Morphometric differentiation in small juveniles of the pink spotted shrimp (*Farfantepenaeus brasiliensis*) and the southern pink shrimp (*F. notialis*) in the Yucatan Peninsula, Mexico

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The morphometric and morphological characters of the rostrum have been widely used to identify penaeid shrimp species (Heales et al., 1985; Dall et al., 1990; Pendrey et al., 1999). In this setting, one of the constraints in studies of penaeid shrimp populations has been the uncertainty in the identification of early life history stages, especially in coastal nursery habitats, where recruits and juveniles dominate the population (Dall et al., 1990; Pérez-Castañeda and Defeo, 2001). In the western Atlantic Ocean, Pérez-Farfante (1969, 1970, 1971a) described diagnostic characters of the genus *Farfantepenaeus* that allowed identification of individuals in the range of 8–20 mm CL (carapace length) on the basis of the following morphological features: 1) changes in the structure of the petasma and thelycum; 2) absence or presence of distomarginal spines in the ventral costa of the petasma; 3) the ratio between the keel height and the sulcus width of the sixth abdominal somite; 4) the shape and position of the rostrum with respect to the segments and flagellum of the antennule; and 5) the ratio between rostrum length (RL) and carapace length (RL/CL). In addition, she classified *Farfantepenaeus* into two groups according to the shape and position of the rostrum with respect to the segments and flagellum of the antennule and the ratio RL/CL: 1) *F. duorarum* and *F. notialis*: short rostrum, straight distally, and the proximodorsal margin convex, usually extending anteriorly to the end of distal antennular segment, sometimes reaching to proximal one-fourth of broadened portion of lateral antennular flagellum, with RL/CL <0.75; and 2) *F. aztecus*, *F. brasiliensis*, *F. paulensis*, and *F. subtilis*: long rostrum, usually almost straight along the entire length, extending anteriorly beyond the distal antennular segment, sometimes reaching to the distal one-third of broadened portion of lateral antennular flagellum, with RL/CL >0.80. Pérez-Farfante stressed that, for the recognition to species level of juveniles <10 mm CL, all the characters listed above should be considered because occasionally one alone may not prove to be diagnostic. However, the only characters that could be distinguished for small juveniles in the range 4–8 mm CL are those defined on the rostrum. Therefore, it has been almost impossible to identify and separate small specimens of *Farfantepenaeus* (Pérez-Farfante, 1970, 1971a; Pérez-Farfante and Kensley, 1997).

Pink spotted shrimp (*F. brasiliensis*) and southern pink shrimp (*F. notialis*) have a wide geographic distribution in coastal environments of the Atlantic Ocean. The pink spotted shrimp is distributed within the western Atlantic from Cape Hatteras, North Carolina, to Cabo Frio, Brazil (22°00′S, 42°00′W: Pérez-Farfante, 1969), including the southwestern Gulf of Mexico and the Caribbean coasts of Mexico (Pérez-Farfante, 1971b). The southern pink shrimp ranges from the northwestern Yucatan Peninsula, Mexico (20°45′N, 90°25′W: Pérez-Castañeda and Defeo, 2000), to Rio de Janeiro (Brazil) in the western Atlantic, including Cuba and the Virgin Islands in the Caribbean Sea. The species is also reported from Mauritania to Angola in the eastern Atlantic Ocean (Pérez-Farfante, 1969; Pérez-Farfante and Kensley, 1997).

The current identification keys show that, for shrimps ≥8 mm CL, the pink spotted shrimp has a proportionately longer rostrum than the southern pink shrimp. However, there are no scientific data to separate these species at individual sizes <8 mm CL (Pérez-Farfante, 1970, 1971a). This is particularly important where both penaeid shrimps are found in the same region, mainly between the Yucatan Peninsula and along the Caribbean coast of Mexico, Puerto Rico, and Colombia. In this geographic region, small juveniles of both species have been almost impossible to separate and have been classified only to genus level (Stoner and Zimmerman, 1998; May-Kú, 1999; Pérez-Castañeda and Defeo, 2001; Criales et al., 2002). In this note we provide quantitative and qualitative information that allows separation of the sympatric *F. brasiliensis* and *F. notialis* in the range of 4–8 mm CL based on shrimp collected in the Río Lagartos and Yalahau coastal lagoons of the Yucatan Peninsula, Mexico.

