Identification of Wild Postlarvae of the Penaeid Shrimps, Genus *Penaeus*, in the Pacific Coast of Central America

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Five species of penaeid shrimps in the genus *Penaeus* exist in the Pacific coast of Central America and are commercially important. The morphology of their wild postlarvae has not been studied for all the species, causing difficulties of reliable identification and resource management.

The present study examined the wild postlarvae of the five species and describes sequentially their morphological characters such as dorsal spinules, antennal spine, relative rostral length, thoracic spines, and rostral teeth. These characters were used to prepare an identification key for the wild postlarvae of the five species. The dorsal spinules on the 6th abdominal somite and those around the epigastric tooth were found to be subgeneric diagnostic characters, and the taxonomic importance of the thoracic spines was demonstrated.

Key words: penaeid shrimps, wild postlarvae, morphology, identification, Pacific coast of Central America

Five species of shrimps in the genus *Penaeus* are known¹⁾ in the Pacific coast of Central America. Three species, *P. vannamei*, *P. stylirostris*, and *P. occidentalis* belong to the subgenus *Litopenaeus*,¹⁾ while the other two, *P. californiensis* and *P. brevirostris* belong to the subgenus *Farfantepenaeus*.¹⁾

The identifications of their wild postlarvae have been studied,^{2,9)} but the keys were not always applicable. Because the characters were not described comprehensively according to the development stage of each species.

Cabrera³⁾ examined the wild postlarvae of *P. brevirostris* and described the rostral form as well as the presence or absence of antennal spines, dorsal spinules on the 6th abdominal somite, and those around the epigastric tooth with reference to the number of rostral teeth. Kitani^{6,7)} observed the wild and the reared postlarvae of *P. californiensis* and *P. vannamei* and described the detailed morphological characters in relation to the growth of carapace, which provided an understanding of the developmental morphology. Kobayashi and Chan⁴⁾ illustrated sequentially the growth of rostrum of the four species excluding *P. occidentalis*, though little description was given on the other characters. The morphological characters of the wild postlarvae of *P. occidentalis* and *P. stylirostris* have not yet been studied, which makes it difficult to identify reliably the five species of wild postlarvae and to study the resources.

This study aims to clarify the developmental morphology of the wild postlarvae of *P. occidentalis*, *P. stylirostris*, and *P. brevirostris* comparing each character^{6,7)} of the five species, and to establish a reliable key for identification. The taxonomic importance of the characters is also discussed.

Materials and Methods

Wild postlarvae were collected using a hand net from August 1986 to

July 1988, and preserved in 5–10% formalin. Specimens of *P. vannamei*, *P. stylirostris*, *P. californiensis*, and *P. brevirostris* were collected off Guatemala, and those of *P. occidentalis* off Costa Rica. Specimens of different carapace length were chosen, and the total numbers examined were 184, 84, 149, 115, and 139, respectively.

Morphological characters such as the number of rostral teeth, rostral length, dorsal spinules on the 6th abdominal somite, those around the epigastric tooth, thoracic spines, and antennal spines were examined, and the lengths of the carapace against the carpus of the 3rd preopod and the 6th abdominal somite were measured. The terminologies used follow those of Kitani.^{5–7)}

Results

The carapace length, CL, ranged from 1.20–2.75 mm in *P. vannamei*, 1.45–3.50 mm in *P. stylirostris*, 1.81–2.75 mm in *P. occidentalis*, 1.50–2.73 mm in *P. californiensis*, and 1.95–2.78 mm in *P. brevirostris*. Specimens over and under these size ranges were not collected.

The sequential changes of morphological characters of each species are tabulated according to the growth of carapace in Table 1.

The spinules around the epigastric tooth were absent in all the specimens of *P. vannamei*, *P. stylirostris*, and *P. occidentalis*, but were present in *P. californiensis* of 2.00–2.73 mm CL, and in *P. brevirostris* of 1.95–2.78 mm CL.

The dorsal spinules on the 6th abdominal somite were absent in all the specimens of *P. vannamei*, *P. stylirostris*, and *P. occidentalis*, and also in 44% of *P. californiensis* of 1.50–1.62 mm CL, but were present in *P. brevirostris* of 1.95–2.78 mm CL, in 56% of *P. californiensis* of 1.50–1.62 mm CL, and in all the specimens of the same species of 1.63–2.73 mm CL.

