

THE WORLD'S CINCHONA BARK INDUSTRY—II, THE PRESENT POSITION OF THE PRODUCTION OF CINCHONA BARK AND QUININE IN EMPIRE COUNTRIES¹ *

COUNTRIES within the Empire, other than India, where the prospects of cinchona cultivation seem to be promising are Tanganyika, the Cameroons under British Mandate and Malaya. A summary of the position in these and in other Empire countries where the tree has been introduced is given in the following paragraphs. In addition it may be mentioned that at one time cinchona bark was produced in Mauritius, Fiji, and Jamaica, but the fall in price of quinine in the eighties killed the industry in these countries. The fact, however, that cinchona apparently succeeded there may be worth bearing in mind when considering possible countries for its cultivation. The climatic conditions in parts of British Guiana have also been regarded as suitable for the tree, but economic considerations would probably prevent the establishment of commercial cultivation in that region at the present time.

TANGANYIKA

In this Territory the conditions obtaining in the Usambara district appear to be particularly suitable for cinchona. Plantations were made there by the Germans 30 to 35 years ago on Bomolo Hill at what is now the East African Agricultural Research Station. The kinds planted include *C. ledgeriana*, *C. succirubra*, *C. robusta* and a hybrid (*C. ledgeriana* X *C. succirubra*). Small shipments of bark were sent to Germany in 1909 and 1912, and during the War the plantations were able to supply all the quinine needed by the German troops in East Africa and some was shipped also to Germany.

In 1918 samples of bark collected from the four types of tree at Amani were sent to the Imperial Institute for examination. That from the hybrid tree proved to be of specially good quality, giving a yield of 11·21 per cent. of quinine sulphate, showing it to be fully equal to the finest Ledger bark from Java.

Small consignments were subsequently sent to this country for sale and realized satisfactory prices.

In addition to these German plantations an area of 5½ acres was planted on the Drachenberg Plantation in the early twenties with Ledger and hybrid seedlings.

¹ The position in India was dealt with in the previous part of this article.

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A full account of the history of cinchona at Amani, with a discussion as to the quality and yield of the bark from the different types of tree, will be found in an article by Dr. R. R. Le G. Worsley, published in this Bulletin, 1935, 33, 14-31.

Lately further development has taken place at Amani and the 38·4 acres under cinchona at Kwamkoro estate were to be increased to 100 acres during 1938. It was proposed that this land should be planted with *C. ledgeriana* as far as seed is available and the remaining area with *C. succirubra* and a hybrid (*C. ledgeriana* X *C. succirubra*). It is hoped by this means to obtain still further evidence as to the commercial prospects of the crop in this region.

Cinchona is also to be found on certain private estates in Usambara. At Ngamba estate, E. Usambara, there are about 75 acres, and at Balangai estate, W. Usambara, about 50 acres. Both these areas were planted by the Germans and harvesting of the bark has taken place fairly regularly. Cinchona is also grown on Mazumbi estate and at Lushote.

CAMEROONS UNDER BRITISH MANDATE

Cinchona plots were started by the Germans over 30 years ago on the Cameroon Mountain with seeds and seedlings from good-yielding Java trees. In 1924 the species then present, as determined by Kew, were *C. near micrantha*, *C. ledgeriana*, *C. succirubra* and *C. calisaya*. Four samples of bark collected from different plots, which were sent to the Imperial Institute for examination in 1918, proved to be of satisfactory quality for the manufacture of quinine, yielding from 6·7 to 8·2 per cent. of quinine sulphate.

Further trials have since been made by the Department of Agriculture. Seed of *C. ledgeriana* and *C. succirubra* from Java was sown by the Department of Agriculture in 1927 at the Botanic Gardens, Victoria, and the seedlings were planted out in 1929. The Ledger plants are reported not to have done so well as the *succirubra*, and it may be found necessary to graft that species on the latter under the conditions obtaining in the Cameroons. Further evidence seems desirable, however, on this point, as the original Ledger plants are now probably over-mature and those planted in 1929 were put out in an open type of country without the support of forest which is so necessary to the successful growth of cinchona.

