

# A Survey of Indigenous Tropical Legumes of Puerto Rico<sup>1</sup>

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## INTRODUCTION

Nitrogen is the principal limiting factor among the major plant nutrients in economic crop production in most cultivated regions of the Tropics. Use of legumes in the cropping system is a very important way to supply this element, especially in those areas of the tropical world where farmers cannot afford costly nitrogen fertilizer. Certain legumes have been included in crop rotation as a long established practice in the old world Tropics. This practice is not followed in the Neotropics presumably because information about indigenous tropical legumes is lacking for this region.

Central and South America are among the most promising areas for finding tropical pasture legumes useful for grazing and improvement of soil nitrogen according to Bryan (3). Research on legumes in the Neotropics is, however, still in its infancy. Bermúdez García (2) found species in the genera *Centrosema*, *Desmanthus*, *Desmodium*, *Stylosanthes*, and *Zornia* in the Cauca Valley in Colombia of potential interest. Dirven (5) noted that 5 percent of the natural grassland vegetation in the coastal region of Surinam consisted of Leguminosae, chiefly *Desmodium triflorum*. Semple (7) reported that legumes in the Costa Rican grasslands constitute 5 to 25 percent of the vegetation. Of 79 legume species examined by De Souza in Trinidad, only 64 were nodulated (4).

Research and selection of tropical legumes for better adaptation, palatability, improved forage, seed yield and protein content is needed badly. A survey of root nodulation and efficiency of nitrogen fixation among native legumes is thus a logical initial step to reveal the *Rhizobium* strains of highest nitrogen-fixing capacity. Then, by cross-inoculation technique, the most efficient *Rhizobium*/legume association hopefully can be established.

To this end, a survey of the Island of Puerto Rico was conducted for indigenous tropical legumes conceivably having potential value for agricultural purposes. The results of this survey are given in this paper with brief descriptions of the nodules and field observations pertaining to the plants, soils, and environmental conditions. This information is of pertinence to rhizobiologists and research agronomists in other tropical and subtropical areas, and especially to agricultural scientists in Puerto Rico.

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TABLE 1.—*Species of legumes found in Puerto Rico with nodule characteristics, habitat, and plant growth habit*

Legume host	Nodule characteristics	Habitat	Plant growth habit
Sub-family Papiliono- ideae <i>Abrus praecatorius</i> L.	Occurrence scarce in dry season, singly on fine roots; round to oval, brownish white; 2-3 mm in diameter.	Wide distribution throughout the Island in open scrubby areas, common in woodlots; prefers well drained soil, acid pH (4.6) with 114-203 cm rainfall.	A deep-rooted vigorous vine, spreading over shrubs and trees about 300 cm long; flowering and fruiting heavily.
<i>Aeschynomene americana</i> L.	Occurrence prolific, roots virtually covered with nodules, confined to principal branches where it forms rows of nodules; round; smooth surface; pink; 1.5 mm diameter.	Widespread in moist roadside and swampy depressions throughout the Island in acid to alkaline soil.	Vigorous herbaceous shrub, 165 cm high; flowers and fruits heavily.
<i>Aeschynomene sensitiva</i> Sw.	Occurrence rare, firmly attached to the main roots; round; brownish white; 1.5-2 mm diameter.	Same as <i>A. americana</i> L.	Same as <i>A. americana</i> L.
* <i>Aeschynomene portoricensis</i> Urban	Occurs in fair numbers, singly distributed on the main branches; round; white to earthy grey; smooth surface; 1-3 mm in diameter.	Siliceous, shale-derived, moist, acid (pH 5.1) sandy soil, high in organic matter.	Rarely found, sparse growing, vine-like, about 80 cm long, creeping; flowers and fruits poorly.
<i>Cassia diffusa</i> DC.	Nodules few, scattered over the branch roots; fairly firm texture; flattish, finger or triangular shape; 1-6 mm long, majority 4 mm.	A local plant, in siliceous sand.	Diffuse, slender, deep rooted plant; poor seeder.
* <i>Cassia swartzii</i> Wickstr.	Abundant, distributed over the whole root system, firmly attached; polymorphic; brownish red with white tips; 1-7 mm long, majority 5 mm.	Moist slope from low to higher elevations; wide distribution in 150-250 cm rainfall areas in all types of soils.	Diffuse to erect shrub, 60 to 180 cm tall; fair seeder; ornamental yellow flowers.

