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Continental copepods (Crustacea: Hexanauplia) of Colombia: revision and additions to the inventory

Copépodos (Crustacea: Hexanauplia) continentales de Colombia: revisión y adiciones al inventario

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Abstract

We present the compilation of published and unpublished records of continental copepods of Colombia, as well as personal observations by the authors, yielding an additional list of 52 species and subspecies (7 calanoids, 20 cyclopoids, 25 harpacticoids). In addition to our former inventory (2007) of 69 species, the total number now reaches 121 taxa, increasing by 75 % the known number of continental copepods. Freshwater taxa increased in 15 species and subspecies. The number of brackish species (and marine species collected in brackish environments), recorded from coastal lagoons and temporal offshore ponds reached 39 species and subspecies. Thirteen taxa with *locus typicus* in Colombia have been described since 2007. Between 2007 and 2018, thirty-nine departmental records were made, and 43 new habitat records were reported (not including the species recorded as new for the country). Parasitic copepods of fish reached six species. However, the number of species is expected to increase with the survey of poorly studied regions like the Amazon and the Eastern Plains, and habitats like groundwater, benthos of lakes and ponds, semiterrestrial environments and additional coastal lagoons.

Keywords. Biodiversity. Geographic distribution. Meiobenthos. Neotropical region. Zooplankton.

Resumen

Como resultado de la compilación de datos publicados y no publicados de copépodos continentales de Colombia, así como de observaciones personales de los autores, se estableció una lista adicional de 52 especies y subespecies (7 calanoideos, 20 cyclopoideos, 25 harpacticoideos). Junto con el inventario del año 2007 (69 taxa), el número actual alcanza 121 especies y subespecies, lo que representa un incremento del 75 %. El número de especies de agua dulce se incrementa en 15 especies y subespecies. El número de especies de aguas salobres (y de especies marinas recolectadas en ambientes salobres), reportadas en lagunas costeras y charcas cercanas a la costa, es de 39 especies y subespecies. Desde el año 2007, se describieron 13 taxones nuevos con *locus typicus* en Colombia. En el periodo comprendido entre el 2007 y el 2018 se registraron 39 especies en departamentos sin registros previos y 43 registros en biotopos no señalados para determinadas especies (sin considerar aquellas especies desconocidas anteriormente en Colombia). Se registraron seis especies de copépodos parásitos de peces. Sin embargo, con el estudio de regiones poco conocidas como el Amazonas y los Llanos Orientales, biotopos poco estudiados como las aguas subterráneas, el bentos de lagos y charcas, ambientes semiterrestres, así como nuevas lagunas costeras, es de esperar un aumento en el número de especies.

Palabras clave. Biodiversidad. Distribución geográfica. Meiobentos. Región Neotropical. Zooplancton.

Introduction

The subclass Copepoda includes small crustaceans inhabiting almost every aquatic biotope, as well as semiterrestrial habitats such as mosses and humid forest soils. Copepods inhabit from deep-sea trenches up to high mountain lakes of the Andes, Mount Kenya and the Himalaya. The total number of copepods exceeds 11,300 accepted species and subspecies; together with nematodes they are the most abundant metazoans on Earth (Walter & Boxshall, 2019). In continental waters, about 2500 species and subspecies are known, but this number increases when coastal lagoons with different salinity values are also considered. The body size of adult copepods ranges from 0.2 to 17 mm, but most average 1-2 mm. Copepods can be free-living, symbiotic as well as internal or external parasites of almost all major aquatic metazoans (Huys & Boxshall, 1991). In freshwaters, parasitic copepods are found only in fish.

A checklist of the free-living copepods of continental waters of Colombia was published 12 years ago (Gaviria & Aranguren, 2007), including 69 species and subspecies (14 Calanoida, 41 Cyclopoida, 14 Harpacticoida).

During the past years, the copepod fauna of new biotopes such as coastal lagoons, phytotelmata of the rain forest, Amazon floodplain lakes (*varzea* and *igapó*), freshwater lagoons (*ciénagas*), wetlands of the eastern Llanos, Andean lakes, ponds, wet mosses and reservoirs have been studied. Moreover, the results presented here include reports of parasitic copepods of fish (Lernaeidae and Ergasilidae) obtained from studies developed in the departments of Valle del Cauca, Meta and Magdalena.

Coastal lagoons were considered in our inventory due to their topotypical character with narrow connection to the sea. Because of their connection to the marine environment, they show a wide range of salinity. Estuaries like those from the Pacific coast are not considered in the inventory. Coastal ponds are morphologically isolated from the sea and can temporarily reach hypersalinity. Thus, the following groups with brackish or marine representatives are considered in the inventory: Calanoida (Acartiidae, Lucicutidae, Pseudodiaptomidae, Temoridae), Cyclopoida (Halicyclopinae, Kelleridae, Oithonidae, *Apocyclops*) and Harpacticoida (Ameiridae, Ectinosomatidae, Laophontidae, Metidae, Miraciidae, Tachididae, Tegastidae, *Cletocamptus*, *Mesochra*). The remaining groups considered are the following: Calanoida (Centropagidae, Diaptomidae), Cyclopoida (Cyclopinae, Eucyclopinae) and Harpacticoida (Canthocamptidae, Parastenocarididae).

Aims of this contribution are to elaborate a revision of the species richness of continental copepods of Colombia, compare their diversity in relation to the previous inventory (Gaviria & Aranguren, 2007), indicate orders, families, genera and species represented in the country, list the records of the copepod species in the different departments and biotopes, compare the species richness of the Colombian genera in relation to the Neotropical Region, and indicate the world distribution of the Colombian species. Finally, we propose points of future research in order to fill the gaps of the knowledge of diversity of the continental copepods of Colombia.

Materials and methods

The list of species presented here is the result of a critical compilation of published and unpublished records that appeared after 2007, and of personal observations of the authors and colleagues. Unpublished records are those indicated in Aranguren (2014) and obtained from the study of zooplankton of Amazonian lakes (*varzea* type: Yahuarcaca, Tarapoto and El Correo; *igapó* type: Zacambú), Andean lakes (Tota, Fúquene, Iguaque and Guatavita) and Caribbean *ciénagas* (Ayapel, Momil, Purísima and Vipis). Part of this information was published in Aranguren *et al*. (2011).

A synopsis of the families, genera, species and subspecies listed for the country until 2007 and until 2018 is shown in Table 2. For comparative purposes, the corresponding number of species and subspecies per genus occurring in the Neotropical region is included.

The published references include species of free-living and parasitic copepods from continental biotopes and coastal lagoons and ponds, recorded during different types of studies, as follows:

1) Zooplankton during limnological studies of Amazonian lakes (Aranguren-Riaño *et al*., 2011), wetlands of the Orinoco basin (five lakes near the Orinoco River) (Rivera-Rondón *et al*., 2010), Andean lakes (Aranguren-Riaño *et al*., 2011) and reservoirs (Villabona-González *et al*., 2007, 2015; Aranguren-Riaño & Monroy-González, 2014) and Caribbean *ciénagas* (Gallo-Sánchez *et al*., 2009; Álvarez, 2010; Aranguren-Riaño *et al.* 2011; Villabona *et al*., 2011; Jaramillo-Londoño & Aguirre-Ramírez, 2012).

2) Benthic harpacticoids collected in phytotelmata of the rain forest during taxonomic studies (Gaviria & Defaye, 2012), and in an Andean lake and a pond of the páramo region during taxonomic and phylogenetic studies (Laguna de Buitrago, Chingaza; pond near Laguna de San Rafael, Puracé) (Gaviria & Defaye, 2012, 2015, 2017a, 2017b).

3) Limnetic and benthic species from coastal lagoons and temporary ponds of the Caribbean region during studies of taxonomy and biodiversity: the investigated coastal lagoons were Laguna del Navío Quebrado (La Guajira) (Fuentes-Reinés & Gómez, 2014; Fuentes-Reinés & Suárez-Morales, 2014a, 2014b, 2015; Suárez-Morales & Fuentes-Reinés, 2014, 2015a, 2015b, 2015c) and Ciénaga Grande de Santa *Marta* (Magdalena) (Fuentes Reinés *et al*.,2013; Fuentes-Reinés & Zoppi de Roa, 2013a, 2013b; Fuentes-Reinés & Suárez-Morales, 2018; Fuentes-Reinés *et al*., 2018). The temporary ponds located in the Magdalena department are located in Pozos Colorados (Gómez *et al*., 2017) and Puebloviejo (Fuentes-Reinés *et al.*, 2015).

