

低木類の生活形と茎の内部構造との関係

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WAKAYAMA, Haruhiko¹ and Hiroaki HATTA²: Correlation between Life Form and Wood Anatomy in Shrub

筆者らは樹形研究の一環として、1) 成熟枝のフェノロジー(植物季節)の観察、2) 主軸がどのように更新し、株が如何に維持されているかの調査、3) 実生(芽生え)の継続観察、を続けてきた(八田 1995, 八田ら 2003, Hatta *et al.* 1999)。

これらの調査を通して常に気掛かりなことは、低木類における枝の伸び方や生活形(外観)と内部構造の関係である。ことに亜低木と呼ばれる種群の場合、例えばヤマアジサイでは根際から新シュートが発生し、1年目に1~2m伸長し、2年目、3年目と開花結実した後4年目から枯れはじめ、主軸が追加して伸長することはない(八田・笠原 1994)。このような成長経過に対し、茎の断面ではこれらの現象がどのように現れるか、年輪はいかに形成されるのだろうか。

筆者らはこれら低木類の茎の断面の顕微鏡写真データを文献、図書から求めようとしたがまとまったものは得られなかった。その断面構造の解析も生活形との関連では報告されていない。

そこで、今後伸長成長の経過と肥大成長の関連を詳しく調べてゆくための基礎資料として、低木類を中心に72種の顕微鏡切片を作成した。今回の報告は茎の断面構造からよみとれる幾つかの形質を判読または計測し、それらの値や事象と生活形との関係を明らかにしようとするものである。つまり、茎の伸び方などを中心とする生活形という概念に内部構造がいかに対応するかを検証しようとする。ことに、亜低木と低木との違いに注目した。同時に筆者等が新たに提示する「草本性亜低木」「追加伸長型低木」、「大型低木」、「偽低木」などにも関心を払った。また、かつてまとまった報告のない、低木類の顕微鏡写真を公表することも本報告の主たる目的の一つである。今後、生態学的にも低木類の研究が多くなると予想され、本報告の写真データが必ず有効に利用されると信ずる。本報告には比較のために数種の小高木、高木類のデータも含めている。

材料および方法

1. 材料はすべて筑波実験植物園植栽植物で、Table 1に掲げる25科、69種(データの記載は28科72種)を供試した。
2. 生活形に関してはラウンキエなどの休眠形や繁殖形、生育形に基づく分類(佐々木・宮脇 1967)を参考にしつつ、筆者らが実生調査、フェノロジー調査を通して得た知見から、本報ではTable 2に示すように定義し区分した。
3. 調査の手順

①太さ1cm前後の枝を採取し、葉痕や芽鱗痕の状態に基づき、その枝の年成長の経過を観察記録し、外部形態を撮影した。

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- ② 2～3年生枝 5 cm 程の髓の中心を含む縦断面標本をつくり、髓の形状、木部の色などを記録し、撮影した。続いて髓の直径、1年目の木部成長幅を実体顕微鏡の下でノギスを使用して計測した。
- ③ 同じ枝の基部 5 cm ほどを切り取り以下の手順で木口の顕微鏡用切片を作製した。
 - a. スライディングマイクロトームを使用し、厚さ20～30 μm の切片を採取し、
 - b. 各切片について、定法に従いサフラニン、ファストグリーンの二重染色をした。
 - c. 染色した切片について脱水後、エタノールをキシレンに置換した後カナダバルサムにより、プレパラートに封入。
- ④ 得られたプレパラート標本の全ての樹種について、50倍及び100倍率で光学顕微鏡写真を撮影した。
- ⑤ 計測には100倍率で、1 mm 対物マイクロメーターを同一視野内に写し込んだ写真を使用した。
- ⑥ 道管の直径については大、小のものを偏らないように30個選びそれらの平均値で示した。
- ⑦ 道管の分布密度は0.25 mm^2 あたりの道管数を数え、1 mm^2 あたりに換算した。
- ⑧ 管孔性については、教科書（伊藤ら 1998、島地・伊藤 1982）に従い、環孔材、半環孔材、散孔材に区分し、実体顕微鏡の下で判定した。
- ⑨ 年度ごとの年輪幅についても実体顕微鏡のもとで、マイクロメーターを使用して計測した。

4. 写真図版について

図版には原則として、A. 茎の形態写真とデータ（1年生および2年生茎の色調）、B. 髓の中心を通る縦断面の写真とデータ（髓の粗密状態、色調、1年生茎の太さに対する髓直径の割合）、C. 100倍率で撮影した横断切片の写真（1 mm の対物マイクロメーターが写し込まれており、この大きさの顕微鏡像または写真に基づいて各種のデータを計測した）、D. 50倍率の横断切片の写真（目盛りの指標を入れていないが常に長さでCのおよそ2倍となる。これには成長輪の境に矢印を挿入した。成長輪の境は不明瞭な種もかなりあり、筆者等の推定できる範囲にとどめた。写真に付した数字は茎の中心から外側に向かって1年生、2年生……と成長輪を示す）を掲げた。各ページのほぼ中央・右に示す帯グラフはDと同じ切片標本を供試（一部例外あり）して、実体顕微鏡の下で測定した成長輪幅である。全体の幅を100とし、各年度の幅を%で表示している。なお、本報告では偽年輪の形成など、必ずしも年輪と断定できない場合が顕微鏡像から判定されるため、「年輪」とほぼ同義で「成長輪」という言葉を使用している。

結果および考察

顕微鏡薄片切片を作成した単子葉植物等3科3種をのぞく25科69種について計測した諸形質のデータ一式を生活形ごとに Table 1 に一覧して示す。生活形ごとの各形質の平均値を Table 3 に、科ごとにみた諸形質の平均値を Table 4 に掲げる。計測資料である写真データを1種ごとに App. 1～74に掲げる。写真データは、外部形態と成長輪を併せて掲げたものと、成長輪のみ9データのものがあるため、Table 1 に示す種の番号とは必ずしも一致しない。そのため、Table 1 に各種に対応する図版番号 (App. No.) を併記した。

1. 調査種群の生活形

筆者らの見解に基づいて区分した生活形を Table 2 に掲げる。

調査に供試した種群をこれにしたがって分類すると Table 1 に示す通りであった。III. 亜低木類にはバラ科、ユキノシタ科が多く、IV. 低木類にはツツジ科とスイカズラ科の一部が含まれ

Table 2. Category of life form

A. Shrub: Main trunk is indistinct, sprouting from near the ground is abundant when young (1 to 5 year-old), and the maximum height is usually less than several meters
I Vine
II Herbaceous semi-shrub: Trees whose upper-ground parts die, but near-ground parts including winter buds over winter
III Semi-shrubs: Longevity of shoots is 2 to 5 years
IV Shrub: Regeneration of secondary axes from the base is less frequent. Regeneration on lateral shoots becomes dominant, and maximum height is ca. 2 m
V Additional-growing shrub: Regeneration mainly occurs on lateral shoots
VI Large shrub: Longevity of secondary axes becomes longer, canopy height is usually ca. 5 m
VII Pseudo-shrub: Group of species originated from tall trees, which is assumed to obtain shrub-like form under environmental stresses
B. Tall tree: Main trunk is distinct, and sprouting from the base never occurs during the seedling phase Regeneration occurs on small branches, having long period of vegetative growth
VIII Small-tall tree: Maximum canopy height is ca. 10 m
IX Tall tree: Canopy height reaches upper than 20 m

Table 3. Life form and average of anatomical values

Life form	Pith diameter (mm)	Pith proportion in one-year-old stem (%)	Vessel diameter (μm)	Vessel density (no./ mm^2)
I	1.63	54.19	44.26	317
II	1.34	51.64	33.66	169
III	3.73	64.31	26.92	307
IV	2.29	55.38	28.02	288
V	3.70	69.52	28.22	306
VI	1.83	28.64	46.51	68
VII	1.66	71.72	17.83	556
VIII	1.95	64.12	35.89	255
IX	2.51	67.86	29.59	387

Table 4. Average of anatomical values for families including over 3 species

Family	Pith diameter (mm)	Pith proportion in one-year-old stem (%)	Vessel diameter (μm)	Vessel density (no./ mm^2)
Araliaceae	5.65	84.88	39.56	145
Caprifoliaceae	3.37	64.52	25.28	261
Celastraceae	1.20	63.04	30.14	463
Cornaceae	1.68	74.74	25.54	244
Ericaceae	1.05	45.16	21.23	629
Lauraceae	2.43	43.27	40.24	76
Rosaceae	3.61	68.72	26.15	304
Rutaceae	1.65	56.89	27.92	259
Saxifragaceae	3.64	66.40	24.79	412

る。本報では低木の生活形として II. 草本性亜低木 (仮), V. 追加伸長型低木 (仮), VI. 大型低木 (仮), VII. 偽低木 (仮) を新たに提示したが, 今回調査した種群ではそれぞれの生活形に, ハマギク, クサボタン, コマツナギ, ヘンルーダ (以上 II 型); ハコネウツギ, ヤブウツギ, ウ

ツギ, ノリウツギ (V型); ムクゲ, アブラチャン, ダンコウバイ (VI型); エゾユズリハ, シャリンバイ (VII型) などが該当した。なお, これら3者を含む樹木の生活形に関する議論は目下別報として準備中である。

2. 生活形と髓の直径

髓の太さの平均値が亜低木では3.73 mm, 追加伸長型低木が3.70 mm に対し, 低木では2.29 mm, 亜高木1.95 mm, 高木2.51 mm であった。前者の値が後者のそれより大きいことは伸長様式の観察などから予想された結果であった。これに対し, つる植物や草本性半低木の値が小さいのは意外である。植物群で見ると, 低木に区分されるツツジ科の平均が1.05 mm で最も小さく, 主に亜低木に区分されるユキノシタ科は3.64 mm と大きい。これらが両生活形の平均値の差に大きく関与すると考えられる (Table 3)。同じ亜低木 (III) に区分されていてもカジイチゴ (App. 20), アジサイ (App. 71) などは10 mm 前後で顕著に大きいが, ヤブサンザシ (App. 73) やコデマリ (App. 21) など直径1.5 mm 以下のものもある。高木はほぼ2 mm 以下にまとまっているが, ハリギリ (App. 60) が異状に太く, 同科のカクレミノ (App. 53) やヤツデ (App. 28) も他に比べて大きく, この種群の特徴であろう。

3. 生活形と1年目の年輪幅に占める髓の割合

Fig. 2 に見るように, 1年生の茎の直径に占める髓の幅の割合は予想に反し生活形間であまり変わらなかった。亜高木や高木でも, その値は高い。ことに亜低木類では髓の占める割合が他の生活形の種群に比べもっと大きいと観察を通して予測されていた。本調査では4~5年生の主軸で測定しているが, 根際から発生した年度のうちに同様の計測をすれば異なる結果が出たと推定される。亜低木類の茎は樹齢の増加に伴い, 内部組織が緊密となり, 髓の占める割合が減少する可能性がある。また大型低木 (VI) の値が28.64と顕著に低い。Fig. 2 に見るこの値が, 種によって分散して示されたのもこの形質の特徴である。

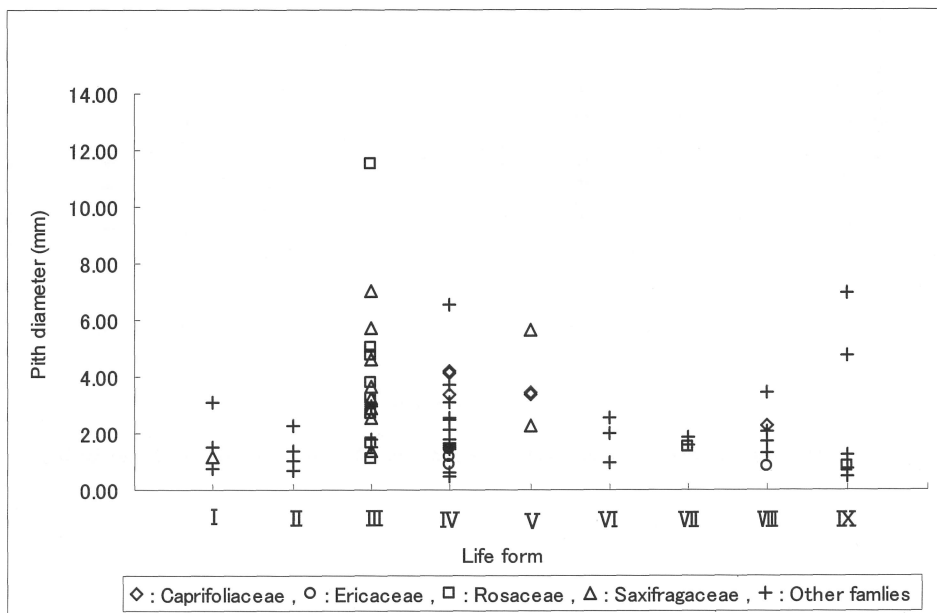


Fig. 1. Correlation between life form and diameter of pith.

