BIOMETRIC AND MORHOLOGIC OBSERVATIONS ON *SALIX FRAGILIS* (SALICACEAE) LEAVES

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ABSTRACT

The paper discloses a research model of leaf investigation, based on biometric measurements and morphologic observations. There are only a few examples of this type of biometric investigation model applied on spontaneous plants leaves in literature. The article comprises biometrical and morphologic investigations on 40 leaves of Salix fragilis L. *The measurements and observations were performed on 40 mature leaves collected from the apex, middle and base of the crown, including linear measurements, percentage ratio, angular measurements and other measurements such* as the number semi-sum of secondary pairs of veins (Np), the teeth number/cm and *the lamina surface as well. The biometric measurements were the basis of a mathematical calculation of the average values on the studied species leaves.*

INTRODUCTION

*Salix fragilis*L.is a species of willownative to Europeand Western Asia. It is known ascrack willow or brittle willow. It is native to riparian habitats, usually found growing beside rivers or strems and as well in marshesand water meadowchannels (Meikle, 1984; Murray, 1980;Rushforth, 1999).It can readily forms natural hybrids with white willow *S. alba* in Europe, Asia and the hybrid being named *Salix* × *rubens*Schrank (Meikle1984; Murray, 1980). Recent research has shown that crack willow, originally called*Salix fragilis*(without the ×) is actually a hybrid of the European*Salix alba* L. (white willow) and a willow from Asia Minor,*Salix euxina*l.V. Belyaeva, that was introduced to Europe (Belyaeva, 2009).

*Salix fragilis*is a medium-sized to large deciduous tree, which grows rapidly to 10–20 m long (rarely to 29 m tall), with a trunk up to 1 m diameter, often multi-trunked, and an irregular, often leaning crown. The barkis fissured in older trees and is dark grey-brown in color. The lanceolate leaves are green, 9–15 cm long and 1.5–3 cm wide with a short petiole; they are very finely hairy at first in spring, but soon become hairless (Cicârlan, 2000; Săvulescu, 1957).

The flowers are grouped in catkins and appear in early spring, being pollinated by insects. They are deciduous, with male and female catkins on separate trees; the male catkins are 4–6 m long, the female catkins are also 4–6 cm long, with the individual that have flowers either one or two nectarines (Meikle, 1984;Rushforth, 1999).In late spring fruit capsules release numerous small cotton-tufted seeds. They are easily distributed by wind and moving water, and germinate immediately after soil contact (Murray, 1980). It can readily forms natural hybrids with white willow *S. alba* in Europe, Asia and the hybrid being named *Salix* × *rubens*Schrank (Meikle, 1984; Murray, 1980).

Many sets of terms and methods have been devised for describing leaves (e.g. Dale et al. 1971; Dickinson et al., 1987; Hickely, 1973; Melville, 1976; Roth & Dilcher, 1978). In Romanian literature there are few examples of this type of leaf investigation and analysis model applied on spontaneous plants leaves (Bercu, 2005; Bercu 2013a,b; Bercu, 2015), mostly of them being paleontological studies (Givulescu, 1999, Givulescu & Soltesz, 2000). Some data refers to general biometric features such as lamina venation,

mentioned in lectures and manuals of Anatomy and morphology of plants or simple Morphology of plants (e.g. Andrei, 1997; Buia & Péterfi, 1965; Ianovici et al. 2015a,b; Niculescu, 2004).

The purpose of this paper is to highlight the features of the leaf of *Salix fragilis* and to contribute with more informationto complete the morphological foliar knowledge concerning this species.

MATERIAL AND METHOD

The morphological observations and biometric measurements were performed on 40 mature leaves of *Salix fragilis*, collected from the top, middle and base of the tree crown, collected in August 2016.The methods and terms for the leaves description form, size, margin and venation follow the leaf architectural system of Givulescu (1999), Mounton (1966a,b, 1967, 1976) and Roth &Dilcher (1978).

The biometrical measurements which had been calculated are: a. the linear measurements: L- leaf length, l- leaf width, h- the height of the maximum width of lamina; A- the tip length, l-l'- the apex width; Lp- the petiole length, followed by b. the percentage ratios: L/l- the finesse of leaf; A/L- the acuminate ratio, h/L- the ovality ratio; A/l-l'- the lamina apex finesse. c. The angular measurements: α- the apical angle, β- the emergent angle of the secondary veins with primaries, ɣ- the emergent angle of the tertiary veins related to the primary one and finally d. other measurements: the teeth number/cm (D), the number semi-sum of secondary pairs of veins (Np) and the lamina surface (S). For each leaf were carried out 20 measurements, amounting 800 determinations, performed for all 40 leaves.

