Beck, 1980; Van Wyk, 1982; Astete and Cáceres, 2000).

In this study, the prevalence and intensity of infestation of *P. humboldtensis* in both host species from three fishing areas in northern Chile were investigated. To evaluate a possible effect of the parasite on the physiology of the host, the relationships between infestation (intensity and prevalence) and size and sex of the host were assessed; the relationship between parasite size and host sizes was analyzed, and finally, the size-weight relationship of infested and uninfested hosts were compared.

MATERIALS AND METHODS

From October 2000 to October 2001, 1460 specimens of *C. johni* and 1677 specimens of *P. monodon* were collected, aperiodically, from the fishing grounds of Caldera (26°16′–26°97′S), Huasco (28°15′–28°41′S) and Coquimbo (29°33′–30°11′S). Squat lobsters were obtained from 26

Table 1. Prevalence (%) of *Pseudione humboldtenis* in *Cervimunida johni* and *Pleuroncodes monodon* populations, according to sex and fishery zone. Sample size in parentheses.

	Cervimunida johni		*Pleuroncodes monodon*	
	Huasco	Coquimbo	Caldera	Coquimbo
Male	8.8 (160)	14.6 (751)	0.8 (357)	15.7 (747)
All Female	1.6 (61)	12.1 (488)	0.6 (106)	22.3 (467)
Nonovigerous	1.6 (61)	18.3 (317)	0 (88)	26.6 (379)
Ovigerous	–	0.6 (171)	0 (18)	0 (88)
Total	6.8 (221)	13.6 (1239)	0.6 (463)	18.2 (1214)

commercial tows carried out between 170 m and 370 m depth. Specimens of *C. johni* and *P. monodon* were frozen (–20°C) onboard the ship until analyzed in the laboratory. After thawing, each specimen was measured (cephalothorax length to nearest 0.1 mm.), weighed (1 mg precision), and sexed. Females were sorted as nonovigerous and ovigerous. The gill chambers of each specimen were searched for parasites and, subsequently, the body lengths of each female and male bopyrid were recorded.

The Mann Whitney U test was used to evaluate differences between sizes of squat lobsters from each fishing ground because the size distribution of both species did not meet prerequisites for the parametric t-test. The same test was used to evaluate mean size differences between different host sexes, and between infested and uninfested host sizes (Zar, 1999). The prevalence and intensity of infestation (*sensu* Bush *et al*., 1997) was calculated independently for each host species, sex, and fishing ground. The G-statitistic was used to evaluate differences in prevalence between host sex and fishing ground for each host species (Zar, 1999).

The relationship between the cephalothorax length (CTL) of the host and male bopyrid length and the relationship between CTL of the host and female bopyrid length were tested with the Spearman correlation coefficient.

Comparison of slopes for length-weight relationships between infested and uninfested hosts were made for those specimens captured during August–October 2001, because only during that period were weights of hosts with and without parasites recorded. An ANCOVA model was used for *P. monodon*, using a logarithmic transformation of the data, while for *C. johni* an ANCOVA for separate (nonparallel) slope model (Statistica 6.0 software) was used.

RESULTS

The mean size of both parasitized and unparasitized individuals for each squat lobster species by sex and fishing ground showed marked variation. Specimens of *C. johni* captured in Huasco were significantly larger than those captured off Coquimbo ($U = 218.4$; $P < 0.001$). Specimens of *P. monodon* captured off Caldera were significantly larger than those from Coquimbo ($U = 448.4$; $P < 0.001$). Males

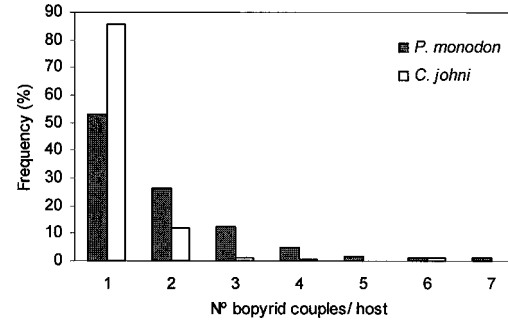

Fig. 1. Number of bopyrids per infested host by host species.

of *C. johni* and *P. monodon* were significantly larger than females ($U = 151.1$; $P < 0.001$ and $U = 199.8$; $P < 0.001$, respectively).

