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Parasitic castration in *Concholepas concholepas* (Gastropoda: Muricidae) due to a larval digenean in northern Chile

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ABSTRACT: Specimens of the edible mollusk *Concholepas concholepas* from Tocopilla, northern Chile, were found to be infected with larval forms of a fellodistomid digenean. Prevalence of infection did not significantly differ between male and female mollusks. A close relationship between first maturity and parasitic infection is suggested. Flukes invade gonadal and hepatopancreatic tissue and adversely affect structure and function of these organs. In heavy infections the penis was absent and destruction of the hepatopancreas was accompanied by disorganization of germinal tissue.

KEY WORDS: Marine mollusk · *Concholepas concholepas* · Digenea · Parasitic castration · Northern Chile · Fellodistomidae

INTRODUCTION

The 'loco' *Concholepas concholepas* (Bruguiere 1789) (Gastropoda: Muricidae) is the most important edible mollusk of the Chilean coast, and is ecologically important in the subtidal communities in central and southern Chile (Moreno et al. 1986). Despite its importance, some aspects of the natural history of the 'loco' (an endemic species), including its parasites, are unknown. The only published work (Cañas & Lozada 1987) regarding the parasites of *C. concholepas* includes the record of an unidentified fellodistomid which can mechanically destroy the digestive gland and the gonads. Mechanical castration by adult fellodistomids has been was described (Oliva 1992) in the marine gastropod *Fissurella crassa* in northern Chile. We analyze herein quantitative aspects of the process of infection and describe the histopathological alteration in the hepatopancreatic-gonadal complex (HGC) due to sporocysts of *Proctoeces* sp., a fellodistomid digenean fluke.

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MATERIAL AND METHODS

Between August–December 1994 and between January–October 1996, 12 samples of *Concholepas concholepas* (Table 1) were collected (irregularly over time) from shallow water (7 to 10 m depth) near Tocopilla, northern Chile (22° S). In the laboratory, peristomal length (= total length) was measured (to the nearest 0.1 mm), and each specimen was dissected and macroscopically sexed according to gonadal coloration and presence/absence of a penis. After dissection, the HGC was isolated, weighed (to the nearest 0.1 g) and the widths of the HGC and gonad were measured. Portions of HGC were fixed in alcoholic Bouin fluid and processed for histology, using standard techniques, serially sectioned (5 µm thickness), and stained with hematoxylin-eosin. Prevalence of infection was calculated for male and female hosts. The following statistical analyses were performed: an analysis of variance was used to test if the mean sizes of male and female mollusks differed significantly; differences in prevalence of infection in male and female hosts were evaluated with the log likelihood '*G*'-test; and regression analysis detected

Table 1. *Concholepas concholepas*. Number of specimens (n), size (±SD; in mm), and prevalence (P, %) in the 12 samples collected near Tocopilla, northern Chile, in 1994 and 1996

Date	n	Size	P
1994			
Aug	48	97.8 ± 2.8	6.3
Oct	18	88.3 ± 14.2	16.7
Nov	70	97.3 ± 7.3	8.6
Dec	75	94.7 ± 12.0	14.7
1996			
Jan	122	81.1 ± 10.0	3.3
Feb	72	90.9 ± 9.8	12.5
Mar	51	93.4 ± 11.1	7.8
Jun	74	77.6 ± 7.93	10.8
Jul	80	80.2 ± 10.7	12.5
Aug	85	84.0 ± 9.2	16.5
Sep	72	90.9 ± 9.8	12.5
Oct	99	73.4 ± 10.3	4.0

relationships between mean size of mollusks and prevalence (Zar 1984, Wilkinson 1990).

