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*Proceedings of the Madras Government, Revenue Department,  
22nd February 1870.*

No. 235. Read the following Report from J. BROUGHTON, Esq., Quinologist to Government, Ootacamund, to the Acting Secretary to Government, Revenue Department, Fort Saint George, dated Ootacamund, 9th December 1869 :—

THE present condition of the Neilgherry Cinchona Plantations, both absolutely and with reference to the changes that have taken place during the past year, may be aptly discussed in the beginning of this Report.

2. Constant examinations of the bark of the oldest part of the plantations of *C. Succirubra* have demonstrated that the amount of alkaloids therein contained has increased during the past year. The amount of this increase has necessarily been determined by the comparative examination of a part only of the plantations conducted at different seasons, and hence a certain error may be committed by applying the definite number thus obtained to the plantation generally. I therefore content myself with stating that the increase in the amount of alkaloids, contained in the trunk-bark of the oldest trees from May 1868 to May 1869, has not been less than 0.5 per cent.

3. In a Report, dated August 17, 1868, (Proceedings of Madras Government, Revenue Department, 22nd September 1868, No. 334,) I had the honour of stating the *a priori* probability of the annual increment of alkaloid therein mentioned decreasing in amount, till an equilibrium is established between formation and internal consumption. The respective numbers representing this annual increment for the last two years coincide with this view, being 0.75 and 0.5 respectively.

4. The mean per-centage of quinine has, on the other hand, diminished during the past year among the red barks, as was the case during the previous year. This diminution will be considered below. Analyses which are believed to fairly represent the mean yield of the bark of the oldest trees, may be stated thus in per-centages of the dried bark :—

|                                        | May 1868. | May 1869. |
|----------------------------------------|-----------|-----------|
| Total alkaloids ... ..                 | 6.74      | 7.43      |
| „ sulphates obtained crystallized*     | 6.06      | 6.43      |
| Quinine ... ..                         | 2.40      | 1.72      |
| Cinchonidine and cinchonine ... ..     | 4.34      | 5.71      |
| Crystallized quinine sulphate obtained | 2.21      | 1.51      |
| „ cinchonidine sulphate obtained       | 3.85      | 4.92      |

\* The numbers express the pure and not the commercial salts. From the crystalline sulphates that of cinchonine is excluded. These observations apply to all analytical statements in this Report.

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5. During the past year I have paid much attention to the varieties of *C.*

*C. Officinalis.*

*Officinalis*, which constitute the "Crown-barks." The varieties we possess of these

are far more numerous than are usually recognized by the botanists who have studied cinchonæ in Europe. With the exception of the very distinct kind (provisionally called *lanceolata*), whose great excellence I have pointed out on former occasions, (Proceedings of Madras Government, Revenue Department, 22nd September 1868, No. 334, paragraphs 12 and 13, and 19th June 1869, No. 422,) I can discover no invariable connection between the external appearance and the chemical constitution; while the varieties themselves merge into one another by slight gradations.

6. But on the other hand the yield of alkaloids varies greatly according to the vigour of growth, size of tree, and consequently with character of soil. The vigorous trees contain most alkaloid.

most vigorous and quickly-grown trees yield a far richer bark than the more stunted ones of the same age; while at the same time they of course yield more bark. This circumstance strongly indicates the advantage of high cultivation: thus an acre of land planted with trees growing at a doubled rate will yield more alkaloid than two acres of trees growing at the ordinary rate. It is a singular circumstance that the alkaloids should be the constituents most affected by the tree's vigour; as it would seem far more likely *a priori* that all the constituents would be affected in equal proportion. I have some reason for thinking this circumstance is closely connected with the amount of nitrogenous constituents in the soil.

7. This variation in the amount of alkaloid, with the size and vigour of the tree (age being constant), renders any numerical estimate of the annual mean increase during past year.

increase in the per-centage of alkaloids exceeding difficult to obtain. I believe the increase during the past year has been considerable, but feel hardly justified in stating a definite number that would apply to the whole plantation. The diminution in the amount of quinine with age, perceptible in *C. Succirubra*, certainly does not obtain in *C. Officinalis*. To illustrate the great difference in the yield connected with the vigour of the trees, I quote the following results obtained from trees of same age (five years old), each analysis being the mean of several trees:—

|                                             | Bark from fine vigorous trees. | Bark from fine vigorous trees. | Bark from trees of mean growth. | Bark from trees of stunted growth. |
|---------------------------------------------|--------------------------------|--------------------------------|---------------------------------|------------------------------------|
| Total alkaloids                             | 6.76                           | 6.94                           | 4.34                            | 2.40                               |
| „ sulphates crystallized                    | 5.39                           | 5.59                           | 3.60                            | 1.65                               |
| Quinine                                     | 3.76                           | 3.80                           | 2.18                            | 0.90                               |
| Cinchonidine and cinchonine                 | 3.00                           | 3.14                           | 2.16                            | 1.50                               |
| Quinine sulphate obtained crystallized      | 3.45                           | 3.55                           | 2.00                            | undetermined.                      |
| Cinchonidine sulphate obtained crystallized | 1.94                           | 2.01                           | 1.60                            | do.                                |