It is considered that there are large areas on the Cameroon Mountain which should be suitable for the cultivation of cinchona for totaquina production, but in spite of earlier results it seems doubtful whether satisfactory yields of quinine can be obtained in this region. In view of this and of the unconvincing results of trials with Indian-made totaquina carried out by the medical authorities in Nigeria, it is proposed to discontinue the experimental cultivation of cinchona in the Cameroons area.

KENYA

There is at present no direct evidence as to the suitability of Kenya for cinchona cultivation, but there may be areas in the Highlands where the tree will succeed. The question has been taken up by the Department of Agriculture.

and seedlings of *C. ledgeriana* and *C. succirubra* are being raised in Government nurseries for issue to planters in the Sotik and Kericho areas for trial and possibly also to natives elsewhere in humid areas.

New experimental plantings of Indian *ledgeriana* seed, obtained through Amani, have recently been started in the Nandi district and at Kakamega under the supervision of officers of the Agricultural Department in collaboration with the Forestry Department. The nurseries established at Sotik and Meru have proved too cold and exposed for rearing the young plants and have accordingly been given up.

UGANDA

Cinchona is also the subject of trial in Uganda. A small plantation of *C. ledgeriana* was started by the Forest Department at their Arboretum at Entebbe in 1921. The growth was very satisfactory and in 1926 the bark was stripped from some of the trees. A sample of this bark examined at the Imperial Institute in 1927 gave a yield of 5.05 per cent. of quinine sulphate, which is quite satisfactory for five-year-old bark. More recent analyses are understood to have given a higher quinine content.

There are also experimental plantations of *ledgeriana* hybrids at various other places in Uganda at elevations ranging from 3,800 to 5,500 ft. A sample of hybrid bark grown at Bukalasa, also examined at the Imperial Institute in 1927, furnished 3.72 per cent. of quinine sulphate.

It may be mentioned that reports on the Uganda barks were published in this BULLETIN, 1928, 26, 17, but at that time the exact botanical source of the material was not known and the Ledger bark was erroneously described as being derived from *C. succirubra* and the hybrid bark as *Crobusta* (?)

NYASALAND

Cinchona officinalis was grown at Chiringa, near Zomba, early in this century, but the area was planted up with Ceara rubber in 1907, and subsequently abandoned. In clearing the land in 1928 it was found that, in spite of neglect and over-crowding with other vegetation, some of the trees were still alive, which suggests that the conditions there are not unfavourable to cinchona. No development, however, seems to have taken place in this country.

NORTHERN RHODESIA

A plantation of about 1,000 trees of cinchona is stated to have been established on Hill Wood Farm, Mwinilunga, in 1929. The trees apparently grew well, as some were reported later to be seeding, but no further information as to their progress or as to the species is available.

BURMA

As a result of recommendations made by Colonel Gage in 1918, after his survey of the possibilities of development in India's production of quinine, plantations were started in the Tavoy District of Lower Burma, but in 1921 and 1922, these were practically destroyed by the heavy rains, and cultivation was transferred to the Mergui District. The plantations consisted mainly of *C. ledgeriana* as it was found at an early stage that *succirubra* did not thrive under Burma conditions.

For a few years the Mergui plantations made rapid progress and the outlook seemed promising, but it later became apparent that the site was by no means ideal for cinchona cultivation and that yields comparable with those obtained in Java could never be expected. The difficulty of bringing the plants through the dry season from November to February, coupled with the damage done by the heavy rains in the monsoon presented a serious problem. Experimental cultivation in Upper Burma was advocated, but this plan never materialized.

From 1931-32 onwards there was no further extension of development of these plantations, operations being restricted to maintaining the existing areas in good condition. Production of bark was to be gradually reduced in accordance with the change in the Government policy.

With the transference of the Mergui reserve to the Government of Burma in 1937, the plantations were closed down as the Burma authorities had no wish to continue operations. All mature bark was stripped off and sent to the Mungpoo factory, Bengal.

The quantity of bark handled in the years 1930-31-32 is given below in comparison with 1934-35-36 after the restriction scheme :—

				lb.
1930-31	..	..	..	131,533
1931-32	..	..	..	177,061
1934-35	..	..	..	64,429
1935-36	..	..	..	81,772

CEYLON

Cinchona cultivation in Ceylon was started in about 1860 and by 1875 the exports of the bark, largely obtained from *C. succirubra*, already amounted to nearly 19,000 lb. annually. The ruin of the coffee industry by leaf disease in 1880, resulted in a further increase in cinchona cultivation and by 1887 Ceylon had become the most important producing country in the world, exporting in that year over 13 million lb. of bark. Over-production followed, with a consequent fall in price of the bark, and cinchona cultivation was practically abandoned in favour of tea.