4) Parasitic copepods and their fish hosts from various rivers and a coastal lagoon, studied by Cressey & Colette (1970) (mouth of Dagua River, Valle del Cauca), Thatcher (1984) (Pital River, Valle del Cauca), Thatcher (2000) (Meta River, Meta), Fuentes-Reinés *et al*. (2012) (southern Ciénaga Grande de Santa Marta, Magdalena), Sarmiento & Rodríguez (2013) and Muriel-Hoyos *et al*. (2015) (Vichada River, Meta).

New records of species for Colombia as well as new records of already known species are listed, indicating their overall distribution, their presence in the different Colombian departments and habitats, and the corresponding bibliographic references.

The records of personal observations (SG – S. Gaviria; NA – N. Aranguren; JM – J. Molina; DD – D. Defaye, DB – D. Baribwegure) are based on samples obtained at the following localities and years:

1. Amazonas: Laguna de Tarapacá, near Rio Putumayo, SG (2001). Laguna de Yahuarcaca, Laguna Zacambú, Laguna El Correo and Laguna Tarapoto, NA (2007).

2. Antioquia: Microestación, Campus Universidad de Antioquia, Medellín, SG (1999). Reservoir La Fé, SG (1999); Reservoir Porce II, SG (1999); Reservoir Riogrande II, SG (2001); lake at fishfarm Gaiteros, Sopetrán, SG (2001); Lake "Dos Lagos", Carmen de Viboral, SG (2001); Lake Cerro del Padre Amaya, Palmitas, SG (2001); Lake Piedras Blancas, Guarne, SG (1999); Ciénaga Vallecitos, Caucasia, SG (1999).

3. Boyacá: Laguna de Iguaque, SG (2010); wet moss páramo de Cómbita, SG & DD (2016); Laguna Verde, páramo de Pisba, NA & JM, 2018; Laguna de Socha, Laguna Peña Negra and Laguna Los Fríos NA (2016).

4. Cesar: Ciénaga de Zapatosa, SG & DB (1999).

5. Chocó: Ciénaga de Tumaradó and Ciénaga de Perancho, SG (2000).

6. Córdoba: Ciénaga de Ayapel, SG 1999; Ciénaga de Betancí, SG 2002; Ciénaga de Lorica, SG (2002).

7. Cundinamarca: Fishpond in La Mesa, NA (1994).

8. Magdalena: Ciénaga de Pijiño, SG (1999).

9. Meta: Laguna Mateyuca, Puerto López, SG (1999).

10. Tolima: Ciénaga de Guarinocito, NA (2007).

Information about the overall distribution of the freshwater species was extracted from Dussart & Defaye (2002, 2006), Defaye & Dussart (2011), Fuentes-Reinés *et al*. (2013) and Perbiche-Neves *et al*. (2014). The distribution of planktonic species from brackish water follows Razouls *et al*. (2005-2018) and of benthic species of brackish water according to Fuentes-Reinés & Suárez-Morales (2013, 2015, 2018), Fuentes-Reinés & Gómez (2014), Fuentes-Reinés & Suárez-Morales (2014a, 2014b), Fuentes-Reinés *et al*. (2013b, 2015, 2018) and Gómez *et al.* (2017). Taxonomy follows Walter & Boxshall (2019) (http://www.marinespecies.org/copepoda).

Results

The taxonomic list (Table 1) presents the new records of copepods in continental waterbodies, including 15 families, 25 genera and 52 species and subspecies not recorded in a previous Colombian inventory. The current number of copepods recorded in Colombia comprises 121 taxa (21 calanoids, 61 cyclopoids and 39 harpacticoids), including taxa from coastal lagoons and ponds, as well as parasitic species.

Besides the new records for the country, we report the occurrence of 39 species in new departments, 43 new habitat records and seven new bibliographic references (Table 1). Eight of the 32 Colombian departments, *i.e*. Arauca, Caldas, Caquetá, Casanare, Guaviare, Putumayo, Quindío and Vaupés, lack reports of copepods. Most records are from Magdalena (42), La Guajira (34) and Cundinamarca (27).

Seventy-four percent of the species are distributed in lowland waterbodies, 17 % in highland regions (from 2000 m a. s. l.) and 9 % in both regions. Finally, the known altitudinal or geographic range of distribution of 29 species has increased.

Table 1. Taxonomic list of the species and subspecies of copepods reported after 2007 in continental waterbodies, semiterrestrial biotopes, coastal lagoons and temporal offshore ponds of Colombia. Taxa known before 2007 but with expanded distribution in new departments, increase of altitude range and habitats not indicated before, are included. Expansion of altitudinal range, departments and habitats are indicated in bold.

Taxon	World distribution	Distribution in Colombia	Altitude (m a. s. l.)	Habitat	Reference collection	Bibliographic reference
ORDER CALANOIDA						
FAMILY ACARTIIDAE						
Acartia (Odontocartia) lilljeborgi Giesbrecht, 1889	Gulf-Mex Car Pac COL	lag	**0**	coas-lag estua pel	UARC	Fuentes-Reinés & Suárez-Morales, 2015
Acartia (Acanthacartia) tonsa Dana 1849	Cosm COL	**lag** mar	0	coas-lag euryhal pel	UARC	Pearse, 1915; Fuentes-Reinés *et al.*, 2013; Fuentes-Reinés & Suárez-Morales, 2015
FAMILY CENTROPAGIDAE						
Boeckella gracilis Daday, 1902	ARG BOL CHL COL ECU PER	cun boy met nar	3000 - 3800	lak **pn**	NHMW	Gaviria, 1989; Aranguren-Riaño *et al.*, 2011; **Aranguren-Riaño, 2014**
FAMILY DIAPTOMIDAE						

Arctodiaptomus dorsalis (Marsh, 1907)	Amer COL CRI CUB GUF MEX NIC PAN Hisp PRI **USA** VEN	ant cau cho cor **nsan san**	0 - **2200**	cie res **riv** pel pn	UIS	Buitrago, 1998; SG. pers. obs. 1999, 2001; Reid, 2007; Villabona-González et al., 2007, 2015; Aranguren-Riaño *et al.*, 2011; Gaviria, 1989; Aranguren-Riaño, 2014
Colombodiaptomus brandorffi Gaviria, 1989	COL	**boy** cun	2900 - **3730**	lak pel pn res	NHMW	Gaviria, 1989; SG pers.obs. 2010; Aranguren-Riaño *et al.*, 2011; Aranguren-Riaño, 2014
Dactylodiaptomus pearsei (Whright, 1927)	**COL** BRA VEN	ama	300	lak		Aranguren-Riaño *et al.*, 2011, 2014
Dasydiaptomus coronatus (G.O. Sars, 1901)	ARG BRA COL VEN	vich	300	lak		Rivera-Rondón *et al.*, 2010
Notodiaptomus coniferoides (Wright, 1927)	ARG BOL BRA COL PRY	***cor*** mag tol	0 - 200	backw cie pel		N.A. & S.G. pers.obs. 1999 (2007); Álvarez, 2010; Villabona-González *et al.*, 2011; Jaramillo-Londoño & Aguirre-Ramírez, 2012; Aranguren-Riaño, 2014
Notodiaptomus dilatatus Dussart, 1984	BRA COL VEN	guai **vich**	300	**lak pel** riv	MNHN	Dussart, 1984; Rivera-Rondón *et al.*, 2010
Notodiaptomus echinatus (Lowndes, 1934)	ARG BRA COL GUF PRY VEN	guai **vich**	300	lak pel riv	MNHN	Dussart, 1984; Rivera-Rondón *et al.*, 2010
Notodiaptomus henseni (Dahl, 1894)	BRA COL GUF PRY VEN	**boy cor** guai vich	100 - **2790**	**cie** lak riv pel		Dussart, 1984; Cicchino *et al.*, 1989; Villabona-González *et al.*, 2011; Aranguren-Riaño, 2014; JM & NA, pers. obs. 2018
Notodiaptomus linus (Brandorff, 1973)	BRA **COL**	ama	0 - 300	lak pel		Aranguren-Riaño *et al.*, 2011; Aranguren-Riaño, 2014
Notodiaptomus maracaibensis Kiefer, 1956	COL VEN	atl ces cho cor mag	0 - 200	cie pel	SMNK	Kiefer, 1956; SG pers. obs. 1999; Álvarez, 2010; Aranguren-Riaño *et al.*, 2011; Villabona-González *et al.*, 2011; Aranguren-Riaño, 2014
Notodiaptomus simillimus Cicchino, Santos Silva & Robertson, 2001	BRA COL VEN	**cor** guai met	300	**cie lak pel** riv		Dussart, 1984 (as *N. coniferoides*); Cicchino *et al.*, 2001; SG pers. obs. 1999 (2007); Villabona-González *et al.*, 2011
Prionodiaptomus colombiensis Thiébaud, 1912	BRA COL SLV GTM HND MEX NIC PER PAN USA VEN	atl boy **cor** mag cun	0 - 2600	**cie** lak pel sw	NHMW	Álvarez, 2010; Gaviria, 1989
Rhacodiaptomus ringueleti Cicchino & Dussart, 1991	COL VEN	guai **vich**	300	**lak pel** pn riv		Cicchino & Dussart, 1991; Rivera-Rondón *et al.*, 2010
FAMILY LUCICUTIDAE						
Lucicutia flavicornis (Claus, 1863)	Atl Ind Med Pac COL	mag	0	coas-lag pel	UARC	Fuentes-Reinés *et al.*, 2013
FAMILY PSEUDODIAPTOMIDAE						

