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Occurrence of Shell Deformities in Green-Lipped Mussel *Perna viridis* (Linnaeus) Collected from Malaysian Coastal Waters

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The concentrations of heavy metals in green-lipped mussel *Perna viridis* in Malaysia were first reported by Sivalingam and Bhaskaran (1980) and then followed by a few authors such as Devi (1986) and Ismail (1993). Only recently, the mussel was suggested as a potential biomonitoring agent for heavy metals in the west coast of Peninsular Malaysia by Ismail et al. (2000). In the practice of 'Mussel Watch' program, marine mussels were usually analysed for their heavy metal concentration in its soft tissues. The heavy metal concentrations analysed in the mussel soft tissues were usually used to assess the heavy metal contamination in the coastal areas (Phillips and Rainbow 1993). During our collection of mussels along the coastal waters of Malaysia, we found some individuals with deformed shells which were not selected for the analysis of heavy metals. An interesting question that arises is can we based on the frequencies of these shell deformities make any conclusion on the sampling sites being contaminated with pollutants such as heavy metals? This paper reports the occurrence of shell deformities in the green-lipped mussel *P. viridis* collected from the waters of Peninsular Malaysia.

MATERIALS AND METHODS

Sampling locations and site description are shown in Figure 1. Mussels were sampled from fifteen locations along the waters of Peninsular Malaysia. The classification of types of shell deformities in *P. viridis* was made based on those described by Sunila and Lindstrom (1985).

RESULTS AND DISCUSSION

Frequencies of shell deformities of all types in all mussel populations are shown in Table 1. Based on the classification made by Sunila and Lindstrom (1985) in the blue mussel *M. edulis*, shell deformities of marine mussels could be classified into continuous deformities and discontinuous deformities. In this study, we found discontinuous shell deformities such as dorsal streak (Figure 2a), posterior streak (Figure 2b), thin-pointed posterior part (Figure 2c) and flattening of anterior part (Figure 2d). Continuous shell deformities were also

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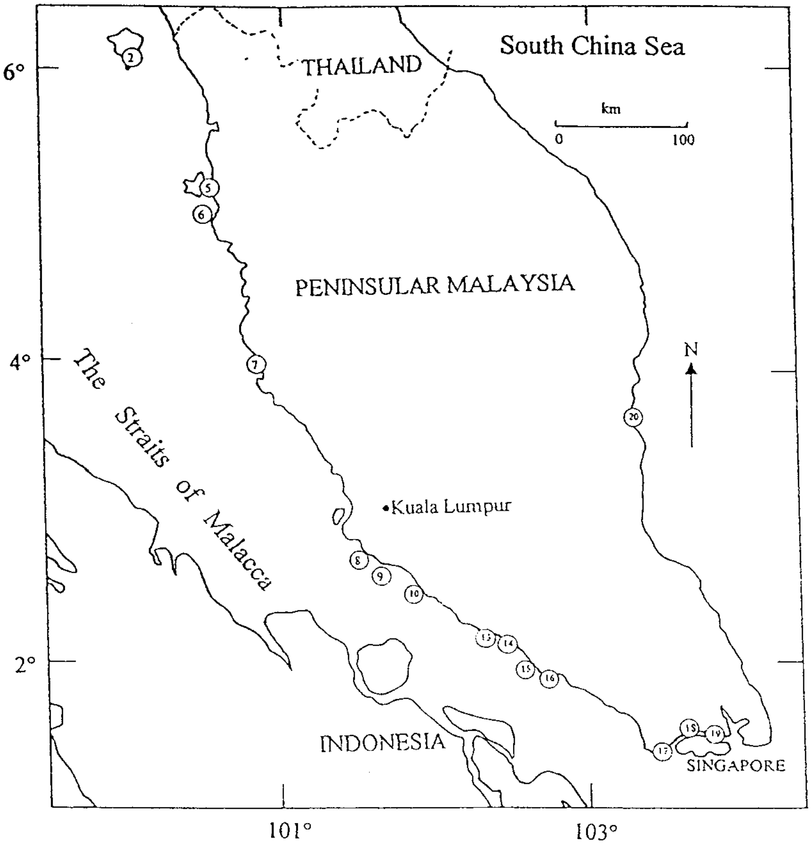

Figure 1. Map showing sampling stations of *Perna viridis* from the west coast of Peninsular Malaysia.

found such as slight posterior score (Figure 3a), slight dorsal score (Figure 3b) and slight ventral score (Figure 3c). These different types of shell deformities had been reported in the blue mussel *M. edulis* (Sunila and Lindstrom 1985). The present work also revealed some unidentified types of shell deformities (Figure 4). These shell deformities are believed to have previously encountered unfavourable environmental factors. One of these could be pollution in general and heavy metal contamination in particular.