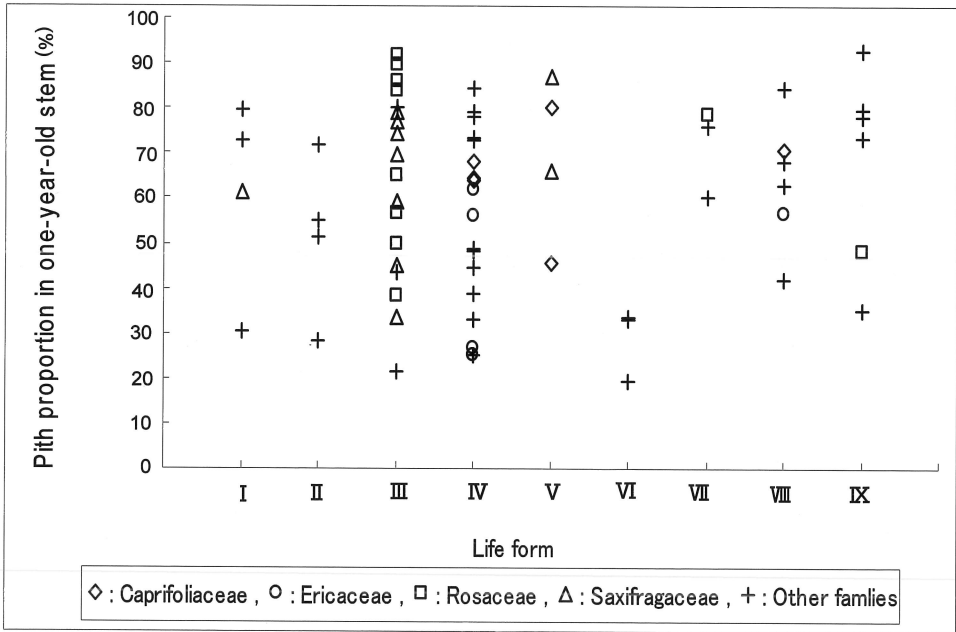


Fig. 2. Correlation between life form and pith proportion in one-year-old stem.

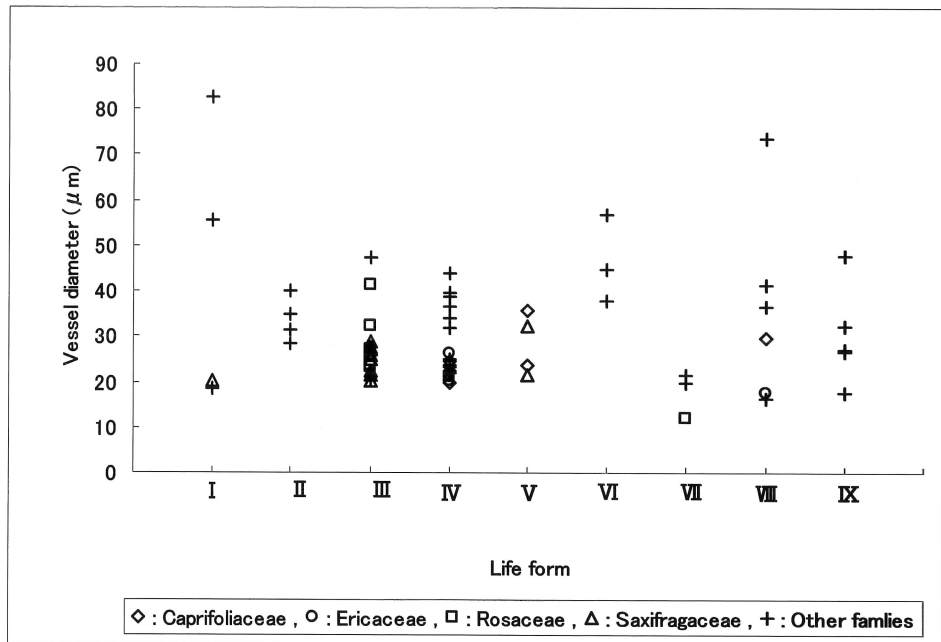


Fig. 3. Correlation between life form and diameter of vessel.

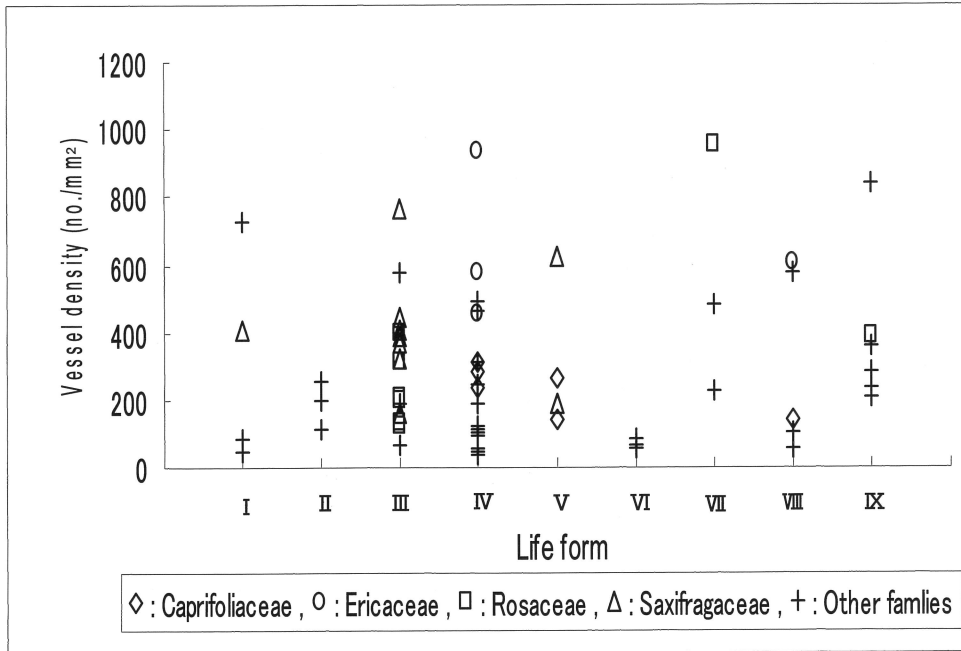


Fig. 4. Correlation between life form and vessel density per square millimeter.

4. 生活形と道管の直径

つる植物のツルウメモドキ (App. 2) やマタタビ (App. 1) が顕著な大きい値を示す。成熟した幹材が環孔材となるハリギリやネムノキ (App. 51) の道管が際立って太く、今回調査対象とした小高木、高木の中でも特異的である。低木類に関しては垂低木 (III) も低木 (IV) も偽低木 (VII: エゾユズリハ (App. 48), シャリンバイ (App. 50), トベラ (App. 49)) もほぼ20~30 μm の範囲に集中した。

メギ科の種群の平均が21.07, ツツジ科で21.23 μm, バラ科が26.15 μm で小さく種群としてまとまった。一方、大型低木 (VI) と認めたアブラチャン (App. 47), ダンコウバイ (App. 46), ムクゲ (App. 45) などは40~60 μm と大きく、高木や小高木に類似するのは興味深い (Fig. 3 および Table 4)。

5. 生活形と単位面積当たりの道管数

Table 3 を見るとまず目立つのが大型低木 (VI) の68の値である。これに区分した3種の断面標本を見ると、いずれも道管は1~3個が単位で離れて分散しており、そのため低い値となったことが理解できる。一方、小高木 (VIII) はエゾユズリハ (App. 48), シャリンバイ (App. 50), トベラ (App. 49) はいずれも道管直径が小さく (ことにシャリンバイ), しかも多くがまとまって配列するため高い値となった。ただし大型低木の低い値や小高木の高い値が両者の属性であるか否かは供試した試料数も少なくして今のところ不明であり、今後の課題である。

6. 道管の直径と分布密度

散孔材では一般に道管の大きさと単位面積当たりの道管数とはFig. 5 に示すように相反する関係にある。例えばツツジ科, メギ科の道管が小さいことを4項で見たが, 1 mm² 当たりの道管

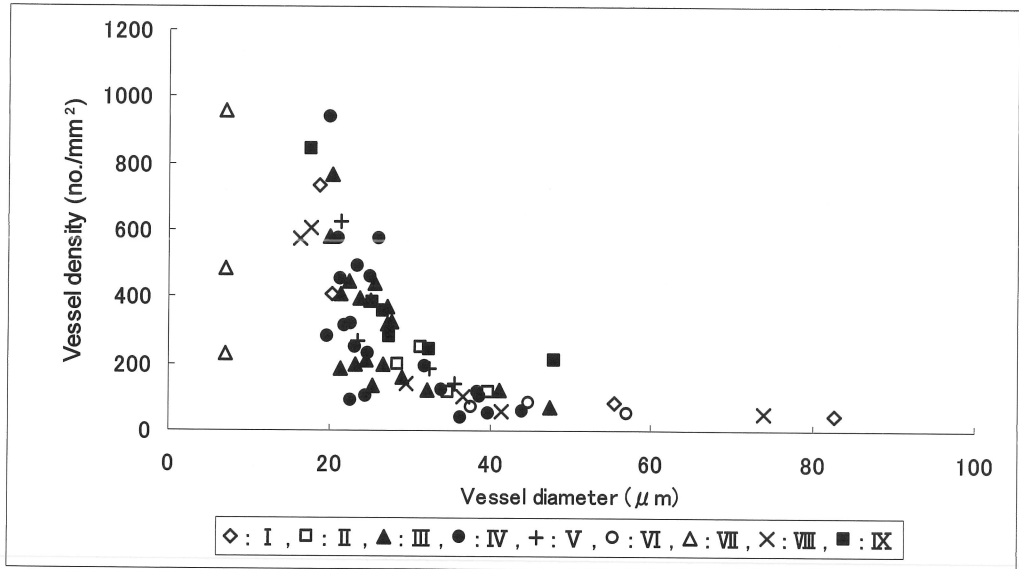


Fig. 5. Correlation between diameter of vessel and vessel density per square millimeter.

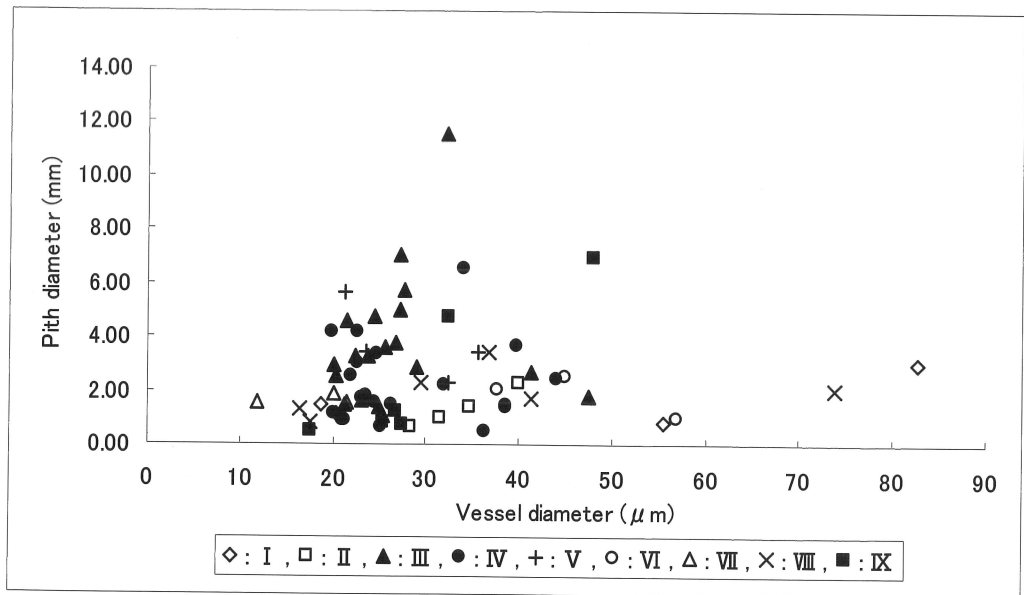


Fig. 6. Correlation between diameter of vessel and diameter of pith.

数ではツツジ科が629個と群を抜いて多く、メギ科も446個であった。また大きな道管をもつウコギ科やクスノキ科では、道管数はそれぞれ145、76個と少ない。ところがニシキギ科の場合、道管の太さは $30.14\ \mu\text{m}$ で、メギ科の $21.07\ \mu\text{m}$ より平均値ではるかに大きいのだが、分布密度も463個でメギ科より多い (Fig. 5 および Table 4)。これ等の事実は分布密度が単に道管の大きさだけで決まらず、配列の形態にも大きく左右されることを示す。Fig. 5 は道管直径がほぼ $30\ \mu\text{m}$ 以上

Table 5. Correlation between life form and porosity

Porosity	Life form*	I	II	III	IV	V	VI	VII	VIII	IX
	Ring-porous wood		0	0	0	0	0	0	0	0
Semi-ring-porous wood		2	3	1	3	0	1	0	2	2
Diffuse-porous wood		2	1	18	17	4	2	3	4	4

*Type of life form, I: Vine, II: Herbaceous semi-shrub, III: Semi-shrub, IV: Shrub, V: Additoinal-growing shrub, VI: Large shrub, VII: Pseudo-shrub, VIII: Small-tall tree, and IX: Tall tree.

