HISTOPATHOLOGY OF THE PARASITIZATION OF *MUNIDA IRIS* (DECAPODA: GALATHEIDAE) BY *MUNIDION IRRITANS* (ISOPODA: BOPYRIDAE)

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ABSTRACT—The bopyrid isopods, parasites of the branchial cavity of decapods, produce a lateral protuberance in the carapace of their host. The large female parasite obtains blood from the host by puncture of the dorsal branchial chamber cuticle. The thickness of the deformed area of carapace is approximately twice that of the remaining carapace. Gill surfaces beneath the parasite exhibit deformation and scar tissue is present.

The family Bopyridae is composed of parasitic isopods which are often found in the branchial cavity of decapods (Richardson, 1905; Tucker, 1931; Pike, 1953; Tuma, 1967; VanArman and Smith, 1970; Markham, 1975). Sexual dimorphism is characteristic of the group: the female is large, often asymmetrical and responsible for the lateral protuberance produced in the host's carapace. The male remains cryptoniscid in form (Naylor, 1972) and is usually found on the female's body near the genital openings.

There are probably more than 100 published papers that have made at least passing reference to the effects of bopyrids on their hosts. Attention has been focused on parasitic castration of the host species (Pike, 1953; Reinhard, 1956); the degree of modification of the host's pleopods is used to index the degree of castration (Pérez, 1926). Other pathologies attributable to the presence of the female parasite have apparently received little attention. Although it is generally believed that the female feeds on the body fluids of the host (Barnes, 1974), feeding methods of these parasites have apparently not been described. This paper presents histological aspects of the parasitization of *Munida iris* A. Milne Edwards by *Munidion irritans* Boone.

MATERIAL AND METHODS

During July of 1973, 1974, and 1975, 6-day training cruises aboard the R/V ANNANDALE of the Marine Science Consortium, Millersville, Pennsylvania, were undertaken with the objective of sampling benthic fauna on the continental shelf from Hudson Canyon to Norfolk Canyon. Specimens were preserved in 10% formalin and later identified and counted.

Of 585 *Munida iris* collected during these cruises, 14 exhibited a strong lateral protuberance on a branchiostegite. Subsequent dissection showed that each protuberance contained a female *Munidion irritans*. A diminutive male was found on the abdomen of the female in seven of the specimens. Examination of the gonophore of the parasitized crabs revealed that all were males. Of the 571 non-parasitized crabs, 348 (61%) were males, 205 (36%) were ovigerous females and 17 (3%) were non-ovigerous females.

Portions of the deformed carapace and impressed gill, as well as uninfested carapace and gill were dehydrated in graded alcohols, cleared in cedarwood oil and embedded in paraffin by conventional methods. Sections were cut at 10 μm, stained in hematoxylin and eosin and examined by the light microscope. Whole parasites were dehydrated in graded alcohols, cleared in cedarwood oil and mounted in balsam.

RESULTS

In six of the 14 parasitized crabs examined, the isopod parasite was found in the left branchial chamber (Fig. 1). In the other eight parasitized crabs, the parasite occupied a corresponding position in the right branchial chamber. The crabs ranged in size from 14 to 25 mm (carapace length). The

female parasites ranged from 9.5 to 18 mm in total body length. Associated male bopyrids were found in seven instances and ranged in length from 1.4 to 4.5 mm. The size of the carapace deformity was similar to the dimensions of the enclosed female parasite. In all cases the protuberance approached the posterior free edge of the branchiostegite.

The ventral surface of the parasite was directed dorsally and the head posteriorly with respect to its host: typical orientation of bopyrid parasites. The dorsal surface of the parasite was pressed against the gills of the host and produced a concave depression which corresponded to the contours of the female isopod.

