Diversity of the Ant Genus *Neoponera* Emery, 1901 (Formicidae: Ponerinae) in the North of the Brazilian Atlantic Forest, with New Records of Occurrence

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Abstract

Composed of two main forest formations, Ombrophilous Forest and Seasonal Forest, the Brazilian Atlantic Forest biome is constituted currently by a mosaic of forest remnants and secondary vegetation. Representatives of the Ponerinae ant genus *Neoponera* are observed mainly in both wet and seasonally dry forests. The aim of this study was to approach the diversity of the genus *Neoponera* in the north of the Atlantic Forest of Brazil (from the extreme north of its distribution to the Doce River hydrographic basin in the south), associating the occurrence of ant species with the types of vegetation. We have compiled occurrence data from the collection of the Myrmecology Laboratory of the Cocoa Research Center, on internet, or available in literature. We found information on 23 species of *Neoponera*, including a new record for the Atlantic Forest, *Neoponera globularia* (Mackay & Mackay, 2010), and a new record for Brazil, *Neoponera fiebrigi* Forel, 1912. The relative composition of the *Neoponera* assemblages was evaluated according to the types of vegetation. We found that the occurrence of the genus *Neoponera* is mainly related to the types of vegetation of the focus region, principally dense forests where a higher diversity was observed.

Introduction

The Brazilian Atlantic Forest is considered a global conservation hotspot (Myers, 2000; Mittermeier et al., 2005), as it is one of the richest biomes in biodiversity as well as one of the most threatened on the planet, since only 12.4% of forest remnants remain compared to the original coverage of 1,315,460 km² in the 16th Century (SOS Mata Atlântica, 2018; INPE, 2018). With this significant reduction of its original coverage, the current landscape of the Atlantic Forest is composed by a mosaic of native vegetation fragments and crop areas, including forest remnants of over 3 hectares of different shapes and sizes, of these two main forest formations: Ombrophilous Forest and Seasonal Forest (Ribeiro et al., 2009; Tabarelli et al., 2010; SOS Mata Atlântica, 2018; INPE, 2018; MMA, 2018). In perennial ombrophilous forests, the incidence of sunlight is low at the lower strata and the trees are tall; on the other hand, in semideciduous or deciduous seasonal forests, a considerable part of the foliage is lost during the dry season, which favors the penetration of sunlight until the floor, contributing to the formation of a more open vegetation structure with few epiphytes (Pereira, 2009; Colombo & Joly, 2010).

Studies on the structure and composition of animal and plant communities are essential for the recovery and preservation of forest remnants (Ferreira et al., 2018), as well as for the conservation of biological diversity. However, we
must understand first the main patterns of their geographic
distribution to carry out these studies (Papes & Gaubert, 2007;
Sigrist & Carvalho, 2008). In view of their high diversity
and sensitivity to changes in the physical and biological
environment, the insects, especially the ants (Hymenoptera:
Formicidae), are useful for such studies (Santos et al., 2006;
Ribas et al., 2012; Schmidt et al., 2013). Some ants directly or
indirectly control the availability of resources, changing the
state of biotic or abiotic conditions for other organisms (Jones
et al., 1997). Their role as ecosystem engineers, coupled
with their abundance in terrestrial ecosystems, reveals the
ecological importance of this group (Folgarait, 1998). These
ants contribute to structure the environment through soil
ventilation and nutrient cycling, seed dispersal, mutualistic
associations with plants and animals, on evolutionary as well
as ecological scales (Moreau et al., 2006; Klimes et al., 2012;
Dejean et al., 2014).

Ponerinae is one of the most diverse groups within
Formicidae with regard to morphology and behavior. In
this subfamily, Neoponera is the second more genus in the
Neotropical Region (after Leptogenys) with 57 species (Mackay
& Mackay, 2010; Schmidt & Shattuck, 2014), occurring from
southern Texas and northern Mexico to northern Argentina
and southern Brazil (Mackay & Mackay, 2010). To date, 35
species of Neoponera have been recorded in Brazil (Feitosa,
2015), with representatives found throughout the country,
preferably in humid forests, at ground level or in trees, but
also in dry forests with seasonal rainfall (Lattke, 2003; 2015).

Ants of the genus Neoponera generally are much
more frequent in conserved areas than in anthropized lands
(Campiolo et al., 2015). This fact strongly suggests that a
set of information on the distribution of this group can help
in monitoring environment quality and, furthermore, will
provide valuable arguments to justify policies aiming at the
implantation of conservation units. Although the pattern of
global ant diversity is similar to that of other taxa (for example,
vascular plants), many regions have much less recorded
diversity than expected. This can be related to several factors,
including climate change and migration, emphasizing that
regions with still unknown diversity are often the regions
where deforestation is occurring most rapidly (Guénard et al.,
2012), such like the Atlantic Forest. The present study aimed
to analyze the current diversity for the Neoponera genus in the
northern part of the Brazilian Atlantic Forest biome, inserting
new records, evaluating the richness and the association of
Neoponera species with different forest formations (types of
vegetation) within the biome.

Material and methods

Study area

The Atlantic Forest covers an area of approximately
1,110,182 km² (IBGE, 2004a), being composed of the two main
formations: coastal forest (perennials ombrophilous forests) and
tropical seasonal forest (Morellato & Haddad, 2000), subdivided
into different vegetation types according to the classification
of the Brazilian Institute of Geography and Statistics (IBGE)
(Fig 1/Table1), such as the: Pioneer Formation Areas under
Marine and Fluvial Influence (Pf), Pioneer Formation under
Marine Influence (Pm), Pioneer Formations with Agricultural
Activities (AA.P), Savannah/Seasonal Forest with Agricultural
Activities (AA.SN), Savannah/Ombrophilous Forest with
Agricultural Activities (AA.SO), Dense Ombrophilous Forest
of Lowlands (Db), Savannah/Ombrophilous Forest (SO),
Open Ombrophilous Vegetation - Secondary Vegetation
and Agrarian Activities (VS-AA.A), Seasonal Deciduous
Forest - Secondary Vegetation and Agrarian Activities (VS-
AA.C), Dense Ombrophilous Forest - Secondary Vegetation
and Agrarian Activities (VS-AA.D) and Semideciduous
Seasonal Forest (Secondary Vegetation and Agrarian
Activities) (VS.AA.F). In addition to associated ecosystems
such as mangroves, sea shore vegetation, highland fields,
inland swamps and forest entrances in the Northeast, housing
thousands of species of plants and animals (Ribeiro et al.,
2009; Tabarelli et al., 2010; SOS Mata Atlântica, 2018;
MMA, 2018).

We defined the Doce River as the southern geographic
boundary to outline the studied area, which is the northern
part of the Brazilian Atlantic Forest (Fig 1). The Doce River

![Fig 1. Map of the study area.](image-url)
is one of the larger Brazilian rivers and its hydrographic basin presents a worrying picture of environmental degradation, since it is within the limits of two global biodiversity hotspots, 98% of its area is in the Atlantic Forest and the remaining 2% in the Cerrado (Mittermeier et al., 2005; Azevedo-Santos et al., 2016; Pires et al., 2017). The Doce River flows 888 km and its basin has an area of about 84,000 km², of which 86% are in the state of Minas Gerais and 14% in that of Espirito Santo. It is considered as an effective biogeographical barrier at least since the Pleistocene (Carnaval & Moritz, 2008). Thus, the analyzed area covers from the Southeast of Brazil, from the north of Espirito Santo and part of Minas Gerais, to the Northeast of the country, and includes the states of Bahia, Sergipe, Alagoas, Pernambuco, Paraiba and Rio Grande do Norte. In the Northeast, the biome is limited to the Caatinga and in the Southeast, to the Cerrado (Pereira, 2009). In general, it presents precipitation index above 1,000 mm per year and several climatic types, such as humid tropical, hot and super humid, tropical altitudinal and mesothermal climates according to the Köppen-Geiger classification (Pereira, 2009).