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8. On the 30th of August last I obtained a mixed sample of Calisaya bark from sixteen trees grown at Noddiwuttum, rather more than two years old. It gave as a result:

|                                            |      |
|--------------------------------------------|------|
| Total alkaloids                            | 4.53 |
| „ sulphates                                | 2.87 |
| Quinine                                    | 3.27 |
| Cinchonidine, quinidine, and cinchonine... | 1.26 |
| Sulphate of quinine obtained               | 2.17 |
| Other crystalline sulphates...             | 0.70 |

9. The above result is very promising, and ought to lead to the extended cultivation of this species; which has a greater established reputation in Europe than any other kind. The numbers above may fairly be taken as expressing the mean general yield at the period stated.

10. I had the honour in May last (Proceedings of Madras Government, Revenue Department, 19th June 1869, No. 422, paragraphs 13 and 14) of adducing some considerations which appeared to me to show the expediency of discontinuing the planting of *C. Succirubra*, of which kind we have a sufficiency. The reasons I then gave I still hold to be sound; but since I wrote, from 100,000 to 150,000 additional trees have been planted. I therefore am compelled to think that Government do not coincide with me on this point. I also in June last addressed the Commissioner of the Neilgherries on the same subject, strongly urging the discontinuing of the planting of red bark trees in favour of other kinds on the small part of land allotted to Cinchona cultivation at that time remaining unplanted. For my present and future justification I respectfully reiterate the substance of what I then said both in the report and letter. The other kinds to which I refer are *Lanceolata*, *Calisaya*, and *Pitayo*, of which the remainder of the plantation should consist.\*

11. In my first Report I had the honour of communicating some facts concerning the occurrence of alkaloids in the leaves of Cinchona. I have since investigated the question more perfectly than I was then able to do. From 20 lbs. of the leaves of *C. Succirubra* I was able to obtain 0.372 gramme of alkaloid, of which 0.153 was quinine. The quinine yielded 0.070 gramme of crystallized sulphate. After considerable labour I was enabled to obtain positive evidence of the presence both of cinchonidine and cinchonine in the leaves, and also to obtain

\* Since the above was written I have received G. O., No. 2,936, of 9th November, in which orders are given on this matter.

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them in well-marked microscopic crystals. Below I give the respective per-centage amounts of the alkaloids in the leaves both fresh and dried :—

|                                            | In fresh leaves. | In dried leaves. |
|--------------------------------------------|------------------|------------------|
| Total alkaloids ... ..                     | 0.0041           | 0.019            |
| Quinine ... ..                             | 0.0016           | 0.0080           |
| Cinchonidine and cinchonine ... ..         | 0.0025           | 0.0110           |
| Quinine sulphate obtained in crystals. ... | 0.00078          | 0.0037           |

12. Similar observations may be made, *mutatis mutandis* respecting the leaves of the crown barks. The following statement expresses the per-centages obtained :—

|                                           | In fresh leaves. | In dried leaves. |
|-------------------------------------------|------------------|------------------|
| Total alkaloids ... ..                    | 0.0035           | 0.0111           |
| Quinine ... ..                            | 0.0015           | 0.005            |
| Cinchonidine and cinchonine ... ..        | 0.0020           | 0.006            |
| Quinine sulphate obtained in crystals ... | 0.0008           | 0.002            |

13. The circumstance of the occurrence of the several alkaloids in the leaves in so definite a manner is one of considerable interest, but as a source of supply it obviously is of no practical value. The state of their occurrence is different to that in which they are found in the bark, and it is laborious and difficult to obtain them in a pure state. The quantity is very small in amount, and certainly gives no support to the impression so often stated as a fact (on slight grounds) that the leaves are an effective febrifuge. According to the above it would take many pounds of leaves to be equal to a dose of quinine.

14. The leaves contain quinovin, to which they owe their bitter taste. The therapeutic effects of quinovin are under trial by the Medical Department.

15. In the original instructions I had the honour of receiving from the Home Government, I am directed to investigate the blossoms of Cinchona for alkaloids, etc. This has been done. The beautiful and scented blossoms contain no alkaloid, but a considerable amount of quinovin. The act of flowering does not appear to have any direct influence on the amount of alkaloid in the bark—a point on which I have made a careful inquiry—though it is by no means unlikely that blossoming has an indirect effect on the seasonal changes which I discuss below.

16. In fulfilment of G. O., Revenue Department, 16th January 1869, paragraph 2, I have continued the examination of the wood for alkaloids. I find

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the wood of *Officinalis*, when dried, to contain 0.0101 per cent. of total alkaloids, of which 0.004 was quinine. This wood does not appear to be of any account as a source of alkaloid; it contains not a tenth of the amount found in the wood of *C. Succirubra*. The wood of *Officinalis* unlike that of *C. Succirubra* is very hard and dense, and may hereafter be found of value.

