

# A PRELIMINARY TREATMENT OF THE GENUS CASTILLA.

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## INTRODUCTION.

### ESTABLISHMENT OF THE GENUS.

The genus *Castilla* was proposed and described for the first time in an inaugural lecture on botany given at the Royal Botanic Garden of Mexico City June 22, 1793, by the titular professor Vicente Cervantes. The text of the lecture was subsequently printed, and the plant figured, in a supplement to the "Gaceta de Literatura," this being the way in which one of Cervantes' few contributions to botany has come down to the present generation.<sup>a</sup>

After mentioning the old Nahuatl name "holguahuitl," and the half-Spanish one of "arbol del hule," under which the Mexican rubber tree was then known, Cervantes provides it, according to the then dogmatically applied Linnæan rules, with Latin generic and specific names. The generic name is *Castilla*, the tree being dedicated as a testimony of "just gratitude for the friendship" and the meritorious work of the major pharmacist and economic explorer, Juan del Castillo (1744-1793). The specific name *elastica* refers to the remarkable property of the gum contained in the latex.

Cervantes's description is far from perfect and its deficiencies were noted even by his contemporaries, as is shown in the "Notas y descripción que hace un imparcial aficionado á la botánica, para aclarar los defectos de la que leyó el catedrático D. Vicente Cervantes, etc." The author of this document, who signs with his initials only (J. L. M.)

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<sup>a</sup>A native of the province of Extremadura (Spain) and a disciple of C. Gomez Ortega, Cervantes went to Mexico in 1786 to fill the newly created and first chair of botany in the vice-kingdom of New Spain. The best Mexican botanists of the time, among them Mocifio and Maldonado, number among his pupils. For eighteen years he also superintended the pharmacy of the San Andrés Hospital, devoting special attention to the medicinal properties of the plants. He died at Mexico City July 26, 1829, at the age of 70. See also N. León, *Biblioteca bot.-mexicana*, p. 88.



objects to both the generic and specific names, the first on account of the Linnæan aphorism 134: "Nomina quae ex graeca, vel latina lingua radicem non habent, rejicienda sunt," and the second as being useless, since there is only one species in the genus. In a further communication<sup>a</sup> the same critic explains how, in forming the generic name, the first step should have been to latinize the name "Castillo," making it "Castellum," from which "Castella," and not "Castilla," would be the right derivative. From our present standpoint the dispute is rather a puerile one, as is also the lengthy dissertation on the superfluity of the specific name. Though the latter would in any case be required, as a matter of fact the genus is widespread and contains several species.<sup>b</sup> "Castilla" is certainly as good a generic name as any and its rejection is not justified, although it was changed and practically dropped less than ten years after its publication in Mexico. In 1805, in a translation of the original memoir published in London as one of the "Tracts relative to botany," Cervantes's name became "Castilloa," and no reason seems to have ever been given for the intercalation of the additional vowel. It may be the result of a slip of the pen or of the officious but ignorant interference of the translator, or it is perhaps a simple typographic mistake. In 1903 Mr. O. F. Cook<sup>c</sup> called attention to the change, which he rightly denounces as "justified by no recognized rule of botanical nomenclature." But botanists at large, and even those who are most strict in enforcing the laws of priority, have concurred in the maintenance of a name which has hardly a claim to be considered even as a synonym.

The description given by Cervantes is very vague: it might apply to any of the known species, and even to other genera of the same family. From the gross exaggerations it contains with reference to the size of the tree, it might be inferred that the author had never seen a standing specimen of the latter. Nevertheless, it seems evident that the species he had in mind was the one growing "en las jurisdicciones de la antigua Veracruz, Cosamaluapan y Acayucan," all three of which are in the State of Veracruz of to-day, and include probably the

<sup>a</sup> Carta del aficionado de la botánica J. L. M., contestando al impreso del catedrático de ella de 14 de Noviembre de 1794, op. cit.

<sup>b</sup> The "Notas" also contain curious considerations that give an idea of the advancement of plant anatomy at the end of the 18th century. Cervantes, namely, had called the receptacular involucre of the male inflorescence a calyx, whereas J. L. M. denominates it a *corolla monopetala*. "El caliz," he says, "tiene su origen de la corteza de la planta, la corola del liber, los estambres del leño, y el pistilo de la médula;" wherefrom it is logically deduced that the stamens being attached to the perianth, this is bound to be a corolla, having its origin in the liber, etc.

<sup>c</sup> Cook, O. F. The Culture of the Central American Rubber Tree. U. S. Dept. Agr. Bur. Plant Ind. Bull. 49, p. 19. 1903.



locality of Motzorongo, whence proceed the samples which are described here as belonging to the typical *Castilla elastica*. Cervantes's critic, J. L. M., also cites the "Departamento de San Blas" as a locality where the Castilla trees are especially numerous. If this is the San Blas of Tepic, it is also the northernmost recorded station of the genus on the Pacific coast, but it is by no means certain that the species found there is identical with the one from the opposite coast.

#### HISTORY OF SPECIES HITHERTO KNOWN.

For more than half a century after its establishment by Cervantes the genus Castilla was considered as monotypic, and all specimens met with from Mexico to Peru were referred to his single species *C. elastica*. Every mention of the rubber trees of the region, also, assumed that there was only the one species. Even to-day, at a time when this genus has acquired a considerable importance as a rubber producer, we find in most treatises and reviews dealing with the economic features of the rubber question the obsolete notion that one of its main sources is *Castilla elastica*, from Central and South America.

In 1851, however, Liebmann published his *C. costaricana*, founded on incomplete specimens collected by Oersted at Turrialba. Liebmann had familiarized himself with the Mexican species, which he had observed and collected at no less than six different localities in the State of Veracruz,<sup>a</sup> and notwithstanding the few and unsatisfactory differential characters presented by the leaves, he did not hesitate to assign Oersted's material to a distinct species.

Thus far *Castilla elastica* had not attracted much attention as an economic tree, but 25 years later rubber exportation from Central America had attained its full swing, and it became more and more urgent to acquire a better knowledge of the sources of supply. In 1800 Cavanilles had reported the presence on the Isthmus of Panama of a rubber tree which he identified with Cervantes's species and the existence of which was confirmed in the fifties by Sutton Hayes, botanical explorer of the route between Panama and Colon. In connection with this information of Cavanilles and Hayes, which later reports and actual experience have shown to be well founded, there should be mentioned here the singular mistake made by James Collins,<sup>b</sup> describing and figuring as "ule-ule," or "Panama rubber," under the name of "*Castilloa markhamiana*," specimens of a *Perebea* collected by Hayes on the Isthmus. The description, and especially the very good illustration accompanying Collins's report, leave scarcely a doubt as to the identity of the small tree, as has already been acknowledged by Hooker and other authorities.

<sup>a</sup> Dansk. Vid. Selsk. Skr. V. 2: 318, 1851.

<sup>b</sup> Report on Caoutchouc of Commerce, p. 12. (1872.)



On the strength of the above information, Robert Cross was detailed to Panama in 1875, by the India Office, to study the tree on the spot and to gather seeds and seedlings for distribution to the British colonies possessing suitable soil and proper climatic conditions. In this way the Central American rubber trees became better known and were introduced into Ceylon, India, and the West Indies. Materials for study began to arrive at Kew, and on December 3, 1885, Sir Joseph Dalton Hooker read before the Linnean Society a memoir "On the *Castilloa elastica* Cervantes and some allied rubber-yielding plants," in which he admitted the probable existence of more than one species of Castilla and insisted on the necessity of a more accurate study of the genus. In this paper, however, he reduced *C. costaricana* Liebm., cited erroneously as "*C. costa-ricensis*," to the rank of a synonym of *C. elastica*, a step that must be considered a retrograde one and justified only by the evident lack of authentic information. Although short descriptions and good illustrations were given, Hooker made no attempt toward establishing any new species.

In recent years, the now adult trees introduced everywhere in the Tropical Zone in botanical gardens and at agricultural stations have been widely experimented upon with varying results and a large amount of capital has been invested in plantations, most of which have failed thus far to justify the oversanguine expectations of the investors. The lack of uniformity in the behavior of the tree under cultural conditions, has awakened a suspicion of specific diversity, but the absence of adequate specimens in the botanical collections has defeated the efforts of most investigators to reach a conclusion as to whether Castilla is or is not a monotypic genus.

In 1900, however, Mr. Hemsley advanced toward the solution of the question by publishing his *C. tunu*, unfortunately founded upon specifically heterogeneous materials, to which he added the following year *C. australis*, growing at the southernmost limit of the generic area.

But the real investigation of the Central American species of Castilla began in 1902, when Mr. O. F. Cook went to southern Mexico expressly to further our knowledge of rubber-producing plants and the possibilities of their systematic cultivation. In 1903 he published in a memoir full of original views and of useful hints the results of his first researches, and these were actively continued during the subsequent years and extended to Guatemala and Costa Rica. In the course of his travels, Mr. Cook lost no opportunity to secure complete material, preserved in alcohol, so as to make possible a thorough study of the anatomical and structural features of the several parts. In 1905, he was able to publish a good synopsis of the characters of no less than seven species, of which four were new and



detached from the original *C. elastica*. Mr. G. N. Collins not only collaborated with Mr. Cook in all his researches, but contributed on several other occasions to the increase of the alcoholic collection of specimens. The present writer had also his modest share of the field work. Mention should also be made here of a fine set of natural-size photographs, made mainly by Mr. C. B. Doyle under the direction of Mr. Cook. This collection is unique of its kind and affords ample and conclusive evidence bearing upon the identification of the several species.

These are the antecedents that have led the writer to undertake the present monograph of the genus *Castilla*, as a preliminary step to the study of questions relating to the availability of the species as rubber producers. The detailed investigation of the above-mentioned material not only established the value of Mr. Cook's species, but led to the segregation of an additional Central American form. Besides these, a new species was discovered by the writer in Colombia, and the well-known German explorer, Doctor Ule, identified as a *Castilla* one of the Brazilian rubber trees, the number of species described in the present paper thus becoming ten. On the other hand, it has not been possible to take into serious consideration certain proposed new species, as, for instance, *C. alba*, *C. nigra*, and *C. rubra* of Koschny, that are mere physiological accidents, the results mostly of differences in light and soil conditions. This has been clearly shown by Mr. Cook's investigations in Costa Rica and by careful examination of the specimens.

#### GENERAL CHARACTERS AND THEIR SYSTEMATIC VALUE.

##### HABIT.

When fully developed, all species of *Castilla* are trees of large size and of striking habit. As noticed by Mr. Cook, they are seldom true forest trees, but they also avoid the open grass-covered savanna. Their natural habitat is in the clearings and other open spots of the virgin forest, where they are generally found in company with *Cecropia*, or in the fertile, sparsely wooded alluvial flats of the valley bottoms.

##### ROOTS.

In these rubber trees the root system consists of a rather short tap root and of several lateral roots spreading horizontally and so near the surface of the soil that they can often be followed for 20 to 30 meters. This disposition is very adverse to the cultivation of the tree in pastures, because the treading of the cattle often damages the trees beyond recovery. In the flat, shady forest the roots often assume a buttress-like shape at their emergence from the main axis. These



wing-like formations were particularly conspicuous on the giant specimens of *C. daguensis* observed by the writer between Córdoba and San José, in the Dagua Valley (Cauca-Colombia). They are also reported as often present at the base of the trunks of *C. costaricana*, in the plains of San Carlos.<sup>a</sup> The lateral roots are more or less ramified, and numerous rootlets spread from their lower side into the surrounding soil.

#### TRUNK.

There is great diversity in the appearance of the trunk and its ramifications, according to the species, the exposure, and the climate. The largest size is probably attained by *C. daguensis*, of which we have seen specimens of no less than 50 meters estimated height and 1.05 meters in diameter. The largest individual of *C. lactiflua* observed by Mr. Cook measured approximately 25 meters in height, with a diameter of 1.50 meters at the same distance from the ground.<sup>b</sup> In the above-mentioned paper,<sup>c</sup> Koschny speaks of trees 1 to 1.72 meters in diameter, with a trunk length reaching up to 24 meters, as not uncommon in the northern forests of Costa Rica. The more scanty the light the more rapid is also the rise of the trunk and the more prompt the appearance of the permanent branches. In the dark Regenwälder of Central America, namely in Costa Rica and Panama, adult Castilla trees are often met with, the trunks of which shoot up to 15 meters and more, smooth and slender, and supporting only a flat, thinly developed crown. In the open dry districts the branching commonly begins at 3 meters or less above the ground and the trees assume a stouter habit. The branches generally form an acute angle with the main axis, but this is not always true, and in *C. daguensis*, according to notes taken on the spot, they are rather horizontal and spreading.

#### TWO FORMS OF BRANCHES.

In the paper already cited Mr. Cook deals at full length with the pseudobranches and self-pruning of Castilla, so that we do not need to dwell on this subject except to note that those deciduous twigs arise from the axils of the leaves, and can be seen also on permanent branches. Their diameter, at the insertion, is never above 3 cm., and they attain from 3 to 4 meters in length, bearing in distichous rows the very large, showy leaves.

#### LEAVES.

The leaves of all species of Castilla are deciduous and alternate, with a  $\frac{2}{1}$  distichous arrangement that is quite characteristic. They

<sup>a</sup> Koschny, T. Die Kultur des Castilloa-Kautschuk. Beiheft zu Tropenpflanzer, vol. 5, p. 125. (1901.)

<sup>b</sup> Cook, Culture of Central American rubber tree, loc. cit., p. 23.

<sup>c</sup> Koschny, op. cit., p. 123.



are mostly uniform in size, shape, and other details, and yet in other respects so variable in the same species, according to age, exposure, etc., that they furnish few constant specific characters. In young trees they are generally larger, the petioles are often quite long, attaining no less than 5 cm. in some of our specimens, and the lamina is more rounded. In mature trees the petioles seem to be very short (0.5 cm.) in *C. ulei*, short (0.8 to 1.5 cm.) in *C. australis*, *C. daguensis*, *C. lactiflua*, *C. panamensis*, and *C. nicoyensis*, relatively long (1.5 to 2 cm.) in *C. fallax*, *C. costaricana*, and *C. elastica*, and longest (up to 2.5 cm.) in *C. guatemalensis*. Curiously enough the austral species seem to have a tendency to be short-petiolate, the boreal ones long-petiolate.

The adult leaves vary from ovate and sublyrate to elliptic-lanceolate; they furnish a good taxonomic character in the form of the blade at the insertion of the petiole, this being in some species deeply cordate, in others subacute or scarcely emarginate. This differential peculiarity again seems to have some connection with the geographical distribution of the several forms, deeply cordate ones occupying the northern part of the generic area, while the others are Andean, with the exception of *C. fallax*. As to size, *C. ulei* has the smallest leaves and *C. costaricana* and *C. elastica* the largest ones, but, excepting perhaps the first-named, there is a great variation in all the species, and the dimensions given in our descriptions do not apply to the very large leaves of the young trees.

At the apex the leaf is always more or less abruptly contracted into an acute point. The margin is setose-denticulate in all the species, but the teeth or sinuities hardly affect the blade itself, except perhaps in *C. costaricana* and *C. panamensis*. Both faces are usually densely hairy, the color of the indument varying from ashy gray or silvery gray to yellowish or brownish. The texture of the whole leaf is mostly coarse and the pinnate venation is very prominent on the lower face.

From the above details it can be seen that on the whole the leaves present very few sharply defined characters and that they could hardly be used alone for the identification of the several species. Leaves of a species from the Atrato Valley in Colombia, which were received not long ago, show, however, such decided peculiarities that we must conclude to the presence of a distinct, undescribed species in that region.

#### THREE FORMS OF INFLORESCENCE.

One of the generic peculiarities of Castilla is that all species are, as Mr. Cook expresses it,<sup>a</sup> partly dioecious, that is to say, there are trees that bear, at least for a single season, only male flowers, while in

<sup>a</sup> Science, ser. 2, vol. 18, p. 437. (1903.)



others each female receptacle is flanked by two staminate receptacles, smaller than and somewhat distinct in shape from the flowers of the male specimens. In other words, there are strictly unisexual individuals bearing only male flowers, and other individuals that are truly monoecious, bearing together pistillate and staminate flowers. It has been noticed that the younger trees, blooming for the first time, bear invariably male flowers, but it is by no means certain that there are trees permanently male and others permanently monoecious, nor do we know the governing cause of the explained sexual conditions. The stamens are fertile in both kinds of male flowers and, while the wind seems to be the main agent of pollen transportation, a direct pollination by means of insects between the male and female flowers of the same clusters, or the transportation of pollen from tree to tree by the same agency, is not out of question. The male flowers are usually crowded with small thrips that are also found, but not so frequently, on the female flowers.

Mr. Cook has called "primary" the larger staminate inflorescences found on the exclusively male trees, and "secondary" or "complemental" the ones on the monoecious trees. These expressions are used in the same sense in the course of this paper.

#### PRIMARY MALE INFLORESCENCE.

The inflorescences of this class appear in pairs in the axils of the leaves, or in defoliate axils, and have the general appearance of a flattened or depressed cone, or of a fan, more or less emarginate at the base. This fan opens longitudinally, sometimes only by a narrow slit at the top (*C. fallax*), sometimes with the lobes spreading out into a flat disk (*C. nicoyensis*). In other cases the inflorescence is more or less distinctly 3-winged (*C. costaricana*), or the lobes are diversely lobulate or distorted (*C. elastica*). As to the number of receptacles in each axil, it seems to vary from 2 to 8, but to be almost constant in one species or in one group of species. There are no data as to *C. ulei* and *C. australis*. In *C. daguensis*, I noted 1 to 3 receptacles in each axil in the only specimen at hand, but this may be either an error of observation or an anomaly, as geminate receptacles seem to be the rule; the same may apply to *C. fallax*, of which only dry, brittle specimens have been handled. From 2 to 8 receptacles in each cluster were ascertained to exist in *C. lactiflua* and *C. guatemalensis*, while the number seems to be limited to 2 or 4 in *C. costaricana*, *C. panamensis*, *C. nicoyensis*, and *C. elastica*.

The receptacles are sessile or subsessile in *C. fallax*, but distinctly stipitate, as far as known, in the other 9 species. Except perhaps in *C. guatemalensis*, the stipe is not a pedicel in the strict sense of the word, but simply the basal attenuation of the body of the receptacle,



as in the common fig. It is usually provided at the base with a more or less complete involucre of free or subconnate bracts, while the remainder of the outer surface of the receptacle is covered with more imbricating bracts, which, for convenience sake, we have called "scales." On the whole, bracts and scales hardly seem to furnish us with any good diagnostical characters.

Of the six rubber-producing species of the Isthmus, half (*C. lactiflua*, *C. guatemalensis*, and *C. panamensis*) have emarginate or kidney-shaped male receptacles, while the remainder do not present that peculiarity, on account either of their irregular shape (*C. costaricana*, *C. elastica*) or of their mode of dehiscence (*C. nicoyensis*).

