Nieves-Rivera, Ángel M.
Paleobotanical notes on mangrove-like plants of Puerto Rico
Asociación Interciencia
Caracas, Venezuela

Available in: http://www.redalyc.org/articulo.oa?id=33912606
PALEOBOTANICAL NOTES ON MANGROVE-LIKE PLANTS OF PUERTO RICO

ÁNGEL M. NIEVES-RIVERA

SUMMARY

Several new trace fossils (ichnofossils) of mangrove-like plants are reported for Puerto Rico; all these fossils are new records for Puerto Rico. The earliest root casts in Puerto Rico were dated Late Cretaceous (probably Santonian, 85.8-83.5 Ma). Earlier paleobotanical studies in Tertiary-dated sites in Puerto Rico are also discussed. Oligocene and Miocene lignitic rocks, traces of amber, and trace fossils (possibly mangrove rhizoliths) also have been found in several geological formations of northern and southern Puerto Rico (e.g., Juanita Díaz Formation and Ponce Limestone). Rhizoliths of Scaveola cf. plumieri (L.) Vahl have been collected from coastal Pleistocene eolianite terraces that occur in northern Puerto Rico. The Puerto Rican material is herein described and illustrated, and a brief paleobotanical discussion provided. To date, the data on ichnofossils of mangrove-like plants are too poor to speculate on such subjects as dispersal and island biogeography, especially in Puerto Rico. Most of the taxonomic information presented herein was collected from fragmentary surveys. However, the data herein suggest that the composition of fossilized mangrove-like plants is more complex than previously suspected. Therefore, it would seem important to continue studying such paleoenvironments, in order to contribute to the conservation and knowledge of the paleoecology of mangrove-like plants of Puerto Rico.

Mangrove forest is considered a dynamic ecotone (or transition zone) between terrestrial and marine habitats. In its simplest sense “mangrove”, as used herein, encompasses a group of woody, halophytic plants that occurs along sheltered tropical and subtropical coasts. Mangroves are derived from a variety of plant families and vary in their dependence upon littoral habitats. Mangrove forests are also referred to as mangrove swamps, tidal forests, tidal swamp forests or mangals. Caribbean mangroves range from 30°N (northern Florida) to 8°N (northwest Colombia) and from 59°W (north of Guiana) to 89°W (eastern Guatemala) (Tomlinson, 1986). Until recently, four mangrove species were known to occur in Puerto Rico (Lugo and Snedaker, 1974; Francis and Lowe, 2000; Little et al., 2001), the most widely distributed of which are the red mangrove (Rhizophora mangle L.), black mangrove (Avicennia germinans (L.) Stearns), white mangrove (Laguncularia racemosa (L.) Gaertn.), and buttonwood (Conocarpus erectus L.). Following Tomlinson (1986), only three species should be considered as “true mangroves” (A. germinans, R. mangle, and L. racemosa) in Puerto Rico. Conocarpus erectus is frequently considered a “true mangrove”, but Tomlinson (1986) suggested that it is better regarded as a mangrove associate because it lacks of the biological features (pneumatophores and vivipary) which characterize true mangroves; furthermore, it occurs in inland communities. A compilation of 125 plants routinely found in mangrove forests, the introduction of a new variety of the mangrove-associated plant, C. erectus var. sericeus Griseb. (Combretaceae), unusual aerial roots in A. germinans (Avicenniaceae) were reported for Puerto Rico (Nieves-Rivera, 2005). The latter study produced an actualized checklist of scientific and common botanical names (English/Spanish), including 3 true mangroves (A. germinans, L. racemosa and R. mangle), and 122 mangrove-associates for Puerto Rico.

The most common trace fossils, also known as ichnofossils or “Lebensspuren” (‘living traces’ in German) left by plant activity are root traces or casts (rhizoliths), which show the branching and irregularities of living root morphology. These casts also reveal plant behavior, by showing growth. Their preservation taphonomy was probably the result of early cemen-
tation around the original roots, followed by cementation of carbonate sand that filled the mold (Martin, 1996). The fossilized mangrove-like plants of Puerto Rico have been less studied. A total of 11 trace fossils (ichnofossils) of mangrove-associated plants are here-in reported for Puerto Rico (Table 1).

