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History of Hylode

Eleutherodactylus johnstonei

(Barbour, 1914)

Origin and Dispersion of the Endemic Species of the Eastern Caribbean



Photos taken in Martinique showing hylodes of the same species: Eleutherodactylus johnstonei

By Marcel BOURGADE

Martinique Caribbean 2024

Abstract

Fundamentally this history of the *Eleutherodactylus johnstonei* endemic to the Caribbean, tracing their origin and their dispersal, reconstituted on the basis of data from paleobiology and paleogeology of the biodiversity of the Caribbean, contributes to a questioning of the vision until then admitted underestimating the tectonic geological history, presenting an eastern Caribbean which would be made up of an archipelago of "oceanic islands which would have emerged one after the other due to volcanic activities", for which the very existence of a terrestrial fauna (insects, molluscs, vertebrates: mammals, reptiles and amphibians, in particular) which would come from elsewhere and then become endemic there, would be explained according to current dominant discourse hypothetically by dubious scenarios of multiple "rafting", that is to say, dispersions of these animal species from the shores of northern South America crossing marine expanses while drifting on rafts of plants to be imagined to run aground randomly on islands.

But the rate of endemism of the central islands of the eastern Caribbean, and particularly of Martinique, and the latest advances and research results in paleogeology tend to invalidate such scenarios of populations of these central islands of Saint Lucia, Martinique and Dominica by rafting successions. The endemic flora and fauna species of the central islands of the Eastern Caribbean have not crossed the sea, nor even crossed the marine expanses by air, to find themselves isolated on these islands; these species found themselves progressively isolated from an average of 35 million years ago, due to a detachment of a northern part of the South American continental crust, which tectonically drifted forming an isthmus then a large island, which will slide along the subduction zone of the Caribbean arc, until a collision at the latitude of the Dominica channel, before disintegrating and being submerged.

Fundamental research for scientific knowledge in paleogeology and paleobiology is crucial for the management and conservation of biodiversity and therefore the fight against invasive exotic species in the Caribbean islands.

The demonstration of the existence of proto-Matīna (35 Ma BP) and Matīna clearly emerged until around 27 Ma BP, should remove the uncertainties expressed by researchers as to the origin of the speciation of the hylode *Eleutherodactylus johnstonei* and therefore resolve the cryptogenic problem concerning this species.

We therefore propose a reconstructed history of the hylodes of the Caribbean through that of the singular species *Eleutherodactylus johnstonei*; history necessarily determined by the geological tectonic history of this geographical region; history consistent with phylogenetic data and current distributions of these endemic hylodes. Historical scenario therefore leading to the current distributions of a number of faunal species on the Caribbean islands, and particularly explaining the endemism known for Saint Lucia and Martinique, concerning animal species of mammals, amphibians, reptiles, and sedentary birds, molluscs and insects.

Keywords: history, hylode, *Eleutherodactylus johnstonei*, Caribbean, Chicxulub, GAARlandia, GrANoLA, Matīna, KaruWétu, geosciences, paleogeology, paleobiology, Curaçao, Bonaire, Margarita, Martinique, Saint Lucia, Saint Vincent, Grenada, Barbados, Trinidad, Venezuela, Saba, Puerto Rico, Jaragua, Haiti, Jamaica, herpetology, biodiversity, speciation, allopatric.

Chicxulub

Located in Mexico, the Chicxulub Crater is one of the largest known impact craters on planet Earth. It was formed some 66 million years ago by the fall of a large asteroid, causing a cataclysm which is famous and known to have most probably been the cause of the disappearance of the dinosaurs.

Around 200 impact craters are currently recorded on Earth. These depressions were formed following the fall of more or less large objects on the surface of our planet. This is the case of the Chicxulub crater; with its diameter of around 170 km wide, it is among the five largest impact craters known to date.

The Chicxulub crater is then located in the Yucatán Peninsula in southeastern Mexico; it is not clearly visible, which also explains why it was only discovered late. It was in 1978 that geophysicists, Glen Penfield and Antonio Camargo, working for an oil company identified an anomaly north of the peninsula in the Gulf of Mexico. Geophysical data revealed a large underground arc 70 km in diameter. In fact, this was not the first time that such a structure had been detected in the area. Ten years earlier, in 1968, another specialist had made a similar discovery but was banned from publishing it. By resuming his work, Glen Penfield noted that there was a second arc, forming with the first a circle of approximately 180 km in diameter whose center was near the town of Chicxulub. The Chicxulub crater was then revealed, but it was not until the 1990s that its existence was confirmed in 1996 by another study. (Smit et al., 1996)

Determining the exact size of the Chicxulub crater is not easy as knowledge is based solely on geophysical data. These indicate that the formation extends over at least 180 kilometers in diameter and 20 km in depth for an area of at least 25,000 square kilometers. Measurements which must have been much larger when the crater was created some 66 million years ago. Enough to give an idea of the size of the object which generated it and the cataclysm it represented.

Different studies have therefore been carried out to identify the origin of the impact: comet or asteroid?

Based on the rocks present in particular, these studies concluded and confirmed that the formation came from a collision between a large cosmic object and the surface of planet Earth which would have occurred approximately 66 million years ago. Comet or asteroid, the two avenues have been considered by scientists who are now leaning more towards the second. One of the latest studies on the subject was published in February 2021 in the journal *Science Advances*. Carried out on samples collected in the crater, it revealed high levels of several elements including iridium, associated with asteroids. Based on the dimensions of the depression, the researchers estimate that the object (whose exact origin remains undetermined) measured at least 10 km in diameter and that its fall caused a real cataclysm. A cataclysm which would have released, according to a study published in 2010, an energy estimated at 100,000 gigatons of TNT, or several billion times that of the atomic bomb dropped on Hiroshima in 1945.

Scientists are still trying to piece together what really happened during this period. In May 2022, a British paleontologist, Robert DePalma, announced in a documentary that he had found a new line of study on a site located in North Dakota in the United States, some 3,000 kilometers from the Chicxulub crater. The paleontologist would have found a tiny fragment of the "Chicxulub asteroid" trapped in amber.

According to the reconstructions carried out, the fall of the asteroid would have dug a cavity several tens of kilometers deep which would have collapsed on itself, forming a crater with a ring in its center. At the same time, phenomenal quantities of dust and other elements would have been thrown into the air, covering the entire surface of planet Earth, blocking the sun's rays and disrupting the climate and the food chain for several years. The different advanced scenarios also evoke gigantic fires, acid rain or even devastating waves. So many phenomena that would have made life on our planet very

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difficult. Today, the impact of this asteroid is one of the main causes cited to explain the mass extinction that occurred at the end of the Cretaceous, some 66 million years ago, and which led to the disappearance of 75% of species, both animal and plant, including non-avian dinosaurs.

Hylodes amphibians, like reptiles such as iguanas of species present in the Caribbean (western and eastern), originally coming from South America, are, like all living beings on the planet, survivors of the cataclysm generated by the impact of the Chicxulub asteroid, whose epicenter is located north of the Yucatan peninsula (present-day Mexico).

New paleogeological data consistent with those of molecular biology (phylogeny)

Molecular biology generally reveals that the genetic divergence of many species of flora and fauna constituting the biodiversity of the Eastern Caribbean with their closest continental South American congeners is much older than the previously accepted presumed dating of 24 millions years of emergence for the proto Martinique. For example, for the hylodes, this genetic divergence between the Caribbean and South American ones, that is to say the dating of the beginning of the speciation process of the hylodes of the Eleutherodactylus group of the Caribbean, is established between 50 and 45 millions years. Another example, for the lizards of the Dactyloa group, of which it is currently accepted that the different species are distributed on the islands of the Venezuelan coast (Bonaire, Blanquilla, ...) up to the latitude of Martinique in the eastern Caribbean diverged from the South American continental Anolis 37 million years ago. To the north of Martinique, the Dominica Channel constituting a geographical barrier for the Anolis species, we have from Dominica to the latitudes of the large islands of the western Caribbean (Guadeloupe, Antigua, Anguilla, Virgin Islands, Puerto Rico, Hispaniola, ...), another group of Anolis, the Ctenonotus, which genetically diverged from the South American continental Anolis about 55 million years ago. Initial results of geological studies carried out by Professor Mélodie PHILIPPON and her team from the Universities of the Antilles and Montpellier, already allow the identification of a scenario of geological tectonic evolution of the Caribbean plate which took place between 50 and 25 million years ago, which would coherently explain the modes of dispersion and speciation processes, and the distributions observed today of the species of endemic flora and fauna constituting the biodiversity of the current islands of the Caribbean; including distributions of extinct or disappeared species from these islands. Let us note that this presumed geological scenario of the formation of the islands of the Eastern Caribbean, originally describing a fragmentation of the emerged surface of the north of the South American continent and a detachment of the upper crust, forming a peninsula then a large island (which we, Mr. BOURGADE, named "Matina" for study), which tectonically slid in a north-east direction, along the subduction zone of volcanoes of the mountain range constituting the arc of the Eastern Caribbean; then collision scenario of this Matina island with the south of an archipelago of two other large islands, the one highlighted by Prof. PHILIPPON named GrANoLA located further north, and the second island south of GrANoLA constituting proto Guadeloupe, Marie-Galante, and Dominique (which we, Mr. BOURGADE, named "KaruWéto" for study), that such a scenario was mentioned by Dr. Roger MAUVOIS who, during a UNESCO Workshop organized by the PNRM in October 2015, explained the formation of the Pitons massifs of Saint Lucia and Martinique by this same

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phenomenon of upper crust migrations or "thrust sheet" phenomenon (described since 1936 by the German mathematician, physicist and geologist STILLE Wilhem Hans). These large islands of Matina, KaruWétu and GrANoLA existing 35 million years ago, disintegrated, were almost completely submerged 24 million years ago, except for the island banks of the protos Martinique, Saint Lucia and the island bank east of Puerto Rico, but also around Marie-Galante.