The prevalence of *P. humboldtensis* varied significantly between fishing grounds. Overall, 13.6% of the *C. johni* specimens and 18.2% of the *P. monodon* specimens from Coquimbo harbored at least one pair of bopyrids (a female joined with a dwarf male), whereas only 6.8% of the *C. johni* specimens captured off Huasco and 0.6% of the *P. monodon* specimens captured off Caldera were parasitized (Table 1). Prevalence of infestation for *C. johni* did not show significant differences between sexes in the fishing grounds of Huasco ($G = 2.99$; $0.10 > P > 0.05$) and Coquimbo ($G = 1.44$; $0.25 > P > 0.10$). Prevalence of infestation for *P. monodon* was higher in females than in males, at least at Coquimbo ($G = 7.81$; $0.01 > P > 0.005$). The absence of infested females in Caldera prevent the analysis of sex on prevalence of infestation from that location.

In Caldera and Huasco, both host species were infested by only one pair of bopyrids, whereas in Coquimbo, *C. johni* as well as *P. monodon* showed multiple infestations, with intensity ranging from one to seven pairs of bopyrids per host. Multiple infestations were more abundant in *P. monodon* (47% of infested hosts bearing between two and seven pairs of bopyrids) than in *C. johni* (14.5% of infested hosts bearing between two and six pairs of bopyrids) (Fig. 1). In Coquimbo, only 0.6% of *C. johni* and none of the ovigerous females of *P. monodon* had one bopyrid in the gill chamber. Only 2 out of 960 uninfested specimens of *C. johni* and none of *P. monodon* presented the typical deformation of the cephalothorax of specimens that have lost the parasite.

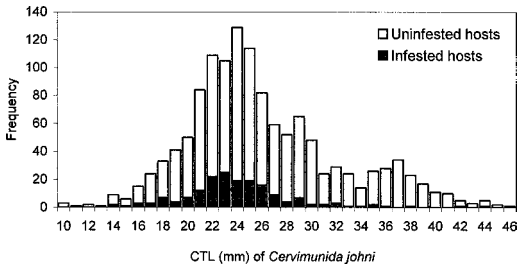

Fig. 2. Size-frequency distributions of uninfested and infested *Cervimunida johni*.

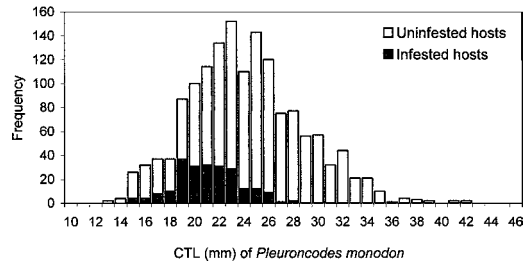

Fig. 3. Size-frequency distributions of uninfested and infested *Pleuroncodes monodon*.

The sizes of infested *C. johni* ($U = 7673$; $P < 0.001$) and *P. monodon* ($U = 7290$; $P < 0.001$) were significantly smaller than their uninfested counterparts (Figs. 2 and 3, respectively). However, the sizes of infested males and females of both host species did not differ significantly (*P. monodon*: $U = 5931$; $P = 0.96$; *C. johni*: $U = 5183$; $P = 0.11$). Spearman correlation coefficients indicate a positive and significant relationship between the size of *P. monodon* and the size of the female bopyrid ($r_s = 0.404$; $P < 0.001$; $n = 118$), but the length of the male bopyrid was not correlated with host length ($r_s = 0.271$; $P = 0.09$; $n = 39$). A similar relationship is evident in *C. johni* for both female ($r_s = 0.383$; $P < 0.05$; $n = 119$) and male bopyrids ($r_s = 0.250$; $P < 0.05$; $n = 119$).

For both galatheid species, the length-weight relationships of infested and uninfested squat lobsters were analyzed by sex, and a linear model was fitted. No significant differences in the length-weight relationship of infested and uninfested *C. johni* females were observed ($P > 0.05$) (Fig. 4B). However, the infested males of *C. johni* had a lower weight ($P < 0.01$) (Fig. 4B). For *P. monodon*, the length-weight relationships of infested and uninfested males and females showed significant differences, indicating also that infested hosts had lower body weights than uninfested ones ($P < 0.01$) (Fig. 5A, B).