RESULTS AND DISCUSSION

Biometrical observations. The 13 leaves were collected from the crown apex (leaves no. 1-13), 13 leaves from the middle of the crown (leaves no. 14-26) and 14 from the base of the crown (leaves no. 27-40) (40 leaves in total) (Table 1, 2, Fig. 1), representing the base for a mathematical calculation, using generalized mathematical formulas, for the average values of the measurements for all three groups of *Salix fragilis* leaves (Table 1 - 4).

1. The average of biometric measurements of *Salix fragilis* leaves from the top of the crown (Table 1, 2: 1-13).

Linear measurements:

$$\overline{L_{Sf}} = \sum_{i=1}^{n} \frac{L_{Sf}}{n} = \frac{L_1 + ... + L_n}{n} = \frac{114 + ... + 112}{13} = 102.76mm$$

$$\overline{l_{Sf}} = \sum_{i=1}^{n} \frac{l_{Sf}}{n} = \frac{l_1 + ... + l_n}{n} = \frac{29 + ... + 23}{13} = 22.38mm$$

$$\overline{h_{Sf}} = \sum_{i=1}^{n} \frac{h_{Sf}}{n} = \frac{h_1 + ... + h_n}{n} = \frac{48 + ... + 50}{13} = 46.23mm$$

$$\overline{A_{Sf}} = \sum_{i=1}^{n} \frac{A_{Sf}}{n} = \frac{A_1 + ... + A_n}{n} = \frac{12 + ... + 18}{13} = 18.76mm$$

$$\overline{I - I'_{Sf}} = \sum_{i=1}^{n} \frac{I - I'_{Sf}}{n} = \frac{I - I'_1 + ... + I - I'_n}{n} = \frac{5 + ... + 9}{13} = 8.61mm$$

$$\overline{Lp_{Sf}} = \sum_{i=1}^{n} \frac{Lp_{Sf}}{n} = \frac{Lp_1 + ... + Lp_n}{n} = \frac{11 + ... + 8}{13} = 10.60mm$$

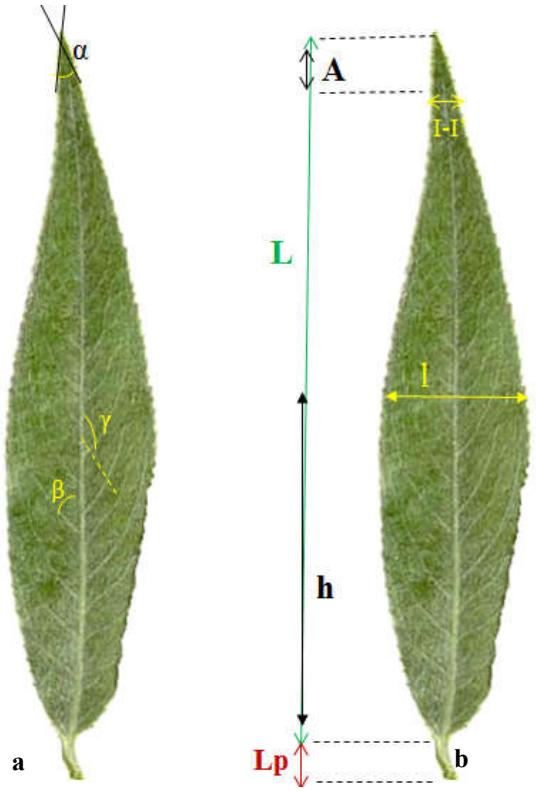

Fig. 1. Salix fragilis L. leaf. Dorsal lamina surface with liniar (a) and angular measurements (b).

Percentage ratios:

$$\overline{\frac{L}{l}}_{Sf} = \sum_{i=1}^{n} \frac{\left(\frac{L}{l}\right)_{Sf}}{n} = \frac{\left(\frac{L}{l}\right)_1 + ... + \left(\frac{L}{l}\right)_n}{n} = \frac{3.79 + ... + 4.77}{13} = 4.35\%$$

$$\overline{\frac{h}{L}}_{Sf} = \sum_{i=1}^{n} \frac{\left(\frac{h}{L}\right)_{Sf}}{n} = \frac{\left(\frac{h}{L}\right)_1 + ... + \left(\frac{h}{L}\right)_n}{n} = \frac{0.43 + ... + 0.41}{13} = 0.40\%$$

