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Presence of the invasive land flatworm *Platydemus manokwari* (Platyhelminthes, Geoplanidae) in Guadeloupe, Martinique and Saint Martin (French West Indies)

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Abstract

The land flatworm *Platydemus manokwari* (Platyhelminthes, Geoplanidae) is recorded from the islands of Guadeloupe, Martinique, and Saint Martin in the Caribbean arc. Photographs and records were obtained mainly from citizen science and ranged from the end of 2018 to February 2021; several specimens were deposited in the collections of the Muséum National d'Histoire Naturelle in Paris, France. Thirty records were from Guadeloupe, but only one from Martinique and from Saint Martin, respectively. The COI sequences of 3 specimens from Guadeloupe show that they belong to the World haplotype also found in many countries. We also report *P. manokwari* from Fort Myers, Florida, USA, with molecular characterization, which was also the World haplotype. This is the first published record of *P. manokwari* for Guadeloupe, Martinique and Saint Martin and the second for islands in the Caribbean, after Puerto Rico.

Key words: Invasive Alien Species, flatworm, citizen science, new records, Antilles

Résumé

Le Plathelminthe terrestre *Platydemus manokwari* (Plathelminthes, Geoplanidae) est signalé dans les îles de Guadeloupe, Martinique et Saint Martin dans l'arc caraïbe. Les photographies et les documents ont été obtenus principalement grâce aux sciences participatives et datent de la fin de 2018 à février 2021; plusieurs spécimens ont été déposés dans les collections du Muséum National d'Histoire Naturelle à Paris, France. Trente signalements provenaient de Guadeloupe, mais un seul a été reçu respectivement de Martinique et de Saint Martin. Les séquences COI de 3 spécimens de Guadeloupe montrent qu'ils appartiennent à l'haplotype mondial également présent dans de nombreux pays. Nous rapportons également *P. manokwari* de Fort Myers, Floride, USA, avec sa caractérisation moléculaire, qui était également l'haplotype mondial. Il s'agit du premier signalement de *P. manokwari* publié pour la Guadeloupe, la Martinique et Saint Martin et le deuxième pour les îles des Caraïbes, après Porto Rico.

Introduction

The land flatworm *Platydemus manokwari* de Beauchamp, 1963 is a highly invasive species, listed among the “100 World’s Worst Invader Alien Species” (Lowe *et al.*, 2000). Originally described from a locality in Papua New Guinea (de Beauchamp, 1962), it has been recorded since in many islands of the Pacific Ocean, Australia, and, more recently, in Puerto Rico in the Antilles, Florida in mainland USA (Justine *et al.*, 2015; Justine *et al.*, 2014), and Asia in Hong Kong (Hu *et al.*, 2019) and Thailand (Chaisiri *et al.*, 2019).

We report here results about specimens of *P. manokwari* from Guadeloupe, Martinique and Saint Martin and use the opportunity of this paper to report unpublished findings and new sequences in Florida, collected by the late Dr John Herman in Fort Myers.

Some preliminary results were published as a preprint, but these included only Guadeloupe records and no molecular information (Justine & Winsor, 2020).

Material and methods

Records and specimens

For Guadeloupe, records were obtained from citizen science. We used the same methods as for our previous research on land flatworms (Justine *et al.*, 2020a; Justine *et al.*, 2020b; Justine *et al.*, 2018a; Justine *et al.*, 2019; Justine *et al.*, 2015; Justine *et al.*, 2014, 2018b, 2020c; Mazza *et al.*, 2016). Photographs were received from various non-professionals through three channels: email directly sent to Jean-Lou Justine, records received through the smartphone application “INPN espèces” (<https://inpn.mnhn.fr/informations/inpn-especes>), and a survey undertaken by DEAL (Direction de l’Environnement, de l’Aménagement et du Logement) (<http://www.guadeloupe.developpement-durable.gouv.fr/veille-des-plathelminthes-en-guadeloupe-a3420.html>). In a few cases, specimens were solicited and received. Specimens were both killed and stored in absolute ethanol, and sent to the laboratory in the Muséum National d’Histoire Naturelle (MNHN) in Paris. The species was identified by the examination of photographs of living animals and preserved specimens, and the identification was confirmed by DNA barcoding.

