

## STRUCTURAL VARIATIONS IN ERYTHROXYLON LEAVES.\*

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## INTRODUCTION.

The genus *Erythroxylon* is indigenous to tropical countries and several species have been under cultivation in South America since prehistoric times. The records of early Spanish explorers note the use of coca leaves by the natives and the stimulating effects resulting therefrom. Botanical records of the coca plant first appear in Monardes' "Historia Medicinal" (1580), repetition being made in "Clusius' Exoticorum Libri Decem" (1605). The first specific description of *Erythroxylon Coca* is that of Lamarck in "Encyclopedie Methodique" (1786), this description being based upon specimens of De Jussieu obtained in Peru. The illustration of Cavanilles (Diss. iii, pl. 229-1789), said by Morris (*Kew Bull.*, xxv. 2) to have been made from the same specimens, pictures the leaves as oval, whereas they are described by Lamarck as ovate and pointed. Cavanilles' figure, although differing in this respect from the description of Lamarck, is said by Rusby to agree with the cultivated *Erythroxylon Coca* of Bolivia as he has seen it and also with the figure in Engler and Prantl (17). Dyer states that this figure agrees with Hooker's illustration of *Erythroxylon Coca* in *Botanical Magazine*, 1836, from a plant collected by Matthews near Chinchao, Peru. But complications have arisen through circulation of a figure showing the leaves as ovate instead of oval. This figure is claimed by Holmes (10) to have been incorrectly copied from Hooker's original, but Rusby holds that both of these illustrations apply to *Erythroxylon Coca* and that Cavanilles' figure is of typical cultivated leaves, whereas the ovate leaves represent those of the wild growing plant. Dr. Burck in an article in *Teysmannia* makes the statement that during his survey he finds no plants in Bolivia and Peru with ovate leaves and if this were an outstanding character of the plant described by Lamarck it was no longer common in those countries. Furthermore all commercial supplies of Bolivian or Huanuco coca leaves show the oval form as illustrated by Cavanilles.

This study was undertaken at the suggestion of Dr. H. H. Rusby who, because of his botanical explorations in South America, has been able to furnish specimens and data at first hand. The first intention was to limit this research to those species of *Erythroxylon* mentioned in pharmaceutical literature, but as the work has progressed the possibilities of a systematic histological survey as related to classification have become apparent and the scope has been broadened beyond the original plan. The work is divided into two major sections—the first dealing with the gross characters of the leaves of several species of *Erythroxylon*; the second treating of the histological structure of the various specimens. In the latter section interest chiefly centers about the question of using histological data as an aid in the determination of closely related species of a given genus and whether or not such evidence might not be made more use of in systematic botany.

From an economic standpoint the comparatively few species of *Erythroxylon* which yield cocaine and the related alkaloids rank first. Other species containing

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but little alkaloid, although only of botanical interest to us, may be used as masticatory agents. An alkaloidal principle was isolated by Gaedeke in 1855 and termed *erythroxyline*, but Dr. Albert Niemann made the first thorough investigation of coca leaves and gave the name *cocaine* to the chief alkaloid. Further investigations disclosed the fact that the several alkaloids occurring in the leaves might upon suitable treatment be converted into cocaine. Perhaps some of the species now only of botanical interest might serve as sources of the alkaloids but as such materials are not cultivated and are therefore not available in quantity, manufacture of cocaine from these is but a remote possibility. Cultivation has, as is the case with many other alkaloidal drugs, resulted in the production of a leaf richer in alkaloid, but as the amount of alkaloid normally present under the best conditions is small, those leaves which contain only traces of it are not likely to be used for manufacturing purposes. The majority of pharmaceutical references deal with those species which are used or have been used for the production of cocaine. The species so used are said to include *Erythroxylon Coca*, Lam.; *E. Truxillense*, Rusby; *E. Coca* var. *Novagranatense*, Morris; and *E. Coca* var. *Spruceanum*, Burck.

Usually coca leaves appear in the market under commercial names, as Bolivian, Truxillo, Huanuco, Ceylon, etc., and frequently such titles bear but little relation to botanical origin. Because of this condition we find the pharmaceutical literature chiefly devoted to an effort to properly place these commercial varieties botanically. Another difficulty encountered in the botanical identification of these *Erythroxylons* is due to the effects of environment upon the habit, gross structure and perhaps the histological characters. The effects of climatic conditions and cultivation or lack of cultivation have undoubtedly been responsible for some of the controversies which have arisen regarding the botanical origin of several members of this genus. Dr. Rusby has noted that when plants of *Erythroxylon Coca* revert to the wild state and are exposed to the tropical sun for several generations the following modifications occur:

1. The leaves become thicker, stronger veined, and the veins are impressed on the upper surface.
2. The upper surface becomes darker and more shining than in the cultivated coca.
3. The lower surface becomes brown and rough, with lateral lines of collenchyma obscure or lacking, or the midvein area is of a different color and surface appearance than the balance of the leaf and this area is enclosed by irregular lines of connecting veins.
4. The leaves become strongly pointed to acuminate.

On the other hand when plants of *Erythroxylon Coca* revert to a wild state but grow under shaded conditions, the leaves become larger, thinner, of paler color and with the lateral lines more prominent (14). Reference to the illustrations accompanying Dr. Rusby's article shows the decided difference between leaves of *Erythroxylon Coca* grown under both of the above conditions as contrasted with the leaves from cultivated plants. These differences are so great that it is easy to understand how disputes have arisen regarding the leaf characters of this plant. In line with these effects of environment upon leaf character is the history of a line of plants distributed to various parts of the world from Kew Botanical Garden. The parent plant, cultivated at Kew since 1869, is noted as grown from seeds of the *Huanuco* variety (*Erythroxylon Coca*, Lam.). According to Dyer this plant agrees with a specimen collected by Triana (Magdalena River, 1851) and a specimen

collected by Purdie (New Granada, 1845) and subsequently named *Erythroxylon Coca* var. *Novagranatense* by Morris (7). But the Huanuco variety of this country as imported from South America is positively identified as *Erythroxylon Coca*, Lam. by Rusby (14). The possibility of modification in leaf characters through change in environment is recognized by Morris in offering his title *Novagranatense* as a variety of *Erythroxylon Coca* and he also admits the possibility of several climatic forms which are nearly all related varieties of the same species (5).

If cultivation or lack of cultivation in the case of *Erythroxylon Coca* results in such marked changes in leaf character as those noted, it is reasonable to suppose that this plant, grown in countries far removed from its natural habitat may, in course of time, become so different as to warrant the establishment of new species, or at least new varieties. This view would be strengthened by the results secured in experimental work on many of our cultivated plants. But the question arises as to how extensive must the variations be in order to justify the adoption of new specific names. A second question concerns the histological characters of a series of more or less closely related forms of the genus *Erythroxylon* and to what extent the changes in leaf character due to environment or other causes are reflected in differences in histological structure.

