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ORIGINAL ARTICLE

A new species and first record of *Pulmoniscus* Leistikow, 2001 (Isopoda, Oniscidea, Philosciidae) from Colombia

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ABSTRACT

A new species of *Pulmoniscus* Leistikow, 2001 from Department of Bolívar, Colombia, is described. It constitutes the first record of the genus for the country and for the continental portion of the Neotropics. *Pulmoniscus turbanaensis* n. sp. is distinguished by the male pereopod 7 ischium with concave sternal margin and the shape of the male pleopod 1. In addition, ecological remarks and a distribution map are provided.

KEY WORDS

Crustacea, Terrestrial isopods, Bolívar, Tropical Dry Forest, Neotropical.

INTRODUCTION

The family Philosciidae Kinahan, 1857 is one of the most diverse within the suborder Oniscidea, surpassed only by the Armadillidae Brandt, 1833 (Sfenthourakis and Taiti, 2015). Philosciidae includes approximately 600 species placed in 115 genera and it is widely distributed in Australia, southern Asia, Africa, Europe, and the Americas (Leistikow, 2001; Schmalfuss, 2003; Taiti and Schotte, 2016). This family constitutes one of the most important groups of terrestrial isopods in tropical and wetlands habitats (Leistikow, 2001). To date, the family is considered paraphyletic due to characteristics shared with the families Halophilosciidae Verhoeff, 1908 and Scleropactidae Verhoeff, 1938 (Leistikow, 2001; Schmidt, 2008).

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The monotypic genus *Pulmoniscus* Leistikow, 2001 (Philosciidae) comprises *Pulmoniscus insularuminfraventum* (Vandel, 1952) from Gran Roque (Winward Islands), Cerros Orientales, Venezuela. The genus is mainly defined by the cephalon without lateral lobes, outer endite of maxillula with crown-shaped and 3-tiped apex teeth on outer set, pleopod exopods with monospiracular covered lungs (Leistikow, 2001).

The present work describes a new species of *Pulmoniscus*, constituting the first record of the genus in Colombia. In addition, ecological remarks and a distribution map are provided.

Material and Methods

Specimens were stored in 75% ethanol and identifications were based on morphological characters. The appendages (antennulae, antennae, buccal pieces, pereopods and pleopods) were prepared in glycerin. The images were obtained with Axio Lab. A1 microscope and SteREO Discovery.V12 ZEISS stereomicroscope with adapted camera Axiocam ERc 5s. The final illustrations were prepared using the software GIMP with the methods proposed by Coleman (2006) and Montesanto (2015; 2016). The coordinates of the *noduli laterales* were obtained and figured as in Vandel (1962).

Abbreviations

CUDC-CRU: Colección de Crustáceos del Programa de Biología de la Universidad de Cartagena, Cartagena de Indias, Colombia.

ICN-CI: Colección de Crustáceos Isópodos del Instituto de Ciencias Naturales, Universidad Nacional de Colombia, Bogotá, Colombia.

Study Area

The three studied localities are placed at the northern Department of Bolívar, western portion of the Colombian Caribbean (Fig. 1). These localities belong to the Tropical Dry Forest (TDF) ecosystems, characterized by high levels of endemism and beta-diversity. TDF is currently one of the most endangered ecosystems in the world (García *et al.*, 2014). There are several factors that have caused the fragmentation of this ecosystem. The high level of human establishment, the intense transformation resulted by livestock farming, thinning wood, and burning for the establishment of crops sowing are among the responsible factors for this fragmentation (Escobar, 1997; Rangel-Ch. *et al.*, 1997).

The Macondo estate, Turbaco is part of one remaining TDF area. It is located at 100 m from the Botanical Garden Guillermo Piñeres, at an altitude of 130 m. The average annual temperature and precipitation are 28°C and 900–1,200 mm, respectively. This region is characterized by having marked dry, rainy, and transition seasons, with annual humidity level of approximately 70% (Alcaldía de Turbaco-Bolívar, 2012). The vegetative cover is composed by fruit and ornamental species such as meddler (*Manilkara sapota*), mango (*Mangifera indica*), bamboo (*Bambusa vulgaris*), and sapodilla tree (*Pouteria sapota*); and by native species such as ceiba tree (*Ceiba pentandra*), purple oak (*Tabebuia rosea*), and mata ratón (*Gliricidia sepium*).

The Mameyal is located at the rural area of Turbana municipality. It is a vegetation fragment that has been preserved for several years. This region shows climate characteristics similar to Macondo estate. The Mameyal is characterized by the presence of mamey fruit (*Mammea americana*), *Mangifera indica*, and *Manilkara sapota*. The dense canopy hinders the passage of sunlight to the ground, preventing the establishment of a structured understory. Those fruit trees are part of the diet of the red howler monkey *Alouatta seniculus* (Linnaeus, 1766) (Ratiarson and Forget, 2011).

The Tierra Bomba Island is located at the occidental portion of the Cartagena Bay, at 3 km from Bocagrande, Cartagena de Indias. The island was formed during the marine transgression dynamics of Pleistocene, and has an area of approximately 2,000 ha (Núñez *et al.*, 1999). The coastal line is marked by the presence of mangroves and dense dry shrubs on its inner portion. To date, both ecosystems are endangered due the urban expansion.