During recent years, however, the industry has to some extent been revived, but the original *C. succirubra* trees, many of which remain scattered about the plantations, yield bark with a low content of quinine. In 1927 the Department of Agriculture attempted to reintroduce *C. ledgeriana* but the trial proved a failure. Experiments are now being carried on with grafting and with the selection of high-yielding strains for scions. Hybrids are also being cultivated experimentally and will be sampled when old enough. On the whole there seems little prospect of successfully developing areas of *C. ledgeriana* in Ceylon.

There is a small export of *succirubra* bark, the figures for the last three years being as follows : 1936, 140,448 lb. ; 1937, 170,128 lb. ; 1938, 155,904 lb.

MALAYA

The first attempt to introduce cinchona into Malaya appears to have been made in 1878, but it was not long before the great fall in the price of quinine occurred and interest in the crop in the Straits then ceased. In 1915 further introductions of *C. ledgeriana* and *C. succirubra* took place, but in most cases

the sites chosen for the plots did not meet the exacting requirements of the tree. Since then trials have been made in the Cameron Highlands with more promising results. Seed obtained from Java was sown at the end of 1926, and in the following year the first seedlings were planted out. Further sowings followed in 1927 and by the beginning of 1929, approximately 2½ acres each of *C. ledgeriana* and *C. succirubra* were planted out on jungle land which had been completely cleared, with an additional acre of each species in thinned out jungle still providing some shade. Three-year-old bark examined in 1930 gave the following satisfactory figures for alkaloid content, but was at the same time remarkably thin :—

		<i>C. ledgeriana</i> Per cent.		<i>C. succirubra</i> Per cent.
Total alkaloids	..	9.40	..	7.31
Quinine sulphate	..	10.53	..	2.51

Subsequent analyses made in 1936, showed that although the figure for total alkaloids in the Ledger bark was practically the same, the content of quinine had fallen off. The average figure obtained, however, was still better than that for Indian bark, and in isolated trees the quinine content sometimes exceeded that normally found in Java bark.

In order to determine the most suitable site and type of plant a new series of experiments was commenced in 1936. Five plots of one acre each are being established in different parts of the Highlands and in each case *C. succirubra*, *C. ledgeriana* (both on its own roots and grafted on *C. succirubra*) and *succirubra* × *ledgeriana* hybrid are being tried. During 1937 some thousands of plants of *C. ledgeriana* and *C. succirubra* were grown from seed for trials and transplanted to nursery beds, and in addition a number of self-sown hybrid seedlings were collected for nursery cultivation.

Although the soils in the Cameron Highlands are friable and the rainfall is adequate for cinchona and is evenly distributed, much of the land is on steep slopes and for plantations to succeed it will be necessary to select sites as free as possible from the dangers of erosion. Many of the conditions in this region are decidedly encouraging, but it is clear that much more experimental work remains to be done before the possibilities of large-scale planting can be definitely decided.

ST. HELENA

The introduction of cinchona to St. Helena dates from 1868. Seeds of *C. succirubra* and *C. officinalis* were sown in this year and by the end of 1869 a small plantation had been started in an area of partially cleared forest at about 2,000 ft. Although the trees made good growth the plantation was soon abandoned. It was stated in 1917 that the trees were then still in healthy condition after years of neglect and had reproduced naturally from seed. Samples of bark from both species were examined at the Imperial Institute in 1917 and gave yields of alkaloid which were higher than the average for *C. succirubra* and *C. officinalis* (see this BULLETIN, 1918, 16, 383.)

NEW GUINEA

Although in Central New Guinea the soil, elevation, climate and rainfall conditions resemble very closely those of Java, the introduction of cinchona into this territory is only very recent. Seedlings have been reared successfully in the Ramu Valley and it was stated early last year that the Government Experimental Station had many hundreds of well-grown plants suitable for distribution. They are as yet too young for determinations of the quinine content.

