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Original Article

Extension of the known range of the snapping shrimp *Alpheus christofferseni* Anker, Hurt and Knowlton, 2007 (Caridea: Alpheidae)

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ABSTRACT

Alpheus christofferseni Anker, Hurt and Knowlton, 2007 was described based on four specimens from Atol das Rocas, northeastern Brazil, and one specimen from Bocas del Toro, the Caribbean coast of Panama. Here, we report the collection of two specimens from Pernambuco, Brazil (~ 8°41'S), thus increasing the knowledge on species distribution along the Brazilian coast by approximately five latitudinal degrees south of its type locality (Atol das Rocas, Rio Grande do Norte, ~ 3°51'S). We also report a substantial increase in the known bathymetric distribution from shallow intertidal to approximately 51 m. Notes on morphological variation are provided based on the new material, and the first sequence of the 16S ribosomal subunit gene for the Brazilian coast is provided and compared with congeners.

KEYWORDS

Bathymetric range, Brazilian diversity, Decapoda, distribution, new record

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INTRODUCTION

Alpheus christofferseni Anker, Hurt and Knowlton, 2007 has been reported from Atol das Rocas, Brazil (type locality) and from the Atlantic coast of Panama, within burrows in very shallow waters (up to 1.5 m), occasionally associated with echiuran worms (Anker et al., 2007; De Grave and Anker, 2017). Herein, we report two specimens of *A. christofferseni* collected on the coast of Pernambuco State, northeastern Brazil, extending the southernmost known distribution for this shrimp in the western Atlantic by approximately five latitudinal degrees. Additionally, we report a substantial increase in the known bathymetric distribution of the species and the first sequence of the 16S ribosomal subunit gene for one specimen from the Brazilian coast, which is compared with sequences of other *Alpheus* Fabricius, 1798 species and with the sequence of *A. christofferseni* from Panama. We provide drawings illustrating the diagnostic characters and report some morphological variation observed between newly collected material and the description of *A. christofferseni*.

MATERIAL AND METHODS

We collected the first specimen (female) in one of several dredgings carried out off Recife (08°13'25.4"S 34°37'43.2"W, Fig. 1A) in 2018, at a depth of 51 m, with the aim to survey crustacean fauna associated with substrate of biogenic origin (e.g., calcareous algae, and dead coral). Calcareous algae and dead corals were brought to the laboratory, and the endolithic fauna was carefully extracted with a hammer and chisel, via substrate fragmentation. The single specimen obtained was anesthetized on ice and fixed in 70% ethanol for later identification.

We collected the second specimen (male) in 2019, at Praia dos Carneiros, Tamandaré (08°41'32"S 35°04' 25"W, Fig. 1A), on the reef near the mouth of the Formoso River. The reefs of Tamandaré are a set of beach rocks approximately 1 km offshore from the beach. The Tamandaré reef complex is part of the Environmental Protection Area "Costa dos Corais", the largest Federal Marine conservation area of Brazil (Maida and Ferreira, 2004). The specimen was collected by using artificial refuge structures (ARS) as described by Bochini et al. (2020).

The female specimen was deposited in the Museum of Oceanography "Prof. Petrônio Alves Coelho" of the Federal University of Pernambuco, Brazil (MOUFPE) and the male was deposited in the Coleção de Crustáceos do Departamento de Zoologia da Universidade Federal do Rio Grande do Sul, Brazil (DZ/UFRGS). The male specimen was used for drawings made under a dissecting stereomicroscope equipped with a camera lucida and for genetic data. Drawings of the specimen were made by using Adobe Illustrator CS6, according to the methods described by Coleman (2003; 2009). The carapace length (CL, in mm – from the postorbital angle to the posterior margin of the carapace) was measured using a stereomicroscope equipped with a camera lucida and image capture system.

DNA extraction from the male specimen, PCR amplification with specific primers for a region of the 16S ribosomal subunit gene (~550 base pairs), amplicon cleanup, and sequencing were conducted following the laboratory protocols described by Soledade et al. (2019). The obtained sequence and some sequences from the GenBank were used for analysis: one sequence from *A. christofferseni* from Panama, six sequences from species morphologically close to *A. christofferseni* belonging to the *brevirostris* group [*Alpheus barbatus* Coutière, 1897, *Alpheus bellulus* Miya and Miyake, 1969, *Alpheus floridanus* Kingsley, 1878, *Alpheus glaber* (Olivi, 1792) and *Alpheus* aff. *macroskeles* Alcock and Anderson, 1899] and two sequences used as the outgroup (Fig. 1B). Other 16S gene sequences from closely related species were not available in GenBank. Sequences were aligned by using the MUSCLE software (Edgar, 2004) with default parameters, and Maximum Likelihood performed using RAxML (Stamatakis, 2014) on the platform Cyberinfrastructure for Phylogenetic Research (Miller et al., 2010). The topology consistency was measured by the bootstrap method, and the phylogenic trees were viewed and edited in MEGA X (Kumar et al., 2018). Only support values above 75% are shown. A genetic distance (p distance) was calculated in MEGAX (Kumar et al., 2018). The sequence obtained in this study was deposited in GenBank (Fig. 1B).