Data collection

*Neoponera* species data were set up from the Myrmecology Laboratory collection of the Cocoa Research Center (CPDC), at Ilhéus-BA, Brazil, looking for information on specimen collection locations and geographic coordinates. Occurrence data were also compiled from the online data networks Antweb.org (accessed on 2018/2019) and Antmaps.org (accessed on 2018/2019). Another search was performed based on literature, using the species names as keywords. We consider the possibility that the species was registered with an outdated name, especially when included in the genus *Pachychondyla* before the revision of this genus by Schmidt and Shattuck (2014). We reviewed information about these species across Brazil and, subsequently, analyze their distribution in the north of the Brazilian Atlantic Forest biome to compile the list of species and data (reference codes are available in Table 5).

Statistical analysis

We built a spreadsheet with data compiled for the occurrence of species recorded in different locations in the north of the Atlantic Forest biome. We assessed the structure of *Neoponera* assemblages according to the types of vegetation (Table 1; Fig 1). For that purpose, we evaluated the similarity of *Neoponera* assemblages (species presence/absence) according the vegetation types using the Jaccard’s index. In addition, the association between species and vegetation types was illustrated using a multidimensional non-metric ordering (NMDS) using the Bray-Curtis index. These analyzes were performed using the software R v. 3.6.1 (R Development Core Team 2019).

### Table 1. Description and classification of vegetation types currently found in the Atlantic Forest in the studied region, Brazil.

| Description of classified vegetation | Classification legend |
|-------------------------------------|-----------------------|
| Pioneer Formations under Marine and Fluvial Influence | Pf |
| Pioneer Formations under Marine Influence | Pm |
| Pioneer Formations with Agriculture | AA.P |
| Savanna/Seasonal Forest with Agriculture | AA.SN |
| Savanna/Ombrophilous Forest with Agriculture | AA.SO |
| Dense Ombrophilous Forest of Lowlands | Db |
| Savanna/Ombrophilous Forest | SO |
| Open Ombrophilous Vegetation (Secondary Vegetation and Agriculture) | VS-AA.A |
| Seasonal Deciduous Forest (Secondary Vegetation and Agriculture) | VS-AA.C |
| Dense Ombrophilous Forest (Secondary Vegetation and Agriculture) | VS-AA.D |
| Semideciduous Seasonal Forest (Secondary Vegetation and Agriculture) | VS-AA.F |

Source: Vegetation map of Brazil (IBGE, 2004b available online at http://www.ibge.gov.br).

Results

The total number of records of the survey comprises 23 species (Table 2) of *Neoponera*, distributed in the Atlantic Forest above the geographical boundary of Doce River (Tables 3 and 4). Between these, *Neoponera globularia* (Mackay & Mackay, 2010) is a new record for the Atlantic Forest, and *Neoponera fiebrigi* Forel, 1912 a new record for Brazil. We also found records of *Neoponera goeldii* Forel, 1912 (species previously known from the Amazonian biome only) in the state of Bahia at least at 1,500 km further east from the nearest record.

The species recorded in the higher number of vegetation types (Table 2) were *Neoponera apicalis* (Latreille, 1802) (recorded in seven vegetation types, 63.6%), *Neoponera villosa* (Fabricius, 1804) and *Neoponera curvinodis* (Forel, 1899) (five vegetation types, 45.4% each). Among the other species, seven were recorded in a single type of vegetation. The species with the highest number of occurrences by type of vegetation were *N. apicalis* (48 records), *Neoponera concava* (Mackay & Mackay, 2010) (52), *Neoponera bucki* (Borgmeier, 1927) (18), and *Neoponera inversa* (Smith, 1858) (14), all for the vegetation VS-AA.D (Table 2).

The types of vegetation that presented a higher number of species of *Neoponera* were: VS-AA.D (19 spp.), VS-AA.C (10) VS-AA.F (7) and SO (6). The number of species in the other types of vegetation varied from one to three (Fig 2). Three vegetation types presented only a single species: VS-AA.A and Db (*N. apicalis*) and AA-SN (*N. villosa*) (Fig 2).
When we test the similarity between vegetation types according to the presence/absence of Neoponera species, we observed that Db and VS-AA.A share the same assemblages (Fig 3). In general, the other types of vegetation present low similarity between them (less than 50%), especially VS-AA.D and VS-AA.C (about 40% of similarity). It is worth noting that the assemblages found in vegetation types Pf and AA.P (38% similarity between them) have low similarity with the other vegetation types (Fig 3).

The relative superposition of certain vegetation types with some Neoponera is observed on NMDS graph (Fig 4). The grouping with the species found in the same vegetation types is evident, such as *N. globularia*, *N. goeldii*, *Neoponera laevigata* (Smith, 1858), *Neoponera schultzi* (Mackay & Mackay, 2010), *Neoponera venusta* Forel, 1912 occurring in VS-AA.D. The same occurs for *N. fiebrigi*, *Neoponera marginata* (Roger, 1861) and *Neoponera moesta* Mayr, 1870 in VS-AA.C, as well as for *Neoponera carinulata* (Roger, 1861) in Pm. The greatest distance was observed for *Neoponera*...
obscuricornis (Emery, 1890), an exclusive species of AA.SO (Fig 4). Some species, although found in more than a single type of vegetation, were more frequent with one or two certain types, for example, Neoponera cavinodis Mann, 1916 with N. villosa, Neoponera magnifica (Borgmeier, 1929) and Neoponera bactronica (Fernandes, Oliveira & Delabie, 2014) with VS-AA.C and AA.SN. In turn, Neoponera verenae Forel, 1922, Neoponera striatinodis (Emery, 1890) and Neoponera crenata (Roger, 1861) group together more with VS-AA.F and AA.P (Fig 4).

Fig 3. Dendrogram of similarity (Jaccard’s distance) comparing the vegetation types of the Atlantic Forest biome, according to the assemblages of species of the genus Neoponera.

Fig 4. Non-Metric Multidimensional Scaling (NMDS) of vegetation types in the Brazilian Atlantic Forest based on Neoponera frequency of occurrence. Circles filled with the same color = exclusive occurrence in the type of vegetation with equivalent color.
Table 4. List of Neoponera species reported from the study area. The codes of localities follow Table 3. (*) new record for Brazil, (**) new record for Atlantic Forest.