THE POSITION IN FOREIGN COUNTRIES¹

Apart from the Netherlands East Indies cinchona has been introduced into a large number of foreign countries, but in most of these cultivation is still in the experimental stage. In the French Colonies trials are being carried out in Reunion, Madagascar, the French Cameroons and Indo-China (where nearly 1½ tons of quinine sulphate were produced in 1938), and much work is being done in the Belgian Congo. There is a small export of bark from the Island of San Thome. In the Far East plantations have been started in Formosa, whence the Japanese in time hope to obtain all their quinine requirements, and in the Philippine Islands, where totaquina has been prepared from locally grown bark. Attempts are also being made to establish the tree on plantation lines in Central America, especially in Guatemala. Other countries where trials are being made include Eritrea, Spain and the sub-tropical parts of the U. S. S. R. An outline of the developments in these countries and of the present position with regard to cinchona production is given in the ensuing paragraphs.

BELGIAN CONGO

Although cinchona is said to have been grown in the Belgian Congo before 1890 extensive trials were not undertaken in the colony until 1901. Since that date there have been many introductions both of seeds and of young plants reared at the Jardin Colonial of Laeken in Belgium. It has been found that the plains of the Congo basin are too low-lying for satisfactory growth of cinchona, but promising results have been obtained from some of the hill stations on the eastern borders of the colony. In the Kivu district the Government experimental stations at Mulungu and Tshibinda, which are under the control of the Institut National pour l'Etude Agronomique du Congo Belge (INEAC), have considerable plantations of *ledgeriana*, *succirubra* and *robusta* at altitudes of 5,000 to 6,500 ft. These trees, which include some derived from seed of high-yielding strains obtained from Java, are giving satisfactory yields, and indeed some of the bark analyses show remarkably high contents of both quinine and other alkaloids.

In addition to the Government experiment stations, where selection work is being carried out, mention may be made of the Synkinac (Synquinak) Society's plantation at Kalonge, also in the Kivu district, which comprises about 80,000 trees, and that of the Fataki Mission in the Ituri district further north with over 50,000 plants. Further extension of the area under cinchona is proposed, but the aim of all these enterprises is to supply quinine for consumption in the Congo rather than for export.

¹ The position in the Netherlands East Indies was dealt with in the previous part of this article.

FRENCH INDO-CHINA

Attempts to establish cinchona in French Indo-China have constantly met with such difficulties that although the earliest introduction dates from 1869 cultivation has still hardly progressed beyond the experimental stage.

The chief problems lie in the comparative scarcity of suitable soil and the lack of available planting space at sufficiently high altitudes, for under the conditions prevailing in the colony it does not appear possible to grow cinchona below about 3,500 ft. without heavy losses from collar rot disease.

The more recent trials commenced in 1917, with the opening by the Institut Pasteur of the Hon-Ba experimental station, which is situated on the Lang-Bian plateau in southern Annam at an altitude of about 4,900 ft. The soil in this locality is of granitic origin, rather shallow and poor in humus, and the young cinchona plants, some of which were grown from seed (*ledgeriana* and *succirubra*) and some from young grafts obtained from Java, did not survive long.

Further plantings in southern Annam were made by the same Institute in 1923 and 1924 at Dran (about 4,900 ft.) and Djiring (3,200 ft.) in the Haut Donnai. These stations have a soil of basaltic origin, somewhat richer than that of Hon-Ba, but the climatic conditions are not very favourable, there being a dry season of about five months. Results were at first encouraging, but after three or four years the plants became unhealthy and weakened by disease and precocious flowering. Plants were reared from the seed of these trees, however, at Petit Langbian (5,200 ft.), where they made good growth and gave yields of from 8 to 12 per cent. of quinine sulphate at the age of seven years. Unfortunately there is no land available for extensive cultivation at this altitude and it has been necessary to concentrate attention on lower stations. The chief of these is at Diom (3,600 ft.) not far from Dran, which was planted with *ledgeriana* in 1932. Here the Institut Pasteur hope eventually to reach a maximum annual production of 3,000 kilos of quinine sulphate for a period of ten years. The actual yields from loppings and thinnings in 1937 and 1938 were as follows :—

				1937.		1938.
Bark	..	..	kilos	20,650	..	21,100
Quinine sulphate	..	..	kilos	1,434	..	1,793
Quinine sulphate	..	..	per cent.	6.92	..	8.50

Cinchona has also been planted at experimental stations of the Institut des Recherches Agronomiques de l'Indochine. These are situated at Langhanh (3,300 ft.) and Blao (2,800 ft.) on the Haut Donnai plateau and at Paksong (3,600 ft.) further north on the Bolovens plateau.