のものは道管密度が低いことをよく表わしている。しかし20~30 μm のものは分布密度が100個前後から1000個くらいまでと変異が大きい。これを生活形で見ると、低木 (IV) は道管直径で20~45 μm 、密度はほぼ50~600個に広がるが、亜低木 (III) はもっとまとまって道管の大きさがほぼ20~30 μm に集まる。これに反し高木類では分散する幅がもっと広い。

7. 道管直径と髓の直径

低木類、亜低木類のほとんどは道管直径20~30 μm 、髓直径7 mm 以下の範囲に納まる。ことに、ツツジ科の低木類はまとまって、道管直径、髓直径共に小さい値を示す。またバラ科やユキノシタ科の種群などでも見るように、植物群によってかなりのまとまりが認められる。カジイチゴ (App. 59) の道管直径は平均的だが、髓の直径が大きくて、またネムノキやマタタビはその逆で、髓の直径は平均的だが、道管直径が大きいために、それぞれの植物群から離れて位置する (Fig. 6)。

8. 生活形と管孔性、成長輪

環孔材と認められたものは今回の標本の中にはなかった。半環孔材と認めたものも13種に過ぎず、他は全て散孔材と区分された。Table 5 に示すように、散孔材はどの生活形の種群にも分布した。

成長輪の境界が明瞭に認められる61種に対し、不明瞭なものは8種であった。不明瞭な8種のうち、6種を亜低木で占めた。

9. 枝の成長様式と成長輪の現れ方

ヤマボウシは栄養枝と生殖成長枝が明瞭で、両者の成長様式が異なる。一旦花芽を形成したシュートはそれ以後数ミリメートルの伸長を続けるにすぎない。葉芽をつけた翌年は2枚の葉をつける1本のシュートを、花芽をつけた翌年は2本のシュートを出し、2枚ずつ計4枚の葉をつける。そして、多くの場合、2年または3年に1回開花する (八田 1990, 2004)。このような場合、成長輪が如何に現れるかは大変興味深い。App. 59 は若い成長盛んな枝の断面を示し、App. 74C-2 は数年間栄養成長を繰り返した後、生殖成長期に変った枝の断面を示す。栄養成長期における成長輪と生殖成長期における成長輪の違いが明瞭に表われている。App. 74C-1 は上述の2~3年毎に花芽をつけることを繰り返している枝の断面である。このように枝の伸び方の違いは明らかな断面構造の違いとして表現されるのであるが、App. 74C-1 及び App. 74C-2 の断面外側部分からは正確に、葉芽が展開した年度と花芽が展開した年度とを判断することは困難だった。

10. その他

Table 1 のリストから外しているが、単子葉植物のナギイカダ (ユリ科) (App. 62) 及び針葉樹

のキャラボク（イチイ科）（App. 64），ハイネズ（ヒノキ科）（App. 63）の3種の横断切片の写真を掲げた。ナギイカダの茎の維管束は木部と師部が相接する並立維管束と呼ばれ，茎断面全体に散在する様子がよく判る。一方針葉樹には道管がなく，機械的支持と水誘導の両方の働きをもつとされる仮道管が隙間なく配列する。

以上，筆者らの観察に基づく生活形の区分に従い，低木類を中心に25科，69種を9つの生活形に分けた。種毎の髓の大きさや道管の大きさとその分布密度などの諸形質を計測し，その結果に基づいて，生活形との関連で考察した。総じて生活形が茎の断面構造に反映されるかという本論の目論みはその期待に対しおおよそ半々であろう。垂低木と低木の相違などについてはかなり支持されたと考えている。本報告で新たに提示したII. 草本性半低木（仮），V. 追加伸長型低木（仮），VII. 偽低木（仮）等に関してはもっと調査例を増やす必要がある。また本報告の低木類の顕微鏡写真は，これまでまとまったものがなく資料として有用であると考える。

Summary

The current study attempts to clarify that how a life form of tree is reflected on its cross-sectional structure of stem. Based on observation of seedling and phenology, new categories of shrub species are suggested, which include: Herbaceous semi-shrub; Additional-growing shrub; and Pseudo-shrub. Using these new categories, selected 69 species (25 families) were divided into 9 life forms. Diameter of pith, size and density of vessels, width of annual ring of the first year and porosity were measured and analyzed in relation to the life forms.

It was different by characteristics how the life forms of trees are reflected on their stem morphology.

There is no such report as the current study, which includes about 70 photographs of microscopic observations in shrub, and these should be very useful resource for the future study.

謝 辞

独立行政法人森林総合研究所木材特性研究領域の能城修一博士からは懇切な指導と本報告の内容全体を校閲いただいた。まず同氏に心から御礼申し上げる。本論で提示した低木類の生活形の概念付けは，いずれも10年間以上にわたって調査を続行されてきた笠原喜久雄氏，持田秀雄氏，磯田恵氏をはじめとする樹形研究会諸氏の調査結果に負うところが大きい。方々に深い感謝と敬意を表す。

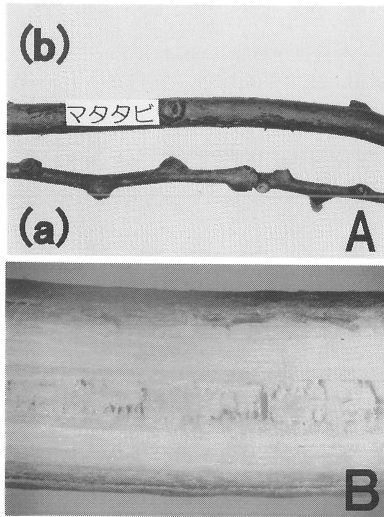
本論作成に際し，グラフの作成など助力いただいた近藤恵氏，羽柴敬子氏にも深謝する。

最後に，材料採集と顕微鏡標本作製のため滞在を許可され，受け入れられた筑波実験植物園の同僚諸氏，及び本研究の機会を与えられた警視庁第一化学科ならびに警察庁犯罪鑑識官付基礎資料係の同僚諸氏に心より感謝する次第である。

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A. Stem morphology

- Bark color
- (a) one-year-old stem: brown
- (b) five-year-old stem: brown

B. Pith in longitudinal section

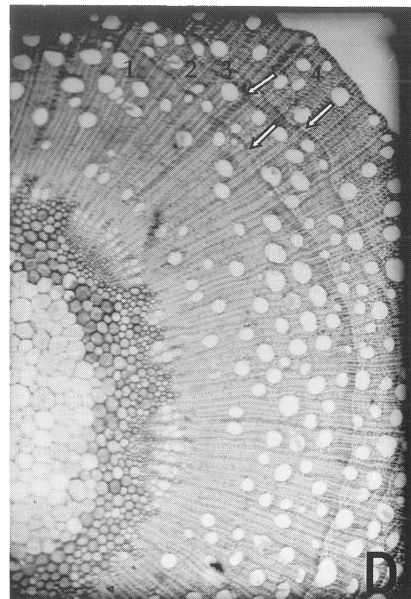
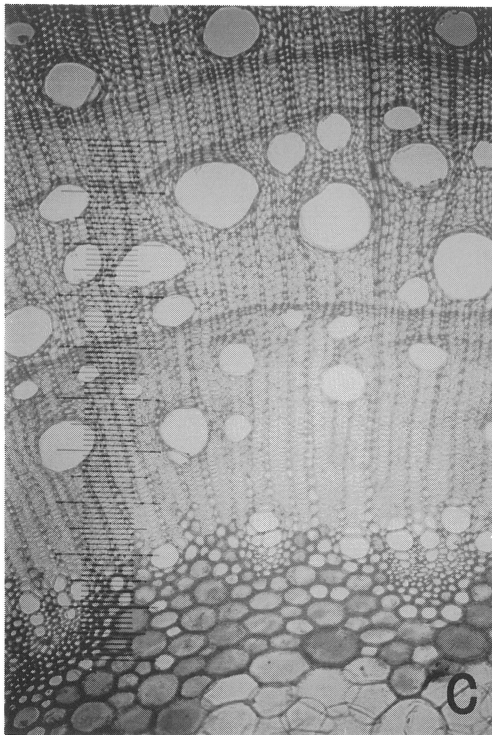
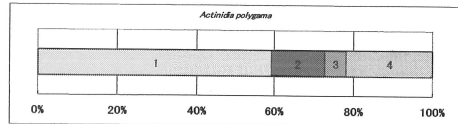
- Condition: rough
- Color: brown
- Proportion in one-year-old stem: 79.74%

C. Cross section of a four-year-old stem with an objective micrometer (1mm)

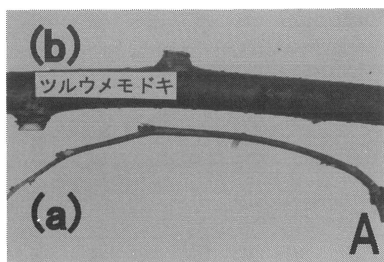
D. Cross section of a four-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary
- Growth rings of 1-3 and 4 are shown in the figure.

Proportion of growth rings in secondary xylem

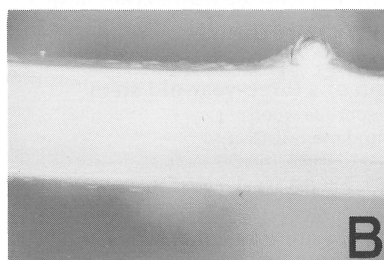


App. 1. *Actinidia polygama* (マタタビ) (Actinidiaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: dark brown
- (b) five-year-old stem: dark brown



B. Pith in longitudinal section

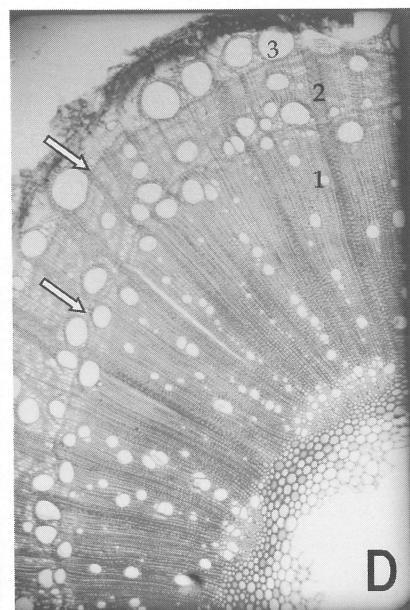
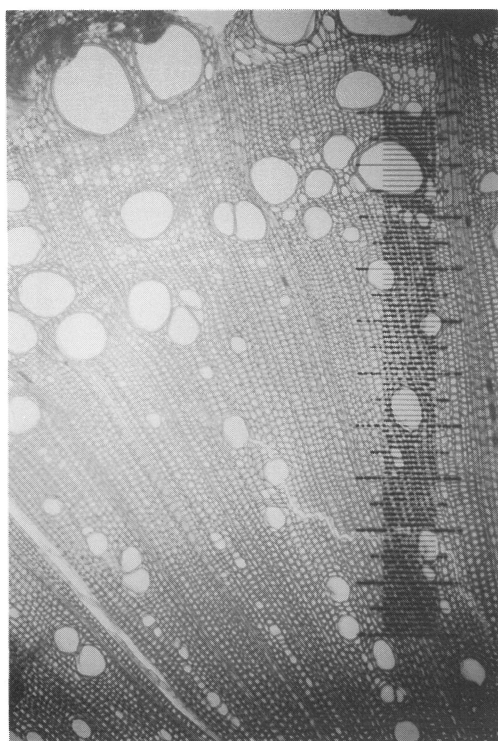
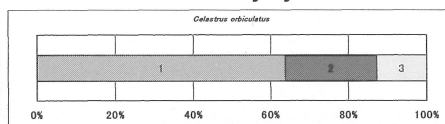
- Condition: dense
- Color: white
- Proportion in one-year-old stem: 30.27%

C. Cross section of a three-year-old stem with an objective micrometer (1mm)

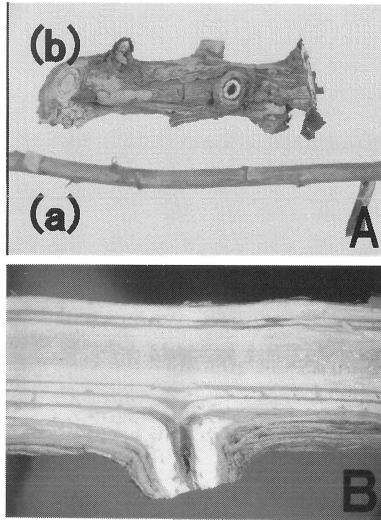
D. Cross section of a three-year-old stem

- Porosity: semi-ring-porous wood
- Growth ring boundaries: distinct
- Pores: solitary, or in radial multiples
- Growth rings of 1, 2 and 3 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 2. *Celastrus orbiculatus* (ツルウメモドキ) (Celastraceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: reddish brown
- (b) three-year-old stem: reddish brown

