



# **Mannikou Matinik History of the Opossum “Manicou Caraibarum” (Plumier, 1690) *Didelphis marsupialis insularis* (Linnaeus, 1758)**

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# Mannikou Matinik

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“Manicou Caraibarum” (Plumier, 1690)

*Didelphis marsupialis insularis*

(Linnaeus, 1758)

Endemic to the Eastern Caribbean



By Marcel BOURGADE

Martinique Caribbean 2024

# **Mannikou Matinik**

## **History of the Opossum**

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***Didelphis marsupialis insularis***

**(Linnaeus, 1758)**

**Endemic to the Eastern Caribbean**



Manicou here observed by the author on the Sainte-Anne peninsula Martinique

**By Marcel BOURGADE**

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## **Abstract**

The history of the Opossums, Manicou of the Eastern Caribbean, *Didelphis marsupialis insularis* (Linnaeus, 1758), distributed from the latitude of Grenada to that of Dominica, reconstructed on the basis of data from paleobiology and paleogeology of the biodiversity of the Caribbean, contributes to a questioning of the vision hitherto accepted underestimating 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 terrestrial fauna (insects, molluscs, vertebrates: mammals, reptiles and amphibians, in particular) would come from elsewhere, in a mode of peripatric speciation; thus in a certain confusion and therefore scientific uncertainty, the current dominant discourse claims:

- that new species considered as such are by peripatric speciation following dubious scenarios of multiple “rafting”, that is to say dispersals of these animal species from the shores of northern South America crossing expanses of sea while drifting on rafts of plants to be imagined running aground randomly on “oceanic islands”.

- and that concerning species considered “non-endemic”, these are said to be “probably introduced” by the first peoples of the Caribbean.

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. Many flora and fauna species endemic to the central islands of the Eastern Caribbean have not crossed the sea, nor even crossed the marine expanses by air, nor yet been transported and introduced by the first peoples, to find themselves isolated on these he is ; these species exist following a process of allopatric speciation and therefore found themselves progressively isolated from an average of 35 millions years ago, due to a detachment of a northern part of the southern continental crust. American, which will tectonically drift 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 'be overwhelmed.

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.

We propose a reconstructed history of the Manicou Opossum *Didelphis marsupialis insularis*, determined by the geological history of this geographical region; history consistent with phylogenetic data and current distributions of the *Didelphis* taxon. This historical scenario being valid for a certain number of mammals; historical scenario therefore leading to a natural distribution of these mammals which were present on the islands of the eastern Caribbean from Grenada to Dominica, and no further north.

**Keywords:** history, Opossum, Sarigue, Marsupials, *Didelphis marsupialis insularis*, Manicou, Mannikou, Matīna, KaruWétu, geosciences, paleogeology, paleobiology, Eastern Caribbean, Grenada, Saint-Vincent, Saint-Lucia, Martinique, Dominica, biodiversity, speciation, allopatric.

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

Molecular biology generally reveals that the genetic divergence of a number of species of flora and fauna constituting the biodiversity of the Eastern Caribbean with their closest South American continental congeners is much older than the presumed dating hitherto accepted. of 24 million years of emergence for proto Martinique. For example, for the hylodes, this genetic divergence between those from the Caribbean and those from South America, that is to say the dating of the beginning of the process of speciation of the hylodes of the Eleutherodactyls group of the Caribbean, is established between 50 to 45 million of 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, etc.) up to the latitude of Martinique in the eastern Caribbean. diverged from the continental South American Anolis 37 million years ago. To the north of Martinique, the Dominica Channel constituting a geographical barrier for Anolis species, we have from Dominica to the latitudes of the islands of the Greater Antilles (Guadeloupe, Antigue, Eels, Virgin Islands, Puerto Rico, Hispaniola , ...), another group of Anolis, the Ctenonotus, which diverged genetically from the continental South American 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 us to highlight a scenario of tectonic geological evolution of the Caribbean plate which took place between 50 and 25 million years ago, which would coherently explain the modes of dispersal and speciation processes, and the distributions observed today of species of endemic flora and fauna constituting the biodiversity of present-day Caribbean islands; including distributions of extinct or extinct species from these islands.

Note that this presumed geological scenario of the formation of the eastern Caribbean islands, 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, have named “Matina” for study), which tectonically slid in a northeast direction, along the subduction zone of volcanoes of the cordillera constituting the arc of the eastern Caribbean; then scenario of collision of this Matina island with the south of an archipelago of two other large islands, the one highlighted by Professor Philippon called GrANoLA located further north, and the second island to the south of GrANoLA constituting proto Guadeloupe, Marie- Galante, and Dominique (which we, Mr. BOURGADE, called “KaruWétu” 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 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 proto island banks of Martinique, Sainte- Lucia and island bank east of Puerto Rico.



Also, the presumed isthmus disintegrates to form islands, "Matina", then "Matigwana", at the top of a cordillera (volcanic arc), located on the South-Eastern edge of the said Caribbean plate, at the junction of the three films ( or plates) lithospheric, Caribbean, North America and South America, south of GrANoLA, and which would have constituted a bridge (second after that known as Aves: GAARlandia) between the Orinoco basin and the large islands of the Caribbean Western; presumed 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 a first mapping below, reconstituting the geological context of 35 Ma ago, presented in January 2024 in Guadeloupe by Leny Montheil.



