Synopsis of the genus *Catalpa (Bignoniaceae)*

Part VI (Addenda)

By

Jiří PACLT

(Biological Section, Forest Products Research Institute, Bratislava 9, Czechoslovakia)

With 1 Figure

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The present supplement completes my monograph of which the parts 1 to 5 appeared as follows:

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Part 3 in Candollea 13: 241—285, 1952;
Part 4 in Sydowia 5: 160—168, 1951;
Part 5 in Biol. Jaarb. 19: 60—73, 1952.

Again, it is a pleasure and a duty to express my best thanks to all who supplied me on application with such plant materials as the bark of tropical species, or various bibliographical data and information for the present supplement. These are: The Conservator of Forests, Forest Department (Kingston, Jamaica); Richard KRÄUSEL, Professor and Head of the Palaeobotanical Section, Natur-Museum Senckenberg (Frankfurt a. M., Germany); Victor PLOUVIER of the Laboratoire de Physique Végétale, Muséum d'Histoire Naturelle (Paris, France); and Felix WIDDER, Professor and Director of the Institut für systematische Botanik (Graz, Austria).

Appendix to Part 1

Anatomy. "When studying the critical points by which the *Bignoniaceae* might eventually differ from the *Scrophulariaceae*, it appears that the morphology of the fruit itself cannot be taken into consideration" (PACLT, Part 1: 257). Indeed, there exist some convergences in the fruit between both families. To show this fact, the capsule of *Rhigozum trichotomum (Bignoniaceae)* and that of *Paulownia tomentosa (Scrophulariaceae)* are figured in the present paper (Fig. 1).

New ecological trends in the modern plant anatomy have contributed, using *Catalpa* partly as material for the investigation, to the knowledge of the structure of the leaves of that genus in relation to environmental factors. Thus, WYLIE 1951 analysed the anatomical differences between sun and shade leaves of *C. speciosa*, and VASILEVSKAJA 1950 studied the effect of annual temperature and other conditions on the ontogenetic development of the leaves of *C. bignonioides* and their anatomical characters. The differences in anatomical structure between shade and sun leaves must naturally be classified physiologically as a response to the requirements of the plant for an adequate transpiration. Accordingly, TURRELL 1936 attempted to determine the area of internally exposed cell walls and to compare this with total area of the leaf; the ratio of internal to external surface of the sun leaf of *Catalpa speciosa* is 19.2, that of the shade leaf being not determined by TURRELL.

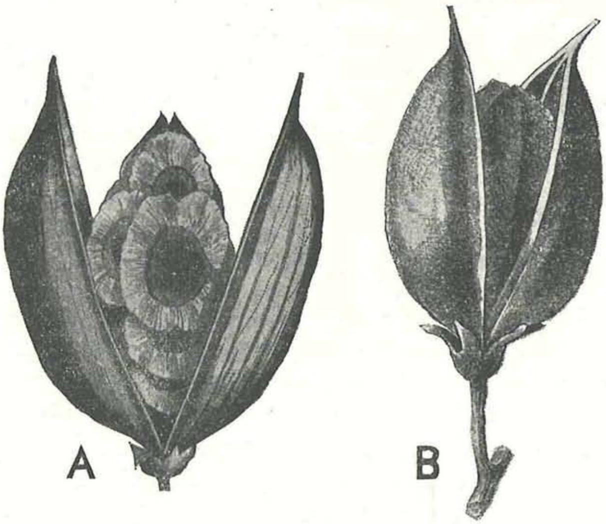

Fig. 1. A: Fruit of *Rhigozum trichotomum* BURCH. (*Bignoniaceae*); B: Fruit of *Paulownia tomentosa* (THNBG.) STEUD. (*Scrophulariaceae*). — Combined after BUREAU ex SCHUMANN (A) and WETTSTEIN (B).

Additional and revised data about the anatomical characters of *Catalpa* in relation to taxonomy are now to be found in the excellent work by METCALFE & CHALK 1950.