The earliest root casts in Puerto Rico were dated Late Cretaceous (probably Santonian, 85.8-83.5Ma; Santos, 1990, 1999). These plant ichnofossils (Figure 1a-e), along with scattered large, near-vertical trace fossils (Skolithos s. str.; Prothero and Schwab, 1996) are present on the top of bioturbated magnetite-rich units (magnetite lenses) of the oldest facies of the Cotuí Limestone, Cabo Rojo-San Germán, in southwestern Puerto Rico (Santos, 1990, 1999). The location of the Cotuí Limestone root casts is given on Table I and was at 25.3m elevation. Cretaceous root casts have been tentatively interpreted to have been caused by mangrove-like plants, e.g., Deltoidospora sp. (= Acrostichum

| TABLE I
| LOCATION OF MANGROVES AND MANGROVE-ASSOCIATED PLANTS PALYNOmorphs (PL) OR IChNOFOSSILS (IF) FOUND IN PUERTO RICO, IN ORDER OF GEOLOGIC TIME |
|---|---|---|---|---|
| Taxa | Accession number | Coordinates | Geological Formation | Geologic time | References |
| Mangrove-like root casts (IF) | — | 8°04.720'N, 67°05.312'W | CM | LC | Santos (1990, 1999); Nieves-Rivera (2005) |
| Ilex sp. (PL) | MO C-47, 15; ESF H-19 | 18°19.998'N, 66°56.918'W | SC | MO | Graham and Jarzen (1969) |
| Myrica sp. (PL) | MO C-42, 4; ESF N-43 | 18°19.998'N, 66°56.918'W | SC | MO | Graham and Jarzen (1969) |
| Pelliciera sp. (PL) | MO C-48, 1; ESF D-38,2 | 18°19.998'N, 66°56.918'W | SC | MO | Graham and Jarzen (1969) |
| Rhizophora (sp.) doctrinalis Hollick (IF) | YPM 27218 (type); YPM 27196 (paratype); YPM 27199 (figure) | 18°19.998'N, 66°56.918'W | SC | MO | Hollick (1928); Graham (1996) |
| Rhizophora sp. (PL) | MO C-47, 1; ESF L-21,3 | 18°19.998'N, 66°56.918'W | SC | MO | Graham and Jarzen (1969) |
| Tournefortia sp. (PL) | MO A-12, 10; ESF U-34,4 | 18°17.413'N, 66°53.411'W | SL | MO | Graham and Jarzen (1969) |
| Mangrove-like root casts (IF)* | — | 17°58.412'N, 66°53.730'W | BL | MO | Nieves-Rivera (2005) |
| Mangrove-like root casts (IF)* | LACMIP 17772 | 17°58.947'N, 66°40.028'W | PC | LM | Nieves-Rivera (2005) |

* New record for Puerto Rico; ESF: England Slide Finder coordinates.

1 Museum abbreviations. LACMIP: Natural History Museum of Los Ángeles County, Department of Invertebrate Paleontology, Los Ángeles, California; MO: Herbarium, Missouri Botanical Garden, Saint Louis, Missouri; YPM: Yale Peabody Museum Herbarium, Yale University, Cincinnati.


3 Geologic Time. LC: Late Cretaceous (Santonian, 85.8-83.5Ma); LM: Late Miocene (11.2-5.3Ma); MO: Middle Oligocene (28.5Ma); PL: Pleistocene (1.8-0.01Ma); QT: Quaternary (1.8Ma-10000 yr).
or the extinct *Brevitricolpites* sp., although recent palynological studies reported the origin of these two candidates in the Eocene (Tomlinson, 1986; Rull, 1998). Another possible candidate is the mangrove-associated palm *Nypa*, which nowadays is widely distributed throughout southwestern Asia and dates back to Late Cretaceous (Tomlinson, 1986; Rull, 1998). These casts (2-20mm wide), which Santos suggested that were derived from some mangrove-like plants, possess many anatomical traits also found in modern mangrove-associated plants (e.g., *Acrostichum* spp.). The original wood material was decomposed and no longer exists; however, the spaces were filled with soft sediment, easily removed by physical and biogeochemical mechanisms (Figure 1c-e). These features are characteristic of intertidal to shallow subtidal marine environments with high energy (active waves and currents) (Santos, 1990, 1999).

