A preliminary checklist of soil ants (Hymenoptera: Formicidae) of Colombian Amazon

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Academic editor: Francisco Hita Garcia
Received: 23 Aug 2018 | Accepted: 18 Oct 2018 | Published: 07 Nov 2018
Citation: Castro D, Fernández F, Meneses A, Tocora M, Sanchez S, Peña-Venegas C (2018) A preliminary checklist of soil ants (Hymenoptera: Formicidae) of Colombian Amazon. Biodiversity Data Journal 6: e29278. https://doi.org/10.3897/BDJ.6.e29278

Abstract

Background

This paper presents an updated list of soil ants of the Colombian Amazon collected in three different river basins: the Amazon, the Caquetá and the Putumayo. The list includes 10 subfamilies, 60 genera and 218 species collected from TSBF monoliths at four different depths (Litter, 0 - 10 cm, 10 - 20 cm and 20 - 30 cm). This updated list increases considerably the knowledge of edaphic macrofauna of the region, due to the limited published information about soil ant diversity in the Colombian Amazon region.

New information

This is the first checklist of soil ant diversity of the Colombian Amazon region. Six new records of species for Colombia are exposed: Acropyga tricuspis (LaPolla, 2004), Typhlomyrmex clavicorns (Emery, 1906), Typhlomyrmex meire (Lacau, Villemant & Delabie, 2004), Cyphomyrmex bicornis (Forel, 1895), Megalomyrmex emeryi (Forel, 1904)
and *Myrmicocrypta spinosa* (Weber, 1937), most of them corresponding to subterranean ants.

**Keywords**

TSBF, Amazon basin, soil macrofauna, biogeography, species distribution.

**Introduction**

In tropical forests, the abundance and diversity of ants is usually high, which brings out the importance of ants for these ecosystems (Floren and Linsenmair 2005, Floren et al. 2002, Dunn et al. 2007, Davidson et al. 2007, Jaffe et al. 2007). Ants, together with earthworms and termites, are known as "ecosystem engineers" due to the positive effect of their activity on ecosystems (Decaëns et al. 1999, Decaëns 2010, Lavelle et al. 1997, Luke et al. 2014, Griffiths et al. 2017). Physical, chemical and biological soil properties are positively affected by the presence of ant nests, chambers, galleries and mineral aggregates that ants create (Seybold et al. 1999, Barros et al. 2001, Sanabria et al. 2014, Wu et al. 2015).

Diversity of soil ants in Amazonian forests is notoriously high (Ryder Wilkie et al. 2010, Ryder Wilkie et al. 2007, Bastos and Harada 2011, Bruna et al. 2008). In Colombia, ant lists include reports from coastal, mountain and Amazonian ecosystems (Pérez et al. 2009, Sanabria-Blandón and Achury 2011, Sanabria-Blandón and de Ulloa 2011, Vergara-Navarro and Serna 2013, Valdés-Rodríguez et al. 2014). However, information on soil ant diversity in the Colombian Amazon region is limited, due to the small number of works on this topic that have been published (Ospina and Fagua 2007).

This paper reports a preliminary checklist of soil ants collected in the Colombian Amazon region, with the purpose of contributing to a better understanding of the biogeographical distribution of these insects in the three most important river basins of the Amazon region of Colombia: the Amazon, the Caquetá and the Putumayo.

**Materials and methods**

**Study area**

Three Colombian states of the Amazon region were sampled: Amazonas, Caquetá and Putumayo (Fig. 1). The study area includes the Andean-Amazonian transition from north to south of the Colombian Amazon region up to the borders with Peru and Brazil along the Amazon River. Sampling altitude went from 78 to 2275 metres above sea level. There, 71 sampling sites in 13 municipalities were sampled: in Caquetá, the municipalities of Belén de los Andaquíes, Florencia, Morelia, San José and Solano; in Putumayo, the municipalities of Puerto Leguizamo and La Tagua; in Amazonas, the municipalities of El Encanto, La Chorrera, Leticia, Puerto Alegria, Puerto Arica, Puerto Nariño and Puerto
Santander. Different natural and anthropic land uses were included in the sampling: primary and secondary forests, young secondary forests, pastures and indigenous slash-and-burn agricultural plots (Table 1).

| River basin | State      | Town        | Land use             | Altitude | Latitude       | Longitude       |
|-------------|------------|-------------|----------------------|----------|----------------|-----------------|
| Amazonas    | Amazonas   | Leticia     | Primary forest        | 80       | S4°10'09", W69°57'25" |
|             |            |             | Primary forest        | 81       | S4°10'09.1", W69°57'27.2" |
|             |            |             | Primary forest        | 98       | S04°07'15.4", W69°57'19.7" |
|             |            |             | Primary forest        | 106      | S04°02'45.7", W69°59'26.8" |
|             |            |             | Primary forest        | 110      | S04°00'32.5", W69°53'43.3" |
|             |            |             | Primary forest        | 119      | S04°00'10.5", W69°53'47.6" |
|             |            |             | Primary forest        | 121      | S04°02'48.0", W70°00'20.4" |
|             |            | Pto. Nariño | Secondary forest      | 87       | S03°46'33.6", W70°21'41.8" |
| Caquetá     | Pto. Santander | Secondary forest | 116     | S00°39'43.3", W72°18'38.2" |
| Caquetá     | Belen      | Pasture     | 233                  | N01°16'08.3", W75°47'17.6" |
|             |            | Pasture     | 242                  | N01°15'59.9", W75°47'23.4" |
|             |            | Primary forest | 500                 | N01°36'17.8", W75°52'50.9" |
|             |            | Primary forest | 625                 | N01°36'28.6", W75°53'12.6" |
|             |            | Primary forest | 750                 | N01°37'50.3", W75°54'21.3" |
|             |            | Primary forest | 875                 | N01°37'40.0", W75°54'16.8" |
|             |            | Primary forest | 1000                | N01°37'27.4", W75°54'04.3" |
|             |            | Primary forest | 1125                | N01°40'14.4", W75°54'13.3" |
|             |            | Primary forest | 1247                | N01°50'36.4", W75°40'18.3" |
|             |            | Primary forest | 1250                | N01°40'45.2", W75°54'12.4" |
|             |            | Primary forest | 1375                | N01°40'54.3", W75°54'17.1" |
|             |            | Primary forest | 1500                | N01°42'06.8", W75°53'57.5" |
|             |            | Primary forest | 1625                | N01°41'49.9", W75°54'18.1" |
|             |            | Primary forest | 1875                | N01°43'04.4", W75°54'11.7" |

