

Research Article

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Abnormal symmetric chelipeds in an specimen of snapping shrimp *Synalpheus fritzmuelleri* Coutiere, 1909

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Abstract

Morphological symmetry abnormalities in cheliped appendages of alpheid shrimps are extremely rare and poorly recorded in the literature. A symmetric minor cheliped were, for example, observed in queen females belonging to *Synalpheus* eusocial species. Symmetric major chelipeds were now described in *Synalpheus fritzmuelleri* individuals living in shallow Brazilian waters. These individuals were found in symbiotic association with the bryozoan *Schizoporella* sp. (biogenic substrate) adhering to the pilings of Ubatuba Bay docks, São Paulo State. Only one of 20 sampled *S. fritzmuelleri* individuals presented anomalous symmetric chelipeds. Based on carapace length, size, and morphological features, the analyzed specimens seemed to be juvenile; thus, the hypothesis of anomalous condition can be directly linked to genetic inhibition of the mechanism accounting for major cheliped development in this ontogeny phase. Studies like the present one often provide remarkable information on animal morphology and can be used as reference in evolutionary assessments to be conducted in the future.

Introduction

Family Alpheidae Rafinesque, 1815 is one of the richest taxonomic groups among caridean shrimp accounting for more than 700 species, which are distributed in approximately 50 genera and exhibit high morphological diversity (Bauer, 2023); these species also stand out for their geographic and ecological distribution, worldwide (Anker *et al.*, 2006; Anker, 2020, 2022; Chow *et al.*, 2021). *Alpheus* Fabricius, 1978 and *Synalpheus* Spence Bate, 1888 are the most species-rich genera based on specific morphological and behavioral features (Bauer, 2023).

The most distinctive morphological feature in both *Alpheus* and *Synalpheus* is heterochely in the first pair of chelipeds: one cheliped is modified into an enlarged ‘snapping claw’ where as the other one has the typical morphology of a cutting or gripping appendage (Bauer, 2023). The typical snapping claw movement turned into one of the most representative sounds of biological noises in shallow marine waters. The snapping-claw mechanics is explained by a remarkably fast movement of the dactylus, which introduces a plunger structure into the propodus’ cavity (Versluis *et al.*, 2000; Patek and Longo, 2018). This interaction produces a straightforward water jet stream that produces the characteristic ‘pistol’ sound which, in its turn, remains one of the popular names attributed to these species (Au and Banks, 1998; Schmitz, 2001; Kim *et al.*, 2010).

Studies in the literature address the use of the ‘pistol’ or ‘snapping’ strategy, for different purposes, by the investigated species throughout their life (Knowlton and Moulton, 1963; Knowlton and Keller, 1982; Hughes, 1996; Lee *et al.*, 2021). However, it is mostly defined as signals emitted in conspecific communication and interspecific interactions, such as in agonistic behaviours, since they can stun their prey with the snapping sound, and many of them behave aggressively in the process to protect their cryptic crevices (Bohnenstiehl *et al.*, 2016).

In members of the genus *Synalpheus* the snapping behaviour gains a unique significance because some species exhibit eusocial colony organization within sponges (Duffy *et al.*, 2000). Communication and colony defence are significant examples of snapping behaviour in these populations (Duffy *et al.*, 2002). *Synalpheus* can be divided into two informal groups, namely: gambarelloides (mandatory symbionts of sponges) and non-gambarelloides (free-living or facultative symbionts found in biogenic substrates, without eusocial condition, as the *S. fritzmuelleri*) (Ríos and Duffy, 2007; Anker and De Grave, 2008). All records available in the literature about cheliped morphology and *Synalpheus* snapping behaviour are associated with specimens belonging to the eusocial gambarelloides group (Duffy, 1996; Duffy *et al.*, 2002; Tóth and Duffy, 2008).



Heterochely variation in eusocial populations of *Synalpheus* species has been described in the literature (Duffy and Macdonald, 1999). This variation is mainly observed in the colony's reproductive 'queens', who spend more energy in reproductive activities and often present both minor chelipeds, whereas the colony's 'helper' shrimps present the major snapping cheliped developed for both host and colony defense purposes (Chace, 1972; Duffy and Macdonald, 1999). On the other hand, according to studies available in the literature, lack of heterochely in non-eusocial species appears to be quite rare (Pearse and Govind, 1987; Anker *et al.*, 2006).

