Hylocereus trigonus

A Fruiting Cactus Growing in Culebra

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Hylocereus trigonus

Introduction:

Several populations of the ***Hylocereus trigonus*** cactus were first identified on the morning of September 26, 2003 in the **Villa Mi Terruño (VMT)** proposed project site on the island of **Culebra**, Puerto Rico. That morning, field biologists of the Environmental Consulting Group (ECG) were performing an investigation of the **VMT** site for the Environmental Impact Statement's **Flora & Fauna Survey**. During the investigation, they noted the possibility of having found a new population of a rare and endangered cactus in two separate transects on the southern side of the central hill and on the southern hill facing **Playa Cascajo** and the Caribbean Sea.

The finding was significant because only one highly exposed population of 50 individuals of ***Leptocereus grantianus***[1], an endangered species that is both federally and locally listed, was known to grow in the **Punta Melones** area of **Culebra** on a rocky, exposed shoreline cliff next to a public beach. Its endangered condition and limited habitat made that cactus a rare one to encounter in cultivation.

The **Leptocereus** *was originally described as a subgenus of the* ***Cereus*** *genus in 1905 by Alvin Surgens. It was raised to full genus status in 1920 by Nathaniel Britton and Joseph Rose.* [2] **Leptocereus** is a bushy, treelike but generally sprawling vine-like or arching shrub, with spiny areoles, thin ribbed with notched margins, many jointed segmented cacti with tubular to bell shaped flowers usually white or pale green. It is native of Cuba, Hispaniola, Puerto Rico and **Culebra** with 15 species, many native to Cuba. [3],

The **Hylocereus** name is derived from the Greek "***Hyle***" which means forest for the climbing on trees and shrubs habit of the cactus and "***cereus***" meaning waxen or waxy for its luster. In Latin "***cereus***" is the word for candle derived from a luster "cere" root. "Trigonus" in Latin refers to three sided. It endangered condition and limited habitat made that cactus a rare one to encounter in cultivation.

The early observations of the three possible cactus populations in the **VMT** property from November 2002 to August, 2003 were later only confirmed in one of the population as ***Leptocereus grantianus*** on the upper southern hill site facing **Playa Cascajo** and dismissed in the other two locations on the central hill.

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[1] Britton, N. L., 1933. ***An Undescribed Cactus of Culebra Island, Puerto Rico***, Cactus and Succulents Soc. Amer. 5:469.

[2] Britton, N.L. and Rose, J.N., 1919-1923, **The Cactaceae**, 4 Vols., Carnegie Institution, Washington, D.C.

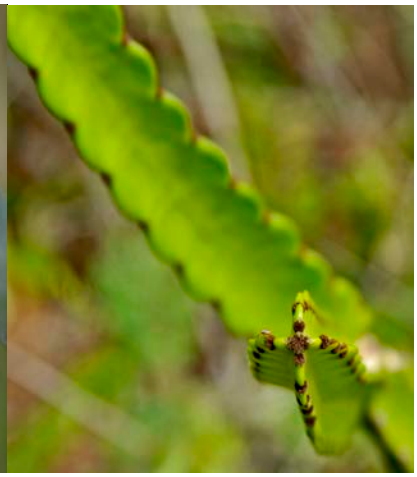
3 Britton, N.L. and Rose, J.N., 1919-1923, **The Cactaceae**, 4 Vols., Carnegie Institution, Washingto

The cactus species dismissed in the suspected sites on the southern side of the central hill was eventually identified as ***Hylocereus trigonus.*** This cactus at first sight looks similar to the endangered one but a close inspection quickly determines that it is definitely a different species. It a native and common cactus and grows in several locations in **VMT** and **Culebra**. It is found in dry forest habitats and coastal thickets. It can also be found in **Vieques, Mona, St. Croix, St. Johns, St. Thomas, Tortola and Virgen Gorda, the Lesser Antilles Hispaniola and the Public Forests of Ceiba, Guajataca, Guanica and Rio Abajo, P.R.**

There are four keys to differentiate ***Hylocereus trigonus*** from the ***Leptocereus grantianus*** cactus genus. Growth habit, spines, spine aeroles location and flowering and fruiting, ***Hylocereus trigonus*** is a sprawling, climbing cacti that needs support from trees or sturdy mature vines or bushes in dry tropical forest while the ***Lepto*** cactus **is self supporting.** ***Hylocereus trigonus*** many jointed elongated stems, without leaves, are thin ***three ribbed*** or thickly three angled, strongly undulated marginally, with areoles with spines borned ***at the tip of the undulations***. The ***Lepto*** cactus' areoles with tiny fuzzy spines when very young seems spineless and the aeroles are located ***at the base of the undulations***. The stems have a mix of three to five ribs. The flowers of the ***Lepto*** cactus are smaller, white-yellow or cream colored, oblong-ovate, obtuse and about 8 millimeters long with many stamens and yellow anthers. The stigma lobes are several and small. The ***Hylocereus*** cactus' flowers are the largest in the cacti family. It is best known for producing exotic, large fruits, known as Dragon Fruit. The fruits are larger than an orange, with pinkish-red skins accentuated by green scales.

Hylocereus trigonus

Hylocereus trigonus



Leptocereus grantianus

Since late 2003, **VMT** management and personnel have been protecting the tropical dry forest that is part of large catchment basin that drains southeast to **Ensenada Fullladosa** we designated as the **Green Valley.** The basin valley is U shapes and includes the southern side of the central hill and the north side if the southern hill in the **VMT** site. The author has been investigating the tropical dry forest habitat and, since June 2006, identifying additional sites on the coastal cliff of **Playa Cascajo** as well as photographing and observing the life cycle of the plant. All photographs included in this article are protected by copyrights rights of the photographer, Manuel H. Dubón, and its licensee, **Fundación Mi Terruño, Inc. (FMT)**, a non-profit

educational, scientific foundation that discharges the conservation and educational functions and acts as title holder of the set aside lands and protective easement rights.