Table 1.
List of TSBF monoliths sampling sites in Colombian Amazon soils.
| Location     | Type            | Latitude          | Longitude         |
|--------------|-----------------|-------------------|-------------------|
| Florecia     | Pasture         | N01°38'54.1"      | W75°38'13.6"      |
|              | Pasture         | N01°39'00.2"      | W75°36'49.3"      |
|              | Pasture         | N01°45'33.7"      | W75°46'41.5"      |
|              | Pasture         | N01°42'29.8"      | W75°41'32.4"      |
|              | Pasture         | N01°42'55.1"      | W75°42'06.0"      |
|              | Secondary forest| N01°26'39.9"      | W75°31'29.1"      |
|              | Secondary forest| N01°40'35.0"      | W75°37'5.86"      |
|              | Secondary forest| N01°42'26.8"      | W75°36'59.5"      |
|              | Secondary forest| N01°43'04.0"      | W75°36'45.6"      |
|              | Secondary forest| N01°42'37.7"      | W75°43'49.1"      |
|              | Secondary forest| N01°50'09.0"      | W75°40'19.2"      |
|              | Young secondary forest| N01°42'52.2"  | W75°36'53.6"      |
|              | Young secondary forest| N01°42'27.6"  | W75°43'26.0"      |
|              | Young secondary forest| N01°26'40.9"  | W75°31'32.1"      |
|              | Young secondary forest| N01°40'47.0"  | W75°37'48.3"      |
|              | Young secondary forest| N01°42'27.9"  | W75°36'59.7"      |
|              | Young secondary forest| N01°50'36.9"  | W75°40'16.1"      |
| Morelia      | Pasture         | N01°27'21.63"     | W75°39'48.10"     |
|              | Secondary forest| N01°26'28.8"      | W75°39'10.3"      |
|              | Young secondary forest| N01°26'18.1"  | W75°45'16.3"      |
|              | Young secondary forest| N01°26'29.9"  | W75°39'12.5"      |
|              | Young secondary forest| N01°39'35.2"  | W75°36'33.9"      |
| San José     | Primary forest   | N01°11'38.4"      | W75°58'16.7"      |
|              | Young secondary forest| N01°11'40.1"  | W75°58'18.7"      |
| Solano       | Young secondary forest| S00°34'30.8" | W72°06'51"       |
| Putumayo     | Amazonas        | N01°37'03.7"      | W73°15'31.7"      |
| Location        | Type             | ID | Latitude       | Longitude         |
|-----------------|------------------|----|----------------|-------------------|
| Primary forest  | 141              | S01°40'34.7", W73°13'51.4" |
| La Chorrera     | Primary forest   | 126 | S02°04'55.2", W72°10'54.8" |
| Primary forest  | 133              | S02°04'14.4", W72°10'14.2" |
| Primary forest  | 146              | S01°26’54.2", W72°48’13.3" |
| Primary forest  | 151              | S01°26’56.3", W72°48’37" |
| Primary forest  | 154              | S01°25’05.7", W72°47’21.2" |
| Secondary forest| 147              | S01°25’11”, W72°47’10.5” |
| Pto. Alegria    | Primary forest   | 154 | S01°00’31.5", W74°04’44.5” |
| Primary forest  | 169              | S00°59’34.3", W74°01’10.4” |
| Pto. Arica      | Primary forest   | 108 | S02°07’55.6", W71°44’42.8” |
| Primary forest  | 120              | S02°07’59", W71°46’54” |
| Primary forest  | 127              | S02°08’10.5", W71°43’16.8” |
| Sabalo          | Primary forest   | 142 | S02°21’11.7", W72°35’53.4” |
| Putumayo        | Pto. Leguizamo   | Secondary forest | 182 | S00°05’14.9", W74°36’38.4” |
|                 | Secondary forest | 213 | S00°08’42.1", W74°46’40.9” |

**Figure 1.** Study area, sampling localities.
Sample collection and analysis

Soil ant collection took place between September 2015 and July 2017. Soil ants were collected using the methodology suggested by the Tropical Soil Biology and Fertility Program (TSBF) for soil macrofauna collection (Anderson and Ingram 1993). In each sampling site, a plot of 60 x 60 metres was selected. There, five monoliths of 25 x 25 x 30 cm of depth were done: one in each corner of the 60 x 60 m delimited square plot and one in the centre of it. In each monolith, macrofauna samples were collected at four depths: litter, 0 – 10 cm, 10 – 20 cm and 20 – 30 cm. Macrofauna collection in each monolith depth was undertaken in the field manually. Recovered samples were preserved in ethanol at 75% until their arrival to the SINCHI Institute laboratories in Leticia, Colombia, where specimens were vouchered and preserved in the CATAC collection.