In view of the diversity of opinions it has been deemed advisable to briefly review the available pharmaceutical literature and group the statements of different authorities under both the botanical and commercial designations of the various species of *Erythroxylon*.

*Erythroxylon Bolivianum*, Burck.—This species must be abandoned in favor of *E. Coca*, Lam., on the ground of priority. Hartwich (3).

This specific name is proposed by Burck because, although figured by Nevinny (*Das Cocablatt*, Vienna, 1885), the Bolivian leaves were not described by Peyritsch in his monograph of 82 species of *Erythroxylon* (*Flora Brasilenses*, Tase, 81) (7).

The leaves of this species are described by Burck as broadly elliptical; broader above the middle and less tapering (than *E. Spruceanum*); midrib ending in a short excurrent point; tapering below; 5 to 8 cm. in length and 2½ to 4 cm. in width; two (lateral) lines apparent on the under surface; a distinct ridge appearing on the upper surface of the midrib; leaves more coriaceous than those of *E. Spruceanum* (7). This description would apply to the figure of Bolivian leaves given by Hartwich (3).

This species according to Holmes represents the Bolivian coca in British commerce (4).

Burck considers the plant cultivated in British India as sufficiently distinctive to constitute a new species which he terms *Erythroxylon Bolivianum* (13).

Burck states the following differences between his *E. Bolivianum* and *E. Spruceanum*. *Bolivianum*—Upper surface of the midrib shows a crest; the leaves are thicker (than *E. Spruceanum*); green above and light green below; more elliptical than *E. Spruceanum*. *Spruceanum*—No crest appears on the upper surface of the midrib; leaves are light green above and pale below; leaves are more tapering below than *E. Bolivianum* (13).

Rusby is of the opinion that *Erythroxylon Bolivianum*, Burck, is *E. Coca*, Lam. (14).

*Erythroxylon Coca*, var. *Spruceanum*, Burck.—Burck (1890) describes this as a variety of *Erythroxylon Coca* (2).

Holmes concludes that Java coca and possibly Ceylon and Indian cocas are from this species, which is differentiated from *E. Coca*, var. *Novagranatense*, by possessing lanceolate leaves (2).

This plant is considered by Dyer as intermediate between *E. Coca*, Lam. and *E. Coca* var. *Novagranatense*, Mor., and agrees with herbarium specimens collected by Spruce in the Rio Negro district in 1854 and subsequently cultivated in India. It differs from *E. Coca Novagranatense*, Mor. in that the leaves of the latter taper less below, are broader at the center and do not show an emarginate apex. It differs from *E. Coca*, Lam. in size, form, color of leaves (dark green) and habit of growth. It is a variety of the same value as *E. Coca*, var. *Novagranatense* (7).

Burck describes the leaves as oval becoming smaller above the middle; midrib ending in a small excurrent point; leaves tapering below into leaf stalk; 4 to 6 cm. in length and 1.5 to 2.5 cm. in width; under surface with two (lateral) lines; no ridge appearing on upper surface of midrib; leaves thinner than *E. Bolivianum*, Burck (7). This description does not agree with figures given by Hartwich (3) for *Buitenzorg Coca*. One of his illustrations is of an elliptical to oblanceolate leaf while the other is obovate, and these figures are accompanied by a notation that both leaves are from the same plant.

The plant cultivated in Java is not an intermediate form between *E. Coca*, Lam. and *E. Coca Novagranatense*, Mor., and Burck proposes the title *E. Coca*, var. *Spruceanum*, because of agreement between it and Spruce's specimens from Rio Negro in Kew (13).

Rusby holds that the title *E. Spruceanum* cannot apply to Java leaves, as it is already preoccupied (*E. Spruceanum*, Peyr.) (14), (16).

*Erythroxylon Spruceanum*, Peyritsch.—Holmes states that this species is nearly allied to *E. Coca*, Lam., with leaves of the same type but larger and longer; agreeing with *E. Coca*, Lam. in color and presence of a distinct ridge on the upper surface of the midrib (10).

*Erythroxylon Coca*, var. *Novagranatense*, Morris.—Morris describes cultivated Peruvian coca under title *E. Coca*, var. *Novagranatense* (2, 5).

Holmes concludes that Peruvian and Truxillo leaves are from this species and also that a mark of distinction is the oblanceolate form of the leaf (2).

It is represented by the plant cultivated at Kew since 1869 and according to Dyer this plant agrees with specimens collected by Triana (Magdalena River, 1851) and by Purdie (New Granada, 1845) (7).

Trimen states that plants grown in Ceylon are from Kew plant (*E. Novagranatense*, Mor.) but that leaves of such plants show characters typical of Peruvian leaves; being  $3\frac{1}{2}$  inches by  $1\frac{1}{2}$  inches; oval; pointed and dark green. Jamaica and St. Lucia plants also show characters of *E. Novagranatense* and are apparently from the Kew plant; the leaves being obovate; blunt or emarginate, membranous and of grass-green color (9).

Bentley and Trimen give a colored illustration of *E. Novagranatense* and also a figure of the *Bolivian Coca* from a specimen in the British Museum. The leaves of the former are shown as obovate to lanceolate, blunt or rounded, lines indistinct, while in the latter the leaves are broader and more elliptical, apex more pointed, lines more prominent and leaves larger. The caption accompanying these illustrations states that they are full size (10), (12).

Holmes states that the Kew plant (*E. Novagranatense*, Mor.) appears to represent the *Huanuco coca* of commerce since the seed from which it was grown was obtained from the latter plant (13).

Rusby holds that the Truxillo leaf of the British market and cultivated in British provinces from seed of the Kew plant and termed *E. Novagranatense* by Morris is distinct from both the Huanuco or Bolivian leaves and the Truxillo coca of the New York market, although nearer the latter than the Bolivian. Also that this variety is probably *E. carthagenense*, Jacq. (14). After further investigation Dr. Rusby is now of the opinion that *E. Novagranatense* is distinct from *E. carthagenense*.

Holmes states that the identity of *E. Novagranatense* and *E. carthagenense* might well be supported by the alterations in the shape, size and apex of the leaves of the Kew plant after five years' cultivation in Lazos but that it is better to retain a separate title until the identity is better proven. (11).

*Bolivian Coca*.—Hartwich states that this commercial variety is from *E. Coca*, Lam. and these leaves are lanceolate, oval, ovate acuminate or obovate; up to 9.5 cm. and with vein ridge well marked (3).

According to Rusby this variety is from *E. Coca*, Lam. (14).

Holmes concludes that this article is from *E. Bolivianum*, Burck, and that the term *Huanuco* is synonymous with *Bolivian* (2).

Holmes describes the leaves of Bolivian or Huanuco coca as 3.5 to 7 cm. in length; 2.5 to 3.5 cm. in width; brownish green; oval; entire; glabrous; with a distinct ridge above the midrib on the upper surface; curved lines on the lower surface; the midrib prolonged into an apiculus which is frequently broken off in handling (4).