<p>Sub-family Mimosoideae <i>Desmanthus depressus</i> H. &amp; B.</p>	<p>Occurs in fair numbers, singly, on fine roots only; young nodules round, but mature ones dumbbell shaped with a constriction in middle; whitish grey color; young nodules: 1.5 mm in diameter; mature nodules: 1.5 mm wide and 2.5-4 mm long.</p>	<p>Coastal slopes, dry to moist areas, near neutral to alkaline soil.</p>	<p>Low growing slender diffused plant; fair seeder.</p>
<p><i>Alysicarpus vaginalis</i> (L.) DC.</p>	<p>1-2 minute nodules found only on main roots of very young seedling, nodules observed only occasionally on adventitious roots from the creeping stems; nodules round with smooth surface; 1-1.5 mm in size.</p>	<p>Widely distributed in moist open weedy areas in all types of soils.</p>	<p>Prostrate, matted vine; fruiting heavily.</p>
<p>*<i>Cracca caribaea</i> (Jacq.) Benth.</p>	<p>Occurrence scarce, on main branch roots; round becoming elongate finger-like with a slight constriction in the middle; white when young but grey when old; firm texture; surface striate; 1-4 mm long.</p>	<p>Grows in open to moist forest, mostly along southern slopes, in alkaline soils (pH 8.2).</p>	<p>Sparse-growing shrub up to 180 cm high, more commonly 60-90 cm; fruiting habit fair to poor.</p>
<p><i>Canavalia maritima</i> (Aubl.) Thou.</p>	<p>Occurs in fair numbers, distributed on branch roots; young nodules round, mature nodules lobed; surface hard; color white which turns dark with age; fairly big in size, range from 1.5 to 2 cm in diameter.</p>	<p>Alkaline sandy beach soils throughout the Island.</p>	<p>A long creeping beach plant; flowering and fruiting heavily.</p>
<p>*<i>Calopogonium orthocarpum</i> Urban</p>	<p>Very few, found on main and adventitious roots arising from the nodes of the creeper; surface smooth or sometimes slightly rough; emits a strong ammoniacal odor when bruised; 1-3 mm in diameter.</p>	<p>Scarcely found plant, occurs in open, siliceous sand and wet, acid, peaty areas (pH 5.0).</p>	<p>A short prostrate vine; flowering and fruiting sparse.</p>

TABLE 1.—Continued

Legume host	Nodule characteristics	Habitat	Plant growth habit
<i>Desmanthus virgatus</i> (L.) Willd.	Occurrence plenty, borne on fine braches; whitish grey color; smooth waxy surface; in size these were the biggest nodules encountered during this investigation. In the month of August in an acid sandy soil on the sea shore, nodules of unusually big size and varied shapes were observed on this legume; the nodules were radially branched giving rise to different shapes, such as fan or coral; 1-3 cm in dimension. However, nodules occurring at other locations were finger or dumbbell shaped and 1-4 mm in size.	Same as <i>D. depressus</i> .	Erect growth, up to 180 cm; heavy seeder.
<i>Centrosema pubescens</i> Benth.	Profuse nodulation, spread all over the roots occurring close together especially on branch roots, few large nodules found only on thick roots; round; white; surface reticulate; size range 1-7 mm, majority measured 3 mm.	In moist to well-drained areas throughout the Island in all types of acidic to alkaline soils.	A twining slender vine; flowering and fruiting throughout the year.
* <i>Centrosema virginiana</i> (var. <i>latifolia</i> ) (L.) Benth.	Very scarce, borne near the crown on principal branches; round; surface reticulate, translucent wall, nodule content clear to light brown; 2-5 mm in diameter, majority 3 mm.	Same as <i>C. pubescens</i> Benth. but also found in acid beach soil.	Same as <i>C. pubescens</i> Benth.
* <i>Clitoria laurifolia</i> Poir.	Scarce, on very fine upper branches; round; yellowish brown; surface rough; 2-3 mm in diameter.	Moist, acid and alkaline sand; occurrence very localized.	A sparse vine, up to 240 cm long; seeds commonly destroyed by insect larvae.
<i>Clitoria rubiginosa</i> Juss.	Occurrence fair, spread all over the fine roots, attached loosely and dislodge easily; round; white; surface reticulate; size up to 2 mm.	Same as <i>C. laurifolia</i> Poir.	Same as <i>C. laurifolia</i> Poir.