Materials and methods

Shrimp were collected by using a Renfro beam trawl (1.6 × 0.5 m mouth, 1.5 m total length, and 1.0-mm mesh), which was hand hauled in two coastal lagoons of northeastern Yucatan Peninsula (Fig. 1). The Río Lagartos

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lagoon (21°26′–21°38′N, 87°30′–88°15′W) was sampled from November 1996 to April 1997, whereas the Yalahau lagoon (21°26′–21°36′N, 87°08′–87°29′W) was sampled from June 2001 to May 2002. These coastal lagoons are considered the main nursery areas for *F. brasiliensis*, accounting for 80–95% of the total shrimp abundance, followed by *F. notialis* (May-Kú, 1999; May-Kú and Ordóñez-López, 2000). Shrimps (4–10 mm CL) were preserved in 10% formaldehyde, prior to examination. Rostrum length (RL; distance from the tip of the rostrum to the postorbital margin of the carapace) and carapace length (CL; distance from the postorbital margin to the posterior margin of the carapace) were measured with an ocular micrometer to the nearest 0.1 mm. Furthermore, the shape and position of the rostrum with respect to the segments and flagellum of the antennule were considered (Pérez-Farfante, 1969; 1970, 1971a). Shrimps ranging from 8 to 10 mm CL were identified to species level according to the characters outlined by Pérez-Farfante (1970, 1971a). The relationship between rostrum length and carapace length (RL-CL) was determined for each species (*F. brasiliensis*, *F. notialis*) in each lagoon, and fitted to the linear function $RL = a + b\ CL$, where a and b are coefficients. One-way analysis of covariance (ANCOVA) was used to evaluate differences between species in the RL-CL relationship for each site, with RL as the dependent variable and CL as the covariate. Assumptions of homoscedasticity and homogeneity of slopes (parallelism) were met after log-transformation of RL. Lastly, the RL/CL ratio was estimated to remove the differences in individual sizes between species, then plotted against CL and determined for each lagoon. A one-way analysis of variance (ANOVA) was conducted to test interspecific differences between mean RL/CL in each lagoon. The original RL/CL values were log-transformed to fulfill ANOVA assumptions.

Results

A total of 13,234 shrimps in the size range 4–10 mm CL were collected. Of the 727 organisms measured in the Río Lagartos lagoon, 74.6% were *F. brasiliensis* and 25.4% *F. notialis*. In Yalahau lagoon, from the 12,507 organisms measured, 91.7% were *F. brasiliensis* and 8.3% *F. notialis*. In the two lagoons, both species showed a significant positive linear RL-CL relationship ($r^2 \geq 0.92$; $P<0.001$). Significant differences were detected between the species (ANCOVA: $P<0.001$; Fig. 2; Table 1)—*F. brasiliensis* having a longer rostrum than *F. notialis* for a given CL.

The RL/CL ratio for both species ranged from 0.42 to 0.94. In both lagoons the scatter plots