Pseudodiaptomus marshi Wright S.,1936	COL CRI BLZ MEX	lag mag	0	coas-lag euryhal de epib veg	UARC	Fuentes-Reinés *et al.*, 2013; Fuentes-Reinés & Suárez-Morales, 2015
FAMILY TEMORIDAE						
Temora turbinata (Dana, 1849)	Atl Indo-Pac Trop Subtrop COL	lag	0	coas-lag brack pel	UARC	Fuentes-Reinés & Suárez-Morales, 1915
ORDER CYCLOPOIDA						
FAMILY CORYCAEIDAE						
Corycaeus (Corycaeus) clausi F. Dahl, 1894	Atl Ind Pac Trop Subtrop	lag	0	coas-lag brackw pel	UARC	Fuentes-Reinés & Suárez-Morales, 2015
FAMILY CYCLOPIDAE						
SUBFAMILY CYCLOPINAE						
Apocyclops panamensis (Marsh, 1913)	Amer COL USA	cho **lag mag** sap	0	cav **coast-lag** euryhal	MBUCV	Reid, 1988; Petkovski, 1988; Fuentes-Reinés *et al.*, 2013; Fuentes-Reinés & Suárez-Morales, 2015
Mesocyclops brasilianus Kiefer, 1933	BRA CAN? COL GTM HND VEN	ama ant cal cho cor mag nar	0 - **1500**	cie **coas-lag mm-pn**	USNM, UARC	**Gallo-Sánchez *et al.*, 2009 (as *M. venezolanus*); Alvarez, 2010 (as** *M. venezolanus***)** Reid, 1988; Gaviria, 1994; Aranguren, 1998. **Fuentes-Reinés *et al.* 2013;** Gaviria *&* Aranguren, 2000 (2007) (as *M. venezolanus*); Aranguren-Riaño et al., 2011 & Aranguren-Riaño, 2014 (as *M. venezolanus*); **per. obs. JM & NA 2016**
Mesocyclops ellipticus Kiefer, 1936	ARG **COL** CUB BRA GUF PRY VEN	lag mag	0	coas-lag-fw veg	MBUCV UARC	Fuentes-Reinés *et al.*, 2013; Fuentes-Reinés & Suárez-Morales, 2015
Mesocyclops longisetus (Thiébaud, 1912)	Am	ama ant cor cun mag	**0** - 2600	**coas-lag ig** lak lit pl **res** riv veg	MBUCV	Gaviria 1988; SG pers. obs. 1999; NA pers. obs. 2007; Fuentes-Reinés *et al.*, 2013; Aranguren-Riaño *et al.*, 2011; Aranguren-Riaño, 2014; Villabona-González *et al.*, 2015
Mesocyclops meridianus (Kiefer, 1926)	ARG BOL BRA COL ECU lan PRY PER VEN URY	**ama** cun guai	100 - 500	est lak riv		Dussart, 1984; NA pers. obs. 2007; Aranguren-Riaño *et al.*, 2011; Aranguren-Riaño, 2014
Metacyclops leptopus leptopus (Kiefer, 1927)	COL BOL **ECU** PER	**ant** cun mag	**2270** - 3500	lak **pn res** sw		Löffler, 1972; Gaviria, 1988; Villabona-González *et al.*, 2015; Torres & Rylander, 2016
Metacyclops leptopus totaensis Reid, Molina Arévalo & Fukushima, 1990	COL	cund boy	3000 - 3700	lag pel	USNM	Reid *et al.*, 1990; Aranguren & Andrade, 2003; Aranguren-Riaño *et al.*, 2011; **Aranguren-Riaño, 2014**

Metacyclops mendocinus (Wierzejski, 1892)	ARG BOL BRA CHL COL ECU GUF HTI NIC PRI PRY PER URY VEN	ant cun san sap	0 - 2600	est gw lak lit pn res tpl		Thiébaud, 1912; Petkovski, 1998; Aranguren-Riaño *et al.,* 2011; **Aranguren, 2014**
Microcyclops anceps anceps (Richard, 1897)	S-Amer	**ama** ant cor cun **lag** mag **vich**	0 - 1500	cie **coas**-est **lag ig** lak lit pn sw	UARC	NA pers. obs. 1994, 2007; SG pers. obs. 1999; Alvarez, 2010; Rivera-Rondón *et al.,* 2010; Aranguren-Riaño *et al.,* 2011; Fuentes-Reinés *et al.,* 2013; Fuentes-Reinés, 2015; Aranguren-Riaño, 2014
Microcyclops anceps pauxensis Herbst, 1962	BRA **COL** VEN	lag mag	0	coas-lag lit veg	MBUCV, UARC	Fuentes-Reinés *et al.,* 2013; Fuentes-Reinés & Suárez-Morales, 2015
Microcyclops ceibaiensis (Marsh, 1919)	Neotr	cor **lag mag vich**	**0 - 300**	cie **coas-lag lak** lit **veg**	MBUCV, UARC	SG pers. obs.1999 (2007); Álvarez, 2010; Rivera-Rondón *et al.,*2010; Fuentes-Reinés *et al.,* 2013; Fuentes-Reinés, 2015
Microcyclops dubitabilis Kiefer, 1934	Neotr USA-fl	ant atl cor cun mag nar	0 - 2600	**cie coas-lag lak** lit **pn** res sw **veg**	UARC	SG & NA pers. obs. 1999 (2007) (as *M. dubitabilis & M. alius*); Alvarez, 2010; Reid, 1988 (as *M. alius*); Villabona-González *et al.,* 2011 (as *M. alius*); Fuentes-Reinés *et al.,* 2013
Neutrocyclops brevifurca (Lownes, 1934)	ARG COL BRA GTM MEX PRY VEN	atl **cor** mag	0 - 100	**coas-lag** lit sw **veg**	MBUCV SMNK	Kiefer, 1956; SG pers.obs. 1999 (2007); Álvarez, 2010; **Fuentes-Reinés *et al.,* 2013**
Thermocyclops crassus (Fischer, 1853) ?	Cosm	ama cor	0 - 300	cie var		Arangure-Riaño *et al.,* 2011; Aranguren-Riaño, 2014; (could be *T. decipiens*)
Thermocyclops decipiens (Kiefer, 1929)	Pantr	ama ant atl **boj** cal **cor** cun hui **lag mag** nar tol	0 - 2000	**coast-lag-fw** lak pel pn res sw **veg**	SMNK UARC	Kiefer, 1956; Aranguren, 1998, 2014; Villabona-González-González *et al.,* 2007; Alvarez, 2010; Aranguren-Riaño *et al.,* 2011; Villabona-González *et al.,* 2011; Jaramillo-Londoño & Aguirre-Ramitez, 2012; Aranguren-Riaño, 2014; Aranguren-Riaño & Monroy-González, 2014; Fuentes-Reinés & Suárez-Morales, 2015
Thermocyclops minutus (Lowndes, 1934)	ARG BRA COL PRY VEN	cor vich	300	cie lak		Alvarez, 2010; Rivera Rondón *et al.,* 2010
Thermocyclops tenuis (Marsh, 1920)	Amer	ces **cor mag** ama	**0** - 100	cie **var**		DB & SG pers. obs. 2007; Álvarez, 2010; Aranguren, 2014
SUBFAMILY EUCYCLOPINAE						
Ectocyclops rubescens Brady, 1904	Pantr	atl nar **mag**	0 - 100	ben **coas-lag** lak pn **veg**	SMNK UARC USNM	Kiefer, 1956; Reid, 1988; Fuentes-Reinés *et al.,* 2013

