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Implication of an Environmentally Induced Hamartoma in Commercial Shrimps

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Abstract

An overgrowth of muscle protruded through the ventral portion of the sixth abdominal segment of *Penaeus aztecus* and *P. setiferus*. This hamartoma was observed in 33 postlarval shrimp and is the first reported from a crustacean. Even though afflicted individuals represented a small proportion of the shrimp examined, nearly all such individuals were collected from the presumed most heavily polluted site. We suggest an unidentified pollutant as the cause of the abnormality.

Keywords: *Penaeus aztecus*, *Penaeus setiferus*, hamartoma

Introduction

We describe the first hamartoma from a crustacean. This non-neoplastic overgrowth afflicted several postlarval brown (*Penaeus aztecus*) and white (*P. setiferus*) shrimp from a Mississippi estuary. Tumors are infrequently noticed in crustaceans (Sparks, 1972; Krieg, 1973), and Sparks and Lightner (1973) suspected the validity of all but one reported case. The shrimps were predominantly from a single polluted habitat, and the hamartoma possibly resulted from an interaction between a pollutant and the normal growth process of shrimp.

Materials and Methods

Localities

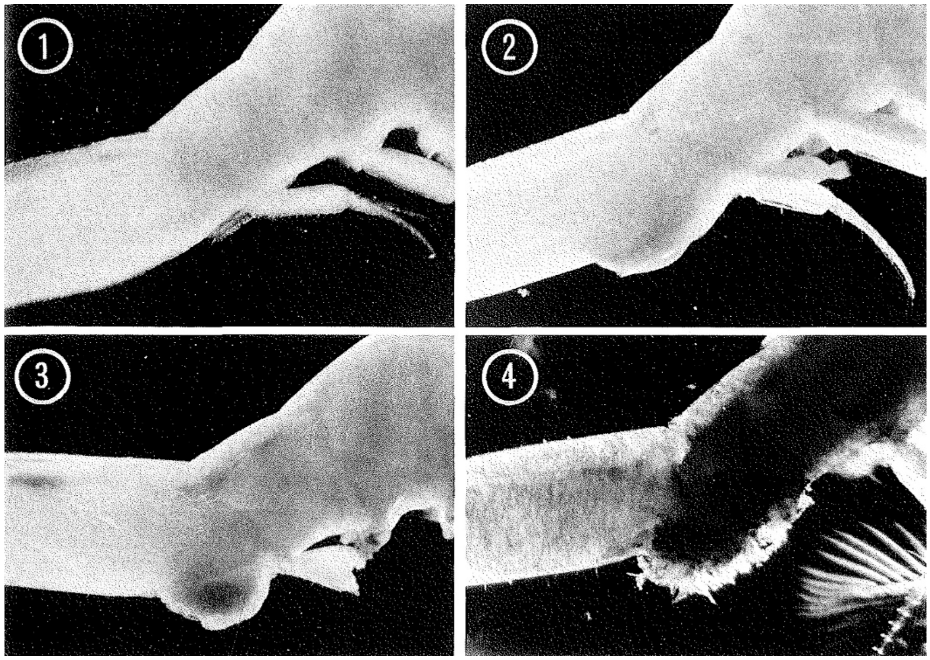
Postlarval brown, white, and pink (*Penaeus duorarum*) shrimps were monitored semimonthly between January 1972 and May 1977, except for July–September 1973 and October–December 1976, from four Mississippi Sound localities: beds of shoal grass east of Chimney Lagoon immediately north of Horn Island, 10 km across the Sound to the mainland at Bellefontaine Point, 8 km westward at Little Deer Island, and 7 km distant across a channel and up Davis Bayou to an area 1.8 km east of Ocean Springs' small boat harbor, which receives the city's treated sewage. In addition to the penaeid postlarvae collected from those sites with a fine-meshed beam trawl, a few other postlarvae plus numerous juveniles and adults were obtained with wider-meshed otter trawls and seines from 26 stations located between 5 km offshore from the barrier islands and inshore up bayous and rivers.

Tissues

After fixing the shrimp in 5% methenamine-buffered formalin, we examined each shrimp individually. The sixth abdominal segment demanded critical inspection to establish the specific identity of the shrimp (Ringo and Zamora, 1968). Some specimens both with and without tumors were processed further for histological examination using both light and electron microscopy. Representative material has been deposited in the National Museum of Natural History in Washington, DC, as RTLA 1663. The terminology of shrimp morphology follows that of Young (1959).