The Geographic Location and Description of Culebra:

Culebra, Puerto Rico is a small Caribbean tropical island archipelago of the eastern platform belt of the Greater Antilles Arc in the West Indies, consisting of one inhabited main island and 23 smaller offshore cays of exceptional beauty and natural attractions. It is located 18 degrees and 19.01 minutes north of the Equator and 65 degrees and 17.24 minutes west of the Prime Meridian. The island enjoys a temperate tropical climate refreshed by the northeastern trade winds.

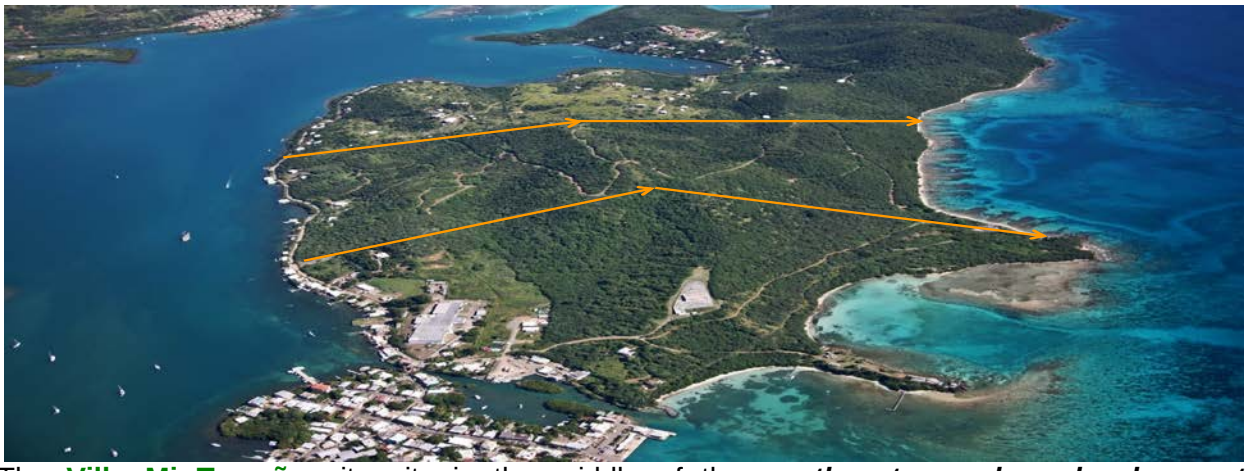
Culebra is volcanic in origin and its geography is characterized by steep hills, sandy beaches, reefs, small neighboring islands, bays, coves and inlets. The island is very scenic with combined views of sea, land and sky and beautiful coves and beaches. The island is located approximately 27 km (17 miles) east of the "big" island of **Puerto Rico**, approximately 19 km (12 miles) west of **St. Thomas, U.S. Virgin Islands (USVI)**, and approximately 14 km (9 miles) north of the island of **Vieques** on the ***Eastern Puerto Rico geologic platform foundation*** of the **Northeastern Geologic Platform Bank of the Greater Antilles Arc**. The **Puerto Rico Platform** extends from Mona Island on the western side of Puerto Rico to the USVI and British Virgin Islands (BVI) to the East. **Culebra** is approximately seven miles long by five miles wide (11 by 8 km) and occupies an area of approximately 11.6 square miles or 28 square kilometers (6,741 *cuerdas*). It has some of the most beautiful beaches of the world. However, predominantly it has shallow shoreline coastal zones behind its beaches and rapidly rises from coastal cliffs to a hilly topography. Its highest hills are **Monte Resaca** with an elevation of 650 feet (198 m) and **Cerro Balcón** with 541 feet (134 m) on the north side. The central hill of the **VMT** parcel is the highest elevation point on the southern side of the island, in the Playa Sardinas II Ward, with an elevation of 350 feet (107 m).

The **Puerto Rico Platform** forms part of the **Northeastern Geologic Platform Bank of the Greater Antilles Arc**. The **Puerto Rico Platform** has to the north the **Puerto Rico Trench**, which includes the deepest part of the **Atlantic Ocean**, with depths exceeding 8,400 meters, where the **Atlantic Plate** does in a southern movement oblique convergence-subduction under the platform with a left lateral strike slip faulting in a westerly direction of about 2 cm per year. To the south, beneath the **Caribbean Sea**, lies the **Muertos Trough**, where oblique under-thrusting in a northern movement of the **Caribbean Plate** occurs. The **Northeastern Geologic Platform Bank of the Greater Antilles Arc** boundary has active tectonics, resulting in high earthquake and daily seismic activity. The most hazardous activity is located a distance from **Culebra**.

The VMT Ecological Corridor ["Villa Mi Terruños Conservation Corridor"]:

Villa Mi Terruño is a ***model ecologically sustainable project of advanced master planning***, proposed on a **104 *cuerdas***[4] land site. It is located on three hills at the center of the **Playa Sardinas II Ward** in the **Punta Soldado** southeastern peninsula-like extension of the island of **Culebra**. It is located on three hills at the center of the **Playa Sardinas II Ward** extension in the southeastern peninsula of the island between the **Ensenada Honda Inlet** to the north and **Playa Cascajo** on the **Vieques Sound** of the **Caribbean Sea** to the south.