For Martinique and Saint Martin, records were obtained by one of us (MC) during a general survey of the soil fauna.

For Florida, we report here the results of a local survey undertaken by John Herman and his team at the Florida Gulf Coast University in 2015. Sadly, John Herman died in 2018 and these results were not published.

Barcoding

For molecular analysis, a small piece of the body (1–3 mm³) was taken from the lateral edge of ethanol-fixed individuals. Extraction of DNA and PCR were performed as in previous similar works (Justine *et al.* 2019). Briefly, a fragment of 424 bp was amplified with the primers JB3 (=COI-ASmit1) and JB4.5 (=COI-ASmit2) (Bowles *et al.*, 1995; Littlewood *et al.*, 1997), and a fragment of 825 bp was amplified with the primers BarS (Álvarez-Presas *et al.*, 2011) and COIR (Lázaro *et al.*, 2009; Mateos *et al.*, 2013). PCR products were purified and sequenced in both directions on a 96-capillary 3730xl DNA Analyzer sequencer (Applied Biosystems). Sequences were edited using CodonCode Aligner software (CodonCode Corporation, Dedham, MA, USA), compared to the GenBank database content using BLAST, and deposited in GenBank under accession number MW279220-MW279225.

Results

Records from Guadeloupe

Thirty records were received, from sixteen localities (Table 1, Figures 1–3). Most were from the main island, but one was from Grand-Bourg, on the small island of Marie-Galante. Records based on photographs or specimens were from January 2019 to January 2021. Observations were from gardens, not wild areas. Two observers recorded additional invasive species (*Bipalium kewense* Moseley, 1868 and *B. vagum* Jones and Sterrer, 2005) in the same garden where they found *P. manokwari*. In addition to the information in Table 1, Observer FF (François Ferrasson) mentioned that the species was present in his garden in Saint François since the end of 2018. He also sent a photograph showing several *P. manokwari* eating a dead lizard (unidentified Anole) (Figure 3).

Specimens from Saint François, Bouillante and Lamentin were received and registered in the collections of the Muséum National d’Histoire Naturelle in Paris under number MNHN JL358, JL378, and JL433, respectively.

The relative abundance of records in November 2020–January 2021 (21/30) compared to previous periods needs an explanation. On November 9th, we published a paper about the presence of *Amaga expatria* Jones and Sterrer, 2005 in Guadeloupe and Martinique (Justine *et al.*, 2020a) and a popular piece about invasive flatworms in the Antilles (in French (Justine & Jones, 2020b) and English (Justine & Jones, 2020a)) and this was relayed by the local media in Guadeloupe, including radio, television and newspapers, and, of course, social media. Consequently, we immediately received more records of several species of land flatworms, including *P. manokwari*.