A pair of antennal spines was absent in *P. vannamei* of 1.20–1.60 mm CL, *P. stylirostris* of 1.45–1.69 mm CL, *P. occidentalis* of 1.81–1.99 mm CL, and *P. californiensis* of 1.50–1.65 mm CL, but was present in *P. vannamei* of 1.90–2.75 mm CL, *P. stylirostris* of 2.01–3.50 mm CL,

Table 1. Morphological characters of wild postlarvae according to the carapace length (CL, mm)

CL	Characters ¹⁾	<i>P. vannamei</i>	<i>P. stylirostris</i>	<i>P. occidentalis</i>	<i>P. californiensis</i>	<i>P. brevisrostris</i>	CL	<i>P. vannamei</i>	<i>P. stylirostris</i>	<i>P. occidentalis</i>	<i>P. californiensis</i>	<i>P. brevisrostris</i>
1.20	Spinules/epigast.	—					2.21	—	—	—	+	+
~	Spinules/6th abdo.	—					~	—	—	—	+	+
1.40	Antennal spine	—	No	No	No	No	2.40	+	+	+	+	+
	Rostral length	2/5–1/2	data	data	data	data		1/2–4/5	4/5–5/5	4/5	4/5–5/5	2/5r
	Thoracic spine	(–/+)(–)						(–)(–)	(–)(–)	(+)(–)	(+)(–/+)	(+)(–/+)
	Rostral tooth	2–3/0						5–7/1	6–7/1–2	6–8/0–2	7–8/1	5–7/0
1.41	Spinules/epigast.	—	—		–/*+		2.41	—	—	—	+	+
~	Spinules/6th abdo.	—	—		–/+		~	—	—	—	+	+
1.60	Antennal spine	—	—	No	—	No	2.60	+	+	+	+	+
	Rostral length	2/5–1/2	3/5–4/5	data	4/5	data		3/5–4/5	4/5–5/5	4/5–5/5	4/5–5/5	2/5r
	Thoracic spine	(–)(–)	(–/+)(–)		(+)(+)			(–)(–)	(–)(–)	(+)(–)	(+)(–/+)	(+)(–/+)
	Rostral tooth	2–4/0	2–3/0		3–4/0			6–7/1–2	6–7/1–2	7–8/1–2	7–8/1–2	6–7/0–1
1.61	Spinules/epigast.	—	—		–/+		2.61	—	—	—	+	+
~	Spinules/6th abdo.	—	—		–/+		~	—	—	—	+	+
1.80	Antennal spine	–/+	–/*+	No	–/+	No	2.80	+	+	+	+	+
	Rostral length	2/5–1/2	4/5	data	4/5	data		3/5–4/5	4/5–5/5	4/5–5/5	5/5–6/5	2/5r
	Thoracic spine	(–)(–)	(–)(–)		(+)(+)			(–)(–)	(–)(–)	(+)(–)	(+)(–/+)	(+)(–/+)
	Rostral tooth	3–5/0	3–4/0		3–5/0			6–7/1–2	6–7/2–3	7–9/1–3	7–8/2	7–8/0–1
1.81	Spinules/epigast.	—	—	—	*–/+	+	2.81	—	—	—	—	—
~	Spinules/6th abdo.	—	—	—	+	+	~	—	—	—	—	—
2.00	Antennal spine	*–/+	–/+	–/*+	–/+	+	3.00	No	+	No	No	No
	Rostral length	2/5–3/5	4/5	4/5	4/5	2/5r		data	5/5	data	data	data
	Thoracic spine	(–)(–)	(–)(–)	(+)(+)	(+)(–/+)	(+)(+)			(–)(–)			
	Rostral tooth	3–7/0–1	5–6/0–1	3–5/0	4–7/0–1	4–6/0			6–8/2–3			
2.01	Spinules/epigast.	—	—	—	+	+	3.1	—	—	—	—	—
~	Spinules/6th abdo.	—	—	—	+	+	~	—	—	—	—	—
2.20	Antennal spine	+	+	–/+	+	+	3.50	No	+	No	No	No
	Rostral length	1/2–3/5	4/5	4/5	4/5–5/5	2/5r		data	5/5–6/5	data	data	data
	Thoracic spine	(–)(–)	(–)(–)	(+)(–/+)	(+)(–/+)	(+)(+)			(–)(–)			
	Rostral tooth	5–6/0–1	5–6/0–2	4–6/0–1	6–8/0–1	4–6/0			6–9/3–4			

–: Absent. +: Present. –/+ : Sometimes absent, and sometimes present. *–/+ : Rarely absent, and mostly present. –/*+ : Mostly absent, but rarely present. r: Stubby tip of rostrum.