Villa Mi Terruño Location in Central Hill of Playa Sardinas II Ward

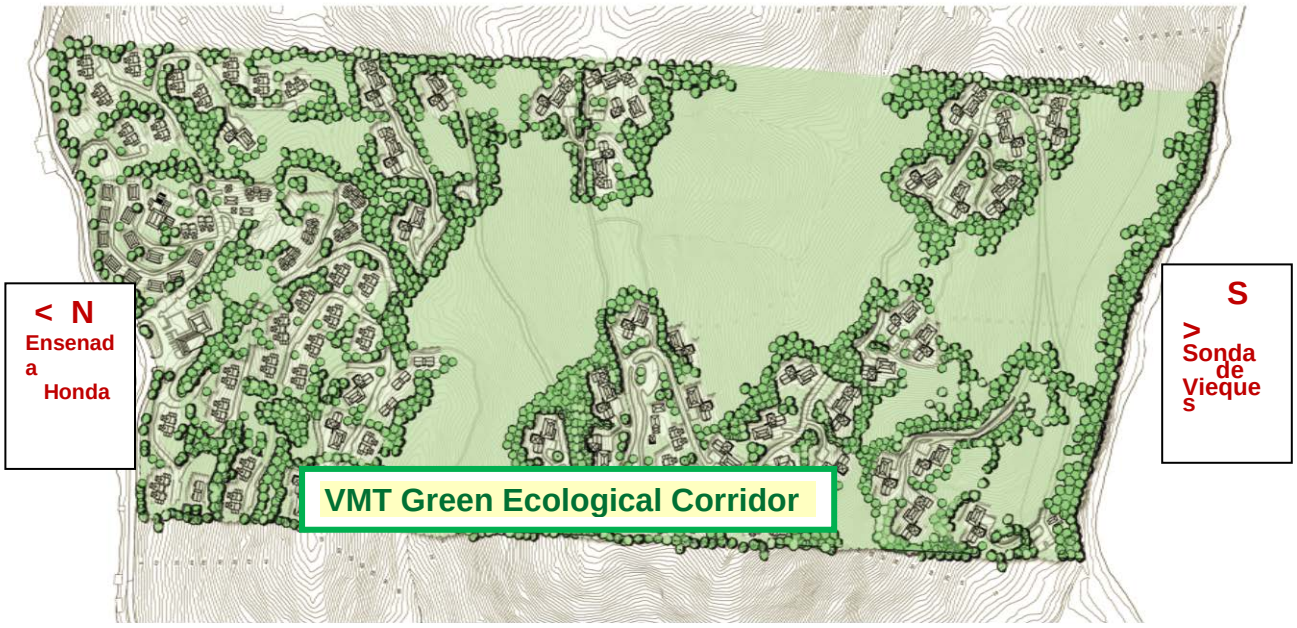


The **Villa Mi Terruño** site sits in the middle of the ***southeastern urban development expansion belt*** from the town of **Dewey.** **VMT is a sustainable development that sponsors a non-profit foundation, Fundación Mi Terruño Inc. ("FMT")** dedicated to sustainable community development and improvement and the ecological, scientific and educational research and conservation of the local marine and land flora and fauna.

VMT is not a 104-cuerda development, as incorrectly alleged by some. As a matter of fact, the 28-cuerda portion of the site where the *Leptocereus grantianus* cactus grows is currently zoned **R0–1-C**, which permits the construction of two (2) homes per *cuerda* or 56 homes in total. All but three (3) of these **56 homes** were "relocated" from the **Playa Cascajo** drainage basin and the development rights transferred to the less sensitive areas of the property, thereby extending the **VMT Ecological Corridor** to protect the endangered cactus species and the **Cascajo Beach** coastal area drainage basin. The proposed ***comprehensive design guidelines of the*** project's Master Plan for the proposed long term recreational development will only gradually develop ***33.7 cuerdas*** of land over a period of 15 to 20 years. P.R. {Panning Board Regulations do not permit fragmented proposed Master Plans and require the entire site to be master planned regardless if the original long term plan will be entirely developed for financing or economic demand reasons. The remaining ***70 cuerdas will be set-aside and protected*** in perpetuity by title transfers and conservation easements. **Such an extensive set aside to protect the natural environment is unique to VMT and generally unknown in propose development projects of this type.**

[4] **One (1) *cuerda* = 0.971 acres**.

The original master plan was revised and the **VMT Ecological Corridor *concept incorporated***, after site visits and formal recommendations of the **USFWS** and **DNER,** to reduce the original conceptual size of the project. This was achieved by relocating and eliminating several of the proposed housing sites from the central hill areas by transferring the home sites in side clusters toward the outside margins of the proposed project site. The revision also included grouping some proposed sites closer together into clusters to minimize possible impacts upon the remaining portions of sensitive undisturbed natural habitat areas, to allow or enhance the area and continuity of the proposed green corridor and to relocate and transfer the proposed residential use to the previously disturbed cattle grazing areas.



The **VMT Ecological Corridor** extends from the **Playa Cascajo** beachfront on the southern side of the property of the **Playa Sardinas II** peninsula to the northern lower hill sides fronting on the **Ensenada Honda Inlet** area. The **Master Plan** proposed that approximately **70 *cuerdas*** be conserved and not developed. This significant protection of the flora and fauna ecosystems for future generations in the most sensitive environmental biota areas of the **VMT** proposed site is most uncommon in development circles. The voluntary set aside proposed by the **VMT *comprehensive design guidelines*** was adopted by the Planning Board of Puerto Rico and made **mandatory** when it approved and authorized the **VMT "Consulta de Ubicación"** or Master Plan in its Resolution of December 2010 and again in its more detailed approval in December 2012. ***The VMT Ecological Corridor includes the Leptocereus grantianus cactus and Hylocereus trigonus habitat areas.***

Villa Mi Terruño
Culebra, Puerto Rico
Culebra Resorts Associates II S. en C. por A., S.E.

July, 2014 Rev. Site Plan

110 residential units within 69 structures
64 parador rooms
15 rooms within 5 camp cabin clusters
1 service area

Leptocereus grantianus concentrations	
Virgin Island Boa suitable habitat	
Set-Aside Land	
Common Open Space (outside parcels, lots and roads)	39.14 cuerdas
Half cuerda out of single family homes	18 cuerdas
"uncleared" land inside single family homes' impacted half acre (avg. 900 sm/lot)	8.5 cuerdas
"uncleared" land inside other lots (min).	4.46 cuerdas
Proposed total Set-Aside Land	***70.10 cuerdas***

The **Green Valley Area** between the central hill and lower south hill that a pristine developed dry tropical forest area.

Green Valley Looking Toward East SE

Mature Tree Cover Area Inside Green Valley

Species Status:

Hylocereus trigonnus, (Haw.)Safford[5], ***Pitahaya, Chickenet, Night blooming cereus, Strawberry pear***, is a much branched vine type sprawling and climbing cactus. It is no epiphytic, but roots on the ground and climbs from its ground base. It climbs on rocks, trees and bushes in dry forest. Its fleshy triangular roots produce adventitious aerial roots and can attain 10 meters (33 ft.) in length.