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 Eastern Caribbean with the global scenario of paleogeographic evolution coherently explaining the dispersals, 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 of the eastern Caribbean today.

In homage to the Taino languages, we attributed the toponym of Gwanaatabey 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.

KaruWetu, 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 Wetu 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 KaruWetu. Matina, is phonetically the oldest Taino toponym known to name Martinique.

## **Proto – GAARlandia and GAARlandia**

Proto-GAARlandia is a supposed predecessor to GAARlandia. In the Late Cretaceous and Early Paleocene there was clearly a land bridge between North and South America, given the arrival of Theria mammals 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 may have been formed by volcanic activity, unlike GAARlandia. This land bridge would have been raised in response to the tectonic movement of the South American plate towards the southwest.

The GAARlandia is the ancient land bridge, which connected the Paleogene, the current large islands of the western Caribbean to South America. 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 the north of Venezuela, passing through the island by Aves. It is believed to have been formed during the transition from the Eocene to the Oligocene, 35 to 33 million years ago, through a combination of tectonic rising in the region and overall falling sea levels.

The biological connection with northern South America allowed flora and fauna to spread across the large islands of the western Caribbean. Fossils of mammals, ground sloths, Caribbean monkeys, porcupines, hutias and cabiais, among others, have been found in the large islands of the western Caribbean and have a certain South American origin (Philippon et al., 2020).

## **Proto-GrANoLA (peninsula) and GrANoLA, than KaruWétu**

The Proto-GrANoLA peninsula, 59 Ma ago, is located in the north of 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 the north of South America, to form the large island GrANoLA, (French-English acronym: GrAN for “Greater Antilles” - and oLA for “of Lesser Antilles” North”). This large island of GrANoLA, 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 drawn up by Lenny Montheil (et al.), 35 million years ago, the island of GrANoLA split into two; and it is this section south of GrANoLA that we named KaruWétu.

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.

## **Proto-Matīna (peninsula) and Matīna**

Matīna, to identify the large island (going 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 along the length of a tectonic context 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 collusion with the island of KaruWétu. Matīna or Matinina is phonetically the oldest Taino toponym known to name Martinique.

## **The Eastern Caribbean arc: archipelagos of remnant islands of Matīna, KaruWétu, and GrANoLA**

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

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

The northern islands of Guadeloupe, Montserrat, Saint Kitts and Nieves, Antigua and Barbuda, St. Martin, St. Barth, Anguilla, are remnants of the great island of GrANoLA.

The island of Saba is a remnant of GAARlandia.



## Opossums

“The origin of marsupials dates back to the end of the secondary era, to the middle of the Cretaceous, but the first known didelphid marsupial, *Peradectes*, did not appear in South America until the end of the Cretaceous, around – 70 millions of years. It was a contemporary of the dinosaurs. At the end of secondary school, mammals, and notably marsupials, experienced explosive development, undoubtedly because of the space left free by the disappearance of their dinosaur competitors. In South America, during the Paleocene, that is to say at the beginning of the Tertiary era (60 millions years ago), more than twelve species of didelphid marsupials, all of which have now disappeared, coexisted . At the end of the Tertiary, from approximately 10 Ma BP to 3 My BP, the diversity of these marsupials was greater than today, but then declined. Most of today's didelphids appeared at this time. » (Sources: [www.larousse.fr/encyclopedie/vie-sauvage/opossum/184559](http://www.larousse.fr/encyclopedie/vie-sauvage/opossum/184559) )

Around 10 to 5 million years ago, the emergence of the Isthmus of Panama connected South and North America and marked the end of the golden age for American marsupials, allowing the passage of many North American placental mammals to South America. The resulting food competition and climatic upheaval led to the elimination of two thirds of marsupial species.

The Virginia opossum also appeared very recently, due to the emergence of the Isthmus of Panama. Its oldest remains, found in the southern United States, date back a few hundred thousand years. The species would have differentiated from a population of common opossums (*Didelphis marsupialis*) from Mexico which, after a drying of the climate, would have found itself isolated in a humid region and would have evolved in isolation until becoming a species distinct, the present-day Virginia opossum. Today, the species is widely established in North America and Central America, and its great adaptation capacities allow it to be currently expanding rapidly.

An opossum can run up to 7 km/h. A good walker and climber, the opossum is also a good swimmer. In the water, it swims like a canine, with a pace close to that of its walk, and can thus exceed a speed of 1 km/h for 10 minutes.

“American marsupials are then grouped under the general name of opossums – not to be confused with Oceanian possums (sometimes also called opossums!) – are distributed between three orders each comprising a family and live on most of the American continent , from the Canadian border to Patagonia. The didelphidae family (order Didelphimorphia) includes 2 subfamilies: the didelphinae (13 or 14 genera and 74 species, mostly intertropical) and the caluromyinae (3 genera and 5 species). The cænolestidae (order Paucituberculata), called in English shrew opossums, opossums-shrews, a name which also designates in French the short-tailed opossums of the genus *Monodelphis* of the family Didelphidae, include three genera (*Caenolestes*, *Lestoros* , *Rhyncolestes*) and six species. Finally, the microbiotheriids (order Microbiotheria), South American and mountainous like the cænolestidae, are only represented by one species, the “monito del monte” (*Dromiciops australis*) or glioides. The vast majority of opossums are omnivorous and nocturnal.