Discussion

The presence of *P. humboldtensis* in the gill chambers of the two squat lobsters species analyzed in this paper was reported earlier by Pardo *et al.* (1998), who described the species and also reported infestations of 5.8% in *C. johni* ($n = 1530$) and 0.4% in *P. monodon* ($n = 1440$) from the northern-central Chilean coast. The prevalences of infestation recorded in this study were similar to those detected in the fishing grounds of Caldera and Huasco (6.8% for *C. johni* and 0.6% for *P. monodon*), but in Coquimbo the prevalences were significantly higher for both host species (13.6% for *C. johni* and 18.2% for *P. monodon*).

In our study, a negative effect of parasites on host growth was found. Infested squat lobsters of both species showed smaller sizes than those uninfested specimens (Figs. 2 and 3). The inhibitory effect of isopods on host growth does not follow a common pattern. Abu-Hakima (1984) showed that the infestation of *Peneaus semisulcatus* by *Epipenaeon elegans* does not inhibit the growth of its hosts and that some infested males even reach larger sizes than uninfested ones, and no significant differences between sizes of infested and uninfested females were described. On the other hand, Somers and Kirkwood (1991) reported that uninfested males of *P. semisulcatus* grew faster and reached larger sizes, whereas infested females grew slower and reached smaller sizes. In another bopyrid-host relationship, Oliveira and Masunari (1998) did not observe negative effects of *Aporobopyrus curtatus* in the crab *Petrolisthes armatus*. We found a loss of body weight ranging 10–25% in infested squat lobsters, when compared with uninfested hosts.

Generally, the bopyrid isopods infest only one gill chamber of the host, and both female and male parasites can be found together. These parasites feed upon host hemolymph, and some species have been reported to consume a mean of 8% (Anderson, 1977) and up to 25% of hemolymph volume per day (Walker, 1977). In addition, the isopod female affects the gills respiratory efficiency, a condition that worsens in the presence of multiple infestations (McDermott, 1991). In *C. johni*, as well as in *P. monodon*, multiple infestations were found, and in particular the latter species had 50% of