$$\overline{\frac{A}{L}}_{Sf} = \sum_{i=1}^{n} \frac{\left(\frac{A}{L}\right)_{Sf}}{n} = \frac{\left(\frac{A}{L}\right)_1 + ... + \left(\frac{A}{L}\right)_n}{n} = \frac{0.12 + ... + 0.12}{13} = 0.14\%$$

$$\overline{\frac{A}{I-I'}}_{Sf} = \sum_{i=1}^{n} \frac{\left(\frac{A}{I-I'}\right)_{Sf}}{n} = \frac{\left(\frac{A}{I-I'}\right)_1 + ... + \left(\frac{A}{I-I'}\right)_n}{n} = \frac{2.50 + ... + 2.11}{13} = 2.31\%$$

Anglar measurements:

$$\overline{\alpha_{Sf}} = \sum_{i=1}^{n} \frac{\alpha_{Sf}}{n} = \frac{\alpha_1 + ... + \alpha_n}{n} = \frac{9 + ... + 12}{13} = 10.15^o$$

$$\overline{\beta_{1Sf}} = \sum_{i=1}^{n} \frac{\beta_{1Sf}}{n} = \frac{\beta_{11} + ... + \beta_{1n}}{n} = \frac{34 + ... + 11}{13} = 13.38^o$$

$$\overline{\beta_{2Sf}} = \sum_{i=1}^{n} \frac{\beta_{2Sf}}{n} = \frac{\beta_{21} + ... + \beta_{2n}}{n} = \frac{29 + ... + 20}{13} = 20.84^o$$

$$\overline{\beta_{3Sf}} = \sum_{i=1}^{n} \frac{\beta_{3Sf}}{n} = \frac{\beta_{31} + ... + \beta_{3n}}{n} = \frac{30 + ... + 25}{13} = 30.23^o$$

$$\overline{\gamma_{1Sf}} = \sum_{i=1}^{n} \frac{\gamma_{1Sf}}{n} = \frac{\gamma_{11} + ... + \gamma_{1n}}{n} = \frac{130 + ... + 127}{13} = 117.92^{o}$$

$$\overline{\gamma_{2Sf}} = \sum_{i=1}^{n} \frac{\gamma_{2Sf}}{n} = \frac{\gamma_{21} + ... + \gamma_{2n}}{n} = \frac{122 + ... + 119}{13} = 135^{o}$$

$$\overline{\gamma_{3Sf}} = \sum_{i=1}^{n} \frac{\gamma_{3Sf}}{n} = \frac{\gamma_{31} + ... + \gamma_{3n}}{n} = \frac{119 + ... + 126}{13} = 121.46^{o}$$

Other measurements:

$$\overline{Np_{Sf}} = \sum_{i=1}^{n} \frac{Np_{Sf}}{n} = \frac{Np_1 + ... + Np_n}{n} = \frac{12.50 + ... + 12.50}{13} = 13.37 \sec veins$$

$$\overline{D_{Sf}} = \sum_{i=1}^{n} \frac{D_{Sf}}{n} = \frac{D_1 + ... + D_n}{n} = \frac{6 + ... + 6}{13} = 6 teeth / cm$$

$$\overline{S_{Sf}} = \sum_{i=1}^{n} \frac{S_{Sf}}{n} = \frac{S_1 + ... + S_n}{n} = \frac{17.492 + ... + 16.477}{13} = 17.60 cm^2$$

Size class - **Microphyll**

2. The average of biometric measurements of *Salix fragilis* leaves from the middle of the crown (Table 1, 2: 14 - 26).

Linear measurements:

$$\overline{L_{Sf}} = \sum_{i=1}^{n} \frac{L_{Sf}}{n} = \frac{L_1 + ... + L_n}{n} = \frac{120 + ... + 120}{13} = 120 mm$$

$$\overline{l_{Sf}} = \sum_{i=1}^{n} \frac{l_{Sf}}{n} = \frac{l_1 + ... + l_n}{n} = \frac{20 + ... + 25}{13} = 23.76 mm$$

$$\overline{h_{Sf}} = \sum_{i=1}^{n} \frac{h_{Sf}}{n} = \frac{h_1 + ... + h_n}{n} = \frac{53 + ... + 58}{13} = 49.53 mm$$

$$\overline{A_{Sf}} = \sum_{i=1}^{n} \frac{A_{Sf}}{n} = \frac{A_1 + ... + A_n}{n} = \frac{19 + ... + 9}{13} = 17.63 mm$$

$$\overline{I - I'_{Sf}} = \sum_{i=1}^{n} \frac{I - I'_{Sf}}{n} = \frac{I - I'_1 + ... + I - I'_n}{n} = \frac{5 + ... + 5}{13} = 7.15 mm$$

$$\overline{Lp_{Sf}} = \sum_{i=1}^{n} \frac{Lp_{Sf}}{n} = \frac{Lp_1 + ... + Lp_n}{n} = \frac{8 + ... + 13}{13} = 11.50 mm$$