The stamens are inserted on the inside surface of both lobes of the receptacles. Most authors seem to have adopted the view that they are distributed without any regular arrangement, and that the bractlets, scales, or floral leaflets that accompany them are all small and isolated. In fact, the disposition of the stamens is dependent on the continuous blades or lamellæ that radiate from the bottom of the receptacle and branch out so as to cover the increasing staminal area. These blades vary in breadth and in the indentation of the margin according to the species, being, for instance, small and irregularly developed in *C. guatemalensis*, and rather broad and conspicuously lobulate in *C. elastica*. The stamens are inserted singly along these blades, or in clusters in the axils or at the ends of their ramifications. The bractlets are very unequally developed in the same receptacle, many stamens being destitute of them, others showing several, while at times bractlets appear where there are no stamens at all. The bractlets also seem to vary in size according to the species; they are few and small in *C. fallax*, *C. nicoyensis*, and *C. panamensis*, numerous and almost exuberant in *C. elastica*. They are generally inserted at the base of the stamen, but in the last species the filament is often provided with an additional foliaceous, accumbent appendage, attached somewhere below the anther. In the same specimens remarkable transitions of a regressive nature occur between stamens and bractlets. Sometimes the bractlet is reduced to an awkwardly long, cylindrical filament, ending with the rudiments of an anther; in other cases the still defective anthers appear on a foliaceous, bract-like filament; and besides these there are perfect anthers borne on a flattened, broad filament, etc. All these anomalies have been noticed in *C. elastica*, the other species investigated being mostly normal.

The stamen itself consists of a rounded, always smooth filament, ending in a claviform connective, on both sides of which are inserted the narrow, elongated anther cells. The connective is in all cases basifix and it is evidently a misinterpreted observation that makes Trécul say that the anther is dorsifix or peltate. The variations in



the length of the filament, in the angle between the latter and the connective, etc., correspond to stages in the development: the normal mature stamen is erect, the dehiscence longitudinal, and the pollen very minute and without peculiarities worth mentioning.

On the whole, as far as is known, these stamens are very uniform in their size and appearance all through the genus. They seem to be of smaller dimensions and sparsely hairy on the connective in *C. fallax*; the cells, usually narrow, are noted as broader in *C. guatemalensis*, where also the connectives were found to have a papillose appearance on one of their faces; a cross section of the filament of *C. elastica* is elliptic with acute edges and the connectives are here larger than in the other species, with narrower cells; and finally, as has already been mentioned, there occurs on these filaments, in at least one species, a small, accumbent bractlet.

#### COMPLEMENTAL MALE INFLORESCENCE.

The small male receptacles accompanying in pairs the pistillate ones, to which this name has been given, have been accurately represented in a considerable number of drawings of the heretofore all-embracing *C. elastica*, beginning with the plate added to Cervantes's original description and ending with the figures in Warburg's work on rubber plants.<sup>a</sup> Trécul<sup>b</sup> gives also a good representation of a complementary inflorescence and may not have known the primary one. But, strange to say, no botanist seems to have noticed the variance of this inflorescence from the primary one up to the time of Mr. Cook's investigations on this subject. In his bulletin on Castilla<sup>c</sup> Mr. Cook says in part: "A pair of much smaller and more fig-like clusters of male flowers is often attached immediately under a cluster of female flowers." As a matter of fact, these auxiliary male inflorescences are always present by the side of the female flowers in every Central American species and very likely also in the South American ones, although information on this point is still lacking. Notwithstanding their reduced dimensions, they are perfect in every way, differing only slightly in shape from the primary inflorescences. They seem to be always geminate, and always clavate or pear-shaped, except in *C. lactiflua*, where they are flabellate. In this species they also seem to open broader than in any of the remaining ones, but the dehiscence is always more or less slit-like, except in *C. costaricana*, where the opening is rounded, and in *C. nicoyensis*, where these receptacles hardly open at all. There seem to be specific differences in the length of the stipe, this being very short in *C. lactiflua* and *C. costaricana*, longer and more slender

<sup>a</sup> Warburg, O. Les plantes à caoutchouc, p. 98. (Paris, 1902.)

<sup>b</sup> Ann. Sci. Nat. ser. 3, vol. 8, pl. 5. (1847.)

<sup>c</sup> Culture of Central American rubber tree, loc. cit., p. 21.



in the other species investigated in this respect. The scales covering the outer surface of the receptacle, as well as the basal bracts, are more or less free, broad, or acute, etc., but on the whole they do not seem to furnish us with any definite character. Neither do the stamens differ in shape, dimensions, or arrangement from those in the primary inflorescences.

PISTILLATE INFLORESCENCE.

In all species of *Castilla* the female inflorescence consists of a cup-like receptacle, more or less open, according to the number of included flowers and also to the stage reached in their development. The figures and descriptions vary according to the period of the investigation. Hooker gives very good figures,<sup>a</sup> and so do Warburg<sup>b</sup> and Cook,<sup>c</sup> but other authors, as even Hemsley in his plate of *C. australis*, give as inflorescences what are really fruit receptacles in a more or less advanced condition.

The imbricate scales are in several rows, more or less free, narrow and acuminate at first, but usually broadened, obtuse, and grown together in later stages. Every degree of transition is observed between the marginal scales or bracts and the perfect flowers, so that the first scales must be considered morphologically as aborted flowers.

The development of the flowers takes place successively from the center to the periphery, the full anthesis being reached with the appearance of the stigmas. The number of flowers on each receptacle is variable within certain limits for the same species, and there usually remain on the outside numerous undeveloped flower buds that are not easily distinguished from the bracts or scales.

The perianth is tubulose and with thick walls. It is always free and attenuate at the tip, entire or obscurely lobulate in *C. fallax*, *C. lactiflua*, *C. costaricana*, and *C. panamensis*, and 3 to 5-lobate in *C. australis*, *C. guatemalensis*, *C. nicoyensis*, and *C. elastica*; hairy without and within in *C. lactiflua* and *C. nicoyensis*, but on the outside only in the other species. In *C. australis* and *C. fallax* these flowers are free to the base; they are slightly connate or free in *C. guatemalensis* and *C. panamensis*, connate for about half their length in *C. nicoyensis* and *C. elastica*, and almost completely concretescent in *C. costaricana*.

Each flower contains one pistil. The ovary is 1-celled and partially adherent to the perianth. There is also only one ovule, more or less lobulate at the lower part and inserted on the placenta near the top of the ovary cell in such a way that the funicle is very close to the micropyle.

<sup>a</sup> Trans. Linn. Soc., ser. 2, vol. 2, pl. 27. (1885.)

<sup>b</sup> Les plantes à caoutchouc, p. 98.

<sup>c</sup> Culture of Central American rubber tree, loc. cit., pl. 6.



The style varies in length, thickness, etc., according to the species thus affording good means of identification. It is long (3 mm. and over), slender, and smooth in *C. daguensis* and *C. panamensis*; long and sparsely hairy in *C. fallax*; slender, smooth, and about 2 mm. long in *C. costaricana*. In *C. lactiflua* it is thick and short (1.5 to 2 mm.) with spinescent bristles at the base only, while in *C. guatemalensis* the hairs, longer and not so stiff, extend around the base and on one side up to the stigmas. *Castilla nicoyensis* has a very short (1 mm.), thick, and quite smooth style, but in *C. elastica* this organ varies in length from 0.8 to 1.5 mm., and is also thick and sparsely covered with short hairs. The style of *C. australis* is the most reduced and is also hairy.

The stigmas are normally two to each style, but very often three or five are found in *C. elastica*, and not seldom three in *C. guatemalensis*. They are short and cushion-shaped in *C. australis*, rather slender and moderately developed in *C. daguensis*, *C. fallax*, *C. costaricana*, and *C. panamensis*, and long, broad, and conspicuously twisted in the other Central-American species. In the Yucatan specimens of *C. guatemalensis* they are so prominently long and otherwise peculiarly shaped that we are in doubt as to whether these specimens do not constitute a separate type. In most of the species the stigmatic surface is more or less papillose-verruculose, but in *C. daguensis* the papillæ, instead of being covered with a sugary nectar, are provided with an indument of long, flagellate hairs. In *C. australis* this same surface is also hairy, if we may judge from Hemsley's plate.

#### INFRUCTESCENCE.

Directly after the pollinating process is over, the perianth usually begins to thicken and it then turns gradually into an orange red pulp. As with the growth of the ovules, now changed to seeds, more space is needed, the receptacle increases its surface, all its parts, but mainly the outer scales, altering their original size, shape, and texture. As these changes are gradual and it is often difficult to decide whether a given receptacle is still an inflorescence or has become an infructescence, the characters derived therefrom are always more or less indefinite and should be used with caution in the identification of the several species.

An exception to the thickening and coalescence of the perianths is found in *C. fallax*, in which they remain free, green, and hairy, with more or less adherence to the seeds. In the other species the ripe pulp is sweetish and eagerly sought for by certain birds; in *C. ulci* it is even a favorite delicacy of the native Indians. In this species the whole infructescence has a quite characteristic appearance, being globose and entirely covered with scales and containing only 3 to 5



achenes. In *C. daguensis* and *C. panamensis* the cup-like receptacle remains rather deep and closed, while it is quite shallow and open in *C. fallax*, *C. lactiflua*, *C. costaricana*, *C. guatemalensis*, and *C. nicoyensis*. The counterpart of the closed receptacles of *C. ulei* is found in *C. elastica*, where these organs are more or less distorted and reflexed so as to embrace the twig on which they grow. As to size, they are exceptionally large in this last species, as also in *C. costaricana*.

No data are available as to the seeds of *C. australis*, *C. daguensis*, and *C. lactiflua*. *Castilla fallax* has the smallest seeds, *C. panamensis* and *C. ulei* the largest ones; they are roundish and also small in *C. nicoyensis*, ovoid-elongate and rather large in *C. ulei*, distinctly ovoid in the remaining species. In all cases they are more or less flattened by being pressed one against another. The integuments consist of a white, translucent testa, covering a brownish or purplish arillus. There is no albumen and the cotyledons are large.

#### PRELIMINARY SURVEY OF SPECIES.

The writer does not make any claims to finality in the status here assigned to the forms described. As the fruit of his own experience in the field, supplemented by the observations kindly supplied by his fellow-workers, Messrs. O. F. Cook and G. N. Collins, and of his careful study of a large amount of well preserved materials, he has been able to satisfy himself that most if not all of these forms offer constant characters to be found in all specimens proceeding from a certain area and to be easily recognized by any skilled botanist. At the same time it must be borne in mind that, owing to the uniformity in the general aspect of the representatives of the genus, it really needs an exercised eye to distinguish them on sight. Microscopic examination of complete specimens, including branchlets with leaves and terminal buds, clusters of both male and female inflorescences, and ripe fruits, is necessary to insure correct identification.

The ten forms here described have not, probably, the same taxonomic value; the distinctive characters may prove more pronounced and weighty in some, and not so sharply defined or of less significance in others. To the former a definite specific status will be readily conceded, while the latter may remain in abeyance or be reduced to the rank of subspecies or even of mere forms. Neither have we necessarily recorded the whole number of specific representatives of the genus; we know almost nothing of several of the rubber-producing trees of South America, especially of those of Ecuador, Venezuela, and Colombia, and it is even probable that *Castilla elastica* may not be the only form peculiar to Central Mexico. The present attempt at a monograph of the genus does not, therefore, pretend to be either complete or final. Among the species the status of which can not be



disputed we have *Castilla ulei*, *C. fallax*, and *C. australis*; that is to say, the known forms of the strictly South American group, with the leaves more or less rounded at the base.

*Castilla ulei* is not yet well known, but its fruits present such well defined peculiarities as to segregate it widely from all other studied species. Each receptacle contains only 3 to 5 elongate nutlets surrounded by a soft pulp; the leaves also appear to be smaller than in any other species.

*Castilla fallax* is another very aberrant type on account of its dry fruits completely detached from each other, as are the female flowers. The leaves are almost glabrous and shiny above, and covered beneath with very short, soft hairs.

*Castilla australis* offers a unique character in the shape of its style and stigmas. These latter are short and broad and completely exerted. The female flowers seem also to be free to the base, with an urceolate perianth. This type is very imperfectly known, but its localization at the southern extremity of the generic area makes it quite probable that it is a well defined species.

We could include among those strongly individualized types my *Castilla daguensis*, but I shall refrain from doing so at present on account of its possible identity with the preceding species. The only obvious difference between the two consists in the shape of the style and stigmas, and the character of these organs as described by Hemsley is so much out of the usual line that I am compelled to suspect an error of observation or a casual anomaly in the specimens investigated at Kew.

The Central American forms have large leaves, distinctly cordate at the base, and they are so uniform in their general aspect that up to the present they have been considered as all belonging to one species, *Castilla elastica*. Observation, however, has shown that the floral parts, as well as the fruits, present constant and definite differences.

In a first subdivision, including *Castilla lactiflua* and *C. costaricana*, the primary male inflorescences are always borne on very short and thick peduncles (pls. 27, 31). This character, which we know to be really constant in both species, is in itself quite sufficient to segregate them from the forms of the remaining group in which the same stipes are relatively long and slender (pl. 37). On the other hand, there can be no doubt as to the characters that distinguish *C. lactiflua* from *C. costaricana*. The complementary inflorescences are unlike; the style is short, thick, and bristly, with long stigmas in the former, while the same organ is long, smooth, and with tongue-like, reduced stigmas in the latter. In the first, further, the drupes are not completely fused together in the pulp, as they are in the latter, and the number of seeds in each receptacle is less.



The second subdivision of the Central American group is the more perplexing one, first, on account of the scarcity in some cases of good material for their study; second, because of my not having had any opportunity to investigate standing specimens of *C. elastica* and *C. panamensis*; and lastly, owing to the fact that imperfect materials have been collected in the territory covered by *C. elastica*, *C. lactiflua*, and *C. guatemalensis*, which either belong to another as yet undescribed form or else appear as connecting links between the above types, considered here as specifically distinct. It is not unlikely, therefore, that further researches may modify the present arrangement of this group.

Meanwhile, *C. guatemalensis* appears as a good type, standing apart from the three remaining species, *C. panamensis*, *C. nicoyensis*, and the original type of Cervantes, on account of its unusually long-stipitate male inflorescences, united in clusters of from 6 to 8. The similarity of the styles may lead one to confound this species with *C. elastica*, but if the small stipules of the latter and its enormous fruiting receptacles, distorted so as to embrace the twig on which they are borne and containing seldom less than 35 seeds, are compared with the same organs in *C. guatemalensis*, the possibility of a specific community between them becomes very small. The same disparity separates *a priori* *C. elastica* from the two southernmost Central American species, *C. nicoyensis* and *C. panamensis*, and these in turn differ from each other by their styles, their fruits, and several peculiarities of the male inflorescences.

## SYSTEMATIC TREATMENT.

### REVISION OF GENERIC CHARACTERS.

**Castilla** Cervantes, Gaceta de Literatura de México, Suppl. July 2, 1794.

*Castella* "J. L. M." loc. cit.

*Castilloi* auct.<sup>a</sup>

Flowers monœcious, thickly set in diversely shaped, unisexual inflorescences, covered outside with imbricate bracts. Male receptacles of two kinds, the primary ones in one to several pairs or sometimes absent, more or less flabellate or compressed and by themselves in the axils of leaves or on defoliate nodes, the complementary ones smaller, clavate or flabellate always accompanying the female inflorescence. Perianth none. Stamens numerous, irregularly scattered along numerous multiform bractlets; filaments and anthers erect, the latter ovate, 2-celled, the cells attached laterally on a broad connective and opening longitudinally. Gynœcium entirely wanting. Female receptacles more or less flattened or cupuliform. Perianth urceolate, briefly 3 to 5-lobate, the lobules thick, closely contiguous. Ovary inclosed, adnate to the perianth; style short, the stigmatic branches normally 2, sometimes 2 to 5, exserted, filiform or lanceolate, papillose, spreading; ovule anatropous, pendent from the apex of the ovular

<sup>a</sup> Name first used in 'Tracts Relative to Botany, London, 1895.



cavity. Staminodes none. Fructiferous perianths enlarged, dry or fleshy, more or less adhering to the receptacle and to each other and inclosing the rounded nutlets (achenes); pericarp crustaceous. Seed pendulous; episperm membranous, brownish; albumen none; cotyledons thick and fleshy, similar in size and shape, the radicle small and superior.

Laticiferous trees. Leaves alternate, short-petiolate, often large, entire or minutely denticulate, penninerve, deciduous; stipules ample, intrapetiole, caducous, connate into the form of a shell.

Species about 10, following the foot of the mountains of the western side of America from Mexico to Peru and Bolivia.

### DESCRIPTION OF SPECIES.

#### KEY TO THE SPECIES.

Leaves subemarginate, rounded, or subacute at base.

Receptacles ovoid; fruits 3 to 5 in each receptacle..... 1. *C. ulci*.

Receptacles flattened; fruits more than 5 in each receptacle.

Fruits free to the base, greenish and dry at maturity..... 2. *C. fallax*.

Fruits more or less coalescent, the pericarp at maturity an orange red, succulent pulp.

Style very short; stigmas cushion-shaped..... 3. *C. australis*.

Style long and slender; stigmas elongate, more or less twisted..... 4. *C. daguensis*.

Leaves cordate or deeply emarginate at base.

Primary staminate inflorescence short-stipitate (stipe not over 1 cm. long).

Complemental male inflorescence flabellate, opening in a long slit. Style short, thick, and hairy-spinescent; stigmas long and twisted. 5. *C. lactiflua*.

Complemental male inflorescence clavate, with a small, rounded opening. Style long, slender, and smooth; stigmas short, flat, and pubescent..... 6. *C. costaricana*.

Primary staminate inflorescence long-stipitate (stipe over 1 cm. long).

Male receptacles in clusters of 6 to 8; each opening broadly by a slit; stipes long and slender; style stiff-hairy at base..... 7. *C. guatemalensis*.

Male receptacles in clusters of 4.

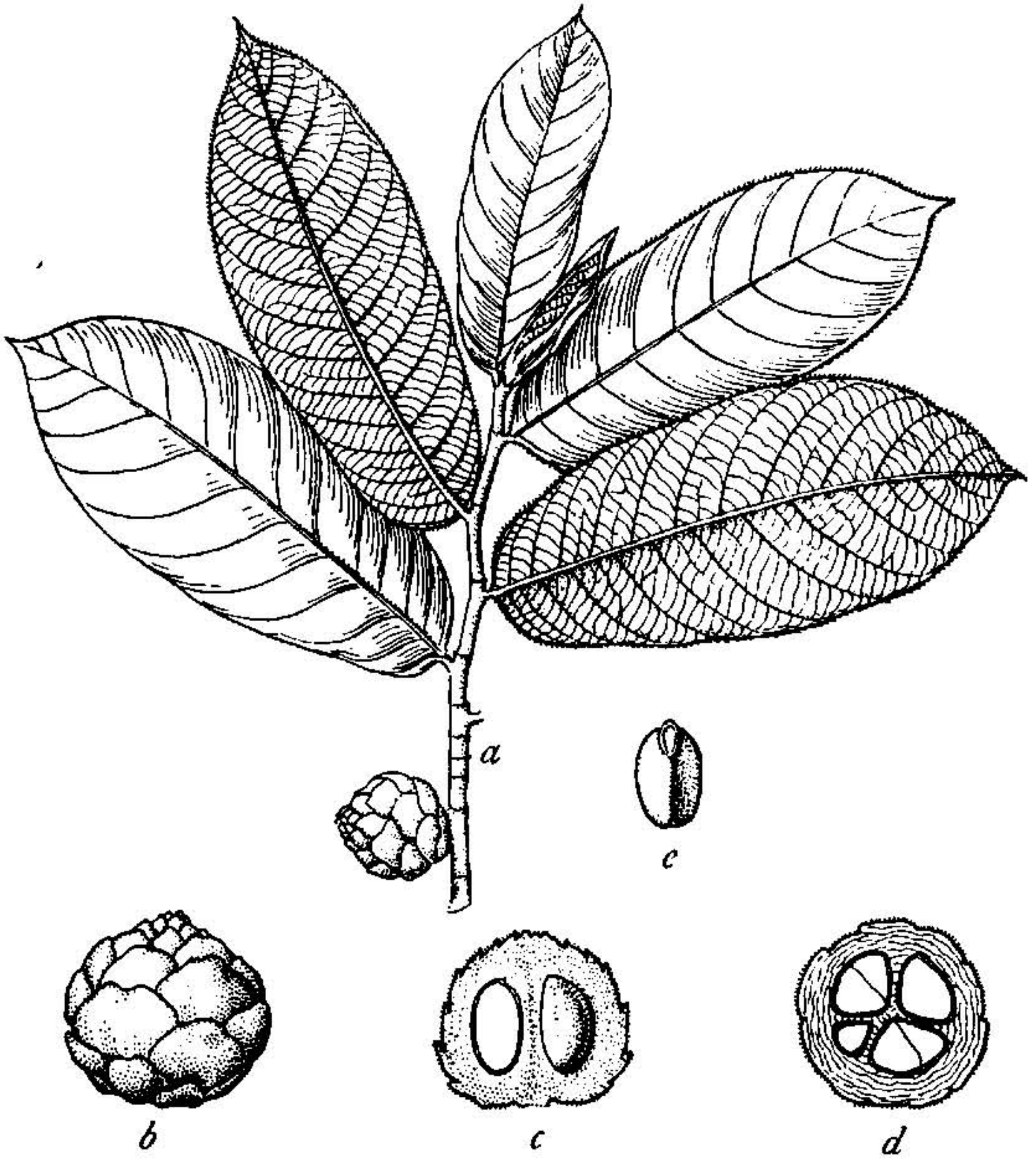
Style long, slender, and smooth; stigmas rather small. Male receptacles regularly flabellate..... 8. *C. panamensis*.