These species are often discreet, small and sometimes rare, which explains why most are poorly known to scientists and the general public.» (Sources: [www.larousse.fr/encyclopedie/vie-sauvage/opossum/184559](http://www.larousse.fr/encyclopedie/vie-sauvage/opossum/184559))

## **Sarigues of the Genus Didelphis**

The *Didelphis* genus is one of the most widespread in America. Six species are formally recognized within this genus: *Didelphis marsupialis*, *D. aurita*, *D. albiventris*, *D. virginiana*, *D. imperfecta* and *D. pernigra*. A seventh species, *D. paraguayensis*, is mentioned by informal sources as occurring in Rio Grande do Sul, Brazil and Paraguay, but little reliable information is available to confirm its validity (Renate Ziller, 2015).

Some taxonomic uncertainty surrounds *Didelphis marsupialis* as some authors consider it to be the same species as *D. virginiana* and also *D. aurita*. Several DNA studies have been undertaken to explore the taxonomy; Caceres and Monteiro-Filho (2006) found that *D. marsupialis* is genetically closer to *D. aurita* than to *D. albiventris*, with *D. virginiana* being considerably more distant. Another study on antihemorrhagic proteins in the *Didelphis* species found that *D. marsupialis* has DM40 and DM43 as inhibitors, while *D. virginiana* has a homologous substance called oprin. Therefore, *D. marsupialis* and *D. virginiana* are considered distinct species (Neves-Ferreira et al., 2000).

4 subspecies recognized for ***D. virginiana***

*Didelphis virginiana virginiana*, distributed in the United States, except southern coastal area, from Florida to Texas.

*Didelphis virginiana pigra*, United States, from Florida to Texas exclusively.

*Didelphis virginiana californica*, extreme southern United States, except California; Mexico, except in the Yucatan Peninsula.

*Didelphis virginiana yucatanensis*, the smallest of the four; Yucatan Peninsula, Mexico.

### **Recognized subspecies of *Didelphis marsupialis* include:**

***D. marsupialis cauae*, *D. marsupialis insularis* and *D. marsupialis marsupialis*.**

The Manicou, Mannikou in martinican language, *Didelphis marsupialis insularis* (Linnaeus, 1758), “Manicou Caraïbarum”, was observed, described and drawn by the European naturalist Charles Plumier in 1690, as being close but different from the South American continental one of Brazilian and Guyanese Northeast, observed and described by the naturalist Georg Marcgrave (1610–1644) in his “Historiae rerum naturalium Brasiliae” published in 1648.

### **The black-eared opossum, known as “common”**

#### ***Didelphis marsupialis* (Linnaeus, 1758)**

It measures 60 to 90 cm (half head and body, half tail); its weight varies between 0.6 and 1.6 kg.

Identification: the back and legs are black, the face and sides dirty yellow.

Distribution: forest and lowland savannah; from southern Mexico to the Amazon, as well as the Atlantic forest of Southeast Brazil and Northeast Argentina.



*Drawing by Plumier representing a Manicou (1690) observed in Martinique*

The black-eared opossum, *Didelphis marsupialis insularis* is distributed in the eastern Caribbean, in Grenada, Saint Vincent, Saint Lucia, Martinique and Dominica and no further north. The island of Trinidad, also home to *Didelphis marsupialis*, located a few kilometers from Venezuela, should be considered as being bioconnected almost almost by land to the South American continental block.