In the 1920s, Hollick (1928) began a paleobotanical survey in Puerto Rico, which was summarized in his *Paleobotany of Porto Rico*, based on his field collections of seeds, leaves, and wood macrofossils of various species, including mangrove species such as *Rhizophora*, in the gray shale walls of the Collazo and Guametaela Rivers of the San Sebastián Formation (SSF), of Oligocene in age (33.7-23.8 Ma). These plant species were also collected in other localities around the island (Hollick, 1928). This author reported leaves of *Rhizophora* sp. (*Rhizophora* (sp.) *doctrinalis* Hollick; Figure 5b, plate 82 of Hollick, 1928) from station B (at the base of the falls below the bridge) in the gray shales of the Collazo River, SSF, northwestern Puerto Rico. A type (YPM 27218), paratype (YPM 27196), and figure (YPM 27199) of *R.* (sp.) *doctrinalis* were deposited in the Yale Peabody Museum (Table I).

Palynological studies in Puerto Rico were conducted by Graham and Jarzen (1969) and Graham (1995, 1996, 2003), collecting at many of Hollick’s original Tertiary surveyed sites, and adding new ones. Palynomorphs (pollen) of these plant species were collected in the shales and organic-rich silty limestone layers of the San Sebastián and Laredo Formations, northwestern Puerto Rico. In their study, Graham and Jarzen (1969) obtained 165 palynomorphs; 44 were identified and 15 are unknown. Graham (1996, 2003) summarized Hollick’s works and demonstrated that there is further need for paleobotanical studies in the region on the diversity and importance of the fossil plant record of Puerto Rico. Graham (1995) carried out palynological studies in the Caribbean, with emphasis on the diversification of the Gulf/Caribbean mangrove communities, especially before and after the appearance of the Isthmus of Panama in the Pliocene (5.3-1.8Ma; s. str. Graham, 1992).

Although fossil pollen of *Avicennia* has not been collected in Puerto Rico, this mangrove was the first to be found in the Late Miocene (11.2-5.3Ma) of the Caribbean (Graham, 1995), although Duke (1995) reported *Avicennia* in Early Miocene (23.8-16.4Ma). *Avicennia* pollen is also common in the Quaternary (1.8-0.01Ma) of Costa Rica, Panama, and in northern South America (Müller et al., 1987; Graham, 1995). Microfossils of *Rhizophora* first appeared in the Late Eocene (37.0-33.7 Ma), *Avicennia* in Late Miocene, *Laguncularia* in the Pliocene (5.3-3.6 Ma), and *Conocarpus* in the Quaternary (Graham, 1995).

More recent palynological surveys by Graham and Jarzen (1969) and Graham (1995, 1996, 2003), reported Puerto Rican Tertiary (Middle Oligocene) mangrove plant microfossils. Mangrove pollen included *Rhizophora* sp. and *Pelliciera* sp. (Graham and Jarzen, 1969; Graham, 1995, 1996, 2003). Palynomorphs of both mangrove species were collected in the light gray and gray shales of SSF. Both mangrove species are typical of coastal habitats with brackish or marine waters; however, *Pelliciera rhizophorae* Triana & Planchon is now limited to the Pacific coasts of Costa Rica, Panama, and both

Figure 2. Pleistocene (Late Quaternary) plant ichnofossils pieces (LACMIP F.A.3912.2004-3), possibly mangrove-like root casts from the aeolian fossilized dunes of Punta Jacinto, Playa Jobos, Isabela, in northern Puerto Rico. a-b: Aeolian dune views, c-e: root casts in situ, f: profile and sectioned views of weathered root casts.
Pacific and Atlantic coasts of Colombia (Tomlinson, 1986).