Style short and thick, with large stigmas. Lobes of male receptacles reflexed or distorted at the time of flowering.

Lobes of the male receptacles opening to a flat disk; interstaminate bractlets very few. Style glabrous..... 9. *C. nicoyensis*.

Lobes of the male receptacle distorted-reflexed; interstaminate bractlets numerous. Style sparsely hairy; fruiting receptacles very large..... 10. *C. elastica*.





CASTILLA ULEI WARBURG.



1. *Castilla ulei* Warburg, Bot. Jahrb. Engler 35: 654. 1905. PLATE 22.

A tree 20 to 40 meters high, with long, spreading, superficial roots. Twigs terete, 3 to 4 mm. in diameter, at first densely hairy, ferruginose-tomentose, later sparsely covered with appressed, stiff hairs; bark brownish.

Petioles short (9.5 cm.), slender and hairy. Leaf blades oblong, 12 to 24 cm. long, 4 to 6 cm. broad, rounded or subtruncate and slightly oblique at base, briefly acuminate or apiculate at tip, densely villose-ferruginose when young, then hispid-glabrescent above, pale and tomentose beneath; margin subentire, minutely setose-denticulate. Stipules caducous, large, spathiform, lanceolate, villose-ferruginose, their annular scars 4 cm. long and 1 cm. broad.

Inflorescences not known.

Fruit receptacles solitary in foliate or defoliate axils, almost sessile, globose and slightly flattened at base, 2 cm. long and 2.5 cm. in diameter when dry, but larger in the fresh condition, covered outside to the apex with imbricate bracts (scales), 3 to 5-seeded. Seeds oblong with three flattened sides, 12 mm. long, 6 mm. in diameter, surrounded by a soft pulp; testa very thin; endosperm wanting; cotyledons thick (according to Warburg and Ule, loc. cit.).

BRAZIL: Marary, September 18, 1909, *Ule* 5359; Belem, Jurua Miry, October, 1900, *Ule* 5900.

This species is distinctly characterized by its remarkable fruits, which are said to be edible when in fresh condition. The leaves are smaller than in any other species of the genus and the seeds proportionately longer.

EXPLANATION OF PLATE 22.—A, branchlet with female flower; B, fruit; C and D, cross-sections of fruit; E, seed. A, one-half natural size; B-E, natural size.

2. *Castilla fallax* Cook, Science n. ser. 18: 438. 1903.

PLATE 23. FIGURES 45, 46.

*Castilloa tunu* Hemsl. Hook. Icon. Pl. IV. 7: pl. 2651. f. 1-7 (f. 8-15 excl.) 1900, in part.

A medium-sized tree. Floriferous branchlets thick, filled with a whitish pith, covered outside with a dense growth of stiff, appressed hairs. Internodes 3.5 to 4 cm. long.

Leaves rather large and coarse. Petioles thick, 1.5 to 2 cm. long, hairy, sulcate. Leaf blades 30 to 40 cm. long, 10 to 15 cm. broad, oblong or lanceolate-oblong, rounded or subacute at base, acuminate, deep green, rough and provided with scanty appressed hairs above, paler and covered with a short, appressed pubescence beneath; midrib and primary veins very prominent; margin of young leaves minutely dentate, but becoming entire with maturity. Stipules caducous, rather short (4 to 5 cm.), marked with wide-spaced, longitudinal ribs, smooth and hairy outside, glabrous and purplish within.

Receptacles of the primary staminate inflorescence sessile or subsessile, single or in pairs in the axils of leaves, small (1.5 to 2 cm. across), flabellate and opening by a long, arcuate slit. Outer scales small (1.5 mm. long, 1.5 to 2 mm. broad), scarcely conerescent, hairy outside. Interstaminate bracts few, small, triangular, subciliate. Stamens 1 to 1.5 mm. long; filament short; connective very thick, with a few stiff hairs on the median line; anther cells small, glabrous.

Secondary staminate inflorescence wanting on specimens examined.

Receptacles of the pistillate inflorescence solitary, sessile, rather small. Scales free, broadly ovate-triangular, acuminate, silky outside, smooth inside. Flowers free to the base. Perianth thick, about 4 mm. long, densely silky out-



FIG. 45.—Male inflorescence of *Castilla fallax*. Scale 3.



side and on the upper part of the inside, divided at the tip into 4 or 5 rounded lobules. Ovary ovate, only partly adhering to the perianth; ovule and style inserted laterally. Style 3 to 3.5 mm. long, slender, sparsely hairy; stigmas rather short, twisted.

Receptacles of the infructescence very shallow. Achenia not fleshy nor confluent, pubescent, carinate on the suture of the lobes of the perianth. Seeds small (about 8 mm. long, 6 mm. in diameter), ovate, slightly compressed.

COSTA RICA: Quebrada de Potrero Grande, near Térraba, Diquís Valley, at an altitude of 150 meters, *Pittier*, flowers and fruit, March 18, 1898 (Instituto fís.-geog. Costa Rica no. 12051).

EXPLANATION OF PLATE 23.—*a, b*, portions of a branch bearing male inflorescences; *c*, piece of bark from the same to show the strigose hairs; *d*, calyptrate bract (or bracts) which shields the male inflorescence; *e*, section of a young male inflorescence; *f*, an involueral scale; *g*, bracteoles between the male flowers; *h*, a male flower; *i*, infructescence seen from below; *j*, the same from above; *k*, a section through a portion of the same, showing that the carpels (pistils) are completely immersed; *l*, a single pistil (fruit); *m*, seeds of different shapes; *n*, embryo; *o*, portion of one cotyledon and axis. Reduced one-half from Hooker's *Icones*, loc. cit., pl. 2637. In the original all the figures more or less enlarged except *a, b, i, o*. The explanations are as in Hemsley; for exclusions see observations immediately below.

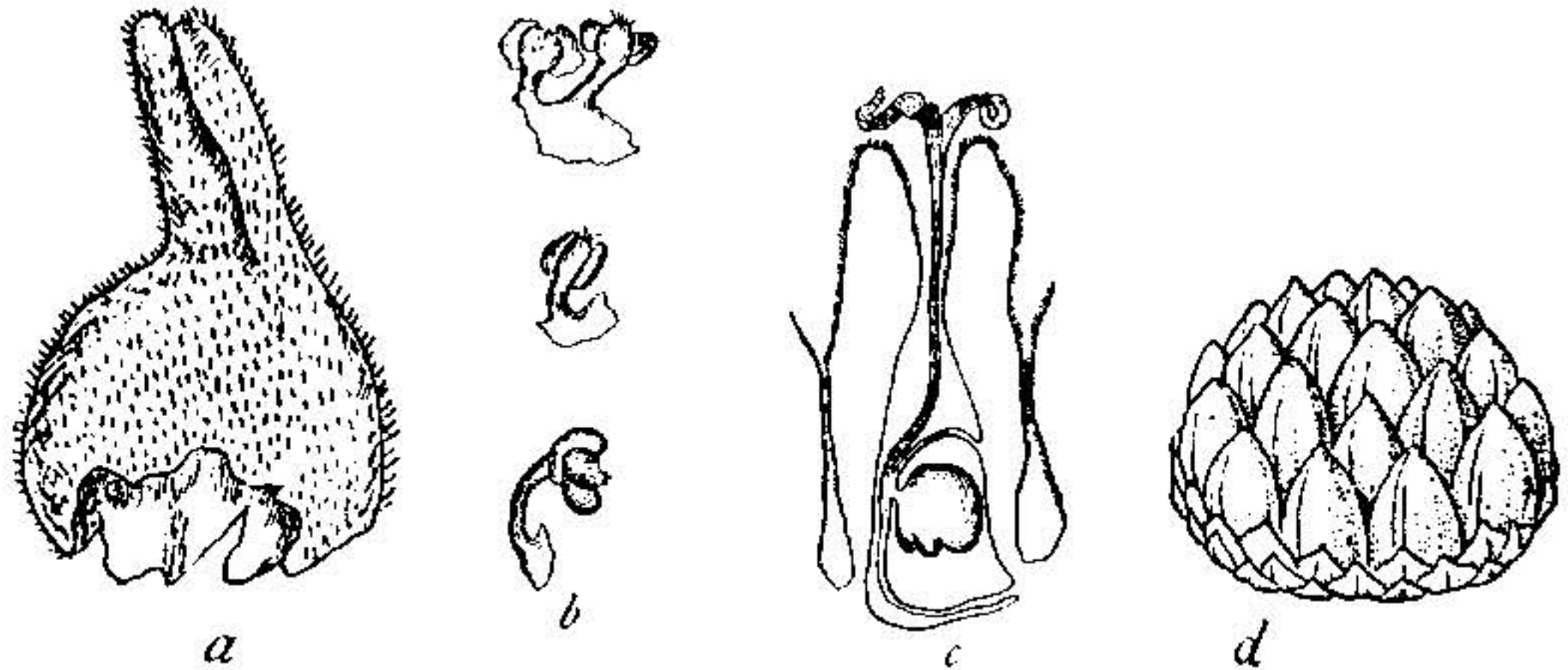


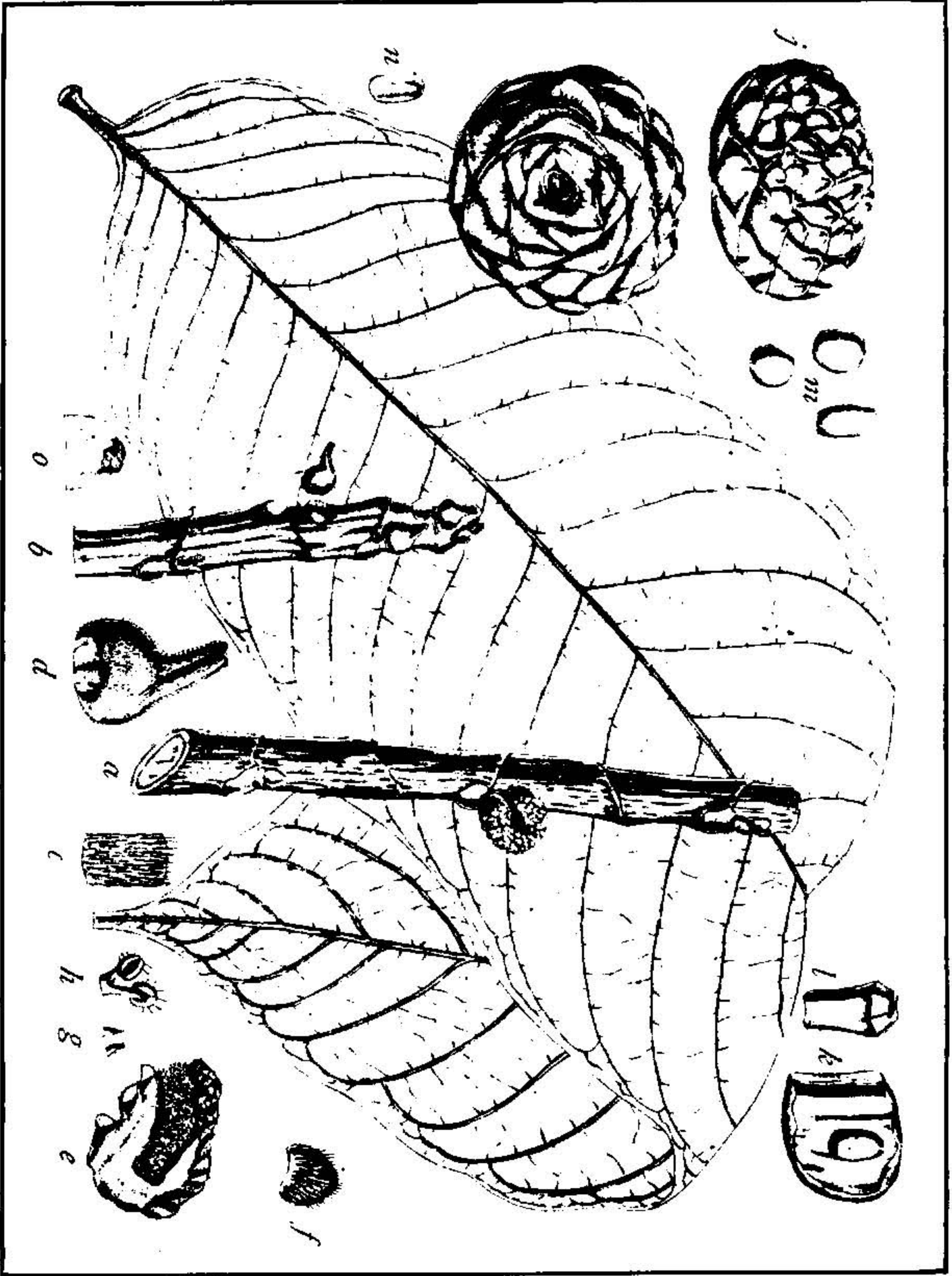
FIG. 46.—Floral details of *Castilla fallax*. *a*, Calyptrate bract protecting the male inflorescence; *b*, forms of stamens; *c*, female flower; *d*, infructescence. *a, d*, after Hemsley; *b, c*, after Warburg. *a, d*, Natural size; *b, c*, scale 3.

According to observations made by me and published in 1903,<sup>a</sup> the leaves of seedlings have remote marginal teeth that soon disappear, except at the base of the blade. On dried specimens from mature trees no such detail is noticeable, which shows that the teeth are really tufts of hairs. Another interesting feature, brought to light by Mr. Hemsley, is the calyptra-like bract that covers the male floral buds. (Fig. 46, *a*.) In plate 2651 of Hooker's *Icones*, already referred to, we have excellent representations of parts of *C. fallax* in the drawing of the leaf and in figures 1 to 7. Figure 8 shows the anthers as hairy, which is not the case with this species, and the stamens are not regularly geminate. The drawings of fruits (figures 9 to 11) do not belong to *C. fallax*, but more likely to *C. guatemalensis*. Figure 12 can hardly refer to a *Castilla*, unless it represents, instead of a pistil, a closed female flower. Of figures 13 to 15 it may be said that they apply to any of the small-seeded forms of the genus.

As to the further distribution of *C. fallax*, we are reduced to oral information, not always from very reliable sources. Personally, the writer has met the tree all over the Diquís Basin, at altitudes not exceeding 600 meters, and also near the mouth of the Savegre River, and along the Coto River in the

<sup>a</sup> Boletín del Instituto físico-geográfico, vol. 3, p. 129 (1903).





CASTILLEJA TENUIS HEMSL.



Golfo de Osa district; it was found only once, however, in condition to be collected. According to Térraba Indians, used to traveling between their village and David in the Republic of Panama, there are several individuals or groves of the same species along the mule-path between Rio Chiriquí Viejo and the mentioned town of David. These localities, as well as those where specimens of the tree have been collected, are on the Pacific side of Central America. A Frenchman who had spent several years in and about Bluefields, in Nicaragua, and whom the writer met in Port Limon in 1902, informed him that the "hule macho," called also "hule colorado" or "gutta-percha" by the native Spaniards and "tunu" by the Miskito Indians, is rather common on the Atlantic coast of Nicaragua. This seems to be confirmed by Koschny. There are also indications, collected in Guatemala, of the presence of such a tree in eastern Spanish Honduras; but, in the absence of herbarium specimens, it is not possible to decide whether the last-mentioned data refer to *C. fallax*, or to the enigmatic *C. tunu* of British Honduras. The only definite character heard of is the absence from the latex of merchantable rubber.

This species and the tunu of British Honduras are distinguished from the other Central American species of the genus by the very important fact that *they do not produce commercial rubber*. The milk coagulates in a hard, sticky, unelastic mass, erroneously called "gutta-percha" by the natives, the price of which is so low as to render its collection unprofitable. It is therefore of urgent necessity to publish accurate and detailed descriptions of these useless species, so as to avoid the mistake of planting or distributing their seeds for agricultural purposes. Unfortunately, however, the attempts hitherto made at formulating their distinctive characters have only resulted in confusion.

As far back as 1883, Sir Daniel Morris mentioned "tunu" in his book on British Honduras, but looked upon it as the local name of the true rubber tree. Nevertheless, his description of the fruit is more suggestive of *C. fallax* than of the Mexican *C. elastica*: "The fruit, of a brownish green color when ripe, has very much the appearance of a raspberry flattened or depressed, about an inch in diameter, the numerous seeds being massed together and enclosed in papery capsules, covered with a brown tomentum."<sup>a</sup> This account does not contain any allusion to the red pulp that characterizes the fruit of the true *C. elastica* and seems to point to the presence in British Honduras of a species the nutlets of which are free and dry. At the same time, it is known from other sources that the name "tunu" applies to a species that does not produce rubber, and is therefore distinct from *C. elastica*.

Sir Joseph D. Hooker does not mention Morris's work in the memoir he presented in 1885 to the Linnean Society on "Castilloa elastica and some allied plants." In Hooker's paper is found a short description of fruits assumed to belong to the tunu of British Honduras, illustrated by 3 drawings;<sup>b</sup> but neither the description nor the figures of these fruits indicate any relation to *C. fallax*. Some of the fruits ascribed on the same plate to *C. elastica* (figs. 1-6) appear even more similar to those of the former species than those that represent the tunu, and these bear a striking resemblance to *C. costaricana*.

Writing in 1898,<sup>c</sup> Mr. Hemsley rectifies the error of Morris in applying the name "tunu" to *C. elastica*, accepting Hooker's statement of the existence in British Honduras of a second species of Castilla. As a further proof, he mentions that Mr. Rowland W. Cater has sent leaves of what is known in that coun-

<sup>a</sup> Morris, D. The Colony of British Honduras, p. 74. (1883.)

<sup>b</sup> Trans. Linn. Soc. Bot. ser. 2, vol. 2, p. 212, pl. 28, figs. 7-9. (1885.)

<sup>c</sup> Kew Bull. Misc. Inform., 1898, p. 141.



try as "tunu," "chaperno," "male rubber-tree," or "sterile rubber-tree."<sup>a</sup> Previously, the same collector had sent fruits, which, as we shall see, have been described as those of *C. tunu*.