Ectocyclops phaleratus (Koch, 1838)	Cosm	cun **mag** nar	0 - 2600	ben **co-as-lag** lak sw pn **veg**	UARC USNM	Thiébaud, 1912; Reid, 1988; Fuentes-Reinés *et al.*, 2013
Eucyclops serrulatus serrulatus (Fischer, 1851)	Cosm outside S-Amer COL	ant boy cun **mag**	**0** - 4000	ben **co-as-lag** est lit lak pl res tan **veg**	UARC USNM	Thiébaud, 1912; Reid, 1987; Gaviria, 1988; Fuentes-Reinés *et al.*, 2013
Eucyclops titicacae Kiefer, 1957	BOL **COL** PER VEN	lag	0	ben co-as-lag veg	UARC	Fuentes-Reinés & Suárez-Morales, 2013
Macrocyclops albidus albidus (Jurine, 1820)	Cosm	ant atl boy cun **mag** met	**0** - 4100	ben **co-as-lag** res lak lit pn sw **veg**	UARC	Thiébaud, 1912; Gaviria 1988; Fuentes-Reinés *et al.*, 2013
Macrocyclops albidus principalis Herbst, 1962	BRA COL VEN	san **mag**	**0** - 1500	cav **co-as-lag veg**	UARC	Petkovski, 1988; **Fuentes-Reinés *et al.*, 2013**
Paracyclops chiltoni (Thompson, 1882)	Cosm	cun **mag**	**0** - 2700	ben **co-as-lag** lak res riv	UARC	Gaviria, 1988; Fuentes-Reinés *et al.*, 2013
Paracyclos fimbriatus (Fischer, 1853)	Palearc COL	**mag**	**0**	**ben res lak coas-lag riv**	MBUCV	Fuentes-Reinés *et al.*, 2013; Fuentes-Reinés & Suárez-Morales, 2015
Tropocyclops prasinus altoandinus Gaviria, 1994	COL	ant cun **boy** met	2000 - 3775	ben lak lit res	ICN - MHN	Gaviria, 1994; Aranguren & Andrade, 2003 (as *T. prasinus prasinus*); Aranguren-Riaño *et al.*, 2011; Aranguren-Riaño, 2014
Tropocyclops prasinus prasinus (Fischer, 1860)	BRA COL	ant atl **boy** cun nar	0 - **3670**	ben est lag lit	USNM	Reid, 1988; Aranguren-Riaño *et al.*, 2011; Aranguren-Riaño, 2014; JM & NA pers. obs. 2016
SUBFAMILY HALICYCLOPINAE						
Halicyclops exiguus Kiefer, 1934	BRA COL CRI HTI GUF	lag mag	0	euryhal coas-lag lit veg	UARC	Fuentes-Reinés & Suárez-Morales, 2015; Fuentes-Reinés & Suárez-Morales, 2018
Halicyclops gaviriai Suárez-Morales & Fuentes-Reinés, 2014	COL	lag	0	cost-lag pel veg	ECO-CHZ UARC	Suárez-Morales & Fuentes-Reinés, 2014
Halicyclops hurlberti Rocha, 1991	COL MEX-si USA-ca	mag	0	coas-lag	UARC	Fuentes-Reinés & Suárez-Morales, 2018
Halicyclops venezuelaensis Lindberg, 1954	BLZ COL MEX VEN	lag mag	0	euryhal coas-lag lit veg	UARC	Fuentes-Reinés *et al.*, 2013; Fuentes-Reinés & Suárez-Morales, 2015, 2018
FAMILY ERGASILIDAE						
Ergasilus argulus Cressey, 1970	COL	val	0	host: *Strongylura fluviatilis & S. scapularis*	FMNH USNM	Cressey & Colette, 1970

Ergasilus curticrus Muriel-Hoyos, Santana-Piñeros,Cruz-Quintana & Suárez-Morales, 2015	COL	met	300	host: *Bryconops giacopinii*	ECO-CHZ IMCN	Muriel-Hoyos *et al.*, 2015
Ergasilus pitalicus Thatcher, 1984	COL	val	< 900	host: *Cichlasoma* sp.	USNM	Thatcher, 1984
Paraergasilus longidigitus Yin, 1954	CHN COL MEX USA	mag	0	lit veg	MBUCV UARC	Fuentes-Reinés *et al.*, 2012
FAMILY KELLERIDAE						
Kelleria reducta Suárez-Morales & Fuentes-Reinés, 2015 (c)	COL MEX	lag	0	coas-lag pel	UARC	Suárez.Morales & Fuentes-Reinés, 2015c
FAMILY LERNAEIDAE						
Lernaea cyprinacea Linnaeus, 1758	Cosm	mag	30	host: *Prochilodus magdalenae*		Sarmiento & Rodriguez, 2013
Lernaea pirapitingae (Thatcher & Paredes, 1985)	COL	met	300	host: *Piaractus brachypomus*		Thatcher, 2000
FAMILY OITHONIDAE						
Oithona amazonica Burckhardt, 1912	BRA COL GUF VEN	vich	300	lak		Rivera-Rondón *et al.*, 2010
Oithona oswaldocruzi Oliveira, 1945	**COL** BRA ECU SLV HND PRI TTO VEN	lag mag	0	coas-lag mg pel	UARC	Fuentes-Reinés *et al.*, 2013; Fuentes-Reinés-Suárez-Morales, 2015
ORDER HARPACTICOIDA						
FAMILY AMEIRIDAE						
Nitokra affinis colombiensis Fuentes-Reinés & Suárez-Morales, 2014 (a)	COL	lag	0	coas-lag euryhal	ECO-CHZ UARC	Fuentes-Reinés & Suárez-Morales, 2014a
Nitokra lacustris sinoi Marcus & Por, 1961	CUB MEX USA-fl COL ROU	mag lag	0	euryhal ben coas-lag mg pel veg	MBUCV, UARC	Fuentes-Reinés & Zoppi de Roa, 2013a; Fuentes-Reinés & Suárez-Morales, 2014b
Nitokra taylori Gómez, Carrasco & Morales-Serna, 2012	SAF COL	lag	0	coas-lag pel	UARC	Fuentes-Reinés & Suárez-Morales, 2014b
FAMILY CANTHOCAMPTIDAE						
Attheyella (Canthosella) chocoensis Gaviria & Defaye, 2012	COL	cho	50	phytot	ICN-MHN MNHN MNRJ	Gaviria & Defaye, 2012