| Species                  | Code                        |
|--------------------------|-----------------------------|
| Neoponera apicalis       | 2, 7, 10, 11, 12, 14, 15, 19, 24, 25, 28, 29, 35, 38, 39, 42, 43, 46, 47, 48, 57, 59, 64, 66, 67, 72, 73, 74, 76, 77, 78, 79, 82, 88 |
| Neoponera bactronica     | 5, 24, 32, 41, 61, 63, 92   |
| Neoponera bucki          | 1, 3, 7, 10, 22, 26, 27, 28, 37, 50, 55, 74, 76, 80, 83 |
| Neoponera carinulata     | 10, 29, 64, 78, 83          |
| Neoponera cavinata       | 13, 29                      |
| Neoponera concava        | 26, 29, 33, 37, 40, 46, 55, 56, 66, 68, 71, 75, 77, 78 |
| Neoponera crenata        | 4, 31, 85                   |
| Neoponera curvinodis     | 18, 24, 29, 34, 44, 49, 81, 90, 91 |
| Neoponera fiebrigi*      | 8, 81                       |
| Neoponera globularia**   | 6, 32                       |
| Neoponera goeldii        | 33                          |
| Neoponera inversa        | 9, 13, 21, 24, 26, 29, 37, 53, 55, 68, 77, 78 |
| Neoponera laevigata      | 29, 78                      |
| Neoponera magnifica      | 4, 17, 81                   |
| Neoponera marginata      | 62                          |
| Neoponera moesta         | 4, 81                       |
| Neoponera obscuricornis  | 7                           |
| Neoponera schultzii      | 43, 51                      |
| Neoponera striatinodis   | 45, 86                      |
| Neoponera unidentata     | 7, 20, 23, 54, 65, 69, 70, 77 |
| Neoponera venusta        | 29, 77, 83                  |
| Neoponera verenae        | 16, 24, 46, 52, 80, 90      |
| Neoponera villosa        | 30, 36, 46, 50, 58, 83, 84, 87, 89 |

Discussion

So far 35 species were recorded for the Neoponera genus in Brazil (Feitosa, 2015). With this survey and insertion of new records and occurrences, this number can be updated to 36 species, 23 of which are found in the northern part of the Atlantic Forest biome. Thus, N. fiebrigi, previously registered only in Paraguay, Argentina (Mackay & Mackay 2010) and Panama (Schmidt & Schattuck, 2014), constitutes a new record for Brazil and the Atlantic Forest.

We observed that the occurrence of many species of the genus Neoponera in the Brazilian Atlantic Forest is related to dense vegetation, such like secondary forests or vegetation at climax. These environments offer a higher number of records and species richness than opened environments. The same was observed by Campiolo et al. (2015) in a study that points out the Ponerinae preferences for forest-type habitats with dense vegetation cover. These characteristics results from the particular habitat requirements of each species of the genus. For example, N. apicalis, N. villosa, N. carinulata, N. crenata, N. curvinodis and N. inversa are arboreal (Mackay & Mackay, 2010). Some species can also nest in undergrowth, trunks and hollow branches fallen on the ground, where moisture and shade conditions are suitable, such as for example, N. verenae (Delabie et al., 2008, Araujo et al., 2019).

The species recorded in a higher number of vegetation types, N. apicalis, is known to occur in both primary and secondary moist forests (Mackay & Mackay, 2010). However, Delabie et al. (2008) suggest that the apicalis group of Neoponera (sensu Wild, 2005) is in fact a complex of at least nine cryptic species, including N. apicalis, N. obscuricornis and N. verenae (Ferreira et al., 2010), which could explain the range of habitats chosen by the ants.

The type of vegetation with the higher diversity of Neoponera was the Ombrophilous Dense Forest. This kind of forests presents moist soil covered by a thick layer of leaf-litter (Pereira, 2009). Because it uses to be more heterogeneous in diversified environments, the leaf-litter offers certainly a range of niches and, as a result, a well-diversified community of soil fauna; in addition, we can expect that the greater the amount of leaf-litter, the greater the availability of resources, such as food and nesting sites (Santos et al., 2006; Ferreira et al., 2018). However, the seasonal deciduous and semideciduous forests, which occur in places with 2 to 5 months of dry season (Colombo & Joly, 2010), also showed a relatively high species richness. Lattke (2003) had already pointed out that some Neoponera species are able to colonize dry forest areas with a marked rainfall regime.

Our observations point out some particularities such as the occurrence of N. goeldii in the Atlantic Forest biome, with an extremely reduced population living isolated in the Peninsula de Maraú, Bahia (J.H.C. Delabie, personal communication, December, 2019), while this species is common in Amazon (Mackay & Mackay, 2010). In fact, there are numerous physiographic, floristic, fauna and climatic similarities between the Atlantic Forest biome, in the coastal strip which runs from the south of the state of Bahia to the north of the state of Espírito Santo (“Central Corridor of the Mata Atlântica”), and the Amazon Forest (Pereira, 2009). According to Joly et al. (1999), the occurrence of species typical of the Amazon region in the Atlantic Forest of southern Bahia confirms that these biomes have undergone expansion and retraction processes during the Pleistocene climatic fluctuations. In other words, at one or several intervals in this period, transition bridges occurred allowing the arrival of typically Amazonian species in the Atlantic Forest biome (Ab’Saber, 2003; Costa, 2003).

The ant species Neoponera globularia, N. goeldii, N. laevigata, N. schultzii and N. venusta follow the same patterns of geographical distribution in the Atlantic Forest, occupying exclusively areas of Ombrophilous Dense Forest. The same occurs with N. fiebrigi, N. marginata and N. moesta, in the Seasonal Deciduous Forest. Neoponera schultzii and N. venusta,
Table 3. Information from the sampled sites. The abbreviations vegetation type follows those reported in Table 1.

| State          | County               | Coordinate           | Vegetation type | Code |
|----------------|----------------------|----------------------|-----------------|------|
| Alagoas        | Quebrângulo          | 9.3167S, 36.4667W    | VS-AA.F         | 1    |
|                |                      | 9.322S, 36.476W      | VS-AA.F         |      |
| Bahia          | Arataca              | 15.2195S, 39.4243W   | VS-AA.D         | 2    |
|                |                      | 15.2803S, 39.3919W   | VS-AA.D         |      |
|                | Aurelino Leal        | 14.3311S, 39.3589W   | VS-AA.D         | 3    |
|                |                      | 14.3679S, 39.4657W   | VS-AA.D         |      |
|                | Barra do Choça       | 14.8081S, 40.5897W   | VS-AA.D         | 4    |
|                |                      | 14.8333S, 40.5536W   | VS-AA.D         |      |
|                |                      | 14.8659S, 40.5779W   | VS-AA.D         |      |
|                | Barra do Rocha       | 14.2068S, 39.6031W   | VS-AA.C         | 5    |
|                |                      | 14.8097S, 39.4233W   | VS-AA.D         | 6    |
|                | Belmonte             | 16.0951S, 39.2745W   | VS-AA.D         | 7    |
|                |                      | 16.1333S, 39.25W     | AA.SO           |      |
|                |                      | 16.1S, 39.2833W      | AA.SO           |      |
| Boa Nova       |                      | 14.3656S, 40.2075W   | AA.SO           | 8    |
|                |                      | 14.6333S, 39.8833W   | VS-AA.C         |      |
|                |                      | 14.7583S, 39.2411W   | VS-AA.F         | 9    |
|                |                      | 15.0144S, 39.2999W   | VS-AA.D         |      |
| Camacan        |                      | 15.3833S, 39.55W     | VS-AA.D         | 10   |
|                |                      | 15.4011S, 39.5664W   | VS-AA.D         |      |
|                |                      | 15.4167S, 39.4833W   | VS-AA.D         |      |
|                |                      | 15.4201S, 39.4964W   | VS-AA.D         |      |
|                |                      | 15.4573S, 39.4516W   | VS-AA.D         |      |
|                |                      | 15.5006S, 39.2206W   | VS-AA.D         |      |
|                |                      | 15.5036S, 39.5156W   | VS-AA.D         |      |
|                |                      | 15.6011S, 39.5211W   | VS-AA.D         |      |
| Camacari       |                      | 12.6972S, 38.3332W   | VS-AA.D         | 11   |
| Camamu         |                      | 13.9443S, 39.1046W   | VS-AA.D         | 12   |
|                |                      | 14.0142S, 39.1667W   | VS-AA.D         |      |
|                |                      | 14.1369S, 39.2775W   | VS-AA.D         |      |
| Canavieiras    |                      | 14.4094S, 39.0337W   | VS-AA.C         | 13   |
|                |                      | 15.6752S, 38.9969W   | VS-AA.D         |      |
|                |                      | 15.6775S, 39.9783W   | VS-AA.D         |      |
| Caravelas      |                      | 17.6794S, 39.6105W   | Pm              | 14   |
| Cruz das Almas |                      | 12.6736S, 39.1017W   | VS-AA.F         | 15   |
|                |                      | 12.6799S, 39.0891W   | VS-AA.D         |      |
| Ecoporanga     |                      | 18.3709S, 40.8229W   | VS-AA.F         | 16   |
| Esplanada      |                      | 12.1144S, 37.6969W   | VS-AA.D         | 17   |
| Estância       |                      | 11.2687S, 37.4385W   | SO              | 18   |
| Eunápolis      |                      | 16.372S, 39.5825W    | VS-AA.F         | 19   |
| Firmino Alves  |                      | 14.9247S, 39.9196W   | VS-AA.D         | 20   |
| Floresta Azul  |                      | 14.8761S, 39.6931W   | VS-AA.C         | 21   |
| Gongogi        |                      | 14.2742S, 39.4842W   | VS-AA.D         | 22   |
|                |                      | 15.2742S, 39.4842W   | VS-AA.D         |      |
| Governador Lomanto Junior | 14.8158S, 39.4839W | VS-AA.D         | 23   |
| Guaratinga     |                      | 16.5625S, 39.8999W   | VS-AA.D         | 24   |
|                |                      | 16.5867S, 39.7753W   | VS-AA.D         |      |
|                |                      | 16.5867S, 39.7808W   | VS-AA.D         |      |
|                |                      | 16.6286S, 39.7983W   | VS-AA.D         |      |
| Ibirarai       |                      | 14.8583S, 39.5918W   | VS-AA.D         | 25   |
|                |                      | 14.9042S, 39.4836W   | VS-AA.F         |      |
| Ibirapitanga   |                      | 14.0709S, 39.4243W   | VS-AA.D         | 26   |
Table 3. Information from the sampled sites. The abbreviations vegetation type follows those reported in Table 1. (Continuation)

