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DESCRIPTION OF A NEW SPECIES OF *PACHYCHELES* (DECAPODA, ANOMURA, PORCELLANIDAE) FROM THE SOUTHERN CARIBBEAN SEA

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ABSTRACT

A new species of porcellanid crab from the southern Caribbean Sea is described. *Pachycheles tuerkayi* n. sp. has been confused with *P. serratus* (Benedict, 1901) since the 1950s because the two species are morphologically and ecologically similar and have overlapping distributions in the southern Caribbean. *P. tuerkayi* n. sp. is restricted to the coasts of Costa Rica, Panamá and Colombia. *P. serratus* ranges from Puerto Rico and the Virgin Islands to the coasts of Panamá, Colombia and Venezuela. Genetic differences based on DNA sequences of the mitochondrial 16S rDNA gene from the two species surpassed those estimated for geminate porcellanids on each side of the Isthmus of Panamá. Field observations where *P. tuerkayi* n. sp. and *P. serratus* overlap indicated that the two species come into contact when sharing the same substrate. The total number of porcellanid species in the western Atlantic rises to 50.

ZUSAMMENFASSUNG

Eine neue Porzellaniden-Art aus dem Karibischen Meer wird beschrieben. *Pachycheles tuerkayi* n. sp. und *P. serratus* (Benedict, 1901), deren Verbreitung sich in der südlichen Karibik überschneidet, sind, seit den 1950er Jahren, wegen ihrer morphologischen Ähnlichkeiten und wegen ihres Vorkommens in der gleichen ökologischen Situation für eine Art gehalten worden. Die Verbreitung von *P. tuerkayi* n. sp. ist auf die Küste von Costa Rica, Panamá und Kolumbien beschränkt, während *P. serratus* in Puerto Rico, den Jungferninseln, sowie in Panamá, Kolumbien und Venezuela vorkommt. Die genetischen Distanzen, die sich aus dem Vergleich von DNS Sequenzen des mitochondrialen 16S rDNS Gens der beiden Arten ergeben, gehen über diejenigen hinaus, die für Zwillingsarten beiderseits des Isthmus von Panamá ermittelt wurden. Feldbeobachtungen im Überlappungsgebiet beider Arten zeigen, dass diese miteinander in Kontakt kommen können, wenn sie das gleiche Substrat bewohnen. Die Gesamtzahl der west atlantischen Porzellaniden beträgt nun 50 Arten.

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INTRODUCTION

The porcellanid fauna of the western Atlantic has been intensively studied since the 1950s (Haig, 1956; Gore, 1970, 1982; Gore & Abele, 1976; Werding, 1977, 1978, 1982; Werding & Hiller, 2002). Werding et al. (2003) reported 48 species (including 2 formerly known only from the East Pacific), and Werding & Hiller (2005) added *Petrolisthes hispaniolensis* Werding & Hiller, 2005, increasing the number to 49 West Atlantic species.

The new species described here as *Pachycheles tuerkayi* n. sp. was first discerned by Haig (1956) as a pubescent form of the tropical *Pachycheles serratus* (Benedict, 1901). Haig highlighted a "thick pile of fine hairs" on the chelipeds of specimens from Bahía Caledonia, Panamá. Later, Gore (1970, 1982) recorded the pubescent and non-pubescent forms from Panamá, although Gore & Abele (1976) only referred to pubescent specimens from the same region. Werding (1977) reported on the two forms in the area of Santa Marta, Colombia, but only on the pubescent form in the Colombian Gulf of Urabá (Werding, 1978) and Islas del Rosario (Werding, 1982).

Here, we describe the pubescent form as *Pachycheles tuerkayi* n. sp. and designate the non-pubescent form as *P. serratus* (fig. 1), as this corresponds to Benedict's (1901) description (see Discussion). Genetic distances based on DNA sequences of the mitochondrial 16S rDNA gene from the two species were estimated to explore species boundaries and to establish intra- and interspecific divergence. The new species becomes the 50th member of the West Atlantic porcellanid fauna.