<i>Crotalaria incana</i> L.	Nodules few, only on very young seedlings; finger-like, pink; 2-4 mm.	An uncommon weedy plant growing in disturbed areas on the southern sea coast; alkaline soil pH.	A small herbaceous shrub; flowering and fruiting fair, but seeds attacked by larvae.
<i>Crotalaria retusa</i> L.	Nodules attached mainly to principal roots near the crown, branched like fingers of the palm; smooth surface; white; pink or purple, nodule terminals darker; nodules easily dislodged; size range 2 mm-1 cm.	Widespread in moist areas on the sea coast as well as at higher elevations.	Same as <i>C. incana</i> L.
<i>Crotalaria striata</i> DC.	Nodules blocky, flat, branched, and frilled, occurring an inch apart on the roots; young small nodules pinkish brown, older ones white and smoky; size range 0.6 mm-1 cm.	Moist disturbed areas from coastal to higher elevations.	A weedy gregarious shrub, up to 200 cm high; flowering and fruiting heavily; seeds attacked by insect larvae.
* <i>Dalbergia monetaria</i> L.f.	Nodules few, attached to main and secondary thick roots; hard and woody; rough surface; color reddish brown turning dark when old; 1.5 to 3 mm long.	A local widespread plant of rocky ravines and open woods of medium elevations (300 meters); soil quite acid (pH 4.7).	A large woody vine; up to 900 cm long; flowering and fruiting heavily.
<i>Desmodium adscendens</i> (Sw.) DC.	Profuse nodulation, occur along the principal branches; round; pink; smooth surface; 1.5-2 mm in size.	Disturbed, moist to wet areas; in low to high elevations; acid soil of pH 5.	A procumbent plant growing in mats, vigorous grower and heavy seeder.
<i>Desmodium axillare</i> (Sw.) DC.	Profuse nodulation, nodules occur on the adventitious roots arising from the nodes of the creeper, occurring in clumps of 2 to 4 nodules at one place; uniformly round; grey color; size 2-5 mm.	In moist open woods, having 125-150 cm rainfall; slightly acid to neutral soils.	A vigorous, matted, stoloniferous plant; seeding fairly abundant.
<i>Desmodium barbatum</i> (L.) Benth.	Nodules abundant, mostly in the vicinity of the main root, on principal branches; round; smooth surface; brown; 1.5 mm average size.	Locally abundant, in moist acid (pH 4.6) sandy soil.	Annual herb, up to 60 cm high; seeding profusely.

TABLE 1.—Continued

Legume host	Nodule characteristics	Habitat	Plant growth habit
<i>Desmodium canum</i> (Gmel.) Schinz & Thellung	Uniformly distributed, at the end of very fine roots; round; brown; surface has a fine prickly and cracked appearance; 2-3 mm size.	Disturbed areas and laws throughout the Island; acid (pH 4.8) to near neutral soils.	Prostrate to bushy, low shrub; flowering and seeding heavily.
<i>Desmodium procumbens</i> (Mill) Hitchc.	Nodules few attached to branching roots; round; white or greenish when young, turning pinkish brown when mature; surface streaked; 1-2.5 mm in size.	Found mostly in dry to moist southern slopes, with 760 cm rainfall; alkaline soil (pH 7.5).	A weak vine-like shrub; fair seeder.
<i>Desmodium molle</i> (Vahl.) DC.	Nodules present in fair number on branch roots; round when young but lobed and streaked when mature; most nodules earthy cream color, but some pink colored; 1-3.5 mm in size.	Same as <i>D. procumbens</i> .	A seasonal shrub up to 180 cm high; flowering and fruiting fair.
<i>Desmodium purpureum</i> (Mill.) Fawc. & Rendle	Occurs in fair number, singly on very fine branches; round; grey; surface rough showing streaks; easily dislodged; size 1.5-4 mm.	Same as <i>D. molle</i> and <i>D. procumbens</i> .	Vigorous shrub up to 240 cm tall; flowering and fruiting heavily.
* <i>Desmodium sintenisii</i> Urban	Very few, borne on fine lateral branches; round; dark grey; uniformly rough surface with whitish fissures; 1 to 3 mm diameter, majority 2 mm.	Rare local plant of moist limestone hills.	Prostrate stoloniferous plant; fruiting light.
<i>Desmodium scorpiurus</i> (Sw.) Kuntze	Borne on thick main roots, most abundant near the crown; round; pinkish brown; smooth surface with whitish cracks; 1-3 mm.	Infrequent but wide spread in moist areas; soil pH near 8.	Vigorous, matted, low shrub; heavy seeder.
<i>Desmodium triflorum</i> (L.) DC.	Occurs in fair numbers, attached firmly to main roots of the creeper; round; white, brown or pink colored; 1.5-2 mm diameter.	Common to moist roadsides and disturbed areas, in low to middle elevations; soil pH may vary from acid (5.1) to alkaline (8.2).	A matted carpet-like growth; less than 5 cm high; flowering and seeding fair.