A further step was taken in 1900 by the same botanist, naming and describing the tunu as a distinct botanical species. The diagnosis agrees with Hooker's account in stating that the fruits are almost entirely immersed, while the detailed description is drawn from incomplete specimens, assembled from localities so far apart as Belize and the Diquís Valley of southern Costa Rica. Mr. Hemsley was certainly justified in trying to settle the status of the Honduras tree, but the validity of a species established on these heterogeneous materials is none the less doubtful.

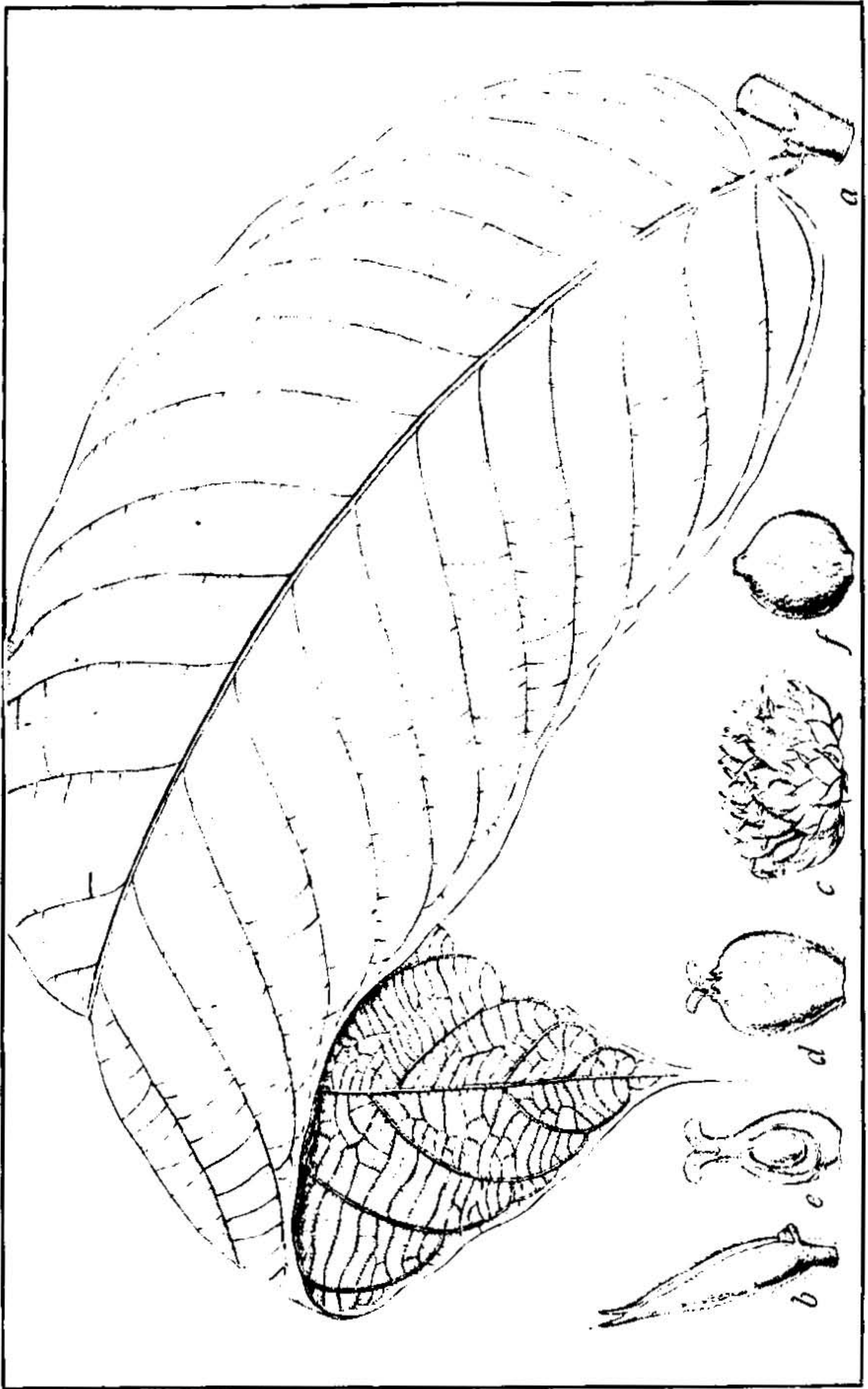
The characters of the twigs, leaves, and primary male inflorescences were obtained from specimens collected by the writer in Costa Rica March 18, 1898, along a small river east from Térraba, and from a tree readily distinguished, even by the Indians, from any of the other species then included under the name of *Castilla elastica*. Several sets of these samples were presented to Mr. Poisson, son of a well-known botanist of the Paris Museum, who in turn sent part of these to the Kew Herbarium. Although most of the specimens were complete, except for the female flowers, which were not generally in season at the time of the collection, Mr. Hemsley seems to have missed the fruits, and having mentioned the fact to the younger Poisson on the occasion of an interview that took place at Kew, the latter offered to send him a few of them, collected by himself and preserved in a formol solution. Now the present writer guided and helped Poisson in every step of his investigations in Costa Rica, and he is consequently in position to affirm that the French explorer did not see a single grown Castilla tree on the Pacific slope of that country, nor did he collect any specimens of "hule macho," which he improperly calls "hule machado." His specimens of fruits, preserved in formalin, all proceeded from trees of *Castilla costaricana*, growing at Santa Rosa, near Guápiles, on the plains bordering the Atlantic. Statements of the case published by the elder Poisson contain several other errors which may well have contributed to support Mr. Hemsley's contention that the fructiferous receptacles sent from Honduras by Mr. R. W. Carter belonged to a species identical with the Costarican hule macho.<sup>b</sup>

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<sup>a</sup> "Tunu" or "toonu" is the name used for the tree by the Caribs inhabiting along the coast from Cape Gracias á Dios to the Mexican border; "chaperno" is a Spanish name, generally applied to certain hard-wood leguminous trees; the qualificative of "male," as used above, is simply the translation of the Spanish "macho," which, applied to plants, indicates often, although not always, the absence of certain useful properties found in near related species, rather than any sexual peculiarity; in much the same way, it is likely, the word "sterile" is used here to indicate the lack of rubber in the tree.

<sup>b</sup> Bull. Mus. Hist. Nat. Paris, pl. 6, p. 138. (1900.) Also Rev. Cult. Colon, pl. 6, p. 302. (1900.) The paper in the Revue is a reproduction of the first, which was presented to the 43rd meeting of the naturalists of the Museum, March 27, 1900. It states that after having mentioned to Mr. Poisson the younger the existence of an undescribed species of Castilla, Mr. Pittier took him to the spot where the tree grows, where they collected twigs with fruits and put some in the preservative fluid; first wrong statement, since the nearest known station of the new species in question is a two days' march south from San José and on the Pacific coast, while the specimens collected and preserved by Poisson were collected on the Atlantic side of the country and belong to *C. costaricana*, a species described by Liebmann in 1851. The distinctive character of the fruit given in the paper by Poisson is precisely one of the specific attributes of the last





*CASTILLA AUSTRALIS* HEMSL.



A deeper and more intricate confusion was thus produced, so that the diagnosis of Hemsley's *C. tunu*—"affinis *C. elastica* Cerv., a qua differt foliis basi haud cordatis utrinque multo minus hirsutis, drupeolis receptaculo fere omnino immersis"—definitely excludes the Costarican species which furnished most of the data of the detailed description. It also appears very doubtful whether the two characters mentioned in the diagnosis are really combined in the Honduran *tunu*, the specific peculiarities of which are practically unknown, though its distinctness is hardly to be denied in advance of more adequate knowledge. The previous history of the species and the application of the local Honduras name "*tunu*" as the botanical designation of the same may also be taken as indications of the Honduran specimens being intended to constitute the type of Hemsley's species. Under such circumstances, and without denying the possible identity of the *hule macho* and the *tunu*, it seems necessary to leave Hemsley's name in abeyance until the real characters of the Honduras species can be made clear.

Such was the view taken in 1903 by Mr. O. F. Cook, of the U. S. Department of Agriculture, after devoting considerable attention to the study of the Central American rubber tree.<sup>a</sup> Rasing upon the conclusive discrepancies in Hemsley's diagnosis and on his own personal acquaintance, mostly acquired in the field, with the several species of *Castilla*, he found it preferable to consider the Costarican *hule macho* as a distinct species, taking as type a more complete set of the same specimens that furnished a part of the description of Hemsley's *C. tunu*, a course that appears to be justified by the evidence reviewed above.

**3. *Castilla australis* Hemsley. Hook. Icon. Pl. IV, 7: pl. 2676, 1901. PLATE 24.**

Evergreen (?) tree with a smooth, erect trunk and horizontal branches. Young twigs and leaves silky-tomentose. Fructiferous twigs thick.

Petioles about 1 cm. long. Leaf blades coriaceous, oblong or oblong-lanceolate, 30 to 40 cm. long, 10 to 18 cm. broad, slightly emarginate at the base, abruptly acuminate at tip, glabrous or at first glabrescent above, hirsute, principally on the midrib and primary veins beneath; margin undulate; primary veins 17 to 19, arcuate, running into each other along the margin, hardly impressed above, prominent beneath. Stipules lanceolate, acute, 4 to 5 cm. long, early deciduous.

Male inflorescences unknown.

Female receptacles stipitate, solitary in the axils of the leaves; stipes 2 to 2.5 cm. long; bracts (scales) in several rows, acuminate, rather narrow and apparently free. Perianth free to the base (according to drawing), lobulate at crown, hairy outside. Style short, thick, and hairy; stigmas very short, cushion-shaped, minutely hairy on the inner (upper) face (?).

Fructiferous receptacles not known.

(Description according to Hemsley and the notes quoted from Pearce, loc. cit.)

PERU: Morro Zungo (region of Cuzco?), common in woods at 1,300 to 1,700 meters above sea level. Female flowers, January, 1866, Pearce.

EXPLANATION OF PLATE 24.—Fig. *a*, leaf; *b*, stipules; *c*, a female inflorescence; *d*, a female flower; *e*, pistil with part of the ovary removed; *f*, an immature nut. Reproduced from Hemsley, loc. cit., on a scale of one-half; in the original *c-f* said to be "enlarged."

species. Further, Mr. Poisson states that "it is wonderful that a tree that supplies a part of the rubber of Costa Rica, etc., is not yet known by botanists;" this is another double mistake, as *C. costaricana* has been known as such for over fifty years and the *hule macho* does not afford any amount of commercial rubber.

<sup>a</sup> See citation, p. 253.



4. *Castilla daguensis* Pittier, sp. nov.

PLATE 25. FIGURE 47.

A tree reaching 50 meters and over; trunks 60 to 100 cm. in diameter. Floriferous twigs covered with not very dense bristly, appressed hairs. Internodes 2 to 5 cm. long.

Leaves rather large, petiolate. Petioles 1 to 1.5 cm. long, flattened laterally, narrowly sulcate and covered with dense, yellowish, stiff, appressed hairs. Leaf blades 20 to 40 cm. long, 10 to 15 cm. broad, elliptic-lanceolate, rounded or scarcely emarginate at base, ending in an acute tip; venation little marked on upper face, except for the hairy midrib and base of the primary veins, prominent and hairy beneath; margin smooth or obscurely sinuate, with thick tufts of short, brownish yellow hairs simulating teeth. Stipules caducous, 4.5 to 6.5 cm. long, bifid at tip, narrowly striate longitudinally and hairy outside, purple and smooth inside.

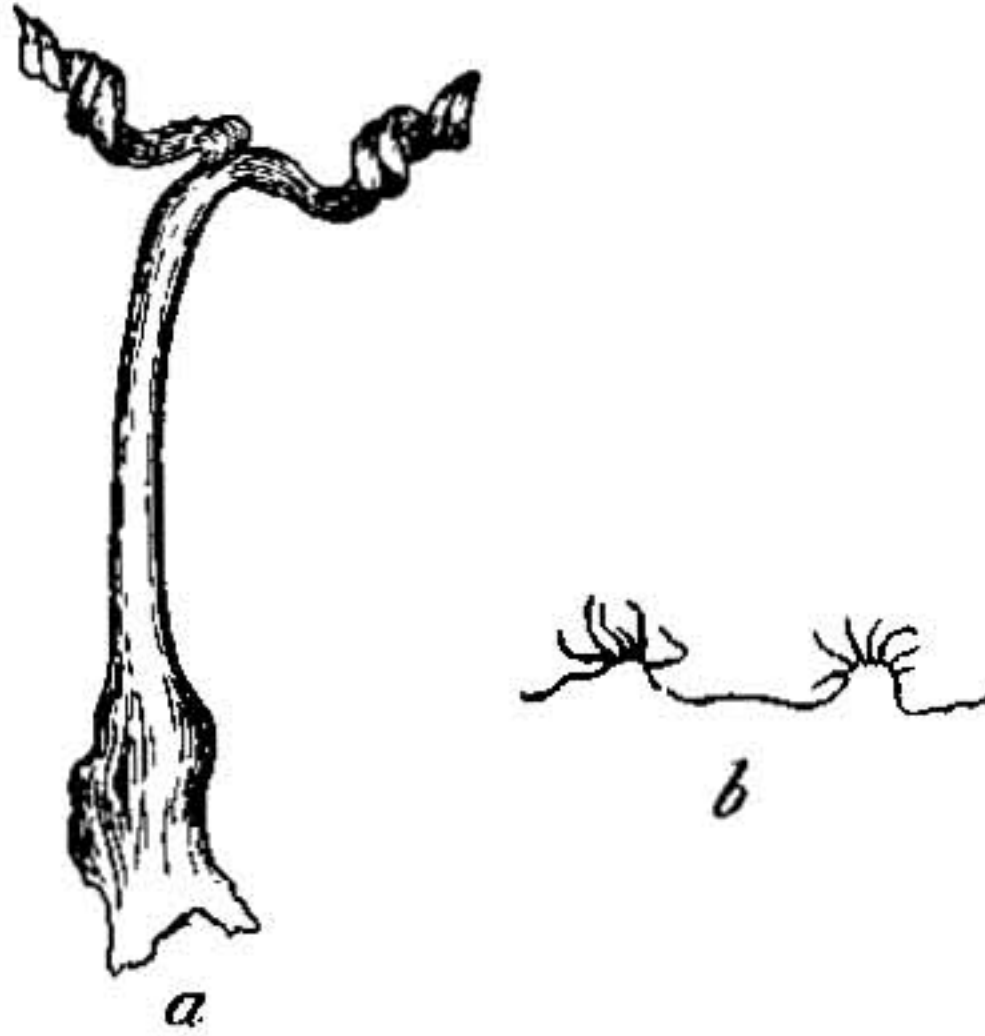


FIG. 47.—Floral details of *Castilla daguensis*. *a*, Style and stigmas; *b*, tufts of hairs on the papillae of the stigmas. *a*, Scale 8.5; *b*, scale 85.

Receptacles of the primary male inflorescence elongate, single or two or three together, rather long-stipitate.

Complemental male inflorescence not seen, but its presence regularly indicated by one scar at the side of each infructescence.

Female inflorescence not known, except the style, this slender, about 3 mm. long, smooth, branching at its emergence from the perianth; stigmas 2 to 2.5 mm. long, narrowly lanceolate, acute, twisted; stigmatic surface covered with rounded papillae, each crowned by a tuft of filmy, flagellate hairs.

Receptacles of the infructescence sessile, rather deep, rounded underneath. Scales hairy, irregular and quite grown together.

Achenia 10 to 18 on each receptacle, closely adhering, except for the broad conical hairy tips, on these the usual furrows replaced by 4 to 6 prominent keels.

Type U. S. National Herbarium no. 530791, collected by H. Pittier (no. 603) near Juntas, Dagua Valley, on the road from Buenaventura to Cali, State of Cauca, Colombia, altitude 300 meters. Flowers and fruit, December 10, 1905. These are the only specimens.

The trees are remarkable for their size; several individuals seen from the road below San José del Dagua assumed truly gigantic proportions, with a somewhat striking habit. The shaft-like trunks attained a height certainly not under, and perhaps over, 50 meters, and the divaricate limbs mostly projected horizontally, beginning about 5 meters from the ground. The tree from which the type specimens were obtained, grew near the probable upper limit of the species, and was of much lower stature, with a rounded crown and a trunk no less than 60 cm. in diameter. Another very interesting and quite characteristic feature of this species is the filmy layer that covers the stigmas. The Dagua Valley, like the adjacent part of the Pacific coast, is known for its almost ceaseless rainfall, and it is not unlikely that this film serves to retain the pollen kernels, taking the place of the sticky excretion of the stigmatic glands of other species, which would here be washed away by the continual showers.

The affinities of this species are with *C. australis* Hemsl., from which it differs in having its female receptacles sessile, as well as in the slender, rather long style, and the acute, twisted stigmas.

EXPLANATION OF PLATE 25.—Fruits and parts of leaves. From type specimen. Natural size.





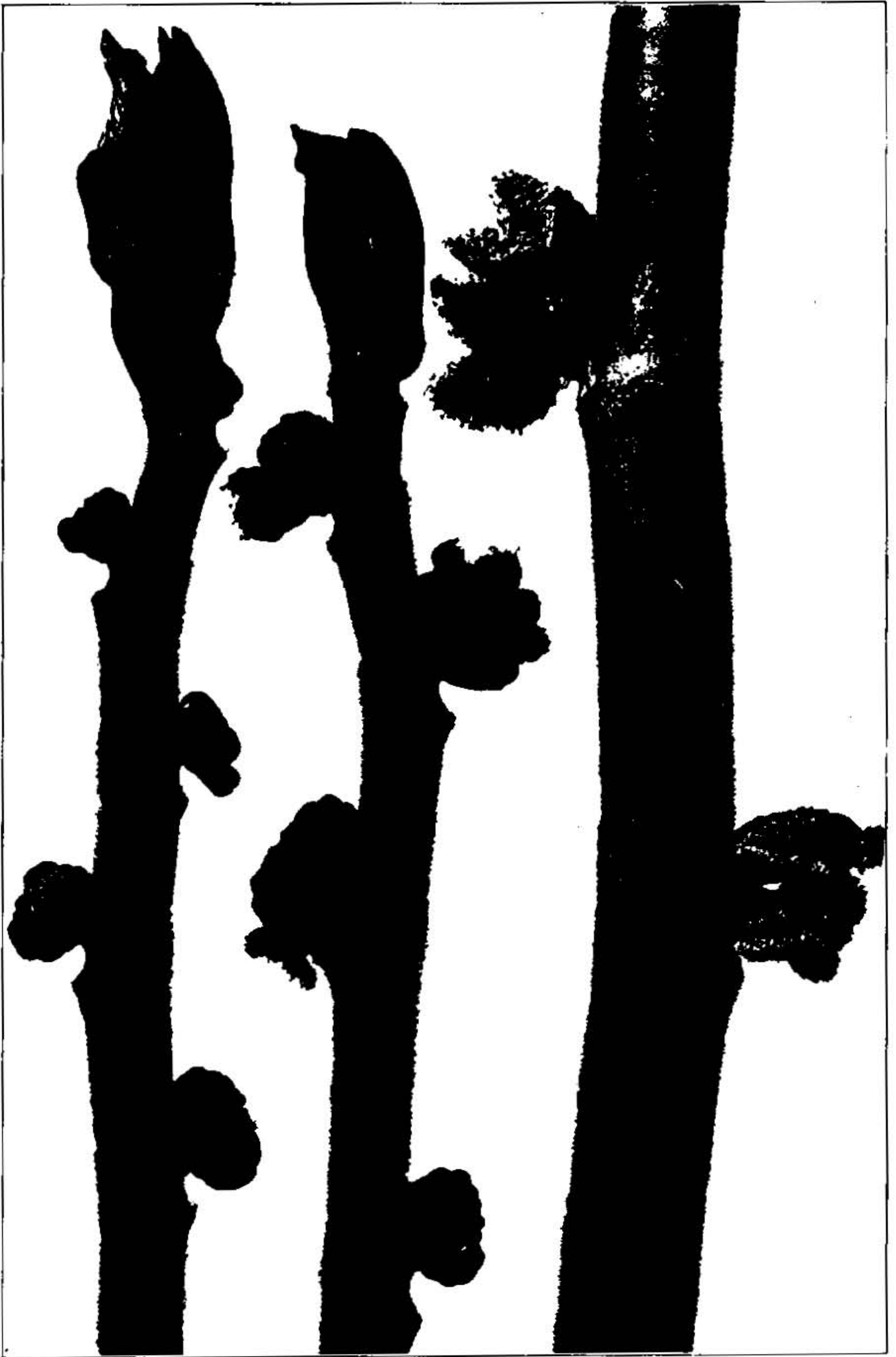
CASTILLA DAGUENSIS PITTIER.