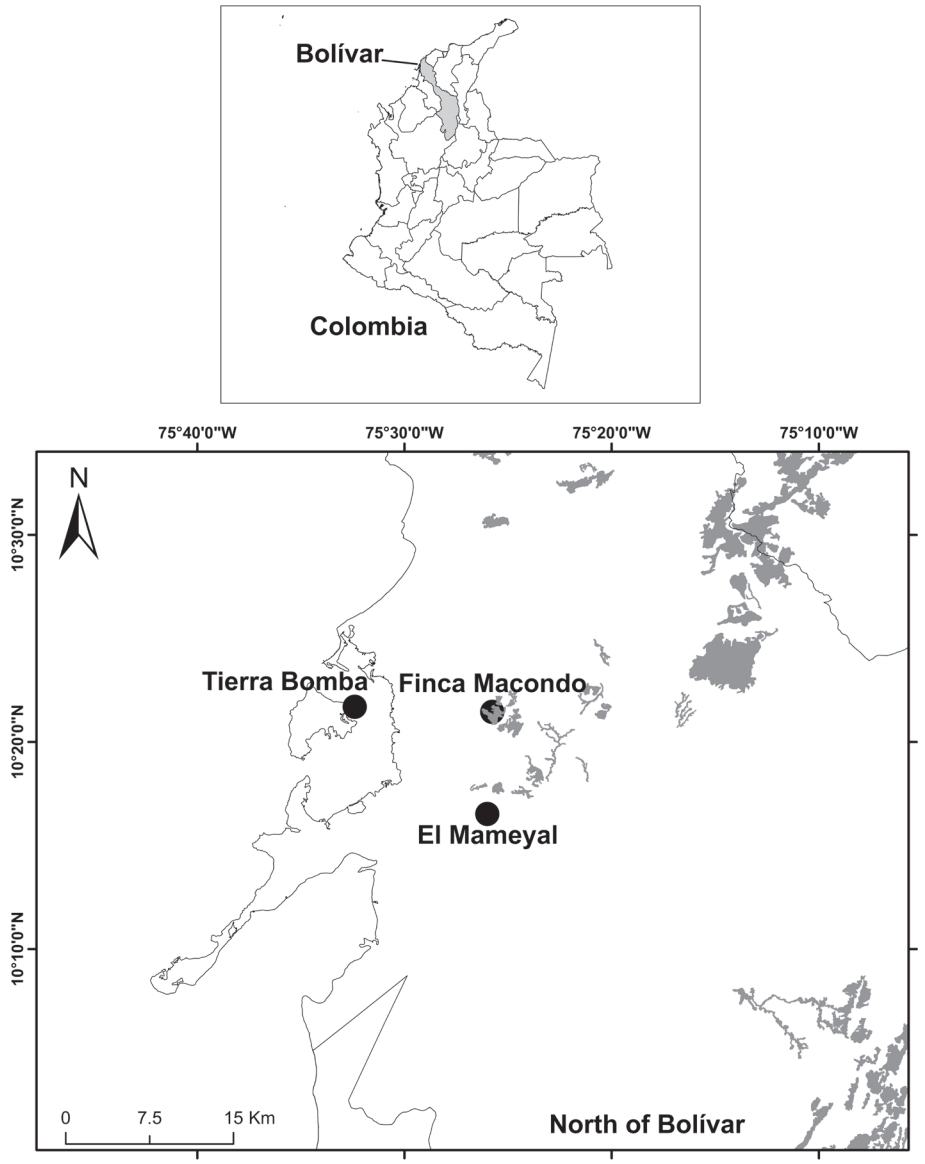

Figure 1. Distribution map of *Pulmoniscus turbanaensis* n. sp. Dark grey areas = Tropical Dry Forest.

Systematics

Philosciidae Kinahan, 1857

***Pulmoniscus* Leistikow, 2001**

Type species. *Balloniscus insularuminfraventum* Vandel, 1952 by monotypy.

Diagnosis. Leistikow (2001).

***Pulmoniscus turbanaensis* López-Orozco, Carpio-Díaz & Campos-Filho n. sp.**
(Figs. 1–5)

Type material. *Holotype*: 1 ♂ (CUDC-CRU 12), El Mameyal, Turbana, Bolívar, Colombia, 10°16'31.32"N 75°26'0.25"W, 23.X.2015, leg. Keiner Meza-T. *Paratypes*: 1 ♂ (CUDC-CRU 13), 1 ♀ (CUDC-CRU 14), same locality and date as holotype, leg. Y. Carpio-Díaz. 7 ♂, 21 ♀ (CUDC-CRU 15), same locality and date as holotype, leg. C.M. López-Orozco. 3 ♂, 2 ♀ (ICN-CI-85), 5.VI.2016, same locality as holotype, leg. Y. Carpio-Díaz. 1 ♂, 2 ♀ (CUDC-CRU 16), Tierra Bomba, Cartagena de Indias, Bolívar, Colombia, 10°21'41.59"N 75°32'24.00"W, 7.VIII.2016, leg. Y. Carpio-Díaz. 12 ♂, 5 ♀ (CUDC-CRU 17), Macondo estate, Turbaco, Bolívar, Colombia, 10°21'26.88"N 75°25'45.92"W, 15.VII.2016, leg. Y. Herrera-Medina.