MATERIAL AND METHODS

Preserved specimens of *Pachycheles serratus* and *P. tuerkayi* n. sp. collected in Panamá (Bocas del Toro, Playa Diablo), Colombia (Islas del Rosario and Santa Marta) and Venezuela were used for morphological examination and molecular analyses. Material of the new species is deposited in the collections of the Museo de Historia Natural Marina de Colombia (INV CRU) at the Institute of Marine and Coastal Research of Colombia, Santa Marta (INVEMAR), and the Forschungsinstitut und Naturmuseum Senckenberg, Frankfurt am Main (SMF), Germany. Specimens were sexed and measured by using a stereoscope with a micrometer. Measurements correspond to carapace length followed by carapace width.

DNA was extracted from the chelipeds or walking legs using the QIAGEN DNeasy® Kit following the protocol for animal tissue. A region of approximately 540 bp of the mitochondrial 16S rDNA gene was amplified with the primers

16Sar-L (5′-CGCCTGTTTAACAAAAACAT-3′) and 16Sbr-H (5′-CCGGTTTGA ACTCAGATCATGT-3′) (Palumbi et al., 1991). Double-stranded amplifications were performed in 25 μl volume reactions containing 5 μl of *Taq* buffer (5×), 2.5 μl of dNTP mix (8 mM, Promega), 1.2 μl of each primer (10 μM), 2.5 μl of $MgCl_2$ (25 mM), 0.2 μl of GoTaq® Flexi DNA *Taq* Polymerase (Promega), 1 μl of DNA template, and 11.4 μl of ddH_2O. Thermal cycling conditions consisted of an initial denaturation at 96°C for 3 min, followed by 30 cycles of 95°C for 1 min, 52°C for 1 min, and 72°C for 1 min. A final extension step at 72°C for 5 min followed the last cycle. PCR products were cleaned using ExoSAP-IT® (Affymetrix-USB) following the manufacturer's protocol. Cleaned products were sequenced in both directions using the BigDye® Terminator v3.1 Cycle Sequencing Kit (Applied Biosystems) in 10 μl reactions as follows: 1 μl of PCR product was mixed with 4 μl of ddH_20, 3 μl of sequencing buffer (5×), 1 μl of primer and 1 μl of BigDye ready-reaction mix. The mixture was subjected to thermal cycling conditions consisting of an initial denaturation step at 96°C for 1 min, followed by 25 cycles of 96°C for 10 s, 50°C for 5 s, and 60°C for 4 min. Cycle sequencing reactions were run on an ABI PRISM 3130xl Genetic Analyzer (Applied Biosystems). Two GenBank sequences were included in the data set: *Pachycheles serratus* (JF900732) and *P. setimanus* (Lockington, 1878) (JF900730), both from Bocas del Toro, Panamá. The later sequence caught our attention because *P. setimanus* is morphologically close to *P. serratus* (see below), but is restricted to the tropical East Pacific (Haig, 1960). Sequences were aligned using MAFFT v.7 (Katoh et al., 2002) with the L-Ins-i algorithm and default gap opening/extension penalties. Genetic distances within and between *Pachycheles serratus* and *P. tuerkayi* n. sp. were estimated using the Kimura-2-parameter model (K2P; Kimura, 1980) implemented in MEGA v.6.06 (Tamura et al., 2013). DNA sequences obtained for this study were given GenBank accession numbers KY860741-KY860763.

RESULTS

Molecular results

The alignment of 23 partial sequences of the 16S rDNA gene was 535 bp long. Average percent K2P distances within *Pachycheles tuerkayi* n. sp. (14 sequences in total) averaged at 0.17%, and within *P. serratus* (9 sequences in total) at 0.04%. Distances between the two species averaged 6.8%. These distance estimations excluded the GenBank sequence labeled as *P. serratus* from Bocas del Toro, Panamá (JF900732), because it matched DNA sequences of the West Atlantic *P. cristobalensis* Gore, 1970 (A.H., unpublished data). The GenBank sequence

labeled as *Pachycheles setimanus* from Bocas del Toro (JF900730) matched sequences of *Pachycheles tuerkayi* n. sp. and, therefore, was included in our distance estimation.