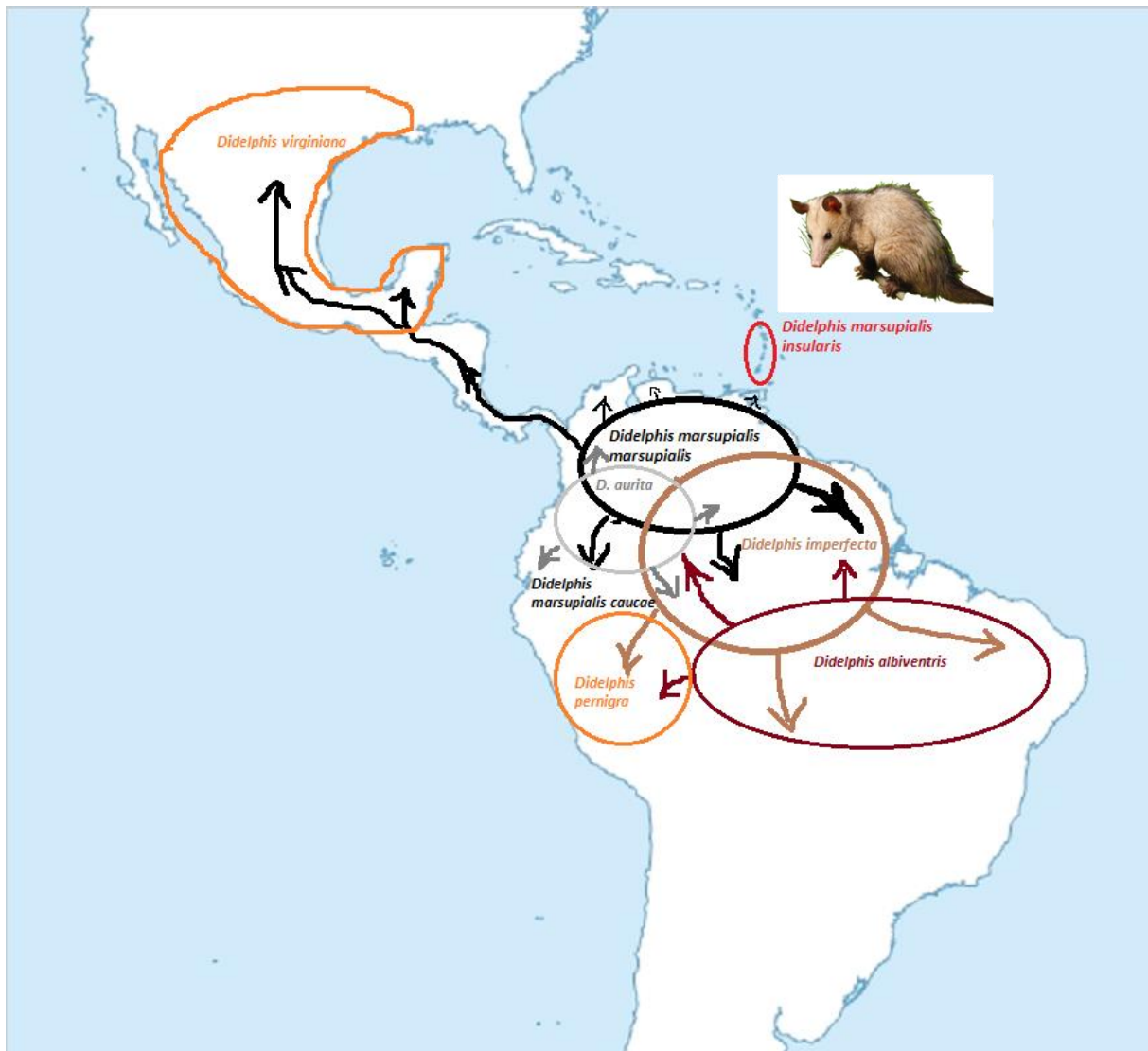
#### **The white-eared possum, *Didelphis albiventris***

Same size and weight as the common opossum.

Identification: lighter back and sides; white, not black, jar hairs; white face with a central black stripe and black rings around the eyes.

Distribution: subtropical humid forests, dry savannahs and at altitude up to 4,000 m; southern Venezuela, from Colombia to northern Chile, eastern, central and southwest Brazil to northern Argentina.

Other species are the Azar sarigue (*Didelphis aurita*), the Guiana white-eared possum (*Didelphis imperfecta*) and the Andean white-eared possum (*Didelphis pernigra*).



**Distribution of species and subspecies of the genus *Didelphis* of American opossums.**

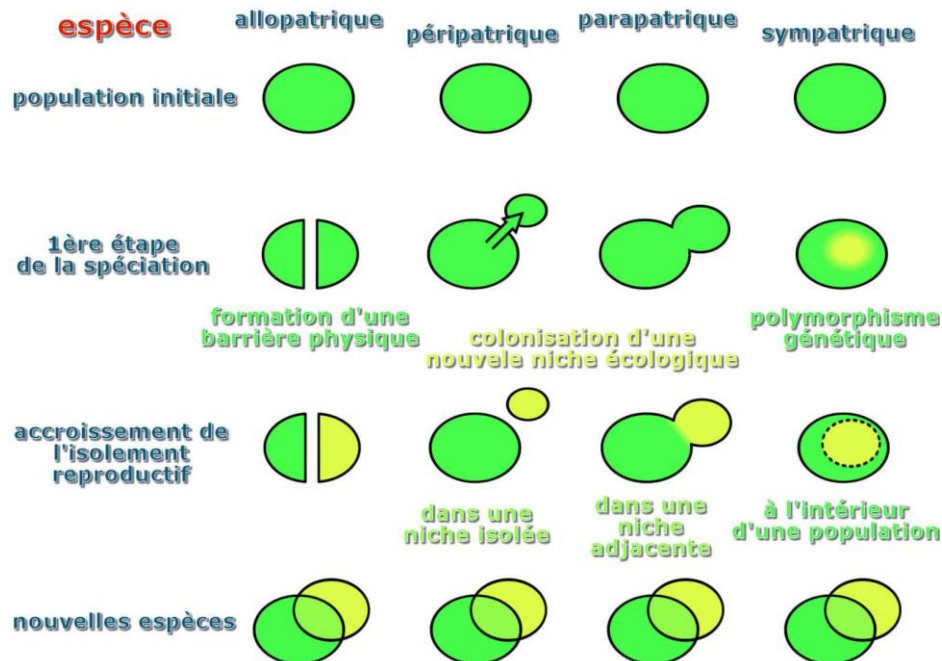
Opossums of the genus *Didelphis*, of the recently appeared species *Didelphis virginiana* (like the iguanas of the species *Iguana iguana rhinolopha*), present in Mexico and the USA (Virginia, Texas, New Mexico), result from the process of speciation peripatric, their ancestors *Didelphis marsupialis marsupialis* originating from northern South America having dispersed as soon as possible from the formation of the Isthmus of Panama 10 to 5 Ma ago.