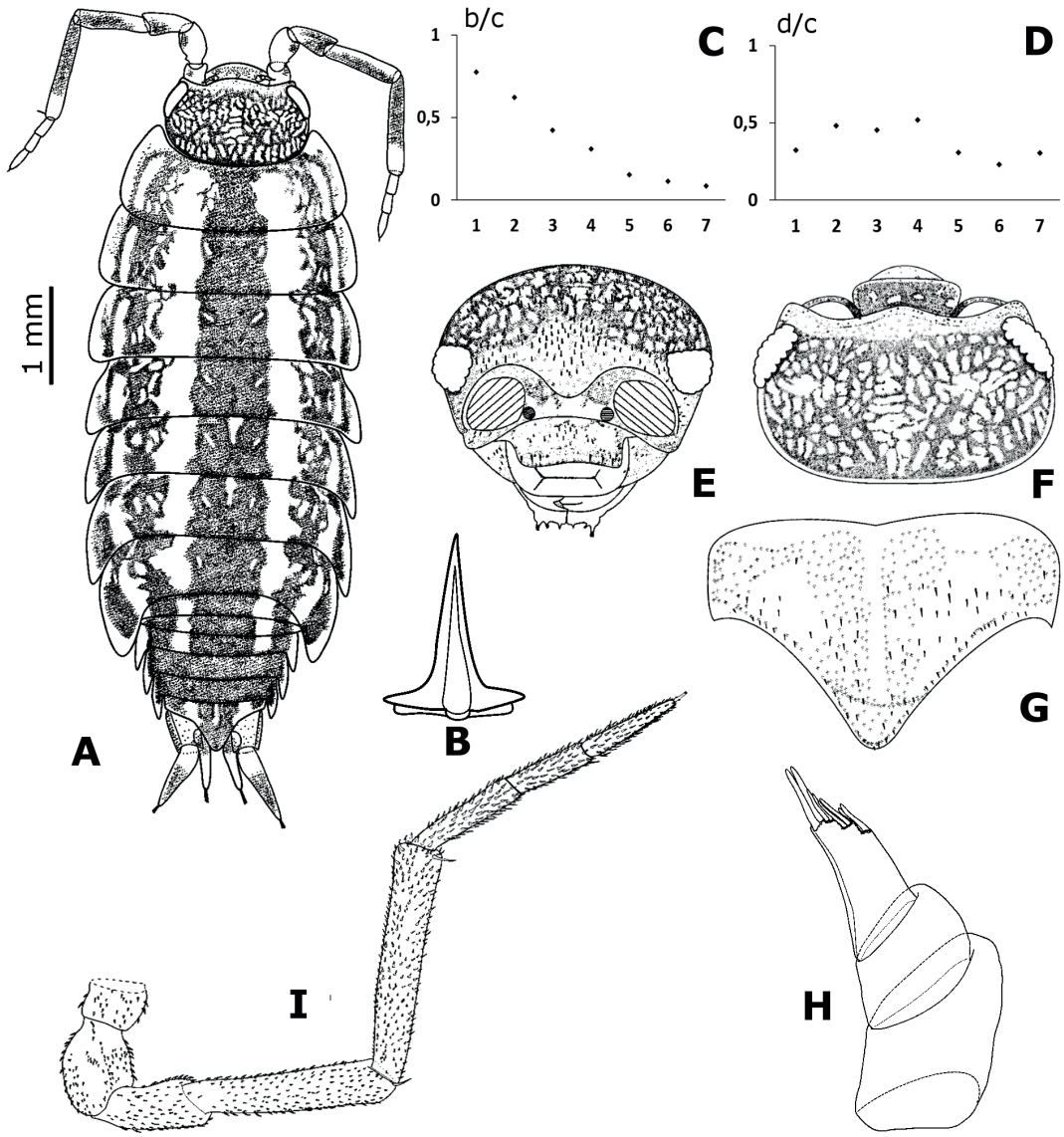

Figure 2. *Pulmoniscus turbanaensis* n. sp. ♀ Paratype (CUDC-CRU 14): A. Dorsal habitus; B. Dorsal scale-seta, C. b/c *noduli laterales* coordinates; D. d/c *noduli laterales* coordinates; E. Cephalon, frontal view; F. Cephalon, dorsal view; G. Telson; H. Antenna; I. Antennula.

Description. Maximum body measurements: ♂ (holotype), 8.5 mm length, 3 mm width; ♀ 6.9 mm length, 2.8 mm width. Body outline as in Fig. 2A. Color light to dark brown; antennal peduncle with first, second and distal portion of fifth article and flagellum unpigmented; cephalon with irregular unpigmented spots; pereon with dark lines on median and paramedian portions; epimera with one distinct unpigmented row, outer margins unpigmented; pleon strongly pigmented, pleonites 1–3 with two unpigmented spots; telson strongly pigmented, two unpigmented spots on paramedian region, one thin unpigmented spot on median portion; uropods weakly pigmented (Fig. 2A). Dorsal surface baring short piliform scale-setae (Fig. 2B). *Noduli laterales* b/c and d/c coordinates as in Fig. 2C, D, respectively. Cephalon (Fig. 2E, F) without lateral lobes and frontal line, supraantennal line bent downwards in middle; eyes with 23 ommatidia in four rows. Pleon (Fig. 2A) slightly narrower than pereon, neopleurae 3–5 well-developed. Telson (Fig. 2G) with lateral margins concave, distal margin right-angled. Antennula (Fig. 2H) with distal article bearing six aesthetascs in three sets plus apical pair. Antenna (Fig. 2I) when extended posteriorly reaching posterior margin of pereonite 3; flagellum of three articles subequal in length, apical organ very short. Mandibles (Fig. 3A, B)