Also, the presumed isthmus disintegrating to form islands, "Matina", then "Matigwana", at the top of a mountain range (volcanic arc), located on the south-eastern edge of the said Caribbean plate, at the junction of the three lithospheric films (or plates), Caribbean, North America and South America, south of GrANoLA, and which would have formed a bridge

(second after that of the Aves: GAARlandia) between the Orinoco basin and the Greater Antilles; The alleged isthmus highlighted by Marcel Bourgade in his publication, Matina then Matigwana, two large islands that have formed over time geologically emerged parts of the southern arc of the eastern Caribbean (November 2020), published on the site <https://hal.science/hal-02994952> was confirmed by an initial mapping below, reconstructing the geological context of 35 Ma ago, presented in January 2024 in Guadeloupe by Leny Montheil.

Proto – GAARlandia and GAARlandia

Proto-GAARlandia is a presumed previous bridge to GAARlandia. In the Late Cretaceous and Early Paleocene, there was clearly a land bridge between North America and South America, given the arrival of mammals belonging to the Theria in the latter continent during this period. Proto-GAARlandia is this inter-American land bridge that made possible the first American biotic exchange (referring to the later great American biotic exchange). This proto-GAARlandia could have been formed by volcanic activity, unlike GAARlandia. This land bridge would have been raised in response to the tectonic displacement of the South American plate towards the southwest. GAARlandia is the ancient land bridge, which connected the current large islands of the western Caribbean to South America in the Paleogene. The term was constructed from the English acronym GAAR, for Greater Antilles-Aves Ridge. The geographical position of this GAARlandia bridge corresponds to the north-south oriented shoals located between the north of the current eastern Caribbean (east of Puerto Rico) and northern Venezuela, passing through the Isla de Aves. It would have been formed during the transition from the Eocene to the Oligocene, 35 to 33 million years ago, thanks to a combination of the tectonic uplift of the region and the global drop in sea level. (Philippon et al., 2020)

The biological connection with northern South America allowed fauna and flora to spread to the large islands of the western Caribbean. Fossils of mammals, ground sloths, Caribbean monkeys, porcupines, hutias and capybaras, among others, have been found in the large islands of the Western Caribbean and have a certain South American origin (Philippon et al., 2020). This is also the case regarding the origin of many groups of animals, including of course that of reptiles and amphibians; the iguanas of the *Cyclura* species, the anolis *Ctenonotus*, *Eleutherodactyls*, are precisely living witnesses in these large islands of the Western Caribbean of this terrestrial connectivity via the GAARlandia bridge with South America, where their ancestors were able to survive the Chicxulub cataclysm.

Proto-GrANoLA (peninsula) and GrANoLA, than KaruWéту

The Proto-GrANoLA peninsula, 59 Ma ago, is located in northern South America, positioned almost parallel to the east of proto-GAARlandia, following a direction from south to north. Thus, this peninsula gradually between 50 Ma and 40 Ma, will detach itself from northern South America, to form the large GrANoLA island, (French-English acronym: GrAN for "Greater Antilles" - and oLA for "of Lesser Antilles du Nord").

This large GrANoLA island, comparable in size to those of the current large islands of the Western Caribbean, clearly existed around 35 Ma ago and allowed terrestrial biological connectivity between the Eastern Caribbean and the Western Caribbean.

According to the map developed by Lenny Montheil et al., 35 Ma ago the island of GrANoLA would have split into two; and it is this section south of GrANoLA that we named KaruWéту.

KaruWéту, to phonetically identify the large island existing 35 million years ago, south of GrANoLA, positioned at the base of the current islands of the Guadeloupe archipelago (Basse Terre, Grande Terre, Désirade, Les Saintes, Marie Galante) and Dominica. Acronym consisting of Karu, prefix of Karukéra corresponding to Guadeloupe and Wéту prefix of Wétukubuli to name Dominica.

Proto-Matīna (peninsula) and Matīna

Matīna, to identify the large island (extending almost from Grenada to Martinique), continental fragment, sedimentary mass, which will dislocate from the peninsula connected to the South American continent (the proto-Matīna), to slide in a tectonic context along the South American plate; by a phenomenon of thrusting on the Caribbean plate, in a north-east direction, during a period ranging from 35 to 25 million years, until collusion with the island of KaruWéту. Matīna or Matīnina is phonetically the oldest Taíno toponym known to name Martinique.

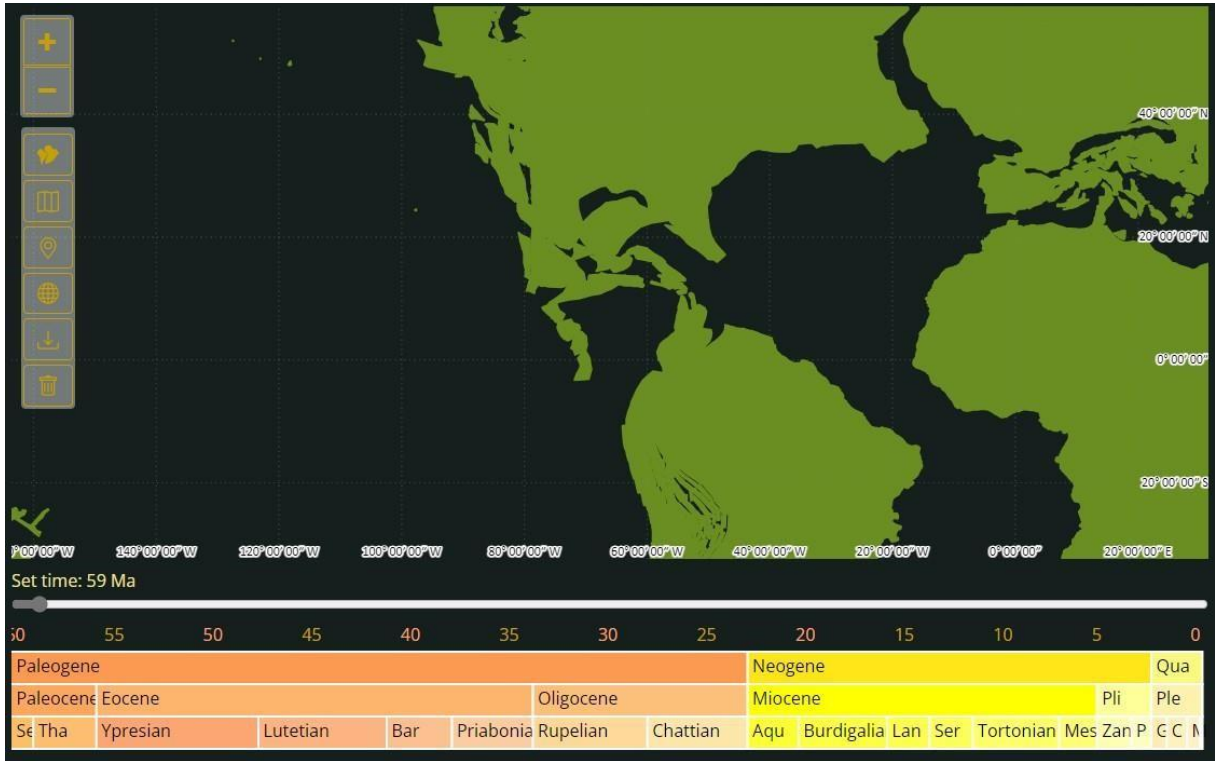
**The Eastern Caribbean Arc:
Archipelagos of island vestiges of Matina,
KaruWétu and GrANoLA**

The islands of Martinique, Saint Lucia, Saint Vincent, the Grenadines, Grenada are the remains of the large island of Matina which was submerged. The islands on the coast of Venezuela, Aruba, Curaçao, Bonaire, Tortuga, Blanquilla, Testigas, Margarita, are also remains of the proto-Matina.