Oligocene and Miocene lenticular rocks, traces of amber, and trace fossils (possibly mangrove rhizoliths) also have been found in several geological formations of northern and southern Puerto Rico (e.g., Juana Díaz Formation and Ponce Limestone s. str. Frost et al., 1983; MacPhee and Wyss, 1990; MacPhee and Iturralde-Vinent, 1995; Iturralde-Vinent, 2001; Nieves-Rivera, unpubl. data, 2002; Table 1). The biostratigraphy of the (Holidy Inn) outcrop, which is part of the Ponce Limestone, is Late Miocene in age and is herein reported (María Ruiz-Yantín, pers. comm., 2004): “During Late Miocene times, this area was active tectonically, whereas the northern part of Puerto Rico was passive. The outcrop has four units. Unit 1 shows a lagoon environment and it is 1.2m in thickness. It is a wackestone composed mainly of the foraminifers *Miosorites cf. americanus* Seigle & Grove, solitary corals, *Pecten* with original shells, and internal gastropod molds. Unit 2 represents a reef front environment and is 4.5m thick; it is a massive unit (packstone) containing solitary corals in growth position, colonial corals such as *Diploria* and *Porites*, unidentified burrows, *Pecten*, crabs remains, *M. cf. americanus* foraminifers, rhizoliths of mangrove origin (LACMIP Ponce, PR 17772), and internal gastropod molds; it shows a coral framework. Unit 3 represents a reef crest environment and is 4.5m thick; the corals are out of place and are not as well cemented in the underlying unit; there are solitary corals, *Montastrea annularis* (Ellis & Solander), *Porites portilis* (Pallas), brain corals that are probably *Diploria*; also, there are few gastropods, bivalves, and crabs remains; there is an erosion surface between unit 3 and 4. Unit 4 is 8.05m thick and shows a lagoon environment similar to Unit 1”.

Pleistocene eolianite terraces (s.str. Taggart, 1992) that occur in southwestern Mona Island and northern Puerto Rico jut out from the coastline. The shoreline of Mona Island terraces sometime shows “dead mangrove roots that protrude from crannies and fissures, and coral fossils (e.g. *M. annularis, M. cavernosa* L., *Diploria* sp., *Acropora palmata* Lamarck) are found everywhere (Hernández-Avila, 1970; Taggart, 1992). In Punta Jacinto, located at Playa Jobos in Isabela, northern Puerto Rico, there is a typical example of aeolian fossilized dunes having plant root casts (rhizoliths). The Isabela rhizoliths were deposited in the Natural History Museum of Los Ángeles County, Department of Invertebrate Paleontology, Los Angeles, California (LACMIP). Pleistocene plant rhizoliths (see LACMIP Isabela PR 17768) are possibly from a mangrove-like plant such as *Scaevola* cf. plumeirti (L.) Vahl (Storrs L. Olson, pers. comm., 2005; Figure 2a-f; Table 1). Similar rhizoliths have been found as reefs at Key Biscayne Bay in Florida (USA: Hofmeister and Mutter, 1965), in aeolian dunes of Hawaii (Olson and James, 1982), and San Salvador Island in the Bahamas (Martin, 1996).

To date, the data on ichnofossils of mangrove-like plants are too poor to speculate on such subjects as dispersal and island biogeography, especially in Puerto Rico. Most of the taxonomic information presented herein was collected from fragmentary surveys from Puerto Rico. However, the data herein suggest that the composition of fossilized mangrove-like plants is more complex than previously suspected. Therefore, it would seem important to continue studying such paleoenvironments, in order to contribute to the conservation and knowledge of the palaeoecology of mangrove-like plants of Puerto Rico.