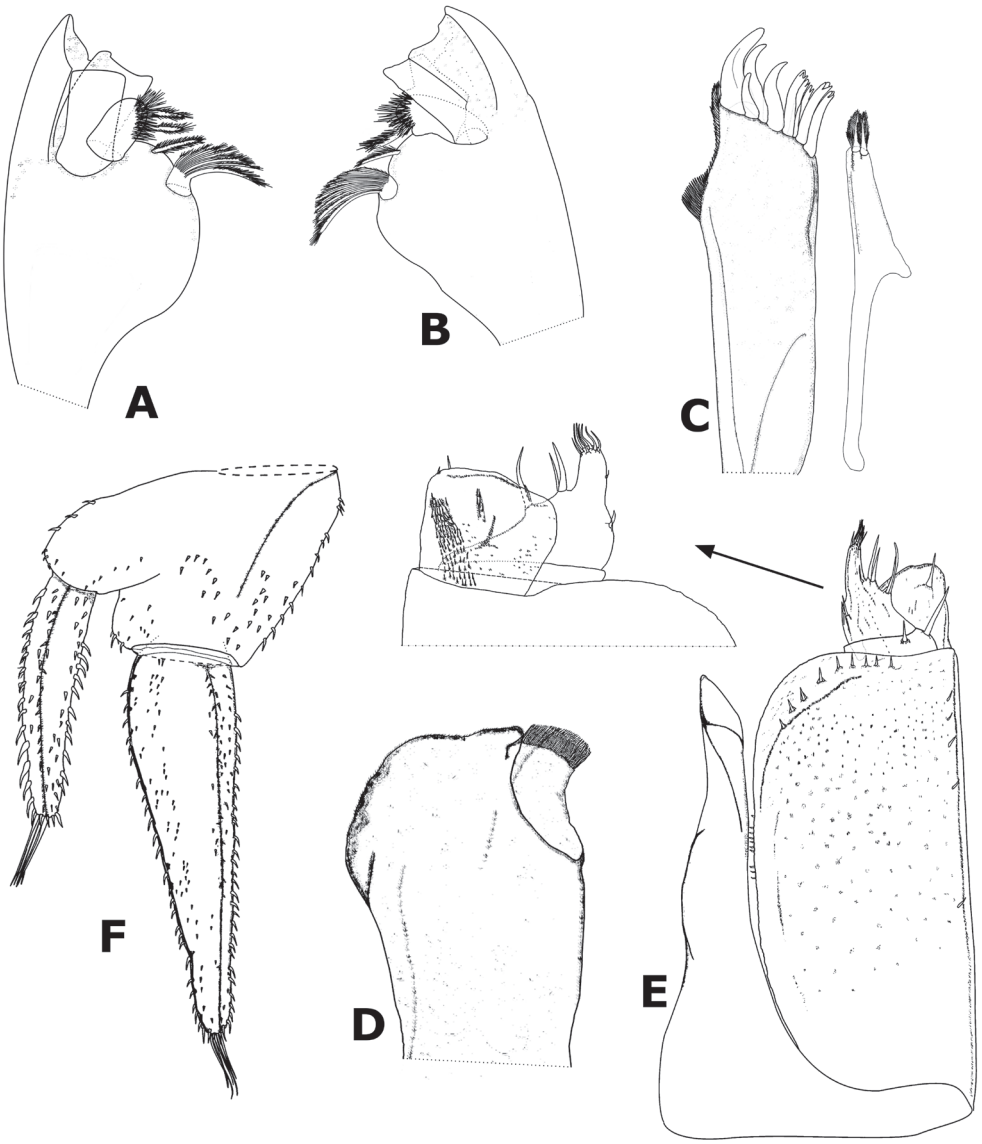

Figure 3. *Pulmoniscus turbanaensis* n. sp. ♀ Paratype (CUDC-CRU 14): A. Left mandible; B. Right mandible; C. Maxillula; D. Maxilla; E. Maxilliped; F. Uropod.

with molar penicil dichotomized bearing ten branches, left with 2+1 penicils, right mandible with 1+1 penicils. Maxillula (Fig. 3C) inner endite with distal margin rounded bearing two hairy penicils; outer endite of 4 teeth stout plus 5 teeth cleft at apex, three of them with apex crown-shaped. Maxilla (Fig. 3D) outer lobe more than twice as wide as inner lobe, distal margin rounded, covered with setae; inner lobe bearing thick setae. Maxilliped (Fig. 3E) base rectangular bearing sparse setae; palp with two setae distinct in length on proximal article; endite sub-quadrangular, medial seta surpassing distal margin, distal margin straight with one small seta. Uropod (Fig. 3F) protopod and exopod grooved on lateral margin, exopod twice as long as endopod, endopod inserted proximally. Pereopods 1–7 slightly strong; pereopod 1 carpus with longitudinal grooming brush; dactylus of two claws, inner claw not surpassing outer claw, ungual seta and dactylar organ simple not surpassing outer claw. Pleopod exopods with monospiracular pleopodal lungs, spiraculum inserted on one third of length of outer margin, perispiracular area covered with concentric cuticular wrinkles.