Percentage ratios:

$$\overline{\frac{L}{l}_{Sf}} = \sum_{i=1}^{n} \frac{\left(\frac{L}{l}\right)_{Sf}}{n} = \frac{\left(\frac{L}{l}\right)_1 + ... + \left(\frac{L}{l}\right)_n}{n} = \frac{4.63 + ... + 4.48}{13} = 4.41\%$$

$$\overline{\frac{h}{L}_{Sf}} = \sum_{i=1}^{n} \frac{\left(\frac{h}{L}\right)_{Sf}}{n} = \frac{\left(\frac{h}{L}\right)_1 + ... + \left(\frac{h}{L}\right)_n}{n} = \frac{0.44 + ... + 0.47}{13} = 0.44\%$$

$$\overline{\frac{A}{L}_{Sf}} = \sum_{i=1}^{n} \frac{\left(\frac{A}{L}\right)_{Sf}}{n} = \frac{\left(\frac{A}{L}\right)_1 + ... + \left(\frac{A}{L}\right)_n}{n} = \frac{0.17 + ... + 0.07}{13} = 0.12\%$$

$$\overline{\frac{A}{I-I'_{Sf}}} = \sum_{i=1}^{n} \frac{\left(\frac{A}{I-I'}\right)_{Sf}}{n} = \frac{\left(\frac{A}{I-I'}\right)_1 + ... + \left(\frac{A}{I-I'}\right)_n}{n} = \frac{1.81 + ... + 2.20}{13} = 2.53\%$$

Anglar measurements:

$$\overline{\alpha_{Sf}} = \sum_{i=1}^{n} \frac{\alpha_{Sf}}{n} = \frac{\alpha_1 + ... + \alpha_n}{n} = \frac{5 + ... + 20}{13} = 12.38^o$$

$$\overline{\beta_{1Sf}} = \sum_{i=1}^{n} \frac{\beta_{1Sf}}{n} = \frac{\beta_{11} + ... + \beta_{1n}}{n} = \frac{8 + ... + 14}{13} = 13.28^o$$

$$\overline{\beta_{2Sf}} = \sum_{i=1}^{n} \frac{\beta_{2Sf}}{n} = \frac{\beta_{21} + ... + \beta_{2n}}{n} = \frac{19 + ... + 23}{13} = 21.15^o$$

$$\overline{\beta_{3Sf}} = \sum_{i=1}^{n} \frac{\beta_{3Sf}}{n} = \frac{\beta_{31} + ... + \beta_{3n}}{n} = \frac{28 + ... + 27}{13} = 28.76^o$$

$$\overline{\gamma_{2Sf}} = \sum_{i=1}^{n} \frac{\gamma_{2Sf}}{n} = \frac{\gamma_{21} + ... + \gamma_{2n}}{n} = \frac{120 + ... + 125}{13} = 123.23^o$$

$$\overline{\gamma_{3Sf}} = \sum_{i=1}^{n} \frac{\gamma_{3Sf}}{n} = \frac{\gamma_{31} + ... + \gamma_{3n}}{n} = \frac{128 + ... + 120}{13} = 127.53^o$$

Other measurements:

$$\overline{Np_{Sf}} = \sum_{i=1}^{n} \frac{Np_{Sf}}{n} = \frac{Np_1 + ... + Np_n}{n} = \frac{11.89 + ... + 11.80}{13} = 12.34 \sec veins$$

$$\overline{D_{Sf}} = \sum_{i=1}^{n} \frac{D_{Sf}}{n} = \frac{D_1 + ... + D_n}{n} = \frac{6 + ... + 6}{13} = 5.53 teeth / cm$$

$$\overline{S_{Sf}} = \sum_{i=1}^{n} \frac{S_{Sf}}{n} = \frac{S_1 + ... + S_n}{n} = \frac{18.277 + ... + 21.888}{13} = 22.10 cm^2$$

Size class – **Notophyll** (occasional microphyll)