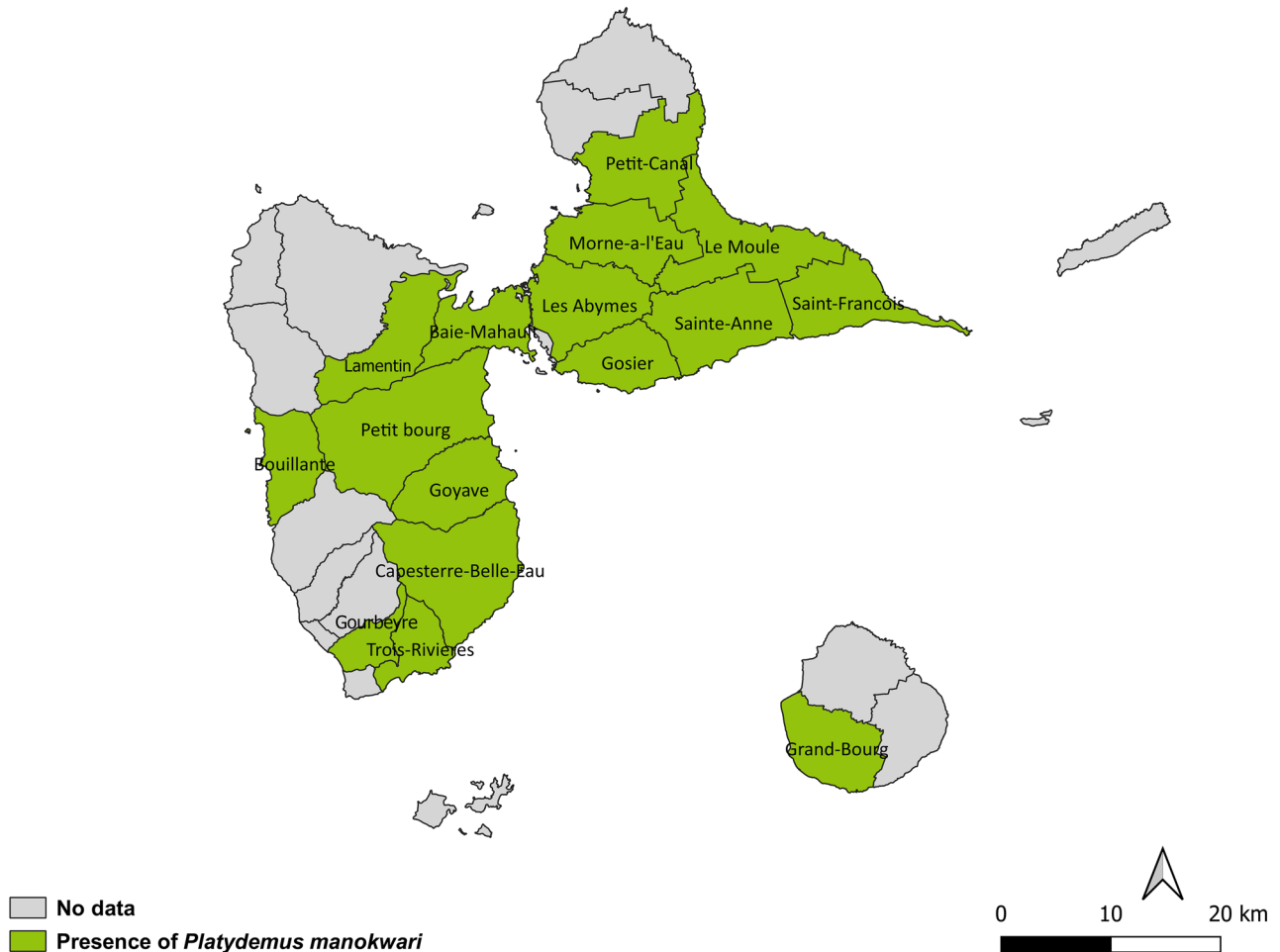


FIGURE 1. Map of Guadeloupe showing the communes where *Platydemus manokwari* was found. Based on Table 1.



FIGURE 2. *Platydemus manokwari*, photographed in Saint François, Guadeloupe, 7 January 2019. Scale in centimetres. Photograph by François Ferrasson, CC-BY.

TABLE 1. Records of *Platydemus manokwari* in Guadeloupe. Names of non-professionals who communicated information are given as initials. The source is detailed in Material & Methods.