While the Manicou of the subspecies *Didelphis marsupialis insularis* result from a process of allopatric speciation, their ancestors having been established for more than 35 My BP. on the peninsula to the north of the South American continent, proto-Matina, which tectonically separated from the continent to give rise to the large island of Matina; which will disintegrate and be submerged around 25 Ma BP. . The islands of Martinique, Saint Lucia, Saint Vincent, the Grenadines, Grenada being the remains of the large island of Matina which was submerged. And those on the coast of Venezuela, Aruba, Curaçao, Bonaire, Tortuga, Blanquilla, Testigas, Margarita, being also vestiges of proto-Matina.

The species *Didelphis marsupialis*, *Didelphis albiventris*, *Didelphis aurita*, would result from a process of sympatric speciation at the base, then parapatric. Opossums of the species *Didelphis imperfecta* are the result of hybridizations between *Didelphis marsupialis* and *Didelphis albiventris*. Opossums of the species *Didelphis pernigra*, isolated in the Andes, would rather result from a process of peripatric speciation.



For the record: The 4 modes of speciation

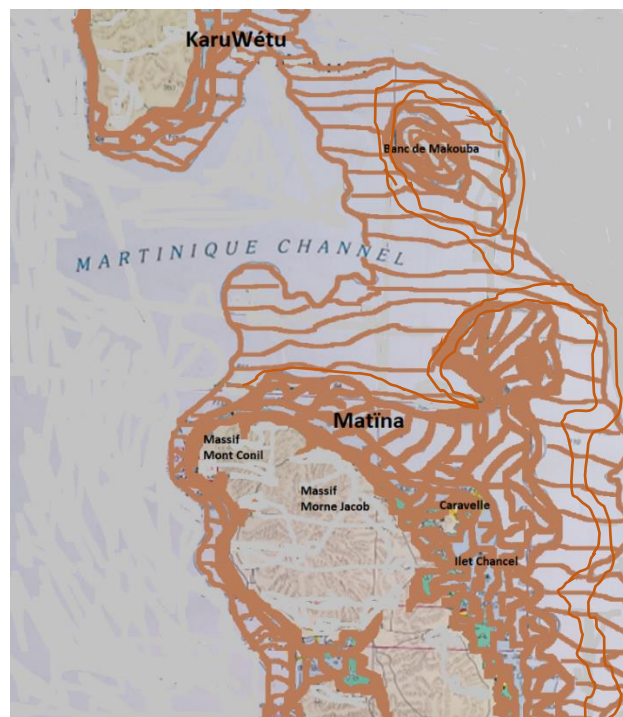


The Manicou opossum *Didelphis marsupialis* already present on proto-Matina 35 Ma ago.

Manicou opossums probably penetrated the GAARlandia peninsula, 35 Ma ago, but did not prosper there, nor therefore survived the submergence of this isthmus, like the *Iguana melanoderma*, on refuge islets of the Saba bank. The ancestors of the Manicou *Didelphis marsupialis insularis*, once detached from the Proto-Matīna peninsula of northern South America, and the isthmus of GAARlandia, were therefore isolated on the island of Matīna.

From 28 Ma BP, as the Matīna gradually submerged, the Manicou survived by finding refuge, on islets that were remnants of the large islands, remaining emerged and constituting proto-Martinique, proto-Saint Lucia, proto- Grenade.

Obviously, the presence in Dominica of Manicou of the species *Didelphis marsupialis insularis* 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 zone of collusion between the extreme north of Matīna, and the south of KaruWétu (current strait between Dominica and Martinique). See cartographic figure below presenting details of this collusion zone, today submerged in the northeast of Martinique, and the southeast of Dominica, in the past and during a period of geological time, also presumed habitat zone and circulation of *Iguana delicatissima*.



**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 found itself for a time constituting a bridge between Matīna and KaruWétu (at least like a super tombolo to the north of the Makouba bank nicknamed by fishermen Martinican “Dièn Bièn Phù”; surface of land remaining above ground for sufficient time to allow passage and dispersal of various animal species in both directions, including among others the hylode amphibian of the species *Eleutherodactylus martinicensis*, iguanas of the Iguana species *I. delicatissima*, ... which then moved in the direction KaruWétu towards Matīna; in the other direction Matīna towards KaruWétu, there were for example the sphaerodactyls, *Sphaerodactylus festus*, the hylod *Eleutherodactylus johnstonei*, and certainly the mammal Manicou *Didelphis marsupialis insularis*.