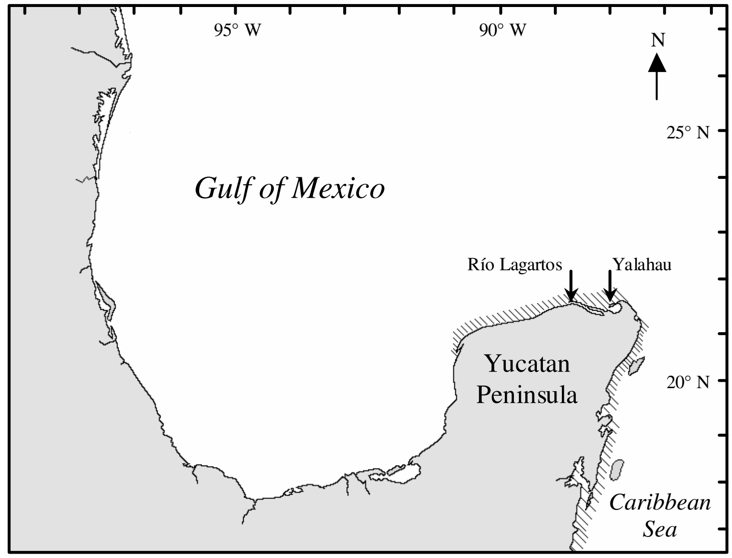

Figure 1

Location of Río Lagartos and Yalahau lagoons off the Yucatan Peninsula. The distribution of *Farfantepenaeus brasiliensis* and *F. notialis* along the Mexican coast of the Gulf of Mexico and Caribbean Sea is indicated by oblique lines.

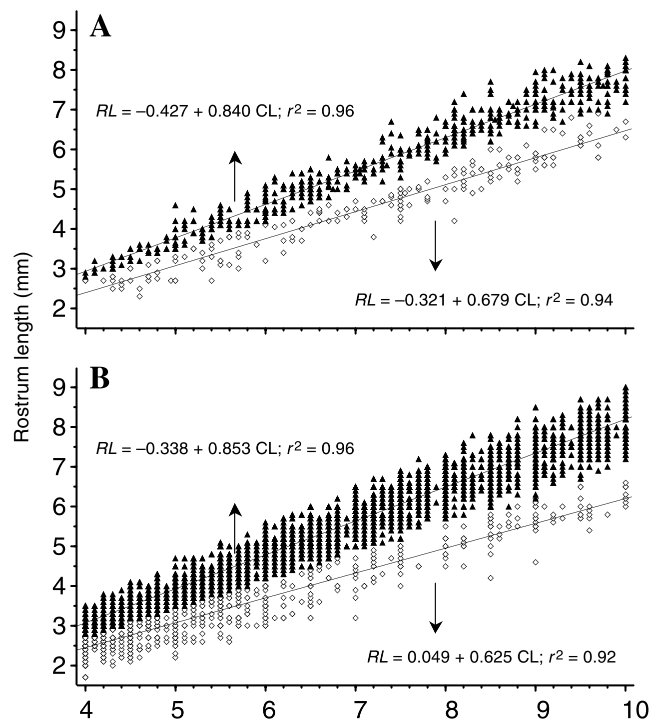

Figure 2

Relationships between rostrum length (RL) and carapace length (CL) fitted by the linear model $RL = a + b\ CL$ for juveniles of *Farfantepenaeus brasiliensis* (▲) and *F. notialis* (◇) from (**A**) Río Lagartos and (**B**) Yalahau lagoons. All regressions are highly significant ($P<0.001$).

Table 1

Parameters of the linear regression model between rostrum length (RL) and carapace length (CL) fitted for *Farfantepenaeus brasiliensis* and *F. notialis*, in the size range of 4–10 mm CL, for Río Lagartos and Yalahau. ANCOVA results (log-transformed RL) are also shown, including tests of homogeneity of slopes and differences in RL at CL (main effect) between species. "*a*" and "*b*" represent, respectively, the intercept and slope of the regression lines. SE = standard error; ns = not significant; *** = $P<0.001$.

	a Mean (SE)	*b* Mean (SE)	r^2	*n*	*P*
Río Lagartos					
F. brasiliensis	−0.427 (0.055)***	0.840 (0.007)***	0.96	542	***
F. notialis	−0.321 (0.091)***	0.679 (0.013)***	0.94	185	***
ANCOVA					
Homogeneity of slopes: $F_{1,723}=1.212$; $P=0.271$					
Main effect: $F_{1,724}=1{,}430.2$; $P=0.00001$					
Yalahau					
F. brasiliensis	−0.338 (0.010)***	0.853 (0.002)***	0.96	11,467	***
F. notialis	0.049 (0.032) ns	0.625 (0.006)***	0.92	1040	***
ANCOVA					
Homogeneity of slopes: $F_{1,12503}=0.966$; $P=0.326$					
Main effect: $F_{1,12504}=12486.4$; $P=0.0001$					