<i>Galactia dubia</i> DC.	Very scarce, on well developed white root and its branches; young nodules round but older ones of irregular shapes mostly finger-like and branching; light yellow turning brown with age; 2 to 4 mm long, sometimes as large as 12 × 6 mm.	Infrequent, in coastal open areas and dry woodlands; alkaline soils.	A slender vine up to 240 cm long twining on shrubs; fruiting fair.
<i>Galactia striata</i> (Jacq.) Urban	Extremely small nodules distributed all over the fine root system, occasionally 2-3 bigger nodules present; round; white; bigger nodules measure 1.5-4 mm in diameter.	Same as <i>G. dubia</i> DC.	Same as <i>G. dubia</i> but heavy seeder.
<i>Indigofera suffruticosa</i> Mill.	Few nodules present on very fine branches; polymorphic in shape (round, oval, finger-like, cuboid), color varied e.g., white, yellowish or brown; size range 1-6 mm.	Dry to moist open areas from coast to middle elevations; soil pH near neutral.	A suffrutescent greyish shrub, up to 240 cm tall; flowering and fruiting heavy.
<i>Phaseolus adenanthus</i> G. F. W. Meyer	Nodules plenty, distributed all over the root system; round; greyish with white streaks; rough surface; 0.5-4 mm in size.	Moist woodlots and moist open forest throughout the Island; wide range of soil pH from acid to alkaline.	Weedy twining vine up to 600 cm long; seeding fair.
<i>Phaseolus lathyroides</i> L.	Profuse nodulation, clustered around the main roots near the crown; round; pink nodules found only in March-May; old nodules blue to dark brown; surface striated; most nodules measure 2.5-3 mm, but a few to 6-7 mm.	Most commonly seen legume in the Island; found in fields, roadsides, and disturbed sites through the Island under a wide range of soil pH.	Herbaceous shrub or vine-like, up to 180 cm, normally 90-180 cm tall; flowering and fruiting heavily.
* <i>Phaseolus trichocarpus</i> C. Wright	Nodules very scarce, borne on branch and adventitious roots growing from stem nodes; round; surface smooth; pinkish green color with white cracks; 1 to 2 mm.	In moist acid sandy peat (pH 5.1); occurrence very rare.	Herbaceous slender vine rooting at nodes.
* <i>Vigna hosei</i> (Craib.) Back	Occurs in sufficient numbers principally on thick main roots, not easily dislodged; round but tend to form 3 to 4 lobes; pink color; smooth surface; 1-3 mm diameter, usually 2 mm.	Locally abundant in moist northern slopes; in near neutral soils.	A slender, matted, stoloniferous vine, sparse fruiting.