The female parasites have the labrum and labium modified to form a cone which surrounds slender spiked mandibles (Fig. 2A). The mandibles penetrated the inner cuticular lining of the branchiostegite (Fig. 2B). Two small puncture wounds were made through the branchial chamber cuticle near the posterior vertical surface of the protuberance into the blood sinuses of the underlying tissue. The wound was small and often difficult to find. It was located by the presence of coag-
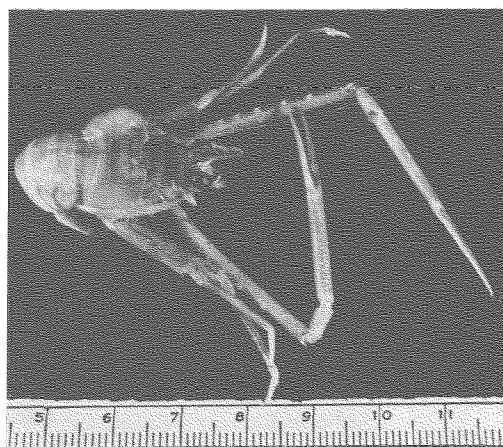

Figure 1. The parasite (*Munidion irritans*) lies under the left branchiostegite of *Munida iris* and produces a dorsolateral deformity of the carapace (scale in mm).

ulated blood which adhered to the cuticle at the wound site. Apparently the blood was clotted by the fixation process since no degeneration of the cells of the coagulum was noted. Indeed there was very little regenerative change in the puncture wound area. Regenerative changes are apparently initiated
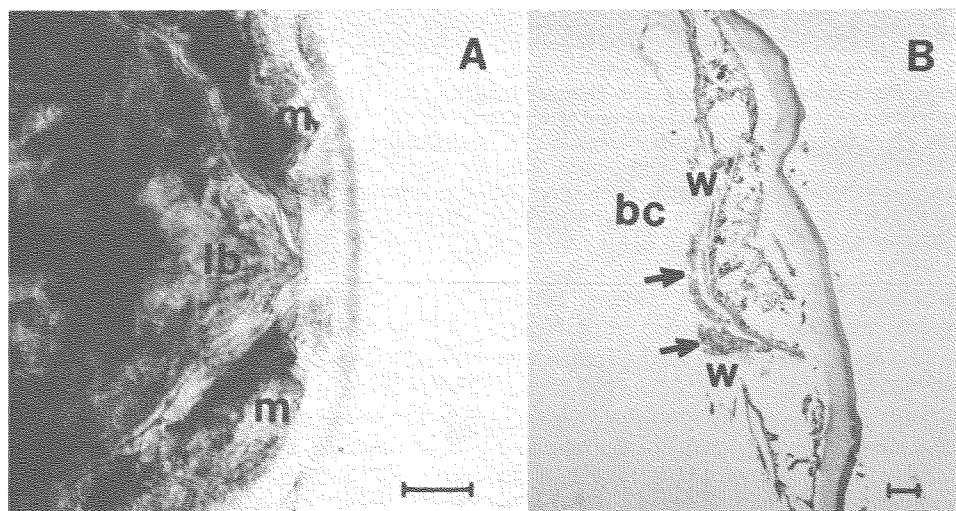