Appendix to Part 2

Growth. HARVEY & ROSE 1915 reported that when one of the physiologically active gases (ethylene) flowed slowly under illumination through soil in which *Catalpa* seedlings grew it caused the development of massive soft white tissue on roots and lower part of the stem. This proliferation tissue resulted both from a multiplication of cells and from an increase in size of some of the cells. (The hyperplasia and hypertrophy induced are described in detail by the authors.)

Recently, GREBINSKIJ & KAPLAN 1948 studied the possibility of a combination of growth substances for the rooting of cuttings. The most stimulating effect on rooting was obtained generally by a 2 to 3 cm. immersion of the cuttings for 24 hrs. in a solution containing 3-indoleacetic acid (10 mg./l.), naphthaleneacetic acid (10 mg./l.), 1% yeast extraction, honey (diluted with 4 parts of water), and vitamin B_1 (10 γ/100 ml.). When the ingredients were tested separately or in certain combinations on the cuttings of *Catalpa bignonioides*, the most successfully rooting (in 100% of the tested cuttings) has been observed when using the combination of 3-indoleacetic acid and honey, or when using yeast extraction separately.

Quite recently, KONOVALOV 1953 determined in his phenological analysis of *Catalpa ovata* in cultivation at Leningrad that the growth rhythm has undergone radical changes in that climate. His studies are based on two age categories of specimens, namely 5- to 6-aged (I) and 16- to 25-aged trees (II). The results of the determination of carbohydrates at various periods of the growth are given for *Morus*, but those obtained for *Catalpa ovata* and not evaluated separately are said to be in harmony with the former.

Fertilization and Germination. The cross-fertilization in *Catalpa* is insured by proterandry as shown first by ENGELMANN 1880: 3. This observation has been omitted in the respective part of my Synopsis. On the other hand, I have reported already that the flowers are entomophilous (see the chapter on Nectaries, Part 1: 257). — Facts about the germination of the seeds of *Catalpa*, their frequency in pods, etc., have been compiled recently by MISNIK 1949 and ZACHARENKO & MORGUNOV 1950.

Metabolism. BROWN & ESCOMBE 1905 found that detached leaves of *Catalpa bignonioides* assimilate, in 4—5 hours, from 50—120% more carbon dioxide than similar leaves attached to the plants, in spite of the disrupted translocation of the carbohydrates. This may be ascribed to the wider opening of stomata in detached leaves. Potassium hydroxide solution (normality 13.0) absorbs carbon dioxide 0.795 lb.-mols per hr. per sq. ft. (maximum rate), i. e. 7,393 per sq. dm. Considering the results indicating the rate of carbon dioxide absorbed by the leaves of *C. bignonioides* and calculated per sq. dm. of leaf surface (the maximum rate being 2.35 — see WRIGHT 1937: 195), indeed, the ability of stomata in the leaf of *Catalpa* to absorb carbon dioxide must be comparatively a considerable one. (When dividing 7.393 by 2.35, we obtain that the carbon dioxide absorption by the leaves of *C. bignonioides* is about a third of that by potassium hydroxide of the corresponding leaf surface.)

Chemical Constituents. GROSSHEIM 1943 (repeated 1952) discovered in the leaves of *Catalpa bignonioides* (cultivated in Caucasus) 11 mg% of vitamin C, not determined formerly in that genus.

While CANNIZZARO 1946, quoted in Part 2, reported that no antibiotic principle occurs in *Catalpa*, especially its leaves, the hot water extract from catalpa wood entirely inhibited the growth of such wood-destroying fungus as *Fomes annosus* (see HAWLEY, FLECK & RICHARDS 1924). Similar toxicity of extracts prepared from catalpa wood (*C. speciosa*) to another fungus (*Schizophyllum commune*) has been proved recently by McDONOUGH, BELL & ARNOLD 1950—1951. Inhibition of the fungus was in proportion to the concentration of extractive used, heartwood extract giving the most inhibition, followed by sapwood, and the bark. Fungistatic materials were also obtained by hot-water extraction, although alcohol extracts of high inhibiting power were demonstrated in the wood even after it had been boiled in water for three hours. Inhibition was inversely proportional to the number of days the wood had been cut from the living tree.