3. The average of biometric measurements of *Salix fragilis* leaves from the base of the crown (Table 1, 2: 27 - 40).

Linear measurements:

$$\overline{L_{Sf}} = \sum_{i=1}^{n} \frac{L_{Sf}}{n} = \frac{L_1 + ... + L_n}{n} = \frac{123 + ... + 122}{14} = 123.78 mm$$

$$\overline{l_{Sf}} = \sum_{i=1}^{n} \frac{l_{Sf}}{n} = \frac{l_1 + ... + l_n}{n} = \frac{20 + ... + 28}{14} = 23.57 mm$$

$$\overline{h_{Sf}} = \sum_{i=1}^{n} \frac{h_{Sf}}{n} = \frac{h_1 + ... + h_n}{n} = \frac{50 + ... + 45}{14} = 54.07 mm$$

$$\overline{A_{Sf}} = \sum_{i=1}^{n} \frac{A_{Sf}}{n} = \frac{A_1 + ... + A_n}{n} = \frac{18 + ... + 18}{14} = 20.78 mm$$

$$\overline{I-I'_{Sf}} = \sum_{i=1}^{n} \frac{I-I'_{Sf}}{n} = \frac{I-I'_1 + ... + I-I'_n}{n} = \frac{7 + ... + 6}{14} = 6.78 mm$$

$$\overline{Lp_{Sf}} = \sum_{i=1}^{n} \frac{Lp_{Sf}}{n} = \frac{Lp_1 + ... + Lp_n}{n} = \frac{12 + ... + 10}{14} = 11 mm$$

Percentage ratios:

$$\overline{\frac{L}{l}_{Sf}} = \sum_{i=1}^{n} \frac{\left(\frac{L}{l}\right)_{Sf}}{n} = \frac{\left(\frac{L}{l}\right)_1 + \ldots\ldots\ldots + \left(\frac{L}{l}\right)_n}{n} = \frac{5.20 + \ldots\ldots\ldots + 4.21}{14} = 4.77\%$$

$$\overline{\frac{h}{L}_{Sf}} = \sum_{i=1}^{n} \frac{\left(\frac{h}{L}\right)_{Sf}}{n} = \frac{\left(\frac{h}{L}\right)_1 + \ldots\ldots\ldots + \left(\frac{h}{L}\right)_n}{n} = \frac{0.42 + \ldots\ldots\ldots + 0.42}{14} = 0.44\%$$

$$\overline{\frac{A}{L}_{Sf}} = \sum_{i=1}^{n} \frac{\left(\frac{h}{L}\right)_{Sf}}{n} = \frac{\left(\frac{A}{L}\right)_1 + \ldots\ldots\ldots + \left(\frac{A}{L}\right)_n}{n} = \frac{0.14 + \ldots\ldots\ldots + 0.10}{14} = 0.13\%$$

$$\overline{\frac{A}{I-I'}_{Sf}} = \sum_{i=1}^{n} \frac{\left(\frac{A}{I-I'}\right)_{Sf}}{n} = \frac{\left(\frac{A}{I-I'}\right)_1 + \ldots\ldots\ldots + \left(\frac{A}{I-I'}\right)_n}{n} = \frac{2.70 + \ldots\ldots\ldots + 3.38}{14} = 2.76\%$$

Anglar measurements:

$$\overline{\alpha_{Sf}} = \sum_{i=1}^{n} \frac{\alpha_{Sf}}{n} = \frac{\alpha_1 + \ldots\ldots\ldots + \alpha_n}{n} = \frac{21 + \ldots\ldots\ldots + 17}{14} = 20.64^o$$

$$\overline{\beta_{1Sf}} = \sum_{i=1}^{n} \frac{\beta_{1Sf}}{n} = \frac{\beta_{1_1} + \ldots\ldots\ldots + \beta_{1_n}}{n} = \frac{14 + \ldots\ldots\ldots + 10}{14} = 14.64^o$$

$$\overline{\beta_{2Sf}} = \sum_{i=1}^{n} \frac{\beta_{2Sf}}{n} = \frac{\beta_{21} + \ldots\ldots\ldots + \beta_{2n}}{n} = \frac{21 + \ldots\ldots\ldots + 25}{14} = 24.64^o$$

$$\overline{\beta_{3Sf}} = \sum_{i=1}^{n} \frac{\beta_{3Sf}}{n} = \frac{\beta_{31} + \ldots\ldots\ldots + \beta_{3n}}{n} = \frac{38 + \ldots\ldots\ldots + 32}{14} = 33.64^o$$