The islands of Dominica, Marie-Galante, Les Saintes, Petite-Terre, Désirade, Grande-Terre, and Basse-Terre of Guadeloupe are remains of the large island of KaruWétu.

The islands north of Guadeloupe, Montserrat, Saint Kitts and Nevis, Antigua and Barbuda, St. Martin, St. Barth, Anguilla, are remains of the large island of GrANoLA.

The island of Saba is a remnant of GAARlandia.



AI-generated mapping of tectonic evolution targeted to America in the context of 59 Ma BP (Before Present).



Targeted details on the central American zone, with indication of toponymic landmarks, 59 Ma BP (Before Present) with precision of the impact point called Chicxulub. We positioned the proto-GAARlandia, as well as the proto-GrAnOLA and KaruWétu, to identify the large island existing 35 million years ago, south of GrAnOLA. KaruWétu, positioned in the basement of the current islands of the Guadeloupe archipelago (Basse Terre, Grande Terre, Désirade, Les Saintes, Marie Galante) and Dominica. Karu, prefix of Karukéra corresponding to Guadeloupe and Wétu prefix of Wétukubuli to name Dominica.

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After SUBUTTEC Kick-off in Guadeloupe, inspired by Montheil et al. Map of lands 35 Ma Before Present, January 2024

In order to correlate the phylogenetic patterns of the endemic species of the herpetofauna of the Eastern Caribbean with the global scenario of paleogeographic evolution coherently explaining the dispersions, speciations and still current distributions of these species, we completed the map developed by Lenny Montheil et al., by naming islands and localities from 35 million years ago, while indicating their correspondence with islands in the eastern Caribbean today.

In homage to the Taino languages, we attributed the toponym of Gwanaatabéy to the locality in the northwest of Cuba, corresponding phonetically today to the Island of Youth and the Cuban province of Pinar del Rio. The lexeme Gwana, being present from north to south of the Caribbean region, to name islands and countries, and used to specify in the group of lizards, the Iguanidae (Gwana => Iguana).

Jaragua, for the island located northwest of the Saba bank, so named today as a province of the Haitian state.

KaruWétu, to phonetically identify the large island existing 35 million years ago, south of GRANOLA, positioned at the base of the current islands of the Guadeloupean archipelago (Basse Terre, Grande Terre, Désirade, Les Saintes, Marie Galante) and Dominica. Acronym made up of Karu, prefix of Karukéra corresponding to Guadeloupe and Wétu prefix of Wétukubuli to name Dominica.

Matina, to identify the large island (going almost from Grenada to Martinique), continental fragment, sedimentary mass, which will break up from the peninsula connected to the South American continent, to slide in a tectonic context along the South American plate; by a phenomenon of thrusting on the Caribbean plate, in a northeast direction, during a period ranging from 35 to 25 million years, until collision with the island of KaruWétu. Matina, is phonetically the oldest Taino toponym known to name Martinique.

Eleutherodactylus johnstonei (Barbour, 1914)



Photos taken in Martinique showing hylodes of the same species: *Eleutherodactylus johnstonei*

1. *E. johnstonei*, specimen observed on the peninsula of southwestern Martinique (Anses-d'Arlet)
2. *E. johnstonei*, specimen observed on the peninsula of southwestern Martinique (Diamant)
3. *E. johnstonei*, specimen observed in the southeast of Martinique (Vauclin)
4. *E. johnstonei*, specimen observed on the peninsula of southeastern Martinique (Sainte-Anne)
5. *E. johnstonei*, specimen observed in the northwest, Caribbean coast of Martinique (Schœlcher).

Eleutherodactylus johnstonei et *Eleutherodactylus martinicensis* dont ancêtre commun a divergé de l'ancêtre du Coqui de Porto Rico il y a 41 Ma !



Eggs of *Eleutherodactylus johnstonei* (Sainte-Anne Martinique)



Eggs of *Eleutherodactylus coqui* (Puerto-Rico)

The Eastern Caribbean is home to hylodes of the same geological age as the species of *Eleutherodactylus*, Puerto Rican Coqui, *Eleutherodactylus coqui* (Thomas, 1966). Among these species are *Eleutherodactylus johnstonei* and *Eleutherodactylus martinicensis* (Tschudi, 1838) for which molecular biology reveals that the common ancestor hylode of these two species present in Martinique, diverged from the ancestor of the Puerto Rican Coqui 41 Ma (million years) ago.



Dispersals of the ancestors of Eleutherodactyls on Proto-GAARlandia and towards the Proto-GrANoLA peninsula -KaruWétu since more than 59 Ma BP (divergence of these hylodes with their congeners remaining in South America, estimated at 43 Ma BP).

Examples for both species :

Eleutherodactylus martinicensis (Tschudi, 1838) et *Eleutherodactylus coqui* (Thomas, 1966)

Eleutherodactylus martinicensis

As soon as possible after surviving the cataclysm caused by the impact of the Chicxulub asteroid 66 Ma ago, the ancestors of the hylodes of the species *Eleutherodactylus martinicensis* dispersed from South America to the peninsula that we have named proto-GrANoLA. These ancestors of *Eleutherodactylus martinicensis* separated from this time of about 50 Ma BP, from the ancestors of *Eleutherodactylus coqui* who also originated from the same dispersal center in South America and headed towards the peninsula further west, that of GAARlandia, in collusion with a large island of the time gathering proto-Puerto Rico, proto-Hispaniola (Jaragua), proto-Jamaica, proto-Cayman, proto-Cuba. These ancestors of *Eleutherodactylus martinicensis*, once detached from the Proto-GrANoLA peninsula of northern South America, isolated on the island of GrANoLA, then especially on the island of KaruWétu, from around 40 Ma BP began a process of speciation, and therefore of genetic divergence with the Eleutherodactyl hylodes of the South American continent (a process of divergence which would have lasted until 22 Ma BP to 18 Ma BP according to estimates by Hedges et al.). From 25 Ma BP, as GrANoLA and KaruWétu gradually submerged, hylodes survived by finding refuge on residual islets of GrANoLA and KaruWétu, which remained emerged and constituted proto-Anguilla, proto-Saint Martin, proto-Saint Barth, proto-Antigua and Barbuda, proto-Guadeloupe archipelago, proto-Dominica and proto-Martinique (North of Matina).

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Clearly, the presence of hylodes of the species *Eleutherodactylus martinicensis*, said to be endemic to Martinique, reveals the fact that very probably there existed between 24 Ma BP and approximately 10 Ma BP a terrestrial connectivity, in the collusion zone between the extreme north of Matīna, and the south of KaruWétu (current strait between Dominica and Martinique). See the map figure below showing details of this collusion zone, today submerged in the northeast of Martinique, and the southeast of Dominica, formerly and during a geological period, presumed habitat and circulation zone of *Eleutherodactylus martinicensis*.



Details of the collusion zone between the north of Matīna and the south of KaruWétu, presumed to have emerged

In the period from 24 Ma BP to 10 Ma BP, this area of the Makouba bank was once a bridge between Matīna and KaruWétu (at least like a super tombolo to the north of the Makouba bank nicknamed by Martinican fishermen "Dièn Bièn Phù"; surface of land that remained above water long enough to allow the passage and dispersion of various animal species in both directions, including among others the hylode amphibian of the species *Eleutherodactylus martinicensis*, the iguanas of the species *Iguana delicatissima*, the large frog *Leptodactylus fallax*, ... which then moved in the direction KaruWétu towards Matīna; in the other direction Matīna towards KaruWétu, there were for example the spherodactyls, *Sphaerodactylus festus*, the hylode *Eleutherodactylus johnstonei*, and certainly the Manicou mammal *Didelphis marsupialis insularis*.



