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HASSKARL'S CINCHONA BARKS
1. HISTORICAL REVIEW

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ABSTRACT

The preliminary results of alkaloid analyses of Hasskaii's cinchona bark collection, made in Peru in 1852/3' is given, and the identity and historical aspects of the material discussed in respect of the role the plants played in the Javanese plantations.

ABSTRAK

Hasil sementara analisis alkaloid koleksi pepagan kina Hasskarl yang dibuat di Peru tahun 1852/1853 disajikan. Identitas dan segi sejarah bahan tadi dibahas dalam kaitannya dengan peranan tanaman di perkebunan di pulau Jawa.

INTRODUCTION

The Dutch were the first to successfully organize Cinchona plantations, which were situated in Java. Materials for these plantations were obtained over a number of years by the import of plants or seeds from various sources either direct, e.g. by Hasskarl, Ledger, Karstens and Schuhkraft, or later indirect through exchange of materials from former British India.

The basis of the first planting stocks of *Cinchona* in the former Dutch East Indies was derived from the plants and seeds collected by Hasskarl on his expedition to S. America in 1852/3. In addition a limited quantity of *'C. calisaya javanica'* was propagated from plants produced from cuttings of the first Cinchona plant introduced into Java, which was obtained by De Vriese (De Vriese 1885) from Messers Thibant & Keteleer in Paris, an offspring from seed collected by Weddell. This latter material is not considered here further in much detail.

The subsequent exploitation of these early Cinchona stocks, the early history of Cinchona growing, and the establishment of plantations formed the subject of a controversy between botanists, pharmacognosists, planters and politicians, which flourished not only in newspapers, but also in a vast array of scientific and other journals, and was ardently nurtured by the contenders in every conceivable type of article even in book reviews.

HASSKARL'S BAKK COLLECTION

Hasskarl not only collected living material but also herbarium material of the different *Cwchona* species he encountered. Furthermore, there are references in the older literature Phoebus (1864, 1867) and Howard (1859-62, 1876) to barks received from Hasskari. Gorkom (1881) and Moons (1882) also allude to the possible existence of such a bark collection, analysis of which would have saved needless effort and expense in the continued propagation of *Cinchona* species, with low quinine yielding barks. In 1980 this bark collection was relocated in the Ryksherbarium and as far as can be deduced corresponds with the herbarium material collected by Hasskarl. HasskarPs bark collection consists of his own material and of duplicate materials exchanged with the english quinologist J. E. Howard and from the Javanese plantations received from Gorkom. These duplicate materials are not considered further here, those from Howard were further divided and sent to Phoebus (Phoebus 1867).

The material was preserved in glass cylinders with wooden lids secured by string and finally sealed with wax bearing an impression of a tree on an ornate shield. Current investigation of these samples posed problems, e.g. the writing on the labels is now practically illegible due to fading and discolouration so that correlation of the barks with the herbarium material was not easy; the most prominent numerals on the lids have nothing to do with the contents of the jars and merely correspond with the size of the jars. However, in the archives of the Rijksherbarium a series of printed lists of the material was found which was prepared for a demonstration held in Cleve at an unknown date. It is not known if this lists has been published or further circulated, but it is unfortunate that the numbers and sequence do not correspond to the barks and herbarium material clue to several printing errors in the alignment of the two columns. Eventually a version (here after referred to as Hasskarl's list) corrected by Hasskarl and dated 24.8.1892.

was found which indicated that there should also be a pencil number on the lids corresponding to the numbers in the list.

Finally, after considerable difficulty, it proved possible to locate, beneath the accumulated grime and dust, the faded numbers which thus enabled the collection to be correlated

IDENTITY OF BARK AND HERBARIUM MATERIAL

One would expect that the identity of this collection is well established and studied by many. Unfortunately this is far from true and even now it is impossible to provide a reliable taxonomic name for the materials as there is no reasonable revision of the genus *Cinchona.*

The first tentative identifications of Hasskarl's material were made by J. E. Howard and a letter from Howard to Hasskarl dated 3 October 1860 is the main content of the article 'Botanisohe Notizen zur Chinologie' by Hasskarl (1860) where Howard mentions characters of the bark of "Cascarilla naranjada" (bark no. 8). The correspondence continues with a letter dated 29 November 1860 and reproduced by Hasskarl on pp 57- 58 of a review of the work 'China verae et Pseudo-chinae regii Lugdunensis . . (1816a). Here Hasskarl notes that he sent herbarium material and barks to Howard. Somewhat later (1861b) Hasskarl reports that the herbarium examined by Howard was forwarded to the Ministry of the Colonies, which informed Hasskarl in a letter dated 12 June 1861. that it had been deposited in the herbarium of the Botanic Garden at Leiden under the supervision of de Vriese. This material was transferee! to the Rijksherbarhim at some period in the following 10 years, probably later than 1869.