The seeds of *Catalpa bignonioides* contain an oil, 24% (according to ANONYM 1890), utilizable in the varnish and lacquer industry (according to SADYKOV 1947). A greasy substance has been isolated also from the pods taken as a whole (GROSSOT in "A. C." 1834; more recently PIUTTI & COMANDUCCI 1902: 616, quoted Part 2). In addition to this greasy substance GROSSOT found, in pods, malic acid and calcium malate ("A. C." 1834).

The bark of *Catalpa* is said to possess certain therapeutic properties: emetic and anthelmintic (GEISSLER & MOELLER 1887: 592), tonic, stimulating and antiseptic (NUTTALL 1855, quoted Part 2), antipyretic (DESCOURTILZ 1833, quoted Part 2) and antasthmatic. The bark of the trunk contains a non-bitter heteroside (catalpinoside), an amaroid (catalposide) and the p-coumaric and ferulic acids; the investigation of the bark of the root has shown the presence of isoferulic acid, sitosterol, catalposide and, perhaps, a mixture of p-oxybenzoic (I) and p-oxybenzoic + protocatechuic acids (II):

$$(OH)\,C_6H_4CO_2H\ (4,1) \qquad (I)$$

$$(OH)\,C_6H_4CO_2H\ (4,1) + (OH)_2C_6H_3CO_2H\ (1,2,4) + 2\,H_2O \qquad (II)$$

According to BUREAU 1894: 182, 204 (quoted Part 1) and WIESNER 1918: 192 (quoted Part 1), the bark of the trunk of *Catalpa (C. longissima, C. bignonioides)* contains tannin. The tannin of the bark of *C. longissima* is then said to be used in the manufacture of leather, etc. („ist ein sehr wichtiges Gerbmaterial auf den westindischen Inseln", WIESNER). However, the Conservator of Forests at Kingston, Jamaica, informs me now (in a letter dated Sept. 11, 1952): "I have made enquiries and have searched our libraries, and have been unable to discover any information regarding the use of *Catalpa longissima* in the West Indian tannin industry."

I have tested the bark of *C. longissima* (from Kingston) and *C. bignonioides* (from cultivation at Bratislava) for the contents of tannin substances with the following result:

Species	% of Tannins	Group Tests	
		Pyrocatechinic	Pyrogallic
C. longissima			
Sample I	5	all positive	all positive
Sample II	7	all positive	nearly all positive
C. bignonioides	6	all positive	nearly all positive

The bark of the trunk of *Catalpa* contains tannins both of pyrocatechinic and pyrogallic groups and their total content varies from 5 to 7%. The tannin extractives show under UV-light a typical fluorescence. The aglycones of these tannins are hardly comparable with the phenolic colouring matter isolated from the bark of the root of *Catalpa ovata* by Hiramoto & Watanabe 1939 (quoted Part 2) who suggested it to belong to the anthraquinone series (their substance gave a red solution with NaOH).

As for the accessory constituents of the wood of *Catalpa* there exist no more detailed accounts than those by Freeman 1944: 574, 662, 668 (quoted Part 2). I prepared, therefore, a water extract from the wood of *Catalpa speciosa*, which on addition of ammonia exhibited a greenish luminescence under UV-light. The fluorescence colour of the alcalized extractive appears darker than that of the acidified solution. However, a number of tests for tannins were negative so that it is impossible to be beyond doubt that the coloration is due to tannin matters. Similarly, the polarographic test for pentosanes was negative. The only positive test which I received was that with Sudan III; the coloration revealed on addition of Sudan III. to the wood extractive, corresponds to Number 152 of Séguy [1]), while the control test (without wood extractive) shows a coloration corresponding to Number 194 of Séguy [1]). The coloration of the wood extractive on addition of Sudan III. is due probably to some lipoids which, however, almost certainly do not play part in the production of the above mentioned fluorescence.

