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New records, extended and updated geographic distribution of the South American native antlion *Dimares elegans* (Perty, 1833) (Neuroptera, Myrmeleontidae)

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ABSTRACT

An extensive review of primary and secondary occurrence data, including several new records, of the South American native antlion *Dimares elegans* (Perty) revealed that this species is endemic to regions of stressful water regime (Caatinga, Cerrado, Chaco and temperate fields) and adjacent areas in Amazon rainforest, Atlantic forest and Pampas. Its known distribution is from Santarém, Pará state, northern Brazil to Río Negro, Chimpay, northwestern Argentina. The known distribution of the species in Brazil has been extended, registering several areas above the São Francisco River (former possible northeastern limit). New limits further east were established from new primary records. For the first time the species is registered from the Brazillian states of Maranhão, Piauí, Rio Grande do Norte, Paraíba, Bahia, Goiáis, Tocantins, Minas Gerais, Mato Grosso do Sul, São Paulo and Paraná, Brazil. Historical data of occurrence in Goiás (Cerrado) have been geopolitically rectified (Tocantins) and, present occurrence in Goiás is reported by primary data in two new localities. Antlions are mostly xerofilous species, however with recent data this species might present much wider distribution than restricted to seasonally dry forests.

Introduction

The order Neuroptera (Linnaeus, 1758) includes a group of insects with holometabolic development, whose larvae are terrestrial or aquatic. The neuropterans are generally predators and its diversity is estimated at 5,800 species of 15 families (Stelzl and Devetak, 1999; Oswald and Machado, 2018; Winterton et al., 2018). Myrmeleontidae (Latreille, 1802), commonly known as antlions, represents the largest family of Neuroptera, with approximately 2000 described valid species in 198 genera distributed predominantly in arid and semi-arid ecosystems (Stange, 2004; Oswald and Machado, 2018; Machado et al., 2019).

In South America, there is a monotypic genus of Myrmeleontidae (Ascalaphinae), the genus *Dimares* (Hagen, 1866). The native species *Dimares elegans* (Perty, 1833) is strongly characterized by sexual dichromatism, in which females of the species have wings that are generally pigmented in bands, while pigmentation is absent in the wings of males. According to Stange (1989), although the genus *Dimares* is monotypic, there is a notable and possibly clinal geographic variation in pigmentation of the wings. Also, according to the aforementioned author, the geographic distribution of *D. elegans* is known from the Northeastern of Brazil, near the São Francisco river, to the western of Argentina, near the Negro river (Stange, 1989). This wide distribution covers Bolivia, Paraguay, Uruguay, Brazil, and Argentina in several phytophysiognomies that associate with the Seasonally Dry Tropical Forests distribution pattern (Werneck et al. 2012).

Little is known about the relationship of *D. elegans* with abiotic (e.g temperature, pluviosity, humidity) and biotic (e. g. competition) factors and distribution patterns on meso- and micro-spatial scale. Until this study, all specialized information involved taxonomic investigations and occurrence records in local biodiversity (Banks, 1915; Penny, 1977; Stange, 1989; Petko et al., 2016). Knowledge about an organism´s geographic distribution may contribute to understanding and delimiting regions, or ecoregions, of fauna distributions (Olson et al., 2001) and, consequently, to the understanding on how the organisms adopted habitat delimitation strategies. By knowing the biogeographic patterns of a species, we can infer information about its biotic and abiotic relationships. Thus, from time to time, reviews of geographic

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distribution comprise temporal understandings of the macro-spatial knowledge about a species.

In this study, we formally record original information on the occurrence and distributional pattern of the South American native antlion *Dimares elegans*. Therefore, the objective of the present study was to record new occurrences of *D. elegans* in South America. Secondly, we reviewed all available literature and known scientific zoological museum records in order to update of the known geographic distribution and analyze possible biogeographic patterns for the species.

Material and methods

In this study, primary data (samplings and *in situ* observations) and secondary data (literature and scientific collections) were collected to update the species geographic distribution.

The specimens that constituted the primary data were collected and observed, along the Brazilian territory, from 1957 to 2020. Collections and observations were performed by several personnel along these years and deposited in the following institutions: Museu de Zoologia da Universidade de São Paulo (MZUSP), Universidade Federal da Bahia (UFBA), Universidade Federal do Tocantins (UFT), Instituto Nacional de Pesquisas da Amazônia (INPA), Escola Superior de Agricultura Luíz de Queiroz (Esalq), Coleção Entomológica do Mato Grosso (CEMT), Coleção Zoológica do Maranhão (CZMA), Coleção Entomológica Pe. Jesus Santiago Moure (DZUP) and Agência Paulista de Agronegócios (APTA) and Invertebrate Collection at the Universidade Federal do Rio Grande do Norte (IC-UFRN).

Species-level identification was conducted using the identification keys proposed by Petko et al. (2016) and Heckman (2017). The specimens from Mossoró, Rio Grande do Norte were examined only through photographic records. The entire process of sampling, humidifying, assembling, and pinning followed the protocol proposed by Almeida et al. (2003).

Secondary data were acquired from two data sources. The first source was the review of specialized literature, publications, species lists, biodiversity studies, and scientific reports. Data from gray literature, such as monographs, dissertations, theses, abstracts of scientific congresses and meetings, and technical reports were not considered. The second source of secondary data was the review of specimens present in scientific zoological collections whose data are deposited and accessible in online databases. The databases analyzed were the Global Biodiversity Information Facility (GBIF, 2019) and SpeciesLink (SpeciesLink, 2019). The institutions consulted through these databases were: Museu Paraense Emílio Goeldi (MPEG), Museum of Comparative Zoology, Harvard University (MCZ), Texas A&M University (TAMU), Lund Museum of zoology (MZLU), Naturalis Biodiversity Center (NL), National Museum of Natural History, Smithsonian Institution (USNM). Through GBIF, integrated photographic data from the iNaturalist application were also consulted. In the iNaturalist records consulted through GBIF, the records considered valid were the ones analyzed by specialists certified by the iNaturalist initiative, and whose photographic record was associated with the information of geographical coordinates. In addition, the specimen records in the iNaturalist were analyzed by the authors of the present study together with the observation of the primarily collected specimens and the compared material. Records with inaccurate taxonomy, invalid geographic coordinates, or missing information from the collections and institutions to which they belonged, were disregarded as proposed by Alencar et al. (2017).