Howard (1859-62) mentions Hasskarl's collections of barks in several places, particularly in the introduction p- 9, and sub *C. pahudiana* Howard (probably 1861), and sub *C. lanceolata* Ruiz & Pavon. In a later publication (Howard 1876) he gives a short list of the herbarium and bark samples given to him by Hasskarl, with little change from that previously published (Hasskarl 1861a) and, again using his own (not Hasskarl's) number sequence, refers to the numbers 1, 1*, 2, 3, 4, 12, 13, 16, 17, 18, 18*, 20, 21, 22, 23, 24, adding a few comments regarding the identifications of Miquel. As Howard's original herbarium has not been traced it has not been possible to compare this supposedly duplicate material with that at Leiden, which also has identifications in Howard's hand writing. The material from Hasskarl's own herbarium, received at Leiden after his death, lacks such annotations.

Table 1. Identity of Hasskarl's bark and herbarium collections

Hasskarl number	herb. material traced	Local name	species
HAiSSKARL'S LIST			
H 1	+	Cascarilla con hoja de durazno	*C. amygdalifolia*
H 2	+	„ punta di lanca	*C. amygdalifolia*
H 3	+	„ baya s. C. amarilla	*C. amygdalifoKa*
H 4	+	„ Calisaya	*C. calisaya,*
H 5	—	„ Calisaya olerosa	*C. calisaya*
H 6	•	_____	*C. calisaya,* var. *josephiaira*
H 7	+	„ Calisaya hembra (femina)	*C. caloptera*
- H 8	+	„ naranjada	*C. caloptera* (C. *pellcteriana)*
H 9	+	„ crespilla chique (parva)	*C. carabayensis*
H 10	+	„ crespilla grande (major)	*C. carabayensis* forma
H 11,	+	Mula cascarilla	*Cascarilla carua*
H 12	?	Cascarilla morada fina fachada	*C. euneura*
H 18	+	? ?	*C. lanceolata*
H 14	+	Cascarilla azuhar	*C. land folia* var. mutisiana
H 15 ◇	—	see footnote	— —
H 16	+	Cascarilla carua carua	*C. magnifolia*
H 17	+	„ pata di gallinazo s. C. loja	*C. magnifolia*
II 18	+	„ calisaya	*C. nwritziava*
H 19	+	„ amarilla	*C. ovata*
H 20	+	„ provincial is	*C. pedunculata*
H 21	+	„ puca quepo	*C. pelletcriana*
H 22	+	„ echenique	*C. purpwescens*
11 23	+	Ichu Calisaya	*C. rugosa* R. & P. non Miq.
H 24	—	Cascarilla morada	*C. serobiculata*
H 25	—	Cascarilla morada	*C. so-obiculata*
H 26	—	Cascarilla morada fina	*C. 1*
II 27	+	„ blanca	*C. 1*
H 28	+	„ zambo morado	*C. subses&ilis*
H 2D	+	„ bobo s. cala delus lomas	*Lucuma argnacoesiiwi*

d no 15 was misplaced in this series and was one of Howard's duplicates vide Hasskarl's list.

C. = *Cinchona:* Case. —*Cascarilla (Ladenbergia,): Lad.* = *Ladenbergia*

— =r not applicable or not mentioned.

Hassk. number	Howard number	J. E. HOWARD determination	MIQUEL determination	STANLEY synonomy
H 1	8	*C. cinchona* sp. nov (C. *australw)**!	*C. amygdafolia*	*C. officinais*
II 2	13	*Pimentelia glomerata*	— —	*1'. glomerata*
H 3	1'6	*C. lanceolata*	*C. carabayensis* var. *lanecolata*	*C. carabayeyisis*
H 4	1,	*C. oalisaya*	*C. calisat/a*	*C. officinalis*
H 5	'—	— —	— —	— —
H 6	—	— —	_ _	— —
H 7	l!l'	indet	— —	*C. pubescens*
H 8	4	*C. purpurea*	*C. calopatra*	*C. pubescens*
II 9	18	*C.* sp. nov.*2	*C. carabayensis*	*C. carabayensis*
H 10	22	*C. ovata*	*C. ovata,*	*C. pubescens*
H 11	5	*cf. Ladenbergia*	*Case, carua*	*Lad. carua*
H 12	9	*Cinchona* sp. nov.*3	*C. euneura*	*C. ? officinalis*
H 13	20	*C. lanceolata*	*C. hasskarliana*	*C. carabayensis*
H 14	21	*C. lancifolia,* (Flora I860, 582)	*C. officiva.1 is*	*C. officinalis*
H 15 *0*	—	— —	— —	— —
H 16	(5	Case. *(Ladenbergia) •magnifolia,*	*Case, magnifolia*	*Ladenbergia magnifolia*
H 17	15	Case. (Ladenbergia) *magnifolia*	*Case, magnifolia*	*Ladenbergia magnifolia*
H 18	24	*Case, moritziana*	*Case, moritziana*	not cited = *Lad. moritziana*
H IS	3	*C. pelleteriana*	*C. subscssilis*	*C. pubescens*
H 20	10	*Case, pediimculata*	— —	*Ladenbergia pedHnc»lata*i*
H 21	12	*C. rufinervis* Wedd.	*C. ovata*	*C. pubescent*
H 22	10	*C.* sp. nov.	*C. amygdalipolia*	*C. officinalis*
H 23	2	*C.* ? *ealisaya* var. nov.	*C. ealisaya* var. *rugosa* Miq.	*C. off-icinalis*
H 24	—	— —	— —	— —
H 25	.—	— —	— —	_ —
H 26	9	*C.* sp. nov. aff. *ealisaya*	? *C. euneura*	*C. ? officinalis*
H 27	14	indet	— —	— —
H 28	7	*C. erythoderma*	*C. subsessilis*	*C, pubescens*
H 20	***17***	*Celastrinea*	— —	*Clethra obovata* (Clethraceae) det. Sleumer