RESULTS

In total, 866 specimens of *Concholepas concholepas* were examined, of which 413 were males and 453 females. The size of mollusks ranged from 41.4 to 120 mm in length. Mean lengths of males (85.0 mm) and females (87.0 mm) were not significantly different ($F_{1,864}$ = 5.73, p = 0.17). From those examined, 85 mollusks were parasitized by larval stages of a fellodistomid digenean, a member of the genus *Proctoeces* (morphological features of the metacercaria agreed well with the characteristics of the genus, as described by Bray 1983). The smallest infected male was 56.4 mm long and the smallest infected female was 78 mm long. Mean size of infected males was significantly smaller than that of females, 87.4 and 94.4 mm respectively ($F_{1,83}$ = 7.79, p = 0.007). Prevalence of infection did not significantly differ between males (9.4%) and females (10.1%) (log-likelihood *G*-test, G = 0.123, 0.50 > p > 0.75, df = 1). Infected mollusks were easily detected macroscopically because the color pattern of infected gonads was altered: healthy male and female gonads were yellow and white respectively, whereas infected gonads showed the typical orange coloration of sporocysts. Prevalence of infection was significantly and positively associated with host size (Pearson r correlation coefficient, after angular transformation of prevalence data, r = 0.76, F = 11.22, p = 0.01, df = 8). Mean intensity and abundance were not evaluated because the large number of sporocysts precluded analysis.

Normal histology

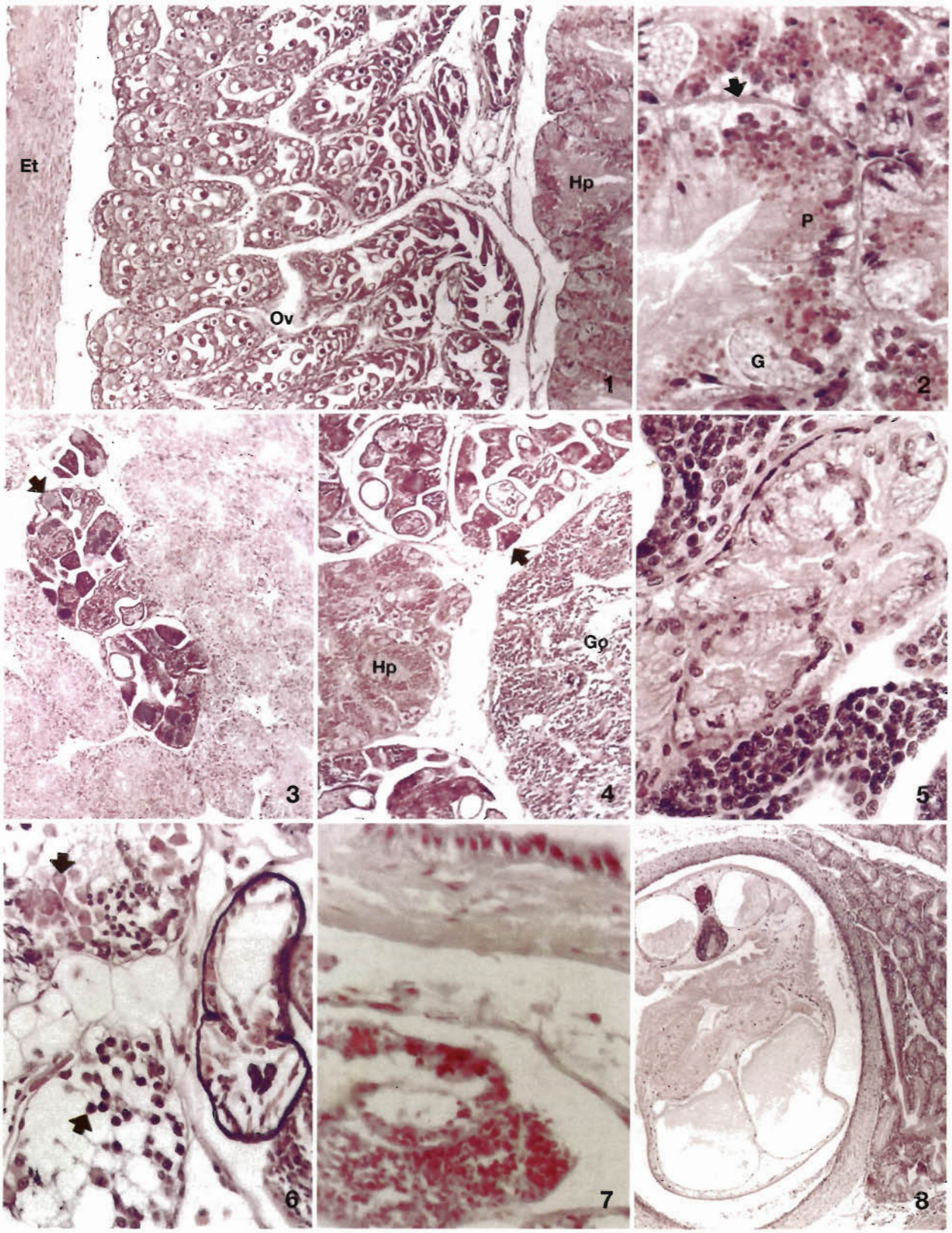
Concholepas concholepas is dioecious. Male and female gonads are closely associated with the digestive gland. Gonadal and hepatopancreatic tissues were separated by a thin layer of connective tissue (Fig. 1). Externally, the testes and the ovary were surrounded by a fibro-collagen connective tissue. Branches of this tissue give rise to internal projections into the gonads; these projections themselves branch and form septa, which define compartments containing gametes at different developmental stages (Huaquin 1979).