B. Pith in longitudinal section

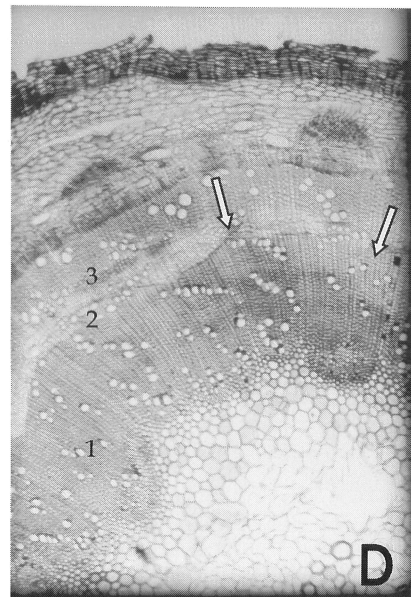
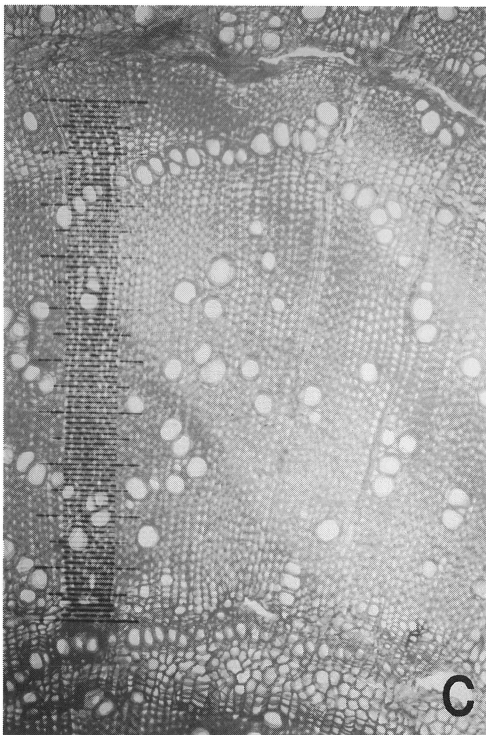
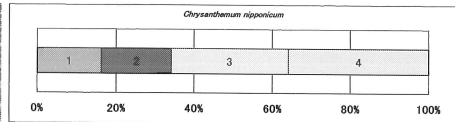
- Condition: dense
- Color: brown
- Proportion in one-year-old stem: 55.20%

C. Cross section of a four-year-old stem with an objective micrometer (1mm)

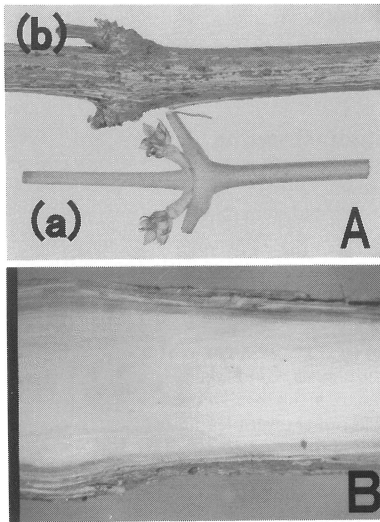
D. Cross section of a three-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary
- Growth rings of 1, 2 and 3 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 3. *Chrysanthemum nipponicum* (ハマギク) (Asteraceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: brownish black
- (b) three-year-old stem: light brown

B. Pith in longitudinal section

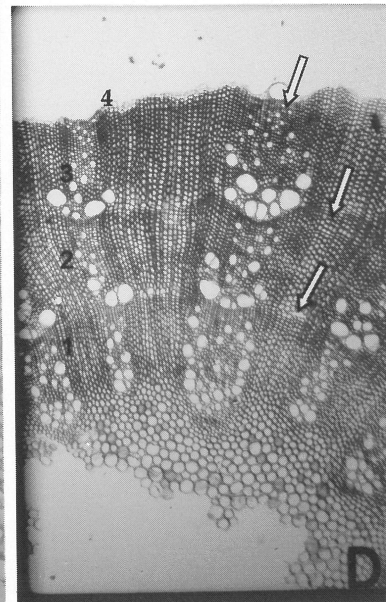
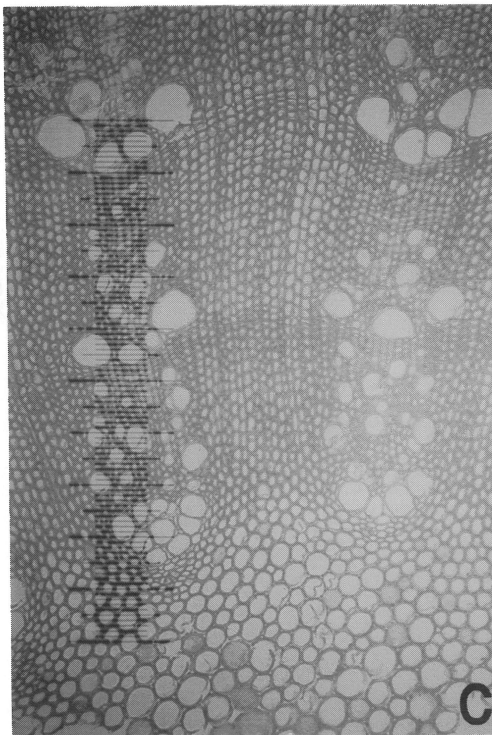
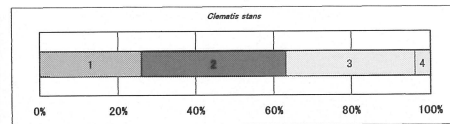
- Condition: dense
- Color: white
- Proportion in one-year-old stem: 71.79%

C. Cross section of a four-year-old stem with an objective micrometer (1mm)

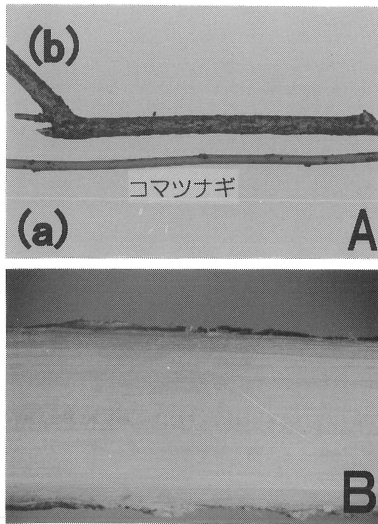
D. Cross section of a four-year-old stem

- Porosity: semi-ring-porous wood
- Growth ring boundaries: distinct
- Pores: solitary
- Growth rings of 1-3 and 4 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 4. *Clematis stans* (クサボタン) (Ranunculaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: green
- (b) three-year-old stem: brown

B. Pith in longitudinal section

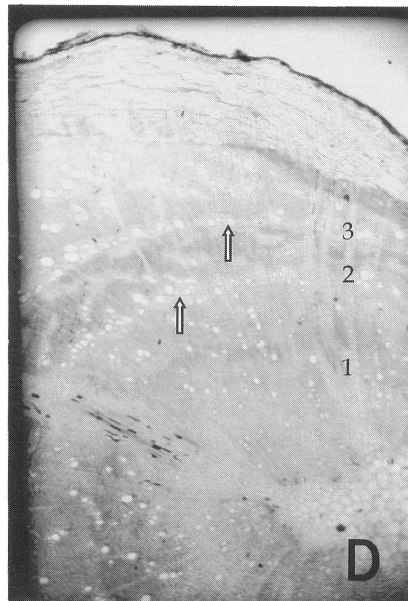
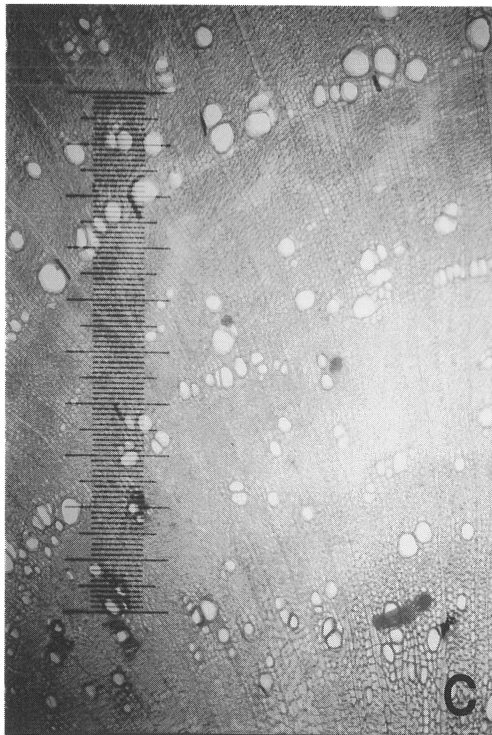
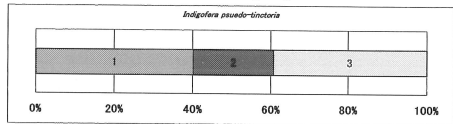
- Condition: dense
- Color: greenish brown
- Proportion in one-year-old stem: 28.03%

C. Cross section of a three-year-old stem with an objective micrometer (1mm)

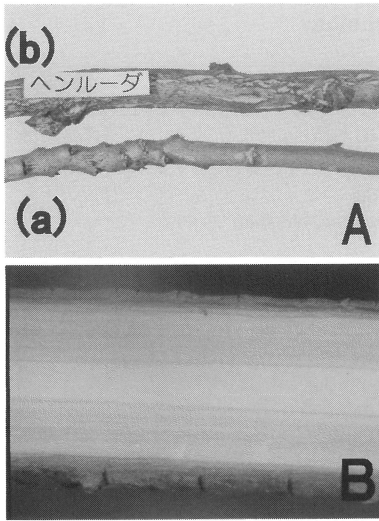
D. Cross section of a three-year-old stem

- Porosity: semi-ring-porous wood
- Growth ring boundaries: distinct
- Pores: solitary, or in radial multiples
- Growth rings of 1, 2 and 3 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 5. *Indigofera pseudo-tinctoria* (コマツナギ) (Leguminosae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: green
- (b) five-year-old stem: brown

B. Pith in longitudinal section

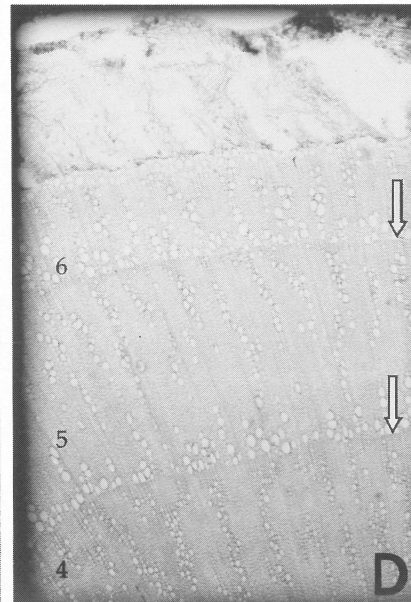
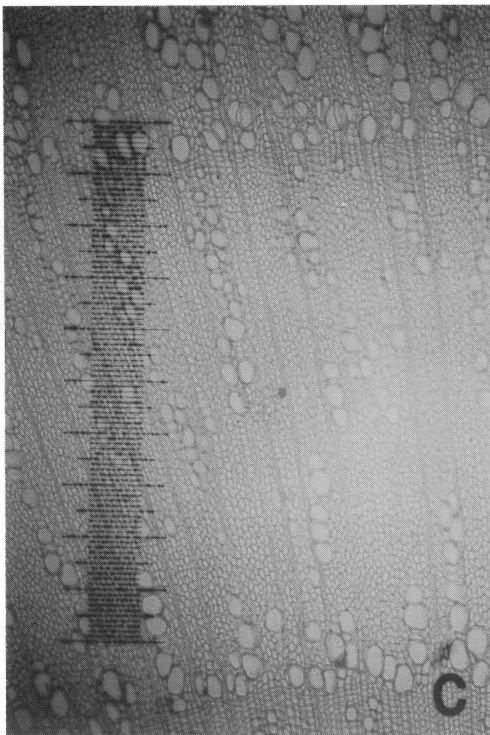
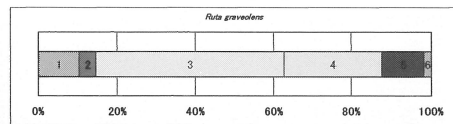
- Condition: dense
- Color: white
- Proportion in one-year-old stem: 51.52%

C. Cross section of a six-year-old stem with an objective micrometer (1mm)

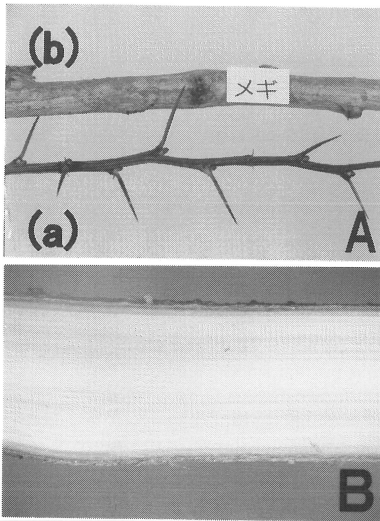
D. Cross section of a six-year-old stem

- Porosity: semi-ring-porous wood
- Growth ring boundaries: distinct
- Pores: solitary, or in radial multiples; in dendritic pattern
- Growth rings of 4, 5 and 6 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 6. *Ruta graveolens* (ヘンルーダ) (Rutaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: green
- (b) four-year-old stem: green and brown