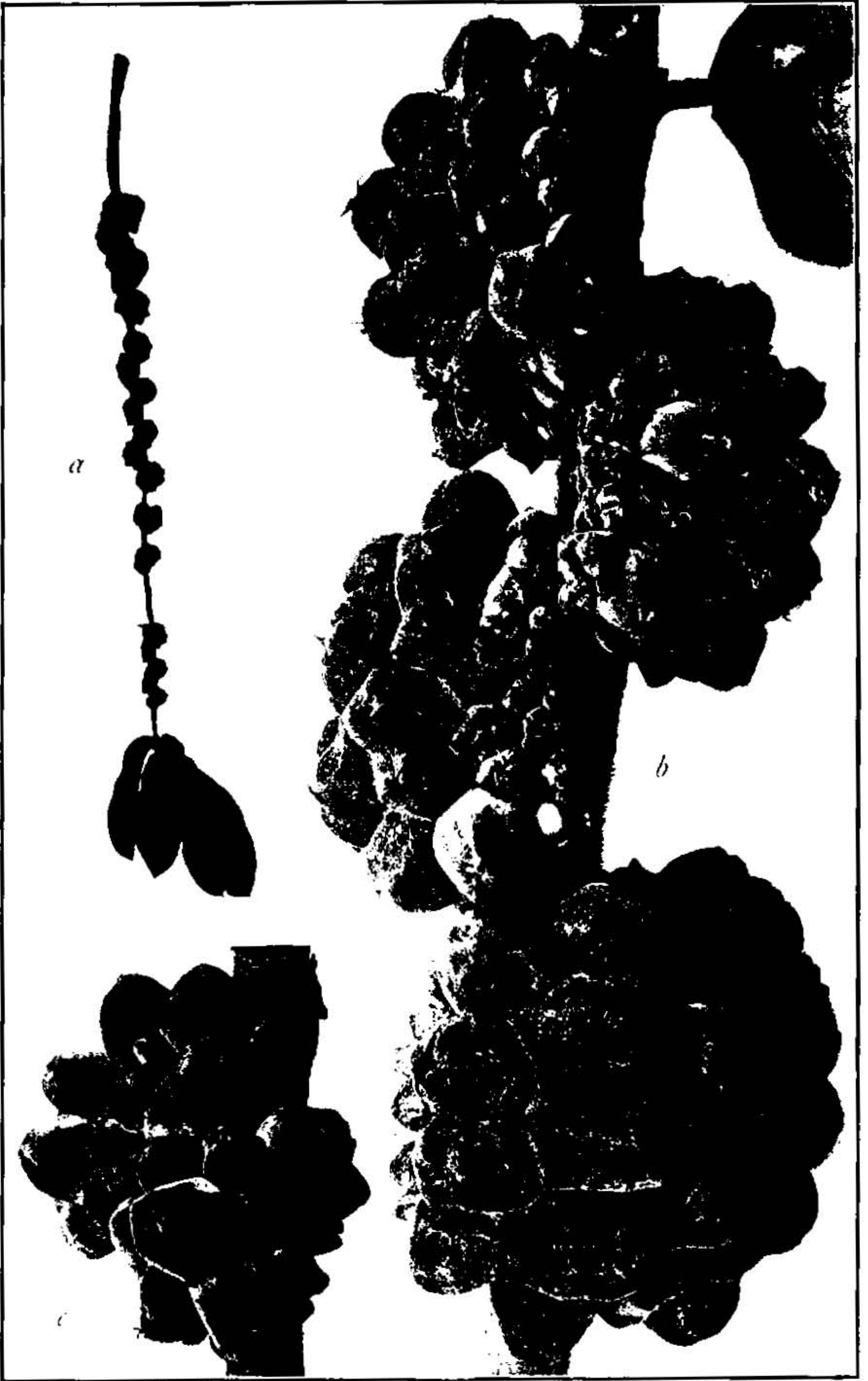
CASTILLA LACTIFLUA COOK.





*CASTILLA LACTIFLUA* COOK.





CASTILLA LACTIFLUA COOK.



5. *Castilla lactiflua* Cook. Science n. ser. 18: 438. 1903.

PLATES 26-28. FIGURE 48.

A medium-sized tree attaining 25 meters and over. Young twigs densely hairy, a thick white pith within.

Leaves rather large. Petioles 1.5 cm. long, thick, hairy. Leaf blades 30 to 45 cm. long, 10 to 15 cm. broad, deep green, rough and covered with scattered hairs above, paler and hairy beneath; midrib and the 20 to 24 primary veins hairy and little prominent on the upper face, the whole venation more marked and thickly covered with stiff hairs on the lower face; margin obscurely sinuate, with tufts of longer, erect hairs between the sinuses. Stipules caducous, 4.5 to 7 cm. long, rather broad, hairy and longitudinally ribbed outside, purplish and smooth inside.

Receptacles of the primary male inflorescence 2 or 3-geminate, small (1.5 to 2 cm. long and broad), the lobes flat, flabellate, more or less cordiform or kidney-shaped. Stipes very short (5 to 7 mm. long), bearing a few free, lanceolate-acuminate bracts. Scales numerous, in 5 to 7 imbricate rows, small (about 4 mm. long, 3 mm. broad), irregularly ovate-lanceolate, velvety, freer and narrower toward the margin. Interstaminate bracts few, irregularly shaped, hairy and ciliate, about the length of the filaments. Stamens 2.5 to 4 mm. long, glabrous, numerous, single or in clusters; filaments 2 to 3 mm. long; connective large, scutellate; anther cells narrow.

Receptacles of the complementary male inflorescence geminate, about 1.5 cm. long, flabellate, with a slit-like opening; stipes short (5 to 8 mm.) and rather slender, covered with imbricate, ovate-acuminate bracts; scales almost free, ovate-lanceolate (about 3 mm. long, 2.5 mm. broad). Interstaminate bracts rather few, irregularly shaped, ciliate and hairy at the tip. Stamens glabrous, 2.5 to 4 mm. long, single or in clusters; filaments rather slender; connective and anther cells as in primary inflorescence.

Receptacles of the pistillate inflorescence unusually numerous on each twig, small, sessile. Scales velvety, the basal ones broadly ovate-acuminate, the marginal ones narrower. Flowers small, concretescent at the base. Free part of perianth thick, hairy outside and inside, usually divided into 4 short, rounded lobes at the tip. Style thick and short (1.5 to 2 mm. long), partly set with stiff minute bristles; stigmas 2 to 3 mm. long, twisted, papillose.

Fruiting receptacles very shallow. Achenia 15 to 25 on each receptacle, deeply parted, scarcely sulcate; pulp orange red. (No specimens available.)

MEXICO: La Zacualpa, Chiapas, Cook, flowers and fruits, April, 1902 (U. S. National Herbarium no. 408562; alcoholic materials of male and female inflorescences; photographs 3967, 3968, 3971, 4323).

EXPLANATION OF PLATES 26-28.—Pl. 26, branchlets showing base of leaves and male inflorescences. Pl. 27, branchlets showing inflorescences and terminal bracts. Pl. 28, *a*, fructiferous branchlet; *b*, *c*, ripe fruits. All natural size.

*Castilla lactiflua* comes very near to *C. clastica*, but differs from it by the flat lobes of the primary male inflorescence, the flabellate complementary receptacles, the fewer interstaminate bracts, and the shallow, flat, fruiting receptacles, each with 15 to 25 seeds.



FIG. 48.—Floral details of *Castilla lactiflua*. *a-c*, Stamens of primary inflorescence; *d*, stamen of complementary inflorescence; *e*, cross section through a pistillate flower. *a-c*, Scale 3.



6. *Castilla costaricana* Liebm. Dansk. Vid. Selsk. Skr. V. 2: 319. 1851.

PLATES 29-34. FIGURE 49.

A tree generally 12 to 15 meters high, but sometimes reaching 18 and 22 meters. Limbs divaricate, thick, nude. Twigs more or less hairy-tomentose, with the leaves crowded at the ends at blooming time.

Leaves deciduous, of very variable size, but rather large when fully developed. Petioles 1.5 to 2 cm. long, thick, hairy-tomentose, longitudinally plicate in dry specimens. Mature leaf blades 29 to 46 cm. long, 12 to 24 cm. broad, coriaceous, ovate, oblong, or slightly lyrate, more or less emarginate-cordate at base, abruptly acuminate, dark green and sparsely soft-pubescent above except on the hirsute midrib, paler beneath and covered with appressed hair, this thick on the midrib and primary veins and sparser elsewhere; venation regular, with 16 to 22 alternate primary veins on each side of the midrib; margin minutely sinuate, with tufts of hair, simulating teeth, between the sinuses.<sup>4</sup> Stipules caducous, very variable in size (4 to 15 cm. long, 3.5 to 4.5 cm. broad), narrower at base, elliptic-ovate, pointed at tip, tomentose outside, purple inside.

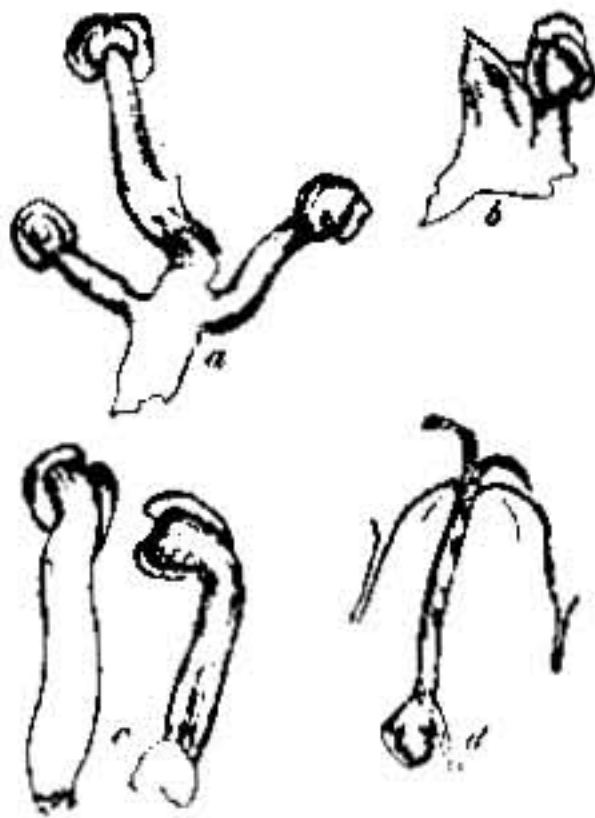


FIG. 49.—Floral details of *Castilla costaricana*. a, Stamens of primary male inflorescence; b, immature stamen of complementary inflorescence with bracteole; c, mature stamen of same; d, cross section of pistillate flower. a-d, Scale 3.

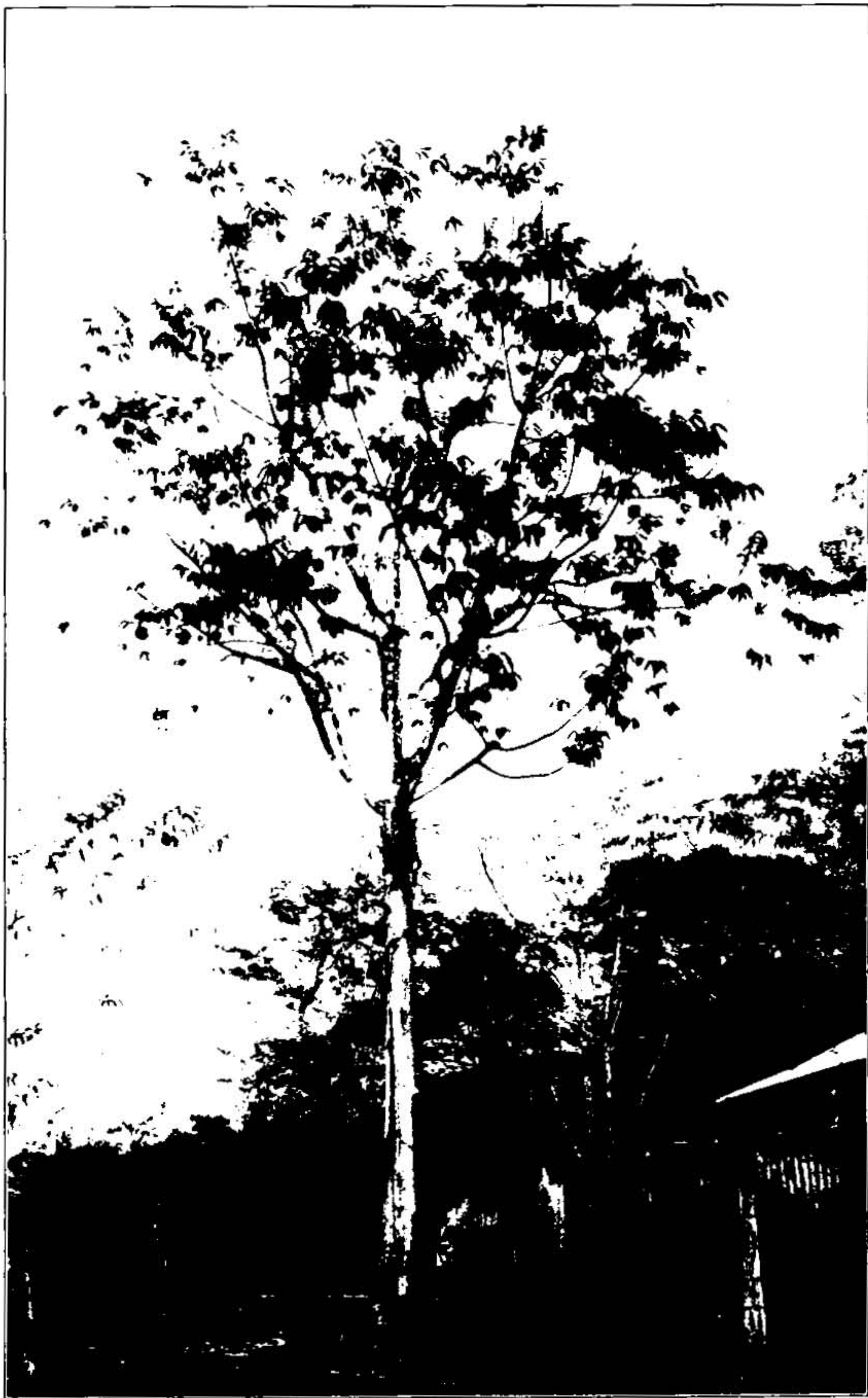
Receptacles of the primary male inflorescence in clusters of 4 or less, caducous, flabellate or 3-winged, but not kidney-shaped nor emarginate at base, about 2 cm. long and up to 5 cm. broad. Pedicels about 1 cm. long, pubescent, bractless at base, but with one whorl of pubescent, acute-tipped bracts near the middle. Receptacle covered outside with 6 to 8 concentric rows of ovate-acuminate, mucronate scales, those of the middle row about 6 mm. long and 5 mm. broad. Interstaminate bracteoles few and of reduced size. Stamens glabrous, 4 mm. long; filaments about 2.5 mm. long, straight, cylindrical; anther cells elongate, subreniform, affixed laterally on both sides of a thick, clavate connective.

Receptacles of the complementary male inflorescence geminate, 1.5 to 2 cm. long, 1 cm. in diameter, more or less obconical and rounded at tip, insensibly attenuated into a short, thick stipe, the whole densely covered with hairy, adhering, distinctly mucronate scales, these of irregular size near the base, but about 5 mm. long and 4 mm. broad in the middle rows. Stamens 3 to 4 mm. long, glabrous, distributed in irregular lines between the diversely shaped, hairy bracteoles of the almost entirely closed cavity of the receptacle; filaments cylindrical, thick, about 2 mm. long, bent at the top; anther cells narrow, affixed to a thick connective.

Receptacles of the pistillate inflorescence shallow-cupuliform, sessile; outer scales broadly ovate-acuminate, adhering, setose, and usually arranged in 3 to 4 imbricate rows. Flowers rather small, closely adhering together for two-thirds of their length. Free part of the perianth 3 mm. long, thick, hairy, parted at the tip into 4 obtuse lobes, these about 1 mm. long. Style slender, about 2 mm.

<sup>4</sup> On young leaves the upper surface is sparsely covered with appressed hairs, these, however, being dense on the midrib and primary veins, which thus neatly project in white or yellowish lines; beneath, the pubescence is also thicker, especially on the midrib and veins, and the tufts of hairs on the margin are quite close. These leaves are often attenuate and simply rounded or scarcely emarginate at base.





CASTILLA COSTARICANA LIEBM.