The present frequency of shell deformities in *P. viridis* of 15 locations collected from Peninsular Malaysia (Figure 1 and Table 1) ranged from 0.0-36.8% with a means value of 7.7% (Table 1). It is clear from the site descriptions in Table 1 that populations collected from Langkawi Island and from Kg. Tg. Batu of the east coast of Peninsular Malaysia had recorded none (0.0%) of shell deformities. In fact, about 70% of all mussel collection sites from Peninsular Malaysia had frequencies of shell deformities less than 10.0%. Sunila and Lindstrom (1985) reported 2.8%, 26.1%, 46.1% and 62.8%

Table 1. Occurrence of shell deformity of all types (severe and slight) in green-lipped mussel *P. viridis* in Peninsular Malaysia.

No	Location	Area description	% of shell deformity
2	Sangkar Ikan, Langkawi Island	Aquacultural area	0.00
5	Penang Bridge, Penang	Port, industry and urban areas	1.18
6	Pulau Aman, Penang	Aquacultural area	2.86
7	Dinding Estuary, Perak	Aquaculture area and near to a jetty	16.36
8	Bagan Lalang, Selangor	Recreational and agricultural areas	2.00
9	Lukut, Negeri Sembilan	Agricultural and aquacultural areas	6.82
10	Pasir Panjang, Negeri Sembilan	Recreational and aquacultural areas	4.88
13	Anjung Batu, Malacca	Agricultural and aquacultural areas	10.87
14	Telok Emas, Malacca	Aquacultural area	36.84
15	Sebatu, Malacca	Aquacultural and agricultural areas	1.49
16	Muar Estuary, Malacca	Agricultural area	2.90
17	Tanjung Kupang, Johore	Port and aquacultural areas	10.64
18	Pantai Lido, Johore	Aquacultural and urban areas	9.33
19	Kg. Pasir Puteh, Johore	Port, industry and urban areas	9.52
20	Kg. Tanjung Batu, Pahang	Recreational beach	0.00
	Overall		7.71 (0.00-36.84)

deformities in natural population, control population, Cu exposed population and Cd exposed population, respectively. Therefore, the high frequency of shell deformities recorded in some stations could be due to heavy metal contamination in the west coast of Peninsular Malaysia (Ismail et al. 2000). They could also be due to other pollutants such as hydrocarbons (Zakaria et al. 2000) and tributyltins (Tong et al. 1996). Other unidentified pollutants and environmental factors might also contribute to the occurrence of shell deformities of *P. viridis* collected from Peninsular Malaysia. Therefore, the cause of these shell deformities remains ambiguous. Further work should be conducted to ascertain that heavy metals directly caused the shell deformities in *P. viridis*, whether the continuous or the discontinuous types. This may help us to understand which of the deformity types was characteristic of which metal or metals or of other pollutants.