B. Pith in longitudinal section

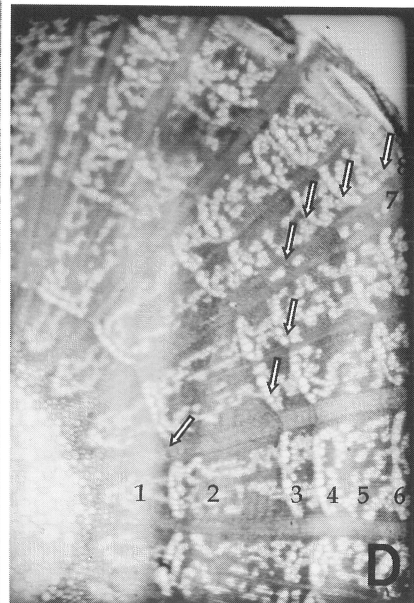
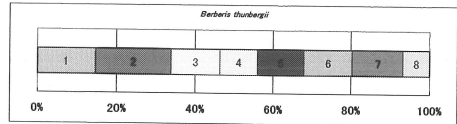
- Condition: dense
- Color: light yellow
- Proportion in one-year-old stem: 79.89%

C. Cross section of a eight-year-old stem with an objective micrometer (1mm)

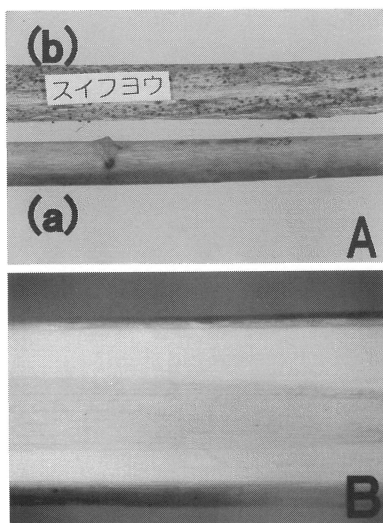
D. Cross section of a eight-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: in radial multiples; in dendritic pattern
- Growth rings of 1-7 and 8 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 7. *Berberis thunbergii* (メギ) (Berberidaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: green and brown
- (b) two-year-old stem: brownish gray

B. Pith in longitudinal section

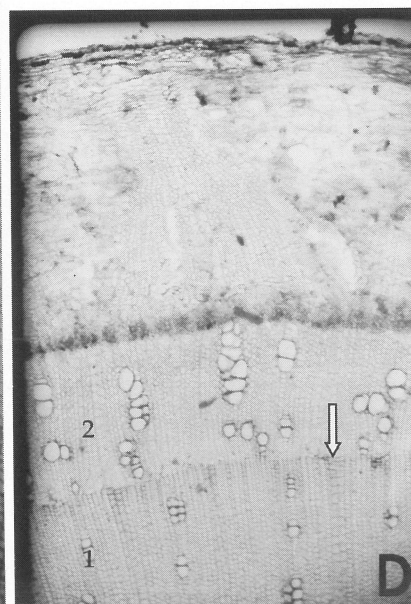
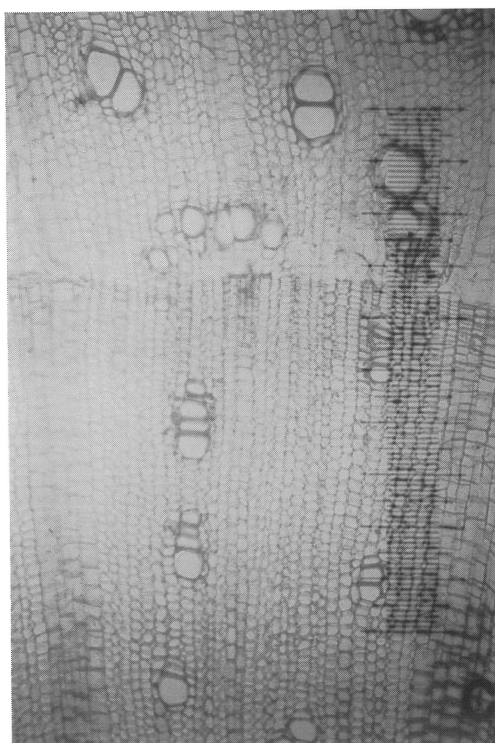
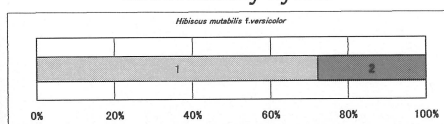
- Condition: dense
- Color: brown
- Proportion in one-year-old stem: 21.34%

C. Cross section of a two-year-old stem with an objective micrometer (1mm)

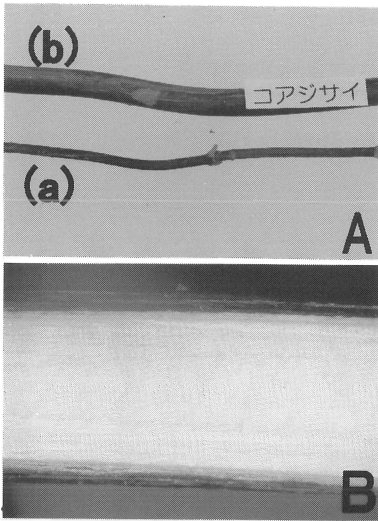
D. Cross section of a two-year-old stem

- Porosity: diffuse-porous-wood
- Growth ring boundaries: distinct
- Pores: solitary, or in radial multiples
- Growth rings of 1 and 2 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 8. *Hibiscus mutabilis f. versicolor* (スweifヨウ) (Malvaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: dark brown
- (b) two-year-old stem: dark brown

B. Pith in longitudinal section

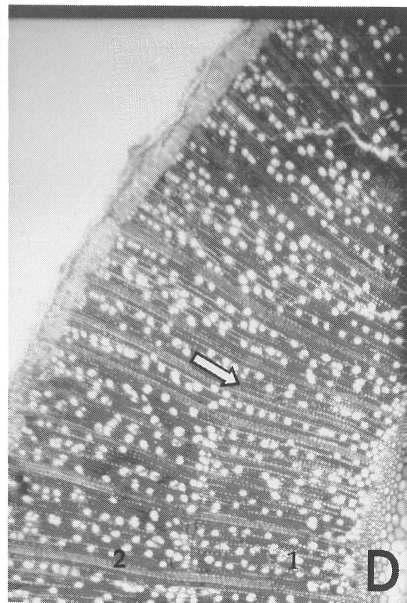
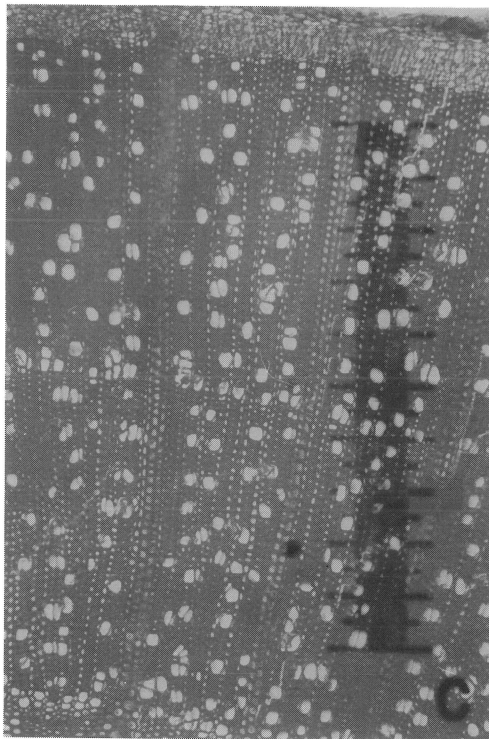
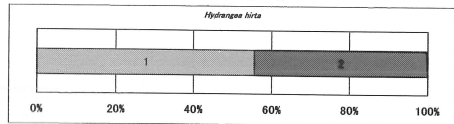
- Condition: dense
- Color: yellowish white
- Proportion in one-year-old stem: 21.43%

C. Cross section of a two-year-old stem with an objective micrometer (1mm)

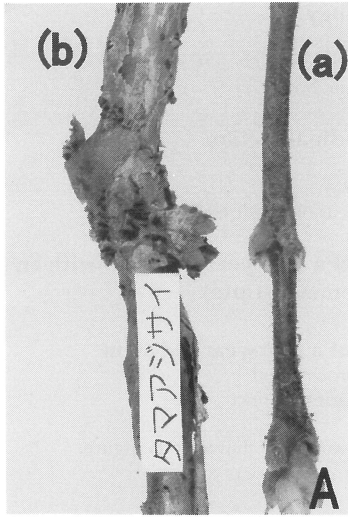
D. Cross section of a two-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary
- Growth rings of 1 and 2 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 9. *Hydrangea hirta* (コアジサイ) (Saxifragaceae).



A. Stem morphology

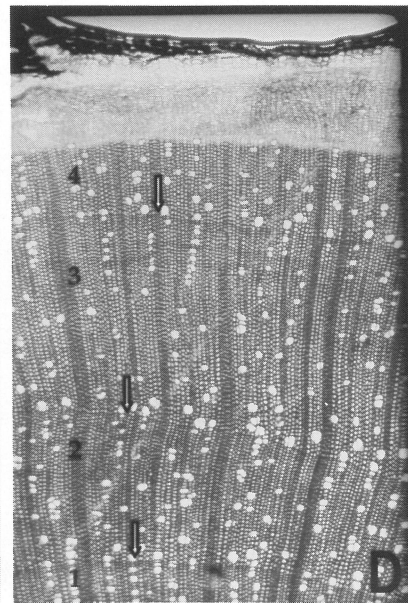
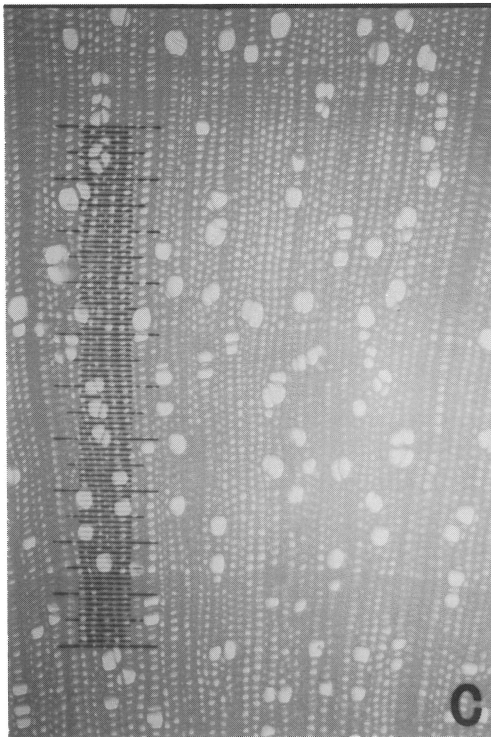
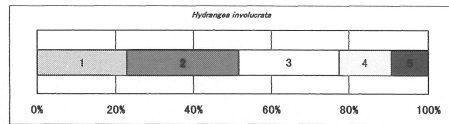
- Bark color
 (a) one-year-old stem: reddish brown
 (b) four-year-old stem: grayish brown

C. Cross section of a four-year-old stem with an objective micrometer (1mm)

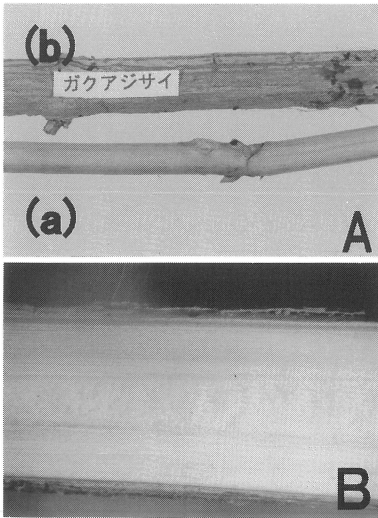
D. Cross section of a four-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary
- Pith proportion in one-year-old stem: 59.42%
- Growth rings of 1-3 and 4 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 10. *Hydrangea involucrata* (タマアジサイ) (Saxifragaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: green
- (b) four-year-old stem: brown

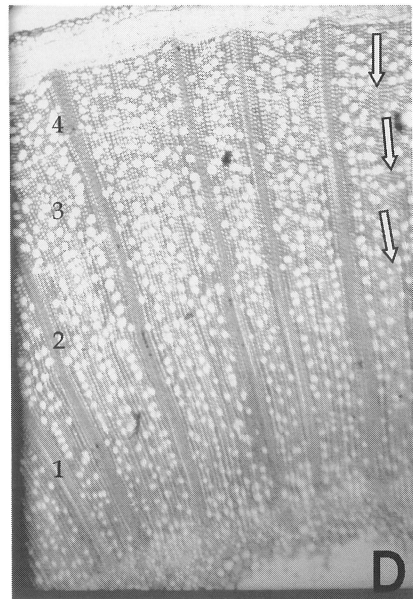
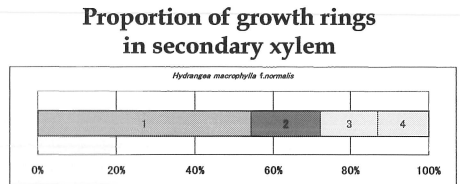
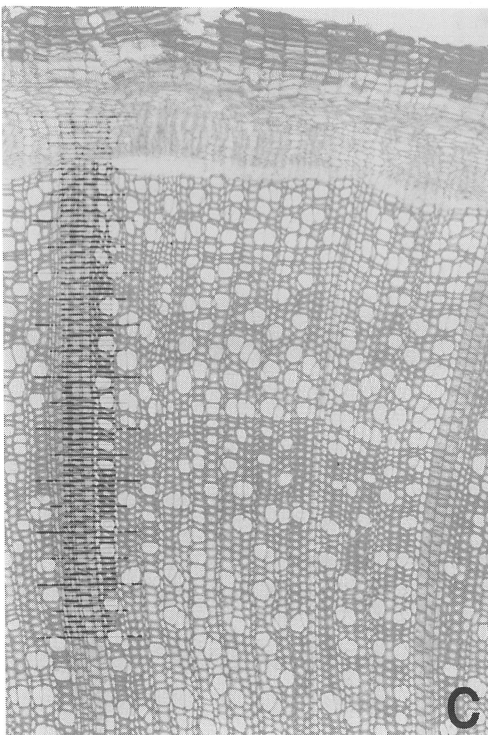
B. Pith in longitudinal section

- Condition: dense
- Color: white
- Proportion in one-year-old stem: 69.55%

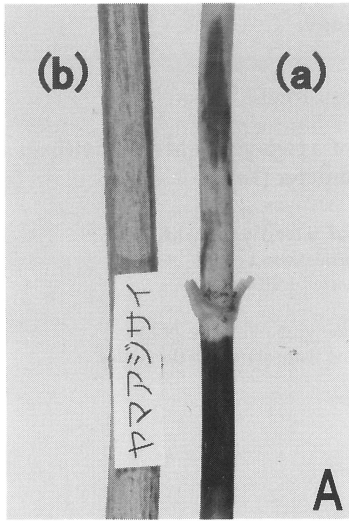
C. Cross section of a four-year-old stem with an objective micrometer (1mm)

D. Cross section of a four-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary
- Growth rings of 1-3 and 4 are shown in the figure.