Systematic account

Family PORCELLANIDAE Haworth, 1825

Pachycheles tuerkayi n. sp.

(figs. 1a, 2, 3)

Pachycheles serratus Haig, 1956 (part, pp. 8-9); Gore, 1970 (part, p. 962), 1982 (part, p. 9); Werding, 1977 (part, p. 194-195); Gore & Abele, 1976 (p. 20); Werding, 1978 (p. 219), 1982 (pp. 441-442); Vargas & Cortés, 2006 (p. 485).

Material examined.— Holotype, male (5.1 × 5.4 mm), INV CRU 8408, Colombia, Magdalena, Santa Marta, El Morro, under boulders, 2-3 m, leg. B. Werding, 9 Sep 1974. Paratypes: 3 males (3.6 mm × 3.8 mm, 4.0 × 4.3 mm, 4.8 mm × 5.1 mm), 2 females (4.8 mm × 5.5 mm, 4.2 mm × 4.7 mm), 2 ov. females (4.3 mm × 5.0 mm, 5.2 mm × 5.8 mm), INV CRU 8409, same data as holotype; 3 males (4.7 × 5.0 mm, 4.5 × 4.9 mm, 4.0 × 4.3 mm), 3 ov. females (5.0 × 5.8 mm, 4.8 × 5.5 mm, 4.0 × 4.3 mm), SMF 50188, Colombia, Gulf of Urabá, Napú, under boulders, 2-4 m, leg. B. Werding, 1977; 4 males (4.5 × 4.8 mm, 4.4 × 4.7 mm, 4.3 × 4.7 mm, 4.2 × 4.5 mm), 1 female (4.7 × 5.2 mm), 1 ov. females (4.8 × 5.2 mm), SMF 59189, Colombia, Magdalena, Santa Marta, under boulders, 0.5-2 m, leg. B. Werding, 1974.

Description.— Carapace somewhat broader than long in both sexes, dorsal surface smooth, metabranchial regions plicate, regions not marked. No epibranchial spine, epibranchial border crested. Front narrow, convex or slightly trilobate, scarcely produced, orbits deep, inner orbital angle rounded, outer orbital angle produced into a forwardly directed prominent tooth. Lateral walls with a trapezoid plate in anterior half and a large sub-quadrate plate frequently followed by a small fragment in posterior half.

First movable segment of antenna with a blunt conical tooth; second granulate and third cylindrical, smooth; flagellum two times as long as carapace. Basal segment of antennules forwardly directed, forming a rectangular, serrated lobe along the frontal margin.

Chelipeds thick, one distinctly larger, inner distal edge of merus produced into a large tuberculate lobe, upper surface with continuous transversal ridges; carpus about as long as broad, surface with transversal scale like ridges and round granules, anterior margin armed with three large, irregular teeth, decreasing in size distally; dorsal surface covered distally with long, plumose setae which hide most of the frontal and distal borders. Posterior border slightly convex. Chelae extremely large, the bigger one exceeding by far the size of cephalothorax in large males (figs. 1a, 2). Distal border of chelae somewhat depressed at the level of the base of the pollex. Upper surface of chelae covered with round granules, most of the surface covered with thick setae, except on inner border and fingers. Fingers of