* 1 *C. australis* vide Howard in manuscript list of his barks in the Pharmaceutical Society Museum, Bradford.

* 2 Type of *C. pahudiana* Howard (1859 - 62) .

* 3 Could be confused with bark 26-C. E. R.

* 4 *Remijia* of most other authors.

Miquel (1869) examined the material at the Rijksherbarium and published an account of the genus, abstracted and condensed versions appearing elsewhere. He refused that *C. pahudiana,* described by Howard, (Hasskarl sample 9), was a distinct species and considered it to be *C. carabayensis* Wedd., and further described 4 new species, three *C. caloptera, C. ,euneura* and *C. subsessilis* being based on Hasskarl's material, and *C. hasskarliana* from Javanese plantation material derived from Hasskarl's plants/seeds (or according to others a hybrid). Miquel seems to have ignored the fact that he had already published two further species (Miquel 1861), *C. coronudata* and *C. govana* from Peru. Furthermore there are some discrepancies regarding the said identities and Hasskarl's herbarium material. MiquePs long awaited work provided no answer to the much debated problems as to the identity if the diverse stocks; The question as to the identity of *C. pahudiana* Howard was then already academic as it was no longer propagated. Triana (1870) completes the confusion by the suggestion that *C. caloptera* Miq. = *C. purpurrea* Ruiz & Pavon, *C. eunura* Miq. = *C. lechleriana* Schl., *C. haskarliana* Miq. — *C. carabayensis* Wedd., and *C. subsessilis:* Miq. = *C. purpurrea* Ruiz & Pavon. Subsequently 0. Kuntze (1898) astounded everyone by proposing various massive hybrid complexes which nobody considered seriously, but everybody exhaustively debated utnil the editors of various journals refused to publish further articles.

Between 1870 and 1893 the experimental plantations in many far flung corners of the globe were on the wane; planters in Ceylon and many in S. India had decided that it was time for tea, and the Dutch had discovered the value of the stocks obtained from the seed from C. Ledger, which with relief, was named *C. ledgeriana.* — whatever that may be. *C. ledgeriana* is a doubtful entity botanieally and is very heterogeneous.

By the end of the century some of the older scientists had already died, Weddell followed by Howard, Hasskarl and de Vrij. Only one man bridged the generations untill the second world war, that was H. Rushby. He visited Howard before the latter's death, and subsequently ardently collected and worked on Cinchonas in S. America, but published little. Unfortunately, by the time of the Second World War, Camp (1949) records that nothing could be traced of his collections or works which had been disposed of in a phase of modernization. Our latest information suggests that his collections may still exist at the Botanical Museum, Harvard University. Rushby (1931) was one who opposed the work of Standley (1930/31) who 'lumped' most of the

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earlier described species of *Cinchona,* Vast collections of *Cinchona* were made by the 'Cinchona Missions' during the second world war, but very little was published regarding the taxonomy. Hodge (1950), who had considerable field experience in Peru, defended the critisism of Rushby and considered that many of the taxa reduced by Standley were worthy of recognition, even *C.pahudiana.*

Finally even Hasskarl's plant collections were apparently forgotten; they are not cited in the 'Flora of Peru' (Standley 1930), many *Cinchona* species, some based on his material were reduced, unseen, into synonomy and also his collections of *Pimentelia, Ladenbergia* and perhaps of *Remijia* were ignored. Unfortunately, since the time of Weddell, Hasskarl seems to have been the only collector of *Pimentelia,* and the collection of *Ladenbergia moritziana* Klotzsch, cited in the older literature, has not been mentioned subsequently.

Faced with these historical problems it is not possible to identify these Hasskarl collections with any degree of certainty at this stage. In table 1 the the material is listed in the numerical sequence accord by Hasskarl; the presence of herbarium material is indicated by a + / —; the next two columns the local names, and botanical identity as accorded to the collection in Hasskarl's list, prepared for a demonstration held at Cleve (with corrections dated 24.8.92) and which is preserved in the archives of the Rijksherbarium. The following column contains the number sequence given to the material by Howard, followed by the identifications of Howard (1876 and Howard in Hasskarl. 1861a). The final columns give the identitv according to Miquel (1R66) followed by the synonomy of Standley (1930/31).