In the laboratory, samples were cleaned and classified into morphotypes and species. All samples were identified by using the keys of recent revisions, verifying the species with the diagnosis and in some cases comparing with photos of type material in AntWeb (Brandão 1990, Kugler 1994, De Andrade and Baroni 1999, Palacio 1999, Fernández 2003, Longino and Fernández 2007, Jiménez et al. 2008, Mackay and Mackay 2010, Ortiz and Fernández 2011, Pacheco and Mackay 2013, Lenhart et al. 2013, Ješovník and Schultz 2017, AntWeb 2018, LaPolla 2004, Snelling and Longino 1992, Brandão 2003, Longino 2010, Fernández et al. 2015, Lattke et al. 2007, Lattke 1997, Longino 2013, Sosa-Calvo et al. 2018, Longino 2003). *Camponotus, Brachymyrmex* and *Pheidole* were identified through the comparison of material identified by specialists and reference collection. All data were organised alphabetically by subfamily, genus and species in an ant checklist following the nomenclature suggested in the Bolton online catalogue of the ants of the world (AntCat, Bolton 2018).

Analysis

Checklist of the soil ant species of Colombian Amazon

A total of 1341 specimens and 4318 individuals were analysed. From the total soil macrofauna, ants were the most abundant and species-richest organisms collected. Ants dominated litter and 0 - 10 cm depths (Barros et al. 2002, Mathieu et al. 2005, Rossi et al. 2006, Velásquez et al. 2012, Suárez Salazar et al. 2015). Litter had the highest species richness with 129 species, followed by the 0 - 10 cm depth with 110 species. Layers from 10 - 20 cm depth and 20 - 30 cm depth had 77 and 45 species, respectively, showing a decreasing ant richness structure in the soil profile with depth.

The preliminary checklist of soil ants from the Colombian Amazon region (Table 2), contains 218 species distributed in 60 genera of 10 subfamilies. The richest subfamily was Myrmicinae with 99 species, followed by Ponerinae with 41 species. Other subfamilies found there included Formicinae with 31 species, Ectatomminae with 18 species, Dolichoderinae with 14 species, Pseudomyrmecinae with 6 species, Dorylinae with 5 species, Amblyopone with 2 species and the Paraponerinae and Proceratiinae with 1
species each, respectively. The richest genus was *Pheidole* Westwood, 1839 with 27 species, followed by *Crematogaster* Lund, 1831 with 16 species. Other genera rich in species are *Camponotus* Mayr, 1861 with 14 species, *Odontomachus* Latreille, 1804 with 10 species and *Gnamptogenys* Roger, 1863 with 8 species.

**Table 2.**

Checklist of the soil ant species of the Colombian Amazon. The list is organised alphabetically by subfamily, genus and species. Species names in bold characters refer to species recorded for the first time in Colombia. River basins corresponded to: A = Amazon river; C = Caquetá river; P = Putumayo river. Depth of species collection: 1 = Litter; 2 = 0 – 10 cm; 3 = 10 – 20 cm; 4 = 20 – 30 cm. Land use corresponded to PF = Primary forest; SF = Secondary forest; P = Pasture; R = Young secondary regeneration forest.