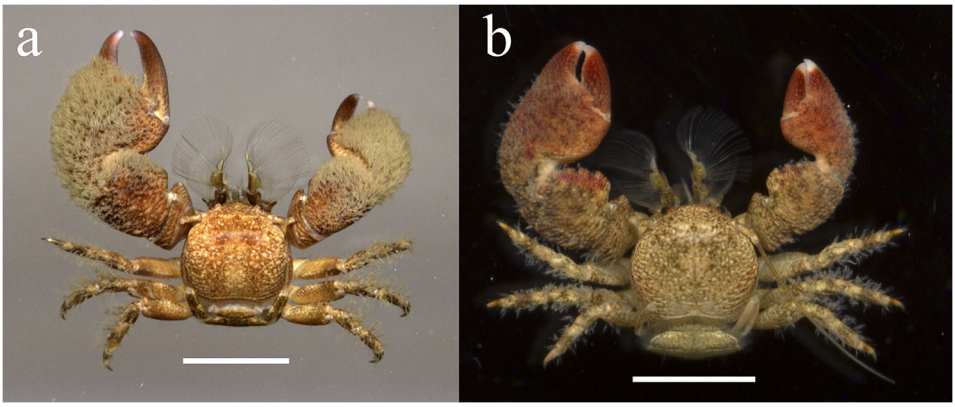

Fig. 1. a, *Pachycheles tuerkayi* n. sp. from Santa Marta, Colombia, large male, INV CRU 8409; scale = 4.5 mm. b, *P. serratus* (Benedict, 1901) from the Gulf of Morrosquillo, Colombia, large male. Scale = 4.5 mm.

chelipeds slender, widely gaping in large specimens, and closing at entire length in smaller ones.

Walking legs slender, with scattered plumose setae more dense on carpus and propodus; dactylus slender, with three movable spines.

Males with pleopods; telson with seven plates.

Coloration.— The smooth carapace of *Pachycheles tuerkayi* n. sp. is brown, sometimes grayish, spotted with irregular light marks. The chelipeds are uniformly brown, darker in the distal parts of the fingers, whose tips are white. Setae on

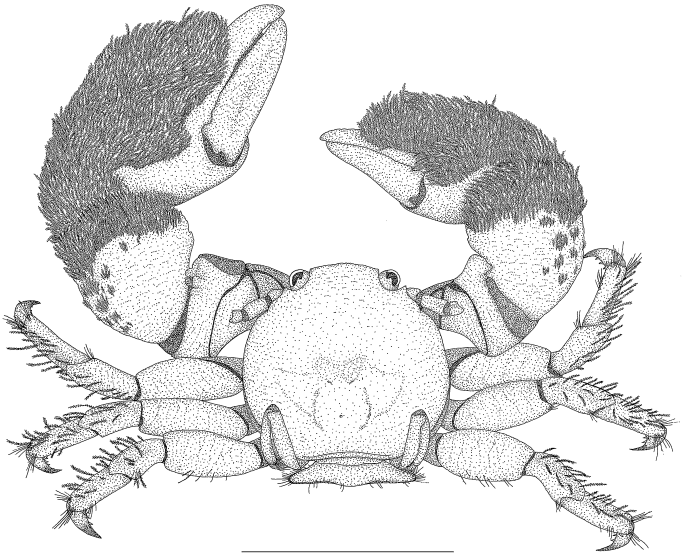

Fig. 2. *Pachycheles tuerkayi* n. sp., male holotype, INV CRU8408, dorsal view. Scale = 5.4 mm.

carpus and manus are beige. Walking legs are of the same colour as the carapace, a bit paler near articulations.

Ecology.— *Pachycheles tuerkayi* n. sp. lives in crevices between stones and other hard substrates in moderately exposed shallow water from intertidal areas to waters 6 m deep, often where there are fine sediments and some brackish water influence. It occurs with *P. serratus* in the same habitat in the Santa Marta region in Colombia.

Distribution.— Atlantic coast of Costa Rica, Panamá and Colombia, from Puerto Vargas (Costa Rica) to Islas del Rosario and Santa Marta (Colombia).

Etymology.— The new species is named after Michael Türkay, long-time friend and colleague.

