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PHOSPHOGLUCOMUTASE POLYMORPHISM IN TWO PENAEID SHRIMPS, *PENAEUS BRASILIENSIS* AND *PENAEUS AZTECUS SUBTILIS*

In a search for subpopulation differences within species of penaeid shrimp in the northern Gulf of Mexico, Proctor et al. (1974) and Marvin and Caillouet (1976) reported genetically controlled polymorphism in the enzyme phosphoglucomutase (PGM) in *Penaeus aztecus* (brown shrimp) and *P. setiferus* (white shrimp). The brown shrimp were collected in the northern Gulf of Mexico, so they are *P. aztecus aztecus* Ives, according to Pérez Farfante (1969). The white shrimp, collected both from the northern Gulf and from the North Edisto River, S.C., are *P. setiferus* (Linnaeus), according to Pérez Farfante (1969). Our paper describes similar polymorphisms in PGM in two more penaeids, *P. brasiliensis* Latreille and *P. aztecus subtilis* Pérez Farfante.

Methods

Specimens were collected off the coasts of Guyana, Surinam, and French Guiana, South America, on cruise 49 of the *Oregon II*, between lat. 6°13′ and 6°29′N and between long. 53°10′ and 53°36′W, at 22-29 fathoms, on 9 and 10 February 1974. They were stored at −20°C or below until analyzed. Preparation of abdominal muscle extracts, electropherograms of general protein patterns, and PGM zymograms followed procedures used by Procter et al. (1974). Each specimen was identified to species by morphological characteristics, then their distinctive general protein patterns (Figure 1) were used to confirm this identification. To do so, each gel was sliced horizontally into two halves after electrophoresis was complete. One half was treated with PGM specific stain and the other half was stained with Coomassie Blue.[1] Specimens of *P. aztecus aztecus*