$$\overline{\gamma_{1Sf}} = \sum_{i=1}^{n} \frac{\gamma_{1Sf}}{n} = \frac{\gamma_{1_1} + \ldots\ldots\ldots + \gamma_{1_n}}{n} = \frac{129 + \ldots\ldots\ldots + 119}{14} = 127.32^o$$

$$\overline{\gamma_{2Sf}} = \sum_{i=1}^{n} \frac{\gamma_{2Sf}}{n} = \frac{\gamma_{21} + \ldots\ldots\ldots + \gamma_{2n}}{n} = \frac{129 + \ldots\ldots\ldots + 122}{14} = 124.71^o$$

$$\overline{\gamma_{3Sf}} = \sum_{i=1}^{n} \frac{\gamma_{3Sf}}{n} = \frac{\gamma_{31} + \ldots\ldots\ldots + \gamma_{3n}}{n} = \frac{129 + \ldots\ldots\ldots + 129}{14} = 122.57^o$$

Other measurements:

$$\overline{Np_{Sf}} = \sum_{i=1}^{n} \frac{Np_{Sf}}{n} = \frac{Np_1 + \ldots\ldots\ldots + Np_n}{n} = \frac{12.50 + \ldots\ldots\ldots + 12.50}{14} = 12.50 \sec veins$$

$$\overline{D_{Sf}} = \sum_{i=1}^{n} \frac{D_{Sf}}{n} = \frac{D_1 + \ldots\ldots\ldots + D_n}{n} = \frac{6 + \ldots\ldots\ldots + 6}{14} = 5.71 teeth / cm$$

$$\overline{S_{Sf}} = \sum_{i=1}^{n} \frac{S_{Sf}}{n} = \frac{S_1 + \ldots\ldots\ldots + S_n}{n} = \frac{13.616 + \ldots\ldots\ldots + 21.706}{14} = 23.91 cm^2$$

Size class – **Notophyll** (occasional microphyll)

Fig. 2. A Salix fragilis L. leaf: upper surface (a) and lower surface (b).

Morphological observations. The leaves of *Salix fragilis* are microphyl, ocazionaly notofil. All *Salix fragilis* leaves are simple symmetrical with a oblonglanceolate shape (the maximum width is in the upper part of the lamina), with an ovalityratio average - h/L = 0.43%.

Al laminas are ended in a narrow acuminate or oblique-acuminate apex with an average α =14.39^o (Table 2, 3).The lamina has a rounded base withserrulate (finely toothed) margin and an average of 5.74 teeth/cm.

Thelamina is glabrous with the upper surface dark-brightgreenish and slightly light green on the lower surface. The leaves have membranous texture (Fig. 1, a, b). The percentage ratio of all *Salx fragilis* leaves indicate a finesse leaf (average L/l = 4.51%) and a fine apex (average A/l-l' = 2.53%) (Table 1, 3).

The larger surface leaves are at the base of the crown (average S = 23.91 cm^2), classified in the notophyll class, followed by those from the middle of the crown (average S = 22.10 cm^2) which are microphyll, ocasioanly notophyll. The smaller surface of the mesophyll surgace has the lamina from the apex of the crown (average S = 17.60 cm^2) (Table 2, 4). As Mouton reported (1966a) the leaves size class values are registered as: leptophyll (0-0.25 cm^2), nanophyll (0.25-2.25 cm^2), microphyll (2.25 - 20.25 cm²), notophyll (20.25 - 40.00 cm²), mesophyll (40.00 - 182.25 cm^2), macrophyll (182-1640.2 cm^2) and megaphyll (over 1600.20 cm^2). The lamina has a coriaceous texture. The mid vein is right and lamina venation is semi-compound craspedodromous (Andrei, 1997; Buia & Péterfi, 1965; Givulescu, 1999). From the primary veins are detached the secondaries with a number around 12.73/cm and rare tertiary veins (Fig. 1).

The emergent angle between the primary and the secondary veins (β) is norrow acute for all leaves (under 45^o). The emergent angle (β) values decrease from the leaf base to the apex. The lower angle value has the middle of the crown leaves. The tertiary veins are oblique constant towards the secondary's, forming an obtuse angle with the primaries (betwen ɣ = 111-140^o) for all three groups of leaves (Table 2, 4). This angle values are lower for the apex and base leaves of the crown (ɣ =124.79^o respectively 124.86^o) than those of the middle of the crown (ɣ = 127.12^o).