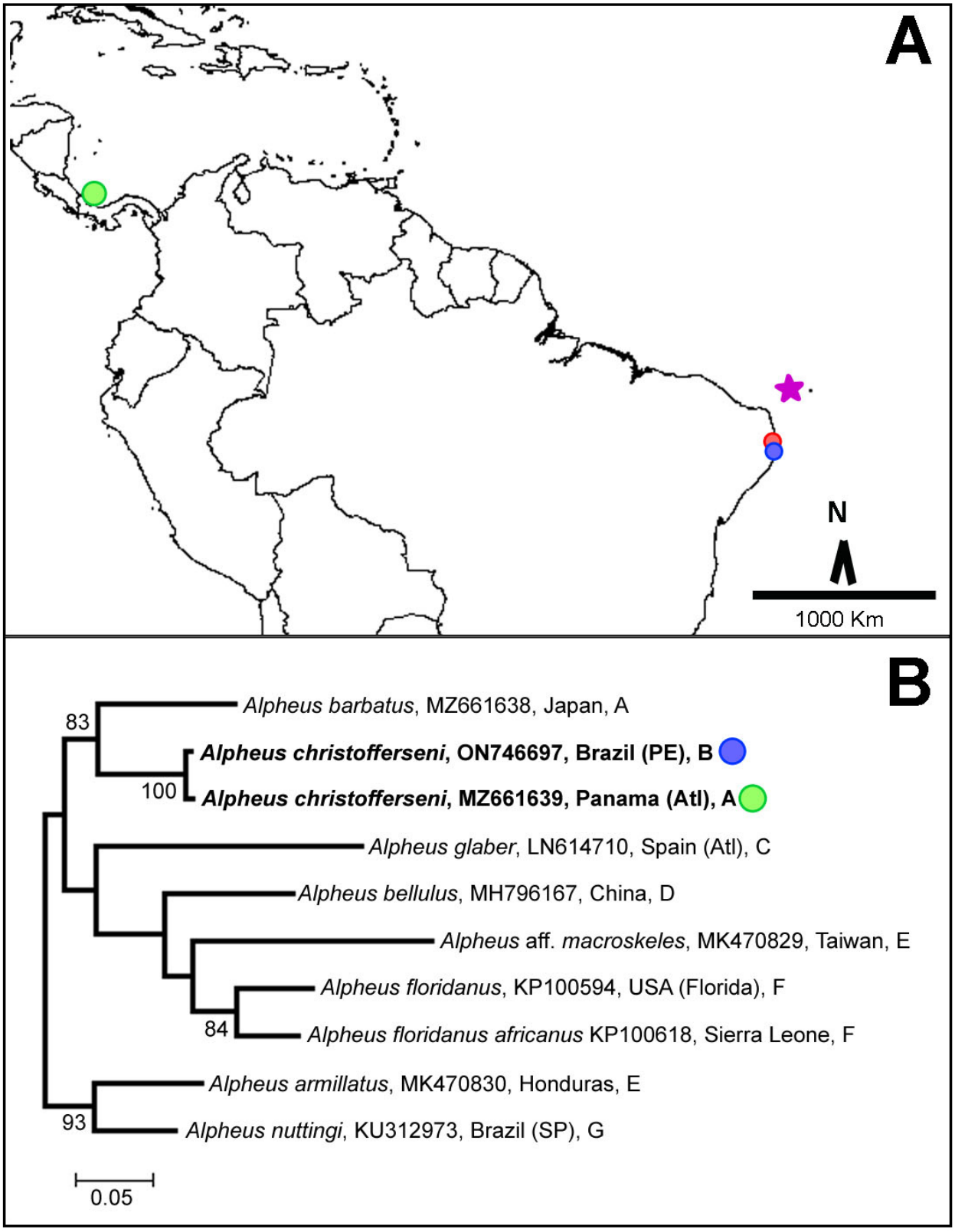

Figure 1. *Alpheus christofferseni* Anker, Hurt and Knowlton, 2007. **A**, Presently known distribution, star represents the type locality, blue and red circles represent the new occurrences, and green circle represents specimen previously reported from Panama. **B**, Phylogram of *A. christofferseni* (bold) and some congeners morphologically similar, using the Maximum Likelihood analysis of the 16S ribosomal subunit gene. Numbers are support values for 960 bootstraps; values < 75% were not included. Atl: Atlantic; PE: Pernambuco; SP: São Paulo. References: A, Chow et al. (2021); B, This study; C, Roura et al. (2018); D, Wang et al. (2020); E, Liao et al. (2019); F, Bracken-Grisson et al. (2014); G, Almeida et al. (2018).

SYSTEMATICS

Family Alpheidae Rafinesque, 1815

Genus *Alpheus* Fabricius, 1798

Alpheus christofferseni Anker, Hurt and Knowlton, 2007

(Fig. 2)

Alpheus christofferseni Anker, Hurt and Knowlton, 2007: 3, figs. 1–6, 11a–c, 12b, c; De Grave and Fransen, 2011: 380; Soledade and Almeida, 2013: 97; De Grave and Anker, 2017: 4.

Material examined. Brazil, Pernambuco: 1 female (CL: 3.8 mm), MOUFPE 20210, of Recife, associated with a biogenic substrate such as calcareous algae, dead coral, and sponges, depth: 51 m, 27.ii.2018, colls. G.L. Bochini, G.O. Soldade and R. Gueron; 1 male (CL: 3.3 mm), DZ/UFRGS 6934 (genetic voucher, GenBank access ON746697), Praia dos Carneiros, Tamandaré, ARS, depth: 3–6 m, 20.viii.2019, colls. G.L. Bochini and G.O. Soledade.

Distribution. The species is found in the Western Atlantic: Panama (Bocas del Toro) and Brazil [Atol das Rocas and Pernambuco (off Recife and Tamandaré)] (Anker et al., 2007; this study).