¹⁾ Spinules/epigast.: spinules around the epigastric spine. Spinules/6th abdo.: spinules on the 6th abdominal somite. Rostral length: relative rostral length. Thoracic spine: each spine on (7th) and (8th) thoracic sternites. Rostral tooth: dorsal/ventral teeth, excluding the epigastric.

Fig. 1. Lateral view of stubby tip of rostrum in *P. brevivirostris* (A) and acute tip of rostrum in *P. vannamei* (B). Scaledivisions represent 0.5 mm.

Fig. 2. Relationship between the lengths of carapace and carpus of 3rd pereopod of *P. vannamei*, *P. stylirostris*, and *P. brevivirostris*.

P. occidentalis of 2.21–2.75 mm CL, *P. californiensis* of 1.90–2.73 mm CL, and in all the specimens of *P. brevivirostris* of 1.95–2.78 mm CL.

The relative rostral length against the combined length of eye and eyestalk in *P. vannamei* ranged from 2/5–3/5, rarely 4/5, and was shorter than that of the other species under the same CL. The rostrum of *P. brevivirostris* was also shorter, but the tip of the rostrum was stubby, while the other species had an acute rostrum (Fig. 1).

A thoracic spine on the 7th sternite was present in all the specimens of *P. occidentalis*, *P. californiensis*, and *P. brevivirostris*. This spine was also present in 24% of *P. vannamei* of 1.20–1.38 mm CL and in 25% of *P. stylirostris* of 1.45–1.55 mm CL, but disappeared in the specimens of both species over 1.38 mm and 1.55 mm CL, respectively.

A thoracic spine on the 8th sternite was absent in both *P. vannamei* and *P. stylirostris*. This spine was present in

Fig. 3. Relationship between the lengths of carapace and carpus of 3rd pereopod of *P. vannamei*, *P. californiensis*, and *P. occidentalis*.

Fig. 4. Relationship between the lengths of carapace and 6th abdominal somite of *P. vannamei*, *P. stylirostris*, *P. occidentalis*, *P. californiensis*, and *P. brevivirostris*.

35% of *P. occidentalis* of 1.81–2.07 mm CL, but disappeared in the specimens of 2.08–2.75 mm CL. This spine was also present in *P. californiensis* of 1.50–1.88 mm CL and in *P. brevivirostris* of 1.95–2.25 mm CL, but was so small as to be rudimentary or absent in the specimens of both species over 1.88 mm and 2.25 mm CL, respectively.

No distinctive difference was detected in the number of rostral teeth among the five species.

The relative growths of the carpus of the 3rd pereopod and the 6th abdominal somite are shown in Fig. 2 to 4.

Fig. 5. Chromatophore patterns of wild postlarvae of the five species, dorsal view. Scaledivisions represent 5 mm.

The relative growths of the carpus in *P. vannamei*, *P. stylirostris*, and *P. californiensis* were similar, while the growths in *P. occidentalis* and *P. brevirostris* were lower (Figs. 2 and 3).

The relative growths of the 6th abdominal somite in *P. brevirostris* and *P. occidentalis* over 2.20 mm CL were distinguishable from those in *P. stylirostris* and *P. vannamei* (Fig. 4). These differences in proportional dimensions are useful for distinguishing the species group in a certain size range.

The chromatophore patterns on the dorsal surface were different among the species. The pigmentation was well developed in *P. brevirostris* and *P. californiensis*, while the body of the other three species was less pigmented (Fig. 5). The pigmentation of *P. californiensis* was developed along the mid-line of the body, and was distinguishable from that of *P. brevirostris*. Few chromatophores were observed in *P. stylirostris*, while many tiny chromatophores were observed in *P. occidentalis*, and small chromatophores were sparsely distributed in *P. vannamei*. These pigment patterns were observed in the postlarvae collected of the five species.