Male. Pereopods 1–4 merus and carpus with brush of setae on sternal margin (Fig. 4A); pereopod 7 ischium sternal margin concave and distal sternal portion slightly prominent, tergal margin with two setae (Fig. 4B). Pleopod 1 (Fig. 4C) exopod subtriangular, outer and inner margins almost straight, outer margin bearing 4 small setae, distal margin obtuse; endopod twice as long as exopod, distal portion directed outwards, apex

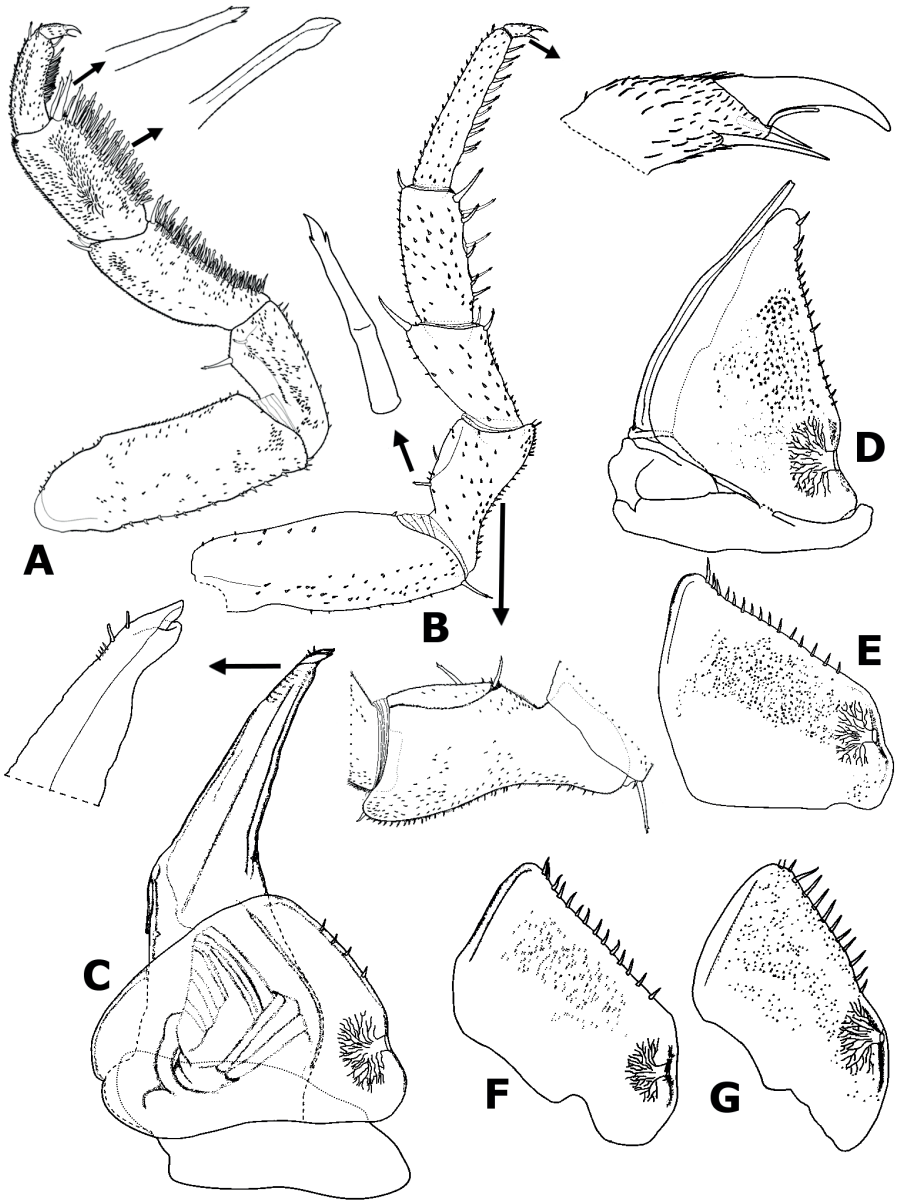

Figure 4. *Pulmoniscus turbanaensis* n. sp. ♂ Paratype (CUDC-CRU 13): A. Pereopod 1; B. Pereopod 7; C. Pleopod 1; D. Pleopod 2; E. Pleopod 3 exopod; F. Pleopod 4 exopod; G. Pleopod 5 exopod.

with two lobes delimiting spermatic channels, one lobe directed outwards and other directed inwards, inner distal margin bearing small setae at apex. Pleopod 2 (Fig. 4D) exopod triangular, outer margin almost straight bearing several setae; endopod slightly longer than exopod. Pleopods 3–5 exopods as in Fig. 4E–G, respectively.

Etymology. The new species is named after one of the localities where the specimens were colleted: Turbana.

Remarks. Vandel (1952) described the new species *Balloniscus insularuminfraventum* from Windward Islands, Archipelago Los Roques, Venezuela. Based on pleopod exopods with covered pleopodal lungs, the author included the genus in the subfamily *Porcellionidae quinquetracheatae* [= Trachelipodidae Strouhal, 1953]. Leistikow (2001) re-examined the type material of *B. insularuminfraventum* and mentioned that all pleopod exopods have monospiracular respiratory structures. Based on this argument, the author erected *Pulmoniscus* to allocate Vandel's species. Currently, the genus is inserted in family Philosciidae, closely related to the genera *Balloniscus* Budde-Lund, 1908, *Plataoniscus* Leistikow, 2001 (Balloniscidae), *Oniscophiloscia* Wahrberg, 1922, and *Philoscia*

Latreille, 1804 (Philosciidae). These taxa share a few characteristics, dorsal tricorn-setae with broad basis, and male pereopod 7 ischium with more than 5 setae on the lateral margin (Leistikow, 2001).