Figure 2. A: The labium (lb) covers the ventral border of the slender spiked mandibles (m) of the parasite. Scale represents 1 mm. B: Two small puncture wounds (w) are made in the cuticle of the branchial chamber (bc). Coagulated blood (arrows) marks the wound area. Scale represents 1 mm.
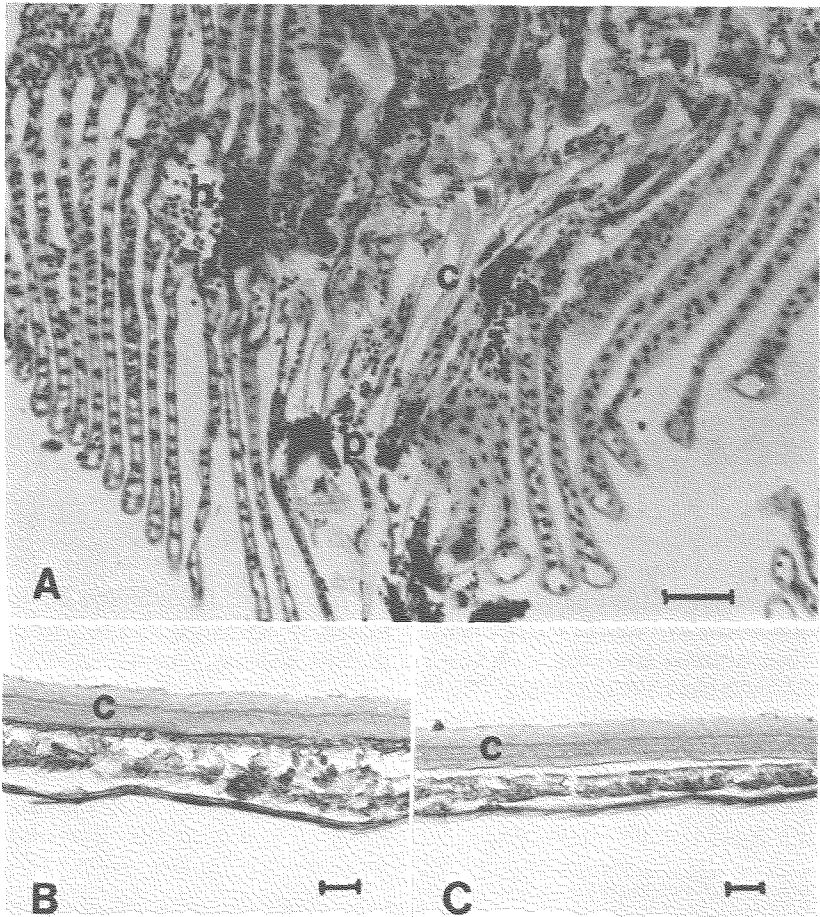
Figure 3. A: Section of damaged gill. Hemocyte infiltration (h) occurs in the damaged area. Necrotic pigmentation nodules (p) are present and denuded layers of cuticle (c) are also seen. Scale represents 0.5 mm. B: Section of deformed carapace. The exoskeleton (c) appears normal but the underlying tissue is thickened. Note the spongy appearance of the cellular layer. Scale represents 0.5 mm. C: Section of non-deformed carapace. The exoskeleton is approximately the same thickness as in Fig. B but the underlying tissue exhibits about one-half the thickness of that in Fig. B. Scale represents 0.5 mm.

by coagulated hemocytes (Sparks, 1973). There did, however, appear to be an increase in the density of hemocytes in the immediate area of the wound.

Damage to the gill of the host was apparently caused by the weight of the parasite (Fig. 3A). This prevented circulation to some areas of the gill lamellae with subsequent tissue damage and repair. Areas of barren gill cuticle were present, accumulations of hemocytes occurred and necrotic

pigment nodules were found throughout the peripheral gill areas adjacent to the parasite. Deep gill tissue and underlying muscle tissue seem to be unaffected.

The structure of the deformed carapace (Fig. 3A) was only slightly different from the non-deformed carapace (Fig. 3B). Grossly, the entire surface of the carapace exhibited a similar texture and no abnormalities of the surface were associated with the deformity. The epicuticle and endocuticle were approxi-

mately the same thickness on both the right and left branchiostegites. The interior branchial cuticle exhibited a slight thickening at the periphery of the deformity, but the remaining areas were similar to the thickness of branchial cuticle in non-deformed areas. The area of underlying epidermis and connective tissue, however, was almost twice as thick and appeared "spongy" in nature rather than the dense appearance of the corresponding tissue of non-deformed areas. The increase in thickness appears to be due to increased blood sinus space in the tissue elements rather than an increase in cell numbers.

DISCUSSION

Bopyrid parasitism of *Munida iris* has been briefly mentioned by Williams and Brown (1972), who report a 10% infestation rate by *Anuropodione* sp. and a 56% castration rate as evidenced by non-ovigerous infested females. No mention of pathological effects was made. The incidence of infestation was much lower in my collections (2%).