A morphological comparison was possible among the five species in the size range of 1.95–2.73 mm CL, and the identification key is as follows:

- 1a.—Thoracic spine present on the 7th sternite. 2
- 1b.—No thoracic spine on the 7th sternite. 4
- 2a.—Dorsal spinules present on the 6th abdominal somite. 3
- 2b.—No dorsal spinules on the 6th abdominal somite. *P. occidentalis*
- 3a.—Tip of the rostrum is acute. *P. californiensis*
- 3b.—Tip of the rostrum is stubby. *P. brevirostris*
- 4a.—Relative rostral length against the length of eye plus eye stalk ranges from 4/5–5/5. Few chromatophores are observed. *P. stylirostris*
- 4b.—Relative rostral length against the length of eye plus eye stalk ranges from 2/5–3/5, rarely 4/5. A few small

chromatophores are observed. *P. vannamei*

Discussion

The spinules on the 6th abdominal somite were detected not in the subgenus *Litopenaeus*, but in the subgenus *Farfantepenaeus*: *P. brevirostris* of 1.95–2.78 mm CL and *P. californiensis* of 1.63–2.73 mm CL. Although this character has been reported⁵⁾ not to be subgeneric in Indonesian waters, the present study indicates that the presence of these spinules is a subgeneric character valid for specimens of 1.95–2.73 mm CL in the Pacific coast of Central America. The presence of spinules around the epigastric tooth is also a subgeneric character, which is valid for the specimens of 2.00–2.73 mm CL. Kitani⁶⁾ reported that the spinules on the 6th abdominal somite and those around the epigastric tooth were present in reared specimens of *P. californiensis* of 2.37–3.80 mm CL and in those of 2.52–3.80 mm CL. Therefore, the maximum CL valid for applying these subgeneric criteria is considered to be more than 2.73 mm CL for wild postlarvae. Cabrera³⁾ observed the antennal spine in the wild postlarvae of *P. brevirostris* with 2 rostral teeth. The present study could not confirm this result, because no specimens with 2 rostral teeth were collected. Cabrera³⁾ also reported the stubby tip of the rostrum in *P. brevirostris* with 3 rostral teeth, and Kobayashi and Chan⁴⁾ reported it in the same species with 9 rostral teeth. These facts are useful for applying this character to postlarvae with 3–9 rostral teeth.

Kitani^{6,7)} reported that the thoracic spine on the 7th sternite in reared specimens of *P. vannamei* and *P. californiensis* was observed at the 2nd mysis, and disappeared gradually in those over 1.24 mm CL and in those over 2.95 mm CL, respectively. These facts suggest that the spine on the 7th sternite may also be present in *P. occidentalis* under 1.81 mm CL and in *P. brevirostris* under 1.95 mm CL. The thoracic spine on the 7th sternite

was absent in *P. stylirostris* of 1.56–3.50 mm CL. This character is thus thought to apply to specimens of 1.56–2.73 mm CL. Kitani⁶⁾ also reported that the thoracic spine on the 8th sternite in reared specimens of *P. californiensis* was observed at the 2nd mysis and present in those under 2.07 mm CL, and disappeared gradually in those of 2.07 mm CL and over. These facts suggest that the spine may be present in *P. brevirostris* under 1.95 mm CL and in *P. occidentalis* under 1.81 mm CL. The present study observed that this spine disappeared gradually in *P. californiensis* over 1.88 mm CL, and was absent in *P. vannamei* and *P. stylirostris*. Accordingly, the specimens of 1.45–1.88 mm CL are classified into two groups by this character. Jackson *et al.*⁸⁾ reported that the thoracic spine formula of (+)(+) was a generic character of *Penaeus* Shrimps with the exception of (+)(-) in *Litopenaeus*, but Kitani^{6,7)} reported that the formula changed from (+)(-) to (-)(-) in *P. vannamei* of *Litopenaeus*, and from (+)(+) to (+)(-/+) in *P. californiensis* of *Farfantepenaeus*. The present study has confirmed this, and revealed that the formula changes from (+)(-) to (-)(-) in *P. stylirostris*, from (+)(+) to (+)(-) in *P. occidentalis*, both of *Litopenaeus*, and from (+)(+) to (+)(-/+) in *P. brevirostris* of *Farfantepenaeus*. Accordingly, the spine formula⁸⁾ is neither a subgeneric, nor a generic criterion.

In conclusion, the present study of wild postlarvae has clarified the morphology of previously unexamined species, compared the morphological characters of the five species, and revealed the taxonomic importance of them, in particular, the dorsal spinules around the epigastric tooth, those on the 6th abdominal somite, and the thoracic spines.

The identification key presented above covers most of the size ranges of wild postlarvae commonly collected in coastal estuaries. However, further studies on postlarvae hatched and reared in a laboratory will be needed for a

complete understanding of their morphology.

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