CAMEROONS UNDER FRENCH MANDATE

The moist climate and volcanic soils of the mountains of the Cameroons seem to present conditions admirably suited to the growth of cinchona and very promising results have been obtained from trials carried out in the territory under French mandate.

Since 1922 numerous consignments of seed have been sent to the territory for planting at the Cinchona Station at Dschang, which is situated at an altitude of about 4,900 ft. Possibly owing to the poor quality of the seed received, these efforts met with no success during the first six years and it was not until 1928 that healthy seedlings were reared. Since then progress has been more satisfactory, and by 1937, there were a few dozen plants of *ledgeriana* making slow development and about 8,000 vigorous *succirubra* plants, the older trees being already up to about 25 ft. high. Analyses of the bark show a quinine sulphate content of 5 to 9 per cent. in the *ledgeriana* but only 1 per cent. in the *succirubra*, which, however, gave satisfactory yields (up to about 8 or 9 per cent.) of total alkaloids. Grafts of *ledgeriana* on *succirubra* stocks were started in 1935 and 1936, but at the time of writing the results of these experiments were not available.

The chief aim of the work, however, seems to be directed towards the growth of *succirubra* for totaquina production. An abundant supply of seed is now available from the plants introduced in the early stages of the work and 40,000 new *succirubra* plants have been put out since 1934 at various stations, some at considerably lower altitudes than Dschang, as, for example, Yaounde (2,600 ft.), on the central plateau of the Cameroons. These new plantations are reported to be making very satisfactory progress.

MADAGASCAR

Early attempts to establish cinchona in Madagascar were made from about 1896 to 1902 with the introduction of seed from Reunion and a number of young *ledgeriana* plants and grafts obtained from Java. Many of the plants died prematurely, but the experiments were abandoned before any decisive conclusions were reached. In 1914 analyses were made of the bark of some of the trees which still survived, but the yield of alkaloids was very poor.

Fresh trials with seed of *ledgeriana* and *succirubra* obtained from Java were started in 1928 at a station in the Forest of Ambre situated at about 3,300 ft. Conditions appeared fairly well suited to cinchona, and the trees made healthy growth, but analyses made in 1933 showed a very poor yield of quinine. The total alkaloid content was in some cases fairly satisfactory, but it can hardly be said that Madagascar appears promising as a future source.

REUNION

Early cultivation trials with cinchona in Reunion were carried out on a considerable scale. The first successful introduction was in 1886, and by 1894 there were said to be as many as 80,000 cinchona plants of various species on the Island. Most of these were *succirubra*, which was found to grow well, particularly between the altitudes of about 1,600 and 3,300 ft. The yields of alkaloid obtained were unsatisfactory, however, and further trees reared from local seed, some of which was doubtless the result of free hybridisation, gave disappointing results. Interest in cinchona culture gradually waned, and many plantations were totally abandoned.

Since 1918 cultivation has been resumed and in 1935 from 1,500 to 2,000 trees were being exploited annually by the Grency Government Forestry Service. The whole of this supply of bark is being purchased by the Government Medical Service.

ERITREA

Cultivation of cinchona in Eritrea is still at an experimental stage. Plants of *ledgeriana* and *succirubra* have been reared from seed introduced from Java in 1926, but so far the results indicate that the local conditions are more suitable to *succirubra* than *ledgeriana*.

SPAIN

It was reported in 1933 that cultural experiments with cinchona were to be made in Spain and the Canary Islands under the auspices of the National Institute of Forestry Research. Seed was obtained from Java, but there appears to be no further information regarding these trials.

PORTUGUESE COLONIES

Cinchona was early introduced into the Portuguese colonies of San Thome Principe, the Cape Verde Islands and Madeira, but although the trees appear to have grown reasonably well in the Cape Verde Islands it is only in San Thome and Principe that cultivation was developed. The Island of Timor has also been considered as a possible producer of cinchona, but there have been no serious attempts to introduce the crop there.