The hepatopancreas includes numerous follicles attached to the connective tissue. Each lobe contains numerous acini and excretory ducts. Acini include goblet cells with chromofugue vacuoles, prismatic cells with eosinophilic granules, and cylindrical and agranular cells (Fig. 2).

Histopathology

Sporocysts were found within the layer of connective tissue of the hepatopancreas (Fig. 3). As the infection developed, parasites progressively invaded the connective tissue, and the glandular and gonadal tissue became compressed (Fig. 4). The width of the gonads of heavily infected mollusks was, on average, only 33% of the width of a healthy gonad. In addition to this mechanical action, structural disorganization of glandular acini became evident. Acini were smaller than those of uninfected tissue; cells became vacuolated and the acidophilic and basophilic contents of cells were not able to be seen (Fig. 5). Chromofugue cells were not altered. Additionally, with the development

Figs. 1–8. *Concholepas concholepas*. Fig. 1. Transverse section of a healthy hepatopancreatic-gonadal complex. Et: external tunica; Ov: ovary; and Hp: hepatopancreas. HE, 429×. Fig. 2. Non-infected hepatopancreas. Pancreatic acinus surrounded by connective tissue (arrow). G: Goblet cells; P: prismatic cells containing eosinophilic granules. HE, 1716×. Fig. 3. Sporocyst (arrow) located inside the layer of connective tissue of the hepatopancreas. HE, 429×. Fig. 4. Compressed hepatopancreas (Hp) and gonads (Go) caused by invasion of connective tissue by sporocysts (arrow). HE, 429×. Fig. 5. Altered structure of hepatopancreas due to heavy infection (compare with Fig. 2). HE, 1716×. Fig. 6. Altered testis. No germinal line is present. Only a few nerotic germinal cells are present (arrows). HE, 1716×. Fig. 7. Heavy infection. Gonadal tissue completely absent (compare with Fig. 1). HE, 429×. Fig. 8. Metacercariae (Fellodistomidae) encysted between hepatopancreatic acini. HE, 429×


Et
Hp
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8

of the parasitic infection, gonadal parenchyma became compressed. In heavy infections, destruction of the hepatopancreas was accomplished by disorganization of germinal tissue of the gonads. Germinal tissues disappeared and total castration was evident (Figs. 6 & 7). Macroscopically, gonads were not recognizable as independent organs and frequently the reproductive ducts and accessory glands appeared atrophied.