App. 11. *Hydrangea macrophylla f. normalis* (ガクアジサイ) (Saxifragaceae).



A. Stem morphology

•Bark color

(a) one-year-old stem: green and reddish brown

(b) two-year-old stem: grayish brown

C. Cross section of a two-year-old stem with an objective micrometer (1mm)

D. Cross section of a two-year-old stem

•Porosity: diffuse-porous wood

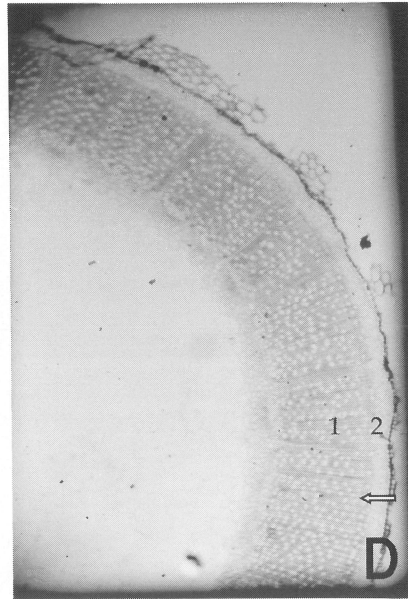
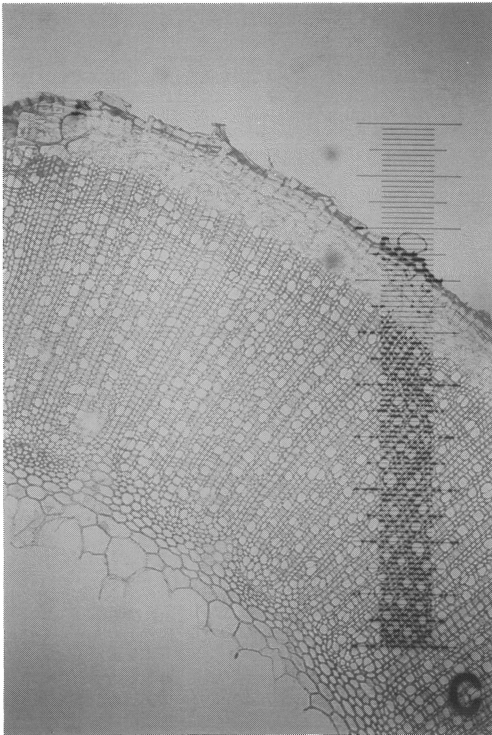
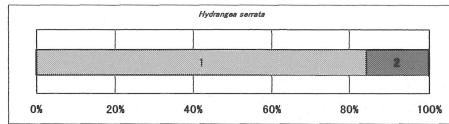
•Growth ring boundaries: distinct

•Pores: solitary

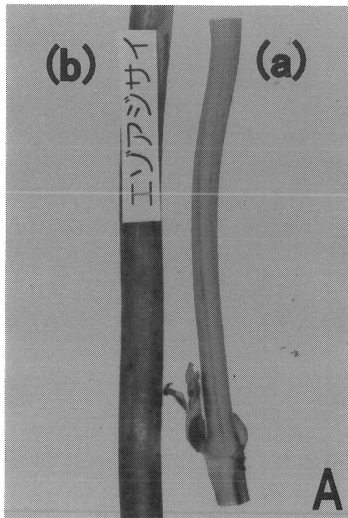
•Pith proportion in one-year-old stem: 74.19%

•Growth rings of 1 and 2 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 12. *Hydrangea serrata* (ヤマアジサイ) (Saxifragaceae).



A. Stem morphology

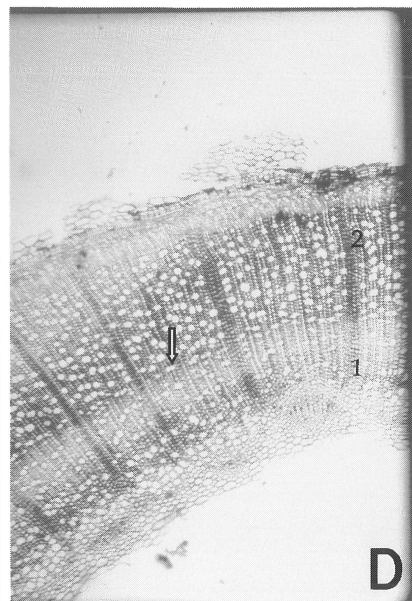
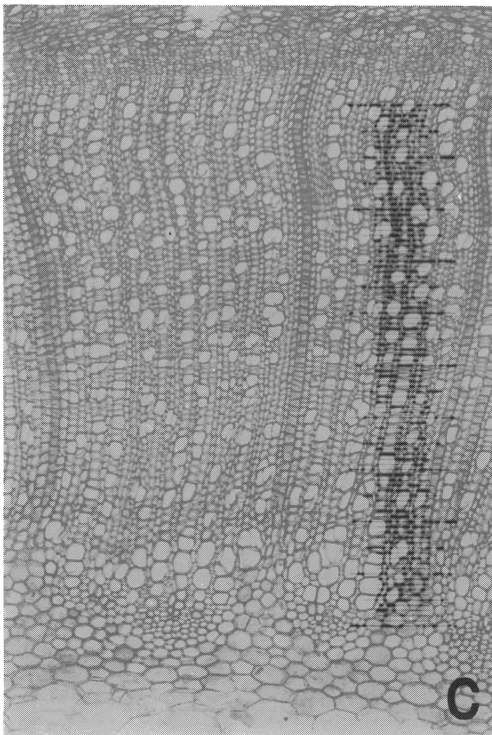
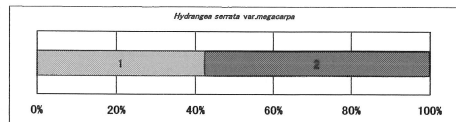
- Bark color
 - (a) one-year-old stem: green
 - (b) three-year-old stem: reddish brown

C. Cross section of a two-year-old stem with an objective micrometer (1mm)

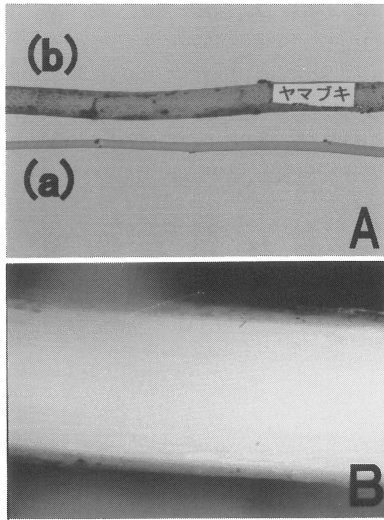
D. Cross section of a two-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: indistinct
- Pores: solitary
- Pith proportion in one-year-old stem: 79.13%
- Growth rings of 1 and 2 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 13. *Hydrangea serrata* var. *megacarpa* (エゾアジサイ) (Saxifragaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: green
- (b) two-year-old stem: green

B. Pith in longitudinal section

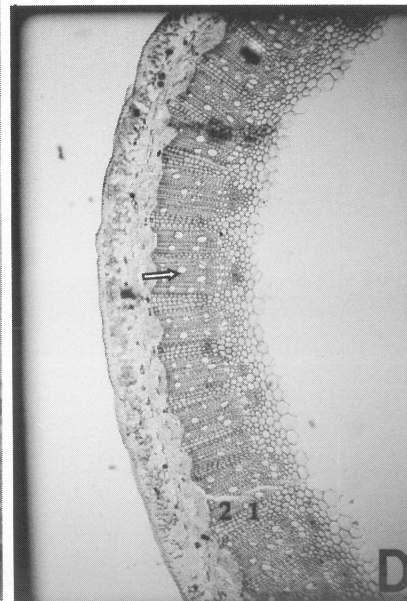
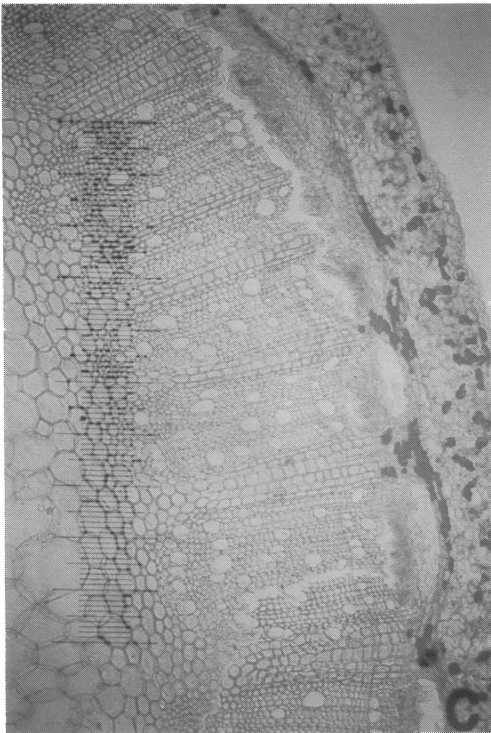
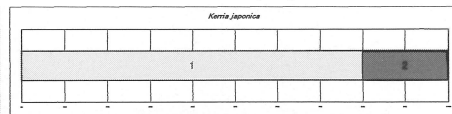
- Condition: dense
- Color: white
- Proportion in one-year-old stem: 85.64%

C. Cross section of a two-year-old stem with an objective micrometer (1mm)

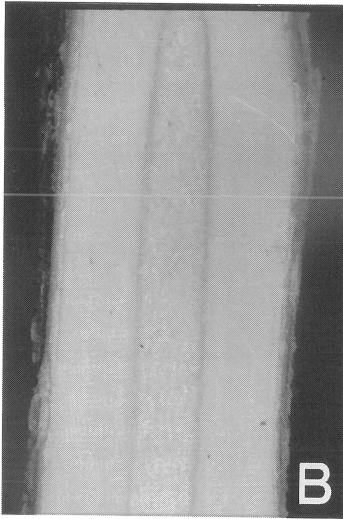
D. Cross section of a two-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: indistinct
- Pores: solitary
- Growth rings of 1 and 2 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 14. *Kerria japonica* (ヤマブキ) (Rosaceae).