Occurrences without geographic coordinates, but with satisfactory details on the description of sampling/collection site, had their location estimated through the GeoNames geographic identification database (www.geonames.org). Then, confirmation of the coordinate was performed in the Google Earth satellite mapping software considering the geographic coordinate system in WGS84. The procedures for compiling and validating secondary data and estimating geographic coordinates by records with only a description of the locality followed the procedure proposed by Alencar et al. (2017).

All the data obtained (primary and secondary) were compiled and organized in a table, detailing the unpublished information. Finally, a map was created through the use of the software QGIS 3.18 version using DATUM WGS84 coordinate system to delimit the updated geographic distribution of the species and detailing the expansion from the previous to proposed new distribution of *D. elegans*. Additionally, the species distribution was also discussed regarding its relationship to South American biomes.

Results

Taxonomy

Order Neuroptera Linnaeus, 1758
Family Myrmeleontidae Latreille, 1802
Genus *Dimares* Hagen, 1866
Dimares elegans (Perty, 1833)

Examined material: Brazil: *Maranhão state***:** Caxias municipality, 11-12.v.1999, one female specimen, 4°49′01″S; 43°25′15″W (INPA); Mirador municipality, PE Mirador, Base Geraldina, 09-16.v.2013, two female and one male specimens, 06º37’25’’S; 45º52’08’’W (CZMA); idem, 03-07.v.2008, six female and two male specimens (CZMA); Mirador municipality, PE Mirador, Posto Avançado do Mel, 02-08.iv.2011, one male specimen, 06º43’50’’S; 44º58’59’’W (CZMA); *Piauí state*: Piracuruca municipality, viii.1961, one female specimen, 3°55′41″S; 41°42′33″W (INPA); Ribeiro Gonçalves municipality, ESEC Uruçui Una, 17.vi.1984, one female specimen, 7°34’06”S; 45°14’12”W (DZUP-381439); Caracol municipality, PN Serra das Confusões, Casa Visitante, 05.vi.2014, one female specimen, 09º13’33’’S; 43º27’48’’W (CZMA); *Rio Grande do Norte state*: Parelhas municipality, one female specimen, 6°42’02.3”S; 36°39’35.0”W (GEEFAA/UFRN-1354); Equador municipality, Quintos de Cima, Sítio Trapiá, three female specimens, 6°51’34”S; 36°43’33”W (GEEFAA/UFRN-1342) (Figure 1); *Paraíba state*: Coremas municipality, vi.1957, one female and one male specimens, 7°00′38″S; 37°58′58″W (MZUSP); *Bahia state*: Curaçá municipality, riacho do Tio Zé, afluente rio Buracão, 5.v.2011, two female and one male specimens, 9º7’48.1’’S; 39º58’45.7’’W (UFBA); Santa Rita de Cássia municipality, iv.1958, two female and one male specimens, 11°01′38″S; 44°35′45″W (INPA); Santa Rita de Cássia municipality, iv.1958, five female and one male specimens, 11°01′38″S; 44°35′45″W (MZUSP); *Tocantins state*: Bielândia, 04-06.iv.2014, two male specimens, 7°29’10”S; 47°51’38”W (UFT); Palmas municipality, 18.v.2005, one male specimen, 10°10′03″S; 48°19′40″W (UFT); Paraíso do Tocantins municipality, v.1965, one male specimen, 10°10′34″S; 48°52′00″W (MZUSP); Porto Nacional municipality, 21.v.2011, one male specimen, 10°42′29″S; 48°25′02″W (UFT); idem, 20.iv.2005, one male (UFT); idem, 07.v.2005, one male specimen (UFT); idem, 08.v.2005, one male specimen (UFT); *Rondônia state*: Vilhena municipality, 5.xi.1979, one female specimen, 12°44′26″S; 60°08′45″W (INPA); *Mato Grosso state*: Utiariti, 23.x.1966, one female specimen, 13°01′17″S; 58°17′13″W (MZUSP); Chapada dos Guimarães municipality, Cachoeira Salgadeira, iv.1988, one female specimen (DZUP); Chapada dos Guimarães municipality, 20.x.1992, one female specimen, 15°27′38″S; 55°44′59″W (MZUSP); Cuiabá municipality, 14.iv.1993, one male specimen, 15°35′46″S; 56°05′48″W (DZUP); idem, 11.v.1993, one male specimen (DZUP); idem, 20.vi.1993, one female specimen (DZUP); idem, 23.i.2003, one female specimen (DZUP); idem, 12.x.2005, one female specimen (DZUP); Cuiabá municipality, UFMT, 10.viii.1981, one female specimen, 15°36′31″S; 56°3′49″W (CEMT); Jaciara municipality, one