*Peruvian Coca*.—Hartwich states that this is from *E. Spruceanum*, Burck. He describes these leaves as more uniform in size and shape (than Bolivian) and with the vein ridge not as prominent (as Bolivian) (3).

Holmes holds that this is identical with the Truxillo variety and is from *E. Novagranatense*, Mor. (2). He also describes these leaves as smaller, narrower and more fragile (than Bolivian); with no ridge on the upper surface of the midrib; 4.5 by 2 cm. and with areolae (lines) not distinct (4).

*Truxillo Coca*.—Rusby states that Truxillo coca cultivated in British possessions is from *E. Novagranatense* but that the Truxillo leaves in American markets are from *E. Truxillense* (14).

Holmes places all Truxillo leaves as from *E. Novagranatense* (2), (4), but later adopts Rusby's title of *E. Truxillense* (11).

*Java Coca*.—Holmes concludes that this is from *E. Spruceanum*, Burck (2). He also states that this variety differs from Bolivian leaves in being paler green and tapering more to the apex and from Peruvian leaves in not showing the ridge over the midrib and tapering less to the base (4).

Burck holds that this variety is not intermediate in form between *E. Coca* and *E. Novagranatense* as claimed by Dyer and proposes the title *E. Coca* var. *Spruceanum* because of its agreement, as determined by Dyer, with Spruce's specimens from Rio Negro (13). He also holds that these leaves differ from those of *E. Novagranatense* by being broadest at the center, tapering less below and in not having an emarginate apex (7).

Trimen states that this variety is from intermediate forms classed provisionally as *E. Bolivianum* but with narrow, oblong, pointed leaves, dark green above and glaucous below (9).

*Indian and Ceylon Coca*.—Holmes concludes that these varieties are from *E. Spruceanum*, Burck (2) but later states that the Ceylon is usually the Bolivian variety (4).

Trimen states that all plants grown in Ceylon are from the Kew plant (*E. Novagranatense*) but differ from this in having leaf characters typical of the Peruvian variety (9).

#### MORPHOLOGICAL CHARACTERS OF ERYTHROXYLON LEAVES.

Bearing in mind the diversity of opinions as shown by the preceding citations we turn to brief descriptions of the leaves of the series of specimens at hand. These materials represent one or more specimens of various species of *Erythroxylon*, as follows:

|                               |             |
|-------------------------------|-------------|
| Erythroxylon Coca, Lam.       | 4 specimens |
| “ Novagranatense, Mor.        | 2 “         |
| “ Truxillense, Rusby          | 3 “         |
| “ Spruceanum, Peyr.           | 1 “         |
| “ carthagenense, Jacq.        | 1 “         |
| “ subracemosum, Turcz         | 1 “         |
| “ pauciflorum, Rusby          | 2 “         |
| “ Bangii, Rusby               | 2 “         |
| “ cumanense, H. B. & K.       | 1 “         |
| “ Popayanense, H. B. & K.     | 2 “         |
| “ areolatum, Linn.            | 5 “         |
| “ anguifugum, Mart.           | 7 “         |
| “ brevipes, DC.               | 2 “         |
| “ Urbanii, O. E. Schulz       | 1 “         |
| “ havanense, Jacq.            | 2 “         |
| “ minutifolium, Griseb.       | 1 “         |
| “ alaternifolium, A. Rich     | 1 “         |
| “ obovatum, Macfad.           | 2 “         |
| “ Pelletierianum, A. St. Hil. | 1 “         |
| “ nitidum, Spreng.            | 1 “         |
| “ Columbianum, Mart.          | 1 “         |
| “ orinocense, H. B. & K.      | 1 “         |
| “ unidentified or uncertain   | 5 “         |

These specimens were obtained from the following sources: The Herbarium and Drug Museum of the School of Pharmacy, Columbia University; the Herbarium and Economic Collection of the New York Botanical Garden and from Dr. H. H. Rusby. The identity of all material was checked by Dr. Rusby, attention was restricted to mature leaves and in instances of doubtful determination this fact has been stated in connection with the description. It must be borne in mind that size and color are variable characters, therefore variations in size have been stated where the amount of material was sufficient for this purpose. In stating colors of these leaves the color standards and terms of Ridgway (18) have been followed. This is perhaps a departure from the usual terminology but I believe there is a real necessity for more exactness in color nomenclature, especially in pharmacognostic work. Ridgway's standards are rather extensive for botanical use, but a

simplified form of these or a standard color chart would go far toward doing away with expressions like "light greenish brown," "ochraceous," "dark greenish brown" and a multitude of others which are so indefinite that no two individuals will agree as to the color meant.

*Erythroxyton Coca, Lam. (wild growing).*—(Plate I, Nos. 1–2.) This specimen is from the Herbarium of Columbia University, School of Pharmacy. The material was collected by Dr. Rusby near Yungas, Bolivia, at an altitude of 6000 feet, in 1885. The exact history is unknown but Dr. Rusby states that it was obtained on the upper Rio Negro from a number of plants having the same general habit and showing similarities to both *E. Coca* and *E. anguifugum*. This statement is borne out by the acuminate apex similar to *anguifugum* and the traces of lateral lines characteristic of *Coca*. The leaves are obovate to oval; range from 95 to 45 mm. in length and from 35 to 18 mm. in width; apex acute to acuminate and with an apiculus but slightly less prominent than that of *E. Coca*; base acute to cuneate; mars brown on upper surface; argus brown on lower surface; thin; the two sides of the leaf being markedly unequal.

A second specimen (Plate I, No. 2) submitted by Dr. Rusby as representing a wild growing *E. Coca, Lam.*, was found to show a fair degree of agreement with the leaf described above. This leaf is oval elliptical; 60 to 25 mm. in length; 29 to 12 mm. in width; apex acute; apiculus present; base acute; upper surface sepia; lower surface snuff brown; membranous; veins not prominent; lateral lines apparent on but few leaves; midvein slightly one side of the central part of lamina.

Rusby has noted (14, 19), the modifying effects of cultivation and exposure on various species of *Erythroxyton* and these specimens would agree, at least in part, with his conclusions. The upper surface is much darker and more lustrous than the cultivated plant. The lower surface, while of lighter color than the upper, is much darker than any of the cultivated varieties and the venation is strong. The lateral lines are more obscure and the apex is more pointed. The single point of disagreement with his conclusions is that the leaves of one of these specimens are thinner than the cultivated *E. Coca*, measuring but 126 microns, whereas the latter averages 150 microns. On the other hand the second specimen closely approximates the cultivated article in this respect, being 157 microns in thickness.