Habitat. The species is mainly found in burrows on intertidal or shallow seagrass flats (0–1.5 m), associated with echiurans (Anker et al., 2007); reef areas (beach rock) 3–6 m; and substrate of biogenic origin such as calcareous algae, and dead coral, 51 m (this study).

Genetic data. The topology obtained (Fig. 1B) showed a clade formed by the two sequences of *A. christofferseni* and a clear separation of these from the other species. The intraspecific genetic distance of *A. christofferseni* was 0.9%, much smaller than the divergence of this species from other species of the *brevirostris* group (9.9% - 14.4%).

Remarks. The distribution range of *A. christofferseni* is extended by approximately five degrees south from the type locality (Atol das Rocas, ~3°51”S, Fig. 1A). The current southernmost record of the species is Praia dos Carneiros, Tamandaré, Pernambuco (~8°41’S). Furthermore, the bathymetric distribution increased significantly considering the collection of a specimen at 51 m depth. The specimens from Pernambuco (female and male) resemble the holotype. However, some morphological variations between the two specimens from Pernambuco and the holotype were observed, such as the exopod of the third maxilliped (Fig. 2B, C) reaches the penultimate segment of the endopod (vs. not reaching the penultimate segment of the third maxilliped in the holotype); telson (Fig. 2H, I) with mesial spiniform setae 4.5 times longer than the lateral spiniform setae (vs. mesial spiniform setae twice the size of the lateral spiniform setae in the holotype); third and fourth pereiopods (Fig. 2F, G) armed with four spiniform setae along the ventral margin and a pair of distal spiniform setae (vs. five spiniform setae and a pair of distal spiniform setae in the holotype).