| Subfamilies | Scientific valid name                               | River basin | Depth | Land use |
|-------------|-----------------------------------------------------|-------------|-------|----------|
| Amblyoponinae | **Prionopelta antillana** Forel, 1909              | A,C         | 1,2,3 | R        |
|             | **Fulakora orizabana** (Brown, 1960)               | C           | 3     | P        |
| Dolichoderinae | **Azteca** sp1                                     | C,P         | 1,2   | PF       |
|              | **Azteca** sp2                                     | A,P         | 1,2,4 | PF, R    |
|              | **Azteca** sp3                                     | A,C,P       | 1,2,3,4 | PF, P, R |
|              | **Azteca** sp4                                     | C           | 2,3   | SF       |
|              | **Azteca** sp5                                     | C           | 1,4   | PF, P    |
|              | **Dolichoderus atteloides** Fabricius, 1775        | A           | 1     | PF       |
|              | **Dolichoderus bidens** Linnaeus, 1758             | C,P         | 1,2   | P, R     |
|              | **Dolichoderus bispinosus** Olivier, 1792          | P           | 1     | PF, R    |
|              | **Dolichoderus imitator** Emery, 1894              | A,C         | 2,3   | R        |
|              | **Dolichoderus quadridenticulatus** Roger, 1862    | C           | 2     | P        |
|              | **Dolichoderus rugosus** Smith, 1858               | A,P         | 1     | PF, R    |
|              | **Linepithema** sp1                                | A,C,P       | 1,2,3,4 | PF, P |
|              | **Linepithema** sp2                                | C           | 1,2,3,4 | PF, P, SF |
|              | **Linepithema** sp3                                | C           | 1,2,3,4 | PF, SF   |
| Dorylinae    | **Cheliomyrmex andicola** Emery, 1894              | C           | 2     | SF       |
|              | **Eciton hamatum** Fabricius, 1782                 | A,C         | 1     | PF       |
|              | **Labidus praedator** Smith, 1858                  | C           | 1,2,3 | P, SF    |
|              | **Leptanilloides** sp.                             | P           | 2     | PF       |
|              | **Neivamyrnex cf. hetschkoii** Mayr, 1886         | C           | 1,4   | PF, SF   |
| Ectatomminae | Ectatomma brunneum Smith, 1858 | A,C | 1 | PF, R |
| Ectatomma edentatum Roger, 1863 | A | 2 | PF |
| Ectatomma lugens Emery, 1894 | P | 2 | PF |
| Ectatomma ruidum Roger, 1860 | A,C | 1,2,3 | PF, P |
| Ectatomma tuberculatum Olivier, 1792 | C | 2 | PF |
| Gnamptogenys cf. illmani Lattke, 1995 | C | 1 | P |
| Gnamptogenys (gr. minuta) sp | A | 2 | PF |
| Gnamptogenys kempfi Lenko, 1964 | A | 2 | PF |
| Gnamptogenys cf. lavra Lattke, 2002 | A,C,P | 1,2 | PF |
| Gnamptogenys porcata Emery, 1896 | C | 3 | R |
| Gnamptogenys striatula Mayr, 1884 | C,P | 1,3 | PF |
| Gnamptogenys strigata Norton, 1868 | P | 3 | PF |
| Gnamptogenys tortuolosa Smith, 1858 | A | 1 | PF |
| Typhlomyrmex clavicornis Emery, 1906 | C,P | 3,4 | PF, SF |
| Typhlomyrmex major Santschi, 1923 | A,C | 3,4 | PF, SF |
| Typhlomyrmex meire Lacau, Villemant & Delabie, 2004 | C | 1,3 | P |
| Typhlomyrmex pusillus Emery, 1894 | C | 1,2,4 | PF, P |
| Typhlomyrmex sp. | A,C | 2 | PF |
| Formicinae | Acropyga aff. epedana Snelling, 1973 | C | 2 | R |
| Acropyga exsanguis Wheeler, 1909 | C | 4 | PF, R |
| Acropyga goeldii Forel, 1893 | C,P | 1,2,3 | PF |
| Acropyga guianensis Weber, 1944 | P | 1,2,3 | PF, P, SF |
| Acropyga smithii Forel, 1893 | P | 2 | PF |
| Acropyga tricuspis LaPolla, 2004 | A | 1,2 | R |
| Brachymyrmex aff. heeri Forel, 1874 | P | 2 | PF |
| Brachymyrmex aff. australis Forel, 1901 | C | 1 | P |
| Brachymyrmex cordemoyi Forel, 1895 | A,C | 1,2,3,4 | PF, SF |
| Brachymyrmex myops Emery, 1906 | A | 2 | PF |
| Brachymyrmex pictus Mayr, 1887 | C | 1 | SF |
| Camponotus aff. ager Smith, 1858 | A | 2 | PF |
| Camponotus atriceps Smith, 1858 | A | 1 | PF |
| Species                                      | Code | Count | Specimens |
|----------------------------------------------|------|-------|-----------|
| Camponotus casicus Santschi, 1920            | C    | 1     | SF        |
| Camponotus femoratus Fabricius, 1804         | A,C,P| 1,2   | PF, P, SF |
| Camponotus latangulus Roger, 1863            | C    | 1     | P         |
| Camponotus nitidior Santschi, 1921           | C    | 2     | PF        |
| Camponotus novogranadensis Mayr, 1870        | A    | 1     | PF        |
| Camponotus rapax Fabricius, 1804             | C    | 1,3   | PF        |
| Camponotus ruﬁpes Fabricius, 1775           | C    | 1     | PF        |
| Camponotus senex Smith, 1858                 | C    | 3     | P         |
| Camponotus sp1                               | C    | 1     | SF        |
| Camponotus sp2                               | A    | 1     | PF        |
| Camponotus sp3                               | C    | 3     | R         |
| Camponotus sp4                               | C    | 2     | PF        |
| Gigantiops destructor Fabricius, 1804         | A,C,P| 1,2   | PF        |
| Myrmelachista sp.                            | C    | 1,3   | PF        |
| Nylanderia sp1                               | A    | 1,2,3,4| PF, P, R, SF |
| Nylanderia sp2                               | A,C  | 1,2,3,4| PF, P, S, SF |
| Nylanderia sp3                               | A    | 1,2   | PF, P, SF |
| Nylanderia sp4                               | A    | 3     | PF        |