The green glabrous petiole is shortwith a lenght average Lp = 11.03 mm for all leaves. The longer petiole have the leaves from the middle of the crown (Lp = 11.50 mm),

followed by the leaves of the base (Lp = 11 mm) and the smaller are those from the apex (Lp = 10.60 mm).

The lamina size: the apex of the crown L = 102.76 mm, l = 22.285 mm; the middle crown L = 120 mm, l = 23.76 mm and the base L = 123.78 mm, l = 23.57 mm.

CONCLUSIONS

The linear measurements of *Salix fragilis* laminas have high values concerning the length (L) and lower for the apex length (A). The percentage ratios of all leaves indicate a fineness of leaf (L/l) and a fineness sharply pointed apex (A/l-l'). Lamina has simple craspedodromous semi-compound venation. Concerning the leaves angular measurements of *Salix fragilis*, the apex is narrow acuminate (α). The emergent angle between the primary and the secondary veins (β) is norrow acute whereas the tertiary to the primaries (ɣ) are obtuse. Membranous texture. The petiole is light green and short (Lp). Concerning the surface (S), the leaves are included in the microphyll and notophyll size class. The biometrical measurements have high values for the leaves of the apex crown and medium values for the middle crown leaves. The lowest values have the base crown leaves, being over shadowed by the other leaves of higher levels.

The morphological and morphometric features such as the ovality ratio, the membranous texture, the venation type and the microphyll and notophyll size class, allow *Salix fragilis* to be adaptable for the temperate zones and less for the semiarid regions.

Table 1

Linear measurements and percentage ratioof all *Salix fragilis*leaves

Leaf no	L mm	l mm	h mm	A mm	l-l' mm	Lp mm	L/l %	h/L %	A/L %	A/l-l' %
1	114	29	48	12	5	3.79	11	0.43	0.12	2.50
2	113	24	51	16	6	4.89	13	0.44	0.11	2.60
3	115	21	48	20	8	4.52	7	0.41	0.16	2.00
4	117	20	52	26	10	5.00	11	0.43	0.19	2.52
5	114	20	50	30	14	4.42	10	0.45	0.29	2.42
6	106	22	46	19	12	3.41	10	0.43	0.15	1.66
7	90	24	52	15	7	4.80	11	0.36	0.12	3.00
8	118	23	59	13	5	5.13	17	0.54	0.10	2.78
9	119	21	58	17	13	4.17	8	0.52	0.12	1.04
10	100	21	39	20	8	4.33	12	0.36	0.14	2.22
11	120	23	52	21	8	3.16	12	0.42	0.16	2.72
12	115	20	48	17	7	4.22	9	0.41	0.12	2.57
13	112	23	50	18	9	4.77	8	0.46	0.10	2.11
14	120	20	53	19	5	4.63	8	0.44	0.17	1.81
15	120	24	47	20	10	3.75	10	0.54	0.15	3.00
16	123	26	34	22	8	5,23	13	0.25	0.16	2.50
17	120	26	55	20	9	2.61	12	0.46	0.13	2.37
18	125	25	49	18	9	4.53	15	0.47	0.14	1.80
19	126	25	52	21	6	4.04	12	0.46	0.14	3.14
20	128	22	60	16	7	5.16	12	0.50	0.12	2.57
21	110	22	50	16	8	3.60	10	0.33	0.13	2.83
22	100	23	61	14	9	4.11	14	0.55	0.10	1.66
23	119	20	71	16	7	4.92	10	0.50	0.10	2.64
24	128	24	42	22	6	5.17	9	0.36	0.15	3.00
25	121	23	59	16	4	5.12	12	0.43	0.09	3.40
26	120	25	58	9	5	4.48	13	0.47	0.07	2.20
27	123	20	50	18	7	5.20	12	0.42	0.14	2.70
28	120	22	50	21	7	5.08	10	0.40	0.15	2.75
29	90	21	48	12	6	4.19	11	0.43	0.10	2.81
30	120	30	60	20	6	4.33	16	0.49	0.13	2.32
31	140	27	53	19	5	4.72	9	0.12	3.40	3.40
32	120	22	53	22	6	5.54	11	0.16	3.00	3.00
33	122	22	53	23	10	4.39	12	0.11	1.80	1.80
34	140	23	54	24	7	5.00	12	0.17	3.22	3.22
35	118	25	60	16	6	3.92	8	0.11	2.57	2.57
36	130	25	62	20	7	5.48	12	0.16	3.09	3.09
37	131	23	60	20	8	4.92	10	0.12	2.50	2.50
38	137	22	60	23	9	5.72	9	0.16	2.20	2.20
39	120	20	49	17	5	4.20	12	0.13	2.83	2.83
40	122	28	45	18	6	4.21	10	0.10	3.38	3.38