Identification criteria: (1) *E. martinicensis*

(2) *E. johnstonei*

Photographs by the author of specimens of the two species in Martinique

Fig. 1

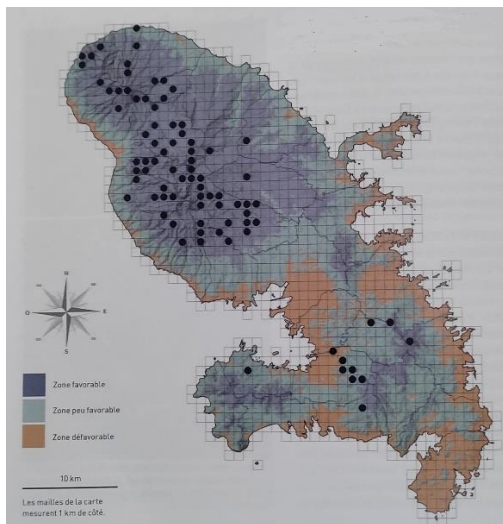


Fig. 2

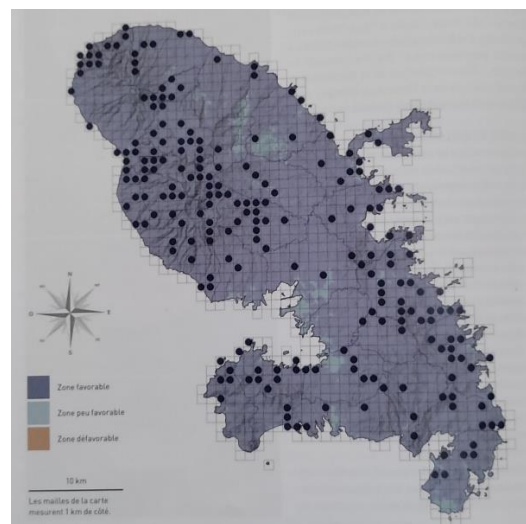


Fig. 1 and Fig. 2: extracts from the Atlas of Amphibians and Reptiles of Martinique pages 80 and 84 (PNRM/ Dewynter, 2018)

Fig. 1: distribution map on the territory of Martinique of the species *E. martinicensis*, originating from KaruWétu (proto-Dominica); and which clearly never inhabited certain areas of southeastern Martinique.

Fig. 2: distribution map on the territory of Martinique of the species *E. johnstonei*; emblematic species of the best distributed herpetofauna, like the reptile *Dactyloa roquet*, throughout the territory of Martinique; **inhabiting this island of Martinique, vestige of Matina, since time immemorial; since proto-Martinique, since the existence of the proto-Matina peninsula, more than 43 million years ago.**

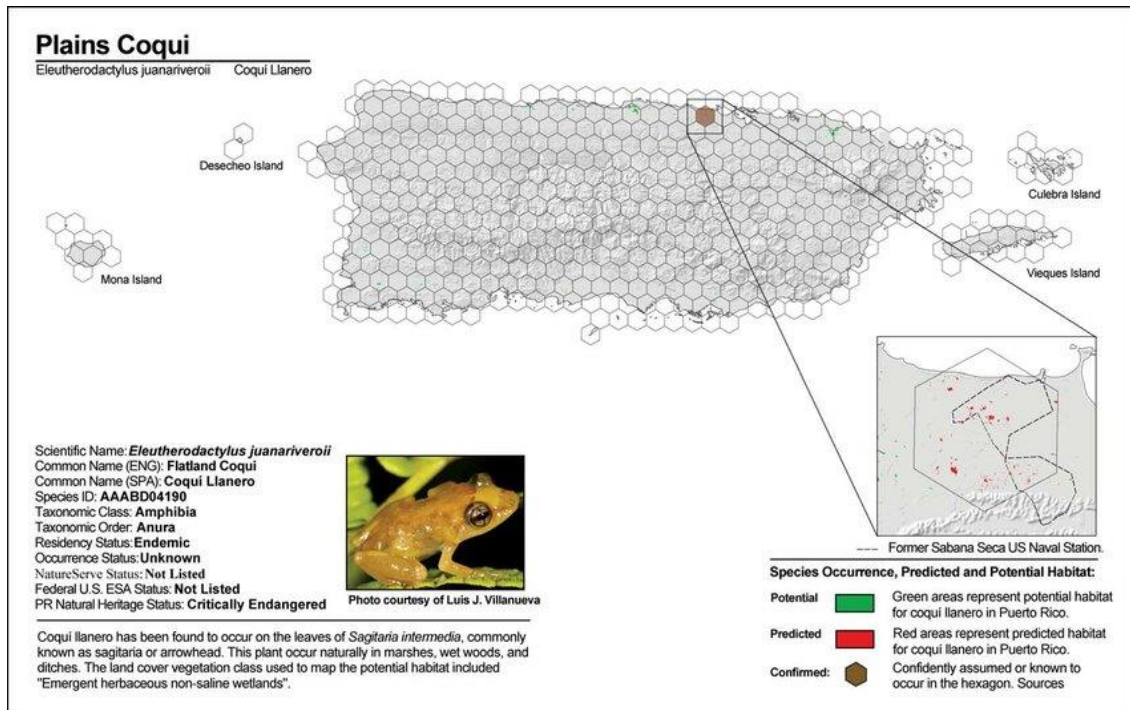
Eleutherodactylus coqui

The ancestors of *Eleutherodactylus coqui* leaving northern South America headed as soon as possible, at least 59 Ma ago, towards the GAARlandia peninsula itself in collusion with proto-Puerto Rico, proto-Jaragua, proto-Hispaniola, proto-Jamaica and proto-Cuba. The speciation process was then initiated, at the rate of the formation of these large islands of the western Caribbean. Thus were generated the species of *Eleutherodactylus cubanus*, ... in Cuba, of *E. jamaicensis*, ... in Jamaica, of *E. alcolae* from Jaragua: Haiti – Dominican Republic, of *E. monensis* on the island of Mona (Puerto Rico), of *E. cooki* from the bank of islands east of Puerto Rico.



Specimens of *E. coqui* photographed in Puerto Rico (Sources: google images / iNaturalist)

https://www.inaturalist.org/observations?place_id=any&user_id=m-bourgade-mk&verifiable=any



https://www.researchgate.net/figure/Elleutherodactylus-portoricensis-predicted-distribution-map-based-on-Rio-Lopez-and_fig26_47504599



Dispersion from Matina to the Saba Bank, then to Jaragua and Jamaica of *E. johnstonei*

The hylodes of the species *E. pinchoni* and *E. barlagnei*, *E. martinicensis* are living witnesses in the eastern Caribbean of terrestrial connectivity with South America via the proto-GraNola peninsula (59 Ma BP), then of the existence of GraNola and KaruWétu (35 Ma BP), where their respective speciation processes took place. Hylodes of the species *E. johnstonei* (Barbour, 1914), *E. montserratiae* (Hedges, 2022) considered as *E. johnstonei* until now, and very likely congeneric species of Eleutherodactyls from the Jaragua Peninsula in Haiti and the Dominican Republic, still distributed:

- on the islands north of Venezuela (Aruba, Curaçao, Bonaire, ..., Margarita),
- in the eastern Caribbean (originally in Grenada, Saint Vincent, Saint Lucia, and Martinique),
- on the remnant islands of GAARlandia, the Saba Bank (hylodes dispersed towards the islands of St. Martin, Anguilla, St. Eustatius, St. Kitts and Nevis, and Montserrat),
- in a mountainous locality, very little urbanized, inland, in the center west from Jamaica.

are living witnesses of terrestrial biological connectivity with South America via the proto Matina peninsula, and Matina, and GAARlandia 35 Ma ago.

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The ancestors of *E. johnstonei*, *E. montserratiae* and evidently other Eleutherodactyl taxa, from the proto-Matina peninsula, passed through the GAARlandia isthmus, to reach the area of the proto-Saba bank, then the proto-Jaragua peninsula (south of present-day Haiti and the Dominican Republic) which formed a single block with proto-Jamaica. One of these lineages probably remained at the end of the journey in Jamaica, genetically close to the hylodes *E. johnstonei* that remained on the proto-Matina, and which are the ancestors of the *E. johnstonei*, from Grenada, Saint Lucia, and Martinique in particular, and this despite their contact with other Eleutherodactyls that had preceded them on the proto-GAARlandia, and which were therefore already present for millions of years on proto-Jamaica, on proto-Jaragua, on proto-Saba bank.

Thus on proto-Saba bank, ancestors of *E. montserratiae* joined Eleutherodactyls already present there; before finding themselves isolated on this end of the Saba bank, north of GAARlandia due to its separation from Jaragua and the progressive submersion of the GAARlandia bridge. Ancestors of the *E. johnstonei* lineage that reached proto-Jamaica, those that remained on Jaragua, will become genetically weakened, from then on the geological tectonic collusion of the Jaragua peninsula with the so-called "Hispaniola" (on our map), northeastern part and eastern part (which the Tainos called Kiskéya) of the large island of Haiti / Dominican Republic. This collusion between Jaragua and Kiskéya is at the origin of the mountain range nicknamed "Dominican Alps" including the highest peak in the entire Caribbean, Pico Duarte, culminating at 3087 meters. These hylodes originating from proto-Matina will therefore find themselves in contact with other Eleutherodactyls already present for millions of years on Kiskéya.