**Myrmicinae**

| Species                                      | Code | Count | Specimens |
|----------------------------------------------|------|-------|-----------|
| Acromyrmex coronatus Fabricius, 1804         | C    | 4     | PF        |
| Apterostigma auriculatum Wheeler, 1925       | P    | 2     | PF        |
| Apterostigma cf. acre Lattke, 1997           | A    | 1     | R         |
| Apterostigma goniodes Lattke, 1997           | C    | 1,4   | PF        |
| Apterostigma (gr. pilosum) sp.1              | A    | 1     | SF        |
| Apterostigma (gr. pilosum) sp.2              | C    | 2     | R         |
| Apterostigma megacephala Lattke, 1999        | C    | 1     | P         |
| Atta colombica Guérin-Méneville, 1844        | C    | 1     | PF, P     |
| Blepharidatta brasiliensis Wheeler, 1915     | A    | 1     | PF        |
| Cardiocondyla nuda Mayr, 1866                | C    | 1     | SF        |
| Carebara brevipilosa Fernández, 2004         | C    | 3     | P         |
| Carebara (gr. escherichi) sp.1               | A    | 4     | PF        |
| Species Name                          | Author, Year | Distribution | Comments |
|--------------------------------------|--------------|--------------|----------|
| Cephalotes aff. cordatus             | Smith, 1853  | C 2 P        |          |
| Cephalotes atratus                   | Linnaeus, 1758 | A,C 1 PF    |          |
| Cephalotes cf. patellaris            | Mayr, 1866   | C 1 SF       |          |
| Cephalotes spinosus                  | Mayr, 1862   | C 1,3 P      |          |
| Crematogaster abstinens              | Forel, 1899  | A,C 1,2,3,4 SF |          |
| Crematogaster acuta                   | Fabricius, 1804 | A 2,3,4 PF |          |
| Crematogaster aff. evallans          | Forel, 1907  | C 2,3 SF     |          |
| Crematogaster brasiliensis           | Mayr, 1878   | A,C 1,2,3,4 PF, SF |          |
| Crematogaster bryophilia             | Longino, 2003 | A 1 PF       |          |
| Crematogaster carinata               | Mayr, 1862   | A,C,P 1,2,3,4 PF, P, SF |          |
| Crematogaster cf. snellingi          | Longino, 2003 | A 1 PF       |          |
| Crematogaster crinosa                | Mayr, 1862   | C 1,3,4 SF   |          |
| Crematogaster erecta                 | Mayr, 1866   | C 2 SF       |          |
| Crematogaster flavosensitiva         | Longino, 2003 | P 1 PF       |          |
| Crematogaster limata                 | Smith, 1858  | A,C,P 1,2,3,4 PF, P, R, SF |          |
| Crematogaster longispina             | Emery, 1890  | A,C 1,2 PF, SF |          |
| Crematogaster minutissima            | Mayr, 1870   | A 1,2 PF     |          |
| Crematogaster nigropilosa            | Mayr, 1870   | A 2,3 PF     |          |
| Crematogaster sotobosque             | Longino, 2003 | C,P 2,3 PF   |          |
| Crematogaster tenuicula              | Forel, 1904  | A,P 1,2,3 PF, R |          |
| Cyphomyrmex bicornis                 | Forel, 1895  | A 2 PF       |          |
| Cyphomyrmex laevigatus               | Weber, 1938  | A,P 1 PF     |          |
| Cyphomyrmex minutus                  | Mayr, 1862   | C 1 PF       |          |
| Cyphomyrmex peltatus                 | Kempf, 1966  | C 1 PF       |          |
| Cyphomyrmex rimosus                  | Spinola, 1851 | C,P 1,2,3 PF, P, SF |          |
| Hylomyrma immanis                    | Kempf, 1973  | A,C 1,2 PF, SF |          |
| Hylomyrma sagax                      | Kempf, 1973  | C 1 PF       |          |
| Kempfidris inusualis                 | Fernández, 2007 | A 2 R       |          |
| Megalomyrmex cf. balzani             | Emery, 1894  | C 3 PF       |          |
| Megalomyrmex emeryi                   | Forel, 1904  | C,P 1,2,3 P  |          |
| Megalomyrmex foreli                   | Emery, 1890  | C,P 1,2,3 PF, P |          |
| Species                                      | Locality | Collection | Education |
|----------------------------------------------|----------|------------|-----------|
| *Megalomyrmex leoninus* Forel, 1885          | C        | 1,3        | P         |
| *Megalomyrmex megadriti* Boudinot, Sumnicht & Adams, 2013 | C        | 1          | PF        |
| *Mycocepurus smithii* Forel, 1893            | A,C,P    | 1,2,3      | PF, SF    |
| *Myrmicocrypta longinoda* Weber, 1938        | A        | 2          | PF        |
| *Myrmicocrypta sp.*                         | C        | 2          | PF        |
| *Myrmicocrypta spinosa* Weber, 1937          | C        | 3          | PF        |
| *Nesomyrmex tristani* Emery, 1896             | C        | 1          | SF        |
| *Ochotomyrmex neopolitus* Fernández, 2003    | P        | 1          | PF        |
| *Octostruma balzani* Emery, 1894             | C        | 1          | PF        |
| *Octostruma impressa* Palacio, 1997          | C        | 1          | PF        |
| *Pheidole aff. biconstricta* Mayr, 1870      | A,C,P    | 1,2        | PF        |
| *Pheidole aff. chocoensis* Wilson, 2003      | P        | 1,3        | PF        |
| *Pheidole aff. cocciphaga* Borgmeier, 1934   | A        | 1          | PF        |
| *Pheidole aff. huliana* Wilson, 2003         | P        | 1,2        | PF, R     |
| *Pheidole aff. radoszkowski* Mayr, 1884      | C        | 3          | SF        |
| *Pheidole aff. sensitiva* Borgmeier, 1959    | P        | 1          | PF        |
| *Pheidole aff. subnuda* Wilson, 2003         | P        | 1          | PF        |
| *Pheidole aff. vafra* Santschi, 1923         | C        | 2          | SF        |
| *Pheidole astur* Wilson, 2003                | P        | 3          | PF        |
| *Pheidole gertrudae* Forel, 1886             | C        | 3          | PF        |
| *Pheidole sp1*                               | C        | 1          | SF        |
| *Pheidole sp2*                               | A,C      | 1,2,3      | PF, SF    |
| *Pheidole sp3*                               | P        | 2          | PF        |
| *Pheidole sp4*                               | P        | 4          | PF        |
| *Pheidole sp5*                               | C        | 3          | P, SF     |
| *Pheidole sp6*                               | C        | 1          | SF        |
| *Pheidole sp7*                               | C        | 2          | SF        |
| *Pheidole sp8*                               | P        | 2,3        | PF        |
| *Pheidole sp9*                               | C        | 3,4        | P, SF     |
| *Pheidole sp10*                              | C        | 2          | P         |
| *Pheidole sp11*                              | C        | 2          | SF        |