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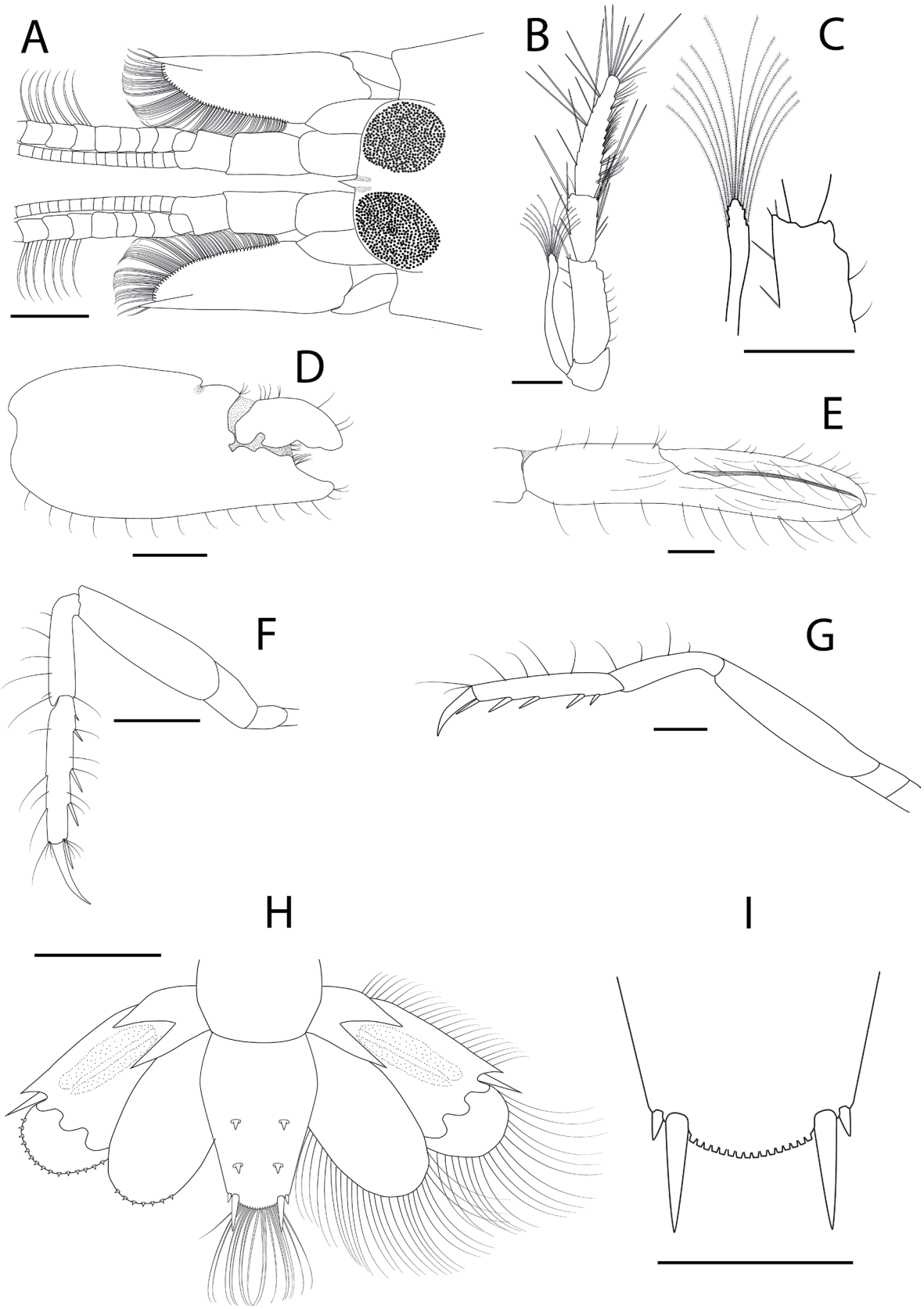

Figure 2. *Alpheus christofferseni* Anker, Hurt and Knowlton, 2007, male from Praia dos Carneiros, Tamandaré, Pernambuco, Brazil (DZ/UFRGS 6934): **A**, Frontal region and cephalic appendages, dorsal view; **B**, third maxilliped, lateral view; **C**, detail of the exopod of the third maxilliped, lateral view; **D**, left major cheliped, lateral view; **E**, right minor cheliped, lateral view; **F**, third pereiopod, lateral view; **G**, fourth pereiopod, lateral view; **H**, telson and uropod, dorsal view; **I**, same, detail of posterior margin. Scale bars: **A**, **D**, **F**, **H**, **I** = 1 mm; **B**, **C**, **E**, **G** = 0.5 mm.

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ADDITIONAL INFORMATION AND DECLARATIONS

Author contributions

Conceptualization and Design: GLB, RG, AOA; Performed research: GLB, RG, AOA; Acquisition of data: GLB, RG, MT, AOA; Analysis and interpretation of data: GLB, RG, MT, AOA; Preparation of figures/tables/maps: GLB, MT; Writing – original draft: GLB; Writing – critical review & editing: GLB, RG, MT, AOA.

Consent for publication

All authors declare that they have reviewed the content of the manuscript and gave their consent to submit the document.

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Conflicts of interest

The authors have no conflicts of interest to declare.

Study permits

Field collection and transportation of specimens were made under the SISBIO permit number 58697-1 issued to G. L. Bochini

Data availability statement

All data generated and analyzed during this study are presented in this article.