*Erythroxyton Coca, Lam.*—(Plate I, Nos. 3–4). This material is from type specimens in the Herbarium of Columbia University, School of Pharmacy, collected by A. Miguel Bang near Yungas, Bolivia, in 1890 ("Plantae Boliviana," No. 268). These leaves range from broadly elliptical to broadly obovate; 39 to 24 mm. in length; 19 to 12 mm. in width; apex acute and occasionally obtuse; apiculus prominent; base acute; upper surface Saccardo olive; lower surface buffy citrine; membranous in texture; lateral lines prominent; veins prominent on upper surface, those of lower surface more prominent outside the lateral lines than between these structures and the midrib; midvein centrally located or very nearly so. Examination of a five-pound sample Huanuco Coca leaves from the drug stock of the school shows that many of the leaves are larger than those of this herbarium specimen.

The figure (Fig. 1) accompanying an abstract of Dr. Burck's article in *Teysmannia* as it appears in (*Pharm. Jour. and Trans.*) p. 817 (April 2, 1892), shows the leaves of this plant as ovate-lanceolate, whereas all specimens at hand are broadly elliptical to obovate.

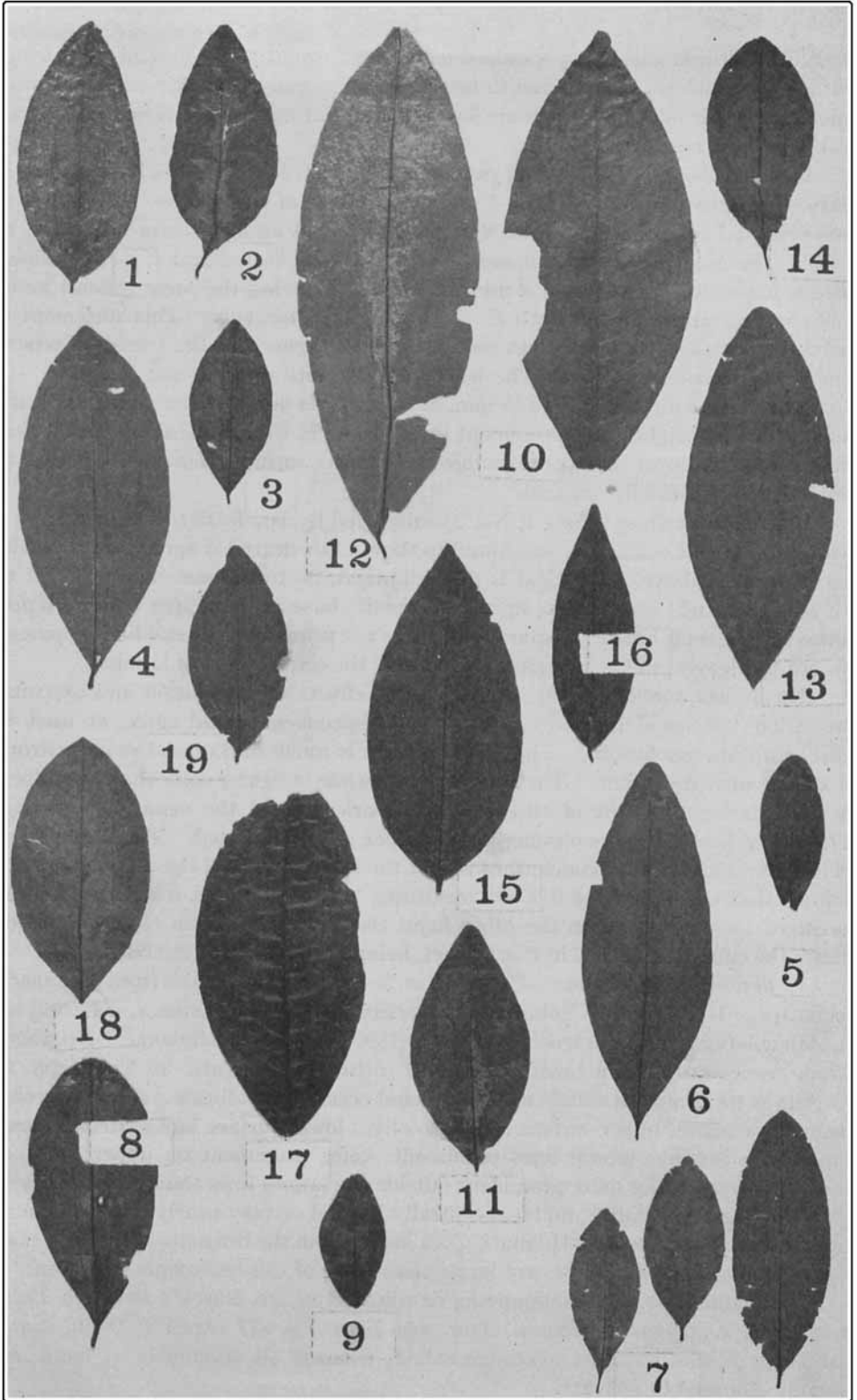


Plate I.



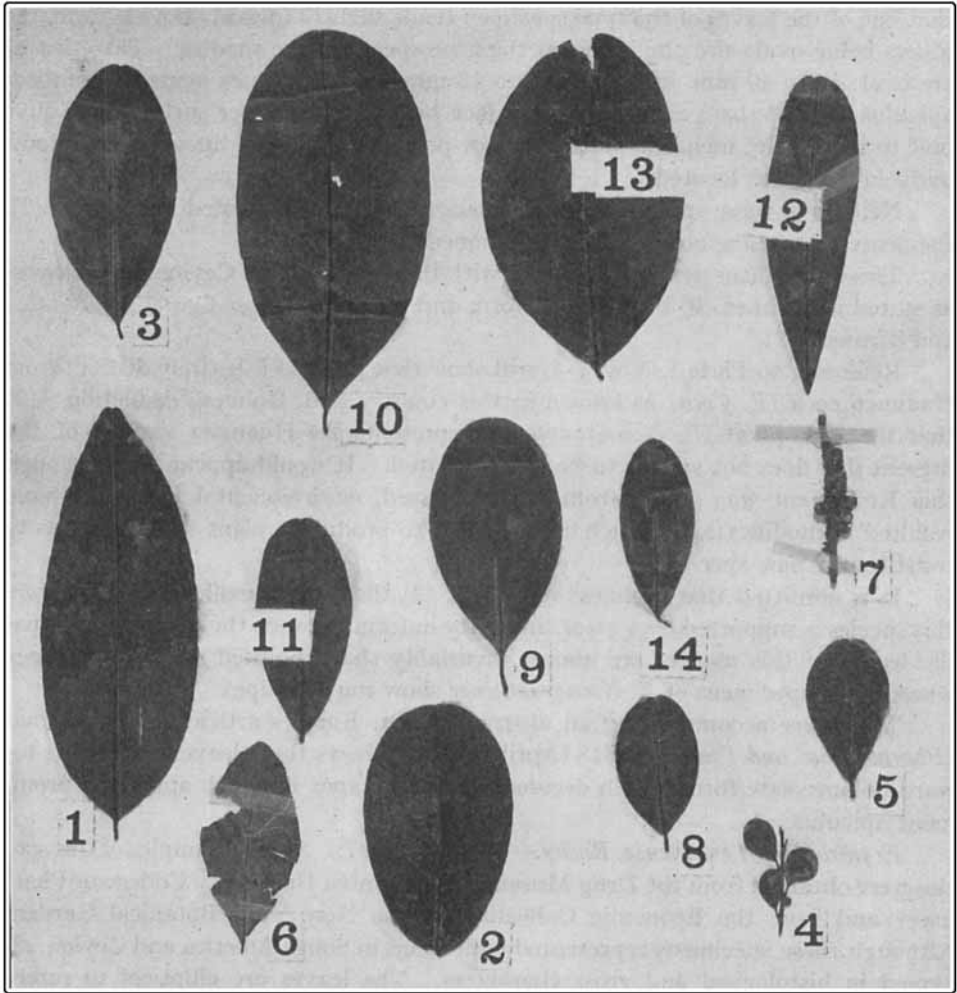


Plate II.