| Species                                | Location | Heat | Food Sources |
|----------------------------------------|----------|------|--------------|
| *Pheidole* sp12                        | C        | 1    | SF           |
| *Pheidole* sp13                        | C        | 2    | P            |
| *Pheidole* sp14                        | A,P      | 2,3,4| PF, SF       |
| *Pheidole* sp15                        | A,P      | 1,3  | PF           |
| *Pheidole* sp16                        | A        | 1,2,4| PF           |
| *Pheidole* sp17                        | A        | 4    | R            |
| *Procryptocerus scabriusculus* Forel, 1899 | C    | 3    | PF           |
| *Rogeria belti* Mann, 1922              | A        | 1,2  | PF, P        |
| *Sericomyrmex bondari* Borgmeier, 1937 | A,C      | 1,2,3,4| PF, R    |
| *Solenopsis geminata* Fabricius, 1804   | C        | 1,2,3| PF, P, R     |
| *Solenopsis* sp1                        | C        | 1    | P            |
| *Solenopsis* sp2                        | P        | 2    | PF           |
| *Solenopsis* sp3                        | A,P      | 1,2,4| PF, P, SF    |
| *Solenopsis* sp4                        | A,C      | 1,3  | PF, P, SF    |
| *Solenopsis* sp5                        | C        | 1,2,3,4| PF, P, SF    |
| *Solenopsis virulens* Smith, 1858       | P        | 1    | PF           |
| *Strumigenys denticulata* Mayr, 1887    | A        | 1    | R            |
| *Strumigenys interfectiva* Lattke & Goltiá, 1997 | C | 1 | PF |
| *Strumigenys smithii* Forel, 1886       | P        | 1    | PF           |
| *Trachymyrmex* sp1                      | C,P      | 1,2,3,4| PF, SF    |
| *Trachymyrmex* sp2                      | A,C,P    | 1,2,3,4| PF, P, SF    |
| *Trachymyrmex* sp3                      | C,P      | 1,3,4| PF, SF       |
| *Trachymyrmex* sp4                      | C        | 3    | PF           |
| *Tranopelta gilva* Mayr, 1866           | A,C,P    | 1,2,3,4| PF, P, SF    |
| *Wasmannia auropunctata* Roger, 1863    | A,C,P    | 1,2,3,4| PF, P, R, SF|
| **Paraponerinae**                       |          |      |              |
| *Paraponera clavata* Fabricius, 1775    | C,P      | 1    | PF           |
| **Ponerinae**                           |          |      |              |
| *Anochetus diegensis* Forel, 1912       | C        | 1    | PF, P        |
| *Anochetus mayri* Emery, 1884           | C        | 1    | PF           |
| *Anochetus cf. neglectus* Emery, 1894   | C        | 1    | PF           |
| *Centromyrmex alfaroi* Emery, 1890      | C        | 2    | SF           |
| *Centromyrmex brachycola* Roger, 1861   | A,C,P    | 1,2,3| PF, P, SF    |
| Species                              | Author(s)           | Collection(s) | Locality | Remarks |
|--------------------------------------|---------------------|----------------|----------|---------|
| Cryptopone guianensis               | Weber, 1939        | C,P            | 2,3      | PF      |
| Cryptopone holmgreni                | Wheeler, 1925      | C              | 2,3,4    | PF, SF  |
| Dinoponera longipes                 | Emery, 1901        | A              | 1        | PF      |
| Hypoponera distinguenda              | Emery, 1890        | A,C            | 1,2      | PF, R   |
| Hypoponera sp1                      |                     | C,P            | 1,2,3,4  | PF, P, R|
| Hypoponera sp2                      |                     | C,P            | 1,2,3    | PF, R   |
| Hypoponera sp3                      |                     | A,P            | 1,2      | PF, R   |
| Hypoponera sp4                      |                     | A,C,P          | 1,2,3    | PF, SF  |
| Hypoponera sp5                      |                     | A,C,P          | 1,2,3    | PF, P, SF|
| Hypoponera sp6                      |                     | A,C            | 1,2,3,4  | PF, P, R, SF|
| Leptogenys (gr. crudelis) sp        |                     | C              | 1        | PF      |
| Mayaponera constricta               | Mayr, 1884         | A,C,P          | 1,2      | PF, P, R, SF|
| Neoponera apicalls                  | Latreille, 1802    | A,C            | 1        | PF      |
| Neoponera commutata                 | Roger, 1860        | P              | 2        | PF      |
| Neoponera unidentata                | Mayr, 1862         | C              | 3        | PF      |
| Neoponera verenae                   | Forel, 1922        | C              | 1        | PF      |
| Neoponera villosa                   | Fabricius, 1804    | A              | 1        | PF      |
| Odontomachus aff. panamensis        | Forel, 1899        | C              | 1        | SF      |
| Odontomachus bauri                   | Emery, 1892        | C              | 1,4      | PF, P   |
| Odontomachus bradleyi               | Brown, 1976        | C              | 1        | PF      |
| Odontomachus caelatus               | Brown, 1976        | P              | 1        | PF      |
| Odontomachus haematodus             | Linnaeus, 1758     | A,C            | 1        | SF      |
| Odontomachus meinerti               | Forel, 1905        | C              | 1,3      | PF      |
| Odontomachus opaciventris           | Forel, 1899        | C,P            | 1        | PF, SF  |
| Odontomachus scalptus               | Brown, 1978        | C              | 1        | SF      |
| Odontomachus spisuas                | Kempf, 1962        | P              | 1        | PF      |
| Odontomachus cf. yucatecus          | Brown, 1976        | C              | 2        | PF      |
| Pachycondyla crassinoda             | Latreille, 1802    | P              | 1,2      | PF      |
| Pachycondyla fuscoatra              | Roger, 1861        | A              | 1        | R       |
| Pachycondyla harpax                 | Fabricius, 1804    | A,C,P          | 1,2      | PF, R   |
| Genus                              | Subgenus | Location            | Identification |
|-----------------------------------|----------|---------------------|----------------|
| *Pachycondyla impressa* Roger, 1861 |          |                     |                |
| *Pseudoponera stigma* Fabricius, 1804 | A,C,P    |                     | 1,2 PF         |
| *Rasopone arhuaca* Forel, 1901    | A,C,P    |                     | 1,2,3 PF, R    |
| *Rasopone becculata* MacKay & MacKay, 2010 | C      |                     | 2,3,4 PF       |
| *Rasopone lunaris* Emery, 1896    | A        |                     | 2 PF           |
| *Rasopone* sp.                    |          |                     | 2 PF           |
| *Proceratium transitionis* de Andrade, 2003 | C      |                     | 1 PF           |