The pleopodal lungs are one of the most important morphological characteristics related to the terrestrialization process of Oniscidea (Ferrara *et al.*, 1994; Leistikow, 2001). This structure evolved several times within many taxa of the suborder (see Ferrara *et al.*, 1990; Paoli *et al.*, 2002; Leistikow, 2001; Schmidt, 2002, 2003; Cardoso *et al.*, 2016). Regarding the family Philosciidae, the pleopodal lungs are also present in other genera of the family such as *Aphiloscia* Budde-Lund, 1908, *Atlantoscia* Ferrara & Taiti, 1981, *Benthana* Budde-Lund, 1908, *Congophiloscia* Schmalfuss & Ferrara, 1978, *Philoscia* Latreille, 1804, and *Tiroloscia* Verhoeff, 1926. As mentioned by Leistikow (2001), the pleopodal lungs of *Pulmoniscus* are similar to those found in *Agnara* Budde-Lund, 1908, characterized by monospiracular structures (see Agnaridae section in Schmidt, 2003). This was also confirmed for *P. turbanaensis* n. sp.

The new species is included in the genus *Pulmoniscus* as defined by Leistikow (2001). *Pulmoniscus turbanaensis* n. sp. can be easily distinguished from *P. insularuminfraventum* by the male pereopod 7 ischium with the sternal margin concave instead of straight. Other distinguishing characteristics are the shape of the male pleopod 1 exopod subtriangular with four setae on outer margin (*vs.* subquadrangular without setae), and the male pleopod 1 endopod with two lobes on apex delimiting the spermatic channels (*vs.* lobes absent).

Ecological remarks. In the Mameyal, *P. turbanaensis* n. sp. has a high population density during rainy and transition seasons. The species can be found among leaf litter of *Mammea americana*, *Mangifera indica*, and *Manilkara sapota*, feeding on their fruits and sheltering under pieces of trees in decomposition (Fig. 5). Some specimens were observed feeding on faeces of *A. seniculus*. Terrestrial isopods contribute significantly to the organic matter decomposition cycle, and are influenced by physico-chemical aspects of the leaf litter and abiotic characteristics (Zimmer and Topp, 1997; 2000; Zimmer, 2002; 2004; Zimmer *et al.*, 2002; Quadros and Araujo, 2008). *Pulmoniscus turbanaensis* n. sp. has a high abundance, being the dominant species throughout the locality.

In Macondo estate, the species is equally abundant as in Mameyal and it is often preyed by domestic chickens. The species seems to be adapted to the leaf litter of *Bambusa vulgaris*, *Mangifera indica*, *Pouteria sapota*, and *Manilkara sapota*, and it was also found under rocks and tree pieces.

In Tierra Bomba, few individuals of *P. turbanaensis* n. sp. were found at 5 meters from the waterfront, collected together with *Ligia baudiniana* Milne Edwards, 1840, and between leaves of *Rhizophora mangle*, *Avicennia germinans*, and *Laguncularia racemosa* in mangroves. This species can be considered as introduced in the island, probably by human activities.

Figure 5. *Pulmoniscus turbanaensis* n. sp., Mameyal, Turbana. A. Specimens feeding on *Manilkara sapota* fruits; B. Specimens under piece of trees of *Mammea americana*, *Mangifera indica* and *Manilkara sapota*.

Discussion

The knowledge of arthropods diversity in TDF of Colombia is still obscure. These ecosystems are highly endangered and degraded (García *et al.*, 2014). Many studies demonstrated high diversity of arthropods in TDF of Colombia (*e.g.* Guerrero and Fernández, 2008; Fontalvo-Rodríguez and Solís-Medina, 2009; Gonzalez, 2014; Medina and González, 2014). The present contribution is the first record of the genus *Pulmoniscus* for Colombia and for the continental shield of the Neotropics. As mentioned by Campos-Filho *et al.* (2014), the taxonomic impediment has been considered the major problem for the knowledge of the biodiversity and proposal of conservation acts. Due to these reasons, taxonomic studies in TDF of Colombia have crucial importance for both the environment and the species and for the proposal of management and conservation acts to TDF. Lastly, any delay in taxonomic research could result in the permanent loss of biodiversity, even before species are discovered and described.

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References

Alcaldía de Turbaco-Bolívar, 2012. Jardín Botánico Guillermo Piñeres. Available at http://www.turbaco-bolivar.gov.co. Accessed on 1 January 2016.

Brandt, I. 1833. Conspectus Monographiae Crustaceorum Oniscodorum Latreillii. *Byulleten moskovskogo Obshchestva Ispytatelei Prirody*, 6: 171–193.

Budde-Lund, G. 1908. Isopoda von Madagaskar und Ostafrika mit Diagnosen verwandter Arten. p. 265–308, pls 12–18. In: A. Voeltzkow (ed), Reise in Ostafrika den Jahren 1903–1905, Wissenschaftliche Ergebnisse, Vol. 2. Stuttgart, E. Schwenzerbartsche Verlagsbuchhandlung.