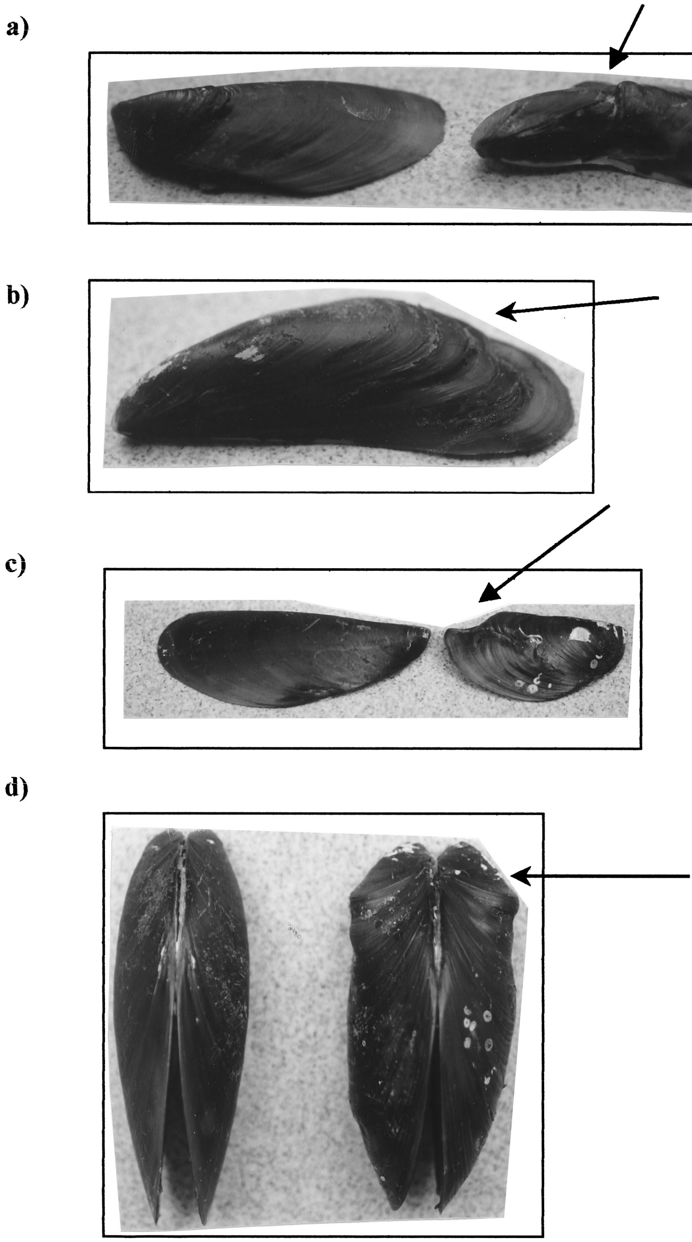

Figure 2. Discontinuous shell deformities observed in green-mussel *P. viridis*. (a: dorsal streak; b: posterior streak; c: thin-pointed posterior part; d: Flattening of anterior part. In photoes where there are two shells, the shell on the left is the control.

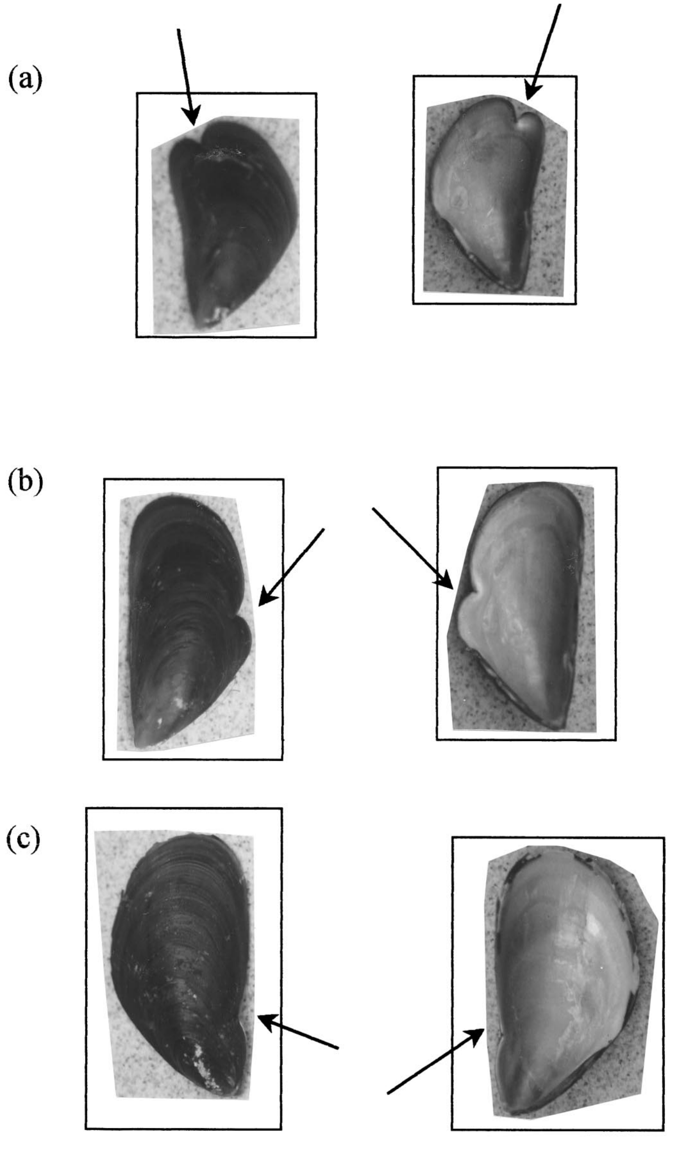

Figure 3. Continuous shell deformities observed in green-mussel *P. viridis*. (a: posterior score; b: dorsal score; ventral score).