It is a native **Culebra** species and is distributed throughout the island. Its general distribution throughout the **Greater and Lesser Antilles** of the **Caribbean** makes it a common cactus that has not needed special protection.

Nearly 20 species of ***Hylocereus*** have been identified throughout the ***Caribbean, Southern Mexico Central and Northern South America***. Because of its exotic fruiting it is cultivated in many areas. A study of its molecular phylogeny of the **Cactaceae** concluded that neither the tribe nor the genus was monophyletic (i.e. neither comprised all the descendants of a common ancestor). Two species of ***Hylocereus*** formed a clade with two species of ***Selenicereus***, suggesting that the genera were not distinct.[6]

[5] Report (Annual) Board of regents, Smithsonian Inst. 1908: 553, 1909
[6] Bárcenas, Rolando T.; Yesson, Chris & Hawkins, Julie A. (2011), Molecular systematics of the Cactaceae, Cladistics 27 (5):470-489, (hhtp://en.wikipedia.org/wiki/Hylocereus)

Description of Family:

The ***Hylocereus*** genus is a sprawling, climbing cacti with adventitious aerial roots; stems elongated, three angled or winged, margins usually undulate, areoles with spines and tuffs of wholly hairs or, when young, with bristles, glotchids wanting. The stems are typically three-angled with wavy or punctuated margins and few short spines. Flowers of the ***Hylocereus*** are the largest in the cactus family with largest easily exceeding 12 inches (30cm) in length and diameter. The floral tubes are thick with leafy scales and no spines or bristles or hairs. The flowers are primarily white fragrant opening at night. Surprisingly, these massive flowers will only remain open a few a few hours and just one night. The combination of large size and short lifespan makes viewing a flower a real and beautiful treat. Well establish plants in warmer climates may produce many flowers over the course of several nights. Fruits usually spineless with persistent succulent leaf like scales, green and red, pulp white, minute black seeds, exarillate.[7] ***Hylocereus undatus*** is the species most cultivated for fruit.

Key to the species:

Margins of stems shallowly crenate, not horny, with spines on apices of the crenations, scales on ovary small, scattered. ….. *H. Trigonus*
Margins of stems undulated, horny, with spines in the depressions, scales on ovary large, imbricate. ….. *H. Undatus*

It belongs to the ***Cactaceae*** family to a genus of, today, some 15 known species first discovered in Cuba. It was more common in the early 20th century before land clearing for cattle grazing and human habitation occurred in its known habitats.

Description of *Hylocereus trigonnus* Species:

Hylocereus trigonnus is a terrestrial or epiphytic appearing shrubby cactus more or less scandent, with ascending and erect branches both at the base and above. [8]It generally grows up to about 10 meters (33ft.) in height and 2 to 4 centimeters in diameter. The cactus bases of

[7] hhtp://cactiguide.com/cactus/?genus=Hylocereus
[8] http://eol.org/pages/588923/details#diagnostic_description

mature specimens are rounder and light gray-brown in appearance up to 2 inches wide. It has aerial roots. It is a much branched vine type sprawling and climbing cactus. It is no epiphytic, but roots on the ground and climbs from its ground base. It climbs on rocks, trees and bushes in dry forests.

Climbs on Trees and Bushes ***Climbs on Rocks***

The many jointed elongated stems, without leaves, are thin ribbed or thickly three angled, slender, green, strongly undulated marginally, not with areoles with spines borned at the tip of the undulations. The stems have 3 prominent ribs in separate stems, distinctly notched and with broadly rolling scalloped edges. Ribs of the young joints are thinner and appear pointed at the tip.

At the tip of the crenelated rolling scalloped edges, small brown-felted areoles bear 6-8 conical spines, 2,4 or 8 mm long, stiff, greenish when young, turning yellowish brown and brown as they mature, often with two accessory bristles. The spines are persistent. The cactus can appear vine-like in mature spread out specimens but requires support of other plants or small trees. It has been observed free standing to at least 1.5 meters.


The upper tips of the younger stems have brown areoles up to the stem tip that are closer in distance and curved in the tip edges from where flower cephalia tubes develop. Some flower perianth stop developing and dry out without flowering, turning orange red before falling off the stem. The ones that flower and fruit equally drop of leaving a noticeable scar on the rib areole that bear the spines.


Maturing Flower Perianth with prior flower scar on stem's left

Drying Flower Perianth with prior two flower scar on right stem

More than one flower tube can be borne from a single rib. In the ***VMT*** populations we have not observed profuse flowering or multiple flowers from the same branch or plant at the same time. The outer perianth segments of the flower tube are green, linear, and have similar smaller areoles like those of the rolling scalloped-edged top of the ribs. The tubes are three 20 to 24 cm long (10-12 inches) and about 3 to 5 cm wide.

The Hylocereus genus of cacti is often referred to as the night-blooming cactus (though the term is used for many other cacti).[9] Its flowers are the largest in the cacti family. It is best

[9] http://en.wikipedia.org/wiki/Hylocereus

known for producing exotic, large fruits, known as Dragon Fruit. The fruits are larger than an orange, with pinkish-red skins accentuated by green scales. ***The combination of a large beautiful flower, short lifespan and large red exotic fruit makes viewing the flowering and fruiting of Hylocereus trigonnus a very special treat!*** Flowering and fruiting has been observed from July to November. Thus the solitary flower that only lasts one night is referenced as nocturnal with an extended early short diurnal period of flower opening. The flower emerges from the obconic (about 4-5 cm wide) perianth and opens at night from about 10 p.m. to about 10 a.m. This nocturnal flowering mechanism of the flower is a protective mechanism of the cactus against bird and animal predations of the flower.