TABLE 2

Angular measurements, other measurements and the size class of all *Salix fragilis* leaves

Leaf no	α°	β1 °	β2 °	β3 °	γ1°	γ2°	γ3°	Np	D/ cm	S (cm²)	Size class
1	9	34	29	30	130	122	119	12.50	6	17.492	Microphyll
2	10	9	22	35	128	116	120	18.00	6	20.955	Notophyll
3	11	10	16	21	125	129	11°	12.50	6	17.321	Microphyll
4	12	17	23	25	120	130	129	12.50	6	18.296	Microphyll
5	12	11	19	30	119	129-	123	12.50	6	15.036	Microphyll
6	10	5	16	27	164	129	126	12.50	6	15.044	Microphyll
7	7	12	20	33	128	127	118	12.50	6	21.100	Microphyll
8	11	14	26	38	111	122	118	12.50	6	16.183	Microphyll
9	9	6	22	30	125	125-	120	12.50	6	18.337	Microphyll
10	10	23	22	44	130	128	120	12.50	5	16.723	Microphyll
11	10	17	20	30	122	130	119	12.50	6	18.939	Microphyll
12	9	5	16	25	118	130	125	11.89	6	16.951	Microphyll
13	12	11	20	25	124	119	126	12.50	6	16.477	Microphyll
14	5	8	19	28	172	120	128	11.89	6	18.277	Microphyll
15	14	19	29	30	144	127	130	12.50	4	21.178	Notophyll
16	10	12	21	32	123	122	128	12.50	6	23.691	Notophyll
17	12	15	20	24	117	118	120	12.50	6	20.904	Notophyll
18	16	14	21	21	119	122	139	12.50	4	28.825	Notophyll
19	6	16	24	25	130	130	131	12.50	6	21.105	Notophyll
20	12	11	20	30	119	113	127	12.50	6	21.607	Notophyll
21	9	18	23	25	119	124	123	12.50	6	24.200	Notophyll
22	19	10	23	38	119	129	133	12.50	6	20.079	Microphyll
23	8	13	27	38	144	116	127	12.50	4	25.888	Notophyll
24	19	18	30	33	128	126	123	12.50	6	18.337	Microphyll
25	16	15	22	23	130	130	129	11.80	6	21.440	Notophyll
26	20	14	23	27	134	125	120	11.80	6	21.888	Notophyll
27	21	14	21	38	129	129	129	12.50	6	13.616	Microphyll
28	20	17	29	43	122	128	130	12.50	4	20.000	Microphyll
29	20	20	18	28	124	120	125	12.50	6	16.336	Microphyll

30	22	14	22	30	133	131	83	12.50	6	24.130	Notophyll
31	15	19	24	40	121	130	130	12.50	6	26.619	Notophyll
32	20	19	24	34	132	125	118	12.50	6	16.130	Microphyll
33	30	19	25	33	128	112	118	12.50	6	18.080	Microphyll
34	16	17	25	40	140	128	131	12.50	6	24.421	Notophyll
35	22	18	29	31	130	120	124	12.50	4	22.297	Notophyll
36	18	12	30	30	129	125	124	12.50	6	21.947	Notophyll
37	23	15	27	32	120	119	131	12.50	6	22.297	Notophyll
38	25	13	25	29	130	127	120	12.50	6	66.519	Notophyll
39	20	10	21	31	128	130	124	12.50	6	20.777	Notophyll
40	17	10	25	32	119	122	129	12.50	6	21.706	Notophyll

Table 3

The average of the linear measurements and percentage ratio of all *Salix fragilis* leaves

Species	**L (mm)**	**l (mm)**	**h (mm)**	**A (mm)**	**l-l´ (mm)**	**Lp (mm)**	**L/l (%)**	**h/L (%)**	**A/L (%)**	**A/ l-l´ (%)**
Salixfragilis	115.51±	23.23	49.94	19.05	7.51	11,03	4.51	0.43	0.13	2.53

Table 4

The average of angular measurements, other measurements and size class of all *Salix fragilis* leaves

Specia	**α°**	**β°**	**γ°**	**Np**	**D/cm**	**S (cm²)**	**Size class**
Salixfragilis	14.39	22.28	125.59	12.73	5.75	21.20	mesophyll and notophyll

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