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Mangrove semiaquatic bugs (Hemiptera: Gerroidea) from Guadeloupe in Lesser Antilles: first records and new data on species distribution

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ABSTRACT

This study aims to illustrate distribution of semiaquatic bug species in Guadeloupe (Lesser Antilles), as there is still little knowledge about the biodiversity of the island's mangroves. In addition to *Limnogonus franciscanus* Stål, 1859 and *Rheumatobates imitator* Uhler, 1894, four species are newly reported for Guadeloupe: *Brachymetra albinerva* Amyot and Servilles, 1843, *Rhagovelia plumbea* Uhler, 1894, *Rheumatobates mangrovensis* China, 2009 and *R. trinitatis* China, 2009 based on taxonomic and phylogenetic analyses. For all recorded species, we provide detailed data on their ecology and distribution in the region of the investigation.

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Veliidae; Gerridae; Caribbean; mapping; ecology; mangrove

Introduction

Semiaquatic bugs are part of the order Hemiptera of insects. They move on the water surface using their hind legs covered with hair, which increases their buoyancy (Andersen 1982). Semiaquatic bugs have piercing and sucking mouthparts (rostrum) to feed on the bodily fluids of their prey (Heckman 2011). Present on every continent, they can be found in a variety of aquatic environments, such as rivers and lakes (freshwater), in estuaries and mangroves (salt to brackish water), and in oceanic waters (Heckman 2011).

These insects have already been studied in various regions throughout the Caribbean such as Colombia, Florida, Guyana, Mexico, Suriname, and Trinidad (Herring 1961; Drake and Van Doesburg 1966; Nieser 1970; Cheng and Lewin 1971; Andersen and Polhemus 1976; Stoner and Humphris 1985; Molano, Morales, and Moreira 2018). In 2011, Heckman listed the aquatic Hemiptera of South America and defined their distribution in the Caribbean without specifying the islands concerned

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(Heckman 2011). In the Lesser Antilles, only a few studies mention aquatic insects. Hungerford (1954) identified three species of *Rheumatobates* Bergroth, 1892 in Trinidad: *R. imitator* Uhler, 1894, *R. mangrovensis* China, 2009, and *R. trinitatis* China, 2009. The macropterous species *Limnogonus franciscanus* Stål, 1859 was also observed and studied in Trinidad (Nummelin 1997) and during a wildlife survey on the island of St Maarten (Yokoyama 2013). Recently, among the 385 species of Hemiptera reported in Guadeloupe, only three species of the superfamily Gerroidea were mentioned in the last survey published: *Limnogonus franciscanus*, *Microvelia pulchella* Westwood, 1834 and *Rheumatobates imitator* (Meurgey and Ramage 2020). However, the range of these species is not specified, and no marine species are listed. Some genera seem to be specifically adapted to marine environments such as the genus *Rhagovelia* Mayr, 1865 which has been identified throughout the Caribbean (Drake and Van Doesburg 1966; Heckman 2011). Unfortunately, only a few studies have been conducted to date in river mouths and mangroves (from marine fringe to swampy areas).

The marine fringe of mangrove in the Lesser Antilles is made up of a single species of mangrove tree *Rhizophora mangle* Linnaeus, 1753, and tidal variations are low (∼30 cm tidal range). These combined two aspects induce a relative stability of the environment (Imbert, Rousteau, and Scherrer 2000; Mantran, Hamparian, and Bouchereau 2009). The mangrove of Guadeloupe is the largest of the Lesser Antilles, about 3000 ha (Imbert et al. 2000) and is mainly located in the Grand-Cul-de-Sac-Marin Bay. This bay is protected by a coral reef and the mangrove is mainly sheltered in the southern part of the bay (Mantran et al. 2009). Despite the coral reef, mangrove islands and the mangrove sea fringe are swept by waves and winds, at least for their windward side. Only a few bodies of water in mangroves and river estuaries are sheltered from these disturbances, such as the Manche à Eau (Mantran et al. 2009) or the mouth of the Canal des Rotours. The Rivière Salée, south of Grand-Cul-de-Sac-Marin Bay, is in fact a seawater canal that cuts the island of Guadeloupe in two (Mantran et al. 2009). Behind the mangrove and located further inland, the swamp forest is mainly composed of *Pterocarpus officinalis* Jacquin, 1763 (Spalding, Blasco, and Field 1997). The swamp forest is waterlogged (3–4‰ of salts) depending on river flooding, rainfall or low tidal range. These different aquatic environments are likely to shelter a great diversity of semiaquatic bugs.