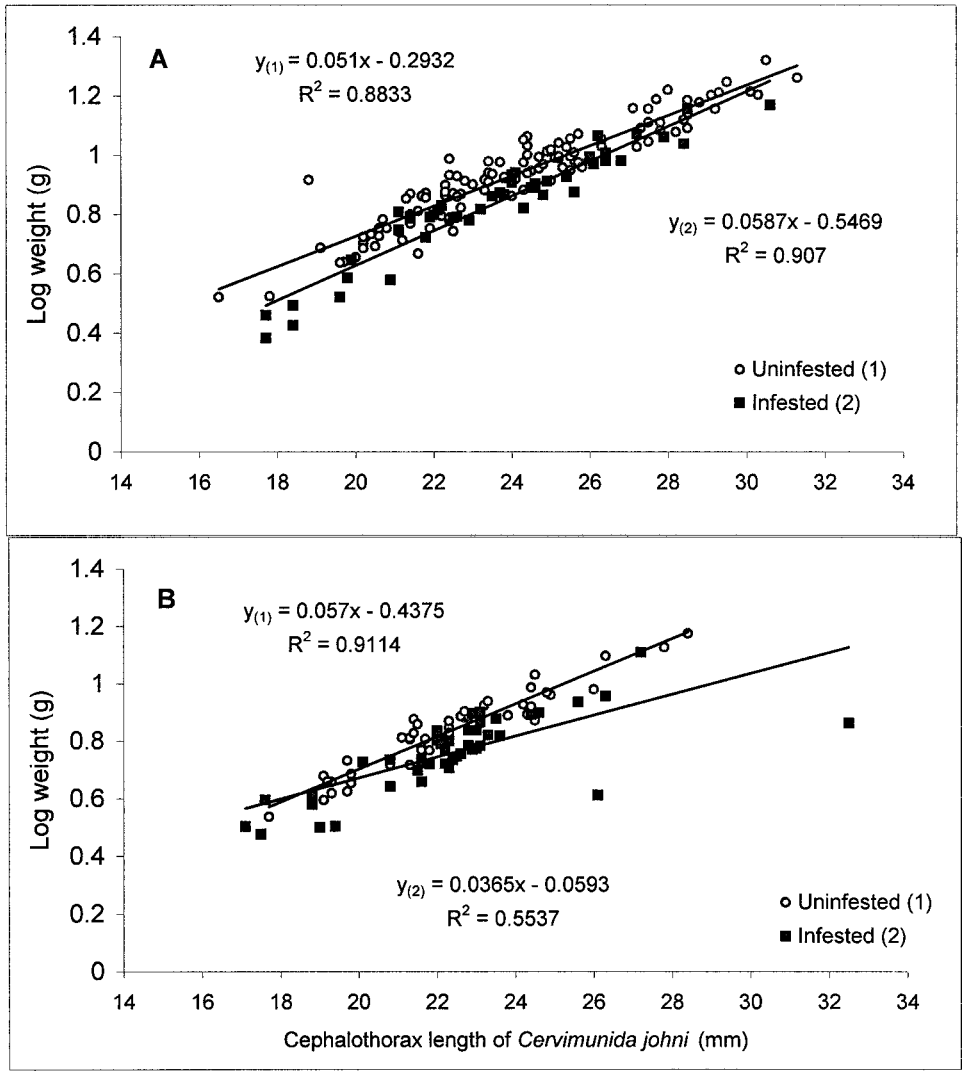

Fig. 4. Length-weight relationships of *Cervimunida johni* infested and uninfested with *Pseudione humboldtensis*. A, male; B, female.

infested hosts that bore between two and seven female bopyrids with their respective males. The multiple infestations in *C. johni* and *P. monodon* result in a strong negative effect on the physiology of these squat lobsters. Those parasitized hosts had 10–30% decreased weight in comparison to those infested with only a single bopyrid couple.

The decrease in the prevalence of infestation with an increase in host size can be explained. The larger hosts lose the parasites, the former presence of which is indicated by the deformation of the cephalothorax. Such deformation would provide evidence of past infestations (McDermott, 1991; Roccatagliata and Lovrich, 1999). In this study, only two *C. johni* and no *P. monodon* showed such cephalothorax deformation. Also, it has been proposed that a decrease in the parasitic load or its dispersion with host age can be considered as evidence of host mortality induced by the parasite (Rousset *et al.*, 1996). Therefore, the strong decrease of bopyrid prevalence in larger host observed in this study could be a consequence of host mortality induced by the parasite as suggested by the prevalence-size histograms (Figs. 2 and 3) or by host growth inhibition as observed in length-weight relationships of infested and