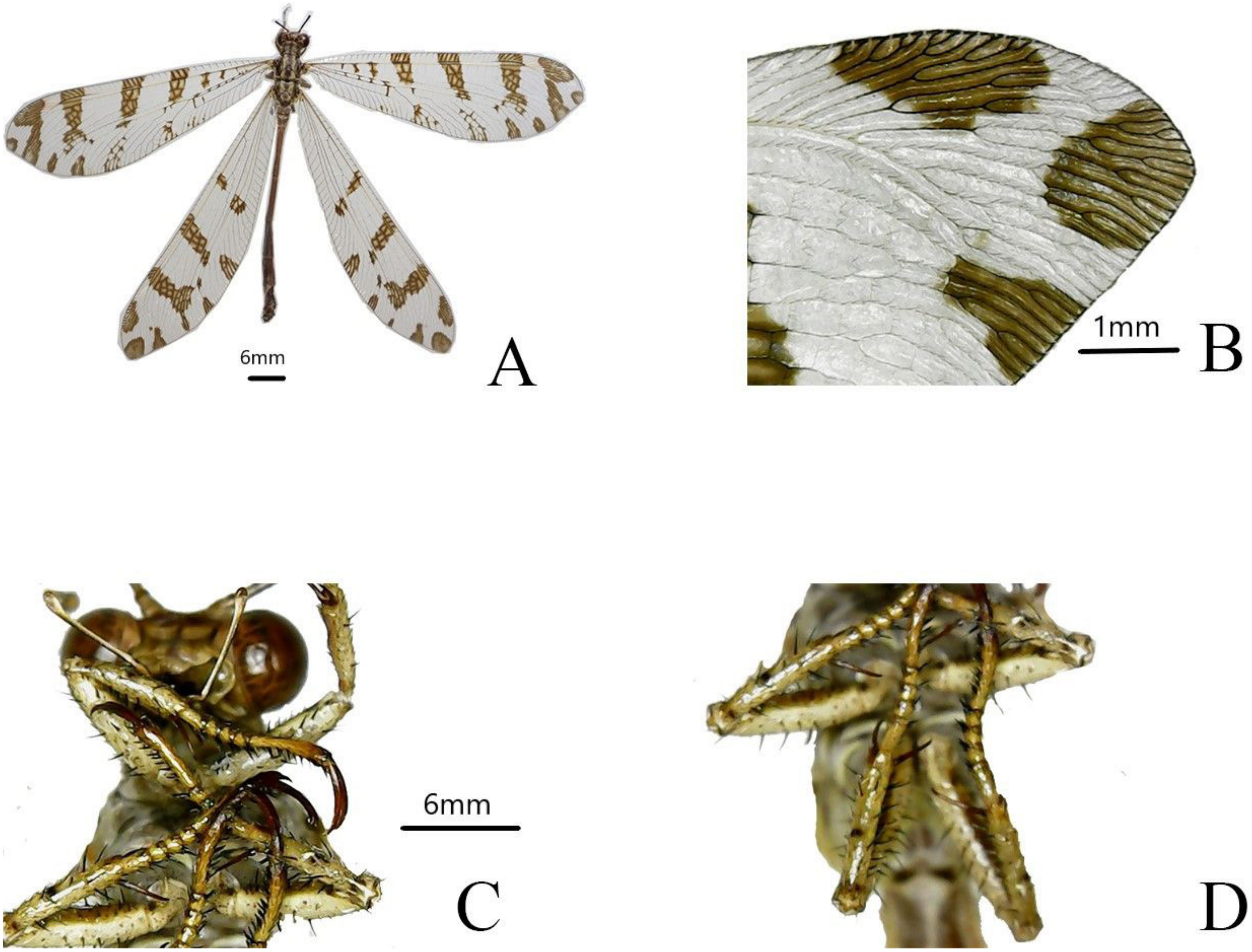

Figure 1 *Dimares elegans* (Perty, 1833) (GEEFAA/UFRN-1342), female specimen collected in Quintos de Cima, Equador, Rio Grande do Norte, Brazil. (a) General dorsal view, (b) dorsal view of the apex of the posterior wing, (c) anterior legs, (d) posterior legs.

male specimen, 15°57′55″S; 54°58′06″W (DZUP); Juína municipality, Estação Ecológica Iquê, 06.ix.1981, one female specimen, 12°00’17”S; 59°17’13”W (DZUP); Juína municipality, Campus IFMT, 13.vi.2013, one female specimen, 11°26’55’’S; 58°43’23”W (DZUP); Nova Xavantina municipality, 20.xi.1988, one female specimen, 14°39′53″S; 52°21′20″W (CEMT); Várzea Grande municipality, one male specimen, 15°38′48″S; 56°07′57″W (DZUP); idem, 24.v.2003, one male specimen (DZUP); idem, 25.x.2017, one female specimen (DZUP); Barra do Garças municipality, 20.iv.1991, one female specimen, 15°53′24″S; 52°15′24″W (DZUP); Poconé municipality, 04.xi.2005, one female specimen, 16°15’24”S; 56°37’22”W (DZUP); *Goiás state*: Caldas Novas municipality, PE Serras de Caldas Novas, 22-23.iii.2008, six female and one male specimens, 17º43’13’’S; 48º39’22’’W (INPA); Porangatu municipality, 22.iv.2017, two female and one male specimens, 13°26′27″S; 49°08′55″W (UFT); *Minas Gerais state*: Monte Alegre de Minas municipality, 13.iv.1972, one female specimen, 18°52′14″S; 48°52′51″W (Esalq); Uberlândia municipality, 1.v.2006, one female, 18°55′07″S; 48°16′38″W (Esalq); 15km sul de Jaíba, 8.iv.1998, one male specimen, 15°21’25”S; 43°40’01”W (DZUP); *Mato Grosso do Sul state*: Cassilândia municipality, Campus UEMS, 10.iv.2004, one female specimen, 19°07’16”S; 51°43’10”W (Esalq); *São Paulo state*: Luiz Antônio municipality, Estação Ecológica de Jataí, mata ciliar, 26.iii.2008, 21º36’47’’S; 47º49’04’’W, one female specimen (APTA); idem, 18.iii.2009, one female specimen (APTA); Piracicaba municipality, 7.vii.1970, one female specimen, 22°43′31″S 47°38′57″W (Esalq); idem, 15.iv.1981, one female specimen (Esalq); *Paraná state*: Carambeí municipality, x.1945, one female specimen, 24°57′09″S; 50°06′57″W (DZUP-381440).

Additional material: Brazil: *Rio Grande do Norte state*: Mossoró municipality, one female specimen, 5°12’35.5”S; 37°18’43.7”W (photographic record); *Minas Gerais state*: Janaúba municipality, one female specimen, 15°49’12.968”S; 43°18’7.582”W (GBIF-33592049, iNaturalist/GBIF) (photographic record); Vazante municipality, one female specimen, 18°0’0”S; 47°0’0”W (MCZ:Ent:1055510555) (photographic record).

Compared material: Argentina: Córdoba, unknown locality, one male specimen (MZLU:Entomology:251117); *Dimares elegans* (Perty) 1833: 125, Plate xxv, figure 5 (color drawing of female). Holotype female, Flumen S. Francisci (Brazil) (ZSMC).