CHEMICAL INVESTIGATION OF HASSKARL'S BARKS

The results of the preliminary analysis of the material for the presence of alkaloids are given in Table 2. Twenty-eight of Hasskarl's twenty-nine samples were available for chemical investigation (number 15 is missing). The powdered bark samples were moistened with dilute ammonia and the alkaloids extracted with chloroform. Subsequent purification by partition techniques resulted in alkaloid samnles. The weights of bark material, the yield of alkaloid and the tentative identification by thin-layer chromatography are given in Table 2. The results clearly show that alkaloids have remained in these samples after 130 years of storage. Preliminary chromatographic data indicates that quinoline-type alkaloids, e.g. quinine, quinidine, cinchonidine and cinchonine, are present in the majority of Hasskarl's barks. Quinine is the

Table 2.

SSample number	Wt. extracted (g)	Total alkaloids (mg)	% Yield	Tentative identification from TLC (Qn = Quinine; Qd = Quinidine Cn = Cinchonine; Cd = Cinchonidine)
H 1	2.48	11	0.44	Major Qn, Qd; minor Cn, Cd
H 2	8.1	4 "	0.05	Major Qn (no others seen!)
H 3	30.2	93	0.31	Major Cn; minor Qn, Qd, trace Cd
H 4	14.0	500	3.57	Major Qn; minor Qd, Cd, Cn
H 5	21.7	893	4.12	Major Qn; minor Qd, Qd, Cn
H 6	41.2	1320	3.20	Major Qn; minor Qd, Cd
H 7	10.1	33	0.33	Major Qn, Cn; minor Qd, Cd
H 8	11.3	83	0.73	Major Qn, Qd; minor Cd, Cn
H 9	32.4	346	1.07	Major Qn; minor Cn, Qd, Cd
H 10	36.2	289	0.80	Major arcine; minor Qn
H 11	28.0	204	0.73	Major Qn, Qd; Cn, Cd
H 12	27.6	940	3.41	Major Qn, Cn, Cd; minor Qd
H 13	26.4	734	2.78	Major Qn, Qd, Cn, Cd
H 14	35.4	648	1.83	Major Qn, Cd; minor Qd, Cn
H 16	14.0	7	0.05	Major Qn, Cd; minor Qd, Cn
H 17	41.4	47	0.11	Major Cn; minor Cd, Qn, Qd
H 18	26.8	6	0.0>2	Major Qn, Cd
H 19	10.4	127	1.22	Major arcine — no others seen
H 20	7.6	2	0.03	Major Cd; minor Qn
H 21	13.4	611	4.56	Major Qn; minor Qd, Cn, Cd
H 22	16.1	17	0.11	Major Qn; minor Qd, Cn, Cd
H 23	2.7	8	0.30	Major Qn; minor Qd, Cn, Cd
H 24	49.8	2074	4.16	Major Qn; minor Qd, Cn, Cd
H 25	36.0	1422	4.95	Major Qn; minor Qd, Cn, Cd
H 26	52.3	2376	4.54	Major Qn; minor Qd, Cn, Cd
H 27	15.3	176	1.15	Major arcine, traces Qn ?
H 28	50.8	1552	3.09	Major areine, some Qn? (similarity to H 27)
H 29	37.1	10	0.03	Major Qn; minor Qd, Cn, Cd

major alkaloid in most of the samples, but there are eome exceptions. Samples 10, 19, 27 and 28 are markedly different in that the indole alkaloid aricine is the major alkaloid present; the chemistry of these four samples is thus pertinent to the discussion on the following section. Samples 3 and 20 are outstanding in that they produce cinchonine and cinchonidine, respectively, as major alkaloids, instead of the corresponding aromatic methoxylated alkaloids, quinidine and quinine. Of particular interest to phytochemistry is the fact that seven of these samples, according to Standley 1930, are no *Cinchona* species but yet contain quinine-type alkaloids. Sample 3 was identified as a species of *Pimentelia,* samples 11, 16, 17, 18 and 20 as *Ladenbergia* species and sample 29 as a *Clethra* species (Tables 1 and 2).

DISCUSSION

Viewed in restrospect the early cultivation and breeding of *Cinchona* was rather haphazard and unsystematic.