This study aims to identify various semiaquatic bugs present in Guadeloupe and to understand their distribution according to the environment in which they occur.

Material and methods

The sampling area was centred on the Grand-Cul-de-Sac-Marin Bay. All insect collection sites are located in the maritime area adjacent to the Parc National Guadeloupe, except for the sites of Îlet Fajou and Îlet Christophe located in the heart of the national park. Samples were collected from a boat using a landing net with a 1 mm mesh size according to the two following permits: Parc National Guadeloupe 'Arrêté 2018-35' and 'Arrêté 2019-15'. Individuals of each species were collected and placed in collection at the Muséum National d'Histoire Naturelle in Paris (France).

Taxonomic and molecular approaches were used for the identification of the species collected. The taxonomic analysis was performed using various determination keys (Hungerford 1954; Andersen and Polhemus 1976; Heckman 2011; Molano, Mondragón, and Morales 2017; Moreira, Rodrigues, Sites, Cordeiro, and Magalhães 2019). For phylogenetic analysis, DNA extraction was performed on a single individual of each morphotype, COI gene was PCR amplified (Folmer, Black, Hoeh, Lutz, and Vrijenhoek 1994) before sequencing by Eurofins (https://eurofinsgenomics.eu/). Once the species identified, it was possible to map their distribution.

Results

All individuals collected in the Grand-Cul-de-Sac-Marin Bay, belong to four genera (*Brachymetra* Mayr, 1865, *Limnogonus* Stål, 1868, *Rhagovelia* and *Rheumatobates*) and six species (*Brachymetra albinerva* Amyot and Serville, 1843, *Limnogonus franciscanus*, *Rhagovelia plumbea* Uhler, 1894, *Rheumatobates imitator*, *R. mangrovensis* and *R. trinitatis*). *Brachymetra albinerva*, *Rhagovelia plumbea*, *Rheumatobates mangrovensis* and *R. trinitatis* are recorded for the first time for Guadeloupe while *L. franciscanus* and *R. imitator* have already been reported from the island (Meurgey and Ramage 2020). The semiaquatic bug distribution is presented species by species, starting with exclusively marine insects, then the species present in swamp forest and ponds, and finally the transient species present in watercourses.

Rhagovelia plumbea Uhler, 1894

The species was discovered in coastal mangroves and mangrove islets of the Grand-Cul-de-Sac-Marin Bay (Figure 1), mainly in mangroves exposed to waves and wind. It was observed either in small groups of two or three individuals or in colonies of thousands of individuals mixing juveniles and adults, around the roots of *Rhizophora mangle* (supplementary data). Moreover, *Rhagovelia plumbea* can coexist with *Rheumatobates trinitatis*, particularly in the Rivière Salée.

Rheumatobates trinitatis China, 2009

The species was discovered in the Manche à Eau, the Rivière Salée, and the Canal des Rotours watercourses (Figure 1). These marine environments are bordered by mangrove trees composed of *Rhizophora mangle* and are mainly protected against winds and waves.

Rheumatobates imitator Uhler, 1894

This species has been observed evolving in large groups (>100 individuals) on the surface of water bodies in Grande-Terre, particularly at the Maison de la Mangrove. On some occasions, small groups of individuals were observed in the mouth of mangrove waterways such as the Canal des Rotours. This species can coexist with *Limnogonus franciscanus*.