Attheyella (Chappuisiella) fuhrmanni (Thiébaud, 1912)	ARG BRA GTM CRI COL URY VEN	ant atl cun **mag**	0 - 2600	ben res lak mm-pd **coas-lag** sw	MBUCV, UARC	Thiébaud, 1912; Chappuis, 1956; Fuentes-Reinés & Zoppi de Roa, 2013a
Attheyella (Delachauxiella) freyi Löffler, 1963	COL ECU	cau	3500	ben pd	MNHN NHMW	SG pers. obs. 2007; **Gaviria & Defaye, 2012**
Cletocamptus dominicanus Kiefer, 1934	Ant COL	mag	20	coas lag pd sa-wa veg	UARC	Gómez *et al.*, 2017
Cletocamptus helobius Fleeger, 1980	MEX COL	lag	0	coas-lag mg euryhal	UARC	Fuentes-Reinés & Suárez-Morales, 2014b
Cletocamptus nudus Gómez, 2005	Neotr	lag mag	0	coas-lag coast-pd mg euryhal	INV	Fuentes-Reinés & Suárez-Morales, 2014b; Fuentes-Reinés *et al.*, 2015
Cletocamptus samariensis Fuentes-Reinés, Zoppi de Roa & Torres, 2015	COL	mag	0	coas-pd	INV	Fuentes-Reinés *et al.*, 2015
Cletocamptus sinoalensis Gómez, Fleeger, Rocha-Olivares & Foltz, 2004	BRA COL MEX	mag	0	coas-lag ben	UARC	Fuentes-Reinés *et al.*, 2018
Elaphoidella grandidieri (Guerne & Richard, 1893)	Pantr	ant **lag**	**0** - 1600	ben **coas-lag** pn **res** veg	UARC	SG pers. obs. 2007; Fuentes-Reinés & Zoppi de Roa, 2013b; Fuentes-Reinés & Suárez-Morales, 2014b
Elaphoidella bidens bidens (Schmeil, 1894)	Cosm	ant **mag**	**0** - 1000	ben lak **coas-lag** veg	UARC	SG pers. obs. 2007; Fuentes-Reinés & Zoppi de Roa, 2013a
Elaphoidella paramuna Gaviria & Defaye, 2015	COL	cun	3500	ben lak	ICN-MHN MNHN NHMW	Gaviria & Defaye, 2015
Elaphoidella sewelli minuta (Chappuis, 1932)	COL CAF REU MDG	mag	0	ben coas-lag veg	UARC	Fuentes-Reinés & Zoppi de Roa, 2013a
Elaphoidella schubarti Chappuis, 1936	BRA COL ECU VEN	mag	4000	ben lak mo pd		Löffler, 1972
Mesochra huysi Suárez-Morales & Fuentes-Reinés, 2015 (a)	COL	lag	0	coas-lag lit pel	ECO-CHZ UARC	Suárez-Morales & Fuentes-Reinés, 2015a
FAMILY CLETODIDAE						
Enhydrosoma lacunae Jakuvisiak, 1933	Amer	lag	0	coas-lag mar mg pel	UARC	Fuentes-Reinés & Suárez-Morales, 2014b
FAMILY ECTINOSOMATIDAE						
Halectinosoma arangureni Suárez-Morales & Fuentes-Reinés, 2015 (b)	COL	lag	0	coas-lag lit pel mg veg	UARC ECO-CHZ	Suárez-Morales & Fuentes-Reinés, 2015b

Pseudobradya gascae Suárez-Morales & Fuentes-Reinés, 2015b	COL	lag	0	coas-lag mg pel veg	UARC ECO-CHZ	Suárez-Morales & Fuentes-Reinés, 2015b
FAMILY LAOPHONTIDAE						
Quinquelaophonte quinquespinosa (Sewell, 1924)	Cosm	lag	0	coas-lag pel	UARC	Fuentes-Reinés & Suárez-Morales, 2014b
FAMILY METIDAE						
Metis holothuriae (Edwards, 1891)	Cosm	lag	0	coas-lag mg pel veg	UARC	Fuentes-Reinés & Suárez-Morales, 2014b
FAMILY MIRACIIDAE						
Sarsamphiascus hirtus (Gurney, 1927)	Eur COL BRA NZL	lag	0	coas-lag mar pel veg	UARC	Fuentes-Reinés & Suárez-Morales, 2014b
Schizopera evelynae Fuentes-Reinés & Gómez, 2014	**COL**	lag	0	coas-lag mg pel	UARC, EMUCOP	Fuentes-Reinés & Gómez, 2014
Schizopera knabeni Lang, 1965	COL Gulf-Mex Pac USA	lag	0	coas-lag sa-wa pel veg	UARC	Fuentes-Reinés & Suárez-Morales, 2014b
Robertsonia propinqua (Scott T., 1894)	Cosm	lag	0	coas-lag pel	UARC	Fuentes-Reinés & Suárez-Morales, 2014b
FAMILY PARASTENOCARIDIDAE						
Colombocaris isabellae Gaviria, Defaye & Corgosinho, 2017	COL	**boj** cun	3000	ben lak mo semiter	ICN-MHN	Gaviria *et al.,* 2017; SG & DD pers. obs. 2016
Noodtcaris columbiensis (Noodt, 1972)	COL	met	300	int-riv	DZMB	Noodt, 1972 (as *Parastenocaris columbiensis*); Gaviria *et al.,* 2017
Noodtcaris kubitzkii (Noodt, 1972)	COL	met	300	int-riv	DZMB	Noodt, 1972 (as *Parastenocaris kubitzkii*); Gaviria *et al.,* 2017
Noodtcaris roettgeri (Noodt, 1972)	COL	met	300	int-riv	DZMB	Noodt, 1972 (as *Parastenocaris roettgeri*); Gaviria *et al.,* 2017
FAMILY TACHIDIDAE						
Euterpina acutifrons (Dana, 1847)	Cosm	lag	0	coas-lag veg pel	UARC	Fuentes-Reinés & Suárez-Morales, 2014b
FAMILY TEGASTIDAE						
Parategastes herteli Jakobi, 1953	BRA COL	lag	0	coas-lag pel veg	UARC	Fuentes-Reinés & Suárez-Morales, 2014b

Abbreviations: World distribution: Amer – America, Ant – Antilles, ARG – Argentina, Atl – Atlantic Ocean, BLZ – Belize, BOL – Bolivia, BRA – Brazil, CAN – Canada, CAR – Caribbean Sea, CAF – Central African Republic, CHL – Chile, CHN – China, COL – Colombia, Cosm – cosmopolitan, CRI – Costa Rica, CUB – Cuba, ECU Ecuador, SLV – El Salvador, Eur – Europe, GUF – French Guyana, GTM – Guatemala, Gulf-Mex – Gulf of Mexico, HTI – Haiti, Hisp – Hispaniola, HND – Honduras, Ind – Indian Ocean, Indo-Pac – Indo-Pacific Ocean, REU – La Réunion, Les-Ant – Lesser Antilles, MDG – Madagascar, MEX – Mexico, MEX-si – Mexico (Sinaloa), Med – Mediterranean Sea, Neotr – Neotropical region, NIC – Nicaragua, NZL – New Zealand, PRY – Paraguay, Pac – Pacific Ocean, Palearc – Palearctic region, Pantr – pantropical, PER – Peru, PAN – Panama, PRI – Puerto Rico, ROU – Romania, S-Amer – South America, SAF – South Africa, Subtrop – subtropical, TTO – Trinidad and Tobago, Trop – tropical, URY – Uruguay, USA – United States of America, USA-ca – United States of America (California), USA-fl – United States of America (Florida), VEN – Venezuela. **Distribution in Colombia** (Departments): ama (Amazonas), ant (Antioquia), atl (Atlántico), boy (Boyacá), cal (Caldas), cau (Cauca), cho (Chocó), cor (Córdoba), cund (Cundinamarca), guai (Guainía), hui (Huila), lag (La Guajira), ces (Cesar), mag (Magdalena), met (Meta), nar (Nariño), nsan (Norte de Santander), san (Santander), tol (Tolima), val (Valle del Cauca), vich (Vichada). **Habitat in Colombia:** coast-lag – coastal lagoon, backw – backwater of a river, ben – benthos, cav – cave, cie – "ciénaga" (=freshwater lagoon), coas-lag - coastal lagoon, coas-lag-fw – coastal lagoon/freshwater zone, coas-pd – coastal pond, de – demersal, epib – epibenthic, est – "estero" (typical meadow in the east plains "Llanos"), estua – estuary, euryhal – euryhaline, ig – "igapó" lake, int-riv – interstitial of a river, lak – lake, lit – littoral, mg – mangrove, mar – marine, mm-pd – man-made pond, mo – moss, pel - pelagic, phytot – phytotelmata, pl – plankton, pn – pond, res – reservoir, sa-wa – saltwater, semiter – semiterrestrial, sw – swamp, tan – water tank, tpl – treatment plant, var –" varzea" lake, veg – macrophytes. **Acronyms**: DZMB – Deutsches Zentrum für Marine Biodiversitätsforschung, Senckenberg am Meer, Wilhemshaven, Germany; ECO-CHZ – Collection of Zooplankton at El Colegio de la Frontera Sur, Chetumal, Mexico; EMUCOP – Copepoda collection of the Instituto de Ciencias del Mar y Limnología, Mazatlán Marine Station, Sinaloa, Mexico; FMNH – Field Museum of Natural History, Chicago, Ill., USA; ICN-MHN – CR – Museo de Historia Natural – Crustacean Colección – Instituto de Ciencias Naturales at Universidad Nacional de Colombia, Bogotá, Colombia; IMCN – Zoological Collection of Scientific References, Departmental Museum of Natural Sciences Federico Carlos Lehmann Valencia, Cali, Colombia; INV Museum Instituto de Investigaciones Marinas INVEMAR, Santa Marta, Colombia; MBUCV – Museo de Biología de la Universidad Central de Venezuela, Crustacean Section, Caracas, Venezuela; MNHN-Muséum Nationale d'Histoire Naturelle, Paris, France; MNRJ – Museo Nacional, Universidade Federal do Rio de Janeiro, Brazil; NHMW – Naturhistorisches Museum Wien, Austria; UARC – Museo de Colecciones Biológicas at the Universidad del Atlántico, Barranquilla, Colombia; UIS – Universidad Industrial de Santander, Colección Limnológica; USNM – U.S. National Museum, Washington, USA. **Bibliographic reference**: pers. obs. – personal observation, DB – D. Baribwegure, DD – D. Defaye, JM – J. Molano, NA – N. Aranguren, SG – S. Gaviria.