[1]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

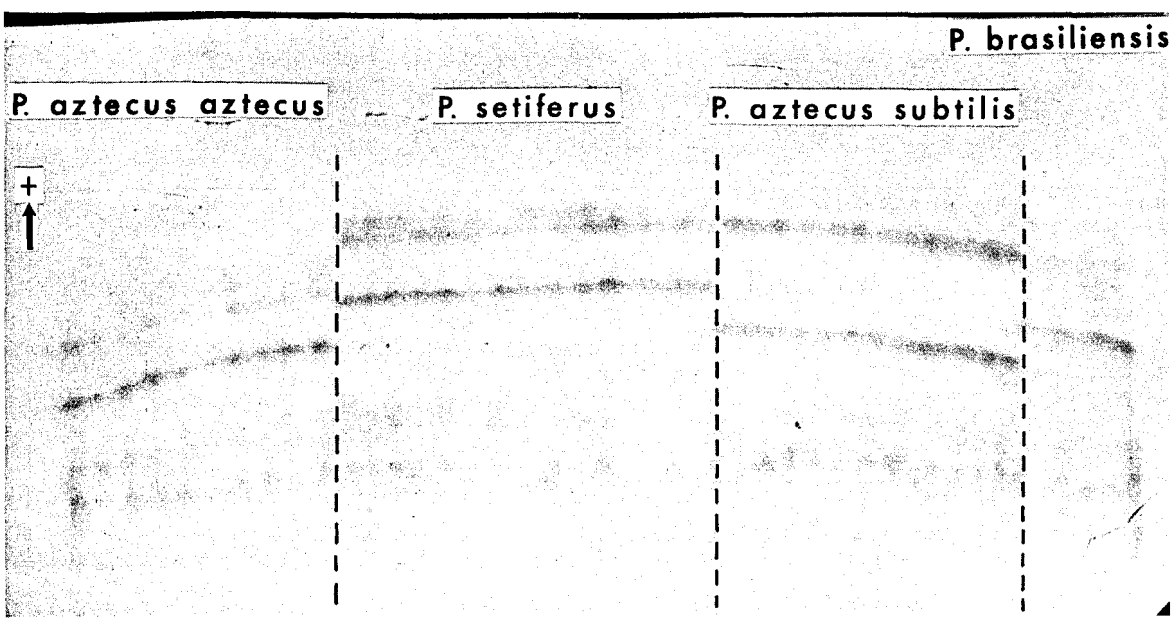

FIGURE 1. — Electropherogram showing general protein pattern of *Penaeus brasiliensis, P. aztecus subtilis, P. aztecus aztecus,* and *P. setiferus.* Stain used was Coomassie Blue. Direction (↑) of protein migration toward the anode (+) is shown.

and *P. setiferus* collected in the northern Gulf were included for comparison with *P. aztecus subtilis* and *P. brasiliensis*.

Results and Discussion

In *P. aztecus subtilis* the zymograms of abdominal muscle extracts exhibited a single region of PGM activity composed of five anodal bands which are labelled a, b, c, d, and e. The same was true for *P. brasiliensis* with the exception that band e was not observed. Bands a, b, c, and d are shown in Figure 2 and bands b, c, and d in Figure 3. Band e, observed in *P. aztecus subtilis*, is shown only diagrammatically (Figure 3). Direct comparison of PGM bands among *P. brasiliensis, P. aztecus subtilis, P. aztecus aztecus*, and *P. setiferus* suggested that bands b, c, and d are similar in these shrimps (Figure 4). This result is supported by Marvin and Caillouet (1976) who showed that *P. setiferus* and *P. aztecus aztecus* have the same five PGM bands. These bands are assumed to be under the control of five codominant allelic genes designated PGM_a through PGM_e (Proctor et al. 1974; Marvin and Caillouet 1976).

Six phenotypes of PGM were observed in *P. brasiliensis* and eight in *P. aztecus subtilis* (Table 1). PGM phenotypes were enumerated from zymograms to determine numerical distributions of phenotypes, and allele (PGM band) frequencies were derived therefrom (Table 1). Two-banded phenotypes (Figures 2-4) observed in some individuals presumably reflect heterozygous individuals. With PGM phenotypes grouped into three categories, cc, cx, and xx (where x includes bands a, b, d, and e), chi-square tests detected no difference ($P>0.05$) in phenotype distribution between the sexes in either species. With the same

