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The Significance of the Structure of Laticifer with Relation to the Exudation of Latex in Hevea brasiliensis

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Many investigations on the structure of the laticifer in Hevea brasiliensis *had been carried out about a century ago. The methods used in previous studies were by tissue sectioning. However, the present study is based on a new technique of isolating the complete network structure of the laticifer from the bark of the tree without sectioning. The procedures of the technique consist of mainly removing the bark from the tree, softening in boiling 10% KOH for about 15–20 min, dehydrating up to 80% alcohol and staining in Sudan III or Sudan IV dissolved in 75% alcohol. The stained tissue will show red indicating that it is ready for examination under the microscope and for taking photographs.*

Through this method of study, it has been revealed that there are two kinds of laticiferous tissues in the same plant. They are the non-articulated laticifer and the articulated laticifer. These tissues differ very much from each other by their origin, structure, ontogenetic development and distribution in the bark of the plant. The accompanying coloured photographs demonstrate the way of transportation and exudation of latex in the network structure of the laticifer.

The laticifer in *Hevea brasiliensis* is a cell type which produces latex. Since last century, investigations have been made through plant sectioning to study the structure of the laticifer and the physiological aspects. Not until recently has the author developed a technique by isolating the complete network structure of the laticifer from the bark of the tree without sectioning. This method of study reveals that the physiology of latex exudation is closely related with the morphological structure of the laticifer.

MATERIAL AND METHODS

The bark of the tree used in this study was obtained from young two- to three-year-old plants which were experimentally cultivated at Fujian Academy of Tropical Crops, Zhangzhou, Fujian, China. The technique used for the preparation of a complete network structure of the laticifer is simple. A description of the technique had been published by the author in Chinese[1]. The procedures are as follows:

1. Remove a piece of the bark from a tree about 10 - 20 cm in length or more.
2. Place the bark directly in boiling 10% KOH solution for about 15–20 minutes.
3. Wash the bark with several changes of water to remove dark brown contents.
4. Remove the peridermal layer of the stem with a pair of forceps to expose the laticiferous tissue which can easily be dissected out with dissecting needles under the dissecting microscope.
5. Dehydrate the tissuue through a series of gradations of methyl alcohol from 30%

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up to 80%. Let the tissue remain in each grade of alcohol for about 10 - 15 minutes.

6. Stain the tissue in Sudan III or Sudan IV (1 g of the dye is added to 90 cc of 75% methyl alcohol) until it becomes red.

Special attention should be paid to the fact that it is better to transfer the tissue from the 80% alcohol to the Sudan III or Sudan IV solution for staining. Precipitations of the stain will usually occur if the tissue is transferred from a lower grade of alcohol to the staining solution in 75% alcohol. Hence this method of preparation is only adequate for quick and temporary observation under the microscope and for taking photographs.

TYPES OF LATICIFER TISSUE IN *HEVEA BRASILIENSIS* AND THEIR STRUCTURE

According to De Barry (as cited by Esau[2]) laticifers are divided into two main types, namely non-articulated and articulated. It has been reported[2-5] that there is only one kind of laticifer in rubber plant. However, in the present study, two types of laticifers were observed to exist simultaneously in the same plant body. Similar phenomenon occurs in other plants, as pointed out by Esau[2] in her book 'Plant Anatomy' that certain species of Asclepiadaceae had two kinds of laticifers in one plant body.

Structure of Non-articulated Laticifers

Figure 1 shows a portion of non-articulated laticiferous tissue isolated from primary phloem of a branch of a *Hevea* sapling, with the linear or thread-like structure of non-articulated laticifer stained in red in Sudan III. These laticifers are arranged alternately with cortical tissues which are not stained.

The non-articulated laticifer is aseptate and coenocytic; that is to say, there are no partitions inside the coenocytic cell. It is formed during embryonic development and then becomes dispersed in the primary structure of the seed (cotyledon), leaf, flower, fruit, root and stem. Hence, it is called a primary laticifer. This kind

Figure 1. A portion of non-articulated laticiferous tissue from the primary phloem of young tree branch of 93-114 clone. Magnification: × 132.

of laticifer usually develops only in the growing season. When the growing season is over, it is shed with the cotyledons, leaves, flowers, fruits and the bark of the tree. Thus, it is also called an ineffective laticifer since it has no economic value.

Non-articulated laticifers spread from the terminal bud downwards to the branches and the stems of the tree. They penetrate into the intercellular spaces of the primary phloem and cortex forming a network structure. Their form and structure vary with the intercellular spaces. The laticifers are coarse and crowded when the intercellular spaces are large. Small laticifers are shown as very fine tubules. The length of the branches of laticifers varies greatly. Long branches may penetrate through several intercellular spaces, coming in contact with distant laticifers in a manner similar to that of a conjugation tube in the articulated laticifer,

whereas short branches look like small papillae or outgrowths.