Date	Locality	Details	Specimens	Observer/ Collector	Source
07/01/2019	Saint-François	Photos (Figures 2–3)		FF	email
09/01/2019	Saint-François	Photos		FF	email
08/11/2019	Saint-François	Photos and 5 specimens	MNHN JL358*	FF	email
01/01/2020	Baie-Mahault	Photos **		MN	email
06/01/2020	Baie-Mahault	Photos		VD	email
05/03/2020	Bouillante	2 specimens	MNHN JL378	FF	email
20/07/2020	Trois-Rivières	Photos		JA	email
17/08/2020	Gosier	Photos		TD	email
24/09/2020	Trois-Rivières	Photos		EC	email
10/11/2020	Petit-Canal	Photos		NF	email
14/11/2020	Lamentin	Photos		V	INPN
16/11/2020	Capesterre-Belle-Eau	Photos		MS	DEAL
17/11/2020	Gosier	Photos ***		CR	email
19/11/2020	Gosier	Photos		GE	email
27/11/2020	Morne-à-l'Eau	Photos		E	INPN
07/12/2020	Sainte-Anne	Photos		CC	email
07/12/2020	Moule	Photos		EU	email
09/12/2020	Baie-Mahault	Photos		M	INPN
10/12/2020	Gourbeyre	Photos		ME	email
14/12/2020	Morne-à-l'Eau	Photos		MJM	email
15/12/2020	Saint-François	Photos		YM	email
25/12/2020	Lamentin	2 specimens	MNHN JL433	Coulis	collect
26/12/2020	Petit Bourg	Photos		MDS	DEAL
04/01/2021	Grand-Bourg ****	Photos		K	INPN
15/01/2021	Bouillante	Photos		M	INPN
18/01/2021	Capesterre-Belle-Eau	Photos		FM	email
25/01/2021	Capesterre belle eau	Photos		LK	DEAL
26/01/2021	Les Abymes	Photos		MP	DEAL
28/01/2021	Capesterre-Belle-Eau	Photos		JDB	email
29/01/2021	Goyave	Photos		CB	email

* Specimens MNHN JL358 provided sequences MW279222-224.

** Also found at same locality: *Bipalium kewense*

*** Also found at same locality: *Bipalium vagum*

**** This record is from Marie-Galante; all others are from the main island.

Records from Martinique

We had a single record of *P. manokwari* from Martinique (Figure 4), although one of us (CM) collected land flatworms in several localities from 2017 to 2020. The specimen (Figure 5), was found on 18-11-2018 at Morne Gallochat, commune of Les Anses d'Arlet (14,52918°N, 61,0791°W, altitude 165m); it was preying on a juvenile snail, *Pleurodonte discolor* (Férussac, 1821), a species endemic to Martinique (Delannoye *et al.*, 2015). The flatworm specimen is deposited as MNHN JL383. The locality is in a natural environment, a deciduous seasonally dry forest, and the nearest human dwelling was more than 500 m away.

Interestingly, no record of *P. manokwari* was received from citizen science in this island. However, it should be noted that the impact of our paper on *A. expatria* on radio and media in Martinique was minor compared to that in Guadeloupe, and this diminishes the significance of the lack of records from non-professionals.



FIGURE 3. *Platydemus manokwari*, photographed in Saint François, Guadeloupe, 7 January 2019; group of flatworms eating a dead lizard. Photograph by François Ferrasson, CC-BY.

Record from Saint Martin

We had a single record of *P. manokwari* from Saint Martin (Figure 6), comprising three specimens collected 31-12-2020 and deposited as MNHN JL432. The specimens were found under a wooden board laying on soil surface in a common garden of a small residence located 500 away from the Saint-Martin Grand Case airport. Numerous *P. manokwari* were easily observed in this locality despite a little searching effort (only one garden and two natural sites were investigated). No specimen was found in natural areas.

Records from Florida

Specimens of *P. manokwari* were collected in August-September 2015 by Dr John Herman and his team (Table 2). A total of seven specimens were collected.

