# THE THICKNESS OF BARK AND BARK PER $dm^2$ OF CINCHONA [1])

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AUTHOR'S SUMMARY.

When measuring sample plots for the construction of yield tables for cinchona stands, investigators found only a low correlation ($r = + 0.208$) between the thickness of the bark and the yield of dry bark per tree. Therefore, when investigations were carried out to check the accuracy of these yield tables, special attention was paid to the thickness of the bark.

Investigations were carried out on:

1 The degree of accuracy of the figures collected when measuring the thickness of the bark and estimating the amount of bark per $dm^2$.
2 The relationship between thickness of bark and the amount of bark per $dm^2$.
3 The changes in the amount of bark per $dm^2$ under influence of age and spacing.

## 1 THE DEGREE OF ACCURACY OF THE DATA OBTAINED:

*a When measuring the thickness of the bark.*
*b When estimating the amount of dry bark per $dm^2$.*

### *a Measuring the thickness of the bark*

The mean thickness of the bark on a sample plot was found by measuring, at 1 metre above the ground, the thickness of the bark of each tree at 4 places on the circumference of the tree. The instrument used was a *Mattson* barkmeter. It consists of a hollow chisel running through a small tube with a plate at one end. The chisel is forced into the tree until it touches the wood, the plate of the tube is pressed with the left hand against the bark of the tree and the thickness of the bark can be read on a scale on the chisel, the other end of the tube being the indicator. To check the accuracy of the figures obtained for the mean thickness of the bark the thickness of the bark was measured twice in 10 of the sample plots by different observers. At the same time another type of barkmeter, constructed by *Lindetevis* for measuring the bark of rubber trees, was tried. The *Lindetevis* barkmeter is provided with a dial and reads to 0.1 mm. This instrument was also used by both observers.

Thus, four sets of data were obtained from each of these 10 plots. The mean values found for the thickness of the bark are given in table 1.

Measuring sample plots for the thickness of the bark was as a rule done once, with a *Mattson* barkmeter. Therefore the first observation in these 10 plots was fixed at 100 and the others expressed in percentages of it to get comparative figures.

The last column gives the highest differences between the 4 values found for the mean thickness of the bark. In 5 out of 10 cases it was more than 10%. Realising that these mean differences are calculated from 80 or more observations, they are surprisingly high.

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Table 1.

| Plot No. | Clone | Age yrs. | No. of trees | No. of obs. | Mean Thickn. of the bark | | | | In % of 1st obs. | | | | Highest diff. % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Mattson* | | *Lindetevis* | | *Mattson* | | *Lindetevis* | | |
| | | | | | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd | |
| | | | | | mm | mm | mm | mm | % | % | % | % | |
| A 86 | W 2 | 20 | 24 | 96 | 7.3 | 7.25 | 7.13 | 7.02 | 100 | 99 | 98 | 96 | 4 |
| 87 | RG 1 | 18 | 20 | 80 | 7.1 | 7.08 | 7.02 | 6.71 | 100 | 100 | 99 | 94 | 6 |
| 88 | RG 1 | 18 | 28 | 112 | 5.9 | 6.14 | 5.41 | 5.25 | 100 | 104 | 92 | 89 | 15 |
| 89 | W 119 | 20 | 23 | 92 | 7.4 | 7.50 | 6.98 | 6.32 | 100 | 101 | 94 | 85 | 16 |
| 90 | RG 1 | 20 | 26 | 104 | 5.7 | 5.45 | 5.45 | 4.96 | 100 | 96 | 96 | 87 | 13 |
| 91 | W 119 | 8 | 20 | 80 | 6.4 | 6.30 | 6.01 | 6.20 | 100 | 98 | 94 | 97 | 6 |
| 92 | W 119 | 13 | 27 | 108 | 5.5 | 5.46 | 5.50 | 5.47 | 100 | 99 | 100 | 100 | 1 |
| 93 | RG 1 | 13 | 36 | 144 | 4.3 | 4.19 | 4.17 | 4.06 | 100 | 97 | 97 | 94 | 6 |
| 94 | P2 H | 19 | 23 | 92 | 8.1 | 7.45 | 7.80 | 7.18 | 100 | 92 | 96 | 89 | 11 |
| 95 | Tjin 1 | 7 | 22 | 88 | 4.6 | 4.64 | 4.09 | 3.99 | 100 | 101 | 89 | 87 | 14 |