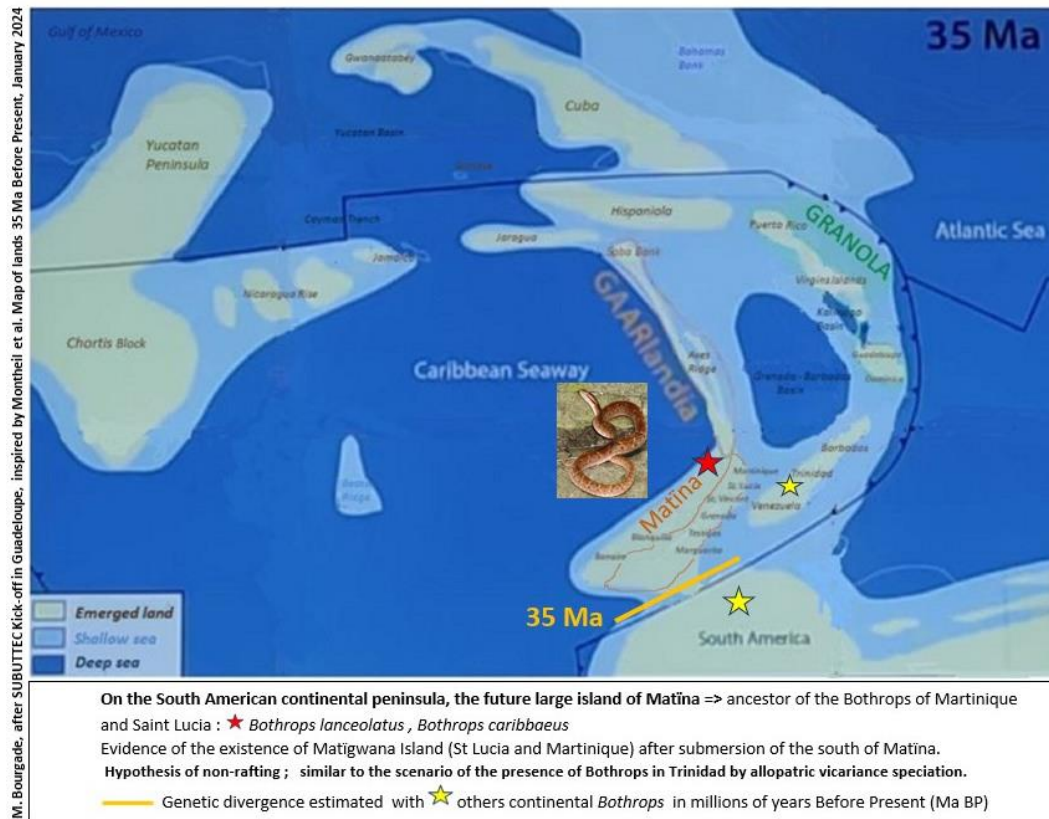


**On the large island of Matina, the ancestors of *Didelphis marsupialis insularis* obviously cohabited with the ancestors of animal species of mammals, amphibians, reptiles, and sedentary birds, molluscs and insects.** With the ancestors of the mammals Pillory Rat or Muskrat, *Megalomys desmarestii* (J. Fischer, 1829); of Agouti, *Dasyprocta antillensis* (Carl Von Linné, 1758) which 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); from the Martinique murine, *Myotis martiniquensis* (LaVal, 1973).

Cohabitation on Matina 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 herminier holotripid, *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); Zanndoli, *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* (Bourgade, 2013); from Gwo Mabouya, *Thecadactylus rapicauda* (Houttuyn, 1782); of Ti Sèpan Tè, Sténostomes, *Tetracheilostoma sp.* (Schlegel, 1839); of the Trigonocephalus, *Bothrops sp.* (Bonnaterre, 1790), *B. lanceolatus*, and *B. caribbaeus*; Ti Grounouy, Hylodes *Eleutherodactylus johnstonei*; of the Martinique Allobate, *Allobates chalcopis* (Kaiser, Coloma & Gray, 1994), small amphibian strictly endemic to the summits of northern Martinique.

**Note:** The South American opossum *Didelphis marsupialis* is known to be very resistant to envenomation by snakes. Opossum serum has been shown to inhibit hemorrhage induced by Crotalinae and Viperinae venoms. Tested against *Bothrops jararaca* venom, the antiothropic complex (ABC) isolated from opossum serum was at least six times more antihemorrhagic than commercial antivenom. ABC showed no proteolytic activity per se and was not hydrolyzed by the venom. It inhibited the hydrolysis of casein by *B. jararaca* venom, but did not inhibit its hydrolytic activities on N $\alpha$ -benzoyl-L-arginine ethyl ester (BAEE) and N $\alpha$ -benzoyl-DL-arginine p-nitroanilide (BAPNA). The inhibitor did not interfere with the activities of trypsin and bacterial collagenase on BAPNA and N-(3-[2-furyl]acryloyl)-Leu-Gly-Pro-Ala (FALGPA), respectively. It reduced chymotrypsin hydrolysis of N-acetyl-L-tyrosine ethyl ester (ATEE) because ABC is also a substrate for this enzyme. By sodium dodecyl sulfate polyacrylamide gel electrophoresis, *B. jararaca* venom preferentially degraded the A $\alpha$  chain of fibrinogen and the  $\alpha$  chain of fibrin. Tested on extracellular matrix proteins, the venom hydrolyzes collagen IV, gelatins I and V, laminin and fibronectin, in addition to depolymerizing the dimers of the  $\alpha$  chain of collagen I. Fibrillary collagen V does not have been designed. These hydrolyses were inhibited by ABC and by EDTA. Our results show that the antiothropic complex is an inhibitor of venom metalloproteinase, which could, at least in part, explain its antihemorrhagic activity. Electrophoretic evidence indicated the formation of a noncovalent complex between antihemorrhagic factor and *B. jararaca* venom component(s). (Neves-Ferreira et al., 2000).