Lines of hylodes that remained on the Isthmus of Aves, certainly disappeared with the submersion of GAARlandia. The ancestors of *E. johnstonei* remained on proto-Matina (dispersal center), will find themselves isolated once the isthmus of Aves is submerged, and formation of the large island of Matina and therefore separation of this one from the north of the South American continent.

The large island of Matina (with a length going almost from Grenada to Martinique), continental fragment, sedimentary mass, broke away from the peninsula connected to the South American continent, to slide in a tectonic context along the South American plate; by a phenomenon of thrusting on the Caribbean plate, in a northeast direction, during a period going from 35 to 25 million years, until collusion with the island of KaruWétu. During this thrusting and sliding of the continental fragment that we have named Matina, there was probably collusion with another large island, bringing together proto-Barbados, proto-Trinidad, and part of proto-Venezuela. This collusion for a time with proto-Barbados and proto-Trinidad would explain the presence of *E. johnstonei* on these islands of Barbados, Trinidad and Tobago today.

E. johnstonei hylodes also remained on islands on the coast of present-day Venezuela, Aruba, Curaçao, Bonaire, Tortuga, Blanquilla, Testigas, Margarita, which are then vestiges of proto-Matina. This is how for millions of years, ancestors of *E. johnstonei* have survived to inhabit the proto-islands of Martinique, Saint Lucia, Saint Vincent, the Grenadines, Grenada, which were and still are the remains of the large island of Matina which has been submerged for more than 25 Ma BP. **The hylodes *Eleutherodactylus johnstonei* do not come from elsewhere, they are endemic to the eastern Caribbean.**

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On the large island of Matïna, the ancestors of the hylode *Eleutherodactylus johnstonei* obviously coexisted with the ancestors of animal species of mammals, amphibians, reptiles, and sedentary birds, mollusks and insects.

With the ancestors of the mammals Pilory Rat or Muskrat, *Megalomys desmarestii* (J. Fischer, 1829); of the Agouti, *Dasyprocta antillensis* (Carl Von Linné, 1758) which was a great consumer of the fruits of *Pachira insignis*; of the Nine-banded Armadillo, *Dasypus novemcinctus* (still present in Grenada, mentioned and drawn by Du Tertre as being present in Martinique); of the Martinique Bat, *Myotis martiniquensis* (Laval, 1973). Cohabitation on Matïna of *Didelphis marsupialis insularis* ; with ancestors of the *Iguana insularis*, with other reptiles and amphibians, ancestors of the Martinique Skink, *Capitellum metallicum* (Plée, 1820); of the Great Skink of Martinique, *Mabuya mabouya* (Bonnaterre, 1789); of the Holotropid of the Herminier, *Leiocephalus herminieri* (Dumeril & Bibron, 1837); of the Kourès or Martinique snake, *Erythrolamprus cursor* (Bonnaterre, 1790); of the Martinique Boa, *Boa sp.* (Moreau de Jonès, 1818); Zannoli, *Dactyloa roquet* (Bonnaterre, 1789); from Chofé Solèy, *Gymnophthalmus pleii* (Bocourt, 1881); of Ti Mabouya: *Sphaerodactylus vincenti* (Boulenger, 1891), *Sphaerodactylus festus* (Barbour, 1915), *Sphaerodactylus microlepis* (Reinhardt & Lutken, 1862) *Sphaerodactylus sp. X* (in prep. Bourgade, 2013); from Gwo Mabouya, *Thecadactylus rapicauda* (Houttuyn, 1782); of Ti Sèpan Tè, Sténostomes, *Tetracheilostoma sp.* (Schlegel, 1839); of the Trionocephalus, *Bothrops sp.* (Bonnaterre, 1790), *B. lanceolatus*, and *B. caribbaeus*; of the Martinique Allobate, *Allobates chalcopis* (Kaiser, Coloma & Gray, 1994), a small amphibian strictly endemic to the summits of northern Martinique; species of *Pristimantis* frogs, one species of which survives in Grenada.

LIST OF ENDEMIC SPECIES OF MARTINIQUE AND SAINT LUCIA VERY LIKELY TO HAVE INHABITED PROTO-MATÏNA AND MATÏNA (not limited)

Known extinct species of mammals from the eastern Caribbean:

Pillory Rat or Muskrat, *Megalomys desmarestii* (J. Fischer, 1829); Agouti, *Dasyprocta antillensis* (Carl Von Linné, 1758); who was a great consumer of the fruits of *Pachira insignis*. The Nine-banded Armadillo, *Dasypus novemcinctus* (still present in Grenada, mentioned and drawn by Du Tertre as being present in Martinique).

Eastern Caribbean mammal species:

Manicou, *Didelphis marsupialis*, present from Trinidad to the latitude of Dominica, the species was protected in Martinique until recently, to be today declared in scientific uncertainty as being "probably introduced into the eastern Caribbean by Native American".

The Martinique Murin, *Myotis martiniquensis* (LaVal, 1973), species of bat strictly endemic to the island of Martinique.

Known species of reptiles and amphibians, extinct or disappeared from Martinique:

Martinique skink, *Capitellum metallicum* (Plée, 1820); Great Skink of Martinique, *Mabuya mabouya* (Bonnaterre, 1789); Herminier holotropid, *Leiocephalus herminieri* (Dumeril & Bibron, 1837); Kourès or Martinique snake, *Erythrolamprus cursor* (Bonnaterre, 1790); Martinique boa, *Boa sp.* (Moreau de Jonès, 1818); Big Frog, *Leptodactylus fallax* (Müller, 1926).

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Species of reptiles and amphibians endemic to the Eastern Caribbean native to South America, distributed from the latitude of Grenada to that of Dominica:

Zanndoli, *Dactyloa roquet* (Bonneterre, 1789); Chofé Solèy, *Gymnophthalmus pleii* (Bocourt, 1881); Ti Mabouya, 4 species of Sphaerodactyls, *Sphaerodactylus vincenti* (Boulenger, 1891), *Sphaerodactylus festus* (Barbour, 1915), *Sphaerodactylus microlepis* (Reinhardt & Lutken, 1862), *Sphaerodactylus sp. X* (Bourgade, 2013); Gwo Mabouya, *Thecadactylus rapicauda* (Houttuyn, 1782); Ligwan, *Iguana delicatissima* (Laurenti, 1768); Ligwan Sent-Lisi, *Iguana sanctaluciae* (Breuil et al., 2019); Ti Sèpan Tè, Stenostomes, *Tetracheilostoma sp.* (Schlegel, 1839) 3 species currently being studied in Martinique, 1 species described in Saint Lucia, 1 species described in Barbados; Trionocephalus, *Bothrops sp.* (Bonneterre, 1790) 1 species in Martinique *B. lanceolatus*, 1 species in Saint Lucia *B. caribbaeus*; Ti Grounouy, Hylodes Eleutherodactyles, 2 species, *Eleutherodactylus johnstonei* and *Eleutherodactylus martinicensis*; Martinique allobate, *Allobates chalcopis* (Kaiser, Coloma & Gray, 1994), small amphibian strictly endemic to the peaks of northern Martinique.

Reptile species strictly endemic to Saint Lucia native to West Africa:

Mabouya, *Hemidactylus palaichthus* (Daltry, 2009), only present on the Maria Islets in the south-east of Saint Lucia. Exception in the Eastern Caribbean with the species of Brazilian hemidactyl also native to West Africa from the islands of the Gulf of Guinea, *Hemidactylus brasiliensis*, unique proof of the possibility but also of the rarity, of transatlantic rafting, there is 16 million years old (Carranza and Arnold, 2005).

Known extinct species of birds from Martinique:

Gwakamayo parrot or Martinique macaw, *Ara martinica* (W. Rothschild, 1905); Kano or Koukou Tè, *Speotyto cunicularia* (Molina, 1782).

Examples of sedentary bird species endemic to the Eastern Caribbean (south latitude of Dominica):

Blue-headed Hummingbird, *Cyanophaea bicolor* (Gmelin, 1788), endemic to northern Martinique and Dominica; Madeira Hummingbird, *Eulampis jugularis* (Linnaeus, 1766), with a distribution of the species in the eastern Caribbean between the latitude of St-Barthelemy in the north and that of St-Vincent in the south, which presents the strait between Martinique and Dominica, as an epicenter of dispersion. The White-throated Thrasher, *Ramphocinclus brachyurus* (Viellot, 1818), endemic species of Saint Lucia and Martinique; Korean nightjar, *Hydropsalis cayennensis* (Gmelin, 1789), very discreet bird present in the north of South America, and enigmatic presence among all the islands of the eastern Caribbean, observed only and only in Martinique.

Terrestrial mollusk species endemic to Martinique

The land snail fauna present in Martinique includes 61 species; among these at least 34 are native; 22 species of snails are endemic (including 3 species that could be newly described for science), and 12 are more widely endemic to the Caribbean.