There are, at least, three studies about specimens with two major chelipeds available in the literature, mainly in *Alpheus* species (Darby, 1939; McClure, 1996; Soledade *et al.*, 2017). Moreover, interpretations about the mechanism inducing symmetry in natural conditions remain poorly explored. With respect to *Synalpheus*, there is only a brief description of one misidentified specimen available in the literature, and it does not provide any discussion about it (Hickman and Zimmerman, 2000).

The *Synalpheus fritzmulleri* Coutière, 1909 is one of the most abundant non-gambarelloides species belonging to genus *Synalpheus* and it is widely distributed in the Atlantic Ocean (Anker *et al.*, 2016). It is often found in Brazilian waters and in association with several invertebrates, such as sponges and corals, besides found free-living in consolidated substrates (Almeida *et al.*, 2018). Despite its ubiquitous nature, little is explored about this species' biology and behaviour, although it is often found as 'pair-bond' in different types of living or non-living substrates (Almeida *et al.*, 2015).

The aims of the present study were to register – for the first time – a *S. fritzmulleri* specimen presenting symmetric major chelipeds, as well as to address the consequences of this abnormality for the investigated species' natural life and behavior.

Materials and methods

Sampling procedures were conducted between October 2022 and May 2023, at Cais do Porto [docks] region, Itaguá Bay, Ubatuba City, São Paulo State, Brazil (23°27'05" S; 45°02'48" W).

Specimens were sampled in symbiosis with bryozoan biogenic substrate *Schizoporella* sp., which adhered to the pilings of the docks, at maximum depth of 4 m. All sampling procedures were performed through free-diving activities always carried out at day time.

Bryozoan fragments were carefully sampled with the aid of a small diving knife and stored in plastic bags. All biogenic substrates were carefully examined to investigate the incidence of caridean shrimp within their pores. All symbiotic species were identified in a laboratory environment; *S. fritzmulleri* specimens were isolated, photographed, and measured to enable morphological comparisons between those presenting normal features and the ones carrying abnormalities.

The following measurements were taken from all specimens in good condition (with all chelipeds intact): Carapace Length (CL);

Major Cheliped Length (MaCL), Major Cheliped Width (MaCW); Minor Cheliped Length (MiCL); and Minor Cheliped Width (MiCW).

All measurements were taken with a stereomicroscope (Zeiss Stemi SV6, fitted with Zeiss Stemi 2000-C image capture system) equipped with a camera and with AxioVisio software (version 4.8). Pictures of both major structures and body plan were taken using a stand and semiprofessional Nikon Coolpix P100 camera at 26x optical zoom.

The abnormal specimen was deposited in the Crustacean Collection of the Biology Department (CCDB) of FFCLRP, University of São Paulo, Ribeirão Preto City, Brazil (CCDB/FFCLRP/USP – Authorization n. 071/2012/SECEX/CGEN): CCDB 7556.

Results

In total, 34 caridean shrimps were recorded in association with the biogenic substrate; 20 of them belonged to species *S. fritzmulleri*. Thirteen specimens of the target species presented both chelipeds intact for measurement purposes, whereas one presented symmetry of the major claw.

Regular specimens ranged from 1.30 to 6.02 mm CL, whereas major cheliped size ranged from 2.65 to 8.87 mm, in length, and from 0.98 to 4 mm, in width. Minor cheliped ranged from 1.06 to 3.42 mm, in length, and from 0.38 to 1.14 mm, in width (mean values are described in Table 1). Anomalous species' major cheliped was 4.18 mm long and 1.71 mm wide, whereas their minor cheliped was 3.39 mm long and 1.28 mm wide.

All morphological features observed for the investigated specimen were classified as normal for regular *Synalpheus* individuals, except for lack of heterochely. Details about the investigated species' overall morphology, and comparison between regular and symmetric *S. fritzmulleri* morphology are shown in Figure 1 (panoramic image) and Figure 2 (cheliped details).