**The opossums, Manicous of Martinique and Saint Lucia, isolated for millions of years on Matina have therefore developed a very strong resistance to the venoms of *Bothrops lanceolatus*, and *Bothrops caribbaeus*.**



**Ancestors of the Trigonoccephali *B. lanceolatus*, and *B. caribbaeus* also present on proto-Matina**

## LIST OF ENDEMIC SPECIES OF MARTINIQUE AND SAINT LUCIA VERY LIKELY TO HAVE INHABITED PROTO-MATINA AND MATINA (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 holotripid, *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).

### **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* (Bonnaterre, 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.* (Bonnaterre, 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.

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

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

*Laevaricella* 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.

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

“There is some confusion as to whether one of the subspecies of *Didelphis* (possibly *D. marsupialis insularis*) was introduced to the Lesser Antilles from Trinidad or whether the species is native” (Long, 2003) .

In Saint Lucia it is classified as native by some and exotic by others, as it is believed to have been introduced by Native Americans (Caribbean Conservation Association, 1991).

Thus since the beginning of the 2000s, in the logic of a vision hitherto accepted underestimating 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 terrestrial fauna (insects, molluscs, vertebrates: mammals, reptiles and amphibians, in particular) would come from elsewhere, in a mode of peripatric speciation, in an approach and a somewhat fixed discourse on the geography of the Caribbean, allegations are conveyed in a certain confusion claiming:

- that new species considered as such in the Caribbean are by peripatric speciation following dubious scenarios of multiple “rafting”, that is to say dispersals of these animal species from the northern shores of the South America crossing expanses of sea while drifting on rafts of plants to be imagined running aground randomly on “oceanic islands”.

- and that concerning species considered “non-endemic”, these are said to be “probably introduced” by the first peoples of the Caribbean.

Such allegations and discourses have led to the consideration “probably” that the Manicou *D. marsupialis insularis* were introduced by “Native Americans” into the Eastern Caribbean. (Breuil, et al., 2012; International conference on island biodiversity, flora, fauna and man in the Lesser Antilles, Martinique, November 8 – 10, 2010).

The services of the French State have not failed to listen to these speeches and allegations, although their authors recognize that they are in scientific uncertainty, and these authorities have nevertheless in violation of their own precautionary principle, taken decisions to repeal texts of laws which protected in Martinique the Manicou *Didelphis marsupialis insularis*, but also still in scientific uncertainty, have called into question the protection of the endemic hyloide of the eastern Caribbean, the *Eleutherodactylus johnstonei*.



Arrêté du 17 février 1989 fi ...

> Article 2

Version en vigueur du 24 mars 1989 au 27 janvier 2018

Abrogé par Arrêté du 17 janvier 2018 - art. 5

Sont interdits dans le département de la Martinique la mutilation, la naturalisation ou, qu'ils soient vivants ou morts, le transport, le colportage, l'utilisation, la mise en vente, la vente ou l'achat des spécimens de l'espèce suivante :

TAXONOMIE : Marsupiaux.

NOM SCIENTIFIQUE : *Didelphis marsupialis*.

NOM VERNACULAIRE : Opossum.

SYNONYME : Manicou.

## Order repealed in 2018

Also a ministerial decree of October 14, 2019 establishing a list of protected amphibians and reptiles represented on the territory of Martinique completes the previous list with new endemic species inventoried, but at the same time unfortunately, proceeds in an inconsistent manner with the withdrawal or excluding the amphibian species *Eleutherodactylus johnstonei*, which is recognized in the current state of herpetological knowledge and molecular biology as an endemic species of the Eastern Caribbean.

These species would therefore no longer have the status of protected species in Martinique, even though they are in their natural context in the eastern Caribbean.

**These decisions to exclude this species of mammal *Didelphis marsupialis insularis* then of amphibian *Eleutherodactylus johnstonei* from lists of protected species represented on the territory of Martinique, a territory geographically in the epicenter of the eastern Caribbean and of course naturally organically connected to the islands of Grenadian Basin, are arbitrary and discriminatory in relation to other species maintained at the status of protected species.**

The decree of February 17, 1989 establishing protection measures for mammals represented in Martinique, providing for the protection and conservation of the Manicou *Didelphis marsupialis insularis* was repealed in 2018 in defiance of the constitutional principle of precaution, in confusion and scientific uncertainty.

Just like the decree of February 17, 1989 establishing measures for the protection of reptiles and amphibians represented in the department of Martinique: this decree of February 17, 1989 establishing measures for the protection of reptiles and amphibians represented in the department of Martinique, makes mention of 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 into the Lesser Antilles” and even “invasive” (Breuil, 2002), even