17. Several remarkable kinds, which are now engaging my attention, have appeared on the plantation. I have many reasons for thinking they are really hybrids. None of them which I have examined appear to yield bark of special excellence, but the subject is nevertheless one of great importance, and merits a thorough study.

18. As the age of the various barks increases they lose less weight on drying. Hence, the fresh bark is more productive than it was, from another cause besides the increased per-centage of alkaloid in the dried bark.

19. In 1867 the oldest red bark contained 73 per cent. of water, and the crown barks 69 per cent. They now contain an average of 68 and 64 per cent., respectively. This progressive alteration is what might be expected, and will doubtless continue to take place for many years to come.

20. I have had many opportunities of examining barks grown in the various parts of India on private and Government plantations. In almost every case the quality has been satisfactory. The *C. Succirubra* appears to flourish almost everywhere, and to produce a bark containing abundance of febrifuge alkaloids. Generally speaking, I find the barks somewhat thinner than those of a similar age on the Government Neilgherry Plantations, and yielding rather less quinine and more colouring matter and resin—qualities doubtless resulting from the less elevated sites of their growth. The crown barks appear to enjoy less favour with cultivators; but the few specimens I have received have always been of good quality.

21. The satisfactory quality of the bark of *C. Succirubra* in all South India localities, where the tree will grow at all, appears to be certain; and this statement may in all probability be still further generalized.

MODE OF DRYING THE BARKS.

22. The greater part of the inquiries given in this and foregoing Reports have been concerned with the Cinchona barks in the fresh green state. I have already in other Reports adverted to the advantages that are experienced by dealing with the bark in its natural state. The labour of drying and powdering, preparatory to the extraction of the alkaloids is avoided; and in addition to this, from the softness of the tissues, the alkaloids are obtained in a state of solution with greater ease and less expenditure of acid. I estimate the saving from the latter cause at rather more than one-fourth.

23. The best means of drying the bark so as to preserve, as far as is consistent with economy, the contained alkaloids from alteration is one of the points which I was directed by the Home Government to investigate. I have therefore, during the past two years, at

various times conducted experiments with this end, both with the red and crown barks. It would be tedious if I were to quote the whole of the numerical results on which I base the conclusions; but in the Appendix to this Report I cite certain of them which indicate sufficiently the influence of the various modes of drying upon the subsequent yield of alkaloids, as determined by analysis. (Appendix A.)

24. The modes of drying that I have studied are, (1), spontaneous drying in vacuo; (2), drying in a stream of air at about 36°—45°C;\* (3), direct exposure to

sunshine; (4), drying at a steam-heat, which at Ootacamund is about 90°C. The results were compared with those obtained with the fresh bark.

25. The results show that the fresh bark gives a larger yield of crystalline sulphates than that artificially dried, though the difference is usually but slight. If the drying be quickly conducted at ordinary temperatures, as *in vacuo* over lime or sulphuric acid, the effect on the barks is not prejudicial. This is also the case with drying in a stream of warm air. The former conditions are not readily obtainable in practice, and from the cost can in no case be applied. It would, however, not be difficult to devise a system whereby the bark could be dried by a current of artificially warmed air; but the trouble and cost would, I think, under present circumstances, render it unadvisable to adopt such a process if it can be avoided.

26. The processes of drying were each carefully tried also, in order to ascertain whether the proportional amounts of quinine and cinchonidine were affected by the methods employed. They were found not to be appreciably altered; and hence, in subsequent trials, the amount of total crystalline sulphates obtained was employed as the standard of comparison of the various modes.

27. The general conditions to be fulfilled in drying the bark as indicated by the results are—to dry it at a low temperature—as quickly as possible—and without prolonged exposure.

28. A high temperature, or even merely a steam-heat, is generally prejudicial to the bark from a remarkable reason. The alkaloids are associated in the bark with a peculiar tannin the so-called quino tannic acid. This, under moderate heat, absorbs oxygen, and unites with the alkaloid to form a compound, which frequently is decomposed with great difficulty by acids. Hence, when such bark undergoes the ordinary manufacturing-process, a part of the alkaloid does not get into solution; and thus a practical loss takes place from the imperfect exhaustion of the bark. This effect of heat occurs in different degrees, being sometimes very marked, and at other times in but small amount. It is singularly apparent in those crown barks which abound in colouring matter, especially in *var. crista*, and was a source of much confusion until the cause was ascertained. Thus a sample, which when green yielded 3.52 per cent. of alkaloid, after two days' exposure to a steam-heat, gave but 1.92 per cent. The loss appears to affect all the alkaloids

\* These methods were necessarily examined for the sake of comparison.

equally. That the above explanation is really the true one has been demonstrated by special experiment. Again if bark be exposed to a temperature much exceeding

100° C. the alkaloids become altered, and lose their property of crystallization, so that the bark becomes worthless. The foregoing reasons, therefore, exclude artificial heat as a general method for drying the bark.