Diagnosis: Dichromatic sexual dimorphism present. Females usually with pigmented bands on the wings (Figure 1a, b), males with absent spots; labial palpi longer than head width; distal labial palpomer with slit-like opening that extends around the apex to the opposite side; basitarsi of the front leg about 2 times longer than the diameter of an average tarsus (Figure 1c), basitarsi of the rear leg about 3 times larger; spurs of the posterior tibia with length equal to or greater than basitarsi (Figure 1d); pretarsal claws at least 1.5 times longer than the posterior basitarsus; tarsal claws about 3 times the width of a tarsomere (based on Stange, 1989, 2010).

A total 125 occurrences were compiled, in which 121 were valid according to the established criteria (Table 1). Of the valid occurrences, 80 were primary data and 41 were secondary data from literature and scientific collections. The geographic distribution of this species extended over several phytophysiognomies in South America, from the Semi-Arid region of Brazil (Caatinga; northeastern distribution) to the Andes (southwestern distribution), between the latitudes 3°55′41″S and 39°9′53″S, including locations in Brazil, Bolivia, Paraguay, Uruguay, and Argentina. The compiled occurrences recorded the species in the biomes: Amazon rainforest, Caatinga, Cerrado, Atlantic rainforest, Pampas, Pantanal, Montane grasslands, Temperate Grasslands, and Savannas & Shrublands (Figure 2). Our study records for the first time the occurrence of *D. elegans* in the Brazilian states of Maranhão, Piauí, Rio Grande do Norte, Paraíba, Bahia, Goiáis, Minas Gerais, Mato Grosso do Sul, São Paulo and Paraná.

The new records on Rio Grande do Norte state – in the localities of Parelhas, Quintos de Cima and Mossoró – are the easternmost extreme records (36°43'33"W to 37°18'43.7"W) expanding the previous known distribution by 1°34'39" degrees (175.42 km). The westernmost occurrence is in Argentina, Pareditas, Mendonza (33°56'27"S; 69°4'42"W) (Figure 2). The specimens collected in Quintos de Cima, Equador municipality (Rio Grande do Norte) was found in a region of mountain formations, shallow and stony soil, deciduous vegetation with trees, small plants (shrubs) and cacti. The specimens were collected in April 2019 and July 2020 in an area close to plantations of subsistence agriculture (Figure 3a). In this same locality, other specimens were observed during the months of April to July 2018, July 2019 and May 2020 (Figure 3b). The specimen collected in Parelhas (Rio Grande do Norte) was found in urban housing near vacant land in May 2020. The observed specimens in Mossoró (Rio Grande do Norte) were seen in an urban housing and photographed (Figure 3c) during the month of July 2019. All collections and observations were on rainy period, at night by light attraction of the urban and farm housings.

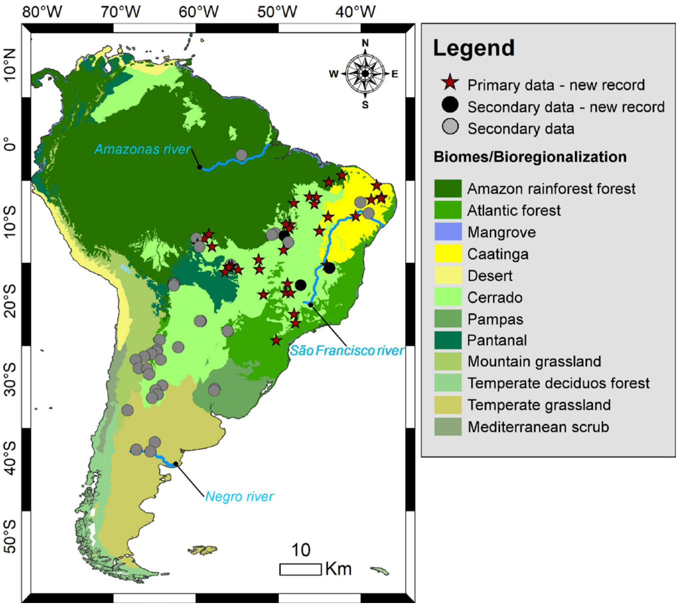

Figure 2 Updated geographic distribution of the antlion *Dimares elegans* (Perty, 1833) highlighting primary and secondary data according to bioregionalization of terrestrial ecosystems.

The historical record of Santarém, Brazil, Pará marked the northernmost occurrence to the north (2° 26' 35"S, 54° 42' 30"W), followed by the new record in Piracuruca (Piauí), the second northernmost occurrence to the north (3° 55' 41"S; 41° 42' 33"W). The southernmost occurrence described until the moment is in Argentina, in Chimpay, Negro river (39°9'53"S) (Figure 2).

The secondary data surveys revealed new localities, which were unknown before this study. These new secondary records were also supported by primary findings. Thus, we provided additional records of *D. elegans* in the Brazilian states of Minas Gerais (localities of Janaúba, 15°49'12.968"S; 43°18'7.582"W; and Vazante, 18°0'0"S; 47°0'0"W) and Tocantins (locality of Gurupi, 11°43′45″S; 49°04′07″W). In addition, we rectified the higher geographical nomenclature of Ilha do Bananal, 11°21'22"S; 50°14'8"W; Santa Isabel do Morro, 11°34' 34"S; 50°40' 6"W and Sul de Peixe 12°31'11.7"S; 48°32'55.0"W records, all in Tocantins state. These localities were previously considered as Goiás state in Stange (1989) and Petko et al. (2016), probably a misinterpretation from original records. Also, we officially record *D. elegans* in Goiás state with the primary records in Porangatu 13°26'27"S; 49°08'55"W and Serras de Caldas Novas 17°43'13" S; 48°39'22" W. Finally, the secondary data survey provided additional records in areas previously known to *D. elegans* in Bolivia (Santa Cruz de la Sierra, 17°47′11″S; 63°10′52″W) and Argentina (Córdoba and Rio Negro) (Table 1, Figure 2).