The flower tube opens to a campanulate ovary crown corolla that also displays the outer scatter scales of the elongated fleshy tepals around the flower crown. White flowers are solitary, hypanthium[10], pendulous, 20-30 cm long, borned auxiliary to the group of spines or terminal on the ribs ridges of the stem, often short spines in axils. The dichlamydeous/heterochlamydeous *perianth* [11]infundbuliform[12] (funnel shaped),with small outer scatter scales, outer tepals are fleshy, yellowish green and ovate, the inner distal petals white, turning yellowish when mature or dry out.

[10] a cuplike floral tube called a **hypanthium, http://en.wikipedia.org/wiki/Hypanthium**
[11] http://en.wikipedia.org/wiki/Perianth
[12] http://en.wiktionary.org/wiki/infundibuliform

The flower's calyx has an outer segments are sepal, acuminate, style elongated 4.5 to 7.5 cm. long, oblong and usually yellow or yellowish green, the corolla's inner segments are white petals, acuminate, style elongated 3.5 to 7.5 cm. long, and twice as wide as the sepals, numerous stamens capped with yellowish anthers and a large finger or tree like style crowned with numerous stigma lobes of the pistil that when appreciated together as a whole flower creates both a beautiful, crowded and very reproductive functional mature flower.

***Hylocereus trigonus* - Inner Perianth Pistil and Detail, Photo P. Acevedo**[13]

[13] http://botany.si.edu/antilles/WestIndies/imagepage.cfm?imagename=PA00419.jpg

The inner periath segments of the flower corona has a circular row of numerous 100-200 white long hair like filament stamens capped by yellow white pollen anthers that radiate and fill around the style. The style stigma is tree or finger like at the ovary crown having 20-25 radiating stigma filaments all joined together in the ovary crown that combine around the crown at full flower opening. [14]

Pollination is similar to most flowers it only requires that the pollen of the stamen be taken and placed on the stigma lobes of the pistil of the flower of the same species. As the flower is pollinated the function of the flowering half of the perianth has been performed completed and it proceeds to dry out into a brownish red thin straw like fashion. The fertilized ovary base of the perianth remains as it starts to mature the coming fruit. Bees and other insects provide the fertilization functions to the flower and ovary.

[14] http://commons.wikimedia.org/wiki/File:Mature_flower_diagram.svg

Fruits develop as an oblong, subglubose to ellipsoid pod in the ovary of the flower-tube as the fertilized ovary shrinks the campanulate flowering crown, and grows and expands inside the cephalia tube to about 5 to 7 centimeters (1.75 to 2.5 inches) in diameter with tepals of the hypanthium or flower-tube remaining persistent around the fruit. Birds are very fast to pray and pick the fruit. In the left photo above we can observe the two initial pricks of a bird beak. Most fruit in the wild suffers this fate for in ***Culebra*** it is not commonly used for fruit.

The fruit is normally between 300 to 600 grams but larger fruit is produced by the ***Hylocereus undatus*** relative that is the preferred hylocereus cacti for commercial production of fruit in Asia. The inside of the fruit produces a white gelatinous matrix full of numerous, minute black seeds. It is eaten scooped out with a little spoon nature fresh or with a dash of lime juice to reduce the sweet taste. It is a very thirst- quenching, mostly when refrigerated. The taste is said to be something like a melon or kiwi (the crunchy seeds contribute to the kiwi comparison): sweet, but not intense. The pulp is also used to make a very delicious ice cream. The fruit is very rich in vitamin C and mineral salts. It is also claimed to have laxative and stimulating properties.[15]

A controlled study in a nursery is needed to observe and document in more detail seed reproduction. It has also been reported and observed that independent stem fragments that fall to the floor after a storm will root into a plant. Digital photographic records by the author over several years evidence flowering from April through mid July. Observation efforts need to be expanded to determine presence of flowering during other months of the year.

Ecosystems and Ecological Associations or *sub-ecosystem*:

Culebra enjoys a warm humid subtropical climate and its ecosystem may be described as a **Subtropical Dry Forest**, the driest life zone of the six zones present in the platform. **Culebra** has a dry season that extends from early spring to summer, except for hurricane events, and a

[15] http://theelderofsaintmartin.blogspot.com/2011_10_01_archive.html

wetter fall and winter with occasional rain events. There are no rivers or streams in **Culebra**. The island has dry drainage basins that activate during significant rain events. **Culebra**, contrary to sections of **Vieques, St. Thomas, and St. John and well as in some of the BVIs**, does not have a subtropical moist forest area. Water and moisture has a significant impact on flora habitat composition.

Three distinct ecological associations or life zones are clearly identified within the **VMT** site. They are described as ***(i) the cliff association***, ***(ii) the dry forest association*** and ***(iii) the grassland association***. The three associations are interconnected as an ecosystem whole.

The ***cliff association*** is found in the extreme southern area of the property where steep seashore cliffs roll down to **Playa Cascajo**.

A particular characteristic of the **dry forest association**, that prevails throughout the interior hillside of **VMT**, is the low density and high separation between the small trees found in such terrain. Trees of some size and higher tree density may be noted generally in limited areas on the northern side of the site, particularly in drainage basins of the northern central hill and in some areas of the basin that drain southwest toward Fulladosa Bay in the southern half of the central hill of the **VMT** property.

A notable characteristic of the **grassland association** is the fact that it is manifested throughout a significant portion of the property; not only on top of the hills, throughout the central hill and southern and northern hill saddles and flat hilltop areas where the local vegetation was removed for cattle grazing, but also in areas where some trees have developed.

The coastal area of **Playa Cascajo**, in **VMT's** southern boundary, provides a proper habitat for coastal vegetation of the **Subtropical Dry Forest** zone of life. This coastal habitat is limited by the seashore's short depth and the immediate rocky cliff associations that are characteristic of the geography of the southern extension of the **VMT** site. The **Playa Cascajo** beach area is not deep or sandy and is covered by rocks or dead coral and crush shells ("cascajo").

The "*Cascajo*" designation for the beach area describes its fractured stone, dead coral and seashell ground cover in Spanish. Other areas of **Culebra** provide wider coastal habitat

extensions allowing for better development of coastal habitat plants within such areas and also allowing, in some sandy beaches, turtle nesting areas.