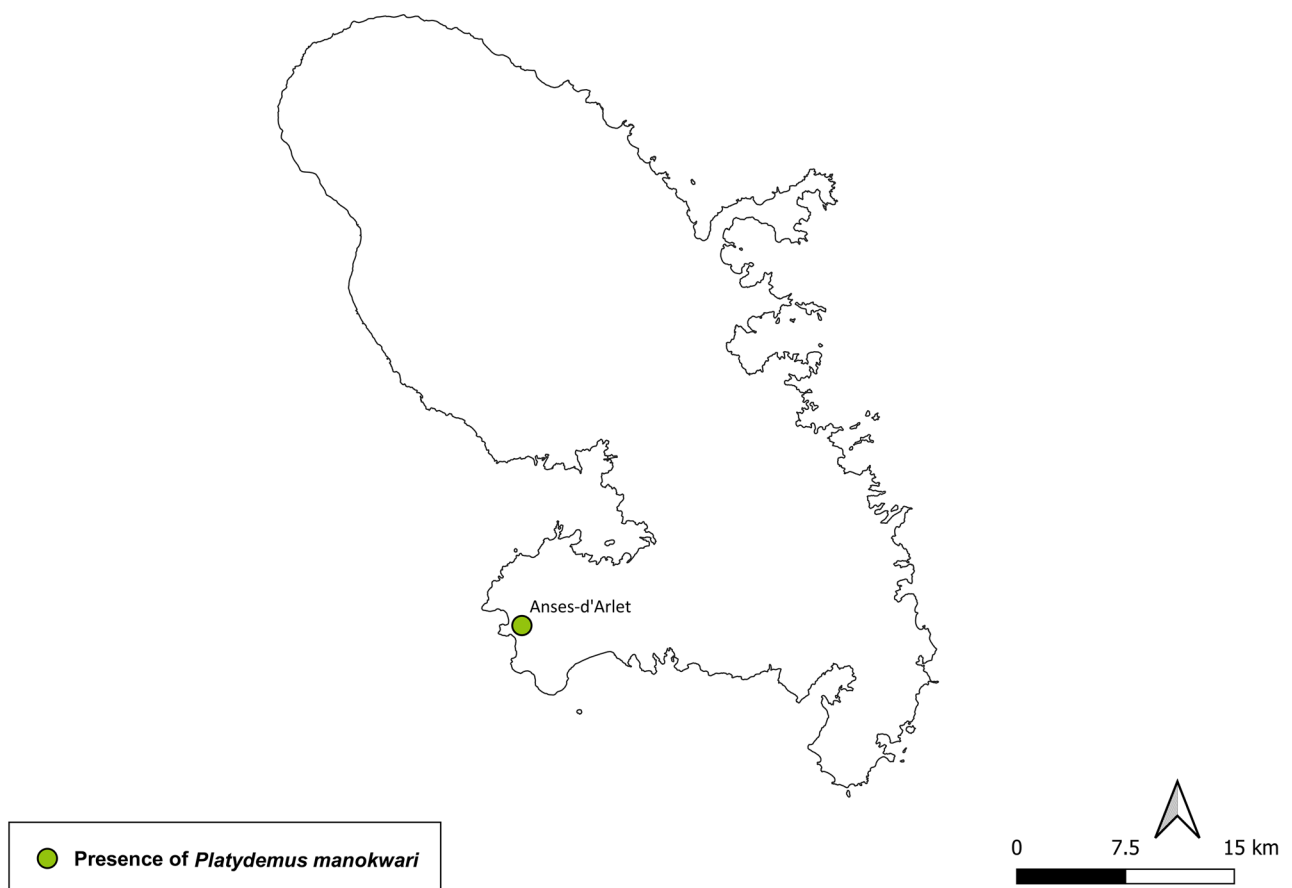


FIGURE 4. Map of Martinique showing the place where *Platydemus manokwari* was found.



FIGURE 5. *Platydemus manokwari*, collected in Martinique, Les-Trois-Ilets, 18 November 2018. Photograph by Mathieu Coulis.

TABLE 2. Specimens of *Platydemus manokwari* collected in Fort Myers, Florida, by Dr John Herman and his team in 2015. FGCU: Florida Gulf Coast University.

Date	Locality	Details	MNHN	Sequence	Collector
22-08-2015	FGCU Campus	4 specimens	JL271	MW279220	JH, TR, DJ
30-08-2015	San Carlos Park	1 specimen	JL273	MW279225	JH
17-09-2015	Old Corkscrew Golf Club	2 specimens	JL274	MW279221	JH, FG, TR, DB, NR

JH: John Herman; TR: Tesla Richards; DJ: Daniela Pareja; FG: Fracis Garces; DB: Damian Baker.



FIGURE 6. Map of Saint Martin showing the place where *Platydemus manokwari* was found.

Molecular results

We obtained 3 new sequences from the material from Guadeloupe (MW279222-224) and 3 new sequences from the material from Florida (MW279220, MW279221, MW279225). For the specimens from Florida, results obtained from both primers were concatenated to obtain COI sequences, 854 bp in length; for the specimens from Guadeloupe, only the primers COI-Asmit provided results and sequences were shorter, 375 bp in length.