In the Neotropical region as a whole, the number of copepods living in inland waters comprises 458 species and subspecies. That value is nearly four times as high as that in Colombia (Table 2).

Table 2. Comparative taxonomic synopsis of the families, genera and subgenera of the copepods reported in continental water bodies of Colombia until 2007 (Gaviria & Aranguren, 2007) and until 2018 (present inventory), and their representation in the Neotropical region. Numbers indicates species for each genus (numbers of subspecies are indicated in brackets). Numbers in bold indicate total number of species and subspecies for each order. * Parasitic genera, ***Ergasilus* comprises 20 species in South America and Mexico, and an unknown (?) number of species in Central America and the Antillean Islands. *** Species of *Parastenocaris* (2007) were allocated to the new genus *Noodtcaris*.

Taxa	Neotropics	Colombia reports until 2007	Colombia reports until 2018
Order Calanoida	**110**	**14**	**21**
Family Acartiidae			
Acartia			
Acanthacartia	3	1	1
Odontacartia	2		1
Family Centropagidae			
Boeckella	15	2	2
Family Diaptomidae			
Arctodiaptomus			
Arctodiaptomus	1	1	1
Colombodiaptomus	1(2)	1(2)	1(2)
Dactylodiaptomus	1		1
Dasydiaptomus	1		1
Notodiaptomus	36	6	7
Prionodiaptomus	2	1	1
Rhacodiaptomus	8(2)	1	1
Family Lucicutidae			
Lucicutia	23		1
Family Pseudodiaptomidae			
Pseudodiaptomus	12		1
Family Temoridae			
Temora	4		1
Order Cyclopoida	**208**	**41**	**61**

Family Corycaeidae			
Corycaeus			
Corycaeus	4		1
Family Cyclopidae			
Subfamily Cyclopinae			
Acanthocyclops	4	1	1
Apocyclops	5	2	2
Diacyclops	10	2	2
Hesperocyclops	2	1	1
Mesocyclops	21(6)	5	7
Metacyclops	25(4)	4(5)	4(5)
Microcyclops	13(4)	5	5(2)
Neutrocyclops	1	1	1
Thermocyclops	8	2	4
Subfamily Eucyclopinae			
Ectocyclops	6	2	2
Eucyclops	24(5)	7	8
Macrocyclops	3(5)	1(2)	1(2)
Paracyclops	8	3	4
Tropocyclops	19(13)	1(2)	1(2)
Subfamily Halicyclopinae			
Halicyclops	19		4
Neocyclops			
Protoneocyclops	4	1	1
Family Ergasilidae			
Ergasilus	20 + ? **		3
Paraergasilus	1		1
Family Kelleriidae			
Kelleria	1		1

Family Lernaeidae			
Lernaea	3		2
Family Oithonidae			
Oithona	5		2
Order Harpacticoida	**140**	**14**	**39**
Family Ameiridae			
Nitokra	9(6)	1(1)	4(3)
Family Canthocamptidae			
Attheyella			
Canthosella	8		1
Chappuisiella	17(2)	2	2
Delachauxiella	23(2)	1	1
Cletocamptus	15(2)		5
Elaphoidella	35(3)	5	8 (1)
Epactophanes	1	1	1
Mesochra	4		1
Family Cletodidae			
Enhydrosoma	2		1
Family Ectinosomatidae			
Halectinosoma	1		1
Pseudobradya	1		1
Family Laophontidae			
Quinquelaophonte	1		1
Family Metidae			
Metis	1		1

Family Miraciidae			
Sarsamphiascus	2		1
Schizopera	8(2)		2
Robertsonia	3		1
Family Parastenocarididae			
Colombocaris	1		1
Noodtcaris	4	3***	3
Family Phyllognathopodidae			
Phyllognathopus	2(1)	1	1
Family Tachididae			
Euterpina	1		1
Family Tegastidae			
Parategastes	1		1
Total species and subspecies	**458**	**69**	**121**

Total freshwater copepods	328	68	82
Total brackish water copepods (incl. marine species and brackish water parasites)	90	5	39

Total without parasitic copepods	434	69	115
Parasitic copepods	24+? **	0	6

Discussion

The increase in copepod diversity presented here for Colombia reflects the exploration of new territories and new biotopes as well as taxonomic changes in the subclass Copepoda during the past 11 years. Thirteen species new to science have been described from Colombia since 2007.

The number of brackish taxa (including marine species collected in brackish environments) found in coastal lagoons and temporal ponds near the coast, reached 39 species and subspecies. The number of copepods parasitic on fish has risen to six species. This number is expected to increase when the Amazonian region is surveyed; it has not yet been studied for ergasilids and lernaeids.

Calanoid copepod numbers have been enriched by the discovery of the family Pseudodiaptomidae (*Pseudodiaptomus marshi*) and one additional species of Acartiidae (*Acartia* (*Odontacartia*) *lilljeborgi*) in coastal lagoons. Two additional families, Lucicutidae (*Lucicutia flavicornis*) and Temoridae (*Temora turbinata*), typical of marine waters, were also found in these environments.

L. flavicornis is an oceanic species that sometimes invades neritic water (Vives & Shmeleva, 2006). A coastal lagoon is not a typical habitat for that species and the two specimens found in the Ciénaga Grande de Santa Marta (Fuentes-Reinés *et al*., 2013) possibly arrived there with tidal currents. The same holds true for the presence of *T. turbinata* in the coastal lagoon Navío Quebrado (Fuentes-Reinés & Suárez-Morales, 2015) because the species is a typical neritic-oceanic species (Vives & Shmeleva, 2006).