Plate I.—1-2, *E. Coca* (wild); 3-4, *E. Coca* (cultivated); 5-6, *E. Coca* var. *Novagranatense*; 7, *E. Truxillense*; 8, *E. carthagenense*; 9, *E. subracemosum*; 10, *E. pauciflorum*; 11, *E. cumanense*; 12, *E. popayenense*; 13, *E.*, wild growing, identity not known; 14, *E. areolatum* (Type C); 15-16, *E. anguifugum*; 17, *E. Columbianum*; 18, *E. "Haya;"* 19, *E.* wild growing, identity not known.

Plate II.—1, *E. Spruceanum*; 2, *E. Bangii*; 3, *E. areolatum* (Type A); 4, *E. brevipes*; 5, *E. Urbanii*; 6, *E. havanense*; 7, *E. minutifolium*; 8, *E. alaternifolium*; 9, *E. obovatum*; 10, *E. areolatum* (Type B); 11, *E. Pelletieranum*; 12, *E. nitidum*; 13, *E. orinocense*; 14, *E. obovatum*.

The leaves of this species at my disposal agree with the illustrations of *E. Coca*, var. *Bolivianum*, Burck, and support Rusby's idea (14) that var. *Bolivianum* is identical with *E. Coca*, Lam.

*Erythroxylon Novagranatense* (Morris) Hieron.—(Plate I, Nos. 5-6). Two specimens of this material were obtained from the New York Botanical Garden. One of these is a type specimen. The only differences in these two specimens are

that one of the leaves of the type specimen tends slightly toward obovate form, the others being oval; also the leaves of the type specimen are smaller. These leaves are oval; 86 to 40 mm. in length; 31 to 15 mm. in width; apex acute to rounded; apiculus present; base acute; upper surface buffy citrine; lower surface dark olive buff to olive lake; membranous; veins not prominent; lateral lines not apparent; midvein centrally located.

Neither of these specimens show oblanceolate leaves as noted by Holmes (2), the nearest being the obovate form mentioned above.

These specimens agree in all points with the description of Ceylon grown leaves as stated by Trimen (9) but differ in form and apex from those figured by Bentley and Trimen (12).

Reference to Plate I, Nos. 3-4, will show that this leaf is entirely distinct from Huanuco coca (*E. Coca*) as known in this country and Holmes' deduction (13) that the Kew plant (*E. Novagranatense*) represents the Huanuco variety of the present day does not appear to be substantiated. It would appear that although this Kew plant was grown from Huanuco seed, environmental influences have resulted in modification to such an extent as to produce a plant so different as to constitute a new species.

It is admitted that Holmes' statement (2) that the Truxillo leaves are from this species is supported by a great similarity in form between them, but the Truxillo leaves of this market are almost invariably sharp pointed at base and apex whereas my specimens of *E. Novagranatense* show rounded apex.

The figure accompanying an abstract of Dr. Burck's article in *Teysmannia* (*Pharm. Jour. and Trans.*) p. 818 (April 2, 1892), shows these leaves as tending toward oblanceolate form with a decided mucronate apex in which appears a prominent apiculus.

*Erythroxylon Truxillense*, Rusby.—(Plate I, No. 7.) Several samples of this species were obtained from the Drug Museum of Columbia University College of Pharmacy and from the Economic Collection at the New York Botanical Garden. Although these specimens represented collections in South America and Ceylon, all agreed in histological and gross characters. The leaves are elliptical to rarely obovate; 60 to 25 mm. in length; 21 to 13 mm. in width; apex acute and with prominent apiculus; base acute; upper surface buffy citrine; lower surface dull citrine; membranous; veins not prominent; marked lateral lines appear in many leaves but an equal if not a greater number show these structures very faintly if at all; the midvein is centrally located.

Although the leaves of *E. Truxillense* and *E. Novagranatense* show great similarity as noted by Holmes (2, 4, 11) the leaves of the former species in the great majority of instances are of elliptical form, obovate leaves being rare, whereas those of *E. Novagranatense* show a rounding of the apex and as a rule are much larger.

Holmes (11) in illustrating this species adopts the name *E. Truxillense* instead of *E. Spruceanum*, Burck.

*Erythroxylon Spruceanum*, Peyr.—(Plate II, No. 1.) Two leaves of this species were obtained from the New York Botanical Garden and according to Dr. Rusby these are from a type specimen bearing the original label of Dr. Spruce. These leaves are oval to obovate; 88 to 70 mm. in length; 34 to 28 mm. in width;

apex acute and retuse; apiculus absent; base acute to obtuse; upper surface Saccardo umber; lower surface Brussels brown; subcoriaceous; veins prominent and raised above the leaf surface; lateral lines not apparent; midvein centrally located.

This specimen agrees with Holmes' statement (2) in having lanceolate leaves and with Dyer's notations (7) regarding leaf form and apex as contrasted with *E. Novagranatense* and *E. Coca*. It differs from the description of Burck (7) as applied to *E. Coca* var. *Spruceanum*, Burck, in not showing an excurrent point at the apex; in being lanceolate instead of oval; in not tapering into the leaf stalk and in not showing lateral lines on the under surface. It differs from Holmes' notation (10) referring to *E. Spruceanum*, Peyr. in that these leaves are entirely different in type from *E. Coca*.

The figure accompanying an abstract (*Pharm. Jour. and Trans.*) p. 818 (April 2, 1892), of Dr. Burck's article in *Teysmannia* shows *E. Coca* var. *Spruceanum*, Burck, with a distinct apiculus and with lateral lines, notwithstanding his description.

*Erythroxyton carthagenense*, Jacq.—(Plate I, No. 8.) This is a type specimen and was obtained from the New York Botanical Garden. As but a single leaf was available the central portion had to be used for the histological study, hence the illustration shows a portion removed. Leaves are obovate; 63 mm. long and 30 mm. wide; apex rounded and with prominent apiculus; base is acute; upper surface sepia; lower surface Saccardo umber; subcoriaceous; veins not prominent; lateral lines apparent on both surfaces and very marked; midvein slightly out of center.