Wholly unexplained remains the apparently considerable resistance of the wood of *Catalpa longissima* against marine xylophages (see Bureau 1894: 204, quoted Part 2).

[1]) E. Séguy, Code universel des couleurs. Paris 1936.

B i o p h y s i c a l D a t a. New data regarding the osmotic pressure of the cell sap of leaves of *Catalpa bignonioides* has been presented recently by KELLER 1952: 205, 208.

<table>
<tr><th>Time of observation</th><th>Maximum osmotic pressure</th><th>Minimum content of water</th><th>Locality</th></tr>
<tr><td>13 o'clock
16 o'clock
18 o'clock</td><td>22.36 atm.
21.06 atm.
17.80 atm.</td><td>66.6%
61.1%
61.1%</td><td rowspan="7">Botanical Garden at Aŝchabad, U.S.S.R.</td></tr>
<tr><th>Time of observation</th><th>Minimum osmotic pressure</th><th>Maximum content of water</th></tr>
<tr><td>7 o'clock
22 o'clock</td><td>17.08 atm.
12.04 atm.</td><td>69.2%
68.0%</td></tr>
<tr><th>Time of observation</th><th colspan="2">Osmotic pressure of young leaves collected May 3rd</th></tr>
<tr><td>5— 6 o'clock
14—15 o'clock</td><td colspan="2">12.52 atm.
13.48 atm.</td></tr>
</table>

Another biophysical matter of importance for the osmotic work is the problem of hydrophily of the protoplasm, i. e. the total water content or hydration of the latter. The observations by LEVITT & SCARTH 1936 indicate that protoplasmic volume of the cortical cells of *Catalpa* increases during frost hardening. Under these conditions the protoplasm occupied about 50% of cell volume. Unfortunately, the knowledge concerning the relationship between the degree of hydrophily developed by frost hardening cells and the amount of the so-called bound water in the protoplasm is very limited. The hardening cells either are able to prevent formation of ice, or have an ability to withstand it. Frost resistance in *Catalpa ovata* and *C. bignonioides* is found to be — 35° C (MAXIMOW 1914).

A p p e n d i x t o P a r t 3

F o s s i l M a t e r i a l s. A fossil species identified as *Catalpa microsperma* has been found later in Germany (KRÄUSEL 1938: 88); it occurs in the Lower Miocene (Aquitanian) at Mainz-Kastell (Weyland, Rhineland). According to KRÄUSEL the same species is represented also in the Silesian Tertiary (Miocene). He writes about it in a letter of Sept. 10, 1952: „über den Fund in Schlesien ist noch nichts veröffentlicht, dies wird aber wohl bald von anderer Seite geschehen.“ Since another occurrence of *Catalpa* in the Neogene (probably Miocene) flora of

Japan has been reported (see Part 3: 245) and that species differs from the true *C. microsperma* [= *C. tenuiloba*], one might question the identity of the Rhenish and Silesian materials with the Eocene species (*C. microsperma*).

Recent Materials. The seedlings are described only in two species of *Catalpa*, namely *C. bignonioides* (by HICKEL) and *C. speciosa* (by PAMMEL & KING). These descriptions are included now in the paper by VASIL'ČENKO 1950. It appears desirable, therefore, to examine seedlings of other species not yet investigated on that line.

The natural distribution of *Catalpa ovata* has been indicated to include the province Liaoning (see Part 3: 252, fig. 10). KOMAROV 1905 (reprinted 1950): 445 holds, however, a different opinion for he states: "*C. Kaempferi* in peninsula Liaodun [= Liaotung] sparse colitur."

According to HANDEL-MAZZETTI 1936, *Catalpa fargesii* f. *duclouxii* may ascend, like *C. ovata*, to an altitude of 2500 m. (prov. Yunnan); furthermore it has been found in the province Kweichow. As for *Catalpa ovata*, HANDEL-MAZZETTI investigated the items collected by MAIRE (see Part 3: 253), and, contrary to my investigation, could check the locality of these (prov. Yunnan which becomes an addition to the distribution of that species as compiled in Part 3).