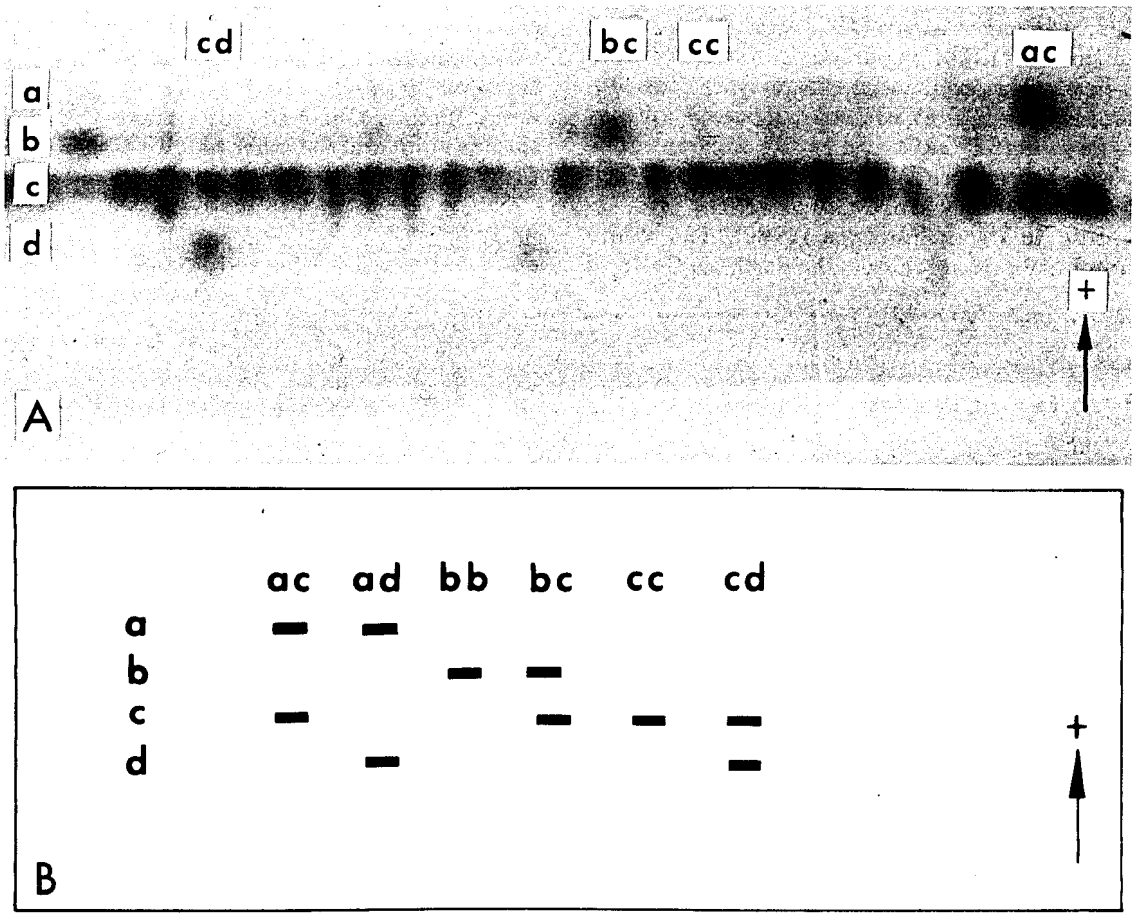

FIGURE 2. — A. Zymogram showing PGM bands a through d (band e not shown) and phenotypes cd, bc, cc, and ac. B. Diagram showing six PGM phenotypes observed in *Penaeus brasiliensis*. Direction (↑) of protein migration toward the anode (+) is shown.