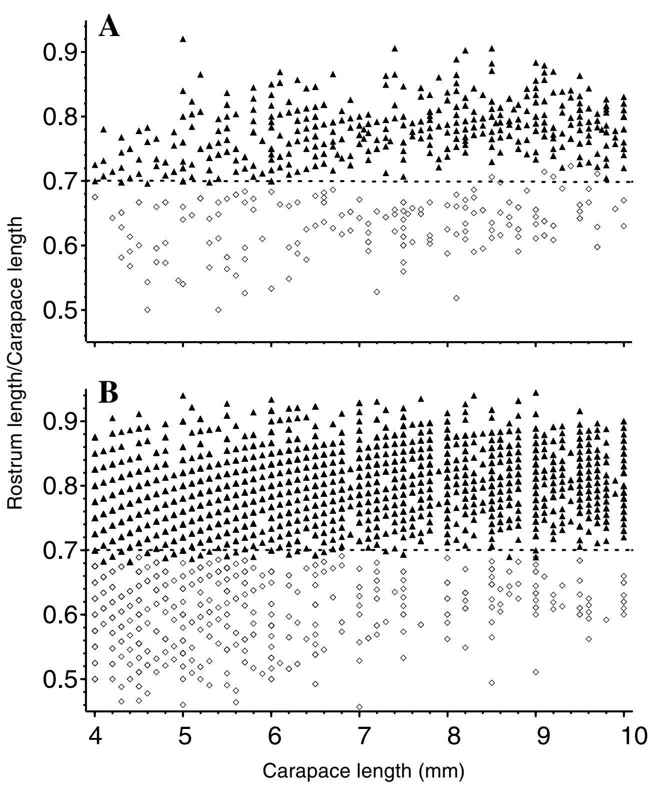

Figure 3

Scatter plot of rostrum length/carapace length (RL/CL) ratios against CL for juveniles of *Farfantepenaeus brasiliensis* (▲) and *F. notialis* (◇) from (**A**) Río Lagartos and (**B**) Yalahau lagoons. The separation between species at RL/CL = 0.70 is indicated by a dotted line.

of RL/CL ratios against CL by species fell into two distinct clouds representing dissimilar morphometric characteristics of the species, with the point of separation between species set at a value of 0.70 (Fig. 3). The RL/CL ratios were significantly higher in *F. brasiliensis* than in *F. notialis*, both for Río Lagartos (ANOVA, $F_{1,725}=1778.33$, $P<0.001$) and Yalahau (ANOVA, $F_{1,12505}=16627.64$, $P<0.001$). For Río Lagartos, *F. brasiliensis* had a mean RL/CL ratio ±SD of 0.78 ±0.04 and a range of 0.70–0.92, whereas the mean RL/CL ratio in *F. notialis* was 0.63 ±0.04, with a range of 0.50–0.72. In Yalahau lagoon, the RL/CL ratio in *F. brasiliensis* was 0.80 ±0.05 (range 0.68–0.94), whereas in *F. notialis* these values were 0.62 ±0.05 (0.43–0.69; Fig. 4). The above values indicate a morphometric divergence between the two species, with higher values corresponding to *F. brasiliensis* and lower ones to *F. notialis*.

Small juveniles presented clear differences between species in the shape and position of the rostrum with respect to the segments and the flagellum of the antennule. *Farfantepeaeus brasiliensis* had a rostrum that was straight and slender, extending beyond the 3rd antennular segment, and generally reaching the broadened portion of lateral flagellum (Fig. 5A), whereas *F. notialis* had a lightly convex rostrum, never extending beyond the third antennular segment (Fig. 5B).