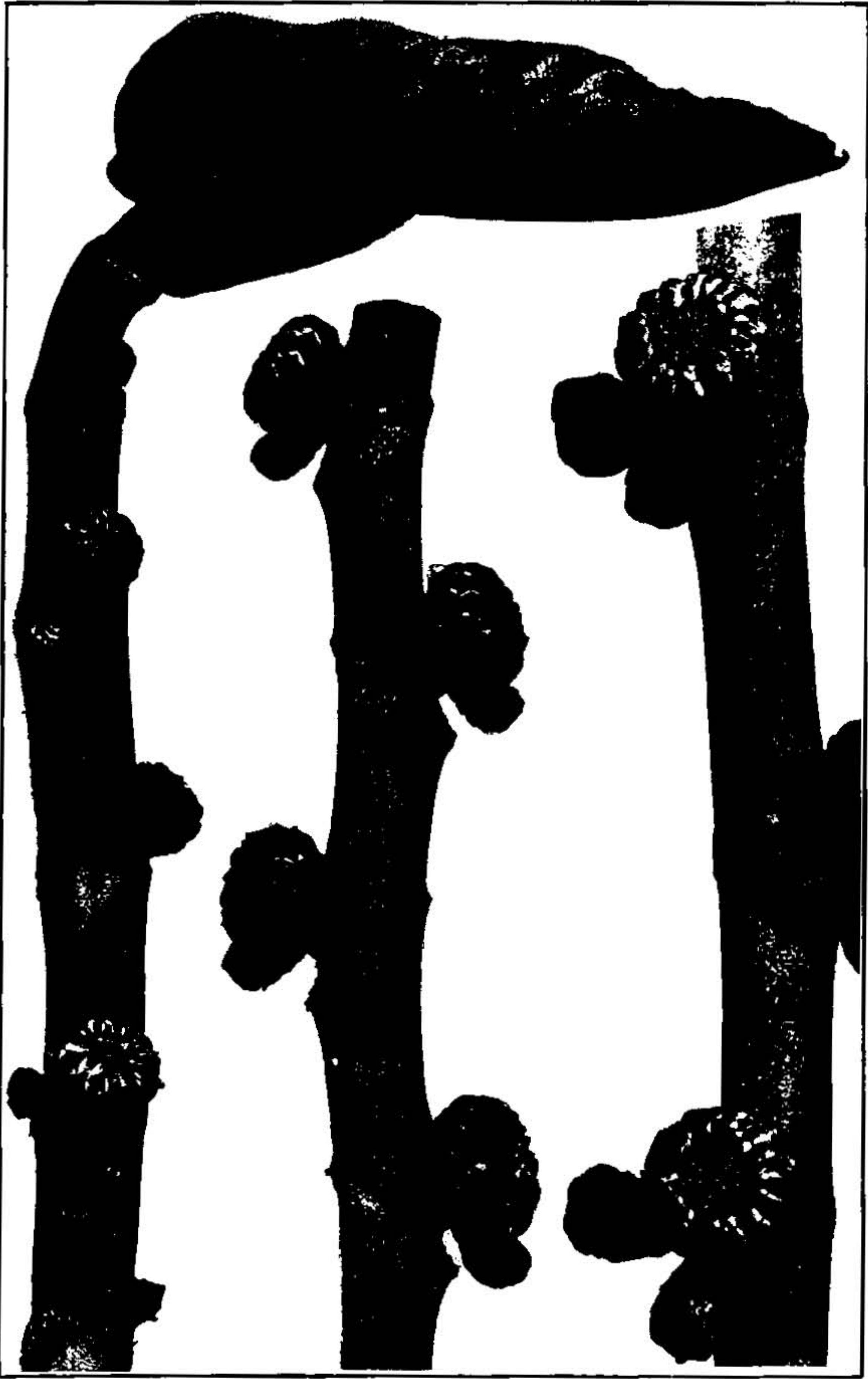
CASTILLA COSTARICANA LIEBM.





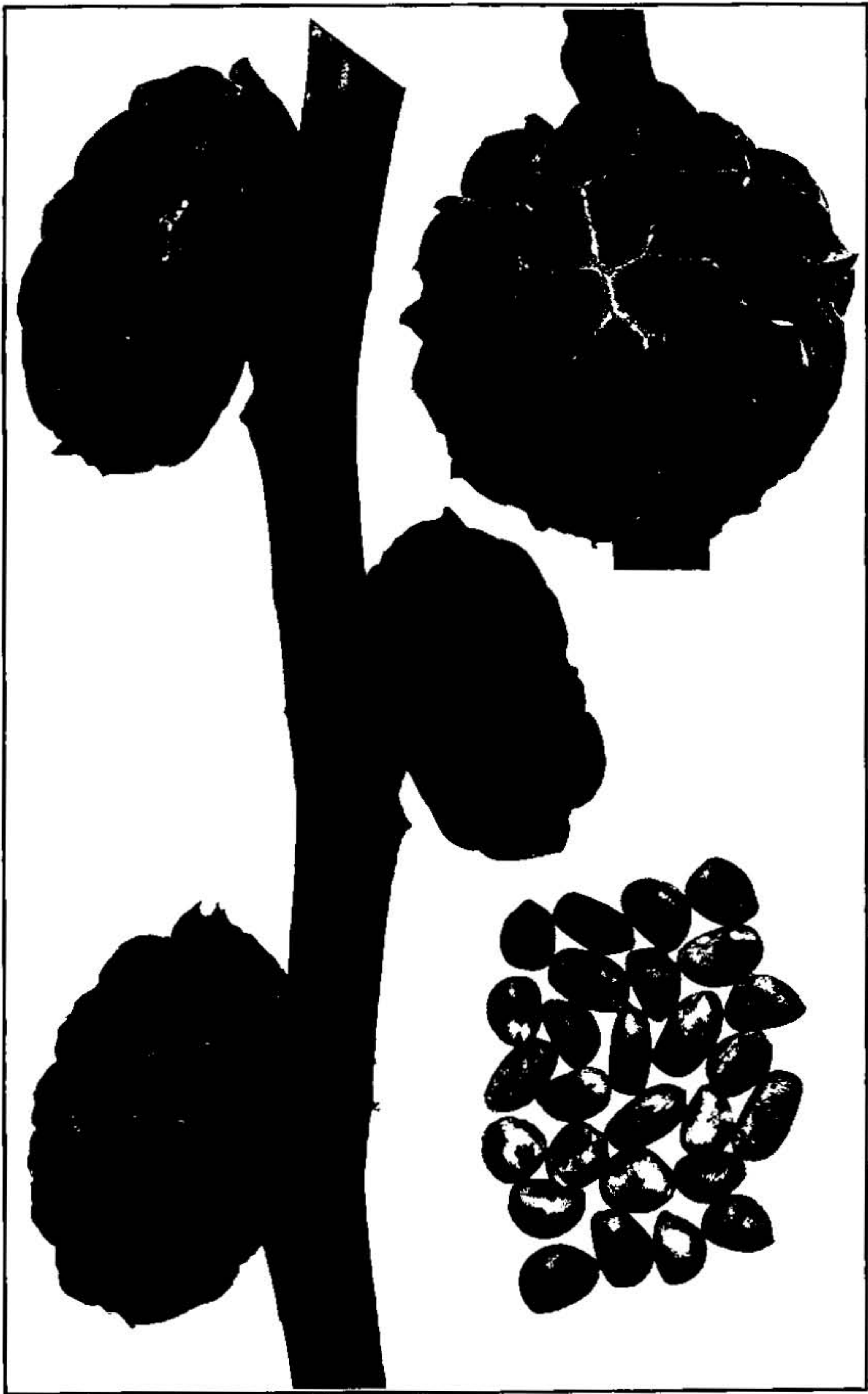
*CASTILLA COSTARICANA* LIEBM.





CASTILLA COSTARICANA LIEBM.





CASTILLA COSTARICANA LIEBM.





CASTILLA COSTARICANA LIEBM.



long; stigmas greenish yellow, thin and pointed, 1.8 to 2.5 mm. long, dividing a little below the tips of the perianth and sparsely hairy on their outer face.

Fructiferous receptacles sessile, shallow-cupuliform, 5 to 6 cm. in diameter, covered outside with greatly enlarged scales. Achenia 20 to 40 to each receptacle, about 2 cm. long, pulpy and orange red at maturity, elongate and more or less tetrahedral or cuneate, contiguous through their whole length, with a rounded top, slightly depressed at the apex around the persistent style.<sup>a</sup> Seeds ovoid, 11 mm. long, 8.5 mm. in diameter; outer episperm white, subtransparent; arillus brownish red, smooth.

COSTA RICA: Turrialba, in the Reventazon Valley, altitude 680 meters, *Oersted*; *Cook & Doyle* 373, flowers and fruit, April 28, 1903; around Peralta, Reventazon Valley, altitude 300 meters, *Pittier*, young fruit, June, 1903 (Instituto ffs.-geog. Costa Rica no. 16704): in banana plantations at Freehold, plains of Sta. Clara, altitude 100 meters, *Pittier*, fruit, May, 1902 (Instituto ffs.-geog. Costa Rica no. 1815): Zent Farms near Port Limon nearly at sea level, *Cook & Doyle*, 475, flowers and fruit, May 2, 1903; plains of San Carlos, altitude 100 meters, *Cook & Doyle* 76, flowers and fruit, April 14, 1903.

EXPLANATION OF PLATES 29-34.—Pl. 29, a fully grown individual of *Castilla costaricana* at San Carlos, Costa Rica, called *Castilla alba* by Mr. Koschny and said to bear only male flowers. Pl. 30, primary male inflorescences at various stages of development. Pl. 31, male inflorescence at a more advanced stage; terminal buds. Pl. 32, pistillate flowers and complemental inflorescences at various stages. Pl. 33, fully mature fruits and washed seeds. Pl. 34, different view of mature fruit; detached drupes; bases of leaves.

Liebmann's specific diagnosis refers entirely to characters taken from the leaf, which experience has shown to be quite inconclusive, so as to justify in some degree the rejection of this species by Hooker. Quite vague, too, and somewhat perplexing, is this further enumeration of the differential characters, given as a supplement to the Latin description: "It resembles very much *C. elastica*, from which it differs by the dimensions and more especially by the nature and color of the pubescence." With reference to the diagnosis it has been found that there is no sensible difference in the size of the leaf in *C. costaricana*, *C. nicoyensis*, and the Motzorongo specimens, which we infer to belong to *C. elastica*; numerous measurements have shown also that the petiole is really longer on the average in Liebmann's species and the characters derived from the pubescence are not constant enough to be taken into consideration. As to the color, it is to be noted, namely, that it seems to be grayish in specimens grown in the sunny open, and fawn-colored (fulvous) only on trees located in the shady forest.

Nevertheless a close examination of the inflorescences and of the fruit shows that there are in their respective parts structural differences that fully support the maintenance of the Costa Rican type as a distinct species. In the primary male inflorescence the receptacles are usually broader and covered with larger scales, the interstaminate bractlets are few and little developed and never occur on the filaments, and those which are present are rounded and fully differentiated from the bractlets. The styles are slender, proportionately longer, and glabrous; the stigmas are two, never more, short and hairy on the outer or lower side. The fructiferous receptacles are on the average smaller, with only 18 to 31 achenia, these completely immersed. These peculiarities, taken together, are certainly more than sufficient to distinguish Liebmann's species from all its congeners.

<sup>a</sup> Many of these achenia are seedless and formed of a compact, reddish, pulpy mass, with a perfect exterior appearance.



The range of *C. costaricana* is as yet undetermined, but seems to be included within narrow limits. So far as it is known the species is restricted horizontally to the northeastern watershed of Costa Rica and the adjoining districts of Nicaragua and Panama, the climate of which is characterized by perennial rains and almost perpetual dampness of both soil and air. The vertical range is from the sea-level to an altitude of nearly 1,000 meters, with the peculiarity, noticed by all *huleros*,<sup>a</sup> that the rubber contents of the latex and the quality of the product decrease with the distance above the lower level. It has also been observed that the tree does not thrive in soils impregnated with salt water or containing an excess of sand, nor when too directly exposed to strong sea-breezes; lastly, it is never met with in or in close proximity to the coast swamps.

*Castilla costaricana* is par excellence a tree of the virgin forest—ein Urwald-baum. While its trunks attain there a great length and a considerable girth, it becomes prematurely old in the open, where it never has the healthy appearance almost invariably noticed in the lofty forest specimens. Like other trees of the Tropics, the surface of the bark is covered with dense colonies of lichens,



FIG. 50.—Female flower of *Castilla guatemalensis*. a, Flower; b, top of perianth open and showing lobules. Scale 3.

the color of which varies with the intensity of the light. This fact has given rise to the belief that there are several varieties of this species, distinguished mainly by the color of the bark and also by the correlative fluidity or richness of the latex. Thus the trees that grow in the thickest forest have also the darkest bark and their latex is very thin and easily collected, but contains less rubber; those which grow in full sun exposure have a light colored bark and a very thick, rapidly coagulating latex.

#### 7. *Castilla guatemalensis* Pittier, sp. nov.

PLATES 35-39. FIGURES 50, 51.

Medium-sized tree; limbs divaricate and spreading. Flowering twigs long, more or less pendulous, densely covered with yellowish, strigose hair, filled with a thick white pith, circled outside by the scars of the stipules. Internodes 3 to 7 cm. long.

Leaves congregated at the ends of the younger twigs, petiolate, stipulate, caducous. Petioles 1 to 2.5 cm. long, thick, densely hairy-strigose. Leaf blades 23 to 46 cm. long, 10 to 18 cm. broad, elliptic, sometimes slightly lyrate, cordate at the base with very narrow sinus, abruptly acuminate, rough and covered with scattered hairs above, tomentose beneath; midrib and the 19 primary veins inconspicuous and sparsely hairy above, prominent and hairy-tomentose beneath; margin obscurely sinuate, with tufts of hairs between the sinuses.<sup>b</sup> Stipules about 6 cm. long, 2 cm. broad, lanceolate, clasping, longitudinally ribbed and tomentose outside, smooth and purplish inside.

<sup>a</sup> Rubber collectors.

<sup>b</sup> A leaf specimen, collected at the Chocon River Plantation (Department of Izabal, Guatemala) by Sereno Watson, and now in the Gray Herbarium, is remarkable by its petiole measuring 8 cm., by the relatively little developed tomentum on the petiole, midrib, primary veins, and lower face, and by its obscurely dentate margin. The general texture of this leaf is also lighter and it is presumable that it grew in the shade and on a seedling or a young tree. The same applies to *Eggers* 15163, belonging to another species growing in Ecuador, with a petiole nearly 5.5 cm. long and a thin blade with distinctly dentate margin.



Receptacles of the primary staminate inflorescence stipitate, flabellate, in axillary clusters generally of 6, geminate, the two exterior pairs flowering first. Basal bracts small (3 to 4 mm. long), ovate-acuminate, hairy outside, smooth inside, involucrate. Stipes about 2 cm. long, hairy and bearing a few more or less developed bracts. Lobes of receptacle 2 to 3 cm. long, 2 cm. broad, kidney-shaped, flat or reflexed. Scales in 5 or 6 imbricate rows, 2 to 3 mm. long and broad, ovate-acuminate, hairy. Interstaminate bracts small (about 1 mm. long), ovate-lanceolate or acuminate. Stamens 2 to 4 mm. long, glabrous and numerous; filaments rather slender; connective thick, papillose on the upper face; anther cells apparently broader than in the other species.<sup>a</sup>

Receptacles of the complementary staminate inflorescence geminate, stipitate, claviform, 2 to 2.5 cm. long, with a slit-like opening. Stipes 1 to 1.5 cm. long, thick, pubescent, squamose. Scales broadly ovate (2.5 to 4 mm. long, 4 to 6 mm. broad), pubescent, almost free to the base. Interstaminate bracts hairy on both faces and ciliate, either simple and narrow, or broad and diversely lacinate. Stamens glabrous, 4 to 5 mm. long.

Receptacles of the pistillate inflorescence sessile or borne on a very short, thick peduncle, cupuliform, covered outside by about 5 rows of imbricate scales, ovate-acuminate, hairy outside. Perianth about 3 mm. long, free to the base, longitudinally 4 or 5-sulcate, divided at the tip into 4 or 5 uneven, more or less acute lobes. Style 1.5 to 2 mm. long, rather thick, more or less covered with stiff hairs at the base and along one side; stigmas 2, seldom 3, 2 to 4 mm. long, linguiform, papillose, purplish or greenish yellow, semierect and more or less twisted.<sup>b</sup>

Fruiting receptacles very much enlarged and reaching often more than 5 cm. in diameter. Achenia 14 to 22 on each receptacle, 18 to 20 mm. long, 12 to 15 mm. in diameter, orange-red at maturity, scarcely conerescent at the base, but simply pressed together without losing their individuality, and always free at the apex. Seed ovoid with more or less flattened sides, 11.3 mm. long, 8.4 mm. in diameter; episperm white, arillus brown.

Type in the U. S. National Herbarium, nos. 408077-8, collected by O. F. Cook (no. 295), March 29, 1902, at Secanquim, Alta Verapaz, Guatemala, altitude 550 meters.

<sup>a</sup> The foliaceous radial crests along which the stamens are usually inserted are here little and irregularly developed, being at times narrow, either smooth or ciliate, and at other times broader and with triangular or rounded, ciliate teeth; bracteoles are never seen high on the filaments; all transitional stages between a bract and a perfect stamen can be found on one receptacle. The stamens develop successively from the base of the lobe toward its periphery, the basal becoming fully mature and having their anther cells open and empty while the marginal ones are still very short, with the connective inflexed on the filament.

<sup>b</sup> In Secanquim dry materials, the pistil had taken the appearance of a foliaceous organ, opening by a side slit, and then forming a bilobulate or trilobulate leaflet, with a distinctly marked midrib. In the specimen with two styles the hairy external zone was found to correspond with the broad interlobular rib.

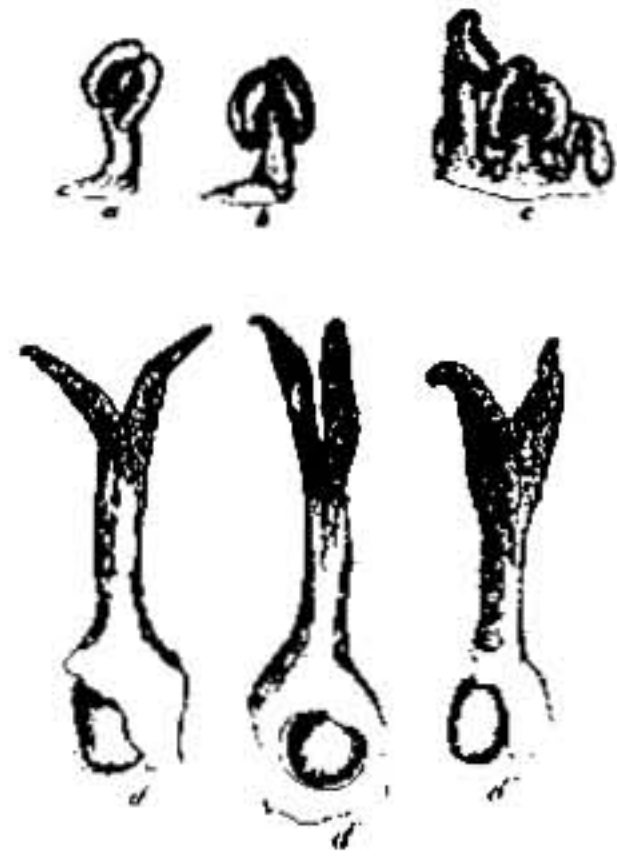


FIG. 51.—Floral details of *Castilla guatemalensis*. a, Stamen, front view, showing large connective; b, stamen, back view; c, group of stamens at various stages, with bracteoles also; d, d', d'', styles. Scale 3.



MEXICO: Lumija (Tabasco), *Cook*, female flowers and fruits, June 25, 1906 (alcoholic materials); Hacienda Kanachen (Yucatan); *Schott* 777, female flowers, March, 1866; Salto de Agua (Tabasco); *Cook* 150, leaves, June, 1906 (U. S. National Herbarium no. 593979).

GUATEMALA: El Crique, Alta Verapaz, *Cook* 803, 807, flowers and fruit, April 4, 1902 (U. S. National Herbarium nos. 408520-1, 408526-8; photographs 3784, 3794-3800, 3802-3; Las Tinajas near El Crique, Alta Verapaz; *Cook* 817, April 4, 1902 (U. S. National Herbarium no. 408540); Secanquim, Alta Verapaz, altitude 550 meters, *Cook* 42, April 19, 1904 (U. S. National Herbarium, nos. 593980-2; alcoholic materials of leaves, flowers, and fruits; photographs 7201, 7214, 7217, 7287-90); Panzos (Alta Verapaz); *Cook* 10, leaves, flowers, and fruits, April, 1904 (U. S. National Herbarium, nos. 593983-4; alcoholic materials; photographs 7133-8, 7142-7); Escuintla, altitude 300 meters; *Donnell Smith* 2506, young fruits, February, 1892; Chocon River Plantation, Alta Verapaz; *S. Watson*, March, 1885, leaf of a seedling (Gray Herbarium).