Remarks.— *Pachycheles tuerkayi* n. sp. (figs. 1a, 2, 3) can be distinguished from *P. serratus* (figs. 1b, 4) by having (1) a carapace with smooth, shiny surface, (2) most of the cheliped's dorsal surface densely covered with setae, and (3) the cheliped's distal margin somewhat depressed on the level of the base of the pollex. In *P. serratus* the surface of the carapace is coarser, the dorsal surface of the chelipeds bears no setae or only a few scattered ones, and the distal margin of the cheliped is not depressed. *P. tuerkayi* n. sp. and *P. serratus* belong to a

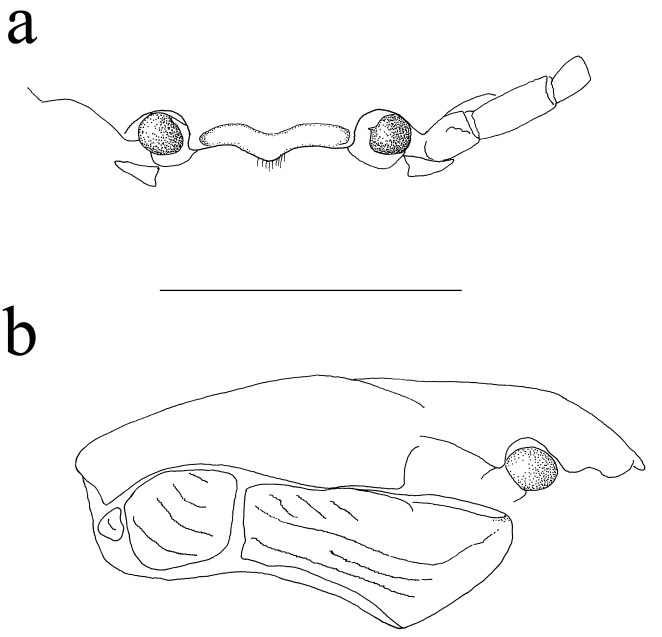

Fig. 3. *Pachycheles tuerkayi* n. sp., male holotype, INV CRU8408. a, carapace, frontal view; b, carapace, lateral view. Scale = 2.8 mm.

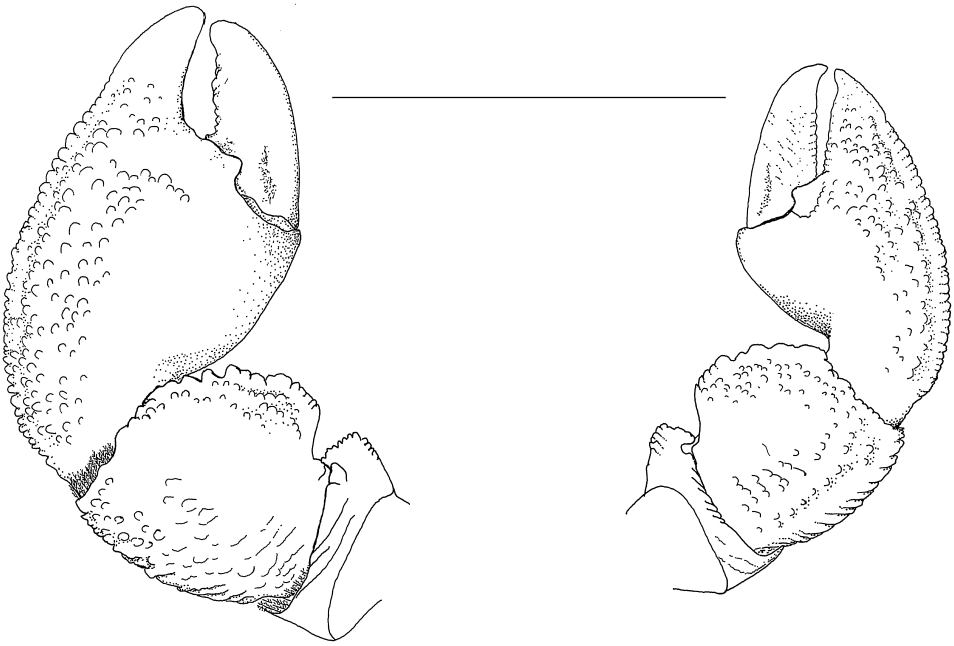

Fig. 4. *Pachycheles serratus* (Benedict, 1901), male, SMF 50196, chelipeds, dorsal view. Scale = 4.5 mm.