The exact source of the seeds **germinated,** in relation to the different plants collected by **Hasskarl,** has never been recorded. The history of the plants cultivated from seed sent to the various Dutch botanic gardens is much better documented, see de Vriese (1855) and v. Gorkom (1881) but Junghuhn (1858) writes (translation) "I here include the **remaining** trees present at Cibodas propagated from seed, among which must bo the young plants brought by Capt. Huidekoper from Plolland; these cannot be identified with certainty as the labels placed by Teysmann on all the Cinchona trees of Cibodas were later removed". Junghuhn then renumbered the trees apparently in a repative number sequences: Calisayas 1—n and Lucumaefolia 1—n. He subsequently transplanted the majority of the plantation to Ciniruan. At Ciniruan were the remainder of the plants brought from Holland by Junghuhn; these were also transplanted from the open ground to the forest, one assumes also similarly numbered in a series 1—n. Indeed the various analyses of De Vriese suggest that each establishment had a separate number sequence for each of the then recognized "species". It seems improbable that the succeeding generations of plantation stocks can ever directly be correlated with the original plantation material formerly at Cibodas. Apparently even Moens could not even do this with certainty. Furthermore, at a later date, these early stocks were interplanted with material derived from other sources such as from seed from Ledger. Schukraft and former British plantations. The final complication is that the published results of the early analysed barks do not contain references to tree numbers on the plantations, though these were probably known.

Furthermore, it is important to remember that Miquel did not publish his results until 1869, by which time the progency of the plants introduced by Hasskarl was scattered over the different plantations.

Hasskarl's collection contains some species which are no longer considered to be placed in the genus *Cinchona.* These false Cinchona barks have never been cultivated on plantations.

False cinchona

Clethra obovata (Ruiz. & Pavon) G. Don (Cletheraceae. — Bark no. 29.

This is a .surprising colection as we have not traced any reference to quinoline type alkaloids in this family. However, there are a few collections of this species made by the 'Cinchona Missions' during the 1940's suggesting that this may be one of the 'false quinines.'

Pimentelia glomerata Wedd. (Rubiaceae). — Bark no 2.

This is a species which has never been exploited for quinim production.

Ladenbergia (Rubiaceae). — Barks no 11, 16, 17, and 18.

In the older literature these are referred to as false-cinchonas, —bark or —quinines. In the previous century they were often encountered as adulterants of parcels of cinchona barks. Mostly only minute traces of alkaloids were reported.

The presence *of* quinoline type alkaloids in the genera *Pimentelia* and *Ladenbergia* is interesting- as it indicates that these alkaloids are not restricted to the genus *Cinchona* as has sometimes been suggested.

Cuprea bark. — Bark no 20.

This false cinchona bark and the herbarium material correspond to the plant originally described as *Cinchona peduncidata* Karstens. However, there is considerable difference of opinion as to which genus this plant belongs and it is surprising that Standley retains this within the genus *Ladenbergia.*

'C. peduncidata' played a passing role in the commercial importations of barks from S. America in the early 1880's, the so-called 'Cuprea barks' or 'China cuprea'. These barks were generaly considered to be derived from two plant species originally described as *Cinchona pedunculata* Karstens and *Remijia purdiana* Wedd. Triana (1881) placed these species in the genus *Remijia.* This disposition was followed by Fluckiger (1883), Planchon (1884), and others. Karstens (1881) disagreed and proposed a new genus *Heterasca* to accomodate at least *C. pedunculata.* Karstens (1887) later reconsidered his opinion and reduced *Heterasca,* together with *Ladenbergia* and *Remijia,* to sections of *Cinchona.* K. Schumann (1889) transferee! *C. peduncidata* to the genus *Ladenbergia.* It is highly probable that *C. peduncidata* is misplaced in the genus *Ladenbergia.* Aricine has been reported in the early literature from Cuprea bark.

At present we have insufficient historical bark materials from these false cinchona barks, and much of what exists is without any form of

voucher material. It is worthy of note that these Hasskarl barks must be among the few where voucher herbarium material is available.

The remaining barks and herbarium material have, to date, always been referred to the genus *Cinchona.*

True cinchonas

Cinchona calisaya Wedd.

Gradually a concept of what *C. calisaya* should be was formed on the plantations and the different entitities cultivated under this name slowly segregated; one of these later emerged as *C. ledgeriana* Moens. ex Trimen. It should be realized that *C. ledgeriana* was delimited pharmacognostically, and not botanically, from fl mixture of plants arising from seed purchased from Ledger originating from some 50 different trees in Bolivia (letter from Ledger in Leersum 1915) and the remaining materials of Calisaya from Hasskarl and Weddell. Schuhkraft plants seem to have been kept apart. It is not known whether any of these early stocks play a part in the breeding or selection process of *C. ledgeriana.* Holmes (1886) notes: 'Still v. Gorkom admits that "there are many of the older Calisaya trees introduced by Hasskarl which do not seem different from the Ledgerianas." ' The early herbarium collections of this seem to be exceedingly heterogeneous botanically.

Weddell's plant obtained via De Vriese. Since the plants were propagated from cuttings from one original plant, the stocks must have been limited as they must have been selfsterile being composed only of micro- or macro-stylous plants (which one is not recorded). Junghunhn (1860) noted "The two older Calisaya no 1 & 2 have continuously flowered and are still flowering but to date have not set a single ripe fruit". This suggests that no suitable cross pollinator was present in the plantation.