Discussion

The native South American antlion *Dimares elegans* historically presented a distribution pattern which is recalled – though never tested for this species – an extensive diagonal along with a latitudinal range in South America including the Seasonally Dry Tropical Forests

Figure 3 Sampling site and observation records of the antlion *Dimares elegans* (Perty, 1833) in the new easternmost records, Rio Grande do Norte, Brazil. (a) Sítio Trapiá, Quintos de Cima, sampling site of the specimen GEEFAA/UFRN-1342, (b) photographic record on previously mentioned locality, (c) photographic record on Mossoró (kindly provided by Heinz T Dantas-UERN).

Table 1
Occurrence data review of *Dimares elegans* from primary data (present study) and secondary data (specialized literature, GBIF, and SpeciesLink databases). Boldly highlighted records are new occurrences. *updated/rectified occurrence data.

Author(s)	Locality (State)	Country	Latitude	Longitude
Walker (1853)	Santarém (Pará)	Brazil	2° 26’ 35” S	54° 42’ 30” W
Present study	**Piracuruca (Piauí)**	**Brazil**	**3° 55’ 41” S**	**41° 42’ 33” W**
Present study	**Caxias (Maranhão)**	**Brazil**	**4° 49’ 01” S**	**43° 25’ 15” W**
Present study	**Mossoró (Rio Grande do Norte)**	**Brazil**	**5° 12’ 35.5” S**	**37° 18’ 43.7” W**
Present study	**Mirador (Maranhão)**	**Brazil**	**6° 37’ 25” S**	**45° 52’ 08” W**
Present study	**Parelhas (Rio Grande do Norte)**	**Brazil**	**6° 42’ 02.3” S**	**36° 39’ 35.0” W**
Present study	**Posto Avançado do Mel, Mirador (Maranhão)**	**Brazil**	**6° 43’ 50” S**	**44° 58’ 59” W**
Present study	**Quintos de Cima, Equador (Rio Grande do Norte)**	**Brazil**	**6° 51’ 34” S**	**36° 43’ 33” W**
Present study	**Coremas (Paraíba)**	**Brazil**	**7° 00’ 38” S**	**37° 58’ 58” W**
Stange (1989)	Barbalha (Ceará)	Brazil	7° 26’ 9” S	39° 21’ 9” W
Present study	Bielândia (Tocantins)	Brazil	7° 29’ 10” S	47° 51’ 38” W
Present study	**Ribeiro Gonçalves (Piauí)**	**Brazil**	**7° 34’ 06” S**	**45° 14’ 12” W**
Stange (1989)	Petrolândia (Pernambuco)	Brazil	8° 50’ 33” S	38° 18’ 12” W
Present study	**Curaçá, Riacho do Tio Zé (Bahia)**	**Brazil**	**9° 7’ 48.1” S**	**39° 58’ 45.7 W**
Present study	**Caracol, Serra das Confusões (Piauí)**	**Brazil**	**9° 13’ 33” S**	**43° 27’ 48” W**
Present study	Palmas (Tocantins)	Brazil	10° 10’ 03” S	48° 19’ 40” W
Present study	Paraíso do Tocantins (Tocantins)	Brazil	10° 10’ 34” S	48° 52’ 00” W
Present study	Porto Nacional (Tocantins)	Brazil	10° 42’ 29” S	48° 25’ 02” W
Present study	**Santa Rita de Cássia (Bahia)**	**Brazil**	**11° 01’ 38” S**	**44° 35’ 45” W**
Stange (1989)	Ilha do Bananal (Tocantins)*	Brazil	11° 21’ 22” S	50° 14’ 8” W
Present study	Juína (Mato Grosso)	Brazil	11° 26’ 55” S	58° 43’ 23” W
Stange (1989)	Santa Isabel do Morro (Tocantins)*	Brazil	11° 34’ 34” S	50° 40’ 6” W
GBIF (2019)	Gurupi, Estrada de Belém, Brasília (Tocantins)*	Brazil	11° 43′ 45″ S	49° 04′ 07″ W
Present study	Juína, Estação Ecológica Iquê (Mato Grosso)	Brazil	12° 00’ 17” S	59° 17’ 13” W
Stange (1989)	Vilhena (Rondônia)	Brazil	12° 1’ 14” S	60° 16’ 30” W
Petko et al. (2016)	48km Sul de Peixe (Tocantins)*	Brazil	12° 31’ 11.7” S	48° 32’ 55.0” W
Present study	Vilhena (Rondônia)	Brazil	12° 44’ 26” S	60° 08’ 45” W
Present study	**Porangatu (Goías)**	**Brazil**	**13° 26’ 27” S**	**49° 08’ 55” W**
Present study	Utiariti (Mato Grosso)	Brazil	13° 01’ 17” S	58° 17’ 13” W
Stange (1989)	Barracão Queimado (Mato Grosso)	Brazil	13° 5’ 15” S	59° 53’ 45” W
Present study	Nova Xavantina (Mato Grosso)	Brazil	14° 39’ 53” S	52° 21’ 20” W
Present study	Cachoeira Salgadeira, Chapada dos Guimarães (Mato Grosso)	Brazil	15° 21’ 25” S	55° 49’ 49” W
Present study	**Jaíba (Minas Gerais)**	**Brazil**	**15° 21’ 25” S**	**43° 40’ 01” W**
Stange (1989)	Cuiabá, Gustavo Dutra (Mato Grosso)	Brazil	15° 25’ 9” S	55° 53’ 24” W
Present study	Chapada dos Guimarães (Mato Grosso)	Brazil	15° 27’ 38” S	55° 44’ 59” W
Present study	Cuiabá (Mato Grosso)	Brazil	15° 35’ 46” S	56° 05’ 48” W
Present study	Cuiabá (Mato Grosso)	Brazil	15° 36’ 31” S	56° 3’ 49” W
Present study	Várzea Grande (Mato Grosso)	Brazil	15° 38’ 48” S	56° 07’ 57” W
GBIF (2019)	**Santo Antônio, Janaúba (Minas Gerais)**	**Brazil**	**15° 49’ 12.96” S**	**43° 18’ 7.58” W**
Present study	Barra do Garças (Mato Grosso)	Brazil	15° 53’ 24” S	52° 15’ 24” W
Present study	Jaciara (Mato Grosso)	Brazil	15° 57’ 55” S	54° 58’ 06” W
Present study	Poconé (Mato Grosso)	Brazil	16° 15’ 24” S	56° 37’ 22” W
Stange (1989)	De la Sierra, El Pamar Oratoria (Santa Cruz)	Bolivia	17° 51’ 0” S	63° 9’ 0” W
Present study	**Serras de Caldas Novas (Goiás)**	**Brazil**	**17° 43’ 13” S**	**48° 39’ 22” W**
GBIF (2019)	De La Sierra (Santa Cruz)	Bolivia	17° 47′ 11″ S	63° 10′ 52″ W
Petko et al. (2016)	De La Sierra, 3km de norte de Brasilio (Santa Cruz)	Bolivia	18° 2’ 0” S	63° 10’ 0” W
SpeciesLink (2019) /GBIF (2019)	**Vazante (Minas Gerais)**	**Brazil**	**18° 0’ 0” S**	**47° 0’ 0” W**
Present study	**Monte Alegre de Minas (Minas Gerais)**	**Brazil**	**18° 52’ 14” S**	**48° 52’ 51” W**
Present study	**Uberlândia (Minas Gerais)**	**Brazil**	**18° 55’ 07” S**	**48° 16’ 38” W**
Present study	**Cassilândia (Mato Grosso do Sul)**	**Brazil**	**19° 07’ 16” S**	**51° 43’ 10” W**
Present study	**Luiz Antônio (São Paulo)**	**Brazil**	**21° 36’ 47” S**	**47° 49’ 04” W**
Petko et al. (2016)	Laguna Capitán (Presidente Hayes)	Paraguay	22° 33’ S	59°42’ W
Petko et al. (2016)	Cruce Loma Plata (Boqueirón)	Paraguay	22° 34’ 38.1” S	59° 50’ 11.1” W
Present study	**Piracicaba (São Paulo)**	**Brazil**	**22° 43’ 31” S**	**47° 38’ 57” W**
Petko et al. (2016)	Reserva Natural Laguna Blanca (San Pedro)	Paraguay	23° 48’ 43” S	56° 17’ 40.8” W
Petko et al. (2016)	Reserva Natural Laguna Blanca (San Pedro)	Paraguay	23° 48’ 43” S	56° 17’ 40.8” W
Petko et al. (2016)	Reserva Natural Laguna Blanca (San Pedro)	Paraguay	23° 48’ 43” S	56° 17’ 40.8” W
Present study	**Carambeí (Paraná)**	**Brazil**	**24° 57’ 09” S**	**50° 06’ 57” W**
Stange (1989)	Las Mesitas (Salta)	Argentina	24° 57’ 0” S	64° 58’ 0” W