In freshwaters, three additional species of the family Diaptomidae were recorded, two in the Amazon (*Dactylodiaptomus pearsei* and *Notodiaptomus linus*) (Aranguren, 2014) and one in the Orinoco basin (*Dasydiaptomus coronatus*) (Rivera-Rondón *et al*., 2010). Within calanoids, *Notodiaptomus* is the genus with the highest species number in Colombia (7), and is also the genus with the highest species richness in South America (Perbiche-Neves *et al*., 2014). The distribution of two species of the genus, *Notodiaptomus dilatatus* and *N. echinatus*, expanded to the Vichada department in the Orinoco basin (Rivera-Rondón *et al*., 2010). Additionally, *Notodiaptomus simillimus* and *N. coniferoides* increased their distribution to Córdoba in the Caribbean region (Villabona-González *et al*., 2011. Jaramillo-Londoño & Aguirre-Ramírez, 2012; Aranguren, 2014).

Notodiaptomus henseni was newly registered in Córdoba and Boyacá. In Boyacá, the species was found in a high mountain lake (Laguna Verde, Páramo de Pisba, 2740 m a. s. l.) (Aranguren & Molano, pers. obs. 2014). This represents the second record of a species of *Notodiaptomus* in mountain waterbodies of the Andes. Recently, Alonso *et al*. (2017) described *Notodiaptomus cannarensis* from a water reservoir in southern Ecuador, located at 2127 m a. s. l.

Notodiaptomus coniferoides has a wide distribution in South America, ranging from the Amazon River to the mouth of the Paraná River (Perbiche-Neves *et al*., 2013; Previatelli *et al*., 2013). In Colombia it has been recorded at the interandean Magdalena valley and in the Caribbean region (Gaviria & Aranguren, 2007). Specimens from Venezuela identified by Dussart (1984) as *N. coniferoides* should be referred to *N. simillimus*, a species very similar to the former (Cicchino *et al*., 2001). It is possible that some Colombian records of *N. coniferoides* correspond to *N. simillimus*, as is apparently also the case in northern Brazil (Previatelli *et al*., 2013).

Notodiaptomus maracaibensis is the species of the genus with the widest distribution in the Colombian Caribbean region. It was found together with three other species of the genus (*Notodiaptomus henseni*, *N. coniferoides*, *N. simillimus*) in the Ciénaga de Ayapel, Córdoba, where it reached the highest abundances among the planktonic copepods (Villabona-González *et al.,* 2011). High densities of *N. maracaibensis* were also observed in the ciénaga-complex of Malambo, near the Magdalena River (Atencio *et al*., 2005). In the Lago de Maracaibo, Venezuela (*locus typicus* of the species), its populations are thought to be threatened. Due to its distribution and populations size in Colombia, its vulnerable status at the IUCN Red List (Baillie & Groombridge, 1996) should be re-evaluated (Reid, pers. com. to SG).

Four species of Diaptomidae, *Rhacodiaptomus ringueleti*, *Notodiaptomus dilatatus*, *Notodiaptomus linus* and *Notodiaptomus echinatus*, seem to be restricted to lakes and rivers east of the Cordillera (Dussart, 1984; Cicchino & Dussart, 1991; Rivera-Rondón, 2010; Aranguren, 2014), whereas records of *N. simillimus* stem from the same region and also from the Caribbean plains (Cicchino *et al*, 2001; SG, pers. obs. 2007; Villabona-González *et al*., 2011).

Arctodiaptomus dorsalis is also widely distributed in Colombia, newly registered in Córdoba (Aranguren, 2014) as well as in Santander (Reid, 2007) and Norte de Santander in the Andean Cordillera (Villabona-González *et al*., 2007). This species has an apparent center of origin in the lowlands around the Gulf of Mexico, Central America, the Greater Antilles and northern South America (Reid, 2007). The latter author discussed the increase of the species' distribution further north in the United States and further south in Colombia, influenced by human activities such as aquaculture and by colonisation of suitable eutrophic waterbodies. New records in the Caribbean region

(Ciénaga de Ayapel) (Aranguren, 2014) and an Andean reservoir (Laguna Acuarela, Norte de Santander) (Villabona-González *et al*., 2007) in Colombia point to an expansion trend to the south.

Prionodiaptomus colombiensis is also widely distributed and was recorded for the first time in Córdoba (Álvarez, 2010) in the Caribbean region. Together with *N. henseni*, it is the only diaptomid copepod distributed from lowland waterbodies up to Andean lakes with an altitude of 2600-2800 m a. s. l.

Colombodiaptomus brandorffi, formely known from the paramo lakes of Cundinamarca, was also recorded from Laguna de Iguaque in Boyacá (SG pers. obs. 2010; Aranguren, 2014). No additional records of the cold stenothermic centropagids (*Boeckella*) were registered.

With 20 new taxa recorded in Colombia, the order Cyclopoida now reaches 61 species and subspecies. Two families, *i.e.* Kelleridae and Ergasilidae, formerly belonging to the order Poecilostomatoida, are now allocated in the order Cyclopoida. Khodami *et al*. (2017) recently demonstrated that the poecilostomatoid lineage lies within the latter order. Thus, *Kelleria reducta* and four ergasilid species were added to the list of cyclopoids.

Other nomenclatural changes have occurred in this order. *Mesocyclops venezolanus* Dussart, 1984 is no longer accepted and is now recognised as a junior synonym of *Mesocyclops brasilianus* Kiefer, 1933, according to Gutiérrez-Aguirre *et al*. (2006). The cyclopoid copepod *Microcyclops alius* (Kiefer, 1935) is a junior synonym of *Microcyclops dubitabilis* Kiefer, 1934 (Gutiérrez-Aguirre & Cervantes-Martínez, 2016).

The exploration of coastal lagoons has also contributed to the increase in the species number of other cyclopoids for the country. Various brackish-water species now form part of the inventory. The genus *Halicyclops,* with four species (*H. exiguus*, *H. gaviriai*, *H. hurlberti*, *H. venezuelaensis*), was found in the plankton of brackish environments (Fuentes-Reinés *et al*., 2013; Suárez-Morales & Fuentes-Reinés, 2014; Fuentes-Reinés & Suárez-Morales, 2015, 2018). Another new family, Oithonidae, contributed with one new species (*Oithona oswaldocruzi*) collected in coastal lagoons (Fuentes-Reinés *et al*., 2013; Fuentes-Reinés & Suárez-Morales, 2015). The species *O. amazonica* was found in freshwaters of the Orinoco basin (Rivera-Rondón, 2010). *Corycaeus clausi* (family Corycaeidae) was registered for the first time in a coastal lagoon in La Guajira department (Fuentes-Reinés & Suárez-Morales, 2015).

Some typical freshwater species were recorded in coastal lagoons. They were apparently collected in the freshwater areas of the lagoons and constitute new species for Colombia: *Eucyclops titicacae* and *Paracylops fimbriatus* (Eucyclopinae), as well as *Mesocyclops ellipticus* and *Microcyclops anceps pauxensis* (Cyclopinae) (Fuentes-Reinés *et al*., 2013; Fuentes-Reinés & Suárez-Morales, 2013, 2015). Other freshwater species, *i.e. Ectocyclops rubescens*, *E. phaleratus*, *Macrocyclops albidus albidus*, *M. albidus principalis* and *Paracyclops chiltoni* (found in the Ciénaga Grande de Santa Marta), are new for the department of Magdalena (Fuentes-Reinés *et al*., 2013).

The Cyclopinae *Thermocyclops minutus*, registered in Caribbean and Orinoco waterbodies (Alvarez, 2010; Rivera-Rondón *et al*., 2010), as well as *Thermocyclops crassus* from Caribbean and Amazonean lakes (Aranguren, 2014), are also new for the country. Collado *et al*. (1984) and Reid (1989) mentioned that most published records of *T. crassus* in South and Central America and the Caribbean region should be referred to *T. decipiens*, and that the only confirmed record of *T. crassus* is from Costa Rica. *T. crassus* has a cosmopolitan distribution outside the Neotropical region. Therefore, new records of *T. crassus* in Colombia should be accepted with caution. The species *Thermocyclops tenuis* extended its distribution to the departments Córdoba and Magdalena in the Caribbean region. *Thermocyclops decipiens*, with records in four new departments, is now present in 13 departments of Colombia. It is probably the most common *Thermocyclops* species in the country, as it was also mentioned for the neotropics (Reid, 1989). The subspecies *Tropocyclops prasinus prasinus* and *T. prasinus altoandinus* were found for the first time in the department of Boyacá (Aranguren, 2014; NA & JM pers. obs. 2018).