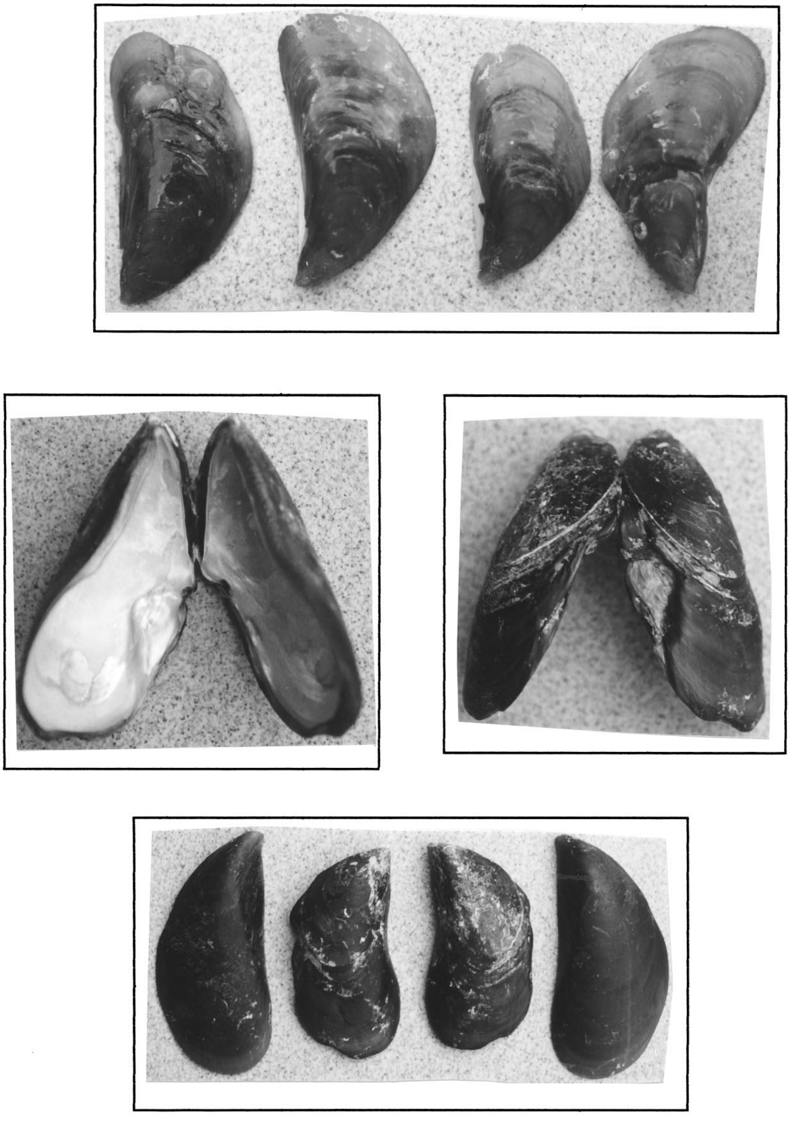

Figure 4. Some unidentified types of shell deformities found in green-lipped mussel *P. viridis* collected from the coastal waters of Peninsular Malaysia. In the bottom photo, the shells on the extreme left and right are the controls.

Sunila and Lindstrom (1985) found the same types of shell deformities in blue mussel *M. edulis*. From their results, they concluded that different shell deformities did not accumulate on individual shells and each deformed shell as a rule only had one type of deformity. The present results agreed with their conclusion. Sunila and Lindstrom (1985) also concluded that the frequency of shell deformities was related to Cd and Cu contamination. The decreased or retarded growth due to metal contamination would usually result in development of shell deformities of mussels. The present results hinted that the deformities found in the shell of *P. viridis* could be due to heavy metal contamination.

The effects of heavy metals on the growth of marine mussels had been reported. Stromgren (1982) found that Cu and Cd retarded the growth of *Mytilus* species after short-term continuous exposure to these metals. Wilson and McMahon (1981) found that *M. edulis* with higher Cu concentration in its soft tissues had thicker and heavier shells than individuals with low Cu concentration.

The growth of the shell is quite different from the growth of somatic and reproductive tissues. The mussel shell is composed of both an organic matrix and crystals of calcium carbonate ($CaCO_3$). There are three major aspects of shell growth and formation. First, the role of $CaCO_3$ metabolism in the synthesis of the organic matrix. Second, secretion of shell components by the mantle. Third, $CaCO_3$ crystal growth (Wilbur and Salueddin 1983). The organic matrix is secreted in insoluble form by the mantle and deposited as a layer on the inner shell surface. The matrix is proteinaceous and is the substrate upon which $CaCO_3$ crystal initiates and grows. Mussels in general possess high physiological demands for calcium for shell formation (Phillips and Rainbow 1993). The elemental composition of molluscs shells had been shown to be related to environmental factors (Bourgoin 1990; Putten et al. 2000). The transport of elevated metal levels into the shell structures would possibly disturb normal shell formation. This could result in all types of shell deformities being observed in *P. viridis*. This hypothesis should be tested in future studies similar to those that were conducted by Sunila and Lindstrom (1985).

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