The results from these preliminary analysis tentatively lead one to conclude that Hasskarl certainly did not collect any *Cinchona calisaya* with a high yield of total alkaloids and quinine. It has been repeatedly questioned if he collected the genuine 'var *josephina',* which, at that time, was thought to be the richest quinine yielding taxon. It would seem that barks 4 & 5 may correspond to this variety and herbarium material somewhat comparable to that of no 4 si also found in Junghuhh's herbarium, and so it would appear that this material may also have given progeny which was planted with Ledger's plants. At present it is not possible to characterize the early stocks of this species with any certainty.

Oimchomi, liasskarliana Miq.

The plants originated mostly from seed collected from tree 'calisaya no 33' from Cibodas, which set fruit from 1858 until its death in May 1860. The first seedlings were planted in the forest at Nagrak and flowered in 1865. Miquel described this new species from plantation material. De Vri.j repeatedly suggested that this was a hybrid. Botanically this is a poorly defined species and it is clear that the early analyses of plantation material supposedly representing this species, refer to two different entities. The confusion begins with Miquel's reference that the plant is to be found in Hasskarl's material collected in S. America. Of the material preserved in the Rijksherbarium Hasskarl's numbers 3, 13 and 14 bear a label *'C. officinalis* var. *liasskarliana* Mlq.'. Indeed Miquel (1869) cited *C. officinalis* from collections made at the locality 'Escalobo St. Raefael' with the reference' *C. condaminea* var. *lancifolia* ab Howard' and mentions the vernacular names 'Cascarilla baya amarilla' (no 3) and 'Cascarilla azuhar' (no 14). The confusion becomes greater as Miquel under *'C. carabayotsis* var. *lanccolata'* notes that this variety probably originated from seed sent as *'C. amygdalifolia-* Hassk. — (7. *lanccolatinn* R. & P.'; logically from the identifications in Table 1, this can only refer to Hasskarl's no 13 (or less likely also no 3). The herbarium material of both no 3 and IB is labelled *C. officinalis* var. *hasskarliava* Miq.'

In the present analyses 3, 13 and 14 all contain cinchonidine. The early published analyses of *C. liasskarliana* from the plantation Nagrak indicate that cinchonidine was absent in the plants called *C, hasskarliana.* De Vrij (1863) analysed 'tree calisaya no 33' and reported per 100 parts 3.148 parts quinine, 0.387 parts quinidine and 1.465 parts cinchonine. The tree 'calisaya no 33' was later identified as *C. pahudiana* Howard and 1 consider that the plants, called *C. liasskarliana,* which originated from seed from this tree and were established at Nagrak, and the subsequent progeny from the Nagrak plants were simply what one would expect, *C. pahudiana* Howard. The herbarium material preserved under the name *C. hasskarliana* has hairy leaves and is also identical with *C. pahudiana*

The second entity cultivated under the name of *C. hasskarliana* differs from the plants mentioned above in the presence of cinchonidine. Whilst cinchonidine was found to be present in Hasskarl's no 3, 13 and 14 in the present investigation these could have been the mother plants of the second entity. However, the leaves of these three numbers are

completely glabrous whilst the second entity of *C. hasskarliana* has narrow leaves with a distinctly hairy midrib. We can, therefore, disregard Miquel's sugestion that 3, 13 or 14 were the mother plants of *C. hasskarliana.* However, Hasskarl no 1 has narrow leaves with a hairy midrib. This was identified as *C. amygdalifolia* by both Hasskarl and Miquel. Further, material corresponding to this is to be found in the herbarium of Junghuhn (ca 1860). It may well be that this group of specimens were the mother plants of the second entity cultivated under the name *C. hasskarliana.* It is not possible to sort out this problem from the results so far obtained.

Cinchona sp. — Barks no 3, 13, 14.

From the herbarium material and Howards letter to Hasskarl (1861a) it is clear that Howard considered that three Hasskarl numbers represented the same species. Indeed, superficially they appear very similar. The present analyses of three differ slightly in details. It is not possible, at this stage, to analyse the role no 13 and 14 may have played in the plantation stocks.

According to Howard (1876), Triana referred Hasskarl's no 3 to *C. purpurea* Ruiz. & Pavon but in this species aricine has been reported in the bark. According to the present analyses Hasskarl's no 3 is a cinchonine producing bark and quinine is lacking. Such species have never deliberately been introduced into the Javanese plantations. C. *micrantha* was introduced by accident in 1862 with material received from British India. This species produces a bark in which cinchonine predominates but cinchonidine is also present. However, searching through the older records there are other non-quinine producing plants recorded in the analyses. These are listed under 'C *calisaya javanica' 'C. calisaya* schuhkraft' and '? *C. hasskarliana'* respectively at Ciniruan (1875), Kuripan (1875), and Ciomas (1876) ; all have an alkaloid composition similar to that found in Hasskarl 3, the herbarium material of which bears seeds. I suspect that Hasskarl no 3 was the mother plant of these stocks.