*Erythroxyton subracemosum*, Turcz.—(Plate I, No. 9.) A small specimen of the leaves of this species was furnished by Dr. H. H. Rusby. This material was collected at Yungas, Bolivia, altitude 6000 feet, 1885, and regarded in this vicinity as *E. Coca* escaped from cultivation. This leaf is oval; 30 mm. in length; 16 mm. in width; apex acute and without apiculus; base obtuse and slightly unequal; olive citrine on upper surface; snuff brown on lower surface; thin to subcoriaceous; the two sides of the leaf being slightly unequal.

*Erythroxyton pauciflorum*, Rusby.—(Plate I, No. 10.) Two specimens of this species were examined. The first was furnished by Dr. Rusby and represents the type specimen used by him in his determination of the species. The second was obtained from the Herbarium of the New York Botanical Garden. In general appearance these samples were identical. These leaves are broadly oval, 110 mm. in length, 45 to 59 mm. in width, acuminate, base acute to obtuse, upper surface buffy olive, lower surface Saccardo olive or light brownish olive, coriaceous, areolae or lateral lines not apparent, veins very prominent, the two sides of the leaf being nearly equal.

*Erythroxyton Bangii*, Rusby.—(Plate II, No. 2.) This material is from type specimens in the Herbarium of Columbia University, School of Pharmacy, collected by A. Miguel Bang near Songo, Bolivia, in November, 1890 ("Plantae Bolivianaë," No. 843). A few of the leaves are broadly oval but the majority, although broad, are distinctly obovate; 75 to 45 mm. in length; 40 to 21 mm. in width; apex rounded to obtuse, in some leaves appearing retuse because of a tendency of the apiculus to bend backward carrying with it a small portion of the leaf apex, in which case the prominent apiculus can only be seen when viewing the under side of the leaf; base rounded to obtuse; upper surface argus brown; lower surface

amber brown; coriaceous; veins, aside from primary, not prominent; lateral lines not apparent but many leaves show a slight impression on each side of the midrib; both sides of the lamina are equal.

*Erythroxylon cumanense*, H. B. & K.—(Plate I, No. 11.) This specimen was obtained from Dr. Rusby and represents material collected by him on the Mulford Biological Exploration of the Amazon Basin. Specimen was collected at San Buena Ventura, in the vicinity of Rurrenabaque, Bolivia, at an altitude of 1000 feet, on December 1, 1921. There is considerable variation in the shape of these leaves and a single branch bears ovate, obovate and a few of elliptical form. Leaves are 62 to 30 mm. in length and 29 to 14 mm. in width; apex acute to acuminate; apiculus small; base rounded to acute; upper surface Roman green; lower surface serpentine green; membranous texture, veins not prominent; a few of the leaves show an alteration of tissue in the form of a brown ridge extending parallel with the midvein, but definite lateral lines or areolae are not apparent; in the larger leaves there is a slight inequality in the halves of the lamina.

*Erythroxylon Popayanense*, H. B. & K.—(Plate I, No. 12.) This specimen is from the lower Orinoco and was collected by Dr. Rusby in 1896. The leaves are oval to elliptical; average length 80 mm.; average width 38 mm.; apex acute, with small but distinct apiculus; base acute; upper surface olive green; lower surface serpentine green; of membranous texture; veins prominent on both surfaces; lateral lines not apparent but lower surface shows a narrow area on each side of the midrib which differs slightly but perceptibly from the general leaf surface in that it is lighter in color and is depressed; midvein is centrally located.

*Erythroxylon areolatum*, Linn.—Specimens of this species were obtained from the Drug Museum and Herbarium of Columbia University, College of Pharmacy, from the New York Botanical Garden collections and from Dr. Rusby. All of these materials are noted as from West Indian sources. Of the four specimens examined, two are identical both in histological and gross characters. The remaining specimens are so different from the preceding and from each other as to create doubts regarding their authenticity. For this reason separate descriptions follow.

*Type A.*—(Plate II, No. 3.) The leaves are obovate to broadly elliptical; 95 to 50 mm. in length; 40 to 26 mm. in width; apex rounded to obtuse and slightly retuse; apiculus slight; base acute to obtuse; upper surface mottled in reds, browns and greens; lower surface wood brown; membranous; veins more prominent on upper surface; lateral lines well marked in most leaves; midvein central or very slightly to one side.

*Type B.*—(Plate II, No. 10.) This specimen is from the Herbarium of Columbia University, College of Pharmacy, and bears label "Plantae Cubenses Wrightianae, No. 2140, E. obovatum, collected by C. Wright, 1860-64." Although this specimen is identified as *E. obovatum* it is quite different in both gross and histological characters from other specimens of this species. Two possibilities present themselves. Either the botanical identification is incorrect or, if it is correct, the differences are due to environmental influences similar to those noted by Dr. Rusby in several South American species (14). Upon submitting the specimen to Dr. Rusby for his opinion, I am assured that the labeling is incorrect and that this is *E. areolatum*. These leaves are broadly oval to obovate; 72 to 46 mm. in length; 42 to 29 mm. in width; apex blunt or rounded; apiculus minute; base acute; upper

surface Saccardo umber; lower surface cinnamon brown; membranous; veins not prominent; lateral lines not apparent; midvein central or but slightly toward one side of lamina.

*Type C.*—(Plate I, No. 14.) This specimen was furnished by Dr. Rusby and marked by him as from the West Indies. The leaves are obovate; 60 to 35 mm. in length; 32 to 17 mm. in width; apex rounded to obtuse with broad apiculus; base acute; upper surface buffy citrine; lower surface brownish olive; of membranous texture; venation not prominent; lateral lines well marked; midvein centrally located.

Because of the manifest differences in morphological and histological characters between this specimen and the two preceding, Dr. Rusby inclines to the view that there may be two forms of *E. areolatum*.

*Erythroxyylon anguifugum, Mart.*—(Plate I, Nos. 15–16.) This specimen was collected November 4, 1921, by Dr. Rusby on the Mulford Exploration and is from small trees with white flowers growing in forest near Lake Rogague, Bolivia. The leaves are broadly oval to ovate; 120 to 65 mm. in length; 51 to 29 mm. in width; apex acute to attenuate; apiculus small; base rounded to obtuse; upper surface brownish orange; lower surface citrine; texture subcoriaceous; veins very prominent on both surfaces; lateral lines not apparent; midvein located centrally in lamina.

A second specimen, consisting of a single leaf from the original type specimen of Martius at the New York Botanical Garden, was examined and found to agree substantially in general and histological characters with the above material except that it was much thicker (Rusby specimen 150 microns; type specimen 252 microns). This leaf is lancovate; 58 mm. length, 19 mm. width; apex attenuate and with slight apiculus; Brussels brown in color. In other respects it agrees with the Rusby specimen.