## b *Measuring the bark per dm²*

Another measure of the thickness of the bark is the weight of a dm² of absolutely dry bark (i.e. 15.500 sq. inches) introduced by KERBOSCH and SPRUIT (1926). It is estimated as follows:

With a hollow drill having an inside diameter of exactly 15.0 mm a number of disks of bark are taken from the tree. These are dried at 105° C. and weighed. The bark per dm² is calculated from the weight and the number of disks of bark (56.6 disks = 1 dm²). If the bark-sample is to be used for an analysis of quinine content, the disks are dried at a max. of 80° C. weighed, ground and analysed for quinine and water-content.

To estimate the mean value for bark per dm² of a sample plot, from 4 to 8 discs are taken from each tree. This number depends on the size of the trees, and number of trees in the sample plot. The bark sample has to be at least 30 g dried bark, which is sufficient for an analysis in duplo.

To check the accuracy of the figures found for the mean value of bark per dm², two bark samples were taken in the same 10 sample plots used for checking the thickness of the bark; for a technical reason it was not possible to take a second sample in plot 88. From each of these 2 samples the mean value for bark per dm² was calculated; the results are compiled in table 2. The samples were taken by two different observers each using his own instrument, the instruments, however, were made in the same factory.

The last column gives the percentage differences between the first and the second observations. They are between 0.2% and 2.6% and in only 3 out of 9 cases more than 1%, in spite of inevitable errors made by drilling and collecting the wet bark, drying, weighing, grinding, sampling the dried bark, and estimating the water content.

That bark per dm² can be estimated more accurately than the thickness of the bark may be explained as follows:

When drilling out a disk of bark from a tree, the bark will break at a very distinct layer, the cambium. Using a bark-meter, the penetration of the chisel depends on the force used by the observer, and on the resistance of the wood. Both are highly variable and may be responsible for the fact that it is impossible to measure the thickness of the bark with sufficient accuracy.

Table 2.

| Plot No. | Clone | Age yrs. | No. of trees | No. of disks | Bark dm² | | In % of 1st | | Diff. % |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1st observer | 2nd observer | % | % | |
| A 86 | W 2 | 20 | 24 | 144 | 21.33 | 21.19 | 100 | 99.3 | 0.7 |
| 87 | RG 1 | 18 | 20 | 120 | 20.99 | 21.18 | 100 | 100.9 | 0.9 |
| 88 | RG 1 | 18 | 28 | – | – | – | – | – | – |
| 89 | W 119 | 20 | 23 | 151 | 24.34 | 24.17 | 100 | 99.3 | 0.7 |
| 90 | RG 1 | 20 | 26 | 156 | 16.55 | 16.51 | 100 | 99.8 | 0.2 |
| 91 | W 119 | 8 | 20 | 120 | 17.82 | 17.43 | 100 | 97.8 | 2.2 |
| 92 | W 119 | 13 | 27 | 162 | 15.73 | 15.58 | 100 | 99.0 | 1.0 |
| 93 | RG 1 | 13 | 36 | 216 | 13.03 | 12.91 | 100 | 99.1 | 0.9 |
| 94 | P2 H | 19 | 23 | 138 | 25.13 | 24.48 | 100 | 97.4 | 2.6 |
| 95 | Tjin 1 | 7 | 22 | 176 | 14.91 | 14.81 | 100 | 99.3 | 0.7 |

## 2 The relationship between thickness of the bark and bark per dm²

The low correlation between thickness of the bark and yield of dry bark per tree led to the study of the relationship between bark per dm² and thickness of the bark.

Dividing the figure for dry bark per dm² by the thickness of the bark (in mm) the dry weight of a layer of bark of 1 dm² surface and 1 mm thickness is found; that is the dry weight of $100 \times 0.1 = 10$ ml wet bark.

The data for 235 sample plots, divided over 10 clones and 2 seedling families of *Cinchona ledgeriana* were available. Both bark per dm² and thickness of the bark had been estimated as a mean of each sample plot (20–40 trees). For each clone and seedling variety, the mean value of the quotient bark per dm² thickness of the bark had been calculated, and compared with the highest and the lowest value. Also, the highest and lowest values for each clone were calculated as a percentage of the mean value. Further, the standard error of the mean was calculated, and in 3 cases the correlation coefficient. The results are compiled in table 3.