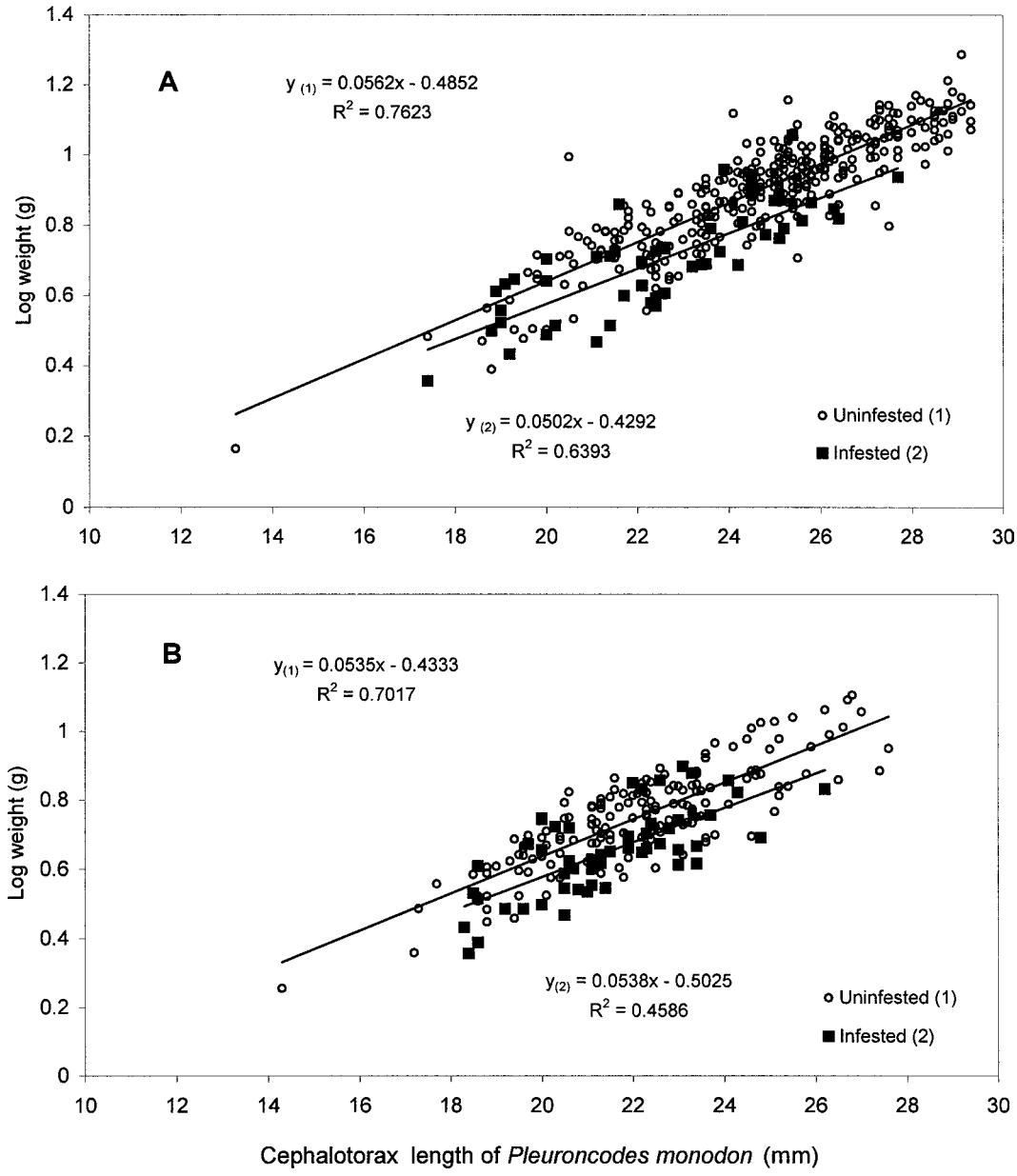

Fig. 5. Length-weight relationships of *Pleuroncodes monodon* infested and uninfested with *Pseudione humboldtensis*. A, male; B, female.

uninfested hosts. However, it is also possible that infestation affects only smaller hosts, and after several ecdyses the parasites are lost and not detected in larger hosts.

Bopyrids have a well-documented negative impact on the reproductive success of their hosts. The parasites inhibit ovarian maturation and reduce the size of the secondary sexual characters (Beck, 1980; McDermott, 1991; Muñoz and George-Nascimento, 1999). Our results also suggest a castration process demonstrated by the fact that only 0.6% of the ovigerous females of *C. johni* were parasitized and none of the ovigerous females of *P. monodon* were parasitized.

A linear positive correlation between the host length and the female bopyrid length has been described in several bopyrid-host relationships,

and several authors have indicated that the infestation is present from the first developmental stages of the host. Thus, the described positive correlation is explained because the parasite grows simultaneously with the host (Cash and Bauer, 1993; Chu and Leong, 1996; Muñoz, 1997; Masunari *et al*., 2000 and others). Although in this study both squat lobster species showed a positive and significant relationship between the female bopyrid length and the host length, this relationship was nonlinear. This could be explained by the narrow size range of infested hosts (15–28 mm of cephalothorax length), suggesting that most of the sampled individuals inhabit the same habitat, and, therefore, they could be exposed to similar infestation rates by the bopyrids.

Our results indicate that prevalence of infestation is higher at the Coquimbo fishing ground, where greater fishing effort is concentrated. Furthermore, the characteristic of infestation processes (around 50% of multiple infections, absence of infested ovigerous females, and lower body weight of infested host) suggests that *P. monodon* is more vulnerable to infestation than is *C. johni*. Therefore, infestation processes with high rates of prevalence, like those recorded in the hosts from Coquimbo, should not be ignored in biological studies (i.e., population dynamics).

Pleuroncodes monodon and *C. johni* sustain approximately 60% of the crustacean fisheries in northern-central Chile (Sernapesca, 2001), and during the past three years, the available biomass of those resources has dramatically declined, with a strong reduction in the authorized captures. A parasitic infestation that can affect the physiology and reproduction of the host, along with a depleted stock, can be synergistic forces that affect the sustainability of these fisheries.

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