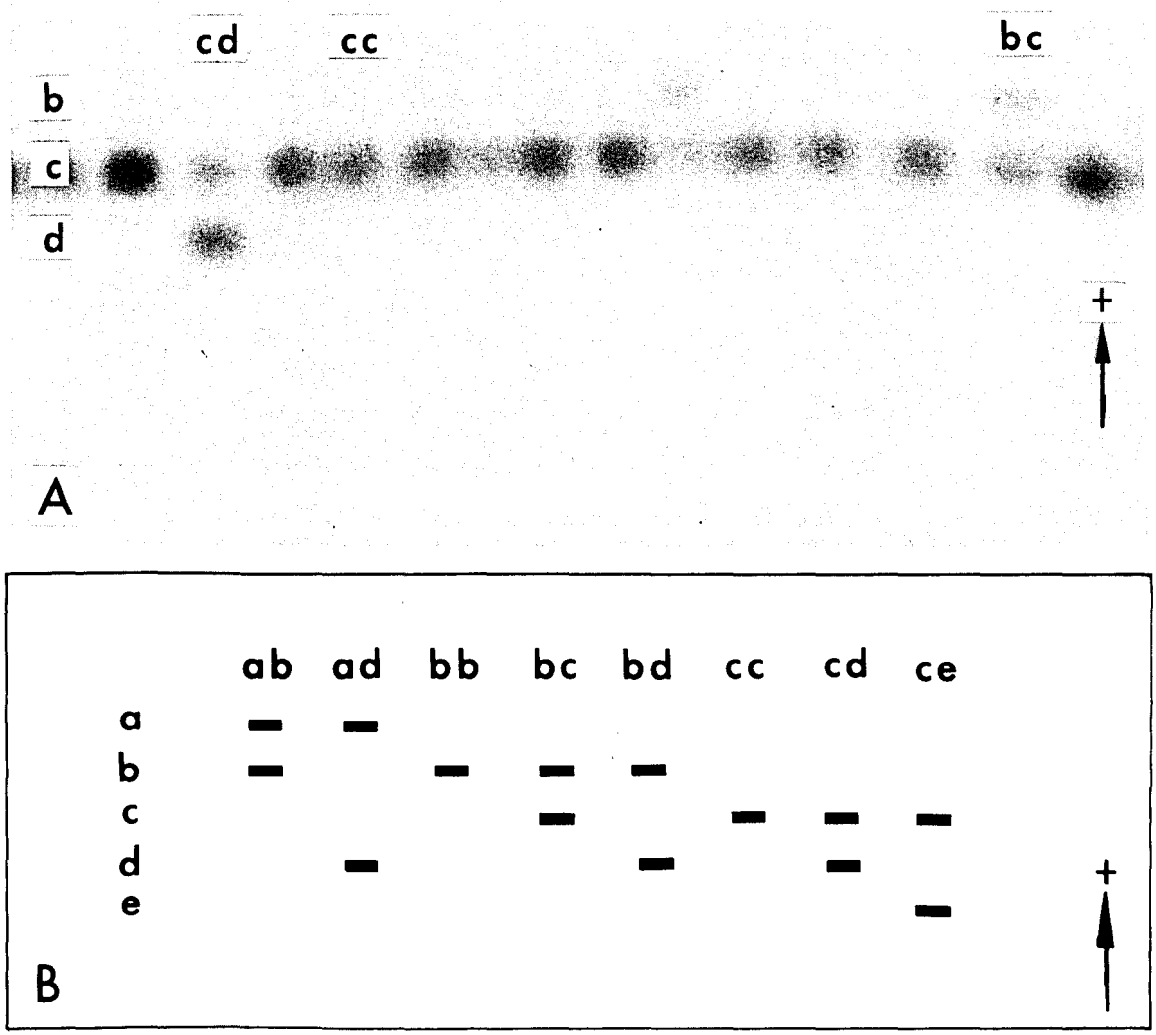

FIGURE 3. — A. Zymogram showing PGM bands b through d (bands a and e not shown) and phenotypes cd, cc and bc. B. Diagram showing eight PGM phenotypes observed in *Penaeus aztecus subtilis*. Direction (↑) of protein migration toward the anode (+) is shown.

TABLE 1. — Distribution (number of specimens) of PGM phenotypes and frequency of PGM alleles in samples of *Penaeus brasiliensis*, *P. aztecus subtilis*, and *P. aztecus aztecus*.

Species	Total length[1] range (mm)	Sex	Phenotypes									Alleles				
			ab	ac	ad	bb	bc	bd	cc	cd	ce	a	b	c	d	e
P. brasiliensis	145-185	Male	0	2	0	1	12	0	172	17	0	0.0049	0.0343	0.9191	0.0417	0.0000
	151-210	Female	0	2	1	0	8	0	161	14	0	0.0081	0.0215	0.9301	0.0403	0.0000
	145-210	Combined	0	4	1	1	20	0	333	31	0	0.0064	0.0282	0.9244	0.0410	0.0000
P. aztecus subtilis	102-152	Male	0	0	2	0	13	2	143	6	0	0.0060	0.0452	0.9187	0.0301	0.0000
	107-175	Female	1	0	0	1	13	0	119	8	2	0.0035	0.0556	0.9062	0.0278	0.0069
	102-175	Combined	1	0	2	1	26	2	262	14	2	0.0048	0.0500	0.9129	0.0290	0.0032
P. aztecus aztecus[2]	60-100	Combined	1	2	0	22	211	5	345	12	2	0.0025	0.2175	0.7642	0.0142	0.0017

[1]Tip of rostrum to tip of telson.
[2]Data adapted from Proctor et al. (1974).