Table 1
Continued...

Author(s)	Locality (State)	Country	Latitude	Longitude
Stange (1989)	Del Estero, Los Tigres (Santiago)	Argentina	25° 54’ 33’’ S	62° 35’ 35’’ W
Stange (1989)	Trancas (Tucumán)	Argentina	26° 13’ 52’’ S	65° 16’ 51’’ W
Stange (1989)	Vipos (Tucumán)	Argentina	26° 28’ 50’’ S	65° 20’ 44’’ W
Stange (1989)	6km sul de Santa Maria (Catamarca)	Argentina	26°45’ 26.8’’ S	66° 02’ 59.9’’ W
Stange (1989)	Del Estero, Las Termas de Rio Hondo (Santiago)	Argentina	27° 29’ 37’’ S	64° 51’ 35’’ W
Stange (1989)	Tinogasta (Catamarca)	Argentina	27° 30’ 0’’ S	68° 0’ 0’’ W
Stange (1989)	Belén (Catamarca)	Argentina	27° 5’ 0’’ S	66° 55’ 0’’ W
Stange (1989)	Campanas (La Rioja)	Argentina	28° 33’ 12’’ S	67° 37’ 36’’ W
Stange (1989)	Mazan (La Rioja)	Argentina	28° 39’ 56’’ S	66° 32’ 7’’ W
Stange (1989)	Capital (La Rioja)	Argentina	29° 20’ 0’’ S	66° 20’ 0’ W
GBIF (2019)	San Marcos Sierras (Córdoba)	Argentina	30° 46’ 59.61’’ S	64° 38’ 9.78’’ W
Stange (1989)	Entre Rios, Salto Grande (Concordia)	Argentina	31° 12’ 58’’ S	57° 55’ 42’’ W
Stange (1989)	Arenitas Blancas (Paysandu)	Uruguay	31° 24’ 58’’ S	57° 59’ 59’’ W
GBIF (2019)	Villa Dolores (Córdoba)	Argentina	31° 22’ 36.72’’ S	65° 28’ 48.91’’ W
Stange (1989)	Villa Dolores (Córdoba)	Argentina	31° 56’ 45’’ S	65° 11’ 22’’ W
Stange (1989)	Lujan (San Luis)	Argentina	32° 22’ 0’’ S	65° 56’ 11’’ W
Stange (1989)	Pareditas (Mendoza)	Argentina	33° 56’ 27’’ S	69° 4’ 42’’ W
Stange (1989)	Sierra Lihuel Calel (La Pampa)	Argentina	38° 0’ 0’’ S	65° 36’ 0’’ W
GBIF (2019)	Rio Iguazú (Río Negro)	Argentina	38° 57’ 27.49’’ S	67° 56’ 15.5’’ W
GBIF (2019)	Rigio Iguazú (Río Negro)	Argentina	38° 57’ 29.2’’ S	67° 56’ 16.6’’ W
Stange (1989)	Chimpay, Chimpa (Río Negro)	Argentina	39° 9’ 53’’ S	66° 8’ 32’’ W