The sample studied by Williams and Brown (1972) was 63.7% female. Among other members of the genus, sex ratios have been reported for *Munida sarsi* (52.9 male: 47.1 female) and *M. tenuimana* (53.5:46.5) (Reverberi, 1942). The sex ratio in my collections was 61 male:39 female. The different sex ratios apparently result from small sample sizes. However, I have no explanation for the lack of parasitized females in my collection.

In the shrimp *Hippolysmata wurdemanni* examined by VanArman and Smith (1970) the bopyrid parasite *Probopyrus* sp. was completely enclosed by a cuticular membrane. They suggested that the parasites might be transitory unless their presence inhibited molting. No such enclosure was found in the specimens examined in this study. In *Munida* the parasite was in direct contact with the cuticular membranes of the branchiostegite and the gills, no extraneous tissue intervened. VanArman and Smith (1970) also report that the underlying gill

and muscle had atrophied. This apparently represents excessive damage to the host and was not seen in the specimens studied here. It is possible that the wound repair process had regenerated a cuticular layer beneath the original layer thus giving the appearance of encapsulation of the parasite. Such growth does occur during the wound repair process (Sparks, 1973; Fontaine and Lightner, 1973). *Munida iris* does show typical crustacean response to injury of the gills. There is infiltration of hemocytes which are packed into layers at the wound site. These layers of cells appear to wall-off and isolate necrotic gill tissue. There were thickened connective tissue fibers throughout the packed hemocyte layers and in several areas necrotic tissue pigment nodules were present. However, these areas appear to be rather small when compared to the total gill area.

Water for gill irrigation is drawn into the branchial chamber along the ventral and posterior borders of the branchiostegite (Barnes, 1974). The wounds in the branchial chamber cuticle are protected from exposure to incoming water by the location of the isopod on the gill. The cone-shaped mouthparts surround the wound and the body of the isopod shelters the wound. Therefore, there seems to be a distinct adaptive advantage to withdrawing blood from the branchiostegite rather than from the gill proper: blood is not diluted with water.

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SIGNIFICANCE OF LIFE HISTORY STUDIES OF CALCAREOUS SPONGES FOR SPECIES DETERMINATION

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ABSTRACT—Studies on *Clathrina coriacea* (Montagu, 1818) and *Clathrina blanca* (Miklucho-Maclay, 1868) were initiated to determine whether the species names are synonymous. Differences in external morphology, spicule dimensions, cytology, habitat preference, reproductive period, larvae, recruitment, growth, and mortality confirm that the two sponges are separate species. This investigation also demonstrates that detailed life history studies of calcareous sponges are essential for separating closely related species.

The nature of sponges was debated until the 18th century when they finally were classified as animals. In the 19th century, serious efforts were made to organize the systematics of sponges. The controversial work of Haeckel (1872) led to an intensification of the study of the taxonomy of calcareous sponges. In the 20th century the monograph of Burton (1963) stands out as the most ambitious attempt to simplify the systematics of the Calcarea. By utilizing only skeletal features to identify species belonging to the group, he reduced the number of genera of existing calcareous sponges from 54 to 22 and the number of species from 623 to 48. Such extensive lumping was viewed with skepticism by Hartman (1964), Jones (1964), Borojević (1967) and Tuzet (1973). Jones (1964) believed that Burton had greatly oversimplified calcareous sponge systematics and felt that, since breeding experiments were not yet possible, the concept of a species depended on observations of the general form, histology, spicule characteristics, embryology, and habitat preference.

Burton's monograph (1963) was utilized by the author in an attempt to identify calcareous sponges from Santa Catalina Island, California. Two of the sponges identified were *Clathrina coriacea* (Montagu, 1818) and *Clathrina blanca* (Miklucho-Maclay, 1868). These names were chosen for the California populations because of agreement with characteristics described for *C. coriacea*, *C. blanca* and their synonyms in the literature (Montagu, 1818; Miklucho-Maclay, 1868; von Lendenfeld, 1885; Dendy, 1891; Minchin, 1900; Burton, 1930; de Laubenfels, 1932; Topsent, 1936; and Sarà, 1953, among others). The study of the external form and spiculation of museum specimens from different parts of the world confirmed the species identification. Al-