Table 3.

$$\frac{\text{Bark per dm}^2}{\text{thickness of the bark}} = \text{dry weight of 10 ml wet bark.}$$

| Clone or Family | No. of Plots | Mean value | Highest value | Lowest value | In % of the mean | | S.E. % | r |
|---|---|---|---|---|---|---|---|---|
| | | | | | Highest value | Lowest value | | |
| W 3 | 18 | 3.82 | 4.41 | 2.86 | 115 | 75 | ± 11.6 | |
| Tjin 1 | 21 | 3.88 | 4.76 | 3.23 | 123 | 83 | ± 10.6 | |
| K 236 | 14 | 3.51 | 4.45 | 2.61 | 127 | 74 | ± 11.8 | |
| P2 Hybr | 11 | 2.92 | 4.48 | 2.29 | 153 | 78 | ± 21.3 | |
| K 35 | 14 | 3.20 | 3.81 | 2.78 | 119 | 87 | ± 8.1 | |
| W 119 | 16 | 3.45 | 3.75 | 3.05 | 109 | 88 | ± 6.6 | |
| T 59 | 13 | 4.05 | 4.71 | 3.49 | 116 | 86 | ± 9.4 | |
| RG 1 | 15 | 3.24 | 3.82 | 2.86 | 118 | 88 | ± 8.1 | |
| K 63 | 35 | 3.31 | 4.18 | 2.01 | 126 | 61 | ± 16.5 | 0.906 |
| MRG z | 31 | 3.87 | 4.55 | 3.15 | 117 | 81 | ± 10.8 | 0.942 |
| Mal z | 28 | 3.74 | 4.65 | 3.24 | 124 | 87 | ± 9.2 | 0.951 |
| Lett B | 19 | 3.98 | 4.50 | 3.56 | 113 | 89 | ± 6.4 | |
| | 235 | | | | | | ± 11.4 | |

The figures show, that the dry weight of 10 ml wet bark is very variable, both from clone to clone and within the clone. This variability is partly due to the faults made when measuring the thickness of the bark and the bark $dm^2$, but chiefly because of differences in water content of the bark. In addition, the dry weight of 10 ml wet bark is a function of the age, and the circumference of the tree.

The influence of the age and the circumference of the tree on the bark per $dm^2$, the thickness of the bark, and their quotient is illustrated by the following figures.

Table 4.