Eucyclops serrulatus has been recorded from several localities of Colombia. Nevertheless, and according with Alekseev *et al.* (2006), *E. serrulatus* is a Palearctic species. Records in America may be from introduced populations or even represent as yet undescribed species (Mercado-Salas *et al.*, 2012). The redescription of *E. serrulatus* and other six species included characters not considered in the past that helped to discriminate the species: pore signature of the cuticula, ornamentation of the antennal basis and of the intercoxal sclerite of the fourth pair of legs (Alekseev *et al.*, 2006). In a study of *Eucyclops*-species from Mexico, Mercado-Salas & Suárez-Morales (2014) redescribed four of them and considered that most of the remaining species of the genus in the Neotropical region should be redescribed. Eight species of the genus are now known from Colombia, but that number is probably an understimation.

As parasitic copepods are now also considered in the inventory, we have listed six species belonging to the cyclopoid family Ergasilidae (4) and Lernaeidae (2). Two ergasilids have been found in fish inhabiting rivers in southwestern Colombia (*Ergasilus argulus* and *E. pitalicus*), one in the Eastern Plains in the Meta departement (*E. curticrus*) and one in the Ciénaga Grande de Santa Marta (*Paraergasilus longidigitus*). The family Lernaeidae is represented by *Lernaea pirapitingae* from fish of the Meta River (Thatcher, 2000) and by *Lernaea cyprinacea*. The latter species was introduced to Colombia with fish (*Carassius auratus* and *Cyprinus carpio*) used in aquaculture, and it has been also recorded in *Trichogaster microlepis* (Rodríguez Gómez, 1981). Alvarado-Forero & Gutiérrez-Bonilla (2002) argued that this parasitic copepod is widespread in the country. It was also found recently as parasite of *Prochilodus magdalenae* from a fish farm in Gaira, department of Magdalena (Sarmiento & Rodríguez, 2013). In Mexico, three species of ergasilids and *L. cyprinacea* have been reported in freshwater fish (Morales-Serna *et al.*, 2012). Most of the parasitic copepods in South America have been recorded from the Amazon and the northeastern region of Brazil. In the Brazilian Amazon, 14 species of *Ergasilus* and 2 members of *Lernaea* have been recorded (Muriel-Hoyos *et al.*, 2015; Luque & Tavarés, 2007). This means that at least ergasilids can be expected also as fish ectoparasites in the Colombian Amazon.

The order Harpacticoida showed the highest increase in species richness (2007: 14, 2018: 39). Within the 25 new species recorded for the country, 10 are new to science. Newly described species with the *locus typicus* in Colombia were *Nitokra affinis colombiensis* (Ameiridae), *Attheyella (Canthosella) chocoensis*, *Cletocamptus nudus*, *Cletocamptus samariensis*, *Elaphoidella paramuna*, *Mesochra huysi* (Canthocamptidae), *Halectinosoma arangureni*, *Pseudobradya gascae* (Ectinosomatidae), *Schizopera evelynae* (Miraciidae), and *Colombocaris isabellae* (Parastenocarididae).

The intensive taxonomic research on harpacticoids from the coastal lagoons Ciénaga Grande de Santa Marta (Fuentes-Reinés *et al.*, 2013; Fuentes-Reinés & Zoppi de Roa, 2013a, 2013b; Suárez-Morales & Fuentes-Reinés, 2015a; Fuentes-Reinés *et al.*, 2018) and Laguna Navio Quebrado (Fuentes-Reinés & Gómez, 2014; Fuentes-Reinés & Suárez-Morales, 2014a, 2014b; Suárez.Morales & Fuentes-Reinés, 2015b), from two temporal ponds in the Caribbean region (Fuentes-Reinés *et al.*, 2015; Gómez & Fuentes-Reinés, 2017), from water bodies in the *páramo* (Gaviria & Defaye, 2012, Gaviria *et al.*, 2017a, 2017b), and phytotelmata from the rain forest (Gaviria & Defaye, 2012) explains this increase in species numbers.

Most harpacticoid copepods are typical inhabitants of benthic environments. The benthic families recorded in Colombia are Ameiridae, Canthocamptidae, Cletodidae, Ectinosomatidae Laophontidae, Metidae, Parastenocarididae, Tachididae and Tegastridae. Few families of the order have worldwide representatives in the plankton of coastal lagoons. In Colombia, only the family Miraciidae is known in this environment, represented by *Schizopera* (two species), *Sarsamphiascus* and *Robertsonia* (each with one species).

A revision of the *columbiensis*-group of Noodt (1972) from the family Parastenocarididae led Gaviria *et al.*

(2017a, 2017b) to propose a new genus (*Noodtcaris*) for *Parastenocaris columbiensis*, *Parastenocaris kubitzkii* and *Parastenocaris roettgeri* together with a Brazilian species. As no other species of *Parastenocaris* has been recorded in Colombia, the genus is no longer part of the Colombian copepod fauna.

Three freshwater canthocamptid copepods (*Elaphoidella bidens bidens*, *Elaphoidella grandidieri*, *Atheyella* (*Chappuisiella*) *fuhrmani*) already known from Colombia were recorded from coastal lagoons (Fuentes-Reinés & Zoppi de Roa, 2013a, 2013b; Fuentes-Reinés & Suárez-Morales, 2014b), probably collected in their freshwater zone. The species *Attheyella* (*Chappuisiella*) *pichilafquensis* Löffler, 1962, also registered in Colombia, is considered by some authors (Löffler, 1962, 1963; Gaviria & Aranguren, 2007) to be an independant species, and by others (Reid, pers. com. to SG) a synonym of *A.*(*Ch.*) *fuhrmanni* (Thiébaud, 1912). This calls for re-studying the comparative morphology of both species. *Elaphoidella schubarti* was recorded by Löffler (1972) in Colombia, collected in high mountain waterbodies of the Sierra Nevada de Santa Marta.

The significant proportion of copepod species recorded in lowland waterbodies (74 %) compared within highland regions (17 %) indicates a high heterogeneity of ecological conditions in this area. Nine percent of the species are distributed in both regions.

Concerning the presence of copepods in the Colombian departments, 8 of the 32 departments (Arauca, Caldas, Caquetá, Casanare, Guaviare, Putumayo, Quindío and Vaupés), have no reports. Except Caldas and Quindío, the remaining departments are located in the Orinoco and Amazonas basins, where few surveys of aquatic invertebrates have been carried out. The departements with the highest number of records are Magdalena (42), La Guajira (34) and Cundinamarca (27), due to the expert taxonomists that have worked in these regions.

The diversity of copepods in Colombian continental waters, including brackish species of coastal lagoons and ponds is with 119 species, lower than in Mexico (159 species) (Suárez-Morales *et al.*, 1998). Considering only freshwater taxa (82 species and subspecies), the diversity of copepods in Colombia is lower than in Brazil (200) (Reid, 1998; Rocha & Botelho, 1998; Santos Silva, 1998; Previatelli & Santos-Silva, 2007; Perbiche-Neves *et al.*, 2013; Silva & Perbiche-Neves, 2016; Corgosinho *et al.*, 2017), similar to Mexico (78) (Suárez-Morales *et al.*, 2000) and higher than in Venezuela (66) (Dussart, 1984), Cuba (56) (Collado *et al.*, 1984) and Costa Rica (25) (Morales-Ramírez *et al.*, 2014).

Conclusions

The list presented here contributes to a better understanding of the biodiversity of Copepoda in Colombia. As only two coastal lagoons and two coastal ponds in the Caribbean region were investigated, surveys in other brackish environments are expected to increase our knowledge about copepod diversity. Ground water environments, including the interstitial of rivers and lakes, continue to be virtually unstudied habitats for copepods. Species of parastenocaridids, canthocamptids, certain ameirids and cyclopoids should occur there. The further study of unexplored territories and poorly studied habitats like benthos of water bodies, ground waters and semiterrestrial biotopes should increase the number of copepods of the continental waters of Colombia.

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Continental copepods (Crustacea: Hexanauplia) of Colombia: revision and additions to the inventory

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