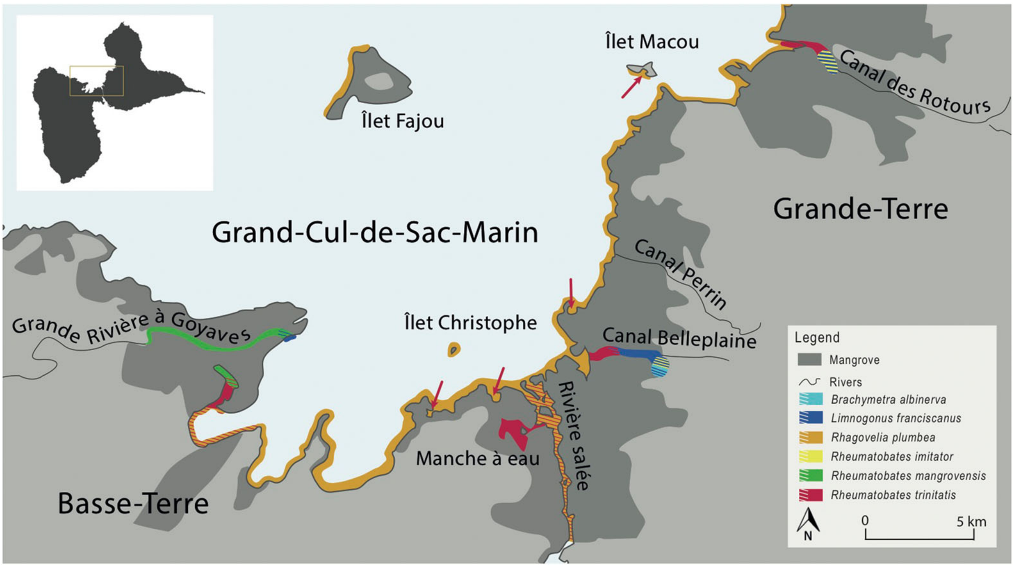

Figure 1. Range mapping of the six species studied in and around Grand-Cul-de-Sac-Marin Bay. The arrows show the small bays where *Rheumatobates trinitatis* China, 2009 were occasionally observed.

Limnogonus franciscanus Stål, 1859

The species was discovered in the freshwater holes of swampy forests, in the ponds of the Grande-Terre, but also at the mouths of rivers such as the Grande-Rivière à Goyaves, and the Canal des Rotours. This species can thus coexist with other species depending on its location. *Limnogonus franciscanus* can coexist with *Brachymetra albinerva* in freshwater holes of swamp forests, or with *Rheumatobates imitator* in ponds and pools, or with *R. trinitatis* in river mouths. This pattern of occupation has been observed in the Canal Belleplaine and the Canal des Rotours; *L. franciscanus* and *R. imitator* share the upstream part of the canals while *R. trinitatis* is found at the mouths of these rivers.

Brachymetra albinerva Amyot and Serville, 1843

The species was discovered in the water holes existing between the roots of *Pterocarpus officinalis* at the Maison de la Mangrove, in groups of a few individuals. *Brachymetra albinerva* coexists with *Limnogonus franciscanus* when water surfaces between roots decrease during dry periods.

Rheumatobates mangrovensis China, 2009

The species was discovered in the mouth of the Grande-Rivière à Goyaves which is characterised by constantly freshwater with shrubby vegetation where they can shelter from the sun. They live in small groups of less than ten individuals.

Discussion

The Hemiptera order includes one of the largest variety of insects in the world, estimated at 89,000 species (Moreira et al. 2019). Aquatic species of the Hemiptera order and the Gerromorpha infraorder have a global distribution. Within the Gerromorpha, it is possible to find marine-only species, saltwater tolerant freshwater species, and freshwater-only species (Schuh and Slater 1995). The genus *Rhagovelia* includes freshwater species, however, nine species are grouped in a 'salina' group (subgenus) which is composed of marine species only (Molano et al. 2018). *Rhagovelia plumbea* is a species perfectly adapted to the marine environment. The presence of a pruinose layer of small silks covering the body protects the insect from the sun's rays and allows it to trap the air when it is submerged by waves (Drake and Van Doesburg 1966; Andersen and Polhemus 1976; Molano et al. 2018). Small fan-shaped silks on its median tarsus ensure stabilisation on the water surface (Drake and Van Doesburg 1966; Andersen and Polhemus 1976). It is therefore not surprising to note the presence of this species in the Grand-Cul-de-Sac-Marin Bay, in poorly protected areas strongly impacted by wave, sea spray, and winds.