29. M. Pasteur has stated on deductive grounds that the drying of Cinchona bark in the sun is injurious. I have abundantly corroborated the general truth of this statement. But to render the change clearly apparent it requires a certain exaggeration in the conditions, such as prolonged insolation, or else exposing the bark in a divided state in order to have an increased surface of action. If this be done a decrease of a half per cent. in the amount of crystalline sulphates obtainable from the bark takes place. If the bark be exposed to sunlight, and at the same time evaporation is checked (as in a box covered with glass), the decrease becomes very marked. If shred bark be allowed to remain a fortnight exposed to the sun of the Neilgherries, the decrease amounts to one per cent.

30. But as the injurious action of sunlight is comparatively slow, and as bark dries rapidly under the fierce sun and dry rarefied air of the Neilgherries, it is not difficult to manage so that, while the action of the light is reduced to a minimum, the conditions of short exposure and moderate temperature may be fulfilled.

31. If recourse be not made to artificial heat it is scarcely possible to dry bark during the south-west monsoon on these hills. But the quality of the bark (as I shall show hereafter) will render any extensive harvesting of bark during that season unadvisable. I feel therefore justified on all grounds in recommending that the bark of the Government Plantations should be dried by natural means only.

32. I have repeatedly satisfied myself that if due care be exercised, the bark may be dried and prepared for export without appreciably deteriorating from the

quality it possessed in its fresh state. The precautions to be taken are simple; the bark must be in as large pieces as possible (in order to expose a proportionally small surface); frequently turned; and so managed as to be as short a time exposed as possible. From January to the end of March when the atmosphere is very dry, bark could be dried on stages one above the other so as almost entirely to avoid exposure to sunlight, in which case no deterioration of quality is possible. Under other circumstances, unless the exposure to sunlight be carelessly prolonged, the alteration in quality is practically imperceptible.

33. Long keeping of the bark in an undried or partially dried state impairs its appearance when subsequently dried. But under such circumstances the quality of the bark is affected to a much less degree than is generally supposed, provided it be not exposed to sunshine. I find by direct trial that bark may be kept

I HAVE been requested to analyse bark which I found subsequently to have been baked in order to dry it. It was of course entirely spoilt.

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more than three weeks without in any degree yielding an inferior amount of alkaloids on analysis. If it be kept six weeks and become mouldy, a deterioration becomes apparent; but it is slight, amounting in my trials to about 0.40 per cent. The alkaloids appear in such circumstances to be very permanent substances, and remain almost unaltered; while other constituents, such as quino-tannic acid, cinchona red, etc., are greatly changed. Even after three months' keeping in a moist place, during which time fermentation accompanied with spontaneous heating took place, I found that at least two-thirds of the original amount of alkaloid was to be obtained from the mouldering mass. In very singular contrast to this is the fact that quinine and cinchonidine are not to be found in the bark of trees that have been dead a short time.

34. The above facts show that, with ordinary management, there is but little risk of deterioration during the harvesting of the bark, provided the simple principles indicated above are kept in mind.

35. Bark carefully dried, kept in a dry state, and analysed at the expiration of six and nine months, respectively, has given me no indications of any deterioration or change whatever. Hence, bark can be exported without loss of quality.

36. The above facts appear to furnish answers to the questions which are likely to arise regarding the preparation of bark for exportation. When the drying of bark is carried on with large quantities, it will of course be useful to ascertain the exact effect of the above principles under the special circumstances.

**INFLUENCE OF THE SEASONS.**

37. The influence of the seasons on the amounts of alkaloid in the bark of the living Cinchona trees is a subject which merited a full inquiry for several reasons. The best time of the year for collecting bark depends on the time of maximum yield. The knowledge of the variations in the amount of the alkaloids under the influence of external circumstances tends to throw light on those conditions of their occurrence on which the possibility of controlling their formation depends. As soon therefore as I possessed means for the investigation of this question, I commenced a series of inquiries. But the subject was found one of considerable difficulty. After nine months' continuance of a series of periodic analyses, I felt some reason to doubt whether my plan of investigation was calculated to exclude disturbing circumstances, some of which might be unknown. I therefore felt it necessary to begin the inquiry afresh; which was accordingly done, with the advantage of knowing the general direction to which the more precise results might be expected to lead.

38. A set of six trees was selected from the oldest part of the plantation. A narrow strip of bark was taken from each, and the mean average sample thus obtained was analysed. This was done periodically throughout the year. The strip being but a very small portion of the whole trunk, its loss would not affect the natural changes which take place in the whole. Except at the latter end of the dry season the bark rapidly renewed itself. As a means of safety and control another

**Method adopted.**

set of six trees was selected whose bark had the average quality of the first six. From these at various times bark was also taken in order to verify and to complete the results obtained.