**Proceratiinae**

**Pseudomyrmecinae**

| Genus      | Subgenus | Location            | Identification |
|------------|----------|---------------------|----------------|
| *Pseudomyrmex* sp1 | A,C |                     | 1,2,3 PF, P  |
| *Pseudomyrmex* sp2 | A,C,P |                     | 1,2,4 PF, P, R, SF |
| *Pseudomyrmex* sp3 | C   |                     | 1,2,3,4 PF, P, SF |
| *Pseudomyrmex* sp4 | C,P |                     | 1,2,4 PF, SF |
| *Pseudomyrmex* sp5 | C   |                     | 1,3,4 P, SF |
| *Pseudomyrmex* sp6 | C,P |                     | 1 PF         |

Ant richness in this report is remarkable when compared with previous reports from the Amazon region. The study done by Ryder Wilkie et al. 2010, which is recognised as the most complete work on ant diversity in the Amazon region, recorded at the Tiputini Reserve in Ecuador 66 genera and more than 300 species between subsoil and canopy. The high diversity reported in our work was certainly the effect of the broad area sampled (which includes three river basins) and the wide range of altitude included (Marsh et al. 2018).

The following are new records for Colombia:

**Acropyga tricuspis** (LaPolla, 2004)

**Specimen Data.** 4 w. AMAZONAS. Puerto Nariño [03°46'33.6"S; 70°21'41.8"W], 84 m a.s.l., 16 Jun 2017, C. Peña. Identification by D. Castro & A. Meneses (CATAC - 0413).

**Comments.** New record for Colombia. This species has been recorded in the Brazilian Amazonia (LaPolla 2004).

**Typhlomyrmex clavicornis** (Emery, 1906)

**Specimen Data.** 3 w. CAQUETÁ. Belén de los Andaquies [01°42'06.8"N; 75°53'57.5"W], 1500 m a.s.l., 23 Jan 2016, D. Castro. Identification by D. Castro & S. Sanchez (CATAC - 0893); 8 w, CAQUETÁ. Florencia, Palmichar [01°42'52.2"N; 75°36'53.6"W], 241 m a.s.l., 23 Mar 2016, Y. Virguez. Identification by D. Castro & S. Sanchez (CATAC - 0292).
Comments. New record for Colombia. This species has been recorded in Bolivia (Type locality), Brazil, French Guiana, Guyana, Paraguay and Suriname (Fernández and Arias-Penna 2008, Wild 2007).

*Typhlomyrmex meire* (Lacau, Villemant & Delabie, 2004)

**Specimen Data.** 2 w. CAQUETÁ: Florencia, Sebastopol [01°43'00.12"N; 75°36'49.3"W], 527 m a.s.l., 29 Mar 2016, Y. Virgüez. Identification by D. Castro & S. Sanchez (CATAC-02563).

Comments. New record for Colombia. This species has been recorded in Brazil (Lacau et al. 2004).

*Cyphomyrmex bicornis* (Forel, 1895)

**Specimen Data.** 1 w. AMAZONAS. Leticia. Tanimboca Natural Reserve, [04°07'15.4"S - 69°57'19.7"W], 98 m a.s.l., 23 Jun 2017, D. Castro. Identification by M. Tocora (CATAC-01582).

Comments. New record for Colombia. This species has been recorded in Brazil (Type Locality) (Kempf 1966).

*Megalomyrmex emeryi* (Forel, 1904)

**Specimen Data.** 6 w. CAQUETÁ. Florencia, Sebastopol [01°43'00.12"N; 75°36'49.3"W], 527 m a.s.l., 29 Mar 2016, Y. Virgüez. Identification by M. Tocora (CATAC-0326).

Comments. New record for Colombia. This species has been recorded in Bolivia, French Guiana, Guyana, Peru and Suriname (Type Locality) (Brandão 2003, Brandão 1990).

*Myrmicocrypta spinosa* (Weber, 1937)

**Specimen Data.** 1 w. CAQUETÁ. Florencia, Arandia [01°26'39.9"N - 75°31'29.1"W], 259 m a.s.l., 2 Jul 2016, Y. Virgüez. Identification by M. Tocora (CATAC-0331).

Comments. New record for Colombia. This species has been recorded in Guyana (Type Locality) (Weber 1937).

**Discussion**

The Caquetá river basin showed the highest number of soil ant species amongst basins (149 species, which corresponded to 68% of the total ants recorded), followed by the Amazon river basin (86 species, 40%) and the Putumayo river basin (71 species, 33%). From all species recorded, 89 species were exclusively registered in the Caquetá river basin, which was twice the number of species reported exclusively in the Amazon river basin (36 species) and in the Putumayo river basin (25 species). The high diversity of the Caquetá river basin may be an reflection of the geographic conditions of the area and the
sampling effort used there. The Caquetá river basin includes the Andean-Amazonian transition where a high turnover of species might occur, but additionally, it was the one with the greatest sampling effort.

From all the ant species recorded, 20 species were found in the four soil depths (Table 2). The most abundant of these species were: *Wasmannia auropunctata* Roger, 1863, *Tranopelta gilva* Mayr, 1866, *Sericomymex bondari* Borgmeier, 1937, *Crematogaster limata* Smith, 1858, *Crematogaster carinata* Mayr, 1862, *Crematogaster brasiliensis* Mayr, 1878, *Crematogaster abstinens* Forel, 1899 and *Brachymyrmex cordemoyi* Forel, 1895.