*Erythroxyylon brevipes, D. C.*—(Plate II, No. 4.) Two specimens of this material were examined. One from Porto Rico bearing legend "Manati, ad lagunam Fortuguero; 12-IV-1887; det. I. Urban; P. Sintenis; Plantae Portoricenses; 6647." The other collected in Cuba by C. Wright, 1860–64 ("Plantae Cubenses Wrightianae," No. 2134). The leaves are oval to obovate; 17 to 4 mm. in length; 8 to 7 mm. in width, the leaves of the Porto Rico specimen being the larger; apex rounded and with a slight apiculus; base acute; upper surface light brownish olive; lower surface Savoy brown; texture membranous; veins not prominent; lateral lines wanting; in general the midvein in the Porto Rico specimen is centrally located while in the Cuban sample this is not the case.

*Erythroxyylon Urbanii, O. E. Schulz.*—(Plate II, No. 5.) This specimen is from the Herbarium of Columbia University, College of Pharmacy, and is labeled "P. Sintenis; Plantae Portoricenses; Manati, ad Rio saliente arriba; 9-IV-1887; *Erythroxyylon obtusum*, D. C. 6613; det. I. Urban." Although this specimen is labeled *E. obtusum*, Dr. Rusby finds this determination incorrect and it is his opinion that it is *E. Urbanii*, being a cotype of the specimen in the New York Botanical Garden Herbarium. The leaves are obovate; 37 to 15 mm. in length; 20 to 10 mm. in width; apex rounded, obtuse and retuse; apiculus not apparent; base acute; both surfaces argus brown in color; texture coriaceous; veins prominent on both surfaces; lateral lines not apparent; one side of the lamina broader than the other.

*Erythroxyylon havanense*, Jacq.—(Plate II, No. 6). This specimen is from the Herbarium of Columbia University, College of Pharmacy, and although no collection data appears on the label it is probably of Cuban origin as it bears the following notation: "Cuban name jiba; San Fernando, May, 1841." This specimen was originally labeled as *E. obtusum*, but Dr. Rusby finds it to be *E. havanense*. The leaves of the specimen are very thin and it has not been carefully mounted. These leaves are oval to elliptical; 34 to 19 mm. in length; 17 to 6 mm. in width; apex blunt to rounded; apiculus slight; base acute to cuneate; both surfaces grayish olive; extremely membranous in texture; veins not prominent; lateral lines not apparent; midvein centrally located.

According to the Kew Index, *E. havanense*, Jacq., is synonymous with *E. ovatum*.

*Erythroxyylon minutifolium*, Griseb.—(Plate II, No. 7.) This specimen is from the Herbarium of Columbia University, College of Pharmacy, and was collected by C. Wright, 1860–64 ("Plantae Cubenses Wrightianae," No. 2133). These leaves are round; 4 to 2 mm. in diameter; apex emarginate; apiculus wanting; base rounded; upper surface olive brown and glossy; lower surface Brussels brown; extremely coriaceous in texture; veins more prominent on upper surface; lateral lines not apparent; midvein centrally placed.

These leaves are different in habit from any of the other species examined, being so crowded on the stems as to fairly cover the latter.

*Erythroxyylon alaternifolium*, Rich.—(Plate II, No. 8.) This specimen is from the Herbarium of Columbia University, College of Pharmacy, and was collected by C. Wright, 1865 ("Plantae Cubenses Wrightianae," No. 344), from a spreading bush six feet in height, on the banks of a stream in the pine woods. The leaves are broadly oval to obovate; 40 to 24 mm. in length; 13 to 7 mm. in width; apex rounded and retuse; small apiculus apparent in most leaves; base acute to rounded; upper surface argus brown; lower surface mars brown; coriaceous; veins more prominent in smaller leaves; lateral lines wanting; sides of lamina unequal with reference to midvein.

This herbarium sheet also shows a branch with smaller obovate leaves not exceeding 17 mm. in length and 8 mm. in width; with cuneate base; apiculus present; dark green upper surface; olive green lower surface; membranous; without lateral lines; midvein centrally placed.

*Erythroxyylon obovatum*, Macf.—(Plate II, No. 9.) Two specimens from the Herbarium of Columbia University, College of Pharmacy, were examined. One of these is labeled "Plantae Cubenses Wrightianae, No. 2141, collected by C. Wright, 1860–64." The other is presumably also of Cuban origin, because of a notation stating the vernacular name "jiba" and the medicinal use of the root. The leaves of these two specimens are identical both in gross and histological characters. Leaves are obovate; 60 to 30 mm. in length; 26 to 15 mm. in width; apex rounded and occasionally slightly retuse; apiculus prominent; base mostly acute, may be obtuse in very broad leaves; upper surface mummy brown; lower surface russet; membranous; veins not prominent on either surface; lateral lines not apparent; the midrib is located centrally.

*Erythroxyylon Pelletierianum*, A. St. Hil.—(Plate II, No. 11.) A single leaf was obtained from the type specimen at the New York Botanical Garden. A

portion of the leaf shown in the illustration had to be used for histological study. The leaf is 45 mm. in length and 21 mm. in width; obovate; apex rounded and slightly retuse; apiculus not apparent; base acute; upper surface mummy brown; lower surface pecan brown; coriaceous; veins more prominent on lower surface; lateral lines not apparent; the midvein is slightly to one side of the center of the lamina.

*Erythroxylon nitidum*, Spreng.—(Plate II, No. 12.) A single leaf was obtained from the type specimen at the New York Botanical Garden and a portion of this leaf was used for histological study. The leaf is 67 mm. in length and 19 mm. in width; oblanceolate; apex rounded and possibly slightly retuse; apiculus present but very small; base cuneate; upper surface Vandyke brown; lower surface Rood's brown; membranous; veins not prominent; lateral lines not apparent; midvein slightly out of center.

*Erythroxylon Columbianum*, Mart.—(Plate I, No. 17.) Two leaves were obtained from the type specimen at the New York Botanical Garden. These leaves are oval elliptical; the larger being 85 by 41 mm., the other 62 by 27 mm.; apex acute; apiculus not apparent; base broadly acute; upper surface Saccardo umber; lower surface walnut brown; coriaceous; veins very prominent on lower surface; lateral lines not apparent; midvein slightly out of center.

*Erythroxylon orinocense*, H. B. & K.—(Plate II, No. 13.) This material was obtained from a type specimen at the New York Botanical Garden. These leaves are broadly oval; average 72 mm. in length and 40 mm. in width; apex acute to rounded; apiculus very slight; base obtuse to rounded; upper surface Saccardo olive; lower surface olive lake; subcoriaceous; veins prominent on lower surface and impressed on upper; lateral lines not apparent; midvein slightly out of center.

"Haya" *Coca*.—(Plate I, No. 18.) This sample is from the Economic Collection of the New York Botanical Garden and is of Colombian origin. The leaves are broadly oval to elliptical; 63 to 33 mm. in length; 32 to 18 mm. in width; apex obtuse with distinct apiculus; base obtuse; upper surface dull citrine; lower surface olive lake; subcoriaceous; veins not prominent; lateral lines not apparent; midvein centrally located.