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The changes in composition observed agreed satisfactorily with other observations, and corroborated those which the former inquiry had shown to take place. The means of checking employed preclude the idea of any other cause seriously influencing the results. I therefore report them, with the conviction that they express with fair accuracy the variations in yield of the bark according to the seasons of the year. As a criterion I place most stress upon the amount of total crystallized sulphates, since that upon the whole is the truest standard of the commercial and practical value of the bark.

39. In order to render the bearing of the results more obvious to the eye, they may be conveniently given in a graphical form. The following diagram, in which the ordinates of the respective curves represent per-centage amounts, and the abscissæ the times, expresses the seasonal changes, and render apparent the numbers which may be obtained by interpolation.

Curve best expresses results.



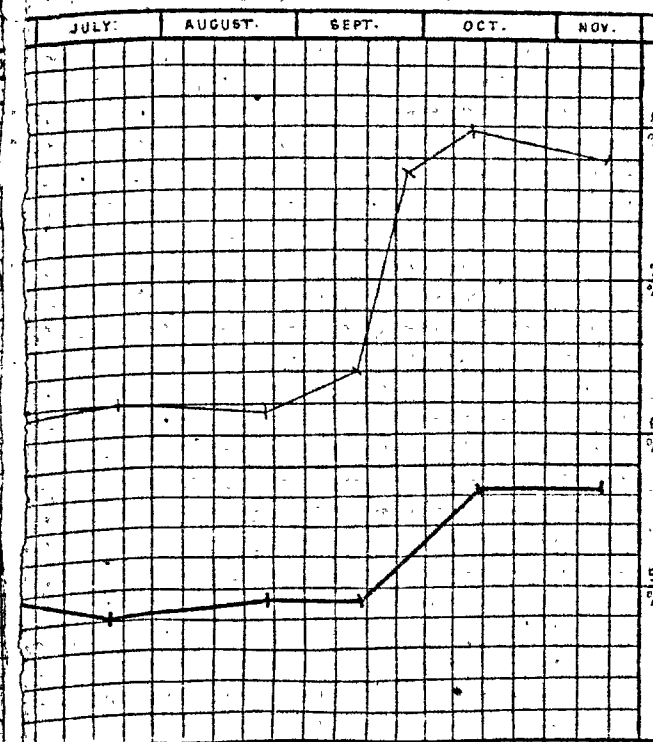
The thin line expresses the total alkaloids.

The thick line expresses the total crystallized sulphates.

The unit of measurement of the abscissæ is one week.

40. The above curves show two "singular points" which are periods of maximum yield. One occurs in October, and the other in May, or nearly at

Discussion of diagram.



the opposite seasons, or shortly before the beginning and shortly after the cessation of the south-west monsoon. The ascent and descent of the sap are less marked in cinchonæ than in the trees of more temperate climates; but there is a connection between the maxima and the latter processes. The period at which the bark is richest in alkaloids that yield the largest amount of crystalline sulphates is during the month of May.

41. The above curve shows a very marked decrease in the amount of alkaloid during the monsoon months, so that it is during the dry season that the operations of cropping, etc., must be conducted. During that time not only is the bark better in quality than during the monsoon, but it is more conveniently dealt with. The exact periods of maximum yield do not indeed, occur at the most convenient seasons; but the amount of alkaloids during the greater part of the winter (if it can be so called) does not greatly differ from the maximum yield. There appears to be no practical reason why a compromise should not be made between slightly opposing grounds of quality and convenience, and why the wide period between November and May should not be that of bark harvest. It is, however, probable that this period must be shortened on other grounds, since the bark at the latter end of the dry season separates with difficulty from the wood. It will always be a loss to collect bark in any quantity during the monsoon.

42. The branch bark appears to share in the progressive changes that are undergone by that of the trunk.

43. Circumstances have scarcely permitted a similar investigation being conducted with the crown-bark trees. The few observations I have made appear to show that those grown at Neddiwuttum vary in yield in a similar manner to their red bark neighbours. The crown-barks of the Dodabet Plantations certainly show a less marked diminution in their yield during the rainy season than the red barks at Neddiwuttum. This is probably a consequence of the climate being not so sharply divided into a very rainy and very dry season as it is at the latter place.

44. I have considerable reason for believing that the variations in the amount of alkaloids in the bark at various seasons become less marked as the trees grow older. During the first year of my acquaintance with the plantations I found some what greater differences in yield between the barks collected during the dry and rainy seasons than the above diagram indicates. This is what might be expected, since the older tissues take a less active share in the vital processes of the plant, than those more recently formed. With increasing age and thickening bark it follows that there is more and more tissue which remains comparatively quiescent, and thus prevents the variations in the younger portions from affecting the gross yield to so great an extent.

CONDITIONS UPON WHICH DEPEND THE AMOUNT OF QUININE IN THE CINCHONA BARKS.