Cinchona caloptera Miq. — Barks no 7, 8.

Bark no 8 must represent a bark sample from the type collection of C" *caloptera* Miq. The taxonomic relationships of this species are uncertain. It may represent *C. gonovana* Miq. or be related to *C. cordifolia* Mutis ex Humb. Plants reputed to be *C caloptera,* were cultivated on the Javanese plantations for a short period and occassionally the

bark was harvested. The published analyses of the bark of this material show that this was a cinchonine/cinchonidine producing- species with some quinine and no quinidine. It may be questioned if these plants were derived from seed from Hasskarl's no 8. The herbarium specimens of plantation material cultivated under this name show much resemblance to the herbarium material of Haskarl no 7, which according to Hasskarl is also *C. caloptera.*

Cinchona euneura Miq. — Bark no 12.

Bark 12 (and probably bark 26) represents a bark sample from the type collection of this species. As far as is known this species was not cultivated in Java. Its relationship to other S. American species is uncertain. Despite the large leaves which are distinctly pubescent on the undersurface, it would seem to be related to the *C. officinalis* complex and may possibly be closest to *C. uritusinga* Pav. ex Howard, one of the earliest barks to be exported from Loxa to Europe in the 17th century. A plant considered to be *C. uritusinga* was grown by Howard from seed sent to him by Riofrio from Loxa. These were sent to British India and thousands were propagated as *C. officinalis* 'Uritusinga'. Later these were exchanged and cultivated in Java. *C. euneura* seems to be different from these plants.

The differences in alkaloid spectra of components of *C. officinalis* complex has been reconfirmed by every investigator in the last 150 years. *C. uritusinga* was one of the first taxa exploited on a large scale, but by the time of Condamine (1753) the trees were rare; Howard confirms this 100 years later and Martin & Gandara (1945) record the analyses of only 10 trees.

Cinchona, subsessile Miq. — Barks no 19, 28.

Cinchona spp. — Barks 10, 27.

Barks 19 and 28 belong to the .syntype collections of *C. subsessilis* Miq. The results are interesting as the barks contain aricine. This is most commonly reported as occurring in *C. pelleteriana* Wedd. from which species the alkaloid was first discovered. *C. pelleteriana* was exported for a short period from the port of Arica (hence aricine) but the barks were considered worthless.

Barks no 10 (the herbarium material identified as *C. ovata* by Howard and Miquel) and bark 27 (no definite identification) also belong to this alliance. There are further some 8 'species' of *Cinchona* where

aricine is reported to be the major alkaloid, most of these were recorded by Howard (1859-62) ; they are: *C. decurrentifolia. C. lutea, C. microphylla,, C. obovata, C. ovata, C. pelleteriana, C. purpureu* and *C. villosa,* Unfortunately it is unknown if aricine occurs in *C. puhesicem* S. St., this may resemble the pubescent, non-arcine producing *C. pahudiana* in alkaloid spectra. Further aricine is reported from Cuprea bark *(Remijia* ? — see Hasskai-1 no 20) and an intense yellow colouring associated with an alkaloid is reported from *Pogonopus tubulosa* (D.C.) Schum. (syn. *Hoivardia febrifugia* Wedd.).

None of the aricine producing *Cinchona* species mentioned had been cultivated on plantations. The presence of aricine in *C. subsessilis* lends some support to the suggestion of Triana (1872) that this may only be a later name for *C. purpur ea* R. & P.

Cinchona calisaya var. *rugosa* Miq. — Bark no 23.

This bark must represent a sample of the type collection of this little known variety. This variety may be incorrectly associated with *C. calisaijn.*

Cinchona soobiculata. — Barks no 24, 25.

Herbarium material and further identification are lacking for these two collections.

CONCLUSIONS

Quinine is bitter, its history likewise, chequered by success and mistakes, import carreers or disillusionment, sickness and death and marked by ferocious scientific disputes between Mutis and Ruiz & Pavon, which at the time shook the learned world. It is not surprising that many problems of the early plantations were exaggerated by bitter personal differences, some recorded in the literature and others long buried in dusty archives. These differences make it difficult to objectively analyse many statements made in the older literature.

The first plantations found place around the time of Darwin's publication of *The Origin of Species,* and into taxonomic field were concurrent with "the Kew rule": distribution of duplicates of diverse origin, under the same number, of plants considered to represent good species. Similarly on the plantations stocks of the 'species' were obtained and propagated, only to find at a later date that these were mixed or had variable characters. Furthermore, both in Java and India the overseers

or heads of department were periodically changed which seems to have been disastrous for continuity of research and publications.