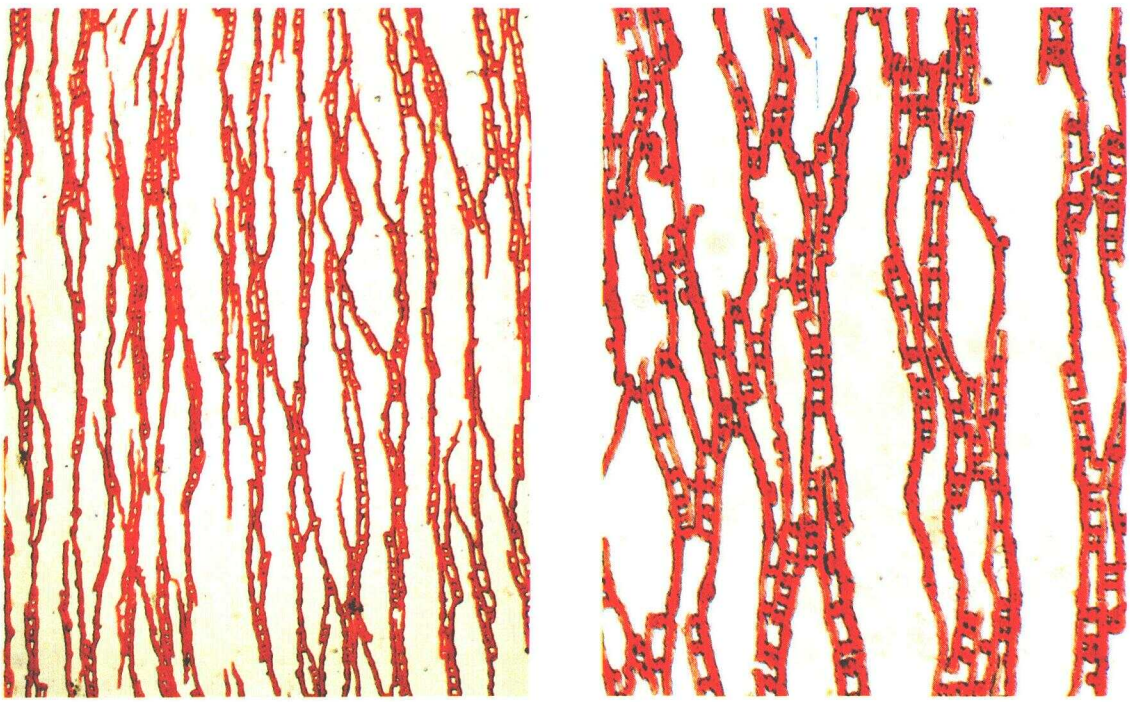
The development, morphological structure and distribution of non-articulated laticifers are different from those of articulated laticifers.

Structure of Articulated Laticifers

Figures 2a–2e show a portion of articulated laticifers isolated from secondary phloem in the stem of a *H. brasiliensis* sapling, with linear or thread-like laticifers. The interspaces are mostly shaped like convex lenses. They are spaces left after isolation of the phloem ray tissue of the secondary phloem. The articulated laticifers also exhibit a network structure.

Articulated laticifers originate from the cambium. In the beginning, they form a series of short columnar laticiferous initial cells. With the disintegration of the end walls of these initial cells, a long tube, the laticifer is formed. Since articulated laticifers originate from the cambium and constitute a portion of the secondary phloem, they are called secondary laticifers. They are also called effective laticifers because they provide the structure for producing latex.

In the developmental stage of the articulated laticifers, before the complete disintegration of the end walls of the laticiferous cells, conjugation tubes start to appear on the lateral walls of the cells. At first, short papillae or outgrowths emerge on the sides of the cells lying opposite one another in two adjacent laticifers. Soon after, the papillae lengthen and their ends meet. Finally, the end walls of the papillae dissolve and the cell cavities form an open tube, the conjugation tube, which connects the two laticifers. The latex in the laticifers can then pass freely through this tube. This process of the formation of the open tube in *H. brasiliensis*

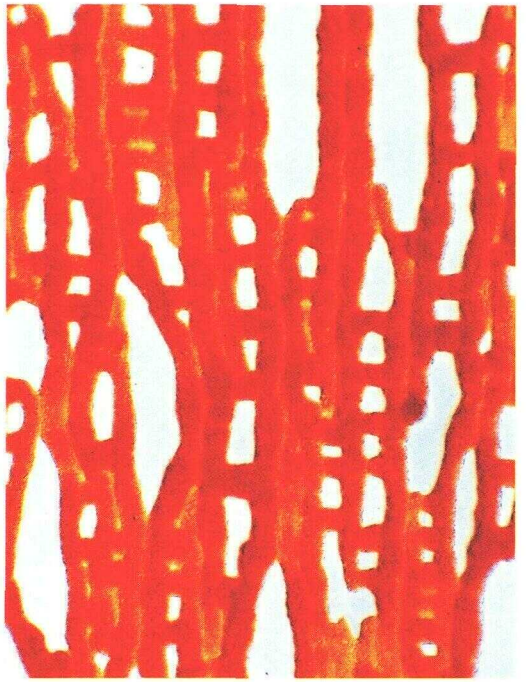


a. Wu-feng clone. Magnification: × 54.