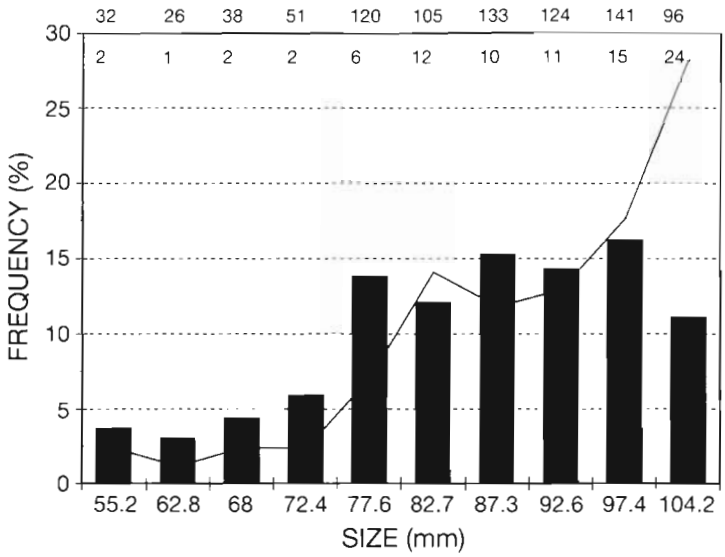

Fig. 9. *Concholepas concholepas*. Length-frequency distribution of non-infected (bars) and infected (line) 'loco'. Numbers at top of graph indicate number of non-infected (upper) and infected (lower) mollusks in each size class

DISCUSSION

The only previous record of parasites in the 'loco' is that of Cañas & Lozada (1987), who found different developmental stages of a fellodistomid, including adult flukes, in a sample of 32 specimens from a mark-recapture experiment in Caldera (ca 650 km south from Tocopilla). Mostly sporocysts were found in our samples; however, a single metacercaria (Fellodistomidae) was found encysted between hepatopancreatic acini (Fig. 8). In contrast to other gastropod-parasite systems with sporocysts or rediae as the infective stage, *Concholepas concholepas* is infected by only 1 parasitic digenean. (Sullivan et al. 1985, Fernández & Esch 1991a, Jokela & Lively 1995, Sokolova 1995). Parasites of other marine gastropods from this zone are also only infected by 1 parasitic species; this has been found to be the case in 5 species of key-hole limpets *Fissurella* spp. (Oliva & Díaz 1988, 1992), suggesting an impoverished pattern of infection similar to those described for marine teleost fishes in central Peru and northern Chile (Oliva et al. 1996).

As in other mollusks (Sokolova 1995, Taskinen & Valtonen 1995), there were no significant differences in prevalence of infection between male and female mollusks. A direct relationship between prevalence of infection and size of molluskan host has been described for infection by larval digeneans (Sousa 1983, Taskinen & Valtonen 1995), and adult digeneans (Oliva & Diaz 1988, 1992). Length-frequency distribution and statistical analysis (Fig. 9) indicated that the proportion of infected mollusks increased with size. The infection is apparently closely related to first maturity. The smallest infected male was 56.4 mm and the smallest infected female 78 mm. This difference is related to the size at the first maturity. Our results shows that first maturity (50% of mature specimens) is reached at 57 mm for males (smallest mature 51.4 mm, largest immature 62.2 mm) and 72 mm for females (smallest mature 69.6 mm, largest immature 75.7 mm).

Digenean flukes as a typical parasitic group influence the population dynamics of the host in 2 ways: first by inducing mortality (directly or indirectly by modifying host behavior); or second by castrating the host (ecological death) (Hurd 1990, Huxham et al. 1993). Apparently, both mechanisms have never previously been described as occurring simultaneously in a host species. Gigantism in mollusks (enhanced host growth), due to castrator parasites, can occur naturally and experimentally (Sousa 1983, Fernández & Esch 1991b). Our results show that induced mortality and castration can occur simultaneously in the same population if the effect of the same parasitic species induces alteration in different organs and/or tissue. The development of infection in the digestive gland causes disfunction; no secretion (i.e. digestive function) occurs. This alteration in the glandular function will inevitably lead to the death of the host. Furthermore, while the infection in the digestive gland develops, the level of castration increases with germinal tissue compression.

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