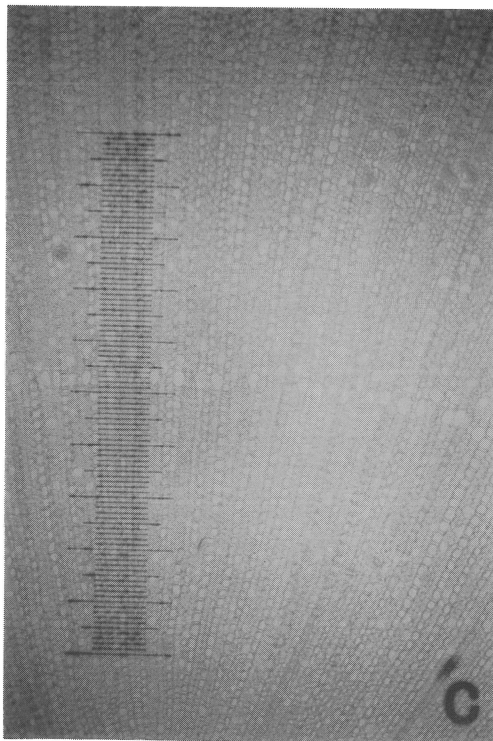
B. Pith in longitudinal section

- Condition: dense
- Color: white
- Proportion in one-year-old stem: 43.44%

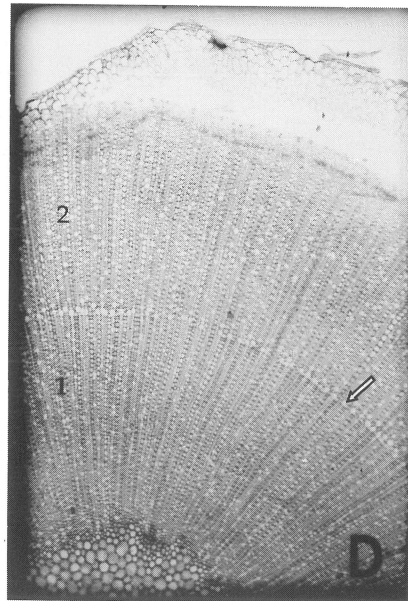
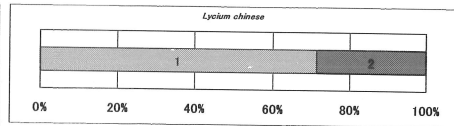
C. Cross section of a two-year-old stem with an objective micrometer (1mm)

D. Cross section of a two-year-old stem

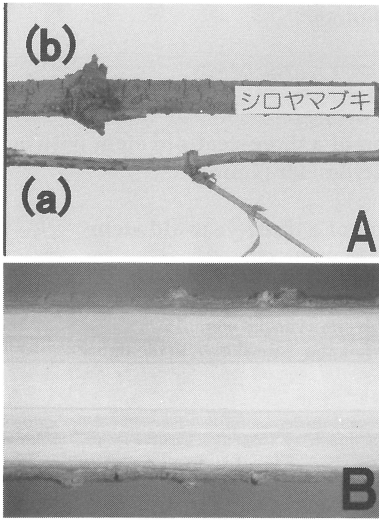
- Porosity: semi-ring-porous wood
- Growth ring boundaries: distinct
- Pores: solitary
- Growth rings of 1 and 2 are shown in the figure.



**Proportion of growth rings
in secondary xylem**



App. 15. *Lycium chinense* (クコ) (Solanaceae).



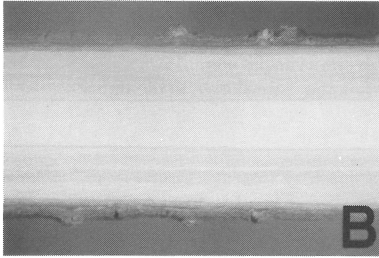
A. Stem morphology

- Bark color
- (a) one-year-old stem: green
- (b) three-year-old stem: dark brown

B. Pith in longitudinal section

- Condition: dense
- Color: white
- Proportion in one-year-old stem: 49.85%

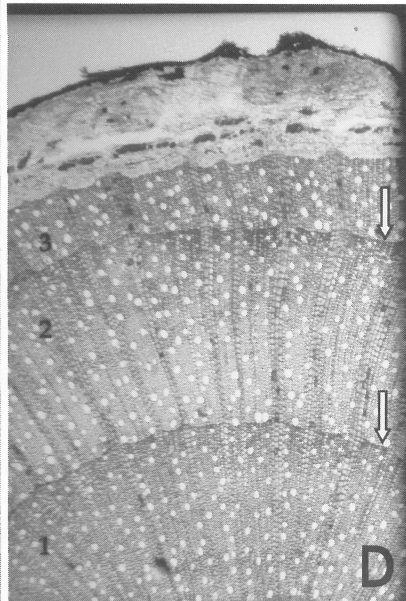
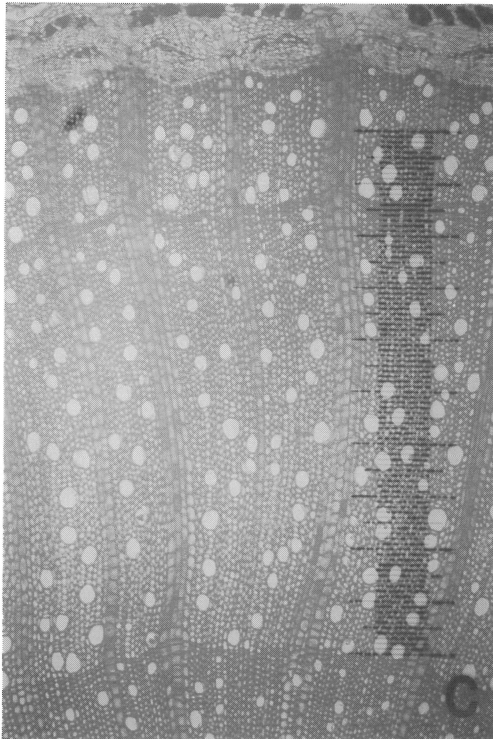
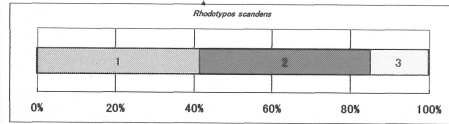
C. Cross section of a three-year-old stem with an objective micrometer (1mm)



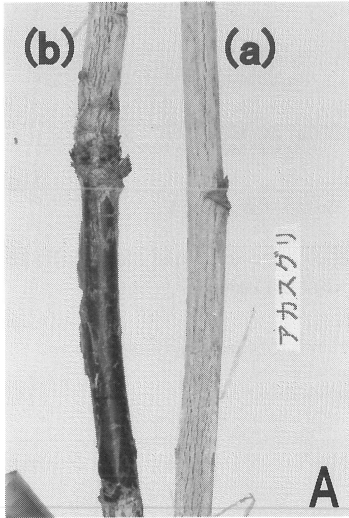
D. Cross section of a three-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary
- Growth rings of 1, 2 and 3 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 16. *Rhodotypos scandens* (シロヤマブキ) (Rosaceae).



A. Stem morphology

- Bark color

(a) one-year-old stem: grayish brown

(b) three-year-old stem: reddish brown

C. Cross section of a three-year-old stem with an objective micrometer (1mm)

D. Cross section of a three-year-old stem

- Porosity: diffuse-porous wood

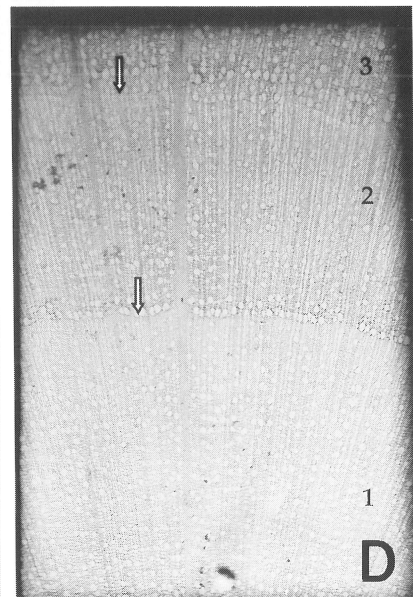
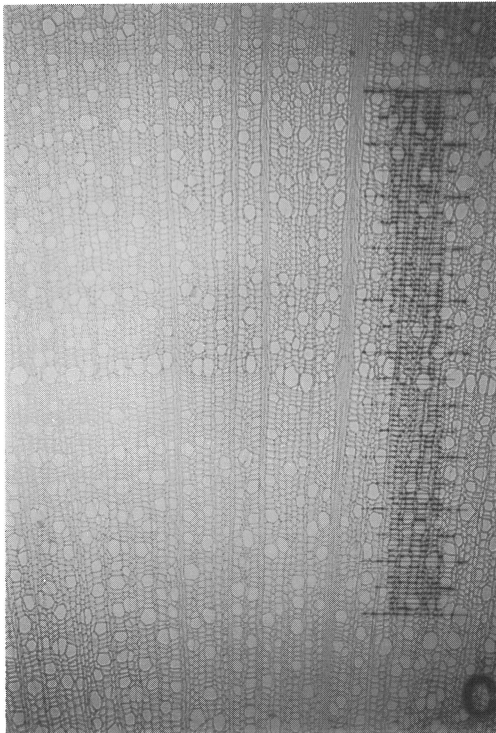
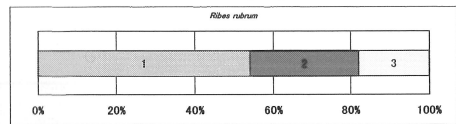
•Growth ring boundaries: distinct

•Pores: solitary

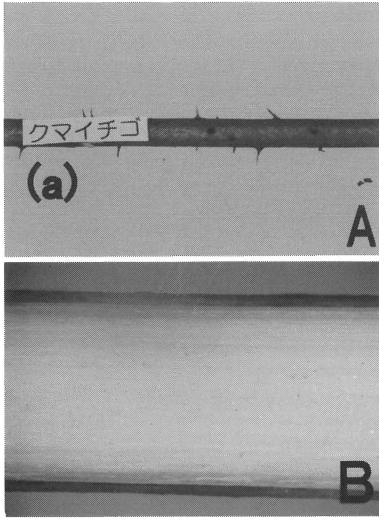
•Pith proportion in one-year-old stem: 45.25%

•Growth rings of 1, 2 and 3 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 17. *Ribes rubrum* (アカスグリ) (Saxifragaceae).



A. Stem morphology

- Bark color
- (a) two-year-old stem: reddish brown

B. Pith in longitudinal section

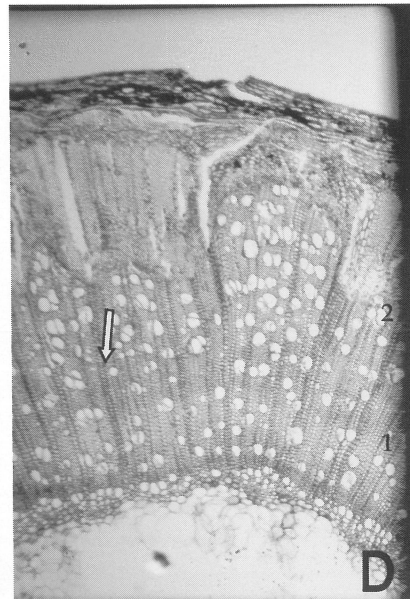
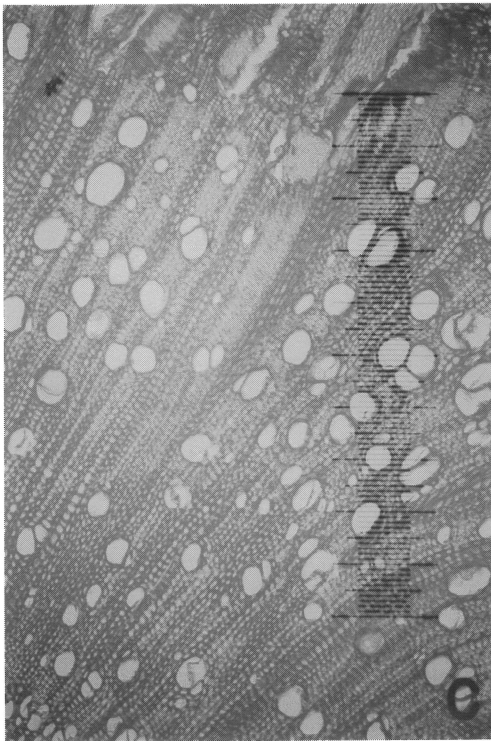
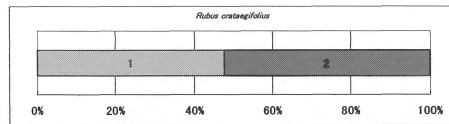
- Condition: dense
- Color: yellowish white
- Proportion in one-year-old stem: 64.96%

C. Cross section of a two-year-old stem with an objective micrometer (1mm)

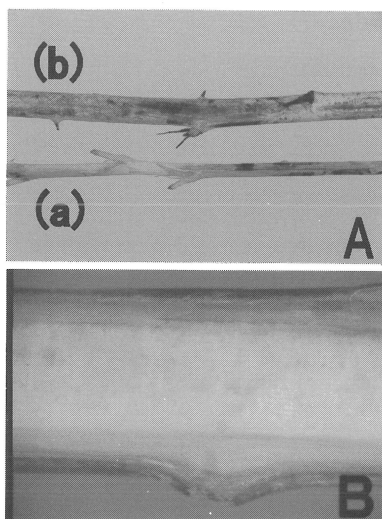
D. Cross section of a two-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: indistinct
- Pores: solitary (one-year-old stem), in clusters (xylem made after two-years)
- Growth rings of 1 and 2 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 18. *Rubus crataegifolius* (クマイチゴ) (Rosaceae).