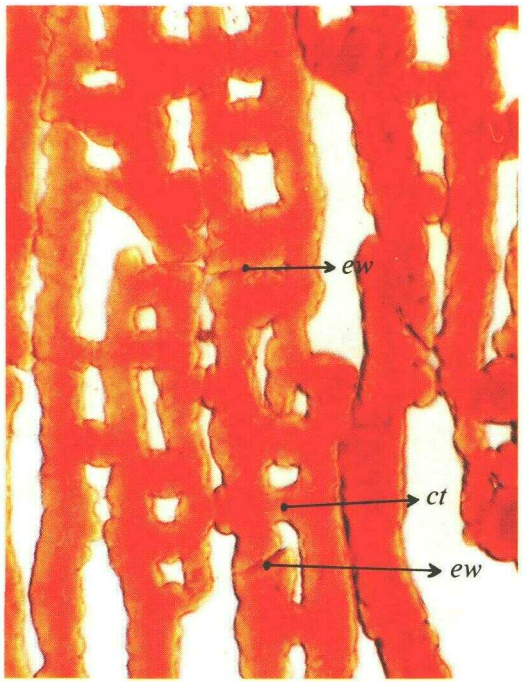
b. Ming-ling clone. Magnification: × 132.

Figure 2. A portion of articulated laticiferous tissue from secondary phloem in the stem of a young tree.

c. RRIM 600 clone. Magnification: × 132.



d. RRIM 600 clone. Magnification × 264.



e. Tian-ren 31-45 clone. Magnification: × 528.
ew = End wall of articulated laticifer
ct = Conjugation tube

Figure 2. A portion of articulated laticiferous tissue from secondary phloem in the stem of a young tree (contd)

is similar to the scalariform sexual reproduction of *Spirogyra* in green algae. The open conjugation tube is thus considered a portion of the structure of articulated laticifer.

Observations show that there are many conjugation tubes in the articulated laticiferous tissue. Each laticiferous cell may have one to five such tubes arranged in a regular pattern, some growing on one side of the laticifer and others on both sides. This accounts for the ladder-like or fence-like appearance of the laticiferous tissue, as shown in *Figures 2b, 2d* and *2e.* The walls of the isolated laticifers as can be seen in the figures are always smooth, rarely having any protrusions. There are no conjugation tubes *(Figures 2a-2e)* on the side of the laticifer contiguous with the phloem ray. The length and the diameter of the conjugation tube as well as the distance between two neighbouring conjugation tubes are almost equal to the diameter of the laticifer. The number of laticifers are always greater in high productive clones than in low productive clones of the plant. These phenomena are noted in the accompanying figures. Since the laticiferous tissues form the structure that produces latex, it is evident that the morphological structure of the laticiferous tissue bears a close relation with the mode of transportation and exudation of the latex.

DISCUSSION AND SUMMARY

The significance of the morphological structure of the laticifers in latex exudation may be summarised as follows.

There are two kinds of latex vessels in *H. brasiliensis,* namely, non-articulated laticifers and articulated laticifers. The former have no bearing on latex production, while the latter originate from secondary meristematic tissues and produce new laticifers every year. All laticifers are inter-connected to form a network structure arranged in concentric layers, thereby providing a special system for the transportation of latex which may pass vertically through longitudinal laticifers or transversely through conjugation tubes. All latex of the plant is confined to the laticiferous system and the latex in certain parts of the bark tends to be transmitted to and exuded at the place of injury or tapping side of the tree *(Figures 2a–2e).*

REFERENCES

1. CHAO HSIU-CHIEN (1980) New Methods for Slide Preparation of the Laticifer of *Hevea brasiliensis* (in Chinese), *Acta Botanica Sinica,* **22(1),** 101.

2. ESAU, K. (1965) *Plant Anatomy.* London and New York. John Wiley & Sons.

3. BOBILIOFF, W. (1923) Anatomy of *Hevea brasiliensis.* Zurich: Institut Orell Fussil.

4. GOMEZ, J.B. (1982) *Anatomy of* Hevea *and Its Influence on Latex Production.* Kuala Lumpur: Malaysian Rubber Research and Development Board.

5. FHAN, A. (1982) *Plant Anatomy,* 3rd ed. New York: Pergamon Press.