morphological group of *Pachycheles* species from the tropical Atlantic and eastern Pacific, characterized by having the carapace with scarce setae, and the carpus and manus of chelipeds covered with granules. This group is represented by *P. chacei* Haig, 1956 and *P. cristobalensis* in the Caribbean, by *P. greeleyi* (Rathbun, 1900) in Brazil, and by *P. sahariensis* Monod, 1933 in the eastern Atlantic. In the eastern Pacific the group is represented by *P. calculosus* Haig, 1960, *P. setimanus* and *P. chacei* (present on both sides of the Isthmus of Panamá). All species have a telson with 7 plates, except *P. chacei*, which has a 5-plated telson. *P. tuerkayi* n. sp., *P. serratus* and *P. setimanus* have the presence of male pleopods in common. Males in the other species in this *Pachycheles* group do not have pleopods.

DISCUSSION

Pachycheles tuerkayi n. sp. poses one more example of cryptic diversity within Porcellanidae. Other cases of species complexes in this family also comprise closely related species with overlapping distributions and ecologies (e.g., Hiller et al., 2006; Hiller & Werding, 2007). The new species and *P. serratus* diverge with average percent genetic distances (K2P = 6.9%) larger than those estimated

between Pacific and Atlantic populations of the porcellanid *Petrolisthes armatus* (Gibbes, 1850) (K2P = 1.5%), which are assumed to have been connected until the last stages of completion of the Isthmus of Panamá (Lessios, 2008). *Pachycheles tuerkayi* n. sp. and *P. serratus* probably diverged before the Isthmus finished emerging. Following the descriptions and observations by other authors, we reconstructed the geographical distribution of these two species. *Pachycheles serratus* was first described from Puerto Rico by Benedict (1901) as *Pisosoma serrata*. In the original description, this author does not mention or depict pubescence on the chelipeds (Benedict, 1901, pl. 3, fig. 7). Following Benedict's description, Schmitt (1935) characterized the species' chelipeds as "quite naked" and "more or less covered with bead-like rounded granules" and reported a range extension to St. Thomas and Cartagena, Colombia. Lira et al. (2007) described *P. serratus* from Venezuela as having sparse or lacking setation. Vargas & Cortés (2006) do not mention this character, but later revision of the specimens from Costa Rica revealed that they correspond to the new species (R. Vargas, personal communication). *P. serratus* seems to be a common species with a northern distribution in Puerto Rico and the Virgin Islands and a coastal one in Panamá, Colombia and Venezuela. *Pachycheles tuerkayi* n. sp. seems to be the predominant species on the Caribbean coasts of Costa Rica, Panamá and Colombia, where it co-occurs with *P. serratus*, occupying the same habitats. More ecological observations are needed to establish how the two species share very similar or the same habitat.

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REFERENCES

BENEDICT, J. E., 1901. The anomuran collections made by the Fish Hawk Expedition to Porto Rico. Bull. U.S. Fish Comm., **20**: 139-148.

GORE, R. H., 1970. *Pachycheles cristobalensis* sp. nov. with notes on the porcellanid crabs of the southwestern Caribbean. Bull. Mar. Sci., **20**: 957-970.

GORE, R. H., 1982. Porcellanid crabs from the coasts of Mexico and central America (Crustacea: Decapoda: Anomura). Smithson. Contrib. Zool., **363**: 1-34.

GORE, R. H. & L. G. ABELE, 1976. Shallow water porcelain crabs from the Pacific coast of Panama and adjacent Caribbean waters (Crustacea: Anomura: Porcellanidae). Smithson. Contrib. Zool., **237**: 1-30.

HAIG, J., 1956. The Galatheidea (Crustacea Anomura) of the Allan Hancock Atlantic Expedition with a review of the Porcellanidae of the western North Atlantic. Allan Hancock Atlantic Expedition Report, **8**: 1-45.

HAIG, J., 1960. The Porcellanidae (Crustacea Anomura) of the eastern Pacific. Allan Hancock Pacific Expeditions, **24**: 1-440.