The first plants in San Thome appear to have been reared from seed received in 1869, but most of the later plantations were derived from seeds and young plants sent from Lisbon from 1873 onwards. These originated from various sources, including Java and British India.

Cultivation developed steadily and by 1891 the annual production of bark in San Thome and Principe amounted to nearly 110,000 lb. These Islands have continued to produce cinchona, but the industry has suffered from the vicissitudes of the quinine market and in recent years there has been a considerable decrease in the output. Interest in cinchona is now reviving, however, owing to the unfavourable state of the market for cocoa, which is the principal export crop of the Islands.

U. S. S. R.

Experimental work is being carried on in Transcaucasia with the object of developing a new method of cinchona production in which the entire plants are used for alkaloid extraction at the age of only one or two years. In this way it is hoped to overcome the difficulty of the rigorous winters of this region.

From the results of trials in which young plants were reported to contain about 1.4 per cent. of total alkaloids, it has been estimated that yields of 31 lb. of alkaloids per acre may be expected. There is no evidence so far, however, that the preparation of the alkaloids from these young plants will prove economical on a commercial scale. It is reported that large experimental plantations of *succirubra* have been laid out in the warmer regions of Georgia, but the results of this work are not yet to hand.

PHILIPPINE ISLANDS

In the Philippines cinchona has been grown by the Forestry Department since 1927 for the preparation of totaquina for domestic consumption. Prior to this date there were a number of fruitless attempts to introduce the crop, but by the beginning of 1937 plantations occupying about 34 acres had been established at Bukidnon at an average altitude of 2,500 ft., with some 39,000 trees over two years old and 110,000 seedlings. A second area at an altitude of about 3,500 to 4,500 ft. was planted more recently and further extension is now planned. The trees consist of *ledgeriana*, *succirubra* and "hybrida" originating from Java seed. The yields of alkaloid have not been very high, but up to the beginning of 1937 a total of some 10 metric tons of bark had been harvested.

Lately there has been serious trouble in the plantations occasioned by disease which is thought to be due in part to unfavourable soil conditions. Planting at higher altitudes has been suggested as the plants appear to be more vigorous under such conditions and should therefore be less susceptible.

FORMOSA

Cinchona is grown in Formosa chiefly by commercial firms operating concessions on government lands. The plant was introduced from Java in 1919, but it is only during the last few years that the cultivation has received much attention. A greatly increased production is now planned and it is hoped that eventually Formosa will be able to supply all Japan's requirements of quinine.

The species introduced are *ledgeriana*, *succirubra* and "hybrida"; they appear to grow reasonably well under Formosan conditions at altitudes of between 2,000 and 3,000 ft., but have not so far given particularly high yields of quinine. No information is available as to the actual production in Formosa.

SOUTH AMERICAN COUNTRIES

The eastern slopes of the Andes form the natural home of the cinchona tree, but there has been so much promiscuous destruction of the plants through wasteful methods of collecting the bark that in many regions the trees only survive in inaccessible forests. There appears to be no systematic cultivation of cinchona, and supplies of bark gathered from trees growing wild in the forests are gradually diminishing. Certain quantities are still exported from Equador (*succirubra*) and Peru.

Proposals to cultivate the trees have not materialized owing to lack of funds and difficulties of transport, but there has recently been established in Bolivia a government plant for the preparation of quinine from local bark. It is reported that the plant will produce considerable quantities of refined quinine for export and in order to ensure an adequate supply of raw material it is proposed to prohibit any further export of the bark.

It was reported in April 1939, that 1,000 seedling cinchona trees raised in the experimental gardens of the United States Department of Agriculture at Washington have been sent to Brazil for trial planting. The seedlings are stated to have stood the journey well and have survived transplanting. The results of this experiment will be watched with great interest.

GUATEMALA

Interest in cinchona cultivation has been revived during the last few years with a view to commercial production. Before extensive planting it is intended to make a careful choice of the localities most suitable for the growth of the crop, and to this end a number of small experimental plots are to be established under varying conditions of climate, altitude and soil. Seed is to be provided from old trees which originate from former abandoned plantations and have become naturalized in the country. A quinine content in the bark of more than 5 per cent. is looked for in trees to be used as a source of seed.