The genera *Acropyga* and *Typhlomyrmex* are underground genera commonly collected at deep soil depths. For example, the genus *Typhlomyrmex* was collected mostly at 10 - 20 and 20 – 30 cm soil depths. Although TSBF was appropriate for collecting these soil ants, which are generally undersampled with other methods of collection, the TSBF method might underestimate army ants and other large ants such as Paraponerinae that were not recorded in the searched Amazon basin area (Ryder Wilkie et al. 2007, Oliveira and Morato 2009, Sanabria-Blandón and de Ulloa 2011, Ryder Wilkie et al. 2010). However, the use of soil monoliths for macrofauna sampling allowed comparisons between macrofauna groups (e.g. ants with other macrofauna groups). The use of more than one method to obtain an accurate image of the community of ants has been proven (e.g. Winkler or pitfall for estimating the abundance of leaf litter ants) (Delsinne and Arias-Penna 2012, Wong and Guénard 2017, Ryder Wilkie et al. 2007). However, in this study, the composition of subterranean ant subfamilies was not affected by the method of collection used (TSBF) as the proportions of subfamilies were similar to those obtained using additional methods (Wong and Guénard 2017).

An important number of canopy and arboreal ant species such as *Crematogaster*, *Azteca*, *Dolichoderus*, *Camponotus* and *Cephalotes* were collected. Studies of ant fauna in the Colombian Amazon (Pérez et al. 2009) highlighted the diversity of these genera in the region. Canopy and arboreal ant species can be an important part of the ant density in the upper strata of soil (leaf litter and the depth of 0 - 10 cm) as occurred in this study where most of these ants were collected in litter. Results inferred that these ants use the soil as a way for transportation or for food provisioning, although they do not live in the soil such as ants of the genera *Pheidole*, *Acropyga*, *Cryptopone* or *Hypoponera*.

Some arboreal species of *Crematogaster*, *Camponotus*, *Myrmelachista*, *Procryptocerus* and *Pseudomyrmex* were found in soil deep horizons, even at 20-30 cm depth such as *Azteca* and *Pseudomyrmex*. Ant collection was done manually in the field. During this process, some arboreal ants could fall down and contaminate monolith samples when the bags were not well closed. However, arboreal ants may realistically be away from their common substrate or nest, as little is known about their biology, even more so when this is not the first time they have been recorded in soil samples (Rosumek et al. 2008, Vasconcelos et al. 2003, Delabie and Fowler 1995).
Ants are the most diverse soil macrofauna group in the Amazon region (Mathieu et al. 2005, Barros et al. 2008) and represent a high density (Table 3). In the Caquetá basin, they are the most dense organisms of the soil macrofauna. In the other two river basins, ants are only exceeded by termites. Differences in ant and termite densities might be a reflection of the land use sampled. Termites tend to be more abundant in less disturbed ecosystems (Mboukou-Kimbatsa et al. 1998, Velásquez et al. 2012), while ants tend to be more abundant in disturbed or degraded ecosystems of the Amazon region. In our study, the Caquetá basin is where the most disturbed coverings, such as pastures and young secondary forests, are found (Table 1) (Aquino et al. 2008, Barros et al. 2002, Marichal et al. 2014, Pinzón et al. 2014, Rousseau et al. 2014).

| Taxa Group     | Amazonas | Caquetá | Putumayo |
|----------------|----------|---------|----------|
| Formicidae     | 274.16   | 173.70  | 82.12    |
| Amblyoponinae  | 0.78     | 0.49    | 0.00     |
| Dolichoderinae | 4.39     | 9.66    | 3.29     |
| Dorylinae      | 0.00     | 2.47    | 0.47     |
| Ectatomminae   | 7.24     | 4.23    | 3.29     |
| Formicinae     | 72.87    | 37.94   | 9.18     |
| Myrmicinae     | 145.74   | 91.96   | 45.88    |
| Paraponerinae  | 0.00     | 0.63    | 0.71     |
| Ponerinae      | 41.34    | 24.26   | 18.82    |
| Proceratiinae  | 0.00     | 0.07    | 0.00     |
| Pseudomyrmecinae | 1.29 | 1.97    | 0.47     |
| Termitoidea    | 289.15   | 146.33  | 142.12   |
| Coleoptera     | 33.59    | 15.80   | 34.12    |
| Araneae        | 26.36    | 15.87   | 17.18    |
| Immature insects | 18.35 | 15.02   | 13.18    |
| Blattodea      | 4.13     | 7.62    | 4.94     |
| Hemiptera      | 9.30     | 5.71    | 5.18     |

Table 3. Density (Individuals/m²) of the main taxonomic groups collected in TSBF monoliths in the Colombian Amazon.
|            |     |     |     |
|------------|-----|-----|-----|
| Isopoda    | 8.79| 3.74| 8.94|
| Diplura    | 8.01| 3.95| 4.00|
| Opiliones  | 8.01| 3.10| 4.24|

The Neotropics (including the Amazon basin) have been recognised as a region of speciation and conservation of multiple lineages of ants (Moreau and Bell 2013). Results presented here increase the knowledge of soil ants from the Amazon region and suggest that ant species richness may increase considerably when sampling effort increases and combined methodologies are used to capture ants in different habitats.

Acknowledgements

We thank the Instituto Amazónico de Investigaciones Científicas SICHI for its financial support. Thanks to AZICATCH, AIZA and OIMA indigenous associations and the Tanimboca, Otra Parte and Cerca Viva Natural Reserves for allowing us to collect ants in their areas. We also thank Jack Longino, Claudia Ortiz and Lina Pedraza for their help in the identification of some ant species. We heartily thank Dr. John Lattke and Dr. Gabriela Camacho for their useful comments and suggestions on the manuscript.

Author contributions

DC and CPPV collected the material. DC and FF analysed data. DC, FF, ADM, MCT and SS identified the material. DC, FF, MCT and CPPV elaborated the manuscript.

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