Culebra's Ecosystems, Ecological Associations and Sub-ecosystems:

Culebra enjoys a warm humid subtropical climate and its ecosystem may be described as a **Subtropical Dry Forest**, the driest life zone of the six zones present in the **Puerto Rico Platform. Culebra** has a long dry season that extends from early spring to the end of summer, except for hurricane event interruptions, and a wetter fall and winter with occasional rain events. **Culebra**, due to the lower elevations of its hills captures less moisture and rain events. In contrast to the more elevated sections of Vieques, St. Thomas, St. John and some of the BVIs, **Culebra** does not have a subtropical moist forest zone of life area or rainforest. This has a significant impact on its flora composition. Due to the limited rainfall there are no rivers or streams in **Culebra.** We can find a few drainage ponds naturally or constructed to control rain flows that also assist to control sedimentation and numerous dry drainage basins that activate during significant rain events. The drainage basins due to their function receive more water and retain creating a limited enhanced vegetation zone. This condition, except during hurricanes and sporadic significant rain events, reduces the regular low river-carried sedimentation transportation into the surrounding coast. This climatic ecosystem without river flows creates the conditions for **Culebra** to enjoy very clean beaches with crystalline water. The beach of **Playa Flamenco** in the northwest tip, for example, has the largest retention lagoon in **Culebra** created by its sand dune natural barriers into what was, originally, a longer shallow bay that naturally protects the beach and its water from the drainage and sedimentation of the surrounding hills to create one of the world's cleanest beach waters.

Ecological Associations

Very Clean Beaches

Ecological Associations:

As previously mentioned, Culebra is classified as a **Subtropical Dry Forest**, the driest life zone of the six zones present in the **Puerto Rico Platform**. Three distinct ecological associations are clearly identified within the **VMT** site. They are described as **(i) the cliff association, (ii) the dry forest association and (iii) the grassland or herbaceous association**. The three associations are interconnected as an ecosystem whole.

The **cliff association** is found in the extreme southern area of the property where significant seashore cliffs roll down to **Playa Cascajo**. This **cliff association,** as its names describes, is characterized by extreme cliff contours and narrow coastal areas.

Cascajo Beach Area

Cascajo Beach Cliffs Association

A particular characteristic of the **dry forest association**, that prevails throughout the interior hillside of VMT, is the low density and high separation between the small trees found in such terrain. Trees of some size and higher tree density may be noted generally in areas on the sides of the central hill of the site, particularly in drainage basins of the northern central hill and in some hillside basin areas that drain southwest toward Fulladosa Bay in the southern half of the central hill of the **VMT** property.

A notable characteristic of the **grassland or herbaceous association** is the fact that it is manifested throughout a significant portion of the **VMT** property; not only on the flatter top of the hills, throughout the central hill and southern and northern hill saddles and flat hilltop areas where the local vegetation was removed for cattle grazing, but also in areas where some smaller invasive trees have reestablished themselves.

Herbaceous Associations

Herbaceous Associations

The coastal area of **Playa Cascajo**, in **VMT's** southern boundary, provides a proper habitat for coastal vegetation of the dry forest association. This habitat is limited by the seashore's short depth and the immediate cliff associations that are characteristic of the geography of the southern extension of the **VMT** site and **Culebra** generally. The beach area is not deep or sandy and is covered by rocks or dead coral and shells ("cascajo" in Spanish).

The "Cascajo" designation for the beach area describes its fractured stone, dead coral and seashell ground cover. Other limited areas of the island of Culebra provide wider coastal habitat extensions and even some sand dune areas allowing for better development of coastal habitat plants within such areas and also allowing, in some sandy beaches, turtle nesting areas.

Meteorology and Climatology:

Winds and Storm Events:

In general, the island of **Culebra** is subject to three wind patterns: (1) the prevailing **Caribbean trade winds** that blows at an average speed of 8 knots from the east-northeast November through January and from the East the rest of the year, (2) the **sea breeze** from the prevailing direction and (3) the **land breeze** that blows generally from the **Caribbean Sea** in the southeast side of the island, but is also known to blow from the equator to the south during the warmer months. Hurricane events produce an additional exceptional wind pattern that creates a changing counter-clockwise circular movement of wind of varying strengths, depending on the event, its speed, intensity, proximity and the direction of storm movement.

The Hurricane season extends annually from June to October with most storms occurring July to September. High energy storms cause significant damage to the property and infrastructure of **Culebra**. The storms originate off the western coast of Africa and generally move west or northwest direction tracking to the south, to the north or infrequently through Puerto Rico. Severe hurricane associated with el **Niño** weather influences from the Pacific ocean, occur every 10 to 20 years. The vegetation on the hillside also suffer damage from the strong winds and the coastal areas and beaches and sand bars suffer from the strong winds, higher se levels from storm surge, wave setup and storm wash. The beaches suffer flattening by reason of erosion and damage to the upper beach deposition of the lower beach away from the beach face. The trajectory also affects which side suffers more damage. However studies conducted following the passage of Hurricane Hugo that struck in September 1989 with its 140 mile per hour sustained winds indicate that the immediate post storm damage to beaches, sand deposits and corals is transitory and the beaches and corals recover. The studies conclude the fact of the recovery but the assertion that high energy storms may be needed to maintain the health of the delicate marine ecologies in the coastal areas.16 The vegetation was back on track and substantially recovered within two years except for the trees that were termite infested or uprooted completely.

The 1989 Hurricane Hugo storm that tracked northwest between St. Thomas and the east cost of Puerto Rico caused extensive damage destroying over 80% of wooden structures and homes in **Culebra**. The storm did considerable damage to hillside tree and bush cover. Approximately 100 of the 300 vessels that took refuge in the "hurricane proof" protected **Ensenada Inlet** were destroyed littering the shoreline The storm and waves lifted and transported a large VI ferry vessels that was on to the hill on the west side of **Fulladosa Bay** as some 70 feet above sea level. The wind rose available in the former Roosevelt Road Naval Station record an all-time high wind gust of 104 knots.