TABLE 1.—Continued

Legume host	Nodule characteristics	Habitat	Plant growth habit
<i>Rhynchosia minima</i> (L.) DC.	Occurrence scarce, distributed over whole root system, borne singly; round or oval on fine branches; long finger-like on main roots; surface reticulate; color grey with whitish cracks; size 4–5 mm.	Abundant, from coastal to middle elevations in well drained soils, in southern part of the Island having alkaline soil.	A vigorous slender vine, but highly susceptible to leaf mosaic; heavy fruiting.
* <i>Rhynchosia reticulata</i> (Sw.) DC.	Very scarce, only few plants found nodulated with 2 to 3 nodules present per plant, borne on very fine lateral roots; easily dislodged; round; yellow; surface rough; 1.5–3 mm in diameter, majority 2 mm.	Less abundant and found in drier areas than <i>R. minima</i> ; alkaline soil pH.	A larger vine than <i>R. minima</i> ; heavy fruiting.
<i>Sesbania sericea</i> (Willd.) DC.	Occurrence abundant, in clusters or strings on thick main branches mostly near crown, oval or egg shape; some nodules so close together that they coalesce giving rise to relatively big nodules; nodules firmly attached; surface smooth; nodules appear pink in June–July, and brown at other times; size 3–4 mm.	Heavy poorly drained marl clay near the coast, in alkaline clay soils derived from shell.	An annual shrub up to 300 cm high; heavy seeder.
<i>Stylosanthes hamata</i> (L.) Taubert	Small round nodules of uniform size occurring singly on fairly thick branch roots. The roots present an appearance of spiked-fence wire with very short branches arising in bunches at intervals. Nodules mostly brown, some pink; smooth surface; size 1–1.5 mm.	Locally abundant in coastal dry to moist open areas and roadsides, with alkaline soil pH.	A sparse growing, low shrub; seeding year-round.

<p><i>*Tephrosia cathartica</i> (Sesse &amp; Moc.) Urban</p>	<p>Nodules few, scattered on fine branches not borne terminally; mature nodules finger-like, sometimes the long ones are bifurcated; wall noticeably transparent through which the inner darker content is visible; very young nodules measured 2 mm in diameter, older finger-like nodules were up to 10 × 3 mm.</p>	<p>Coastal alkaline sand and drier areas.</p>	<p>A low growing greyish annual shrub; heavy seeder.</p>
<p><i>Tephrosia cineria</i> (L.) Pers.</p>	<p>Occurrence fair, scattered along the fine branches, not borne terminally; mostly long finger-like, some bifurcate; wall almost transparent through which the dark inside content visible; size ranged from 2 mm in diameter for round nodules to 10 × 3 mm for long nodules.</p>	<p>Open sea coasts to coastal slopes with alkaline soil pH.</p>	<p>Vine-like, procumbent, greyish plants; heavy seeder.</p>
<p><i>Teramnus labialis</i> (L. f.) Spreng.</p>	<p>Very few nodules, on very fine branches, delicately attached so that they are easily dislodged; round; surface reticulate and transparent through which the inner dark content visible; young nodules clear white, older show dark content; size 1-4 mm.</p>	<p>Coastal sand and shrubby areas in the southern part of the Island with alkaline soil (pH 7.8).</p>	<p>Slender twining vine; fair seeder.</p>
<p><i>Teramnus uncinatus</i> (L.) Sw.</p>	<p>Occurrence fair, borne singly all over the root system; round; earthy grey; 1-2 mm in diameter.</p>	<p>An uncommon vine found mostly in thickets at lower to middle elevations; soil with near neutral pH.</p>	<p>A slender hairy vine, 180 cm long; flowering and seeding fair.</p>
<p><i>Vigna repens</i> (L.) Kuntze</p>	<p>Occurrence profuse during March and April but scarce in December; when profuse they occur all along the roots arising from the creeping stem; occur in clumps of 4-5 at intervals of 10 to 25 mm on thick</p>	<p>Abundant in coastal wet areas, also found at higher elevations; very acid (pH 4.5) to neutral soils.</p>	<p>Herbaceous, creeping or twining vine with ornamental yellow flowers; heavy seeder.</p>