Painted helicine, *Helicina fasciata picturata* (Mazé, 1874), endemic to Martinique, only on the northern central Pitons massifs.

Helicina pudica (Drouët, 1859), endemic to Martinique, south-western peninsula.

Helicina sp. 1, endemic to Martinique, known only on the Montagne du Vauclin.

Helicina sp. 2, endemic to Martinique, known only from Absalon Balata.

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Hoary Cyclophorus, *Amphicyclotulus cinereus* (Drouët, 1859), endemic to Martinique, considered extinct.

Martinique cyclophore, *Amphicyclotulus martinicensis* (Shuttleworth, 1857), endemic to Martinique, northern massifs and Vauclin mountain.

Reddish Cyclophore, *Amphicyclotulus rufescens* (G.B. Sowerby I, 1843), endemic to Martinique.

Reddish ambrette, *Amphibulima rubescens* (Deshayes, 1830), endemic to Martinique, present only in the north.

Multifasciated Bulimee, *Drymaeus multifasciatus* (Lamarck, 1822), endemic to Martinique.

Martinique bulbime, *Protoglyptus martinicensis* (L. Pfeiffer, 1846), endemic species rarely observed and very localized in the south of Martinique.

Mazé's Bulimet, *Protoglyptus mazei* (Crosse, 1874), endemic to Martinique.

Protoglyptus sp. , endemic to Martinique.

Rank glandine, *Laearicella semitarum* (L. Pfeiffer, 1842), endemic species not commonly observed, present exclusively in the north of Martinique.

Laearicella sp., endemic species of northern Martinique, Pitons and massifs of Mont Conil.

Depressed pleurodont, *Discolepis desidens* (Rang, 1834), endemic species of Martinique, currently known from a single station of very limited area in Fonds Saint Denis.

Golden tooth pleurodont, *Gonostomopsis auridien* (Rang, 1834), endemic present only in the north of Martinique.

Pleurodonte discolor (Ferussac, 1821), endemic to Martinique.

Brown Pleurodont, *Pleurodonte hippocastanum* (Lamarck, 1792), endemic to Martinique.

Pleurodonte Petit-Noyau, *Pleurodonte nucleola* (Rang, 1834), endemic to northern Martinique.

Beck's pleurodont, *Pleurodonte obesa* (Beck, 1837), species endemic to the coast of the southwest peninsula of Martinique, threatened by the urbanization of its habitat.

Marbled Pleurodont, *Pleurodonte parilis* (Ferussac, 1822), endemic species of northern Martinique.

Endemic insect species of Martinique

Concerning Coleoptera, 11 species are endemic to Martinique, out of the forty-four (44) species of Scarabeidae that have been recorded, including 10 species endemic to the Eastern Caribbean.

The only species of Scarabeidae endemic to Martinique benefiting from protected status is the Hercules dynasty, *Dynastes reidi* (Chalumeau, 1977)

For long-horned beetles, among the 60 species of Cerambycidae present in Martinique, 13 are endemic to the island, and 30 to the eastern Caribbean.

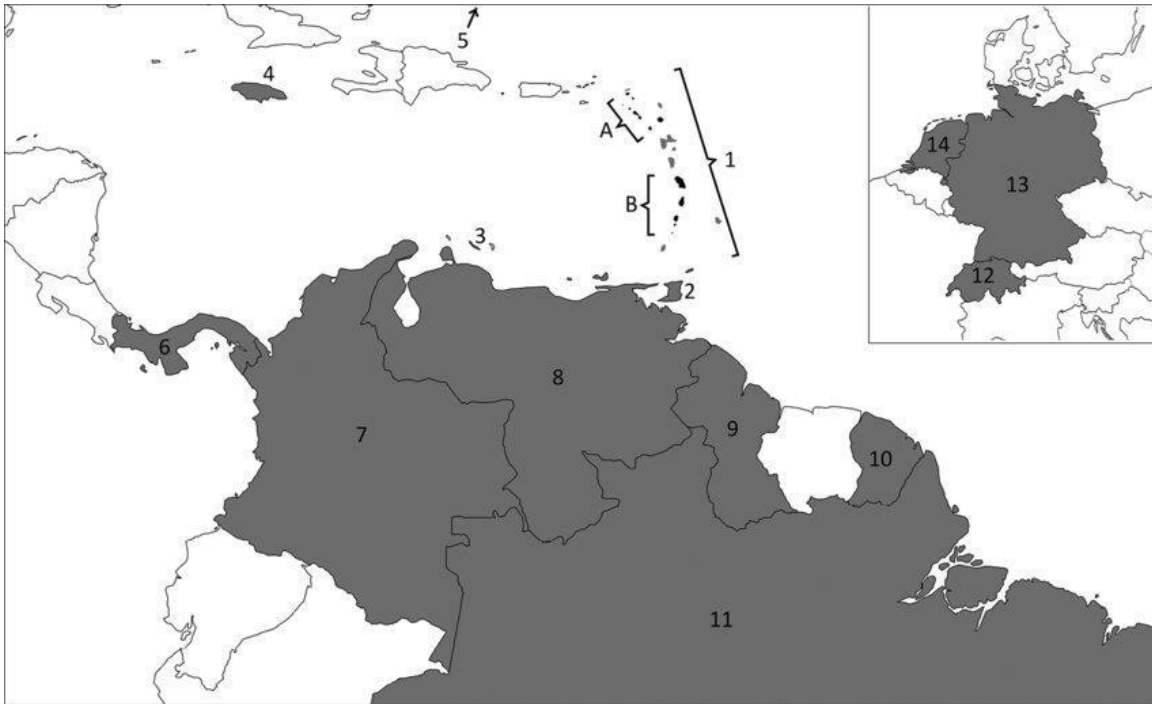
Concerning other Coleoptera, there are other families which are also taken into account during ZNIEFF inventories. Almost every year, new species for science are discovered in Martinique.

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For dragonflies, in Martinique, 26 species of anisoptera (damselflies) and zygoptera (dragonflies) are present, including *Protoneura ailsa*, endemic to the islands of Dominica, Martinique and Saint Lucia.

Regarding Butterflies, let us cite an example of a nocturnal species endemic to Martinique which is the Pinchon Castnia (*Castnia pinchoni*). This butterfly, flying by day, is present in the humid mountainous areas of the northern part of the island, at the peaks of Carbet, at Morne Jacob and at Mount Pelée, between approximately 350 and 600 m altitude. It is uncommon to encounter it and the specimens observed so far are all males.

Discussion



« Global distribution (country-wide) of *Eleutherodactylus johnstonei*. Black, presumed native range (A or B); grey, introduced range (1-13). In Saint-Martin, Saba, Saint-Eustache, Saint-Kitts-and-Nevis, Antigua (Kaiser 1997) **B** Montserrat, Martinique, Saint-Lucia, Saint-Vincent (Kaiser 1997) ; 1 : Anguilla, Barbuda, Guadeloupe, Dominica, Barbados, Grenadines, Grenada (Kaiser 1997) ; 2 : Trinité-and-Tobago (Hardy et Harris 1979) ; 3 : Curaçao (Hardy et Harris 1979) ; 4 : Jamaïca (Barbour 1910) ; 5 : Bermuda (Pope 1917) ; 6 : Panama (Ibáñez et Rand 1990) ; 7 : Colombia (Ruiz-Carranza et al. 1996) ; 8 : Venezuela; Top right inset: Greenhouse populations in Europe: 12: Switzerland (this study); 13: Germany (this study); 14: Netherlands la (Hardy et Harris 1979) ; 9 : Guyane (Hardy et Harris 1979) ; 10 : Guyane (Lescure et Marty 1996) ; 11 : Brésil (Melo et al. 2014) ; (this study). »

According to Franziska Leonhardt, Juan David Jiménez, and Raphaël Ernst; map from their 2019 publication entitled: “Whistling invaders: status and distribution of Johnstone’s whistling frog (*Eleutherodactylus johnstonei* Barbour, 1914), 25 years after its introduction in Colombia.”

Critical analysis

These authors recognize that the center of dispersion of the species *E. johnstonei* is indeed the Eastern Caribbean; they then specify two geographical zones A and B of this Eastern Caribbean, under discussion to define a true center of dispersion of this species of hylode.