| State  | County           | Coordinate          | Vegetation type | Code |
|--------|------------------|---------------------|-----------------|------|
|        |                  | 14.1942S, 39.4231W  | VS-AA.F         |      |
|        |                  | 13.8448S, 39.1127W  | VS-AA.D         | 27   |
|        |                  | 14.6416S, 39.198W   | VS-AA.D         | 28   |
|        |                  | 14.6439S, 40.1533W  | VS-AA.D         |      |
|        |                  | 14.255S, 39.2314W   | VS-AA.D         | 29   |
|        |                  | 14.4274S, 39.5705W  | VS-AA.D         |      |
|        |                  | 14.5006S, 39.0676W  | VS-AA.D         |      |
|        |                  | 14.5294S, 39.0661W  | VS-AA.D         |      |
|        |                  | 14.5533S, 39.4275W  | VS-AA.D         |      |
|        |                  | 14.6207S, 39.1397W  | VS-AA.D         |      |
|        |                  | 14.6808S, 39.2567W  | VS-AA.D         |      |
|        |                  | 14.6935S, 39.0966W  | VS-AA.D         |      |
|        |                  | 14.7422S, 39.1056W  | VS-AA.D         |      |
|        |                  | 14.755S, 39.2314W   | VS-AA.D         |      |
|        |                  | 14.7561S, 39.2314W  | VS-AA.D         |      |
|        |                  | 14.7813S, 39.0795W  | VS-AA.D         |      |
|        |                  | 14.7935S, 39.0774W  | VS-AA.D         |      |
|        |                  | 14.7961S, 39.211W   | VS-AA.D         |      |
|        |                  | 14.7972S, 39.0798W  | VS-AA.D         |      |
|        |                  | 14.798S, 39.1722W   | VS-AA.D         |      |
|        |                  | 14.8239S, 39.1W     | VS-AA.D         |      |
|        |                  | 14.9197S, 39.197W   | VS-AA.D         |      |
|        |                  | 14.9504S, 39.0631W  | VS-AA.D         |      |
|        |                  | 14.9903S, 39.0583W  | VS-AA.F         |      |
|        |                  | 13.1495S, 39.7368W  | VS-AA.D         | 30   |
|        |                  | 19.7501S, 43.2323W  | VS-AA.D         | 31   |
|        |                  | 14.7772S, 39.3647W  | VS-AA.D         | 32   |
|        |                  | 14.78S, 39.284W     | VS-AA.D         |      |
|        |                  | 14.2794S, 39.4852W  | VS-AA.F         | 33   |
|        |                  | 14.3092S, 39.0194W  | VS-AA.D         |      |
|        |                  | 14.3568S, 39.1752W  | VS-AA.F         |      |
|        |                  | 14.2329S, 39.8579W  | VS-AA.C         | 34   |
|        |                  | 14.233S, 39.8579W   | VS-AA.D         | 35   |
|        |                  | 15.1652S, 39.7756W  | VS-AA.D         | 36   |
|        |                  | 14.6757S, 39.3725W  | VS-AA.D         | 37   |
|        |                  | 14.7033S, 39.4981W  | VS-AA.D         |      |
|        |                  | 16.8675S, 39.9175W  | VS-AA.D         | 38   |
|        |                  | 16.9167S, 39.2667W  | VS-AA.D         |      |
|        |                  | 16.9917S, 39.4253W  | VS-AA.D         |      |
|        |                  | 17.0382S, 39.5389W  | VS-AA.D         |      |
|        |                  | 13.7273S, 39.6312W  | VS-AA.D         | 39   |
|        |                  | 14.6519S, 40.3397W  | VS-AA.F         | 40   |
|        |                  | 15.9693S, 39.5321W  | VS-AA.D         | 41   |
|        |                  | 15.2461S, 39.9403W  | VS-AA.D         | 42   |
|        |                  | 14.4228S, 39.565W   | VS-AA.D         | 43   |
|        |                  | 14.4319S, 39.565W   | VS-AA.F         |      |
|        |                  | 14.5108S, 39.6105W  | VS-AA.D         |      |
|        |                  | 13.4537S, 39.8785W  | VS-AA.D         | 44   |
|        |                  | 13.9572S, 40.0308W  | VS-AA.C         | 45   |
|        |                  | 14.9586S, 39.0643W  | VS-AA.C         | 46   |
|        |                  | 14.9586S, 40.0425W  | VS-AA.F         |      |
|        |                  | 14.9614S, 40.0425W  | VS-AA.D         |      |
|        |                  | 14.9778S, 40.0364W  | VS-AA.D         |      |
Table 3. Information from the sampled sites. The abbreviations vegetation type follows those reported in Table 1. (Continuation)