45. The alkaloid, which first appears in the bark, is one which has all the properties of quinine, except that of yielding crystalline salts. It is found in very young plants, and in considerable quantity in the freshly formed bark which re-replaces the loss of strips of original bark, when the latter is removed without injury to the cambium. It forms, indeed, nearly the whole of the alkaloid that is to be found in renewing bark. As time goes on the alkaloid acquires the property of crystallization, and is then *quinine*. Cinchonidine does not appear in any quantity till a later stage. This is no hypothesis, but the conclusion from many concurrent observations. For example, I may cite the following series of analyses of bark of *C. Succirubra* for the first seventeen months of its natural renovation, without any artificial protective:—

|                                     | I.           | II.         | III.        | IV.             | V.                |
|-------------------------------------|--------------|-------------|-------------|-----------------|-------------------|
|                                     | Four Months. | Six Months. | Ten Months. | Fifteen Months. | Seventeen Months. |
| Total Alkaloids ... ..              | 4.30         | 5.3         | 5.03        | 6.00            | 5.47              |
| Quinine ... ..                      | 4.20         | 4.4         | 4.02        | 3.03            | 3.65              |
| Cinchonidine and cinchonine ... ..  | 0.10         | 0.9         | 1.01        | 2.97            | .....             |
| Sulphate of quinine obtained ... .. | 0.25         | 1.56        | 2.20        | 2.30            | 3.12              |
| .. of cinchonidine obtained ... ..  | none.        | .....       | .....       | 1.13            | 1.24              |

46. These results leave no doubt that quinine is the alkaloid first produced. The gradual acquirement of the property of crystallization with the increase in the amount of cinchonidine is also clearly shown. The order in which the alkaloids are formed in the cells of new and rapidly forming tissue are, uncrystallizable quinine—ordinary quinine—and cinchonidine. Cinchonine is also formed at a late stage.

47. It is thus scarcely possible to resist the conclusion, that it is in this order they are actually formed in the plant. Since the amounts of the first formed alkaloids diminish, and are re-placed by others as age increases, an actual conversion of one into the other is at least a legitimate hypothesis.

48. Though I have never yet succeeded in converting quinine into cinchonidine or *vice versa* by artificial means, the intimate relationship and close resemblance of the two substances taken in connection with appearance of the latter in increasing amounts with the increasing age of the bark, lead me to consider it in the highest degree probable that cinchonidine is formed in the tree by the progres-

sive alteration of quinine, and not as an independently formed substance. There are further corroborations of this view on quite other grounds.

49. It is remarkable among the crown-barks that the most rapidly growing trees are richest in quinine, and contain but a comparatively small amount of cinchonidine. If there be trees which, while quite healthy, are stunted in their growth, and in a quiescent state, such trees are almost sure to be poor in quinine and rich in cinchonidine.

50. All the Cinchona alkaloids are altered in composition by long exposure to light, but in different degrees. The salts of quinine are particularly sensitive. It is well known that samples of sulphate have to be kept in a shaded or dark place, or else they become discoloured.\*

51. I am by no means justified, by direct evidence, in stating that quinine is converted in the living tree into cinchonidine by the action of light; but it seems certain that such conversion is greatly expedited by that agency. Trees, whose bark has been long exposed to sunshine, and whose growth has been sluggish, always contain the largest proportion of the latter alkaloid.

52. The above observations apply to *C. Succirubra* and *C. Officinalis* and their varieties. I am strongly inclined to believe that the chemical changes, connected with the occurrence of alkaloids, are identical in the various species, and differ only in degree.

#### FORM IN WHICH THE ALKALOIDS OCCUR IN THE LIVING BARK.

53. The state of combination in which the alkaloids occur in the living bark has not hitherto been known with certainty. As this is a point of great importance, from its bearing on the chemistry of the formation and functions of the alkaloids, I have endeavoured to ascertain it as completely as possible. As this is scarcely the place in which to detail the methods employed in the investigation, I merely state the results.

54. In the bark of *C. Succirubra* four-fifths of the whole amount of the alkaloids are contained in the solid state within the tissues (most probably, almost exclusively in the parenchymatous cells) of the bark in combination with quino-tannic acid. These alkaloid tannates are but slightly soluble in cold water, more soluble in hot, but are quite insoluble in the surrounding plant juices. They thus cannot be very active constituents. They are, in all probability, the stored alka-

\* A slight admixture of cinchonidine sulphate renders it far less easily affected. A specimen of quinine sulphate containing five per cent. of cinchonidine salt retains its whiteness, while a pure specimen becomes brown when exposed to the same circumstances.

loids of the bark, of which only a small portion at the most, shares in the changes incident to growth. When freshly taken from the plant the substance has a grey colour; but rapidly absorbs oxygen from the air, and becomes of a dirty red tint. This substance has all the appearance of the artificially prepared quino tannate, and is, as mentioned above, liable when dried at 96° C. to pass into a state in which the alkaloid is separated with great difficulty. The remaining one-fifth of the alkaloid is in solution in the juice of the bark. It is there associated with quino tannic acid, quinic acid, and probably also another acid, which exists in small quantity. As the tannic acid present in the juice is amply sufficient to form a tannate with the whole alkaloid present, it seems probable that the juice contains the alkaloids also in form of tannate, held in solution by the free acids.