Discussion

The present study provides for the first time a record of an abnormality in the symmetry of both major chelipeds in *S. fritzmulleri*. Abnormalities and uncommon structures' growth, mainly after ecdysis processes in crustaceans, are not rare. They have been reported in several groups, namely: extra claws, in crayfishes (Nakatani *et al.*, 1997); multiple morphological deformations, in Penaeoidea shrimps (Betancourt-Lozano *et al.*, 2006; Béguer *et al.*, 2008), as well as growing deformation in the cheliped of some Brachyura crabs (Ramírez-Rodríguez and Félix-Pico, 2010). Most study results and reports available in the literature focused on isolated cases, like the one reported in the present study, according with, only one or just a small number of specimens in the investigated populations presented physical anomalies.

It is common to find situations requiring cheliped autotomy or amputation in snapping shrimps, either from in a fight or escape

Table 1. Morphological approaches by specimens of *Synalpheus fritzmulleri* Coutière, 1909 associated with bryozoarian substrates at Ubatuba Bay, SP, Brazil

<i>Synalpheus fritzmulleri</i> (Mean ± standart deviation)					
	CL	MaCL	MaCW	MiCL	MiCW
Regular condition	3.91 ± 1.30	6.01 ± 2.12	2.21 ± 0.81	2.23 ± 0.74	0.77 ± 0.21
Abnormality condition	3.01	4.18	1.71	3.39	1.28

MaCL, major cheliped length; MaCW, major cheliped width; MiCL, minor cheliped length; MiCW, minor cheliped width. Regular conditions indicate specimens with heterochely and abnormality condition indicates the specimen with symmetric chelipeds. All measures are indicated in millimetres (mm).

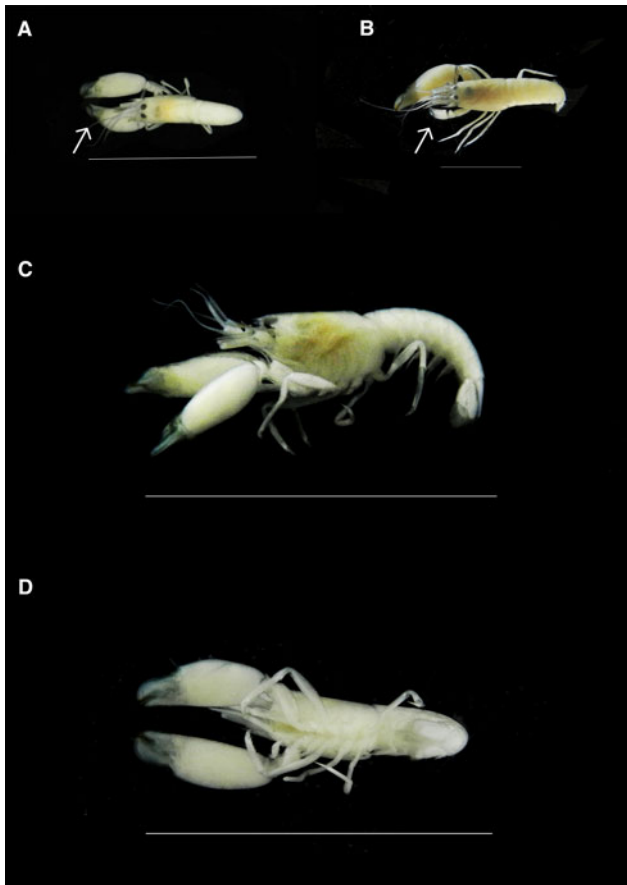


Figure 1. Overall view of the entire body of *Synalpheus fritzmuelleri* Coutière, 1909 specimen with regular conditions and with symmetric chelipeds. (A) dorsal view of the specimen with abnormality in symmetric chelipeds; (B) dorsal view of the specimen with regular asymmetric chelipeds; The white arrow points to differences in minor asymmetric cheliped and anomalous structure (C) Lateral view of the specimen with symmetric chelipeds; (D) Ventral view of the specimen with symmetric chelipeds. Scale bar: 1 cm.

from predators. Whenever autotomy takes place in the major snapping claw, the pincer (or minor claw) undergoes significant transformation into a new major cheliped (Young *et al.*, 1994; Pereira *et al.*, 2014). The transformation of the minor cheliped into snapping claw happens exactly one moult cycle after the loss of the original appendix (Read and Govind, 1997). Studies available in the literature advocate that this process takes place because the minor cheliped is likely to be the suppressed major structure, and that when the major cheliped is missing, a specific gene is activated to turn the minor claw into a major claw (Stephens and Mellon, 1979).