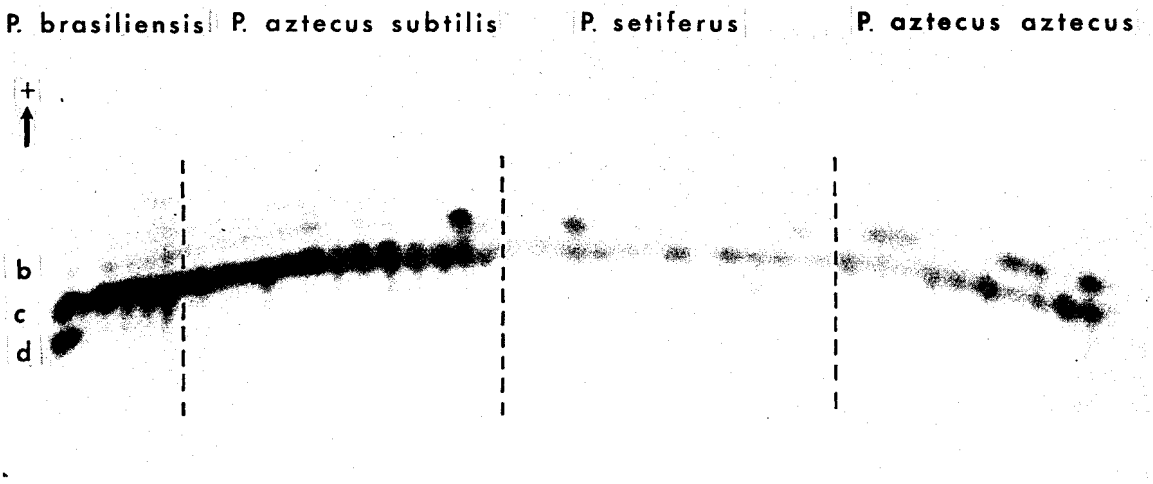

FIGURE 4.—Zymogram comparing PGM bands b through d (bands a and e not shown) in *Penaeus brasiliensis, P. aztecus subtilis, P. aztecus aztecus*, and *P. setiferus*. Direction (↑) of protein migration toward the anode (+) is shown.

phenotype categories, but with data for sexes combined, the phenotype distribution of *P. aztecus subtilis* deviated significantly ($\chi^2 = 7.086$, $0.025<P<0.05$) from that expected from Hardy-Weinberg equilibrium (Stern 1943). The reason for this deviation is not known. Johnson et al. (1974) noted a deviation from Hardy-Weinberg expectation for PGM phenotype distribution of a pandalid shrimp *Pandalus hypsinotus* Brandt, in Alaska, and they suggested that it might be related to depth of capture as found in, Pacific ocean perch, *Sebastodes alutus* (Johnson et al. 1971).

Our study provided an opportunity to compare the subspecies *P. aztecus subtilis* and *P. aztecus aztecus,* therefore distribution of PGM phenotypes and frequency of PGM alleles for the latter subspecies (data adapted from Proctor et al. 1974) also are shown in Table 1. This comparison is based on the assumption that bands a and e as well as bands b, c, and d are similar in the two species. However, even if this is not the case, the small frequencies of the rare a and e alleles would not appreciably affect the comparison. Both subspecies exhibited eight phenotypes, but not all were the same. Phenotype ad was detected in *P. aztecus subtilis* but not in *P. aztecus aztecus.* Phenotype ac was detected in the latter but not in the former. With phenotypes grouped into categories cc, cx, and xx, and with sexes combined, a chi-square contingency test detected a significant ($P<0.05$) difference in phenotype distribution between the subspecies, and this result provides an additional characteristic to existing evidence of differences between these subspecies (see Pérez Farfante 1969).