Some *Rheumatobates* species are considered marine insects. Of the 34 *Rheumatobates* species described (Hungerford 1954), only six are exclusively marine (Andersen and Polhemus 1976) while the others live in freshwater or euryhaline water (Cheng and Lewin 1971). *Rheumatobates* is undergoing an evolutionary process toward becoming exclusively a marine genus (Andersen and Polhemus 1976). The representatives of *Rheumatobates* do not move more than 10–20 m from the roots of *Rhizophora mangle* in order to avoid displacement by currents and tides (Cheng and Lewin 1971). Hungerford (1954) made the first observations and descriptions of *Rheumatobates* in the Lesser Antilles. He highlighted the presence of *R. trinitatis* on the island of Trinidad, in coastal mangroves, as well as the presence of *R. mangrovensis* in the mouth of the great Yarra River (Hungerford 1954). *Rheumatobates imitator* was also observed in Trinidad in the Hollis Reservoir, an inland freshwater pond (Hungerford 1954). These observations in Trinidad are similar to the distribution currently observed in Guadeloupe. Thus, *R. trinitatis* lives in saltwater and coastal mangroves, *R. mangrovensis* in the mouths of large rivers, and *R. imitator* in freshwater pools behind mangroves and deeper into the lands of Grande-Terre.

Limnogonus franciscanus has only been observed in small populations (<10 individuals) in the Canal des Rotours and at the mouth of the Grande-Rivière à Goyaves. On the other hand, this species is easily observed in freshwater areas behind the mangrove swamps and in freshwater ponds through Grande-Terre. Its presence in river mouths is potentially linked to a transfer between the freshwater pools of Grande-Terre, the water holes behind the mangroves and the river mouths. The light topography, the rains – which can be abundant – and low tides (maximum 30 cm tidal range) can allow individuals to drift on a thin film of freshwater to the river mouths in contact with marine environments. *Limnogonus franciscanus* has also been observed in Trinidad and St Maarten (Nummelin 1997; Yokoyama 2013) but this drifting phenomenon has not yet been described.

The reason for the distribution of these insects may be related to various factors such as (i) the water salinity, (ii) the swell, (iii) their adaptation to warmth and (iv) their predation capacities and food choices. Ditrich and Papáček (2016) observed and compared the predation behaviour of gerrids and veliids in temperate environments. Veliids, which live in rivers, are sharper and faster in their predation behaviour to adapt to the turbulent environment of the rivers. Unlike the veliids, gerrids live in a lentic environment and do not need to be fast in their predation (Ditrich and Papáček 2016). In Guadeloupe, the veliid *Rhagovelia plumbea* lives in open water disturbed by waves. They are adapted to life in an environment not yet occupied by other subaquatic bugs where preys are available. Conversely, the gerrids of *Rheumatobates* spp. live in less turbulent waters found in mangrove bays. The marine species of Gerroidea can be separated into two groups, coastal and pelagic species (Cheng 2006) and their trophic regime is not well known. Coastal species feed on small insects from the land: such as collembolas, copepods, midges or any insects that fall to the water surface (Andersen and Polhemus 1976). Pelagic species of the *Halobates* Eschscholtz, 1822 genus feed on zooplankton trapped at the surface of the sea but also on small fishes, anemones or jellyfishes (Andersen and Cheng 2004). These semi-aquatic bugs (coastal and/or pelagic species) are opportunistic and adaptable, they feed on what they find and it is hard to determine their diet. Molecular-based approach, such as metabarcoding, is used to assess the diet composition of some arthropods and for understanding the trophic network of the environments they occupy (Sow, Haran, Benoit, Galan, and Brévault 2020). Like other molecular based approaches, metabarcoding only gives qualitative results on the presence/absence of prey species in the gut or faecal samples of various animals (Greenstone, Payton, Weber, and Simmons 2014) but this could represent a very nice opportunity to determine in a near future the diets of the semiaquatic bugs studied here.

This study allows us to identify the semiaquatic bugs species found in the mangrove environment (marine fringe and swamps in further inland) of Guadeloupe and it also allows us to determine their preferred environments and the interactions that can occur between them. In the future, it would be interesting to focus on the species' physiology and metabolism in order to improve our knowledge and better understand their implications on Guadeloupe's mangroves and by their capacity to give indications on the state of the fragile environment (disturbances, pollution, climate change) that mangroves constitute. By studying their physiology, we will thus be able to better understand their capacity to adapt to these potentially changing environments at the interface between land and sea.

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