Campos-Filho, I.S.; Araujo, P.B.; Bichuette, M.E.; Trajano, E. and Taiti, S. 2014. Terrestrial isopods (Crustacea: Isopoda: Oniscidea) from Brazilian caves. *Zoological Journal of the Linnean Society*, 172: 360–425.

Cardoso, G.M.; Campos-Filho, I.S. and Araujo, P.B. 2016. The genus *Dubioniscus* Vandel, 1963 (Oniscidea, Dubioniscidae) with descriptions of two new species from Brazil. *Tropical Zoology*, 29: 111–133.

Coleman, C.O. 2006. Substituting time-consuming pencil drawings in arthropod taxonomy using stacks of digital photographs. *Zootaxa*, 1360: 61–68.

Escobar, F. 1997. Estudio de la comunidad de coleópteros coprófagos (Scarabaeidae: Scarabaeinae) en un remanente de bosque seco al norte del Tolima. *Caldasia*, 19: 419–430.

Ferrara, F.; Paoli, P. and Taiti, S. 1990. Morphology of the pleopodal lungs in the Eubelidae (Crustacea, Oniscidea). p. 9–16. In: P. Juchault and J.P. Mocquard (eds), The biology of terrestrial isopods III. Poitiers, Université de Poitiers.

Ferrara, F.; Paoli, P. and Taiti, S. 1994. Philosciids with pleopodal lungs? The case of the genus *Aphiloscia* Budde-Lund, 1908 (Crustacea: Isopoda: Oniscidea), with a description of six new species. *Journal of Natural History*, 28: 1231–1264.

Ferrara, F. and Taiti, S. 1981. Terrestrial isopods from Ascension Islands. *Monitore Zoologico Italiano, Nuova Serie, Supplemento*, 14: 189–198.

Fontalvo-Rodríguez, L. and Solís-Medina, C. 2009. Ensamblaje de hormigas (Hymenoptera: Formicidae) en fragmentos de Bosque Seco en el complejo carbonífero El Cerrejón (La Guajira, Colombia). *Revista Intropica*, 4: 5–15.

García, H.; Corzo, G.; Isaacs, P. and Etter, A. 2014. Distribución y estado actual de los remanentes del Bioma de Bosque Seco Tropical en Colombia: insumos para su gestión. p. 229–251. In: C. Pizano and H. García (eds), El Bosque Seco Tropical en Colombia. Bogotá, Instituto de Investigación de Recursos Biológicos Alexander von Humbolt.

Gonzalez, V.H. 2014. Abejas del Bosque Seco Tropical Colombiano. p. 215–227. In: C. Pizano and H. García (eds), El Bosque Seco Tropical en Colombia. Bogotá, Instituto de Investigación de Recursos Biológicos Alexander von Humbolt.

Guerrero, R.J. and Fernández, F. 2008. A new species of the ant genus *Forelius* (Formicidae: Dolichoderinae) from the dry forest of Colombia. *Zootaxa*, 1958: 51–60.

Kinahan, J. 1857. Analysis of certain allied genera of terrestrial isopods; with description of a new genus, and a detailed list of the British species of *Ligia*, *Philougria*, *Philoscia*, *Porcellio*, *Oniscus* and *Armadillium* [sic]. *Natural History Review*, 4: 258–282.

Latreille, P. 1804. Cloportides. In: *Histoire naturelle, générale et particulière, des crustacés et des insects*. Vol. 7. Paris: 25–49.

Leistikow, A. 2001. Phylogeny and Biogeography of South American Crinocheta, traditionally placed in the family "Philosciidae" (Crustacea: Isopoda: Oniscidea). *Organisms Diversity and Evolution*, 4: 1–85.

Medina, C.A. and González, F.A. 2014. Escarabajos coprófagos de la subfamilia Scarabaeinae. p. 195–213. In: C. Pizano and H. García (eds), El Bosque Seco Tropical en Colombia. Bogotá, Instituto de Investigación de Recursos Biológicos Alexander von Humbolt.

Milne Edwards, H. 1840. Histoire Naturelle des Crustacés, Comprenant l'Anatomie, la Physiologie et la Classification de ces Animaux. *Encyclopédique Roret*, Paris. Vol. III, 638 pp., plates 1–42.

Montesanto, G. 2015. A fast GNU method to draw accurate scientific illustrations for taxonomy. *ZooKeys*, 515: 191–206.

Montesanto, G. 2016. Drawing setae: a GNU way for digital scientific illustrations. *Nauplius*, 24: e2016017.

Núñez, S.G.; López, N.H.; García, C.B. and Navas, G.R. 1999. Caracterización y comportamiento bimensual de la comunidad sésil asociada con el litoral rocoso de Bocachica, Isla de Tierra Bomba, Caribe colombiano. *Ciencias Marinas*, 25: 629–646.

Paoli, P.; Ferrara, F. and Taiti, S. 2002. Morphology and evolution of the respiratory apparatus in the family Eubelidae (Crustacea, Isopoda, Oniscidea). *Journal of Morphology*, 253: 27–289.

Quadros, A.F. and Araujo, P.B. 2008. An assemblage of terrestrial isopods (Crustacea) in southern Brazil and its contribution to leaf litter processing. *Revista Brasileira de Zoologia*, 25: 58–66.