EXPLANATION OF PLATES 35-39.—Pl. 35, a young *Castilla guatemalensis* at El Crique, showing habit; U. S. National Herbarium photograph 3784. Pl. 36, *a*, clusters of primary male inflorescences; *b*, another cluster, showing long stipes and insertion on branchlet; *c*, complementary inflorescence, after taking away the female receptacle; *d*, female receptacle with the accompanying complementary male receptacles; *e*, female receptacle inserted on branchlet; on the left are seen the scars left by the leaf (below) and by the complementary male inflorescence (above); *f*, a ripe fruit; *g*, seeds, some with the testa partly cut to show arillus. Pl. 37, flowering branchlets, the one on the left with primary male inflorescences, the one on the right with complementary and female inflorescences. Pl. 38, fruits at various stages, none ripe. Pl. 39, fructiferous branchlets, at Secanquim.

**8. *Castilla panamensis* Cook, Science n. ser. 18: 438. 1903.**

FIGURE 52.

A medium-sized or large tree, rather low and spreading, as seen in the open. Limbs divaricate, obliquely ascending, nude. Bark of young twigs longitudinally plicate (in dry specimens) and densely hairy.

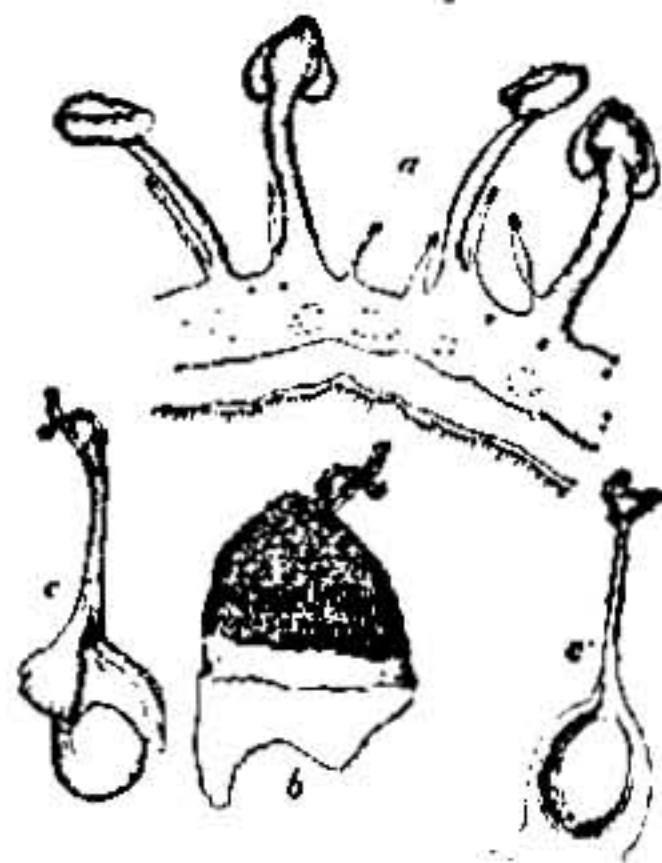
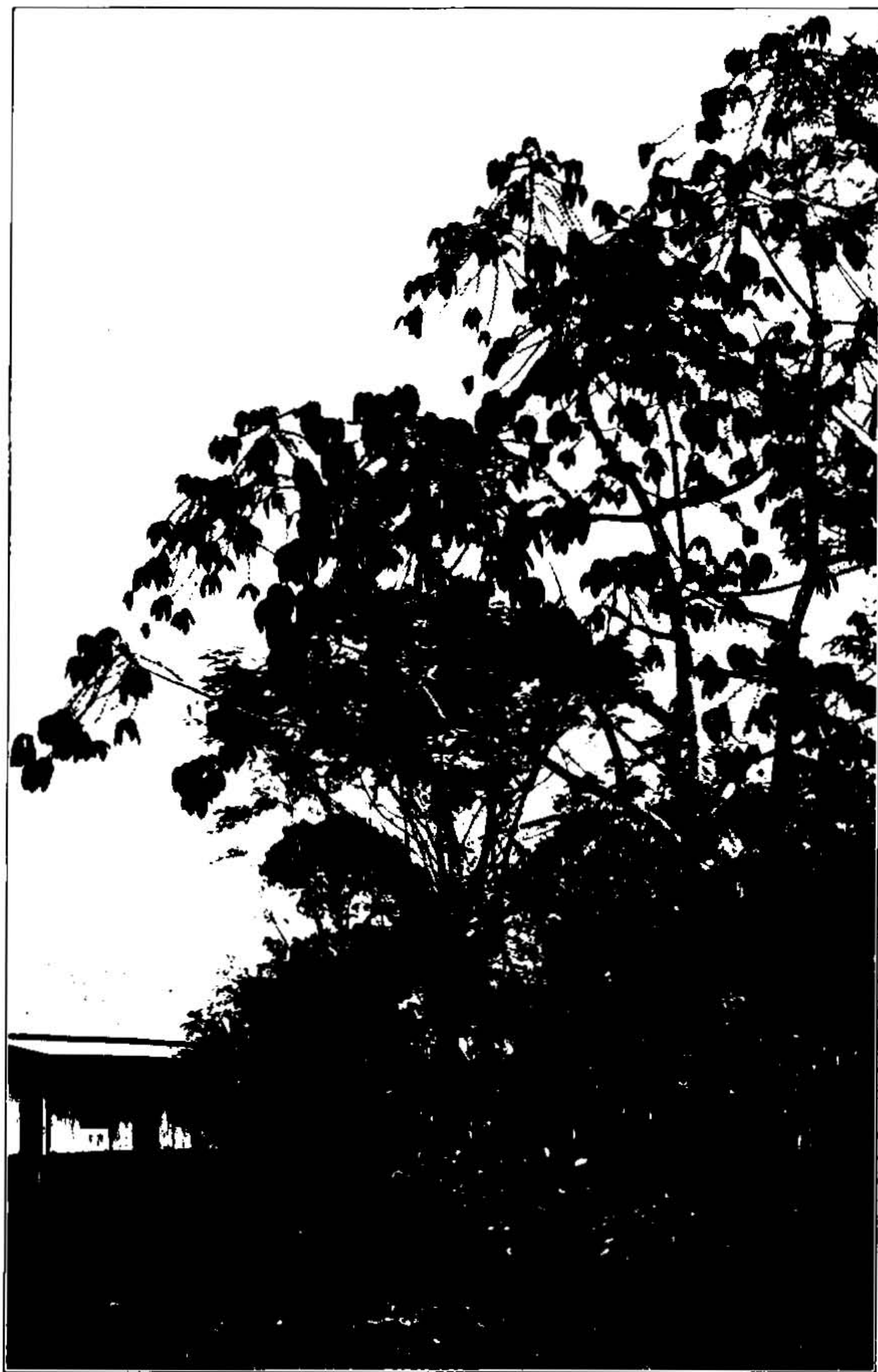


FIG. 52.—Floral details of *Castilla panamensis*. *a*, Transverse section of primary male inflorescence; *b*, male flower; *c*, style and ovary. *a-c*, Scale 3.

Petioles thick, densely hairy, 0.8 to 1.2 cm. long. Mature leaf blades ovate-elliptic, cordate at base, more or less rounded above and abruptly contracted into a narrow acumens nearly 2 cm. long, 20 to 30 cm. long, 10 to 12 cm. broad, dark green, rough and sparsely pubescent above except on the hairy midrib, paler or rufescent below, with the midrib and primary veins hairy, and the finer veins and anastomosis more sparsely hairy-pubescent; 23 to 27 primary veins on each side of the midrib; margin obscurely sinuate, the intermediary teeth marked by tufts of stiff hairs. Stipules caducous, at times short and broad (3.5 by 3.5 cm.), at times longer and narrow (6 by 2.5 cm.), pubescent outside, smooth and of the same pale brown color inside.

Receptacles of the primary male inflorescence in clusters of 4, caducous, flabellate, more or less kidney-shaped, very uniform in size, about 1.4 cm. long and 2 cm. broad. Pedicels over or under 1 cm. long, with a calyx-like bracteal involucre, 8 mm. long, at the base. Receptacles covered outside with 6 to 8 concentric rows of ovate-acuminate, imbricate, dark-tipped scales. Stamens glabrous, about 4 mm. long, irregularly distributed, isolated along the radial blades or in clusters at the ends of the lateral branches of the same, and with or without bractlets; blades and bractlets ciliate-pubescent; filaments 2.5 to 3 mm. long; anthers ovoid or subreniform; connective thick.





*CASTILLA GUATEMALENSIS* PITTIER.





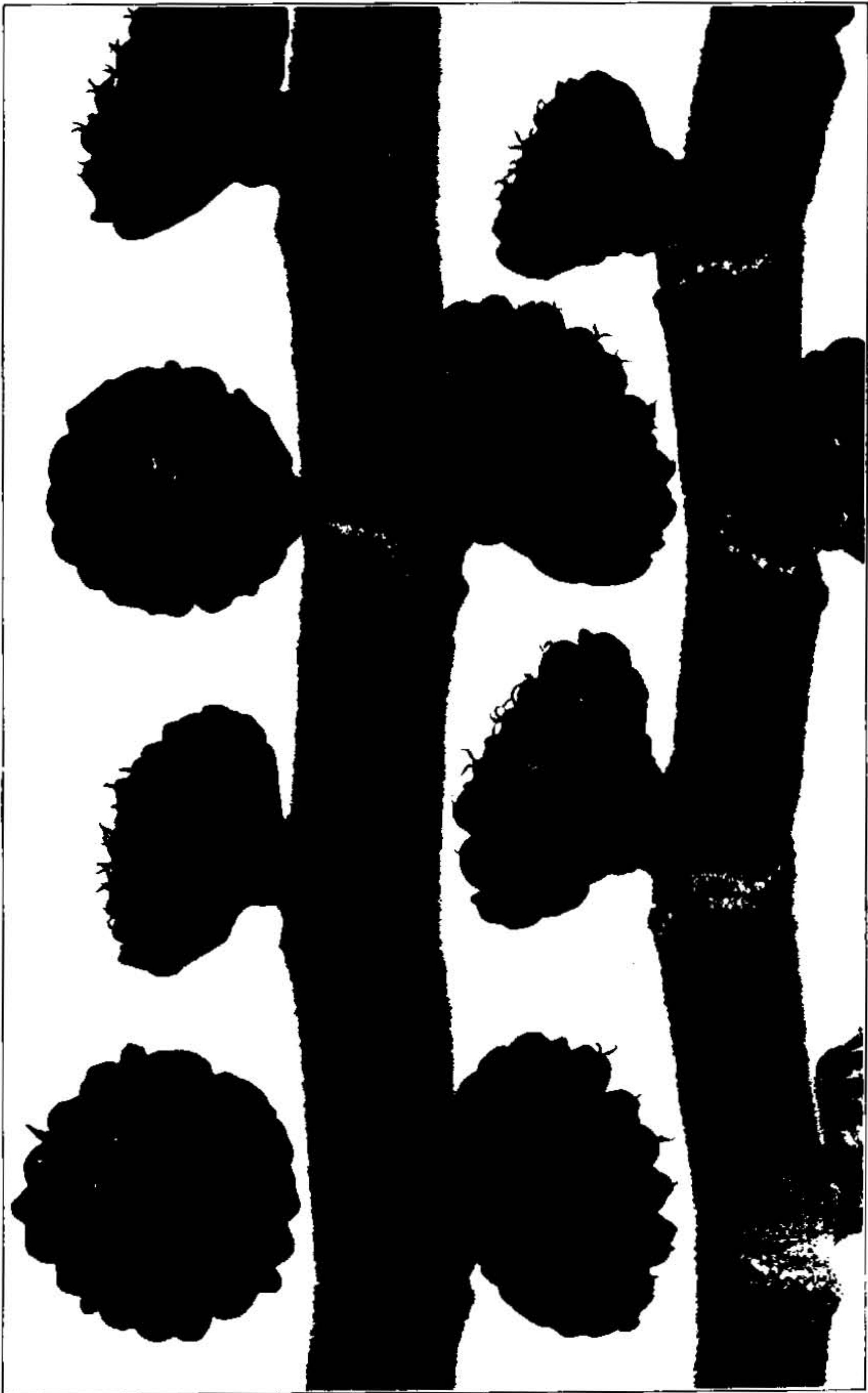
CASTILLA GUATEMALENSIS PITTIER.





*CASTILLA GUATEMALENSIS* PITTIER.





CASTILLA GUATEMALENSIS PITTIER.





CASTILLA GUATEMALENSIS PITTIER.



Receptacles of the complementary male inflorescence geminate, 1.5 to 2 cm. long, 1.3 cm. in diameter, broadly obconical and attenuate into a rather long and slender stipe, provided at the base with a short bracteal involucre. Scales broad, short, and with dark tips. Dehiscence slit-like. Blades, bracteoles, and stamens as in primary inflorescence.

Receptacles of the pistillate inflorescence rather deeply cupuliform and with the marginal bracts still strongly incurved at the time of anthesis. Outer scales very broad, rounded at tip, rarely mucronate, tomentose, imbricate in 3 or 4 rows. Flowers 3 to 4 mm. long, free almost from the base. Free part of the perianth hairy, not lobulate at tip, closed but for a small round aperture giving egress to the style. Ovary immersed in the receptacle. Style slender, about 2.5 mm. long, entirely glabrous; stigmas 1.5 to 2 mm. long, linguiform, dividing a little below the tip of the perianth, papillose-rugose on the inner (upper) face, smooth outside.

Fructiferous receptacles sessile, deep cupuliform, 4 to 5 cm. in diameter, the outer scales large, partly confluent and indistinct. Achenia 12 to 16 to each receptacle, about 2 cm. long, contiguous through their whole length, with a prominent, pyramidal, acute tip. Seeds more or less ovoid, 12 to 13 mm. long and about 9 mm. thick; episperm transparent; arillus (in alcohol) brownish.

PANAMA: Around the hospitals at Ancon, Canal Zone, Mrs. K. D. Gaillard, flowers and fruit, February, 1910 (U. S. National Herbarium no. 593174).

The above description is based on the fresh material kindly sent from Ancon by Mrs. Gaillard, but the first idea of the specific status of the Panama type was gathered from the comparison by Mr. O. F. Cook of Hooker's plate<sup>a</sup> with material of the other Central American species. Our specimens are found to possess all the characters attributed by Mr. Cook to his *C. panamensis*, and to agree also fairly with Hooker's descriptions and illustrations, so that there is little doubt left as to the identity of our tree with the one grown in Ceylon from seeds or cuttings collected on the Isthmus.

9. *Castilla nicoyensis* Cook, Science n. ser. 18: 438. 1903.

PLATES 40-42. FIGURE 53.

A medium-sized tree, 10 to 20 meters high. Limbs divaricate, ascending, or horizontal. Floriferous twigs covered with a dense coating of rather long, brownish hairs, longitudinally striate when dry and filled with a thick, white pith.

Leaves of medium size, deciduous. Petioles 1 to 2 cm. long, thick and densely hairy. Leaf blades 20 to 46 cm. long, 10 to 20 cm. broad, more or less cordate-emarginate at base, acuminate at tip, covered on the upper face with sparse hair, this thicker on the midrib and primary veins, paler and hairy, especially on the veins, beneath. Nervation regular, prominent beneath. Margin distinctly dentate-sinuate, with tufts of hair on the teeth.<sup>b</sup> Stipules caducous, rather small (5 to 7 cm. long, 2 to 3 cm. broad), lanceolate-acuminate, purplish and smooth inside, hairy-tomentose outside, with a whitish marginal line.

Receptacles of the primary male inflorescence caducous, geminate, usually two pairs in each axil, opening out when mature into a flat disc, 2.5 to 3.5 cm. in diameter. Stipes 1.5 to 2 cm. long, rather slender, hairy, provided with free, triangular bractlets. Scales of receptacles in 5 or 6 rows, rather large (about

<sup>a</sup> Trans. Linn. Soc. II. 2: 209. pl. 27. 1885.

<sup>b</sup> The young leaves are dark green and sparsely hairy above, densely hairy-tomentose beneath; the indentation of the margin is scarcely noticeable, and the base is often only rounded or scarcely emarginate.



5 mm. long, 3 mm. broad), ovate to ovate-lanceolate, with free tips. Interstaminate bracts very few, small, ovate-lanceolate or acuminate, ciliate. Stamens glabrous, numerous and very close together, 3 to 4.5 mm. long; filaments 2.5 to 3 mm. long, slender; anther cells narrow, attached laterally on a thick, expanded connective.

Receptacles of the secondary staminate inflorescence single or geminate, hairy, 1.8 to 2.8 cm. long, clavate, rounded and scarcely open at the tip. Stipes thick, 1 to 1.2 cm. long, provided with 1 to 3 irregular whorls of scale-like bracts, with dark, free, scarious tips. Scales of the receptacle broadly rounded, acuminate, also with free, dark tips. Interstaminal bracts absent. Stamens 3.5 to 6.5 mm. long, glabrous, distributed in irregular lines connected by a thin membranous band; filaments cylindrical, rather slender, 2 to 4 mm. long; connective large, scutellate; anther cells narrow. Receptacle of the pistillate inflorescence sessile, shallow, covered outside with 4 or 5 rows of hairy, concrescent, imbricate scales, these broadly ovate-acuminate near the base, lanceolate-acuminate near the margin. Flowers 5.5 to 6 mm. long, half immersed in the receptacle. Free part of the perianth thick, hairy outside and inside, irregularly 3 to 5-toothed.

Style rather thick, about 1 mm. long; stigmas yellow, elongate, narrowly lanceolate, spirally twisted at the ends.

Fructiferous receptacles cupuliform but very shallow, 4 to 5 cm. in diameter, their scales broadly ovate-acuminate, the marginal ones thick, pointed, half-free, and corresponding to aborted flowers. Achenia 10 to 15 to each receptacle, orange red at maturity, adhering together for their lower half, the upper half being free, more or less pyramidal, and slightly grooved.<sup>a</sup> Seeds roundish, 9.31 mm. long, 8.13 mm. in diameter, more or less deformed by compression;<sup>b</sup> inner pellicula light cacao brown; embryo small, conical, bifid, about 1.5 mm. long.

COSTA RICA: Around Nicoya, at an altitude of about 300 meters. *Ponduz*, flowers, February, fruit, May, 1899 (Instituto fis.-geog. Costa Rica no. 13723); *Cook & Doyle*, 673, flowers and fruit, May 22, 1903; *Pittier*,



FIG. 53.—Floral details of *Castilla nicoyensis*. *a*, *b*, Stamens at various stages; *c*, longitudinal section of female flowers. Scale slightly less than 3.

flowers and fruit, January, 1904 (U. S. National Herbarium no. 578510); Colonia Maceo, at about 100 meters altitude, *Cook & Doyle* 640; May 21, 1903, flowers and fruit; Las Huacas, altitude, 900 meters, *Cook & Doyle* 730, leaves only.