HILLER, A., H. KRAUS, M. ALMON & B. WERDING, 2006. The *Petrolisthes galathinus* complex: species boundaries based on color pattern, morphology and molecules, and evolutionary interrelationships between the complex and other Porcellanidae (Crustacea: Decapoda: Anomura). Mol. Phylogenet. Evol., **40**: 547-569.

HILLER, A. & B. WERDING, 2007. Redescription of *Petrolisthes edwardsii* (de Saussure) and description of a new, sibling species from the eastern Pacific based on different colour, morphology and genetic identity (Crustacea: Anomura: Porcellanidae). Org. Divers. Evol., **7**: 181-194.

KATOH, K., K. MISAWA, K. KUMA & T. MIYATA, 2002. MAFFT: a novel method for rapid multiple sequence alignment based on fast Fourier transform. Nucleic Acids Res., **30**: 3059-3066.

KIMURA, M., 1980. A simple method of estimating evolutionary rates of base substitutions through comparative studies of nucleotide sequences. J. Mol. Evol., **16**: 111-120.

LESSIOS, H. A., 2008. The great American schism: divergence of marine organisms after the rise of the central American isthmus. Annu. Rev. Ecol. Evol. Syst., **39**: 63-91.

LIRA, C., G. HERNÁNDEZ, J. BOLAÑOS, K. GRATEROL & M. PIÑATE, 2007. Cangrejos porcelánidos (Decapoda: Anomura) de las islas nororientales de Venezuela. II. El género *Pachycheles* Stimpson, 1858. Bol. Inst. Oceanogr. Venez., **46**: 37-50.

PALUMBI, S. R., A. MARTIN, S. ROMANO, W. O. MCMILLAN, L. STICE & G. GRABOWSKI, 1991. The Simple Fool's Guide to PCR, ver. 2: 1-45. (Department of Zoology and Kewalo Marine Laboratory, University of Hawaii, Honolulu, HI).

SCHMITT, W. L., 1935. Crustacea Macrura and Anomura of Porto Rico and the Virgin Islands. Scientific Survey of Porto Rico and the Virgin Islands, **15**: 125-227.

TAMURA, K., G. STECHER, D. PETERSON, A. FILIPSKI & S. KUMAR, 2013. MEGA6: molecular evolutionary genetics analysis version 6.0. Mol. Biol. Evol., **30**: 2725-2729.

VARGAS, R. & J. CORTÉS, 2006. Biodiversidad marina de Costa Rica: Crustacea: infraorden Anomura. Rev. Biol. Trop., **54**: 461-488.

WERDING, B., 1977. Los porcelánidos (Crustacea, Anomura, Porcellanidae) de la región de Santa Marta, Colombia. An. Ist. Invest. Mar. Punta de Betín, **9**: 173-214.

WERDING, B., 1978. Los porcelánidos (Crustacea: Anomura: Porcellanidae) de la región de Acandí (Golfo de Urabá) con algunos encuentros nuevos de la región de Santa Marta (Colombia). An. Ist. Invest. Mar. Punta de Betín, **10**: 213-221.

WERDING, B., 1982. Porcellanid crabs of the Rosario Islands, Caribbean coast of Colombia, with a description of *Petrolisthes rosariensis* new species (Crustacea: Anomura). Bull. Mar. Sci., **32**: 439-447.

WERDING, B. & A. HILLER, 2002. A new species of the *Petrolisthes galathinus* complex from the southern Caribbean Sea, with a discussion on the identity of *P. galathinus* (Bosc, 1802) (Decapoda, Porcellanidae). Crustaceana, **75**: 849-857.

WERDING, B. & A. HILLER, 2005. A new porcellanid species from the Caribbean Sea, with a discussion on the American "*Petrolisthes lewisi*-group" (Decapoda, Anomura, Porcellanidae). Crustaceana, **78**: 1185-1190.

WERDING, B., A. HILLER & R. LEMAITRE, 2003. Geographic and depth distributional patterns of western Atlantic Porcellanidae (Crustacea: Decapoda: Anomura) with an updated list of species. Proc. ICC5-Anomuran Symposium. Mem. Mus. Victoria, **60**: 77-85.

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