The discovery of bark material with correlating herbarium material of the mother-plants or-populations of the original stocks cultivated on the Javanese plantations enables one to draw certain tentative conclusions. These original stocks of *"C. ealisaya"* were more heterogeneous than previously considered. There are little or no original correlated data regarding seed source, plants cultivated and bark analyses. This has led to the assumption that *Cinchona* is exceedingly variable and that numerous hybrids or hybrid swarms have been produced. Considering the experimental work of Engelbeen (1949) such hybridization is unlikely. Some experimental crosses are reported in the early literature but no further details are given. The most well known is *C. robusta* which 'originated' in India; it had an alkaloid spectrum intermediate between *C. officinalis* (i.e. *C. ealisaya)* and *C. suecirubra.* Material closely corresponding to *'C. robusta'* was widely collected from wild populations in S. America by the Cinchona Missions of 2nd Word] *Wnr* and were considered by Martin & Candara (1945) as ? *C. luciimaefolia.* The Javanese material originated from the plants cultivated in India plus seedlings from the ledgeriana mother tree 28, supposedly crossed with *C. Succirubra)* . Perhaps Robert Cross was correct when he wrote in a letter to Hooker, 'Sir, there has been a terrible mistake, they are cultivating the wrong species'.

In fact the success of the early cinchona breeding selection may seriously be questioned; perhaps they were simple re-selecting the original breeding stocks. Early herbarium collections of *C. ledgeriana* made from Javanese plantations by Gorkom are certainly the most heterogeneous assemblage one could meet. Unfortunately, in the yearly reports of the government cinchona plantations, the comment that there was no time to make a representative herbarium collection of the different species and clones, occurs very often, indeed there is little herbarium material.

The history of *Cinchona* is also one of terrible mistakes and shortcomings, each successive phase of research ignoring the results previously obtained. The result is over a 1000 publications (Moreau 1945, Rehder 1912, 1915) which show little correlation with each other. The vast number of collections and results obtained by the Cinchona Missions oi' the 2nd World Wai- (Fosberg 1945, Steere 1945) mostly have remained unstudied and unpublished. The research in the genus covers some of

the earliest work on bark morphology and anatomy (Berg 1865, Phoebus 1864, Howard 1850-62, 1872 and Vog] 1S67) and that of formation of Avound tissue. There is a mass of data on the pharmacognosy of *Cinchona* and some 40 or more alkaloisd are said to occur in the genus. However, many "alkaloids" are merely names for **uncharacterised** compounds isolated many years ago and their purity as single substances must be **in doubt.** Classical analytical techniques **were** developed for the separation of four major alkaloids, viz., quinine, **quinidine,** cinchonidine, cinchonine, and many samples have been investigated chemically for the presence of these four alkaloids. Finally there is a mass buried data on the distribution of the different species and populations Avhich indirectly give an indication of the composition of the vegetation that dissappeared **in** areas depleted during the last 200 years It is hoped that the investigation on the historical collections Avill be continued and that shortly it will be possible to give quantitative results. Further it may Avell be possible that the alkaloids found **in** the leaves (Phillipson & HemingAvay 1980) may, **at** a future data, provide further **characters** for comparison of the different species.

It is considered that the analysis of bark and leaves of **a** limited number of Avidely distributed historical collections of *Cinchona,* both Avild and early cultivated stocks, could provide a basis for further more detailed research. This could be directed on the one hand at interpretation of the different cultivated clones and species, requiring limited further analyses, and, on the other hand, on the analysis and reassesment of the mass of collections and data assembled from the **wild** stands of *Cinchona* during the 2nd World War. Furthermore reassesment, of the early **work** of Berg (1865) **Howard** (1859, 1862, 1872) and Vogl (1867) and that of Little (1947) on bark anatomy would be possible and could be based **on** the same documented collections.

The experimental works of Engelbeen (1949) indicated that cross pollination of plantation stocks in former Belgian Congo is effectively nil at a distance of 150 m and further that different clones may be safely isolated at a distance of 300 m. These experimental data certainly exclude the possibility of hybrid **swarms** and introgression on **a** scale proposed by Camp (1949) and make one question many of the **earlier** conclusions regarding hybrids in plantations. Important tropical genera of Avoody crops such as cocoa, coffee, rubber and tea yield products based on **the** fruits, latex or leaves respectively and selection of these has been on a clonal basis from original wild stocks. *Cinchona* yields alkaloids, all species have alkaloids as far as is knoAvn, and only certain species

have been subjected to clonal selection. On all these crops there is a tremendous amount of literature, particularly on the cultivated strains. *Cinchona* is exceptional as vast documented collections have been made throughout the known ranges of the different species. There is a mass of historical documentation and furthermore its products can be analysed from dried specimens of plants and bark. Correlation of the mass of information of the genus coupled with a serious rexamination of it, using modern techniques would make *Cinchona* one of the best studied tropical plant genera and could provide a blue print of genetic variation in a genus tropical trees.

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