| Clone | Tjib. 5 | | | | | | Tjin. 1 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | I | II | III | IV | V | VI |
| Age yrs. | Dry bark per square decimeter. | | | | | | | | | | | |
| 7 | 13.65 | 13.30 | 12.80 | 12.25 | 11.75 | 11.30 | 15.40 | 14.80 | 14.30 | 13.80 | 13.75 | 13.65 |
| 8 | 14.95 | 14.35 | 13.80 | 13.30 | 12.75 | 12.15 | 16.80 | 16.10 | 15.50 | 14.95 | 14.30 | 13.70 |
| 9 | 16.05 | 15.40 | 14.80 | 14.30 | 13.65 | 12.90 | 18.35 | 17.45 | 16.70 | 16.00 | 15.40 | 14.65 |
| 10 | 17.25 | 16.55 | 15.85 | 15.35 | 14.60 | 13.95 | 19.95 | 18.80 | 17.85 | 17.15 | 16.60 | 15.85 |
| 11 | 18.60 | 17.90 | 17.00 | 16.45 | 15.80 | 15.15 | 21.85 | 20.25 | 19.15 | 18.40 | 17.90 | 17.50 |
| | Thickness of the bark (mm). | | | | | | | | | | | |
| 7 | 4.6 | 4.3 | 4.1 | 4.0 | 4.0 | 4.0 | 4.2 | 4.1 | 4.0 | 3.9 | 3.9 | 3.8 |
| 8 | 5.1 | 4.8 | 4.6 | 4.4 | 4.3 | 4.3 | 4.9 | 4.7 | 4.5 | 4.4 | 4.3 | 4.1 |
| 9 | 5.7 | 5.3 | 5.1 | 5.0 | 4.8 | 4.7 | 5.6 | 5.4 | 5.2 | 4.9 | 4.8 | 4.6 |
| 10 | 6.5 | 6.1 | 5.8 | 5.6 | 5.5 | 5.3 | 6.4 | 6.1 | 5.9 | 5.6 | 5.4 | 5.2 |
| 11 | 7.7 | 7.3 | 7.0 | 6.7 | 6.5 | 6.3 | 7.5 | 7.1 | 6.8 | 6.5 | 6.3 | 6.1 |
| | $\frac{\text{Bark per dm}^2}{\text{thickness of the bark}}$ = dry weight of 10 ml wet bark in g. | | | | | | | | | | | |
| 7 | 2.97 | 3.09 | 3.12 | 3.06 | 2.94 | 2.83 | 3.67 | 3.61 | 3.58 | 3.54 | 3.33 | 3.59 |
| 8 | 2.93 | 2.99 | 3.00 | 3.02 | 2.97 | 2.83 | 3.43 | 3.43 | 3.44 | 3.40 | 3.33 | 3.34 |
| 9 | 2.82 | 2.91 | 2.90 | 2.86 | 2.84 | 2.74 | 3.28 | 3.23 | 3.21 | 3.27 | 3.21 | 3.18 |
| 10 | 2.65 | 2.71 | 2.73 | 2.74 | 2.65 | 2.63 | 3.12 | 3.08 | 3.03 | 3.06 | 3.07 | 3.05 |
| 11 | 2.42 | 2.45 | 2.43 | 2.46 | 2.43 | 2.40 | 2.91 | 2.85 | 2.82 | 2.83 | 2.84 | 2.87 |
| | Circumference (cm). | | | | | | | | | | | |
| 7 | 21.3 | 20.0 | 18.8 | 18.0 | 17.4 | 16.8 | 19.8 | 18.9 | 17.9 | 17.3 | 16.7 | 15.8 |
| 8 | 23.9 | 22.3 | 21.1 | 20.2 | 19.6 | 18.9 | 22.4 | 21.3 | 20.3 | 19.5 | 18.8 | 17.8 |
| 9 | 26.2 | 24.5 | 23.2 | 22.1 | 21.5 | 20.7 | 25.0 | 23.7 | 22.5 | 21.5 | 20.7 | 19.7 |
| 10 | 28.5 | 26.6 | 25.3 | 24.1 | 23.3 | 22.6 | 27.4 | 25.9 | 24.6 | 23.5 | 22.6 | 21.6 |
| 11 | 30.7 | 28.5 | 27.3 | 25.9 | 25.1 | 24.3 | 30.0 | 28.0 | 26.6 | 25.4 | 24.3 | 23.4 |

These data were collected in an experiment on the influence of spacing and thinning on the yield of *Cinchona ledgeriana*, which was carried out with 2 clones, Tjibeureum 5 and Tjinjiroean 1; 6 treatments with 9 replications of each. The number of trees at the beginning of the experiment was approximately 5000, 6000, 7200, 8600, 10.400 and 12.600 trees per ha. The number of trees was diminished each year by thinning out, but the ratio between the number of trees in each treatment was kept constant.

In table 4 the widest spacing is marked I the narrowest spacing VI. The table has been compiled after graphical correction of the data.

The table shows that the amount of bark per $dm^2$ increases with age but decreases with circumference, the latter being a function of spacing. Also the thickness of bark increases with age and decreases with circumference, but more quickly than bark per $dm^2$. Thus, their quotient, i.e. the dry weight of 10 ml wet bark decreases with age. From trees of the same circumference the oldest trees have the lowest figure for dry weight of 10 ml wet bark; this may be due to a lower proportion of bark fibre in the older bark.

## Conclusion

Comparison of the direct measurement of the thickness of bark with estimation of the amount of dry bark per $dm^2$ shows that the latter method is to be preferred by reason of its greater accuracy. Working even with experienced observers, considerable differences were found in the mean value for bark thickness of the trees in a sample plot. These differences make this figure unfit for practical use when estimating the bark value of a cinchona stand.

The investigation of the relationship between bark per $dm^2$ and thickness of the bark and especially their quotient (which is the dry weight of 10 ml wet bark) shows that this value, even within the clone, is highly variable. Data collected in an experiment on spacing and thinning show the changes in this value with age.

The low correlation found between thickness of bark and yield of dry bark per tree can be explained by:

1 faults in measuring thickness of the bark
2 variability of the bark per $dm^2$/bark thickness.

## References

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