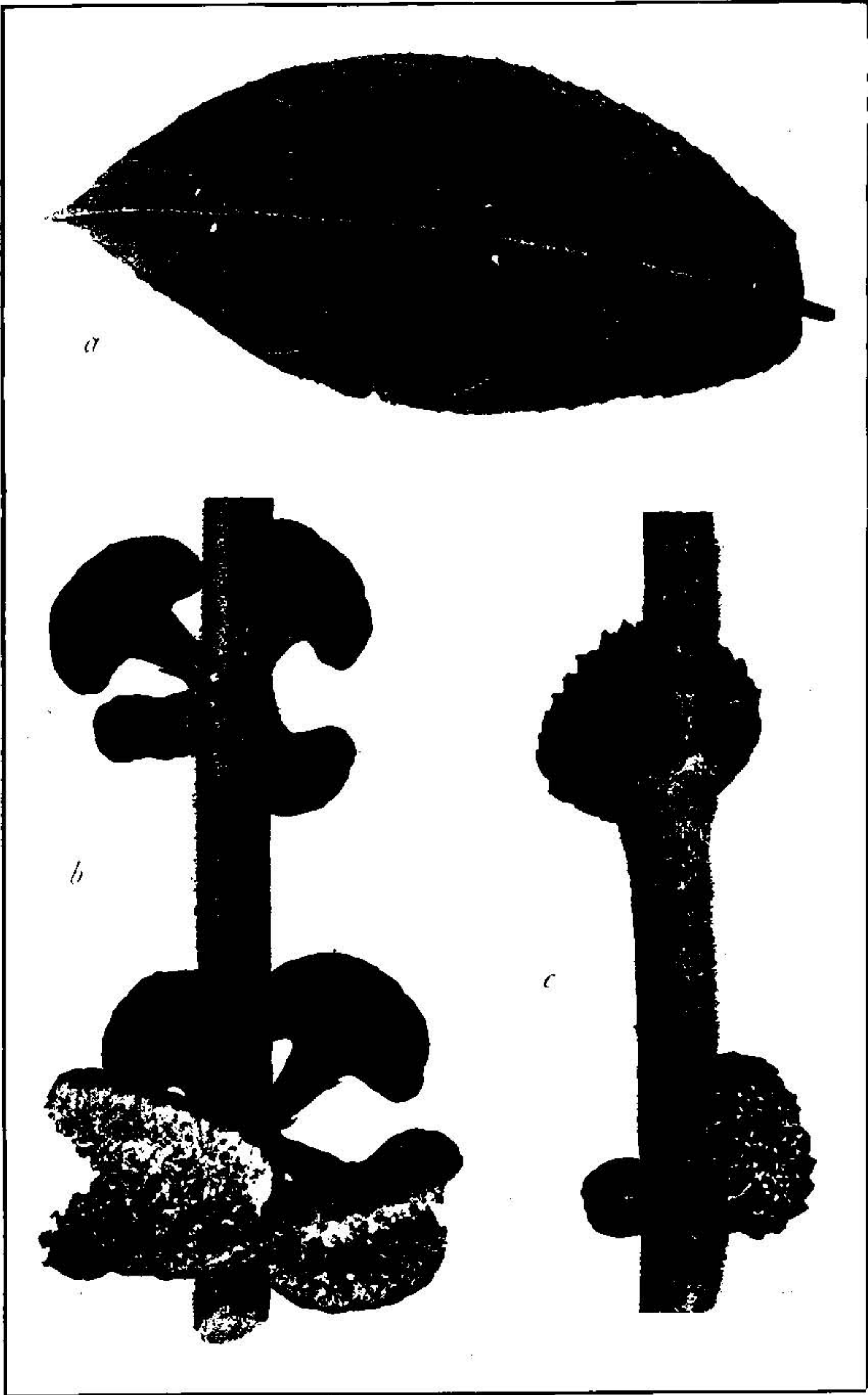
EXPLANATION OF PLATES 40-42.—Pl. 40, *a*, young leaf of a seedling, showing serrate margin; *b*, primary male inflorescence; *c*, part of branchlet showing complemental and pistillate inflorescences. Pl. 41, base of leaves and complemental and pistillate inflorescences. Pl. 42, fruits, terminal buds, and base of leaves. All natural size.

This species has, in common with *C. elastica*, the long-stipitate male receptacles, but it differs from that species by these being usually in clusters of only 4 and each opening into a flat circular disk. These receptacles are also smaller, with more slender stipes and larger scales. There are no interstaminate bracts on the complemental inflorescences, while they are few or reduced to narrow, continuous lamellae on the primary male receptacles. The styles are glabrous, and the pubescence on the twigs and leaves is longer, not so dense, and more erect.

<sup>a</sup> Many of these achenia are abortive.

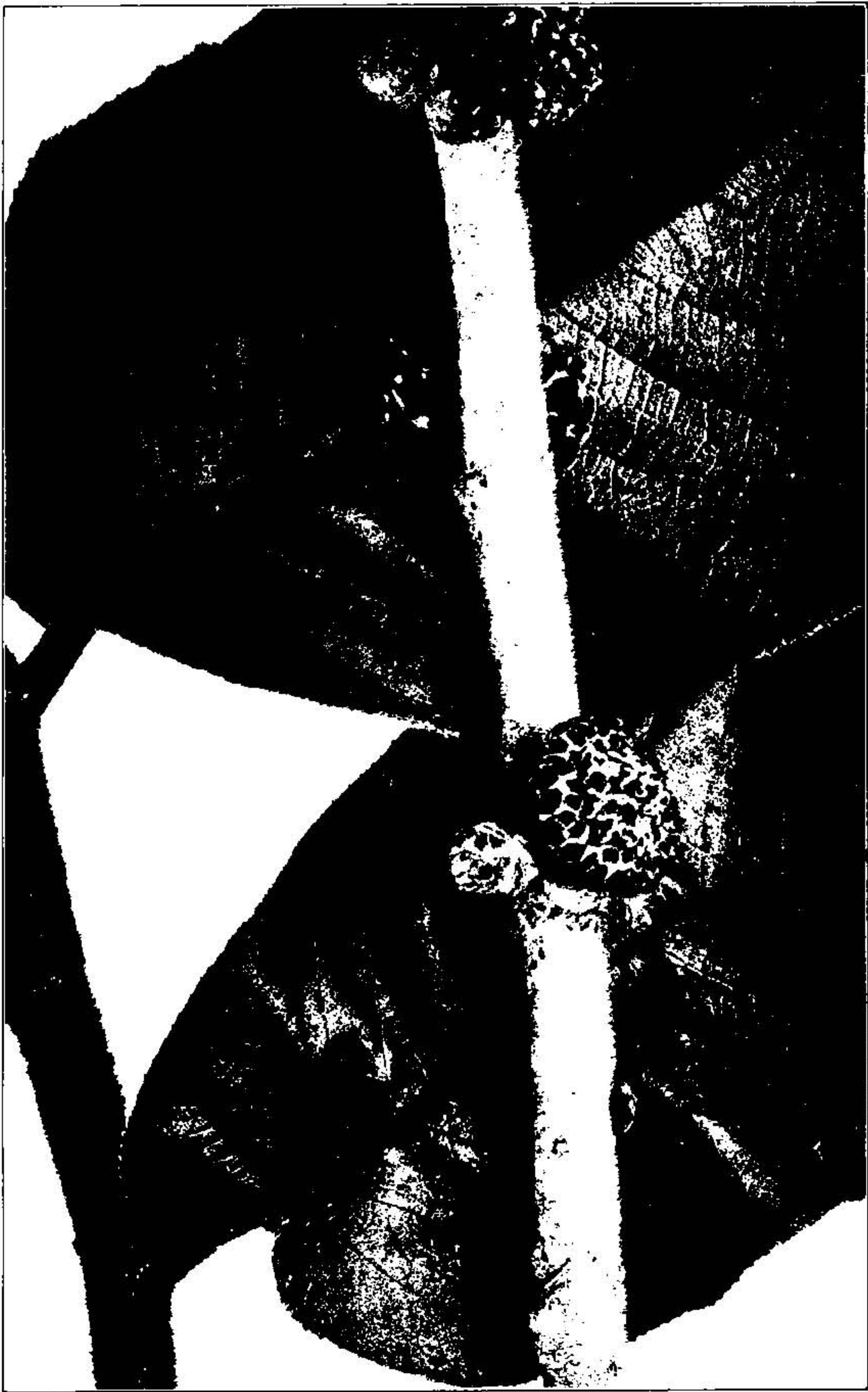
<sup>b</sup> Extreme dimensions of 10 seeds: Length, 8.04 and 10.60 mm.; diameter, 7.58 and 9.18 mm.





CASTILLA NICOYENSIS COOK.





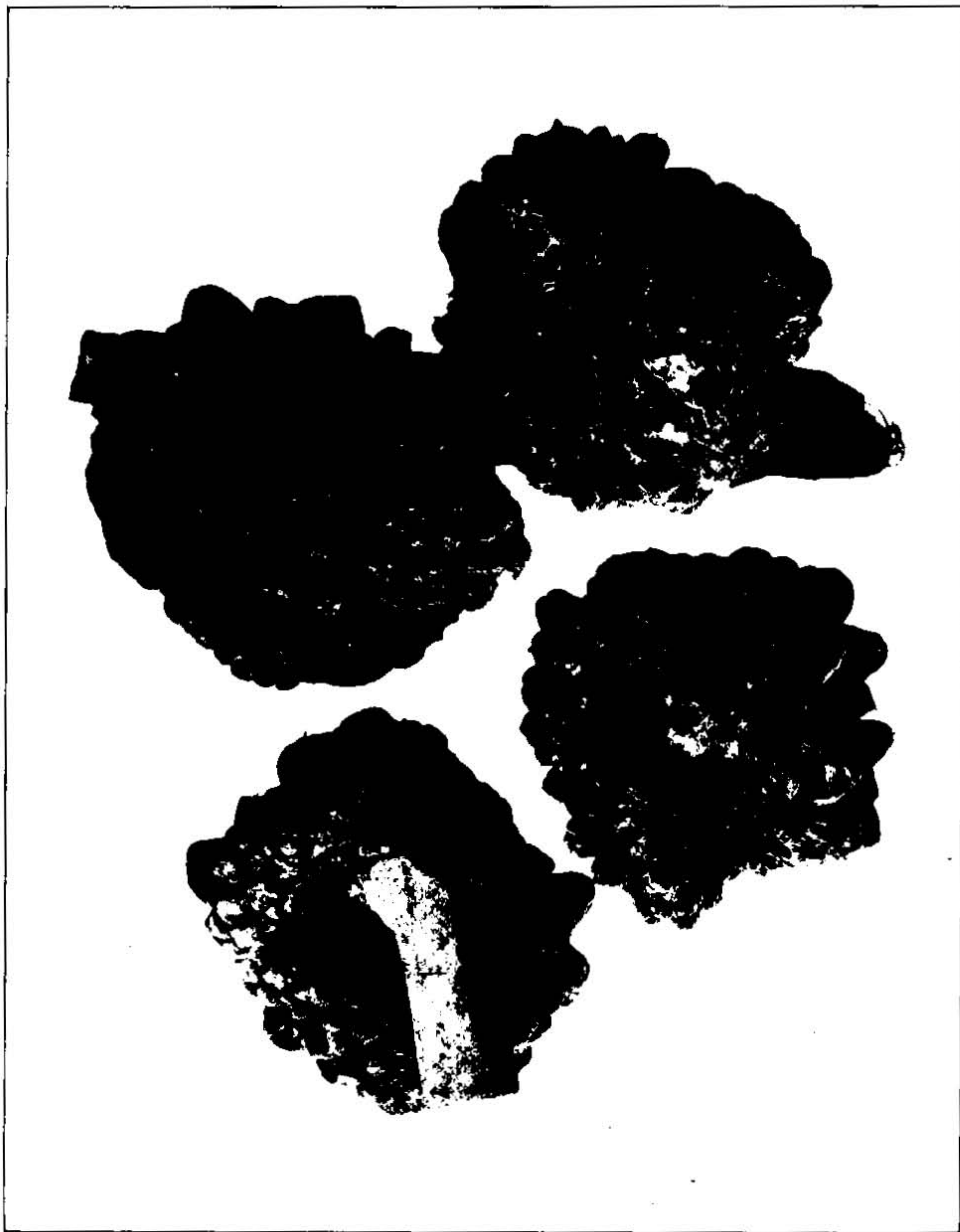
*CASTILLA NICOYENSIS* COOK.





CASTILLA NICOYENSIS COOK.





CASTILLA ELASTICA CERVANTES.



So far *Castilla nicoyensis* is reported from the peninsula of Nicoya only, but the probability is that it will be found all along the coast of the Pacific, from Nicaragua to Panama. It is a good rubber producer, the milk being particularly abundant toward the end of the dry season, and to this fact is due its almost complete extermination in the western forests of Costa Rica. Besides being met with in widely isolated clumps in the forests of Nicoya, Guanacaste, Savegre, and the Diquís Valley, there are several small plantations of this species scattered in the first two districts and around Puntarenas and an extensive one in the "hacienda" of Dr. J. P. Valverde, near Las Cañas, on the southwestern slope of the volcano of Tenorio.

10. *Castilla elastica* Cervantes, Gac. Lit. Mex. Suppl. 1794.

PLATE 43. FIGURE 54.

A large tree, attaining 20 meters and over. Young twigs densely covered with yellowish or grayish hair.

Mature leaves rather large. Petioles 1 to 2 cm. long, thickly clad with grayish, brownish, or yellowish hair. Leaf blades 25 to 40 cm. long, 10 to 15 cm. broad, oblong-lanceolate or slightly lyrate, more or less deeply cordate at base, acuminate, rough, sparsely hairy and dark green above, velvety and paler beneath; midrib and primary veins (the latter alternate, 17 to 20 on each side of the first) little conspicuous and pubescent on the upper face of the leaf, prominent, neatly anastomosed and hairy beneath; margin obscurely sinuate, with tufts of hairs between the sinuses.<sup>a</sup> Stipules caducous, small (5 to 6 cm. long, 2 cm. broad), hairy outside, smooth and purplish inside.

Receptacles of the primary male inflorescence caducous, stipitate, 1 to 1.5 cm. long, 2 to 2.5 cm. broad, almost uniformly in clusters of 4 (bigeminate), covered outside with 6 or more imbricate rows of small (about 3.5 mm. long, 3 mm. broad), lanceolate, obtuse scales free at the tip; lobes flabellate, reflexed, and diversely plicate and distorted at time of anthesis. Stipes 1 to 1.5 cm. long, with a whorl of small, ovate-acuminate bracts at the base and a few more higher up. Interstaminate bracts numerous, shorter than the stamens. Stamens 2 to 3 mm. long, inserted sideways, either singly or in clusters, along dichotomous, radial, foliaceous, diversely shaped crests; filaments flattened, 1.5 to 2.5 mm. long, often bearing a broad, ear-shaped bracteole; connective very large, scutellate; anther cells narrow.<sup>b</sup>



FIG. 54.—Floral details of *Castilla elastica*. a, Cluster of stamens, primary inflorescence, 1 and 2 being abnormal forms; b, Isolated stamens, one with bracteole; c, style with two stigmas; d, style with three stigmas. a-d, Scale 3.

<sup>a</sup> The leaves of seedlings and young trees (*Emrick* 20) are thinner, obovate and sharply acuminate. On immature leaves of adult trees the pubescence is thicker on both faces.

<sup>b</sup> The clusters of stamens are at the branching points of the crests, the isolated individuals scattered along the latter. The filaments are often adherent to the bracteoles for part of their length. Morphologically the bracts and the stamens seem to be equivalent; the filaments are flattened and membranous, like the crest itself. Toward the margin of the receptacle the crests and bracteoles disappear and the stamens issue directly from the floor of the receptacle. Often the filament is the direct outgrowth of a bracteole. On the bracteoles are sometimes seen anther cells adhering just in the same way as



Complemental male inflorescence not represented in the material; according to Cervantes's picture of the plant, receptacles clavate with an elongated stipe.

Receptacles of the pistillate inflorescence sessile or subsessile, covered outside with thick, gibbose, ovate-acuminate or lanceolate-acuminate scales, more or less free at the tips. Perianths adnate for their lower half, the free part velvety without and divided at the top into 3 or 4 lobules. Style very short (0.8 to 1.5 mm.), thick, sparsely hairy; stigmas 2, 3, or 5, broadly lanceolate, 3 to 4 mm. long, smooth or sparsely hairy outside and with a papillose, purple, stigmatic surface.

Fruiting receptacles large (4 cm. and more in diameter), distorted, partly reflexed, and often embracing the contiguous twig. Stipes nearly 1 cm. long or less, covered with velvety, thick, oblong-lanceolate bracts. Achenia 35 to 45 in each receptacle, their free upper half 1.5 to 2 cm. long, large, rounded, 3 to 4-grooved, fleshy and brick red when quite ripe, depressed at tip. Seeds more or less regularly ovoid, 9.6 to 10 mm. long, 6.2 to 6.8 mm. in diameter, "testa white and papery, cotyledons thick, plano-convex, radicle minute, superior (Hooker)."

MEXICO: Motzorongo, Veracruz, *Cook*, flowers and fruits, May, 1905 (U. S. National Herbarium nos. 615100-102; alcoholic materials); Coahuayula, Michoacan, *Enrick* 2, 20, only leaves, probably from young trees, the identification doubtful (Herbarium Field Museum nos. 95462 and 95480); scattered in the bottoms around Wartemberg, near Tantoyuca, Huasteca, Veracruz, *Ervendberg* 371, 1858, leaves and young fruits only, the identification doubtful (Gray Herbarium).

EXPLANATION OF PLATE 43.—Ripe fruits of *Castilla elastica*. From Motzorongo specimens. Natural size.

#### EXCLUDED OR DOUBTFUL SPECIES.

These are here listed with references to the text and with a few additional notes. Poisson's *Castilla elastica ligu*, not entered in the text, is also commented upon.

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<i>Castilla markhamiana</i> Collins = <i>Perebea markhamiana</i> Benth.....	249
<i>Castilla tunu</i> Hemsl.....	264-267
<i>Castilla alba</i> Koschny.....	251
<i>Castilla nigra</i> Koschny.....	251
<i>Castilla rubra</i> Koschny.....	251

*Castilla tunu* is discarded on account of its having been established on heterogeneous materials, belonging in part to *C. guatemalensis*, in part to *C. fallax*, and for the remainder to an insufficiently investigated species of British Honduras and the Eastern coast of Central America, known among the natives under the name of "tunú." Koschny's three species, which have never been described botanically, are mere variations due to environment. The difference is mainly in the bark and the specimens all show clearly the specific characters of *C. costaricana*.

anthers do in full flowers on the petals, resulting from the reversion of the stamens.

The disposition of the bracteole on the filament may be peculiar to the Motzorongo form and *C. elastica*, as it has not been noticed in materials of Central or South American origin. In this case it would constitute a very good specific character.

The stamens of the Motzorongo specimens seem to be partially affected by some disease located in the anther cells, these looking sometimes abnormally swollen and enlarged, with black spots on the outside.



In 1901, Mr. J. Poisson, of the Paris Museum, published in an informal way his *Castilla elastica* var. *liga*<sup>a</sup>, collected somewhere in Guatemala by Mr. René Guérin, Chief of the Chemical Laboratory of the government of that country. This variety is characterized mainly by the fact that it does not produce commercial rubber. Besides this, the leaves are said to be smaller, less hairy, and of a darker color than those of *Castilla elastica* (or rather of a species supposed to be that, since *C. elastica* has not yet been found in this part of Central America); the infructescences and seeds are also smaller, but the figured specimens are evidently immature ones.

The form referred to by Mr. Poisson may be identical with *Castilla tunu* Hemsley as to Honduran material, but this can not be decided on the fragmentary information at hand. At best, these data indicating the presence in Guatemala of a form that does not produce rubber might be accepted as a further testimony to the real existence of Hemsley's enigmatic species.

Mr. Poisson's suggestion that his *C. elastica* var. *liga* may be the primitive type of *C. elastica* Cervantes, this being an "ameliorated form" (?), is scarcely worth mentioning. Only modern man has reaped the benefit of such "natural selection" and times are long since past when the whole creation was considered as subservient to his needs.

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<sup>a</sup> Bull. Mus. Hist. Nat. Paris. 7: 373-377. 1901.