According to the wind rose available in the former Roosevelt Road Naval Base Airport and the St. Thomas Airport, the nearest official data published by the U.S. Weather Bureau, the wind in

[16] Swab, Dr. Williams ,High Energy Storms Shape Puerto Rico Fact Sheet, USGS Coastal & Marine Ecology Program, hhtp://pubs.usgs.gov/fs/high-energy-storms/index.html

the proposed development site of **VMT** blows predominantly from the east around 40% of the time and from the east-northeast 20% of the time. These two wind vectors represent the predominant wind direction 60% of the time. Windy days can produce wind bursts of up to 32 knots.

The trade winds generally blow from the east during the winter and from the southeast during the summer and in the evenings. The trade winds tend to refresh and cool the island surface and ambient temperature both during daylight and at night. The sea breeze and the land breeze generally blow in opposite directions. The counter movement from the southwest and the easterly counter flow cause inductive flows. Sea breezes are produced during the day due to the faster heating of the earth's surface on the island, which causes the cooler sea breezes to rise due to the inductive flow. During the evening, as the land cools, the circulation pattern is inverted. Limited precipitation ensues due to the lower elevation of the hills.

Temperature:

Culebra enjoys a year round tropical marine climate with gentle breezes. Temperatures in the main island of Puerto Rico generally become cooler with the elevation as we travel up to the central mountain range with slight temperature variances. In **Culebra,** the hills don't enjoy such microclimate differences due to their low heights. The **Culebra** hilltops will generally feel cooler due mainly to stronger breeze patterns and not real temperature differentials. During the winter season, the average temperature is 74 degrees Fahrenheit with November through April being the cooler months. During the summer season, from June to September, temperatures average 90 degrees Fahrenheit. Relative humidity averages 67% to 70% during the year but can fluctuate to above 80% during the wet seasons or during or after significant rain events. The more humid months are August to January.

Historical Precipitation or Rainfall:

There is general consensus that the late Pleistocene, Wikipedia defines it as "the geological epoch which lasted from about 2,588,000 to 11,700 years ago, spanning the world's recent period of repeated glaciations"17 was much dryer and as much as 8^{o}C cooler than today18 ." Relying on data from Curtis et al.200119 Lazell summarizes the last 8,000 years of precipitation as follow:

> "Precipitation increased dramatically to a peak about 8,000 ybp [years before present], when sea levels was about 20 m. below its current level. There followed a dry spell, with precipitation falling off to today's levels for about 800 years, then increasing to set the highest [during] Holocene, Wikipedia defines Holocene as "the geological epoch which

[17] http://en.wikipedia.org/wiki/Pleistocene
[18] Lazell,2005, Ibid. p. 108
[19] Curtis, J.,Brenner,M., and Hodell, D, Climate Change in the circum-Caribbean (late Pleistocene to Present) and Implication for regional biogeography. In Biography of the West Indies, 2nd Ed., 2001, Woods, C.A. & Sergile,F.E., eds. Pgs. 35-54, CRC Press, Boca Raton, Fla.

began at the end of the Pleistocene (around 12,000 to 11,500C years ago) and continues to the present."20, record of about 7,200 ybp (ca. 8,200 radiocarbons ybp). There was another drop to today's precipitations levels at about 6,000 ybp (ca. 7,500 radicarbons ybp). Then rainfall increased and continued to be high, right through the hypsithermal21 maximum, 6,000-4,000 years ago. The dramatic raise in sea level that brought the ocean up very close to today's levels, ca. 4,000 ybp, was not complemented by changes in precipitation: Conditions remained much wetter than they are now. About 1,680 ybp, a 500-year spell of rainfall (similar to ours today), a relative draught, began. Following the 500 year draught, rainfall increased sharply after 1,200 ybp and peaked in a brief pluvial-period centered about 1,000 ybp with conditions as wet as they were during the long Holocene span of 6,800 to1,680 ybp – and much wetter than now. Since that time climate has died down to what we live with today."22

Precipitation and Rainfall:

Precipitation on the island of **Culebra** is mostly of (1) **orographic nature**. When masses of air in sea breezes containing moisture pushed by **Trade Winds** are swept from the ocean onto land up the side of a higher hill, adiabatic cooling results and, ultimately, condensation and precipitation of short duration follows. The higher hilltop range in the north side of the island, by visual appreciation of cloud cover and precipitation events, seems to enjoy more rainfall during the year.

I have observed over the years that moisture clouds arrive to **Culebra** predominantly from the neighboring St Thomas in the northeast and during stronger easterly fronts or hurricane events from both the USVI and BVI. The masses of air in sea breezes containing moisture over the warmer ocean pushed by **Caribbean trade winds** are first swept from the ocean onto land on the neighboring higher elevations of St Thomas where they produce rain events. This generates moisture laden clouds that are pushed again by the same **trade winds** and continue to travel south westerly over **Culebra.** Its highest hills are **Monte Resaca** with an elevation of 650 feet (198 m) and **Cerro Balcón** with 541 feet (134 m) on the north side of the island. The higher elevation of these northern hills of **Culebra** have a cooler condition that allows them to receive slightly more rain than the lower elevations of the southwestern side but during the two rainy season, first in, May and next in September to November, many rainfall events reach the **Punta Soldado** side and southwestern shores of the island accumulating some rain and moisture.

[20] http://en.wikipedia.org/wiki/Holocene

[21] A climatic phase in the early to middle part of the Holocene (q.v.)-lasting several thousand years-when conditions were appreciably warmer than today, is called *hypsithermal*. http://www.springerreference.com/docs/html/chapterdbid/4549.html

[22] [22] Lazell,2005, Ibid. p. 108-09

There are two additional mechanisms responsible for rainfall in the Northeastern Caribbean: the (2) **tropical wave currents** coming from the east and the (3) **cold fronts (or "troughs")** coming generally from the northeast from the North Atlantic area of the North American Continent. **Caribbean trades winds** are refreshing and **the cold fronts (or "troughs")** from the North Atlantic area generate more winds and cooler temperatures in **Culebra** and its surrounding waters. The cold fronts events bring a northwesterly wind pattern that travels in southeasterly direction over the island pushing the moisture laden clouds from the neighboring **Caribbean** islands and St. Thomas away from **Culebra** to the **Cuenca de Vieques** channel south of **Culebra.** The cool air and ocean wave action that accompanies the front, cool both the island's ocean water and land. This cooler climate and coastal water temperature annual climate period coincides with its dry season from January to April.