**ACKNOWLEDGMENTS**

The author thanks Hernán Santos, Jorge Vélez-Juarbe and María Ruiz-Yantín (Dept. of Geology, University of Puerto Rico at Mayagüez –UPRM-) for their help in locating the trace fossils; “Storrs L. Olson (Smithsonian Institution, Washington, D.C.) for his help on rhizoliths; Alan Graham (Missouri Botanical Garden, St. Louis, Missouri) for his aid on Table I; Juan A. Rivero (Dept. of Biology, UPRM) and Ariel E. Lugo (USDA, Institute of Tropical Forestry at Río Piedras) for corrections to the text; and Peter Rocafort (Dept. of Marine Sciences, UPRM) for digitalization of figures. This project was supported by the University of Puerto Rico Alliance for the Graduate Education and the professorate fellowship (Grant No NSF/AGEP– hRD # 0302696).

**REFERENCES**


NOTAS PALEOBOTÁNICAS ACERCA DE PLANTAS PARECIDAS A MANGLES EN PUERTO RICO
Ángel M. Nieves-Rivera

RESUMEN

Se informa para Puerto Rico varios nuevos fósiles traza (icnofósiles) de plantas parecidas a los mangles; todos estos fósiles son nuevos registros para Puerto Rico. Los moldes de raíces más antiguos en Puerto Rico fueron datados del Cretácico Tardío (probablemente Santoniano, 85,8-83,5Ma). También se discuten los estudios paleobotánicos previos en los yacimientos datados del Terciario en Puerto Rico. Las rocas ligníticas, trazas de ámbar y fósiles trazas (probablemente rizolitos de mangle) del Oligoceno y Mioceno también se han encontrado en varias formaciones geológicas del norte y sur de Puerto Rico (e.g., la Formación Juana Díaz y la Caliza Ponce). Los rizolitos de Scaevola cf. plumieri (L.) Vahl han sido colectados de las terrazas costeras de eoliatos del Pleistoceno que ocurran al norte de Puerto Rico. El material puertorriqueño se describe y se ilustra y se proporcionó una breve discusión paleobotánica. Al presente, los datos sobre icnofósiles de plantas parecidas a los mangles es muy escasa como para especular sobre temas como la dispersión y biogeografía de la ilha, especialmente en Puerto Rico. La mayor parte de la información taxonómica aquí presentada fue reunida de los reconocimientos fragmentados. Sin embargo, los datos sugieren que la composición fósilera de las plantas parecidas a los mangles es más complejo que lo previamente sospechado. Por consiguiente, parece importante continuar estudiando dichos paleoambientes para contribuir a la conservación y el conocimiento de la paleoecología de las plantas parecidas a los mangles de Puerto Rico.

NOTAS PALEOBOTÁNICAS SOBRE PLANTAS PARECIDAS A MANGLES EN PORTO RICO
Ángel M. Nieves-Rivera

RESUMO

Informa-se para Porto Rico, vários novos fósseis traza (icnofósseis) de plantas parecidas aos mangues; todos estes fósseis são novos registros para Porto Rico. Os moldes de raízes mais antigos em Porto Rico foram datados do Cretáceo Tardio (provavelmente Santoniano, 85,8-83,5Ma). Também se discutem os estudos paleobotânicos prévios em os yacimientos datados do Terciário em Porto Rico. As rochas ligníticas, trazas de ámbar e fósseis trazas (provavelmente rizolitos de mangle) do Oligoceno e Mioceno também se têm encontrado em várias formações geológicas do norte e sul de Porto Rico (e.g., a Formação Juana Díaz e a Caliza Ponce). Os rizolitos de Scaevola cf. plumieri (L.) Vahl têm sido recolhidos dos terraços costeiros de eoliatos do Pleistoceno que ocorrem ao norte de Porto Rico. O material porto-riqueno descrito e ilustrado proporcionou uma breve discussão paleobotânica. Atualmente, os dados sobre icnofósseis de plantas parecidas aos mangues são muito escassos como para especular sobre temas como a dispersão e biogeografia da ilha, especialmente em Porto Rico. A maior parte da informação taxonómica aqui apresentada foi reunida dos reconhecimentos fragmentados. No entanto, os dados sugerem que a composição fósilera das plantas parecidas aos mangues é mais complexa que o previamente suspeitado. Por conseguinte, parece importante continuar estudando ditos paleoambientes para contribuir à conservação e o conhecimento da paleoecologia das plantas parecidas aos mangues de Porto Rico.