TABLE 1.—Continued

Legume host	Nodule characteristics	Habitat	Plant growth habit
<p><i>Vigna vexillata</i> (L.) A Rich.</p>	<p>fleshy roots; also occur as beaded chain along roots; round; smooth surface; pink color; usual size of individual nodules 3 mm diameter when in cluster but when occurring isolated and singly they tend to grow larger, 4–5 mm in diameter. Occurrence scarce, attached mostly to secondary roots, a few on main roots, not present on fine roots; very young nodules are round, becoming 3–4 lobed as they grow; surface becoming rough in fully grown nodules; color white in young nodules turning to pink with white streaks, in mature nodules; size 1–4 mm in diameter.</p>	<p>A local plant of open or grassy fields, in very acid soils (pH 4.5).</p>	<p>A long creeping vine rooting at the nodes; fair seeder.</p>
<p><i>Zornia diphylla</i> (L.) Pers.</p>	<p>Uniformly small round nodules occurring all along the length of the firm roots; surface smooth; nodule color white or light pink; size 1–1.5 mm.</p>	<p>A rare local plant, found in siliceous sand and moist shale to sandy clay soils; soil pH range from 5 to 8.</p>	<p>A sparse growing deep rooted procumbent plant with small slender leaves in pairs; flowering and fruiting year around.</p>
<p>Sub-family Caesalpinioideae <i>Cassia mimosoides</i> Benth</p>	<p>Fair number of nodules, borne on fine branches mostly close to crown, delicately attached and easily dislodged; young nodules round, mature nodules long jointed finger-like, some branching to give glove-like appearance; surface smooth; color distinctly brown; 1–1.5 mm thick, and 4–5 mm long, occasionally some very large nodules measured to 1.0 cm in length.</p>	<p>Cosmopolitan distribution in dry to moist areas; near neutral to alkaline soil (pH 6.6–8.2).</p>	<p>Herbaceous, dense, slender shrub, up to 75 cm tall, usually gregarious; seeding fair to heavy.</p>

\* Not previously recorded for nodulation.

### EXPERIMENTAL PROCEDURE

Field trips were taken periodically to different parts of the Island. The same sites were revisited at different times of the year. Normal healthy plants were collected and field observations were recorded regarding the plant, soil, and environmental conditions. The root system with associated nodules were dug out, placed in plastic bags and chilled in an ice-chest, where they remained until reaching the laboratory where the roots were washed and nodule characteristics noted and recorded.

*Rhizobium* bacteria were isolated after surface sterilization of the nodules with 0.1-percent zephiran chloride solution followed by inoculation of yeast-mannitol agar medium (1) containing asparagus extract with the crushed nodule sap as described earlier (6). Presence of gram-negative banded bacteria was taken as presumptive evidence of the *Rhizobia* isolates.

### RESULTS

Among the indigenous tropical legumes surveyed, a total of 49 nodulated species were considered to have some potential value for agricultural use. Of these, 13 species had not been recorded for nodulation previously according to the global listing of nodulated and non-nodulated legumes maintained by Dr. O. N. Allen (personal communication). These were reported earlier (6) and are marked with an asterisk in table 1 which lists the 49 species and furnishes a description of the root nodule, plant habit, and habitat.

Contrary to the usual belief that nodulation occurs mostly in near-neutral to alkaline soils, the following well-nodulated native legumes were found to occur in acidic soils: *Abrus praecatorius* L., *Aeschynomene portoricensis* Urban, *Calopogonium orthocarpum* Urban, *Dalbergia monetaria* L.f., *Desmodium adscendens* (Sw.) DC., *Desmodium barbatum* (L.) Benth, *Phaseolus trichocarpus* C. Wright and *Vigna vexillata* (L.) A. Rich.

A few legumes were found in soils which varied in reaction from very acid to near-neutral, for example: *Desmodium canum* (Gmel.) Sching & Thellung, *Vigna repens* (L.) Kuntze., *Zornia diphylla* (L.) Pers.

These legumes may prove of real interest for cross-inoculation and legume-breeding investigations.

### SUMMARY

A search was conducted in Puerto Rico for nodulated indigenous tropical legumes which show possible potential for agricultural purposes. Forty nine such legume species were encountered, of which 13 were new records for nodulation. Descriptions are given for the rhizobial nodules on the 49 species and agronomic observations on the growth habits of the plants and their habitats are furnished.

## RESUMEN

Se llevó a cabo en Puerto Rico una búsqueda por legumbres nativas tropicales noduladas de posible utilidad agrícola. Se hallaron 49 de estas especies de legumbres, de las cuales 13 eran noduladas y no se habían informado antes. Se describen los nódulos rizóbicos de las 49 especies y, además, se presentan observaciones agronómicas sobre el hábito de crecimiento de las plantas y sus habitats.

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