55. Quinovin is a less abundant constituent than the alkaloids. It is to be detected in the clear juice in very small quantity, but is mainly to be found in the solid cell-contents. As the combination of quinovin with the alkaloid is so readily destroyed by acids, it appears almost certain that the quinovin is in the free state.

56. A speculative opinion has been long held concerning the functions of the vegeto-alkaloids in the plants producing them, whose importance is so great that its practical verification or contradiction is almost necessary to the scientific cultivation of those plants. This hypothesis is mainly due to Liebig, and dates as far back as 1840, and since that time has continued to rest on little else than speculative grounds.

57. It is believed that the alkaloids are the substitutes for the mineral bases which are the constituents of all plants, and which constitute the larger portion of the ash obtained when the plants are burnt. The alkaloids possess the same general properties as these mineral bases; they completely neutralize acids; and comporting themselves in so chemically similar a manner, it is thought that their functions were identical, and that certain tribes of plants were enabled to produce actual substitutes for these necessary bases, which are frequently meagrely furnished by the soils in which they grow.

58. The simplicity and beauty of this hypothesis has always rendered it, in the absence of more precise information, a favourite one. On my first acquaintance with the living Cinchonas (*par excellence* the alkaloid-producing plant) there were several circumstances which seemed to show its truth. Among these were the exceptionally large yield of alkaloids in the Neilgherry Cinchonas, combined with singular poverty of the soil of the Neilgherries in lime—a base which is the main constituent of the ash of most plants. These circumstances led me to institute a series of experiments in which the amount of organic bases was compared with the amount of ash yielded by the same bark. This has been carried on with all the species of Cinchonas, and under all the diversity of conditions, I could

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22nd February 1870.*

devise. During the last two and-a-half years upwards of seventy determinations have been made with this object.

59. The results have convinced me that the relations of the organic to the mineral bases is by no means so simple as the hypothesis assumes. The contradictions are numerous. Trees growing under similar circumstances may have the same amount of mineral constituents, while the organic bases are as 1:2. The general distribution of the mineral bases is quite similar in Cinchona to that which obtains in other trees yielding no alkaloids; and what is still more important, I find that trees grown for two years in a soil made artificially calcareous have not shown any difference, either in their yield of alkaloid or amount of ash.

60. But there are several cases in which the amount of organic bases do really show a tendency to appear in the inverse amounts, which would result from a mutual substitution. These cases occur, however, in an incoherent manner, and can frequently be explained satisfactorily on quite other grounds. I am therefore compelled to believe that the physiological equivalence of function attributed to the organic and inorganic bases, is either untrue or much more partial than is assumed to be the case in this application of the "mineral theory." I do not, however, propose to abandon the subject, since collateral points remain which require thorough investigation.

During these inquiries I have received valuable help from Mr. C. Dawson, the Assistant Superintendent of the Neddiwuttum Plantations, which are the most advanced. I therefore take this opportunity of acknowledging my obligations to his knowledge of the details of the present and past operations under his charge, and for the active and intelligent assistance I have constantly received.

APPENDIX A.

The following results form a portion of the grounds upon which the conclusions in the Report are based, and are here quoted for the sake of illustration.

A quantity of the bark finely shred was submitted to the various methods of drying. The various amounts of alkaloid and crystalline sulphates are given in the following table; A. being the amounts yielded by the fresh bark:—

*Red Bark.*

|                                                                         | A.   | Dried at 17°C. in vacuo. | Dried at steam-heat. | Dried in current of air at 35°-45°C. | Dried in sunshine. | Dried in sunshine slowly. |
|-------------------------------------------------------------------------|------|--------------------------|----------------------|--------------------------------------|--------------------|---------------------------|
| Total alkaloids ... ..                                                  | 6.89 | 6.67                     | 5.92                 | 6.64                                 | 5.90               | 5.85                      |
| Crystalline sulphates obtained ... ..                                   | 6.12 | 5.98                     | 5.31                 | 5.89                                 | 5.28               | 4.78                      |
| Comparative amounts of acid required to neutralize the alkaloids ... .. | 13.2 | 13.1                     | 11.8                 | 13.1                                 | 12.0               | 11.6                      |

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*Mixed Crown-barks.*

|                                       | A.   | Dried at 17°C. in vacuo. | Dried at steam-heat. | Dried in current of air at 35°-45°C. | Dried in sunshine. | Dried in sunshine slowly. |
|---------------------------------------|------|--------------------------|----------------------|--------------------------------------|--------------------|---------------------------|
| Total alkaloids ... ..                | 3.93 | 3.92                     | 3.52                 | 3.85                                 | 3.63               | 3.04                      |
| Crystalline sulphates obtained ... .. | 3.67 | 3.52                     | 3.01                 | 3.50                                 | 3.11               | 2.88                      |
| Comparative amounts of acid required  | 7.2  | 7.0                      | 6.6                  | 6.6                                  | 6.7                | 5.9                       |

The amounts of crystalline sulphates obtained were adopted as the most accurate numerical standard of comparison.