| State            | County                        | Coordinate       | Vegetation type | Code |
|------------------|-------------------------------|------------------|-----------------|------|
|                  |                               | 15.1185S, 40.0661W | VS-AA.D         |      |
|                  |                               | 15.4744S, 40.0503W | VS-AA.D         |      |
|                  | Ituberá                        | 13.736S, 39.1466W | VS-AA.C         | 47   |
|                  | Jaguaripe                      | 13.1956S, 39.0239W | VS-AA.D         | 48   |
|                  | Jequié                         | 13.8591S, 40.0838W | AA.SN           | 49   |
|                  | Jiquiriçá                      | 13.3193S, 39.5899W | VS-AA.D         | 50   |
|                  | Jussari                        | 15.1406S, 39.5247W | VS-AA.D         | 51   |
|                  |                               | 15.1535S, 39.5167W | AA.P            |      |
|                  | Laje                           | 13.1761S, 39.3414W | Pm              | 52   |
|                  | Lauro de Freitas               | 12.8642S, 38.2697W | VS-AA.D         | 53   |
|                  | Macarani                       | 15.5303S, 40.3905W | VS-AA.D         | 54   |
|                  | Marãú                          | 14.1503S, 39.1127W | SO              | 55   |
|                  | Mascote                        | 13.7189S, 39.41W  | VS-AA.D         | 56   |
|                  |                               | 15.5636S, 39.3094W | VS-AA.D         |      |
|                  |                               | 15.5772S, 39.41W  | SO              |      |
|                  |                               | 15.6969S, 39.445W  | VS-AA.D         |      |
|                  |                               | 15.7344S, 39.3844W | VS-AA.D         |      |
|                  | Mucuri                         | 18.0825S, 39.8909W | VS-AA.D         | 57   |
|                  | Mutuípe                        | 13.2288S, 39.5047W | VS-AA.D         | 58   |
|                  | Nazaré                         | 13.0399S, 39.0034W | VS-AA.D         | 59   |
|                  | Nilo Pecanha                   | 13.6494S, 39.2103W | VS-AA.D         | 60   |
|                  | Pau Brasil                     | 15.4897S, 39.6931W | VS-AA.D         | 61   |
|                  | Planalto                       | 14.6991S, 40.4772W | VS-AA.C         | 62   |
|                  | Poçôes                         | 14.6147S, 40.3411W | VS-AA.C         | 63   |
|                  | Porto Seguro                   | 15.6694S, 38.9942W | Pm              | 64   |
|                  |                               | 16.3883S, 39.1814W | Db              |      |
|                  |                               | 16.4444S, 39.0984W | VS-AA.D         |      |
|                  | Pratas                         | 15.1956S, 39.4453W | VS-AA.D         | 65   |
|                  | Presidente Tancredo Neves      | 13.3911S, 39.3183W | VS-AA.D         | 66   |
|                  | Salvador                       | 12.9292S, 38.5014W | VS-AA.D         | 67   |
|                  |                               | 12.9722S, 38.5014W | VS-AA.D         |      |
|                  | Santa Luzia                    | 15.3897S, 39.305W  | VS-AA.D         | 68   |
|                  | Santo Amaro                    | 15.4233S, 39.2791W | VS-AA.D         |      |
|                  |                               | 12.5465S, 38.7111W | VS-AA.D         | 69   |
|                  | São Francisco do Conde         | 12.6655S, 38.59W  | VS-AA.D         | 70   |
|                  | São José da Vitória            | 15.0517S, 39.3133W | VS-AA.D         | 71   |
|                  |                               | 15.0617S, 39.3442W | VS-AA.D         |      |
|                  | Simões Filho                   | 12.7701S, 38.4219W | VS-AA.D         | 72   |
|                  |                               | 12.7717S, 39.5219W | VS-AA.C         |      |
|                  | Teixeira de Freitas            | 17.54S, 39.7422W  | VS-AA.D         | 73   |
|                  | Ubaíra                         | 13.1192S, 39.6594W | VS-AA.D         | 74   |
|                  | Ubaíta                         | 14.2503S, 39.3214W | VS-AA.D         | 75   |
|                  |                               | 14.2503S, 39.3242W | VS-AA.D         |      |
|                  |                               | 14.3089S, 39.3226W | VS-AA.D         |      |
|                  |                               | 14.4247S, 39.3233W | VS-AA.D         |      |
|                  | Ubatã                          | 14.0699S, 39.5278W | VS-AA.D         | 76   |
|                  |                               | 14.2256S, 39.4656W | VS-AA.D         |      |
|                  | Una                            | 15.0892S, 39.295W  | VS-AA.D         | 77   |
|                  |                               | 15.177S, 39.1055W  | VS-AA.D         |      |
|                  |                               | 15.1844S, 39.0546W | SO              |      |
|                  |                               | 15.2028S, 39.0531W | SO              |      |
|                  |                               | 15.2091S, 39.196W  | VS-AA.D         |      |
|                  |                               | 15.2336S, 39.1844W | VS-AA.D         |      |
together with *N. concava*, which likewise predominates in dense forest, are endemic from Brazil (Mackay & Mackay, 2010). In the Atlantic Forest, four areas of endemism are reported (Silva et al., 2004; Sigrist & Carvalho, 2008; Peres et al., 2020), and three of which are considered in our area of study: i) Central Bahia, ii) Central Corridor of the Atlantic Forest, and iii) Pernambuco. These are biogeographic regions supported by several taxonomic groups, being a valid representation of regionalization for studies and conservation of biodiversity (Peres et al., 2020). The *Neoponera* data obtained in our study basically comprise records for the Central Corridor of the Atlantic Forest, an area of endemism that extends from the south of the state of Bahia to the north of Espirito Santo, with *N. schultzi* being an endemic species of that region. Thus, we understand that the occurrences of ants reinforce the importance of the conservation of these ants in the Central Corridor of the Atlantic Forest.

Some studies carried out in the Atlantic Forest (Santos et al., 2006; Silva et al., 2007) have shown that ant communities use to be affected by anthropogenic disturbances. It is expected that in areas where landscape fragmentation is dominant and land use is excessive and disordered, many species will not be able to face climatic changes and migrate at a sufficient rate to maintain their population (Pearson & Dawson, 2003).

### Table 3. Information from the sampled sites. The abbreviations vegetation type follows those reported in Table 1. (Continuation)

| State          | County                  | Coordinate            | Vegetation type | Code |
|----------------|-------------------------|-----------------------|-----------------|------|
| Espírito Santo | Linhares                | 15.2617S, 39.1533W    | SO              | 78   |
|                |                         | 15.2792S, 39.0414W    | SO              |      |
|                |                         | 15.2792S, 39.0914W    | SO              |      |
|                |                         | 15.2795S, 39.0769W    | SO              |      |
|                |                         | 15.2808S, 39.089W     | SO              |      |
|                |                         | 15.2858S, 39.1175W    | SO              |      |
|                |                         | 15.3897S, 39.1975W    | SO              |      |
|                | Uruçua                  | 14.4514S, 39.0478W    | VS-AA.D         | 87   |
|                |                         | 14.4649S, 39.0532W    | VS-AA.D         |      |
|                |                         | 14.4655S, 39.0567W    | VS-AA.D         |      |
|                |                         | 14.5125S, 39.2003W    | VS-AA.D         |      |
|                |                         | 14.5155S, 39.2999W    | VS-AA.D         |      |
|                |                         | 14.5635S, 39.2739W    | VS-AA.D         |      |
|                |                         | 14.6S, 39.2667W       | VS-AA.D         |      |
|                | Valença                 | 13.3422S, 39.1953W    | VS-AA.D         | 79   |
|                |                         | 13.3709S, 39.0759W    | VS-AA.D         |      |
|                | Vera Cruz               | 13.0229S, 38.7159W    | VS-AA.D         | 80   |
|                | Vitória da Conquista    | 14.7936S, 40.7231W    | VS-AA.C         | 81   |
|                |                         | 14.8411S, 40.8389W    | VS-AA.C         |      |
|                |                         | 14.8619S, 40.8445W    | VS-AA.C         |      |
|                |                         | 14.8892S, 40.8304W    | VS-AA.D         |      |
|                |                         | 15.0392S, 40.9097W    | VS-AA.C         |      |
|                | Wenceslau Guimarães     | 13.5539S, 39.7019W    | VS-AA.D         | 82   |
|                |                         | 13.5832S, 39.6931W    | VS-AA.D         |      |
|                | Espírito Santo          | 19.1514S, 40.0708W    | VS-AA.C         | 83   |
|                | Linhares                | 19.15S, 40.05W        | VS-AA.D         |      |
|                | Linhares                | 19.394S, 40.0653W     | VS-AA.D         |      |
|                | Linhares                | 19.6455S, 39.855W     | VS-AA.D         |      |
|                | São Mateus              | 18.7002S, 40.0633W    | VS-AA.D         | 84   |
|                | Minas Gerais            | 18.7667S, 42.9167W    | VS-AA.D         | 85   |
|                | Guanhães                | 18.7667S, 42.9167W    | VS-AA.D         |      |
|                | Timóteo                 | 19.5816S, 42.6475W    | VS-AA.F         | 86   |
|                | Paraíba                | 7.1195S, 34.855W      | VS-AA.D         | 87   |
|                | João Pessoa             | 7.1195S, 34.855W      | VS-AA.D         |      |
|                | Pernambuco              | 7.9S, 35.0833W        | VS-AA.A         | 88   |
|                | São Lourenço da Mata    | 5.9072S, 35.1984W     | Pm              | 89   |
|                | Rio Grande do Norte     | 10.8122S, 37.1711W    | VS-AA.D         | 90   |
|                | Parnamirim              | 11.419S, 37.4284W     | AA.P            | 91   |
|                | Sergipe                | 11.419S, 37.4284W     | AA.P            |      |
|                | Santa Luzia do Itanhy   | 10.9238S, 37.1019W    | AA.P            |      |
|                | São Cristóvão           | 10.9238S, 37.1019W    | AA.P            |      |
Table 5. References of the data sources used in the study.