Now I think it might be useful to bring a complete list of all illustrations which are of any interest to plant taxonomists and appeared in the various preceding parts (1, 3, 4, 5) of my Synopsis:

Appendix to Part 4

Diseases. If WESTCOTTS data of 1950 are reliable, we have to add the following species of Fungi to our previous enumeration:

No. 42 a — *Helicobasidium purpureum* PAT.

No. 54 a — *Armillaria mellea* (FRIES) QUÉL.

No. 83a — *Rhizoctonia solani* KÜHN.

No. 83b — *Sclerotium rolfsii* SACC.

Another species should be included in the list of *Myxomycetes*:

No. 4a — *Arcyria nutans* (BULL.), on wood of *Catalpa bignonioides* (collected March 1952, Košice, Slovakia, leg. Dr. PACLT).

Furthermore a member of *Basidiomycetes (Pucciniaceae)* omitted in the list should be mentioned now:

No. 31a — *Prospodium* sp., on *Catalpa longissima* from Santo Domingo (GÓMEZ MENOR 1935, quoted Part 5).

Also, the following fungus should be added to the enumeration:

No. 87a — *Thielaviopsis basicola* (BERK. & BR.), mentioned only sub No. 11 of my list.

A correction of the printer's error is to be made regarding the Nos. 47 and 51. The observation "Found further on *C. bignonioides* at Nové Zámky, Slovakia . . ." relates to *Schizophyllum commune* (and not *Trametes albida*).

MEYER 1951 describes a case of wilting of *Catalpa bignonioides* in German cultivation. The same disease had been observed by GARMAN 1912 in U. S. A., who considered it to be due to bacteria (cf. No. 95 of my list). Later investigation has led, however, to the result that a disease with identical symptoms is caused by *Verticillium* sp. (No. 93), especially *V. albo-atrum* R. & B. (for details see also WESTCOTT 1950).

Appendix to Part 5

Pests. The following pests of *Catalpa* are to be added to the list published previously.

A. *Hemiptera* — *Aphididae*: *Doralis helianthi* (MONELL), *D. nerii* (KALTENBACH), *D. pomi* (DE GEER), *D. spiraecola* (PATCH), *Chromaphis juglandicola* (KALTENBACH), *Macrosiphum solanifolii* (ASHMEAD) = *M. euphorbiae* (THOMAS), *Phorodon cynoglossi* WILLIAMS and *Sipha bignoniae* MACCHIATI. All referred to by PATCH 1938.

Since *Paulownia* is often compared with *Catalpa* in our Synopsis, we may notify that, according to PATCH 1938, only two species are known to occur on *Paulownia*, namely: *Myzus persicae* (SULZER) and *Doralis laburni* (KALTENBACH), the former occurring on *Catalpa*, too.

B. Hemiptera — *Coccidae*: *Diaspidiotus ancylus* (PUTNAM) and *Clavaspis ulmi* (JOHNSON nec L.). Both referred to by FERRIS 1938.

Zusammenfassung

Der behandelte Stoff ist organisch gegliedert in die fünf Teile: Anatomie (Nachtrag zu „Part 1“ meiner *Catalpa*-Synopsis), Physiologie (Wachstum, Befruchtung, Keimung, Stoffwechsel) und

Biochemie (chemische Bestandteile, biophysikalische Angaben) — beides als Nachtrag zu „Part 2", Systematik (Nachtrag zu „Part 3"), Pathologie durch pflanzliche Organismen (Nachtrag zu „Part 4") und tierische Schädlinge (Nachtrag zu „Part 5"). Die in den vorigen Teilen meiner *Catalpa*-Synopsis nicht berücksichtigten Ergebnisse der Forschungen werden nun nach dem Muster einer Monographie kritisch dargestellt. Zum ersten Male wird in der vorliegenden Arbeit u. a. über die Resultate einiger Tannin-Analysen der *Catalpa*-Borke berichtet.

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