The two-major-chelipeds condition in specimens belonging to family Alpheidae is extremely rare, and this condition seems enables neutral or impossible the reversal control to an asymmetric morphology. Soledade *et al.* (2017) observed symmetry in *Alpheus* specimens and suggested at least three hypotheses capable of explaining the observation of this condition in the investigated animals: (1) symmetry was developed at the juvenile stage due to genetic inhibition of the mechanism accounting for developing asymmetric chelipeds; (2) symmetry was generated at the adult stage, after a single case of major cheliped autotomy and the minor cheliped's non-transformation into a snapping claw; and, finally, (3) after the adult specimen was autotomized and lost the major cheliped, it was sampled during the 'asymmetry reversal process', that is the process responsible to maintain the heterochely when some of the chelipeds are lost or are being formed.

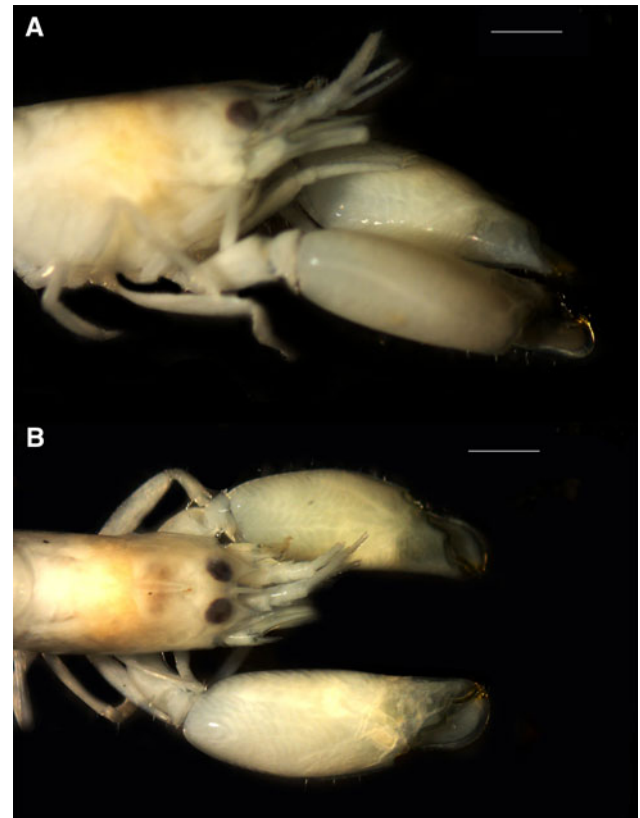


Figure 2. Image detail showing *Synalpheus fritzmuelleri* specimen, with emphasis on the symmetric cheliped. (A) lateral view; (B) dorsal view. Scale bar: 1 mm.

Based on the CL size of the herein investigated *S. fritzmuelleri* specimen, one can say that it was likely a juvenile. Its major cheliped was also smaller than the mean size observed for other specimens in the same population, whereas the minor cheliped was considered bigger than that of other individuals due to symmetry, as shown in Figure 1. The first hypothesis suggested by Soledade *et al.* (2017) appears to be herein corroborated, since the symmetry observed for the investigated *Synalpheus* specimen can result from the genetic inhibition of snapping claws' development.

It is important registering cases like this, since they present a rare condition in *Synalpheus* species; moreover, discussions about these anomalies can drive evolutionary assessment to be conducted in the future.

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Authors' contributions. *Isabela Ribeiro Rocha Moraes*: Sampling, main text writing, bibliography observation, photograph taking and edition. *Larissa Zacari*: First abnormality observation, measurements, bibliography observation, formal manuscript revision. *Rafael de Carvalho Santos*: Main text revision, English grammar correction, bibliography observation. *Gabriel Felipe Rodrigues*: Sampling, main text revision, English grammar correction, bibliography observation. *Antonio Leão Castilho*: Samples' coordination, text writing, photograph taking and full text revision. He also secured the funding that made the current study possible.

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Competing interest. None.

Ethical standards. Besides working with invertebrates, all ethical standards were applied, with licenses and procedures conducted in the best way possible for this work.

Data availability. The data that support the findings of this study are available from the corresponding author, IRRM, upon reasonable request. The abnormal specimen was deposited in the Crustacean Collection of the Biology Department (CCDB) of FFCLRP, University of São Paulo, available for consultation by number: CCDB 7556

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