Discussion

We found clear morphometrical and morphological rostrum differences between small juveniles

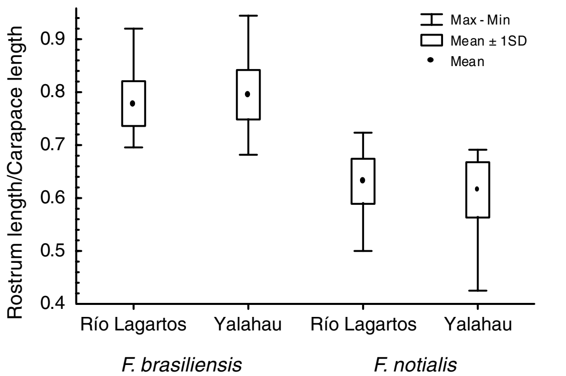

Figure 4

Box and whisker plots of the rostrum length/carapace length (RL/CL) ratios for *Farfantepenaeus brasiliensis* and *F. notialis*, discriminated by lagoon.

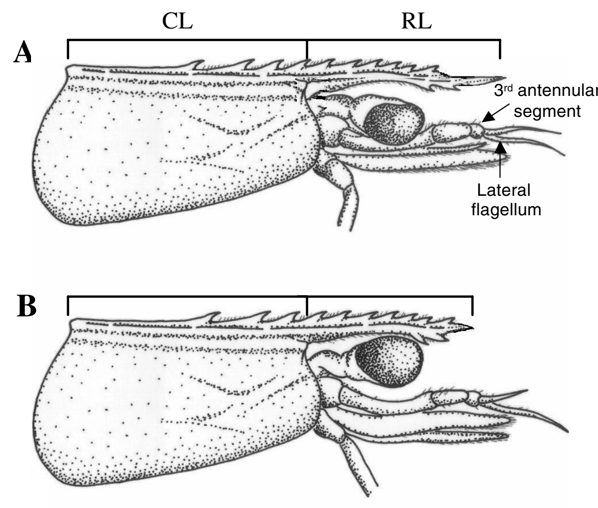

Figure 5

Distinguishing features of the shape of the rostrum and its position with respect to the segments and the flagellum of the antennule in *Farfantepenaeus brasiliensis* (**A**) and *F. notialis* (**B**). CL = carapace length, RL = rostrum length.

(4–8 mm CL) of *F. brasiliensis* and *F. notialis* in two coastal lagoons of the Gulf of Mexico. Our results also complement those obtained by Pérez-Farfante (1969; 1970, 1971a) because the unique characters of the rostrum highlighted by that author for juveniles ≥8 mm CL persisted in our study for small juveniles (<8 mm CL). We also found interspecific differences in the growth patterns given by the RL-CL relationship (slopes) and in the RL/CL ratio (intercept differences). These results have important implications. Dall et al. (1990) mentioned that the shape and increase in size of different body structures in crustaceans depend on the species, age, sex, and the surrounding environment. Our comparison of the regression lines between RL and CL of the two shrimp species analyzed in the present study, coming from Yalahau and Río Lagartos lagoons, showed unambiguously that the growth pattern, or degree of change in RL in relation to CL, differed between the two species at all sizes of the specimens. Different intercepts, on the other hand, implied that although the growth patterns may be the same over the size range measured (regression lines are almost parallel), the relative body proportions of both species are different. These differences are likely due to different growth rates at some earlier size (Haddon and Willis, 1995). Both types of difference imply that the relative proportions of the body, or the body shape, are distinct for the species analyzed (Haddon and Willis, 1995). An analysis of the RL-CL relationship revealed that, at a given CL, the RL in *F. brasiliensis* grows 1.23–1.29 times faster than in *F. notialis*. On the other hand, the marked differences in the RL/CL ratio imply that this morphometric character is species-specific and, at a given CL, the pink spotted shrimp has a consistently longer rostrum than southern pink shrimp, with a value of 0.70 as a point of separation between species. These results are also qualitatively observed in the shape and position of the rostrum with respect to the segments and the flagellum of the antennule in both species.

In conclusion, we successfully separated small juveniles of two shrimp species that are found in coastal lagoons of the Gulf of Mexico. Both species can be identified by easily observed and quantified rostrum characteristics.