It appears that a phenomenon similar to the one that occurs in the Galapagos Islands in the Pacific Ocean is repeated in **Culebra** annually. In Galapagos the prevailing climate effect of the cool Humboldt Current causes the shores of the southern islands to be bathed in cool waters, chilling the air and creating unusually cold conditions for equatorial islands. During this period, rain is scarce on the coastal regions. Only plants that can survive long periods of time without water can establish and develop in these climatic conditions. In **Galapagos** every seven years the pastern is reversed, when the cooler Humboldt Current is interrupted by the **El Niño** climate phenomenon, which drives warm waters that are normally sent westward by wind and the Earth's rotation, toward the shores of South America and the **Galapagos Islands**. The **El Niño** inducted warm seas bring very heavy rainfall to the **Galapagos**. In **Culebra** the rain pattern impact of the cooler waters and **cold fronts (or "troughs") from the North Atlantic area** appears to occur annually. The **El Niño** phenomenon changes wind and temperature patterns that warm the waters of the Caribbean Sean and South Atlantic Ocean around the Equator with consequent changes in weather and climate patterns in the Caribbean Sea area and the southern Atlantic Ocean to the north. The **El Niño** inducted warmer climate and ocean waters also change the intensity, direction and frequency of annual Hurricane Events from July to October in the West Indies and the Gulf of Mexico.

Culebra's rainy season extends from September to November. Rainfall also usually occurs during the month of May followed by a dryer summer. This dry summer rainfall pattern is disrupted, by the annual hurricane or tropical storm season that lasts from July to October. During the hurricane season rain events depend on the direction, intensity and speed of travel.

Culebra, however, is considered to have a dry tropical island climate due to **extended dry seasons and low total annual accumulated rainfall**. The mean annual precipitation in **Culebra** averages 842 mm (84.2 cm) or 33.55 inches of rain annually.23 In 1994, the **USFWS' Recovery Plan** estimated mean annual precipitation was 975 millimeters (or 38.38 inches).24 However,

[23] Geoffrey M. Bonnin, Deborah Martin, Bingzhang Lin, Tye Parzybok, Michael Yekta, David Riley, 2006: *NOAA Atlas 14*, ***Precipitation-Frequency Atlas of the United States***, *Volume 3 Version 4.0: Puerto Rico and U.S. Virgin Islands*. Silver Spring, Maryland, p. A.4-20.

[24] 1 inch = 24.5 mm

rainfall in **Culebra** can range from a low of 16 inches recorded in 1967 to a high of 59 inches recorded in 1942.25 The greatest amount of rainfall was 27 inches recorded in May of 1979.26

A 2009 publication by Dr. Jose A Colón, who served as Director of the San Juan Office of the U.S. Weather Service for 23 years, provides a higher annual rainfall estimate. The publication indicates that "the data for a period of 19 years of the island of **Culebra** – located some twenty five miles from Fajardo – **indicates an annual rainfall of 41.5 inches or 1,054.1 mm**. The rainy season extends from May to November with less rain in June and July and a dry season from January to April."[27] (Translated from the original in Spanish) During 2013 we did an informal measure at **VMT** of some 39.5 inches.

Reproductive and Species Status:

The ***Hylocereus trigonus*** is a commonly observed native species to ***Culebra*** although little is known about the cacti its flowers and fruit. Some property owners have plants in their land and have never seen it flower or fruit over extended years. It is also possible to see it flower become a bud and never see it fruit. There has been no need to protect the species and the fact that it is not well known protects is native and stable vegetative status. **Flowering** has been observed to occur in the dry tropical forest of VMT and in **Culebra**. **However, the frequency of flowering and fruiting is highly influenced by the dry tropical climate of Culebra. *Hylocereus*** plants grow normally and withstand the dry rain extended season but rarely bear flower or fructify spontaneously**.**

Pollination or fertilization of the ovary is generally carried out by insects, bees being the natural most efficient agents in carrying out the function during the short nocturnal flowering interval. Natural pollination because of the size of the bees and short overnight pollination window is inefficient in laying sufficient pollen in the anthers of the pistil to produce commercial size fruit. In commercial plantings the more pollen received at the anthers the better the fertilization and size of fruit. Manual pollination is commonly practice in commercial production to assist. It has also been proven and discovered that it is best to cross pollinate the ***Hylocereus undatus*** planted and grown commercially with the pollen ***Hylocereus costaricemsis*** or ***Hylocereus purpusii*** to produce larger fruit.

Hylocereus plants will grow both from cuttings as from seedlings. The plants reproduced from cuttings develop and bear fruit faster including within a year compared for three years for plants developed from seedlings. The cacti is not often grown in pots in Greenhouses due to the size and spread of its stems and its rapid pace of growth making them a burdensome plant to keep in a Greenhouse. Due to a shallow rooting system it demands little amount of mineral

[25] Ordnance and Explosive Waste Search Repot [OEW], Feb, 1995, **USACE Defense Environmental Restoration Program**, Project No. I02PR006802, p. 8
[26] Ibid
[27] Colon, José A. (2009). ***Climatología de Puerto Rico***. La Editorial, Universidad de Puerto Rico: San Juan, p. 123 and Figure 43.

and organic mineral notwithstanding is large size. Regular watering of the plant will favor the flowering and fruiting.[28]

Two ***Hylocereus trigonus*** specimens were plante in mid January 21, 2015 in the **VMT** greenhouse to observe reproduction be rooted and non rooted stem growth habits and to observe speed and general plant development. The plants will received more frequent watering that in the natural habitat and fertizer assited feeding.

Updated – January 19, 2015

[28] Ditto