| Species              | State          | References                  |
|----------------------|----------------|----------------------------|
| Neoponera apicalis   | Bahia          | 1, 3, 9, 11, 14, 19, 22, 23, 25, 26, 31, 34 |
|                      | Pernambuco     | 33                         |
| Neoponera bactronica | Bahia          | 1, 5, 12, 13, 15, 35       |
|                      | Sergipe        | 1, 13                      |
| Neoponera bucki      | Alagoas        | 10, 36                     |
|                      | Bahia          | 1, 34                      |
|                      | Espírito Santo | 2, 36                      |
| Neoponera carinulata | Bahia          | 1, 23, 25, 34              |
|                      | Espírito Santo | 1                         |
| Neoponera cavinodis  | Bahia          | 1, 6, 34                   |
| Neoponera concava    | Alagoas        | 1                         |
|                      | Bahia          | 1, 6, 26, 28, 32, 34       |
|                      | Espírito Santo | 2                         |
|                      | Sergipe        | 1                         |
| Neoponera crenata    | Alagoas        | 10                        |
|                      | Bahia          | 1, 2, 5, 7, 15, 23, 24, 25, 27, 34 |
|                      | Minas Gerais   | 1                         |
| Neoponera curvinodis | Bahia          | 1, 3, 7, 13, 25, 27, 34, 35 |
|                      | Sergipe        | 1, 13                      |
| Neoponera fiebrigi    | Bahia          | 1                         |
| Neoponera globularia | Bahia          | 1                         |
| Neoponera goeldii    | Bahia          | 1, 18, 21                  |
| Neoponera inversa    | Alagoas        | 10                        |
|                      | Bahia          | 1, 3, 5, 7, 8, 10, 13, 15, 17, 20, 25, 35, 37 |
|                      | Espírito Santo | 13                        |
| Neoponera laevigata  | Bahia          | 1, 28                      |
| Neoponera magnifica  | Bahia          | 1, 15, 26                  |
| Neoponera marginata  | Bahia          | 1, 34                      |
| Neoponera moesta     | Bahia          | 1, 7, 8, 15, 24, 25, 34    |
| Neoponera obscuricornis | Bahia       | 1, 31                      |
| Neoponera schultzi   | Bahia          | 1, 34                      |
| Neoponera striatinodis | Bahia      | 1, 19, 34                  |
|                      | Minas Gerais   | 1                         |
| Neoponera unidentata | Bahia          | 1, 5, 7, 11, 14, 15, 21, 22, 23, 25 |
| Neoponera venusta    | Alagoas        | 30                        |
|                      | Bahia          | 1, 4, 9, 11, 14, 21, 25, 28, 30, 31 |
|                      | Espírito Santo | 1, 2, 11, 36              |
| Neoponera venenae    | Bahia          | 1, 3, 11, 19, 25, 26, 30, 34 |
|                      | Espírito Santo | 1, 2                      |
|                      | Sergipe        | 1, 16                      |
| Neoponera villosa    | Bahia          | 1, 5, 7, 8, 9, 12, 13, 14, 20, 23, 25, 29, 31, 34, 35 |
|                      | Espírito Santo | 1, 13, 35                 |
|                      | Paraíba        | 1, 13                      |
|                      | Rio Grande do Norte | 1                 |

References corresponding to the codes are available in the annex.

Nevertheless, we observed here that the vegetation types with the higher diversity of Neoponera correspond to landscapes with secondary forests in association with agriculture. This has important implications for the future of the biome conservation, since it suggests that secondary forests conserve an important pool of species that, face to the climatic changes, will contribute to the genus resilience in the region.

Since ants are organisms faithful for a specific type of habitat, and may allow inferences about the rehabilitation of an area (Schmidt et al., 2013), the occurrence of some Neoponera in more than a single type of vegetation, like N. apicalis, N. villosa, N. bucki, N. curvinodis, Neoponera unidentata (Mayr, 1862) and N. inversa (Fig 4), strongly suggest the connectivity between vegetation types. Thus, the conservation of forest
remnants and even some kinds of agriculture which maintains a forest structure (cocoa agroforestry, for example) can be decisive for the conservation of this group of ants (Delabie et al., 2007; Campiolo et al., 2015). Further studies should evaluate the relationships between the occurrence and distribution of the species of *Neoponera* and the habitat conservation including also the other areas covered by the biome.

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**Author Contributions**

All authors conceived this study, PSS and EA conducted performed research/acquisition of data. E.B.A.K performed the data analyses. All authors contributed to the writing, discussed the results and commented on the manuscript.

**References**

Ab’Sáber, A. N. (2003). Os domínios de natureza no Brasil: potencialidades paisagísticas. 3. ed. São Paulo: Ateliê Editorial.

Antmaps.org. (2018). Available from https://antmaps.org (accessed date: July-September 2018).

AntWeb.org. 2018. Available from https://www.antweb.org (accessed date: July-September 2018).

Araujo, E.S., Koch, E.B.A., Delabie, J.H.C., Zeppelinì, D., DaRocha, W.D., Castaño-Meneses, G. & Mariano, C.S.F. (2019): Diversity of commensals within nests of ants of the genus *Neoponera* (Hymenoptera: Formicidae: Ponerinae) in Bahia, Brazil. Annales de la Société entomologique de France (N.S.), 55: 291-299. doi: 10.1080/00379271.2019.1629837

Azevedo-Santos, V.M., Castilho, M.C.A., Pelicice, F.M., Vitule, J.R.S., Garcia, D.A.Z. & Esteves, F.A. (2016). A dura lição com a tragédia do rio Doce. Boletim AB Limno, 42: 09-13. doi: 10.13140/RG.2.1.1270.5688

Campiolo, S., Rosario, N. A., Strenzel, G.M.R., Feitosa, R. & Delabie, J.H.C. (2015). Conservação de Poneromorfas no Brasil. In: Delabie, J.H.C., Feitosa, R., Serrão, J. E., Mariano, C.S.F. & Majer, J.D. (org.), As formigas Poneromorfas do Brasil. (pp. 447-462). Editus, Ilhéus – BA, Brasil.