Ernst, R. et al. consider in their observation of the distribution of *E. johnstonei*, that this species would have been introduced (by humans), on Caribbean islands other than zones A and B, and on zones of South American continental countries (note: except Suriname, we think for lack of data; as seems to be the case for the Dominican Republic and Haiti). This publication tends to establish demonstration, that the species *E. johnstonei*, has dispersed naturally since the proto-Matīna (35 Ma BP) towards the north of the South American continent, and also by GAARlandia towards the proto Saba Bank, Jaragua and proto Jamaica; then from Matīna in collusion with Barbados and Trinidad, and part of Venezuela, then still always in biological connectivity by land, *E. johnstonei* dispersed from proto-Martinique and proto-Saint Lucia, towards proto-Dominica, and proto-Marie-Galante (meeting and cohabiting the same biotopes for millions of years with *E. martinicensis*), ... It is only recently with the advances in the state of knowledge in herpetology, and especially with the progress of molecular biology, that we are able and have the means to detect or not the presence of genetic lines of this or that species, in the complexity of studies of speciations of hylodes. Moreover, before the advent of molecular

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biology and technology for the study of DNA, herpetologists based on criteria of morphotypes and phenotypes, confused several species of Eleutherodactyls with the species *E. johnstonei*; enigmatic species that clearly turns out to be among all the Eleutherodactyl taxa of the Caribbean including the north of the South American continent, the one that has developed the greatest number of phenotypes. In-depth investigations concerning the Eleutherodactyles, targeted on the Jaragua Peninsula in Haiti and the Dominican Republic, could reserve surprises.

The distribution of the Eleutherodactyls present in Jamaica considered as dependent on the taxon of *E. johnstonei*, hylodes located in the mountainous region of the island, Cockpit Country, very little urbanized, inland, area in the center west of this Jamaica which was fully connected to the Jaragua Peninsula, ... 35 Ma ago, really does not plead in favor of a hypothesis called "introduction" more or less recent of these Eleutherodactyls.



Jamaica: in red the locations of the two largest urban centers, the capital Kingston in the southeast where the large port is located, and the largest airport on the island, and Montego Bay in the northwest. The area circled in green is the epicentral one constituting a refuge where Eleutherodactyls considered as *E. johnstonei* are represented.



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The real recent introductions of *E. johnstonei*, that is to say those intentional or unintentional linked to anthropogenic activities, are those observed, for the moment in Bermuda (5) and in Europe (12,13,14) Germany, the Netherlands and Luxembourg.

Concerning the definition of the center of dispersion of *E. johnstonei*, to know if it is zone A or B on the map, we can claim that the problem has been partially resolved by Hedges, by describing in 2022 for zone A corresponding to the Saba Bank, a new species of hylode for science, the taxon *E. montserratae* (Hedges, 2022) Implicitly remains as the real center of dispersion the *E. johnstonei* of zone B, of the Eastern Caribbean, that corresponding well to the current islands in particular of Martinique and Saint Lucia, vestiges of the large island of Matīna.

This description by Hedges of the new taxon *E. montserratae* confirms the meaning of our publication, which demonstrates that the ancestors of this new species of hylodes inhabiting the geographical area corresponding to the Saba Bank (remnant of GAARlandia) originated from proto-Matīna 35 Ma ago.

Also in 2022, in a publication preceding this description of a new taxon for the hylodes of the Saba Bank, entitled “Endemism, invasion, and overseas dispersal: the phylogeographic history of the Lesser Antillean frog, *Eleutherodactylus johnstonei*”, Yuan, M.L., Frederick, J.H., McGuire, J.A., Bell, R.C., Smith, S.R., Fenton, C., Cassius, J., Williams, R., Wang, I.J., Powell, R. & Hedges, S.B., formulate the following conclusions:

"Regarding phylogenetic inference and divergence dating; there is strong support for two distinct mitochondrial clades of *E. johnstonei*; one clade comprising the eastern Caribbean islands to its northwest, Montserrat, Nevis, Saba, St. Kitts, St. Eustatius and St. Martin (corresponding to the Saba Bank); the other clade comprising the eastern Caribbean islands to its southeast, Antigua, Guadeloupe, Martinique, St. Lucia, St. Vincent, Grenada and Barbados, as well as Jamaica, Curacao, Trinidad and the South American mainland. Also there is significant support for the overall monophyly of *E. johnstonei*. No support was found for the previous phylogenetic hypothesis that *E. johnstonei* is sister to the clade consisting of *E. amplinympha* and *E. martinicensis* (Hedges et al. 2008); and that therefore there is confirmation that *E. martinicensis* is distinctly another species with an ambiguous natural range (Kaiser, 1992). There is evidence that these two clades (the Saba Bank hylodes, and the southeastern eastern Caribbean hylodes) may represent distinct species. In conclusion, it is affirmed that there are two major clades in the eastern Caribbean representing western and eastern *E. johnstonei*, although these authors could not identify the source population of the eastern clade, they consider that their results “suggest that the eastern clade is primarily responsible for widespread introductions and has established itself in communities with native competitors, in contrast to the western clade” (Yuan et al., 2022).

Critical analysis

While being in scientific uncertainty, as to the identification of the source population of the eastern clade of the hylode *E. johnstonei*; and moreover without fundamentally worrying about the identification of the source population of the western clade, that of the Saba Bank, for hylodes that have become *E. montserratae*, these authors nevertheless conclude by declaring, in our opinion contradictorily, that the hylodes present in Martinique, Saint Lucia, Saint Vincent, Grenada, Barbados, ... now the only ones to be identified by the taxon *E. johnstonei*, would be "introduced", coming from who knows where?

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We observe that these authors still subscribe to their logic of a vision hitherto accepted underestimating the geological tectonic history, presenting an eastern Caribbean that would be made up of an archipelago of "oceanic islands that would have emerged one after the other due to volcanic activities", for which the very existence of a terrestrial fauna (insects, mollusks, vertebrates: mammals, reptiles and amphibians, in particular) would come from elsewhere, on a mode of peripatric speciation, in a somewhat fixed approach and discourse of the geography of the Caribbean. This fact is verifiable, when they write while acknowledging being in uncertainty and in the "probably" and the difficulty of knowing:

"Assuming a model of colonization by stages, it is possible that neither of the two genera of terraranan frogs successfully dispersed on the island before the introduction of *E. johnstonei*. (...) The highly variable biogeographic divides across the Lesser Antilles are likely a consequence of random overwater dispersal that is the mechanism responsible for colonization of the region (Hedges 2006; Crews and Esposito 2020; Ali and Hedges, 2021). (...) Significant anthropogenic activity has facilitated the dispersal of introduced species to these islands since prehistoric times (Wing 1989; Kaiser 1992, 1997; Olson and López 2008). However, historical records of biodiversity in the region are poor, making it difficult to determine the native ranges of many species (Lazell 1973; Censky 1988; Kaiser 1992; Olson and López 2008; Breuil 2013). This not only complicates conservation and management efforts in the region, but also our understanding of the biogeographic history and assembly of communities. (...) »

In other words:

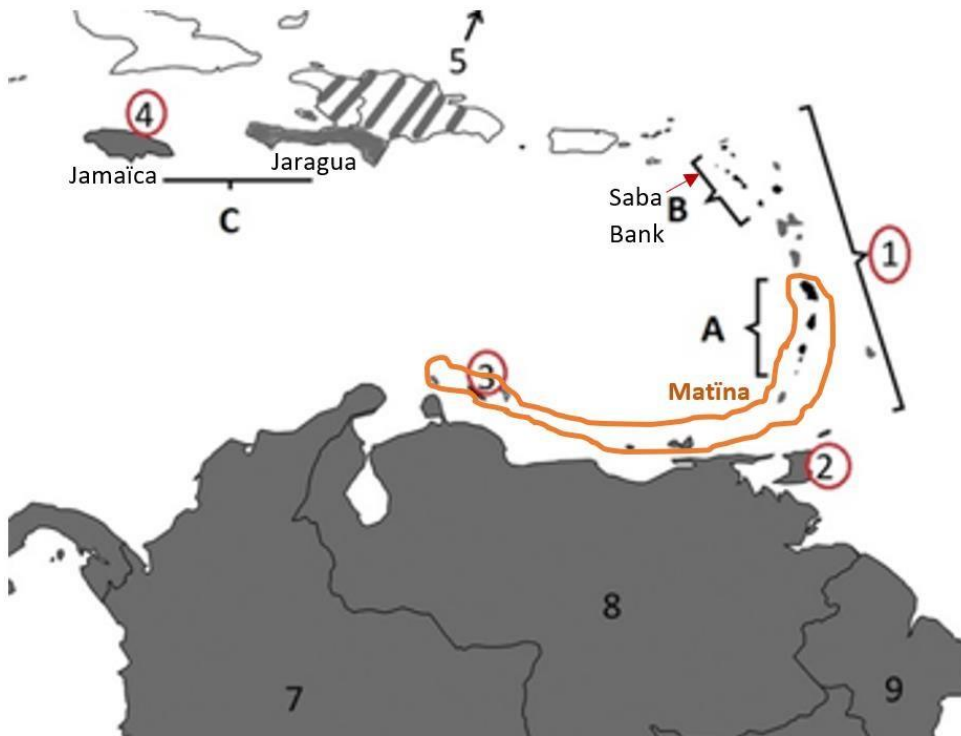
- that many species considered as such in the Caribbean, are originally so by peripatric speciation following dubious scenarios of multiple "rafting", that is to say dispersions of these animal species from the shores of northern South America crossing large marine expanses drifting on rafts of plants to be imagined to be stranded randomly by currents on "oceanic islands". Or again following equally dubious scenarios of zoochory, by birds and bats, which would have transported and seeded these islands with propagules of micro-herpetofauna and insects.