(Werneck et al., 2012). This new distribution range extends from the Caatinga biome (Northeastern and northern part of Southeastern Brazil), Savana Cerrado (central Brazil) to the Chaco biome (Southwest of South America) (Uetanabaro et al., 2007; Werneck et al., 2012; Demétrio et al., 2017). In the literature, this area has been historically known as the savanna corridor (Schmidt and Inger, 1951) (or diagonal of open formations, Vanzolini, 1963), a region that includes dry biomes, characterized by low rainfall and well-defined seasonal variation (Werneck, 2011). These areas also have similar vegetation that are adapted to these climatic conditions, in addition to complex mosaic-like distributions (Mooney et al., 1995; Furley and Metcalfe, 2007). Thus, many initial interpretations led to the understanding that throughout this distribution range, the organisms were on the same evolutionary history. However, recent studies from the last few decades indicate that both Caatinga and Cerrado have diverse fauna, owning particular areas of endemism and complexes of species (Colli et al., 2002; Colli, 2005; Werneck, 2011; Gamble et al., 2012). Species with wide distribution in the seasonally dry tropical forests suggest that Caatinga, Cerrado, and Chaco have elements of historical connection. Specifically, an interconnection originated in the expansion period of dry forests during the Pleistocene, around the old central Cerrado (‘Pleistocene Arc’; Werneck et al., 2012). Therefore, the Cerrado has become a probable region for the exchange of species (Prado, 2000). In the last decades, many studies have been testing phylogeographic hypotheses that supports the seasonally dry tropical forests (Leal et al., 2003; Amorim et al., 2009; Simon et al., 2009; Nogueira et al., 2011; Gamble et al., 2012; Werneck et al., 2012; Oliveira et al., 2015; Guarnizo et al., 2016).

To date, there were only records along with this biogeographic range and no records in adjacent rainforest regions. Details on the geographic distribution of this species in Heckman’s South American Myrmeleontidae illustrated identification guide (Heckman, 2017) cited the occurrence of *D. elegans* in Pará and Amazonas, North Brazil, both localities in the Amazon Rainforest region. Recent publications on *D. elegans,* which comprise distribution update information (Stange, 2010, Petko et al., 2016) have not mentioned occurrence of the species in these localities or other locality in the Amazon Rainforest. We were unsuccessful in obtaining information about which material Heckman’s work (Heckman, 2017) relied on to cite the species occurrence in these localities. Therefore, we assumed that the Heckman´s material (Heckman, 2017) refer to the male *Myrmeleon albidilinea* Walker, Trans. ent. Soc. London 5:189 (Amaz. (BMNH)) and female *Myrmeleon conicollis* Walker Trans. ent. Soc. Lond. 5:188, (Santarem (Brazil) (BMNH)). The holotypes of these two species are considered synonyms of *Dimares elegans* (Walker, 1853, 1860; Stange, 2004). The expression ‘Santarem’ may refer to ‘Santarém’, western locality in Pará (2° 26’ 35’’ S, 54° 42’ 30’’ W; estimated from Geonames; Figure 2) and the expression ‘Amaz.’ could be an acronym to ‘Amazonas’, Brazilian state (as Heckman, 2017 proposed) or ‘Amazon’ (rainforest) in reference to the biome. In the present study, we obtained new primary records on the Amazon Rainforest (Brazil; Maranhão, Tocantins, Mato Grosso and Rondônia). Based on this, we suggest that Walker record could be a reference to the biome instead to the Brazilian state. Besides the Amazon rainforest records, we provide new primary records on Atlantic forest (Brazil; São Paulo). Mostly locations on Amazon and Atlantic forest are adjacent to the savannah corridor pattern.

These previous cited records are not the majority of the comprised data, therefore, two possible outcomes can be suggested based on total data: First, these are adjacent records to a species within the diagonal of open formation pattern, otherwise, these are the first records of a wider distribution not restricted to the savannah corridor, and within a geographic distribution not totally known. In both cases, further biodiversity investigation in biomes along the South America are crucial to better understand this question and provide further accurate distributional records. Indeed, considering these new records presented herein, the localities indicated by Walker (1853, 1860) may provide a more comprehensive interpretation on the distribution of the species in the Amazon rainforest. Since the new records presented here are located mainly in areas near the east (Maranhão, Tocantins) and southwest boundaries of this biome, Walker´s record in Pará is in the central areas of the Amazon rainforest. Possibly, the distribution of *D. elegans* in the Amazon rainforest is much wider than presumed here. Occurrences in rainforest raise important information about the evolutionary history of this species in South America, because it would no longer be restricted to the hypothesis discussed in the literature for species that have distribution related to the diagonal of open formations.

In South America, Myrmeleontidae represents the second largest family of Neuroptera in species richness, with Brazil having the greatest biodiversity on the continent (Oswald and Machado, 2018; Martins, 2019). Recently, a survey conducted by Machado and Martins (2022) showed that the Myrmeleontidae is found in all major biogeographic domains. The cited authors maintain that Amazon and Atlantic Forest are the most diverse domains, followed by Cerrado and Caatinga. In the present study, our review and new data indicates that occurrences of *D. elegans* corroborate Machado and Martins (2022), despite the higher concentration in drier biomes, the species occurs in adjacent tropical forests.

Other new primary and secondary occurrences of *D. elegans* reported here were concentrated in the biomes under the Seasonally Dry Tropical Forests. The new localities registered in Piauí and Rio Grande do Norte states extended the known limit of the occurrence area, further north and east, respectively, as well as the known occurrence along with the Caatinga biome. The Caatinga is the predominant phytophysiognomy in the northeast region of Brazil. According to the Ministry of Science and Technology (MCT, 2006), it covers a total area of 735,000 km^2, exclusively belonging to Brazil, with a unique diversity of fauna and flora. The Caatinga biome is characterized by irregular rainfall (Silva et al., 2018), with the presence of two seasonal periods, rainy (January to May) and dry (June to December) (Santana and Souto, 2011; Costa et al., 2018). The average annual rainfall is between 500mm and 800mm and average annual temperature between 25°C to 30°C. These aspects favor the adaptation of small plants (Lucena et al., 2017) of the xerophilous and deciduous type, which commonly exhibits arboreal, shrub, and herbaceous forms, with deciduous trees (Pereira-Filho et al., 2010; Souza et al., 2017). The Caatinga is present in eight states in the Brazilian Northeast: Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe, and Bahia, in addition to the north region of Minas Gerais (Southeast Brazil). Among the Caatinga domain, *D. elegans* has now confirmed records in the areas of Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Bahia and Minas Gerais.