Carnaval, A.C. & Moritz, C. (2008). Historical climate modelling predicts patterns of current biodiversity in the Brazilian Atlantic Forest. Journal of Biogeography, 35: 187-1201. doi: 10.1111/j. 1365-2699.2007.01870.x

Colombo, A.F. & Joly, C.A. (2010). Brazilian Atlantic Forest *lato sensu*: the most ancient Brazilian forest, and a biodiversity hotspot, is highly threatened by climate change. Brazilian Journal of Biology, 70: 697-708. doi: 10.1590/S1519-69842010000400002

Costa, L.P. (2003). The historical bridge between the Amazon and the Atlantic Forest of Brazil: a study of molecular phylogeography with small mammals. Journal of Biogeography, 30: 71-86. doi: 10.1046/j.1365-2699.2003.00792.x

Dejean, A., Labrière, N., Touchard, A., Pettitclerc, F. & Roux, O. (2014). Nesting habits shape feeding preferences and predatory behavior in an ant genus. Naturwissenschaften, 101: 323–330. doi: 10.1007/s00114-014-1159-1

Delabie, J.H.C., Jahyny, B., Nascimento, I.C., Mariano, C.S.F., Lucau, S., Campiolo, S., Philpott, S.M. & Leponce, M. (2007). Contribution of cocoa plantations to the conservation of native ants (Insecta: Hymenoptera: Formicidae) with a special emphasis on the Atlantic Forest fauna of southern Bahia, Brazil. Biodiversity and Conservation, 16: 2359-2384. doi: doi: 10.1007/s10531-007-9190-6

Delabie, J.H.C., Mariano, C.S.F., Mendes, L.F., Pompolo, S.G. & Fresneau, D. (2008). Problemas apontados por estudos morfológicos, ecológicos e citogenéticos no gênero *Pachycondyla* na região neotropical: o caso do complexo apicalis. In: Vilêa, E.F., Santos, I.A., Schoedereder, J.H., Serrão, J.E., Campos, L.A.O. & Lino Neto, J. (Org.), Insetos Sociais da Biologia à Aplicação (pp. 197-222). Viçosa, Ed. UFV.

Feitosa, R. (2015). Lista das formigas poneromorfas do Brasil. In: Delabie, J.H.C., Feitosa, R., Serrão, J.E., Mariano, C.S.F. & Majer, J. As formigas poneromorfas do Brasil (pp. 95-101). Editus, Ilhéus - BA, Brasil.

Ferreira, R.S., Poteaux, C., Delabie, J.H.C., Fresneau, D. & Rybak, F. (2010). Stridulations reveal cryptic speciation in Neotropical sympatric ants. Plos One, 5: e15363. doi: 10.1371/journal.pone.0015363

Ferreira, C.R., Correia, M.E.F., Camara, R., Resende, A.S., Anjos, L.H.C. & Pereira, M.G. (2018). Brazilian Atlantic Forest lato sensu: the most ancient Brazilian forest, and a biodiversity hotspot, is highly threatened by climate change. Brazilian Journal of Biology, 70: 697-708. doi: 10.1590/S1519-69842010000400002

Folgarait, P. J. (1998). Ant biodiversity and its relationship to ecosystem functioning: a review. Biodiversity Conservation, 7: 1221-1244. doi: 10.1023/A:1008891901953

Guénard, B., Weiser, M.D. & Dunn, R.R. (2012). Global models of ant diversity suggest regions where new discoveries are most likely are under disproportionate deforestation threat. PNAS, 109: 7368-7373. doi: 10.1073/pnas.1113867109

Instituto Brasileiro de geografia e Estatística (IBGE) (2004a). Mapa de Biomas do Brasil, Primeira Aproximação. Available
online at http://www.ibge.gov.br (accessed date: December 2018).

Instituto Brasileiro de geografia e Estatistica (IBGE) (2004b). Mapa de Vegetação do Brasil, Terceira Edição. Available online at http://www.ibge.gov.br (accessed date: December 2018).

Instituto Nacional de Pesquisas Espaciais (INPE) (2018). Available online at http://www.inpe.br (accessed date: August-September 2018).

Joly, C.A., Aidar, M.P.M., Klink, C.A., McGrath, D.G., Moreira, A.G., Moutinho, P., Nepstad, D.C., Oliveira, A.A., Pott, A., Rodal, M.J.N. & Sampaio, E.V.S.B. (1999). Evolution of the Brazilian phytogeography classification systems: implications for biodiversity conservation. Ciência e Cultura, 51: 331-348.

Jones, C.G., Lawton, J.H. & Shachak, M. (1997). Positive and negative effects of organisms as physical ecosystem engineers. Ecology, 78: 1946-1957. doi: 10.2307/2265935

Klimes, P., Idigel, C., Rimandai, M., Fayle, T.M., Janda, M., Weihlen, G.D. & Novotny, V. (2012). Why are there more arboreal ant species in primary than in secondary tropical forests? Journal of Animal Ecology, 81: 1103-1112. doi: 10.1111/j.1365-2656.2012.02002.x

Lattke, J.E. (2003). Subfamília Ponerinae. In: Fernandes, F. (ed). Introduccion a las Hormigas de la Region Neotropical (pp. 261-276). Instituto de Investigación de Recursos Biológicos Alexander von Humboldt, Bogotá, Colômbia. XXVI.

Lattke, J.E. (2015). Estado da arte sobre a taxonomia e filogenia de Ponerinae do Brasil. In: Delabie, J.H.C., Feitosa, R., Serrão, J.E., Mariano, C.S.F. & Majer, J. As formigas poneromorfas do Brasil (pp. 55-73). Editus, Ilhéus - BA, Brasil.

Mackay, W.P. & Mackay, E.E. (2010). The Systematics and Biology of the New World Ants of the Genus Pachycondyla (Hym.: Formicidae). Edwin Mellon Press, Lewiston, 2010.

Mittermeier, R.A., Gil, R.P., Hoffmann, M., Pilgrim, J., Brooks, T., Mittermeier, C.G., Lamoreux, J. & Fonseca, G.A.B. (2005). Hotspots Revisited: Earth’s Biologically Richest and Most Endangered Terrestrial Ecoregions. 2. ed. University of Chicago Press, Boston.

Moreau, C.S., Bell, C.D., Vila, R., Archibald, S.B. & Pierce, N.E. (2006). Phylogeny of the ants: diversification in the age of angiosperms. Science, 312: 101-104. doi: 10.1126/science.1124891

Morello, L.P.C. & Haddad, C.F.B. (2000). Introduction: The Brazilian Atlantic Forest. Biotropica, 32(4b): 786-792. doi: 10.1111/j.1744-7429.2000.tb00618.x

Ministério do Meio Ambiente (MMA) (2018). Available online at https://www.mma.gov.br (accessed date: August-September 2018).