APPENDIX B.

THE remarkable effect produced in some barks by exposure to a temperature of boiling water with access of air is shown by the following analyses of the same bark. In A. analysed while fresh; in B after three days' exposure to a steam-heat:—

|                                       | A.   | B.   |
|---------------------------------------|------|------|
| Total alkaloids ... ..                | 3.52 | 1.93 |
| Quinine ... ..                        | 2.48 | 1.03 |
| Cinchonine and cinchonidine ... ..    | 1.04 | 0.90 |
| Quinine sulphate obtained ... ..      | 2.46 | 0.88 |
| Cinchonidine sulphate obtained ... .. | 0.66 | 0.56 |

The peculiar insoluble compound which gives rise to the above apparent loss of alkaloid is decomposed by the action of alkalis, and the missing alkaloid can thus, in great part, be recovered. Nearly all acid extracts of Cinchona barks, if evaporated to dryness at a steam-heat, undergo a similar change. Certain methods occasionally employed in the analysis of Cinchona barks (such as that known as Wöhler's) yield inaccurate results from this cause.

(Signed) KRISTNIENGAR,

No. 236.

ORDER THEREON, 22nd February 1870, No. 268.

Miscellaneous.

THE Right Honourable the Governor in Council has perused Mr. Broughton's satisfactory Report with much interest. It will be forwarded for the information of the Right Honourable the Secretary of State, and copies will be furnished to the Government of India, the local Governments, and to the Governments of Ceylon, the Straits Settlement, Batavia, and the French Settlements in India.

2. His Lordship in Council does not understand why the further plantation of the red bark variety was not discontinued in favour of those mentioned in Mr. Broughton's Report, dated 24th April 1869. The necessary instructions to

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22nd February 1870.*

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this effect should have been issued by the Commissioner of the Neilgherry Hills on receipt of the G. O., under date 19th June 1869, No. 1,740; but, as observed by Mr. Broughton in his foot-note, in the Orders of 9th November 1869, Nos. 2,935 and 2,936, specific instructions have been issued for the extended cultivation of the new varieties.

3. Mr. Broughton's experiments on the leaves, blossoms, and wood of the Cinchona tree are highly interesting, and his remarks on the best system of drying the bark and regarding the proper period of the year for collecting it, will prove of great value to all who are connected with the cultivation.

(True Extract.)

(Signed) R. A. DALYELL,

*Acting Secretary to Government.*

To J. Broughton, Esq:

- „ the Commissioner of the Neilgherries.
- „ the President of the Cinchona Commission.
- „ the Board of Revenue.

Ed. F. R. Bantleman.

PROCEEDINGS of the MADRAS GOVERNMENT.

Under date the 22<sup>d</sup> February 1870.

Read the following. Letter from the  
Govt. Quinologist,

Forwarding Report on the  
Neilgherry Cinchona Plantations

N.C. 9. Decemb. 1869.

The Right Honble  
the Governor in Council has  
perused Mr. Broughton's  
satisfactory report with  
much interest. It will be  
forwarded for the information  
of ~~Mr. Grace~~ the Secretary  
of State and copies will  
be furnished to the Govt.  
of India, the local Govts.,  
and to the Govts. of Ceylon,  
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Report to the Govt. of Madras

Vol. of 1870

REVENUE.

J. BROUGHTON, Esq.,

Secy. to Govt.

Dated February, 22nd.

Encl.

G. O. 22nd February 1870, No. 268.

FEBRUARY.  
Nos. 235-236.

Cinchona Plantations.—Report from Mr.  
Broughton regarding their present condition, etc.,  
with orders thereon.

the Straits Settlement, Batavia, and the French Settlements in India.

2. His Lordship in Council does not understand why the further plantation of the Red Bark variety was not discontinued in favor of those mentioned in Mr. Broughton's report dated 24 April 1869. The necessary instructions to this effect should have been issued by the Commissioner of the Nilgerry Hills on receipt of the G. O. under date 19 June 1869, No 1740, but as observed by Mr. Broughton in his foot note, in the order of 9 Novr 1869

No 2935

No 2935 & No 2936 specific instructions have been issued for the extended cultivation of the new varieties.

3. Mr. Broughton's experiments on the leaves, bopons, and wood of the chincona tree are highly interesting, and his remarks on the best system of drying the bark and regarding the proper period of the year for collecting it, will prove of great value to all who are connected with the cultivation.

7 John J. Broughton Esqre Govt Secy  
17 Commr of the Nilgerry Hills  
13 - President of the Chincona Commission  
14 - Secy of Cult

H. H. Bell

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Cpl  
Mr. Broughton  
report on the  
Kulghany Chan  
Cham Plains

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Respected