The histological characters would indicate that this material is a variety of *E. Coca*, Lam., thus supporting Rusby's views (14).

"Wild" *Coca*.—(Plate I, No. 19.) This sample is from the Economic Collection of the New York Botanical Garden. Dr. Rusby informs me that this specimen was collected in Curacoa, at an altitude of 5000-6000 feet, from plants growing around the edges of coca plantations. The shrubs appear similar to the cultivated plants occurring in abandoned plantations. The natives believe that this represents the cultivated plant run wild.

The leaves are oval to elliptical; 63 to 30 mm. in length; 32 to 14 mm. in width; apex acute to obtuse and with slight apiculus; base obtuse; upper surface dark olive; lower surface mummy brown; membranous; veins not prominent; lateral lines not apparent; midvein centrally located.

"Wild" *Coca*.—(Plate I, No. 13.) This specimen was furnished by Dr. Rusby and represents material collected by Dr. O. E. White on the Mulford Exploration in the vicinity of Rurrenabaque, Bolivia, December 10, 1921. Dr. Rusby states that this leaf is from plants grown in the shade. These leaves are

TABLE I.—SUMMARY OF MORPHOLOGICAL CHARACTERS.

|                                | Form.       |       |          |               |        |         |        |            |                 |            | Apex.   |             |        |                 | Base.    |           |                | Size.            |          |                 |          |
|--------------------------------|-------------|-------|----------|---------------|--------|---------|--------|------------|-----------------|------------|---------|-------------|--------|-----------------|----------|-----------|----------------|------------------|----------|-----------------|----------|
|                                | Elliptical. | Oval. | Obovate. | Broadly oval. | Ovate. | Rotund. | Acute. | Acuminate. | Obtuse-rounded. | Attenuate. | Retuse. | Emarginate. | Acute. | Obtuse-rounded. | Cuneate. | Apiculus. | Lateral lines. | Length, maximum. | Minimum. | Width, maximum. | Minimum. |
| <i>E. Coca</i> (wild)          | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 60             | 25               | 29       | 12              |          |
| <i>E. Coca</i> (wild)          | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 95             | 45               | 35       | 18              |          |
| <i>E. Coca</i> (cult.)         | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 39             | 24               | 19       | 12              |          |
| <i>E. Coca</i> (cult. Huanuco) | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 48             | 22               | 10       | 10              |          |
| <i>E. subracemosum</i>         | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 30             | 16               | 16       | 10              |          |
| <i>E. pauciflorum</i>          | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 110            | 45               | 45       | 10              |          |
| <i>E. Bangii</i>               | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 75             | 45               | 40       | 21              |          |
| <i>E. cumanense</i>            | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 62             | 30               | 29       | 14              |          |
| <i>E. popayenense</i>          | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 80             | 35               | 38       | 17              |          |
| <i>E. areolatum</i>            | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 60             | 32               | 40       | 21              |          |
| <i>E. areolatum</i>            | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 95             | 44               | 40       | 21              |          |
| <i>E. anguifugum</i>           | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 72             | 46               | 42       | 29              |          |
| <i>E. brevipes</i>             | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 120            | 58               | 51       | 19              |          |
| <i>E. Urbanii</i>              | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 17             | 14               | 8        | 6               |          |
| <i>E. havanense</i>            | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 37             | 15               | 20       | 10              |          |
| <i>E. minutifolium</i>         | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 34             | 19               | 17       | 6               |          |
| <i>E. alaternifolium</i>       | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 4              | 2                | 4        | 2               |          |
| <i>E. obovatum</i>             | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 40             | 13               | 24       | 7               |          |
| <i>E. Truxillense</i>          | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 60             | 30               | 26       | 15              |          |
| <i>E. carthaginense</i>        | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 60             | 25               | 21       | 13              |          |
| <i>E. Pelletierianum</i>       | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 60             | 30               | 30       | 20              |          |
| <i>E. nitidum</i>              | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 45             | 21               | 21       | 19              |          |
| <i>E. Columbianum</i>          | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 67             | 41               | 27       | 19              |          |
| <i>E. Novagranatense</i>       | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 85             | 41               | 31       | 15              |          |
| <i>E. orinocense</i>           | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 86             | 40               | 43       | 37              |          |
| <i>E. Spruceanum</i>           | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 72             | 72               | 43       | 28              |          |
| <i>E. "Haya"</i>               | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 63             | 70               | 34       | 18              |          |
| <i>E. wild</i> (unidentified)  | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 117            | 90               | 50       | 35              |          |
| <i>E. wild</i> (unidentified)  | +           |       |          |               |        |         |        |            |                 |            |         |             |        |                 |          |           | 63             | 30               | 32       | 14              |          |



oval; 117 to 90 mm. in length; 50 to 35 mm. in width; apex obtuse to rounded; apiculus slight; base obtuse to acute; upper surface light yellowish olive; lower surface olive green; of membranous texture; lateral lines well marked; halves of lamina equal; veins very prominent on both surfaces.

It is noteworthy that coca is not cultivated in this vicinity and the occurrence of plants in this locality is possibly due to transportation of the seeds, either by birds or water, from distant coca plantations. The natives regard this plant as a wild growing coca.

#### SUMMARY.

The salient points of the preceding descriptions are summarized in tabular form as Table 1, page 358. Although variations in general characters of the leaf are to be expected, we may make use of the following characters with reasonable assurance in identification work:

1. The presence or absence of areolae or lateral lines.
2. The presence or absence of an apiculus or short projection of the midvein beyond the lamina.
3. The texture of the lamina.
4. The form of the leaf.
5. The type of apex.
6. The type of base.
7. The position of the midvein (equilateral or inequilateral).

*(To be continued)*

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## THE EFFECT OF CERTAIN AMIDES ON THE STABILITY OF MODIFIED DAKIN'S SOLUTION.\*

BY JOHN C. KRANTZ, JR., AND MANUEL J. VIDAL.<sup>1</sup>

### INTRODUCTION.

Since the introduction of the Surgical Solution of Chlorinated Soda into the Pharmacopœia, a great deal of investigation has been carried out with the purpose of finding a preservative for this solution. Becker<sup>2</sup> has studied the stability of the solution at various temperatures and Harrison<sup>3</sup> has shown that certain compounds are capable of stabilizing the solution for long periods of time, even when employed in low concentrations.

The latter investigator claims saccharin to be an excellent preservative for the Modified Dakin's Solution and also suggests that the addition of saccharin does not alter the therapeutic value of the solution.

The purpose of this paper is to show that amides in general including saccharin do not stabilize Modified Dakin's Solution and to propose a theory to account for the reactivity of these products with sodium hypochlorite.

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<sup>2</sup> Becker, *JOUR. A. PH. A.*, 14, 192 (1925).

<sup>3</sup> Harrison, *JOUR. A. PH. A.*, 13, 902 (1924).