Myers, N., Mittermeier, R.A., Mittermeier, C.G., Fonseca, G.A.B. & Kent, J. (2000). Biodiversity hotspots for conservation priorities. Nature, 403: 853-858. doi: 10.1038/35002501

Papes, M. & Gaubert, P. (2007). Modelling ecological niches from low numbers of occurrences: assessment of the conservation status of poorly known viverrids (Mammalia, Carnivora) across two continents. Diversity and Distributions, 13: 890-902. doi: 10.1111/j.1472-4642.2007.00392.x

Pearson, R.G. & Dawson, T.E. (2003). Predicting the impacts of climate change on the distribution of species: are bioclimate envelope models useful? Global Ecology and Biogeography, 12: 361-371. doi: 10.1046/j.1466-822X.2003.00042.x

Pereira, A.B. (2009). Mata Atlântica: Uma abordagem geográfica. Nucleus, 6: 27-52. doi: 10.3738/1982.2278.152

Peres, E.A., Pinto-da-Rocha, R., Lohmann, L.G., Michelangeli, F.A., Miyaki, C.Y., Carnaval, A. C. (2020). Patterns of Species and Lineage Diversity in the Atlantic Rainforest of Brazil. In: Rull V., Carnaval A. (eds) Neotropical Diversification: Patterns and Processes. Fascinating Life Sciences. Springer, Cham. doi: 10.1007/978-3-030-31167-416

Pires, A.P.F., Rezende, C.L., Assad, E.D., Loyola, R. & Scarano, F.R. (2017). Forest restoration can increase the Rio Doce watershed resilience. Perspectives in Ecology and Conservation, 15: 187-193. doi: 10.1016/j.pecon.2017.08.003

R Development Core Team (2018). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available in: http://www.project.org/

Ribas, C.R., Schmidt, F.A., Solar, R.R.C., Campos, R.B.F., Valentim, C.L. & Schoereder, J. H. (2012). Ants as indicators in Brazil: A review with suggestions to improve the use of ants in environmental monitoring programs. Restoration Ecology, 20: 712-720. doi: 10.1111/j.1526-100X.2011.00831.x

Ribeiro, M.C., Metzger, J.P., Martensen, A.C., Ponzoni, F.J. & Hirota, M.M. (2009). The Brazilian Atlantic Forest: How much is left, and how is the remaining forest distributed? Implications for conservation. Biological Conservation, 142: 1141-1153. doi: 10.1016/j.biocon.2009.02.021

Santos, M., Louzada, J.N.C., Dias, N., Zanetti, R., Delabie, J.H.C. & Nascimento, I.C. (2006). Riqueza de formigas (Hymenoptera, Formicidae) da serapilheira em fragmentos de floresta semidecidual da Mata Atlântica na região do Alto do Rio Grande, MG, Brasil. Iheringia, Sér. Zool., Porto Alegre 96: 95-101. doi:10.1590/S0073-47212006000100017

Schmidt, F.A., Ribas, C.R. & Schoereder, J.H. (2013). How predictable is the response of ant assemblages to natural forest recovery? Implications of their use as bioindicators. Ecological Indicators, 24: 158-166. doi: 10.1016/j.ecolind.2012.05.031

Schmidt, C.A. & Shattuck, S.O. (2014). The higher classification of the ant subfamily Ponerinae (Hymenoptera: Formicidae), with a review of ponerine ecology and behavior. Zootaxa. 3817: 1-242. doi: 10.11646/zootaxa.3817.1.1
Appendix

References corresponding to the codes of the Table 5.

1. CPDC
2. Antmaps/Antweb
3. Araújo, E.S., Koch, E.B.A., Delabie, J.H.C., Zeppelini, D., Darocha, W.D., Castaño-Meneses, G. & Mariano, C.S.F. (2019). Diversity of commensals within nests of ants of the genus Neoponera (Hymenoptera: Formicidae) in Bahia, Brazil. Annales de la Société entomologique de France, 55 (4): 291-299. doi: 10.1080/00379271.2019.1629837
4. Campiolo, S. & Delabie, J. H. C. (2000). Caractérisation de la myrmécofaune de la litière de la Forêt Atlantique du sud de Bahia - Brésil. Actes des Colloques Insectes Sociaux. 13: 65-70.
5. Cobb, M., Watkins, K., Silva, E. N., Nascimento, I. C. & Delabie, J. H. C. (2006). An exploratory study on the use of bamboo pieces for trapping entire colonies of arboreal ants. Sociobiology 47 (1): 215-223.
6. Conceição, E. S., Delabie, J. H. C., Costa Neto, A. O., Moura, J. I. L. (2009). Atividade de formigas nas inflorescências do coqueiro no sudeste baiano, com enfoque sobre o período entre a antese e a formação do fruto. Agrotropica 21(2): 113-122.
7. Conceição, E.S., Della Lucia, T.M.C., Costa-Neto, A.O., Koch, E.B.A. & Delabie, J.H.C. (2019). Ant community evolution according aging in Brazilian cocoa tree plantations. Sociobiology, 66(1): 33-43. Doi:10.13102/sociobiology.v66i1.2705
8. DaRocha, W.D., Ribeiro, S.P., Neves, F.S., Fernandes, G.W., Leponce, M. & Delabie, J.H.C. (2015). How does bromeliad distribution structure the arboreal ant assemblage (Hymenoptera: Formicidae) on a single tree in a Brazilian Atlantic forest agroecosystem? Myrmecological News, 21: 83-92. ISSN 1994-4136 (print), ISSN 1997-3500 (online)
9. Delabie, J.H.C. & Fowler, H.G. (1995). Soil and litter cryptic ant assemblages of Bahian cocoa plantations, Pedobiologia, 39: 423-433.
10. Delabie, J.H.C., Godé, L., Nascimento, I.C., Santos, J.R.M., Carmo, A.F.R., Mariano, C.S.F. & Souza, P.R. (2015). Formigas (Hymenoptera) da Reserva de Pedra Talhada. In: Studer, A., Nusbaumer, L. & Spichiger, R. (ed.). Biodiversidade da Reserva Biológica de Pedra Talhada (Alagoas, Pernambuco - Brasil). Boissiera 68: 277-288. ISBN 978-2-8277-0084-4, ISSN 0373-2975.
11. Delabie, J.H.C., Lacau, S., Nascimento, I.C., Casimiro, A.B. & Cazorla, I.M. (1997). Communauté des fourmis des souches d’arbres morts dans trois réserves de la forêt Atlantique brésilienne (Hymenoptera, Formicidae). Ecologia Austral, 1997, 7: 95-103.
12. D’Ettorre, P., Kellner, K, Delabie, J.H.C. & Heinze, J. (2005). Number of queens in founding associations of the ponerine ant Pachycondyla villosa. Insectes Sociaux 52: 327-332. Doi:10.1007/s00040-005-0815-z
13. Fernandes, I.O., Oliveira, M.L. & Delabie, J.H.C. (2014). Description of two new species in the Neotropical Pachycondyla foetida complex (Hymenoptera: Formicidae: Ponerinae) and taxonomic notes on the genus. Myrmecological News, 19: 133-163. ISSN 1994-4136 (print), ISSN 1997-3500 (online).
14. Fowler, H.G. & Delabie, J. H. C. (1995). Resource partitioning among epigaeic and hypogaecic ants (Hymenoptera: Formicidae) of a Brazilian cocoa plantation. Ecologia Austral, 5: 117-124.
15. Freitas, J.M.S., Delabie, J.H.C. & Lacau, S. (2014). Composition and diversity of ant species into leaf litter of two fragments of a semi-deciduous seasonal forest in the Atlantic forest biome in Barra do Choça, Bahia, Brazil. Sociobiology 61(1): 9-20. doi:10.13102/sociobiology. v61i1.9-20
16. Gomes E.C.F., Ribeiro, G. T., Souza, T.M.S. & Sousa-Souto, L. (2014). Ant assemblages (Hymenoptera: Formicidae) in three different stages of forest regeneration in a fragment of Atlantic Forest in Sergipe, Brazil. Sociobiology, 61(3): 250-257. Doi:10.13102/sociobiology.v61i3.250-257