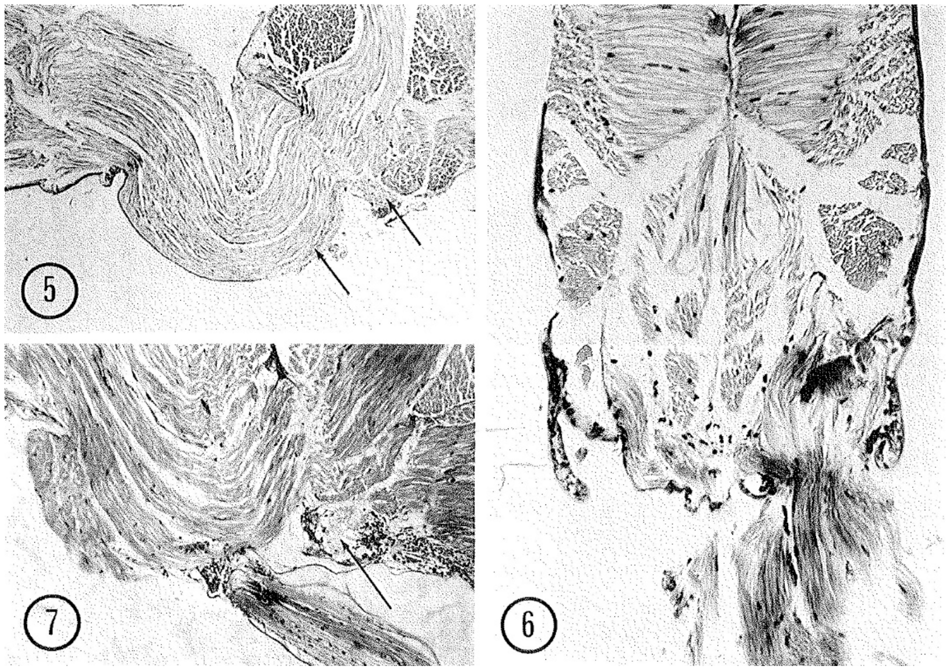
Results

The conspicuous, relatively small to large ventrally protruding hamartomas (Figs. 1–4) were examined histologically from three cross-sectioned and three sagitally sectioned individuals. Sections revealed that in anterior oblique muscle No. 6, immediately posterior to the joining of the fifth and sixth segments, a conspicuous U-shaped fold formed (Fig. 5). In some shrimp, it extruded ventrally along the median line, whereas, in others, separated muscle bundles initiated their protrusion near one side (Fig. 6). In most cases, the external arms of anterior oblique muscle also curved downward, but usually not extensively into the external protrusion. A thin cuticle, and what appeared in one specimen to be a second set of laterotergal plates, surrounded most growths. The primary laterotergal plates usually elongated adjacent to but separate from the sides of the protrusions. Cuticle surrounding the ventral portion not protected by plates was absent or lost during processing on some material.



Figures 1–4. Fourth through sixth abdominal segments of preserved postlarval *P. aztecus*. (1) Control without hamartoma; (2) small hamartoma; (3) medium-large hamartoma; (4) large frayed hamartoma of 13-mm shrimp (previous shrimp measured about 10 mm in total length).

We noticed some additional altered tissues. The ventral nerve cord, slightly stretched, either became incorporated in muscle near or passed directly along the ventral margin of the protrusion (Fig. 5). Also, a few basophilic cells, some apparently phagocytic (Parry, 1960) and some hematopoietic, associated with the base of the fifth pleopods (swimming legs), encroached on the growth (Fig. 7).



Figures 5–7. Histological sections of hamartomas from penaeid postlarval shrimp. (5) Medial sagittal section showing U-shaped fold in anterior oblique muscle. Ventral nerve cord is following ventral aspect of fold along anterior of growth (extending slightly more than between two arrows); Heidenhain's iron hematoxylin, ×124. (6) Cross section near fifth segment showing periphery of growth with lateroventral extrusion of muscle bundles through cuticle; Heidenhain's iron hematoxylin, ×219. (7) Sagittal section of fifth pleopod associated with growth. Note basophilic hemocytes at and near base of the appendage and note unaffected ventral nerve tissue to right of appendage (arrow); Harris' hematoxylin and eosin, ×93.

Cellular structure appeared normal using a light microscope. Cursory ultrastructural examination for viruses by John Couch of the U.S. Environmental Protection Agency Laboratory, Gulf Breeze, Florida, failed to reveal either abnormalities or viral organisms (Couch, 1978).

The growth occurred in 33 postlarvae as indicated in Table 1. It involved 0.56% of 2320 white shrimp, 0.08% of 26,238 brown shrimp, and none of 4573 pink shrimp. Observations of 8937, 10,135, and 2259 juvenile or adult white, brown, and pink shrimp, respectively, failed to disclose a tumor.