- and that concerning species considered as "non-endemic", these are said to be "probably introduced" by the first peoples of the Caribbean and/or in recent times since colonization (1492).

Such allegations and discourses have led to the "probable" consideration that, for example, the Manicou mammal *D. marsupialis insularis* "would have been introduced by the Amerindians" in the Eastern Caribbean. (Breuil, et al., 2012; International Conference on Island Biodiversity, Flora, Fauna and Man in the Lesser Antilles, Martinique, 8–10 November 2010). The same goes for the Eleutherodactyls of the species *E. johnstonei*, ...

To this fixed approach and vision of the geography of the Caribbean, we oppose the following superposition of maps:

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Superposition of the map of the land emerged 35 Ma ago, with that of today; note the evidence of the existing correlation between the current distribution of *E. johnstonei* and the biological connectivity by land of GAARlandia (Aves Bridge) in the form of an arc, between the extreme southwest of Matina (Aruba Curaçao) and the extreme northwest of the arc, proto Jamaica.

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The French government services have not failed to listen to these speeches and allegations, whose authors nevertheless acknowledge that they are in scientific uncertainty, and these authorities have nevertheless, in violation of their own precautionary principle, taken decisions to repeal legal texts that protected the endemic hylode of the Eastern Caribbean, *Eleutherodactylus johnstonei*, in Martinique.

Also, a ministerial decree of October 14, 2019 establishing the list of protected amphibians and reptiles represented on the territory of Martinique completes the previous list with new inventoried endemic species, but at the same time, unfortunately, proceeds incoherently to the withdrawal or exclusion of the species of Amphibian *Eleutherodactylus johnstonei*, however recognized in the current state of herpetological knowledge and molecular biology as an endemic species of the Eastern Caribbean. This species would therefore no longer have protected species status in Martinique, and is wrongly considered an "exotic species", while it is indeed in its original environment and natural context of the Eastern Caribbean.

This decision to exclude the amphibian species *Eleutherodactylus johnstonei* from the list of protected species represented in the territory of Martinique, a territory geographically in the epicenter of the Eastern Caribbean and of course naturally bioconnected to the islands of the Grenadian basin, is arbitrary and discriminatory relative to other species maintained under protected species status.

The decree of February 17, 1989 establishing protective measures for reptiles and amphibians represented in the department of Martinique was repealed in 2019 in defiance of the constitutional principle of precaution, in confusion and scientific uncertainty.

This decree of February 17, 1989 establishing measures for the protection of reptiles and amphibians represented in the department of Martinique, mentions four species supposedly recognized at the time of *Eleutherodactylus sp.*, including the two species *Eleutherodactylus johnstonei* and *Eleutherodactylus martinicensis*. Dr. Michel Breuil put forward his hypothesis in 2002 "declaring" in a publication that the hylode *E. johnstonei* as a species "introduced in the Lesser Antilles" and even "invasive" (Breuil, 2002), even though this author recognizes an origin that would be Barbadian of the species compared to the other Caribbean islands, while suggesting that it would have been introduced there too, and that it would in fact come from elsewhere." Initial molecular biology data from Hedges et al. published since 2008, then more recent ones from 2015 specifying phylogeny and molecular clock, definitively invalidate the hypotheses of Dr. Michel Breuil "declaring" wrongly in 2002 the hylode *E. johnstonei* as a species "introduced in the Lesser Antilles" and even "invasive". The biologist Hedges suggests a Saint-lucian origin of the hylode *E. johnstonei* (Hedges et al. 2008), understanding well and anticipating following his first work in molecular biology that its indisputable natural environment of speciation is the eastern Caribbean, and that the common ancestor of the two hylodes *Eleutherodactylus johnstonei* and *Eleutherodactylus martinicensis* diverged genetically from the other Eleutherodactyls of the Puerto Rico bank of islands, and of the South American continent, since the Eocene, more than 41 million years ago. It is therefore in this context since 2008 of scientific certainty of the eastern Caribbean origin of the hylodes *Eleutherodactylus johnstonei* and *Eleutherodactylus martinicensis*, but despite uncertainties concerning the origin, or place(s) of speciation, or even center(s) of dispersion, of these two species of hylodes attested as having diverged since the Eocene from their continental hylodes congeners, that the administration then arbitrarily took the decision to still classify one of the two species as being endemic to Martinique and the other not. In disregard of the precautionary principle, the administration proceeded to the implicit classification of *E. johnstonei* as an invasive species in Martinique, in the decree of February 8, 2018 relating to the prevention of the introduction and spread of invasive exotic animal species. Moreover, in the "Atlas of Amphibians and Reptiles of Martinique" published in 2018, one of the authors of the "Taxonomic list of herpetofauna in French overseas territories: III. Territorial collectivity of Martinique" published in 2019, Maël Dewynter, while classifying

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E. johnstonei in a list of "established introduced species" in 2019, nevertheless expresses in 2018, and recognizes the scientific uncertainties as to the unknown origins (i.e. location of dispersal centers) of the two species of hylodes present in Martinique, attested as existing since the Eocene on island banks of the proto-eastern Caribbean.

It is undeniable that there were uncertainties, given the state of scientific knowledge in 2019, as to the precise origins in the Eastern Caribbean, that is to say, the centres of dispersion, or the places where the speciation processes of the two species *Eleutherodactylus johnstonei* and *E. martinicensis* took place. And in such a context of requirements in terms of protection and conservation of biodiversity, the precautionary principle is essential. The precautionary principle is a philosophical principle which aims to put in place measures to prevent risks, when science and technical knowledge are not able to provide certainties, mainly in the field of the environment and health. The precautionary principle is imposed on administrations. It obliges them to develop forecasting and assessment procedures within them in order to try to prevent major risks that could lead to their liability being incurred. **The precautionary principle was introduced into French law by the Barnier Act of 2 February 1995 on strengthening environmental protection. According to this principle, "the absence of certainties, taking into account current scientific and technical knowledge, must not delay the adoption of effective and proportionate measures aimed at preventing a risk of serious and irreversible damage to the environment at an acceptable economic cost".** The Council of State applied this principle. In its Association Greenpeace France ruling of 25 September 1998, it issued a stay of execution on this basis of an order of the Ministry of Agriculture and Fisheries which authorised the marketing of genetically modified corn varieties. **This principle now has constitutional value. Indeed, the constitutional revision of 1 March 2005 annexed the Environmental Charter to the Constitution. However, Article 5 of the Charter states: "When the occurrence of damage, although uncertain in the state of scientific knowledge, could seriously and irreversibly affect the environment, the public authorities shall ensure, by applying the precautionary principle and within their areas of responsibility, the implementation of risk assessment procedures and the adoption of provisional and proportionate measures in order to prevent the occurrence of the damage".** Furthermore, in its judgment, Commune d'Annecy of 3 October 2008, the Council of State specified that all the rights enshrined in the Environmental Charter had a legally binding value.

Conclusion

The evidence of the existence of proto-Matīna (35 Ma BP) and of Matīna clearly emerged until about 27 Ma BP, should remove the uncertainties expressed by researchers as to the origin of the speciation of the hylode *Eleutherodactylus johnstonei* (Barbour, 1914), and thus resolve the cryptogenic problem concerning this species.

If we admit that the Eastern Caribbean arc is made up of archipelagos of islands that are vestiges of larger islands. That the islands of Martinique, Saint Lucia, Saint Vincent, the Grenadines, Grenada are the vestiges of the large island of Matīna that was submerged. That the islands on the coast of Venezuela, Aruba, Curaçao, Bonaire, Tortuga, Blanquilla, Testigas, Margarita, are also vestiges of proto-Matīna. That the proto-Matīna was connected 35 Ma ago, by GAARlandia (bridge of the Aves), to the proto-Saba bank, itself remained connected to the proto Jaragua-Jamaica long enough to allow the dispersion of a lineage of hylodes originating from the proto-Matīna to the western end of the proto Jaragua-Jamaica.

That on this large island of Matīna, the ancestors of hylodes of the species *Eleutherodactylus johnstonei* obviously coexisted with the ancestors of animal species of mammals, amphibians, reptiles, and sedentary birds, mollusks and insects.

Everything becomes coherent.

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