though this author recognizes a origin which would be Barbadian of the species compared to the other Caribbean islands, while suggesting that it was also introduced there, and that it in fact came from elsewhere. Initial molecular biology data from Hedges et al. published since 2008, then those more recent from 2015 specifying phylogeny and molecular clock, definitively invalidate the hypotheses of Dr. Michel Breuil therefore wrongly “declaring” 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 sensing following his first molecular biology work that its incontestable 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 *Eleutherodactylus* of the Puerto Rico island bank, and the South American continent, since the Eocene, there are more than 41 million years old. It is therefore in this context since 2008 of scientific certainty of the eastern Caribbean origin of the common ancestor of the two 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 to be present since the Eocene on island banks in the eastern Caribbean, which 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 with 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 the *E. johnstonei* in a list of “established introduced species” in 2019, however expresses in 2018, and recognizes the scientific uncertainties regarding 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 are uncertainties, in the current state of scientific knowledge, as to the precise origins in the Eastern Caribbean, that is to say the centers of dispersal, or the places where the processes of speciations of the two species *Eleutherodactylus johnstonei* and *E. martinicensis*. 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 certainty, mainly in the field of the environment and health. The precautionary principle is binding on administrations. It requires them to develop forecasting and evaluation procedures within themselves 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 law of February 2, 1995 on strengthening environmental protection. According to this principle, “the absence of certainty, 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 a cost economically acceptable. The Council of State applied this principle. In its Association Greenpeace France judgment of September 25, 1998, it pronounced on this basis a stay of execution of a decree from the Ministry of Agriculture and Fisheries which authorized the marketing of varieties of genetically modified corn. This principle has constitutional value today. Indeed, the constitutional revision of March 1, 2005 annexed the Environmental Charter to the Constitution. However, Article 5 of the Charter provides: “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 application of the precautionary principle and in 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 damage. Furthermore, by its judgment, Commune of Annecy of October 3, 2008, the Council of State specified that all the rights enshrined in the Environmental Charter had binding legal value.

**Apart from the facts of geological history presented in this present publication which refute the discourse according to which the endemic species considered as such in the Eastern Caribbean are by peripatric speciation; the second part of this discourse which claims that it was the first peoples of the Caribbean who introduced the Manicous into the eastern Caribbean deserves the following observations:**

- 1) The phylogeny of the Manicous attests that it is indeed a single species *Didelphis marsupialis* ssp. which inhabits the islands of the eastern Caribbean, from the latitude of Grenada to that of Dominica. This already implies that as for the Caribbean Bothrops, the origin of dispersal of these Manicous is the Orinoco basin (geographical area of northern South America, present-day Venezuela). This excludes the possibility that it was people from the Guiana plateau, Arawaks and/or Kalinas who most recently migrated to the Caribbean who could have introduced these Manicous into the islands.
- 2) Even if this would have been the case for the very first peoples migrating to the Caribbean, such as the Siboney, originating from the Orinoco basin (present-day Venezuela), the latter having populated almost all of the Caribbean islands, to the extreme west of Cuba, Gwanaatabéy (Pinar el Rio, Island of Youth), then why have they not systematically introduced this same species of Manicou in all the islands(?) that they have a populated time, beyond Wéitubuliki (Dominica).
- 3) The systematic transport of these opossums, night owls and rebels against human presence, emitting highly unpleasant and unbearable odors when they feel threatened, to intentionally distribute them on islands would not have been an easy undertaking in the Kanwa (boats).
- 4) These peoples inhabiting the Orinoco basin and especially indigenous to the coastal coastal areas of Venezuela, practiced more fishing, and were therefore more consumers of seafood and nutrients from the rivers, than of meat from terrestrial fauna .
- 5) These people living in the Orinoco basin, over several generations, in great coordination, would have curiously systematically selected one and the same species of Didelphis, to transport it and introduce it to the Caribbean islands, while several species Dildelphis and other kinds of opossums were at their disposal. Moreover, to corroborate our observation, the Arawaks and Kalinas, who transported land turtles called Molokoy from the Guiana plateau, transported without distinction towards the Caribbean the two species of the Testunididae family at their disposal: *Chelonoidis carbonarius* and *Chelonoidis denticulatus*.

## Conclusion

The scenario of an intentional introduction of a single species of *Didelphis*, on the islands of Grenada, the Grenadines, Saint Vincent, Saint Lucia, Martinique and Dominica, which would have taken place over several generations, by humans from first peoples migrating to the Caribbean is clearly improbable, implausible and without serious foundation.



If we accept that the Eastern Caribbean arc is made up of archipelagos of islands remnants of larger islands. That the islands of Martinique, Saint Lucia, Saint Vincent, the Grenadines, Grenada are the remains of the large island of Matina which was submerged. That the islands on the coast of Venezuela, Aruba, Curaçao, Bonaire, Tortuga, Blanquilla, Testigas, Margarita, are also vestiges of proto-Matina.

That on this large island of Matina, the ancestors of *Didelphis marsupialis insularis* obviously cohabited with the ancestors of animal species of mammals, amphibians, reptiles, and sedentary birds, molluscs and insects. Everything becomes coherent. The Manicou, like other mammals such as the Pillory Rat or Muskrat, *Megalomys desmarestii*, the Agouti, *Dasypsecta antillensis*, the Nine-banded Armadillo, *Dasypus novemcinctus*, the Martinique Murin, *Myotis martiniquensis*, existed on Matina and still exist on islands in the Eastern Caribbean.

## Manicou conservation issues

Understand that the opossums, Manicous of Martinique and Saint Lucia, isolated for millions of years on Matina have therefore developed a very strong resistance to the venoms of *Bothrops lanceolatus*, and *Bothrops caribbaeus*, species declared since 2015 by the IUCN, as having critically endangered species status; it is to understand, if only for anthropogenic needs, that the protection and conservation of *Bothrops* snakes goes hand in hand with that of *Didelphis marsupialis insularis*.

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