New occurrences of *D. elegans* were also reported in the Cerrado, in the Brazilian states of Tocantins, Goiás, Mato Grosso do Sul and Minas Gerais. The Cerrado is the second largest biome in South America, covering an area of 2,036,448 km^2, and is considered an important biodiversity hotspot (Myers et al., 2000). According to Klink and Machado (2005), this biome presents a seasonality defined by a rainy period (October to March), followed by a dry period (April to September), with average temperatures between 22°C to 27°C and average annual rainfall of 1,500 mm. The vegetation is composed of semideciduous or open forest, also characterized by having xerophytic habitats, a mesophytic environment, with humid regions, defined by containing medium-sized trees and dense roots (Reis and Schmiele, 2019). In this biome, some records of *D. elegans* have been corrected regarding the Brazil geopolitical divisions. Historically, Stange (1989) and Petko et al. (2016) pointed out the species occurrence in Goiás. However, the localities mentioned by the authors are currently in Tocantins state, as mentioned before. Therefore, with our survey, we officially reported, for the first time, new occurrences in Tocantins, rectifying records from the works previously mentioned, as well as, with new primary data, occurrences in the current Brazilian state of Goiás. Presence in Goiás is now official with two records: Porangatu and Serras de Caldas Novas.

Among all valid records (primary and secondary), twelve were in the Caatinga, which 75% are new records in the present study. For Cerrado, 41 records were compiled, which around 30% are new records. Records known in Caatinga and Cerrado are scarce and, apparently, there are not many studies of Myrmeleontidae biodiversity in Brazil, while the largest number of studies and material are concentrated in collection sites in Paraguay and Argentina. On the other hand, we are starting to presume the distribution of the species in South American rainforests. According to current knowledge of species with wide geographical distribution, the distribution of *D. elegans* in the Caatinga, Cerrado and Rainforests might be underestimated. For example, suppositions under common sense about known data (previous to the present study) suggested geographical barriers for *D. elegans*. Before the present study, the southern limit of the species distribution was the Negro River (Argentina), while the São Francisco river was the northernmost biogeographic limit area. Together with the new data from Piauí, Paraíba and Rio Grande do Norte (Northeast Brazil), it is now known that the species is distributed beyond the regions adjacent to the São Francisco river. In addition, with the new records on the Amazon rainforest and considering that Pará is a precise locality for *D. elegans* occurrence, perhaps the Amazon River might be the northernmost limit of distribution until new data emerges. Finally, after several new records along the distribution, northernmost Piauí, Maranhão (comprising Cerrado and Amazon Rainforest) and Minas Gerais, São Paulo and Paraná (comprising Caatinga, Cerrado, Atlantic Forest and Pampas) we believe that its distribution might be wider than previously expected as corresponding to the Seasonally Dry Tropical Forests. Recently, Machado et al. (2021) reviewed distributional data of other Ascalaphinae species, *Albardia furcata* van der Welle, 1903, and founded a similar pattern of distribution on Brazilian biomes, mainly on Seasonally Dry Tropical Forests along with records on adjacent rainforests. Therefore, further investigations on adjacent rainforest might picture a better understanding about the distribution of *Dimares elegans* in South America.

A clinal effect on the morphotypes of this species seems to exist according to Stange (1989). According to the aforementioned author, the color banding pattern of the wings in the females and the male stigma; basitarsi length; tibial spurs, and pretarsal claws show defined variations between the extreme populations of this range (populations from Argentina and Northeast Brazil). The studies by Stange (1989) and Petko et al. (2016) briefly present characteristics and records in two ways, highlighting their similarities and differences. Here, in the present study, we do not focus on establishing whether the specimen collected and those observed are of the variation '*lepida*' Navás (1912) or '*elegans*' Perty (1833). We understand that our study does not allow us to draw these conclusions, but now with our current review and an updated distribution for the species, we suggest that evaluations of the population genetic structures among these biomes might help to better understand their distribution and population structure, and in general, the distribution and richness patterns (Werneck et al., 2012).

Conclusion

Antlions are xerophilous insects that live, and are predominantly diverse, mainly in arid (and semi-arid) conditions (Oswald, 2018; Machado et al., 2019). According to the data reviewed here, the antlion *D. elegans* appears widely associated with regions of water stress regime (Caatinga, Cerrado, Chaco, and Temperate Grasslands) and lesser with humid biomes (Amazon Rainforest, Atlantic Forest). Although several factors can affect the distribution and occurrence of an organism, we can suggest based on the occurrence areas, until the present moment, that *D. elegans* should be considered as fauna of a wide distribution on South America, having as a proxy the rainfall, humidity, and temperature variations as relevant in its distribution. Thus, local and regional surveys of Myrmeleontidae biodiversity are emergent for South America. In addition, species modeling distribution might be the next step to provide further information about the environmental suitability of *D. elegans* in South American rainforests and provide additional information to the Seasonally Dry Tropical Forest hypothesis.

Reviews of distribution data are a consequence of the initial steps of biodiversity surveys and checklists. These are compilations of information at a certain moment in space-time and, therefore, are temporal estimates of biological knowledge. The results presented here constitute the first compilation of data and biogeographic understanding for the genus *Dimares*, a monotypic native South America genus. Additionally, to date, no systematic review of occurrence data of this species has been conducted, as proposed here. Therefore, the presented results identify *D. elegans* as a species of relevant biogeographic interest, which can provide valuable insights into the biogeography of Myrmeleontidae in South America.

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Conflicts of interest

The authors declare no conflicts of interest.

Author contribution statement

CERDA Conceptualization (Lead), Investigation (Lead), Methodology (Lead), Writing – Original Draft (Lead), Data Curation (Equal), Visualization (Supporting), Resources (Equal). FJSG Data Curation (Equal), Investigation (Supporting), Visualization (Lead), Writing – Original Draft (Supporting), Writing – review and editing (Equal). ICFA Investigation (Supporting), Writing – Original Draft (Supporting), Writing – review and editing (Equal). RJPM Investigation (Supporting), Writing – review and editing (Lead), Resources (Equal).

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