This and previous studies by Proctor et al. (1974) and Marvin and Caillouet (1976) suggest that zymogram analysis may provide a useful tool in the study of population genetics of the Penaeidae. The wide distribution (Mistakidis 1968), commercial importance, and relatively short generation time of the Penaeidae should make them particularly attractive subjects of study by population geneticists.

Acknowledgments

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FIRST RECORD OF THE MELON-HEADED WHALE, *PEPONOCEPHALA ELECTRA*, IN THE EASTERN PACIFIC, WITH A SUMMARY OF WORLD DISTRIBUTION

Peponocephala electra (Gray 1846) is a tropical pelagic delphinid previously known to occur in the eastern Atlantic, Indian, and western and central Pacific oceans. It is also known as the electra dolphin, the Hawaiian blackfish, and the many-toothed blackfish. Since van Bree and Cadenat (1968; localities 1-4, 6-9, 11, 13, 14, 16, 18, and 19 in Figure 1) summarized world records, the species has been reported from Thailand (Pilleri 1973, locality 17), the Philippine Sea near Cebu (W. H. Dawbin pers. commun., locality 15), near Townsville, Australia (G. E. Heinsohn pers. commun., locality 12), the New Hebrides (Rancurel 1974, locality 10), and the Tuamotos-Marquesas region (K. S. Norris pers. commun., locality 5). Records cited by van Bree and Cadenat (1968) as "in litteris" or in press, have subsequently been published (Dawbin et al. 1970, locality 11; Mörzer Bruyns 1971, localities 6-9). The purpose of this note is to report a capture that extends the known range of the species some 3,000 miles into the eastern tropical Pacific off Central America (Figure 1; triangle).

The specimen (Figure 2), a male calf 112 cm long (tip of upper jaw to base of notch in flukes) and weighing 15 kg, was captured in a tuna purse seine that had been set on an aggregation of yellowfin tuna, *Thunnus albacares*, and dolphins, *Stenella* sp., approximately 90 nautical miles (about 167 km) due west of Champerico, Guatemala (lat. 14°20'N, long. 91°52'W), in May 1974. More precise information on date and locality of capture is not available. A crew member found the calf dead in the net, placed it in the ship's freezer, and on return to port donated it to the National Marine Fisheries Service, La Jolla. The specimen was identified using X rays of the dentition. The high tooth count ($\frac{23+|23+}{22+|22+}$), combined with the blunt head and dark coloration, is diagnostic of the species. The specimen was then photographed, measured, weighed, cast in plastic, and sent frozen to the U.S. National Museum (USNM), Washington, D.C., where it was preserved whole

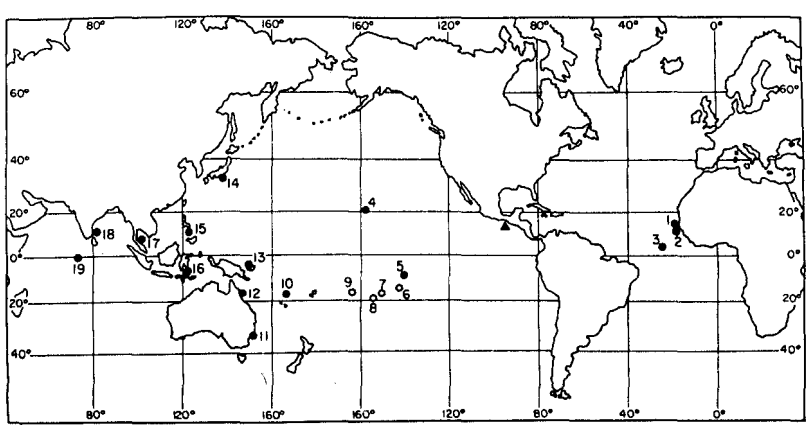

FIGURE 1. — Known distribution of *Peponocephala electra*. Triangle is new record; sources of others in text. Closed circles are specimen localities, open circles are sightings. Some circles represent multiple records from single localities, e.g., Hawaii and Honshu, Japan.