Table 1. Prevalence of Hamartoma in Postlarval Penaeid Shrimp from a Mississippi Estuary

						Number of shrimp in same station's sample/number from same station during entire month			
Date	Station	Species of shrimp	Number of afflicted shrimp	Prevalence in percentage of similar-sized shrimp of same species in same sample	Length (range) of afflicted shrimp (mm)	Brown	White	Pink	Relative status of hamartoma
May 25, 1973	Near harbor	Brown	13	3.7	9.9–13.8	350/724	40/40	0/0	Medium large
May 20, 1974	Near harbor	Brown	4	14.3	10.2–12.7	42[a]/323		0/0	Medium large
May 20, 1974	Near harbor	White	4	100.0	6.3–7.1		4/11		Very small
June 12, 1975	Near harbor	Brown	1	100.0	9.3	8[a]/243	3/140	0/0	Small
October 17, 1975	Near harbor	White	9	9.6	6.7–8.0	58/184	94/110	4/24	Small
February 18, 1976	Bellefontaine[b]	Brown	1	1.7	13.3	59/145	0/0	0/0	Large and frayed
September 16, 1976	Fort Point[b]	Brown	1	7.7	14.8	18[a]/112	24/97	8/932	Very small

a. Includes some postlarval shrimp larger than those with hamartoma.
b. Bellefontaine and Fort Point are about 12 and 4 km, respectively, from the harbor.

Discussion

Hamartoma designates an excessive focal overgrowth of mature normal cells and tissues in an organ or tissue composed of identical cellular elements (Robbins, 1967). A ready explanation exists for the overgrowth of tissue in the postlarval shrimp. The relative length of the sixth abdominal segment decreases considerably in both penaeid species between 6 and 25 mm long but thereafter remains nearly constant. Apparently, rather than decreasing in relative length like the encircling exoskeleton, the anterior oblique muscle of afflicted individuals continued to develop at its previous rate. Thus, the tissue necessarily protruded through the weakest adjacent portion of the exoskeleton. We observed no necrotic lesions associated with chitinoclastic bacteria nor other evidence of injury or other factors that would permit muscle stretching through an externally caused opening. Once initiated, the hamartoma continued enlargement without being restricted by the normal muscular configuration.

We also offer an explanation for the apparent absence of these growths in adults. The sixth anterior oblique muscle, inserting posteriorly upon the tail fan, flexes the uropods, telson, and sixth segment. According to Young (1959), unusual arrangements and attachments of the oblique muscle and other ventral abdominal muscles prevent distortion and damage to the thin cuticle during flexions of the abdomen. Since these flexions draw the shrimp quickly backward, providing a rapid means of locomotion and an escape response, loss of any effectiveness of the muscles enhances vulnerability to predation. In addition, as the nerve cord becomes increasingly insulted, the shrimp becomes progressively vulnerable.

We must relate our findings with the tentatively diagnosed benign neoplasm protruding laterally from the sixth abdominal segment of a pond-reared brown shrimp in Texas (Sparks and Lightner, 1973). Relationships remain unclear, but the Texas growth differed from those we report by having a connective tissue core partially surrounded by hypertrophic epidermis, rather than predominantly skeletal muscle; Sparks and Lightner (1973) suggested for it an epidermal and subepidermal origin. They also stated that the tumor might contain some muscle fibers, and we believe that their growth could be a variant of those reported here. Since the nerve cord was not involved, the growth could have originated similarly to that observed by us and enlarged, but with less muscular involvement. After a considerable passage of time, not unlikely in view of the small and abnormal tail fan, the growth could have become modified and traumatized with ensuing inflammation, degenerating unfunctional muscle tissue, and accelerating growth of other components. A lack of predators and nerve involvement would allow the disabled pond-reared shrimp to survive.

We suggest that an unknown pollutant or combination of pollutants related to sewage or use of boats interfered with the shrimp's normal growth process to cause the abnormality in the shrimp we observed. First, 93.9% of the affected postlarvae occurred adjacent to a small boat harbor that receives Ocean Springs' treated sewage and where only 46.0% of the postlarvae were caught. The remaining shrimp came from stations 4 to 24 km away in presumably less polluted water, judging from their distance from the harbor, population centers, and industries. Moreover, when restricting percentages to individual samples with afflicted individuals near the harbor, values reached 100% prevalence in some samples, and hamartomas appeared seasonally, occurring twice in May, once in June, and once in October (Table 1). Since we sampled semimonthly for over 5 years, the finding of seasonally restricted cases makes it plausible that a seasonal concentration of a pollutant induced the abnormality. According to the Mississippi Air and Water Pollution Control Commission, operation of the sewage treatment facility has improved since October 1975, when we last observed afflicted shrimp from near the harbor. Other reasons for suspecting a pollutant are that we did not observe external signs of injury or disease and that we doubt any direct genetic influence. Both brown and white shrimps spawn offshore from barrier islands, and young stages from a given parent invade the brackish estuary and disperse over a wide range. A genetic trait not triggered by external influences should be manifested in individuals from all localities.

The highest prevalence of afflicted individuals occurred in white shrimp and could relate to the preference by that shrimp for low-salinity water. Most local sources of both industrial and domestic pollution discharge wastes into fresh to low-salinity water. We have not collected postlarvae from a variety of low-salinity and polluted sites but hope to in the future. As for the lack of afflicted pink shrimp, this finding could reflect the collection of most of those shrimp from relatively clean high-salinity water near Horn Island.

Assuming the hamartoma could be experimentally induced, it would provide an excellent model to study the triggering and inhibiting mechanisms in the growth process of shrimp.

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