The three sequences from Guadeloupe were identical between them, as were the three from Florida. A BLAST analysis showed that all new sequences had 100% similarity with sequences of *P. manokwari* of the World haplotype (Justine *et al.*, 2015).

Discussion

Platydemus manokwari is an invasive species and a threat to the biodiversity of land animals, including molluscs (Gerlach, 2019; Gerlach *et al.*, 2020; Iwai *et al.*, 2010; Ohbayashi *et al.*, 2005; Sugiura, 2010; Sugiura & Yamaura, 2009). It has been recorded in many islands of the Pacific, and more recently in France, but only in a

hothouse (Justine *et al.*, 2014) and was not recorded later in the field (Justine *et al.*, 2015). In North America, it has been recorded in Florida (Justine *et al.*, 2015). Information available from iNaturalist (https://www.inaturalist.org/observations?taxon_id=199342, date: 01-12-2020) suggests that it has now invaded a large part of Florida and Texas, and has also been recorded in Louisiana, North and South Carolina.

In the Antilles arc, *P. manokwari* has been recorded in Puerto Rico (Justine *et al.*, 2015). It is likely that the species is present in other islands of the Antilles arc, and there is a probable report from Jamaica (Kostik, 2019) and citizen science records in iNaturalist from Vieques Island off Puerto Rico (<https://www.inaturalist.org/observations/36952964>), Anguilla (<https://www.inaturalist.org/observations/38130960>), and the US Virgin Islands (<https://www.inaturalist.org/observations/65525697>). Land flatworms are usually distributed through the transport of plants (Sluys, 2016) and citizen science generally provide reports from gardens. Our records from citizen science from Guadeloupe show without any doubt that the species has invaded many parts of the island, and non-professionals reported abundant populations in their gardens. Martinique and Guadeloupe are both French departments in the Antilles and are similar in terms of climate, human populations, and access to media. For Martinique, it is puzzling that we obtained a record of *P. manokwari* in a natural environment, and not a single record from citizen science from human-modified environment such as gardens, although we obtained numerous records of other flatworm species in this island (Justine *et al.*, 2020a; Justine *et al.*, 2018b). From the observations of one of us (MC) it is clear that *P. manokwari* has not yet invaded the gardens in Martinique, as it has in Guadeloupe.

A study of the COI gene sequence of *P. manokwari* has shown that two haplotypes, namely the Australian haplotype and the World haplotype could be differentiated, but that only the latter invaded most of the world (Justine *et al.*, 2015). The complete mitogenome of the species has also been sequenced (Gastineau *et al.*, 2020). The identification of the World haplotype in Guadeloupe does not come as a surprise, since other records in the region with molecular information yielded similar results (Puerto Rico and South-East Florida (Justine *et al.*, 2015)); similarly, the record from Fort Myers, in South-West Florida, matches with previous records from Miami, South-East Florida. The most widespread population of *P. manokwari*, the World haplotype (Chaisiri *et al.*, 2019; Hu *et al.*, 2019; Justine *et al.*, 2015) has now reached North America.

The presence of *P. manokwari* is alarming for biodiversity since Lesser Antilles Islands such as Martinique and Guadeloupe have moist tropical forests with a high number of endemic species. In Martinique, 35% of the snail species are endemic (Delannoye *et al.*, 2015), and in Guadeloupe 16 out of 28 species earthworms present are native (James & Gamiette, 2016). As recently outlined (Gerlach *et al.*, 2020), the presence of *P. manokwari* is a danger for the native soil fauna.

In July 2020, authorities in Guadeloupe have placed *P. manokwari*, as well as species of *Bipalium*, on the list of species forbidden for “introduction into the territory, including transit under customs supervision, introduction into the natural environment, possession, transport, peddling, use, exchange, offering for sale, sale or purchase of live specimens” (Anonymous, 2020a). The same was done for Saint Martin in November 2020 (Anonymous, 2020c). In Martinique, a similar text in July 2020 listed several land flatworms species, but not *P. manokwari* (Anonymous, 2020b).

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