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Literature cited

Criales, M., C. Yeung, F. Amaya, A. López, D. Jones, and W. Richards.
2002. Larval supply of fishes, shrimps, and crabs into the nursery ground of the Ciénaga Grande de Santa Marta, Colombian Caribbean. Caribb. J. Sci. 38:52–65.
Dall, W., B. J. Hill, P. C. Rothlisberg, and D. J. Staples.
1990. The biology of the Penaeidae. Adv. Mar. Biol. 27:1–489.
Haddon, M., and T. J. Willis.
1995. Morphometric and meristic comparison of orange roughy (*Hoplostethus atlanticus*: Trachichthyidae) from

the Puysegur Bank and Lord Howe Rise, New Zealand, and its implications for stock structure. Mar. Biol. 123:19–27.

Heales, D. S., H. G. Polzin, and D. J. Staples.
1985. Identification of the postlarvae of the commercially important *Penaeus* species in Australia. *In* Second Australian national prawn seminar (P. Rothlisberg, B. Hill and D. Staples, eds.), p. 41–46. Seminar Sponsor, Cleveland, Queensland, Australia.

May-Kú, M. A.
1999. Características biológicas y ecológicas de los juveniles de camarón del género *Farfantepenaeus*, en el área oeste de la laguna costera de Río Lagartos, Yucatán. M.Sc. thesis, 108 p. Centro de Investigación y de Estudios Avanzados (CINVESTAV), Unidad Mérida, Mérida, México.

May-Kú, M. A., and U. Ordóñez-López.
2000. The shrimp *Farfantepenaeus notialis* (Decapoda: Penaeidae) in the Gulf of México. Rev. Biol. Trop. 48:271.

Pendrey, R. C., N. R. Loneragan, R. A. Kenyon, and D. J. Vance.
1999. Simple morphometric characters, confirmed by gel electrophoresis, separate small juvenile banana prawns (*Penaeus indicus* and *P. merguiensis*). Mar. Freshw. Res. 50:677–680.

Pérez-Castañeda, R., and O. Defeo.
2000. Population structure of the penaeid shrimp *Farfantepenaeus notialis* in its new range extension for the Gulf of Mexico. Bull. Mar. Sci. 67:1069–1074.
2001. Population variability of four sympatric penaeid shrimps (*Farfantepenaeus* spp.) in a tropical coastal lagoon of Mexico. Estuar. Coast. Shelf Sci. 52:631–641.

Pérez-Farfante, I.
1969. Western Atlantic shrimps of the genus *Penaeus*. U.S. Fish Wildl. Serv., Fish. Bull. 67:461–591.
1970. Diagnostic characters of juveniles of the shrimps *Penaeus aztecus aztecus*, *P. duorarum*, and *P. brasiliensis* (Crustacea, Decapada, Penaeidae). U.S. Fish Wildl. Serv., Special Rep.—Fisheries 599, 26 p. U.S. Dep. Interior, U.S. Fish and Wildlife Serv., Bureau of Comercial Fisheries, Washington, D.C.
1971a. Características diagnósticas de los juveniles de *Penaeus aztecus subtilis*, *P. duorarum notialis* y *P. brasiliensis* (Crustacea Decapoda Penaeidae). Mem. Soc. Cienc. Nat. La Salle 30:159–182.
1971b. Range extension of the shrimp *Penaeus* (*Melicertus*) *brasiliensis* Latreille, 1817 (Decapoda, Penaeidae). Bull. Mar. Sci. 21:745–746.

Pérez-Farfante, I., and P. Kensley.
1997. Penaeoid and sergesteoid shrimps and prawns of the world. Key and diagnoses for the families and genera. Mem. Mus. Nat. Hist. Natur. Paris 175, 233 p.

Stoner, A. W., and R. Zimmerman.
1998. Food pathways associated with penaeid shrimps in a mangrove-fringed estuary. Bull. Mar. Sci. 86: 543–551.