Rangel-Ch., J.O.; Lowy-C, P.; Aguilar-P, M. and Garzón-C, A. 1997. Tipos de vegetación en Colombia. p. 89-382. In: J.O. Rangel-Ch. ; P.D. Lowy-C and M. Aguilar-P. (eds), Colombia Diversidad Biótica II. Bogotá, Instituto de Ciencias Naturales, Universidad Nacional de Colombia.

Ratiarson, S. and Forget, P.M. 2011. Fruit availability, frugivore satiation and seed removal in 2 primate-dispersed tree species. *Integrative Zoology*, 6: 178–194.

Schmalfuss, H. 2003. World catalog of terrestrial isopods (Isopoda: Oniscidea). *Stuttgarter Beiträge zur Naturkunde*, 654: 1–341.

Schmalfuss, H. and Ferrara, F. 1978. Terrestrial isopods from West Africa, Part 2: Families Tylidae, Ligiidae, Trichoniscidae, Styloniscidae, Rhyscotidae, Halophilosciidae, Philosciidae, Platyarthridae, Rhyscotidae, Trachelipidae, Porcellionidae, Armadillidiidae. *Monitore Zoologico Italiano, Nuova Serie, Supplemento*, 11: 15–97.

Schmidt, C. 2002. Contribution to the phylogenetic system of the Crinocheta (Crustacea, Isopoda). Part 1 (Olibrinidae to Scyphaidae s. str.). *Mitteilungen aus dem Museum fur Naturkunde in Berlin*, 78: 275–352.

Schmidt, C. 2003. Contribution to the phylogenetic system of the Crinocheta (Crustacea, Isopoda). Part 2 (Oniscoidea to Armadillidiidae). *Mitteilungen aus dem Museum fur Naturkunde in Berlin*, 79: 3–179.

Schmidt, C. 2008. Phylogeny of terrestrial Isopoda (Oniscidea): a review. *Arthropod Systematics & Phylogeny*, 66: 191–226.

Sfenthourakis, S. and Taiti, S. 2015. Patterns of taxonomic diversity among terrestrial isopods. In: S. Taiti, E. Hornung, J. Štrus, and D. Bouchon (eds), Trends in Terrestrial Isopod Biology. *ZooKeys*, 515: 13–25.

Strouhal, H. 1953. Die Cylisticini (Isop. terr.) der Türkei. *Istanbul* Üniversitesi *Fen Fakültesi Mecmuasi, Seri B*, 18: 353–372.

Taiti, S. and Schotte, M. 2016. Philosciidae Kinahan, 1857. In: C.B. Boyko, N.L. Bruce, K.L. Merrin, Y. Ota, G.C.B. Poore, S. Taiti, M. Schotte and G.D.F. Wilson (eds), World Marine, Freshwater and Terrestrial Isopod Crustaceans database. Available at http://www.marinespecies.org/aphia.php?p=taxdetails&id=246825. Accessed on 27 October 2016.

Vandel, A. 1952. Étude des isopodes terrestres récoltés au Vénézuela par de Dr. G. Marcuzzi. *Memorie del Museo Civico di Storia Naturale di Verona*, 3: 59–203 .

Vandel, A. 1962. Isopodes terrestres (Deuxième Partie). p. 417–931. In: Fédération Française des Sociétes de Sciences Naturelles (ed), *Faune de France, 66*. Paris, P. Lechevalier.

Verhoeff, K.W. 1908. Neue Isopoden-Gattungen. *Zoologischer Anzeiger*, 33: 520–525.

Verhoeff, K.W. 1926. Über Isopoden der Balkanhalbinsel, gesammelt von Herrn Dr. Buresch. *Mitteilungen der Bulgarischen Entomologischen Gesellschaft in Sofia*, 3: 135–158.

Verhoeff, K.W. 1938. Weltstellung der Isopoda terrestria, neue Familien derselben und neues System. *Zoologische Jahrbuecher Abteilung fuer Systematik Oekologie und Geographie der Tiere*, 71: 253–264.

Wahrberg, R. 1922. Einige terrestre Isopoden der Juan Fernandez-Inseln. p. 277–288. In: C. Scottsberg (ed), The Natural History of Juan Fernandez and Easter Island, vol. 3, Part 2. Uppsala, Almqvist & Wiksells Boktryckeri.

Zimmer, M. 2002. Nutrition in terrestrial isopods (Isopoda: Oniscidea): an evolutionary-ecological approach. *Biological Reviews of the Cambridge Philosophical Society*, 77: 455–493.

Zimmer, M. 2004. Effects of temperature and precipitation on a flood plain isopod community: a field study. *European Journal of Soil Biology*, 40: 139–146.

Zimmer, M.; Pennings, S.C.; Buck, T.L. and Carefoot, T.H. 2002. Species-specific patterns of litter processing by terrestrial isopods (Isopoda: Oniscidea) in high intertidal salt marshes and coastal forests. *Functional Ecology*, 16: 596–607.

Zimmer, M. and Topp, W. 1997. Does leaf litter quality influence population parameters of the common woodlouse, *Porcellio scaber* (Crustacea: Isopoda)? *Biology and Fertility of Soils*, 24: 435–441.

Zimmer, M. and Topp, W. 2000. Species-specific utilization of food sources by sympatric Woodlice (Isopoda: Oniscidea). *The Journal of Animal Ecology*, 69: 1071–1082.