A. Stem morphology

- Bark color
 - (a) one-year-old stem: green
 - (b) three-year-old stem: reddish purple

B. Pith in longitudinal section

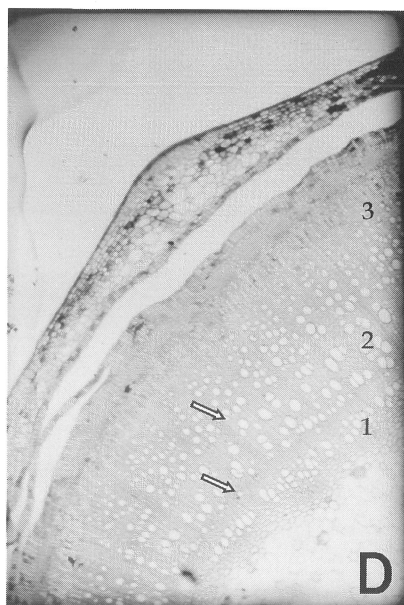
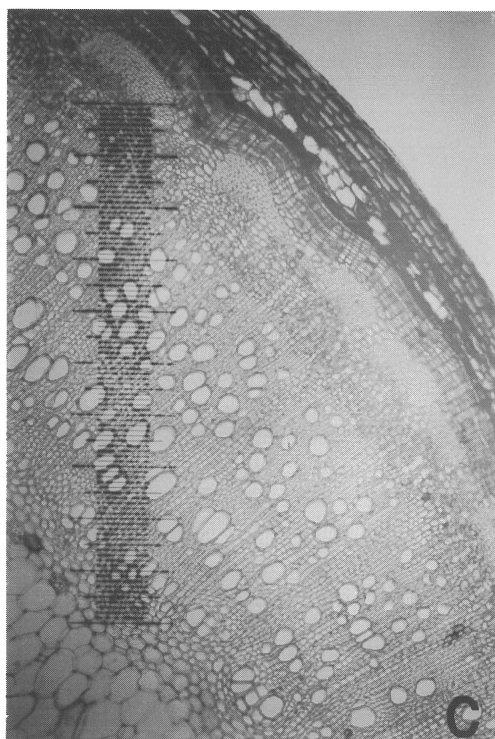
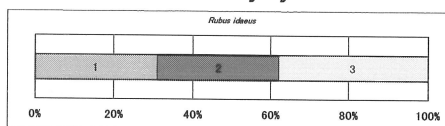
- Condition: dense
- Color: white
- Proportion in one-year-old stem: 91.61%

C. Cross section of a three-year-old stem with an objective micrometer (1mm)

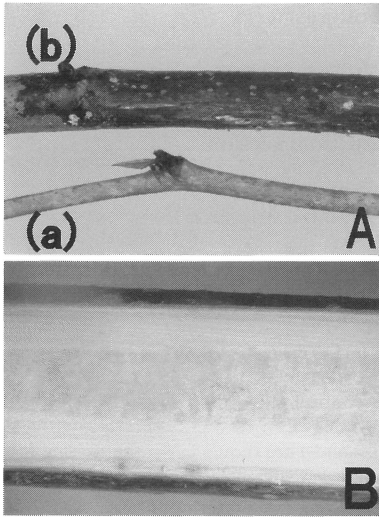
D. Cross section of a three-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: indistinct
- Pores: solitary, or in clusters
- Growth rings of 1, 2 and 3 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 19. *Rubus idaeus* (ラズベリー) (Rosaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: green
- (b) three-year-old stem: reddish brown

B. Pith in longitudinal section

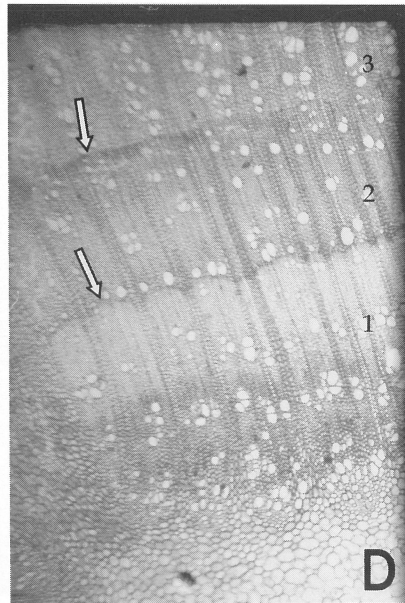
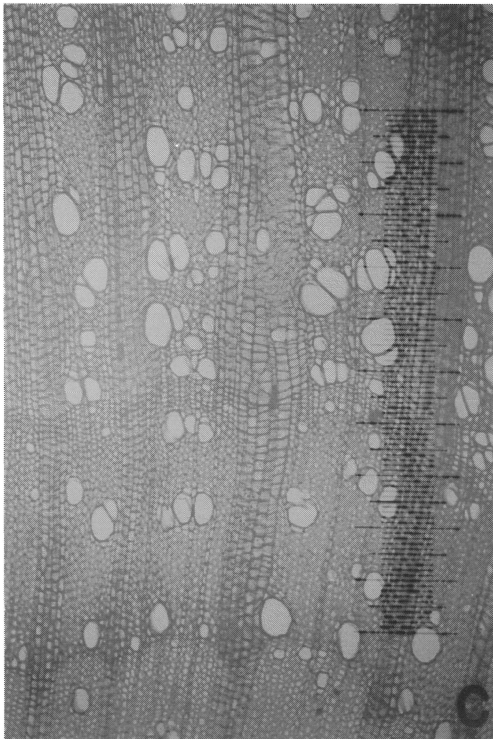
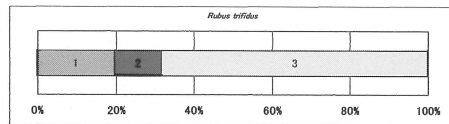
- Condition: dense
- Color: reddish brown
- Proportion in one-year-old stem: 89.46%

C. Cross section of a three-year-old stem with an objective micrometer (1mm)

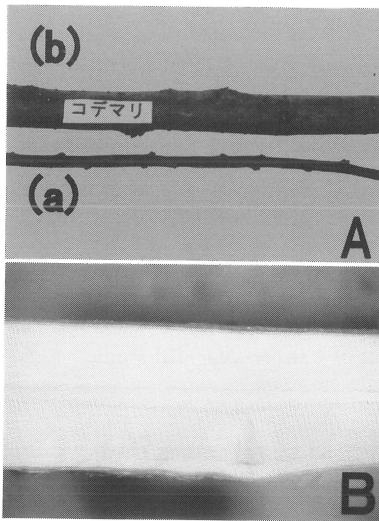
D. Cross section of a three-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary, or in clusters
- Growth rings of 1, 2 and 3 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 20. *Rubus trifidus* (カシイチゴ) (Rosaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: dark brown
- (b) four-year-old stem: dark brown

B. Pith in longitudinal section

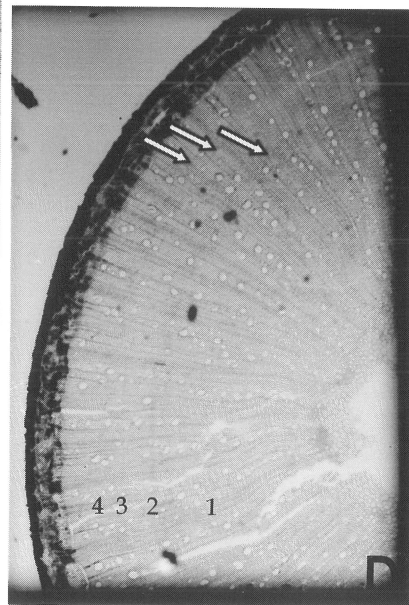
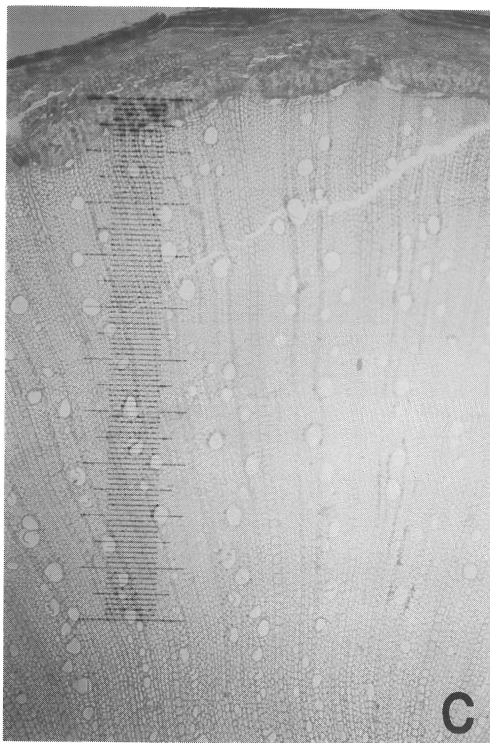
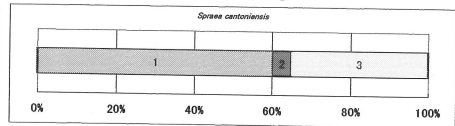
- Condition: dense
- Color: yellowish brown
- Proportion in one-year-old stem: 38.25%

C. Cross section of a three-year-old stem with an objective micrometer (1mm)

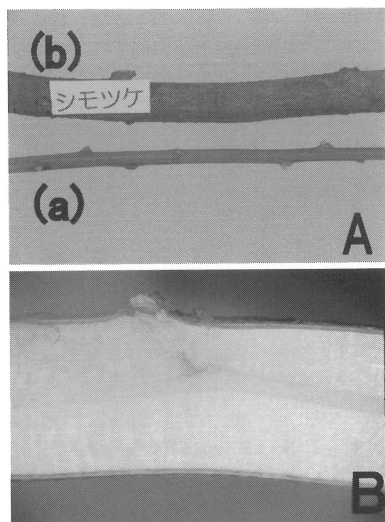
D. Cross section of a four-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: indistinct
- Pores: solitary
- Growth rings of 1-3 and 4 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 21. *Spiraea cantoniensis* (コデマリ) (Rosaceae).



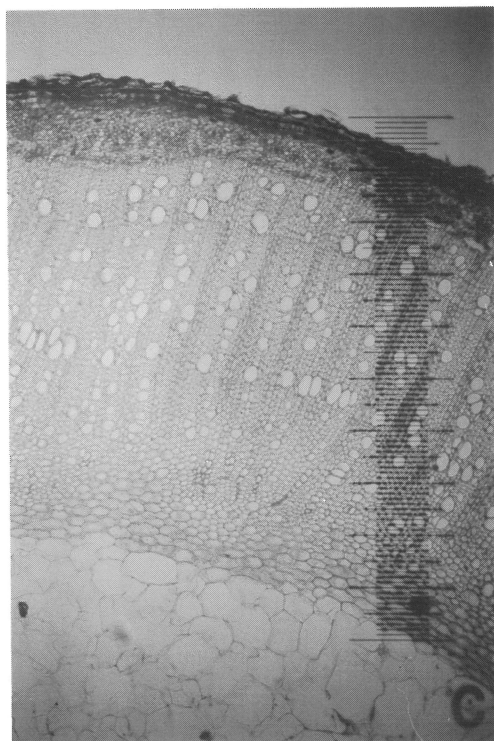
A. Stem morphology

- Bark color
- (a) one-year-old stem: reddish brown
- (b) three-year-old stem: dark brown

B. Pith in longitudinal section

- Condition: dense
- Color: light yellow
- Proportion in one-year-old stem: 83.94%

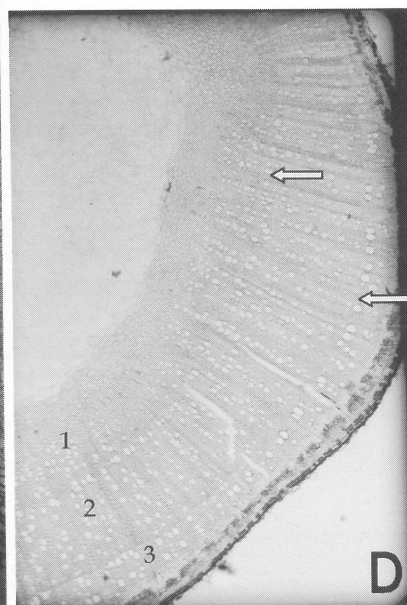
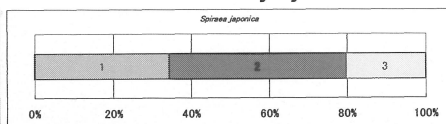
C. Cross section of a three-year-old stem with an objective micrometer (1mm)



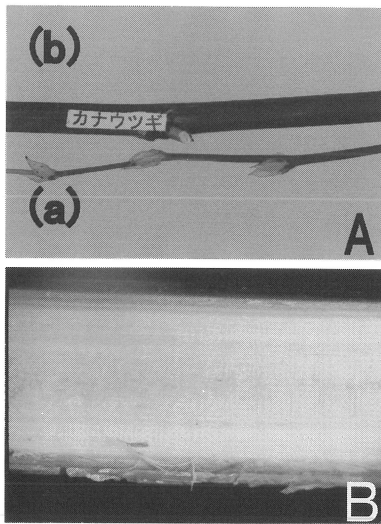
D. Cross section of a three-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary
- Growth rings of 1, 2 and 3 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 22. *Spiraea japonica* (シモツケ) (Rosaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: reddish brown
- (b) three-year-old stem: reddish brown

B. Pith in longitudinal section

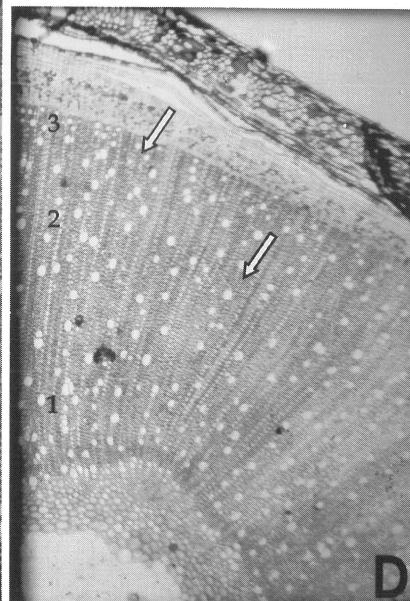
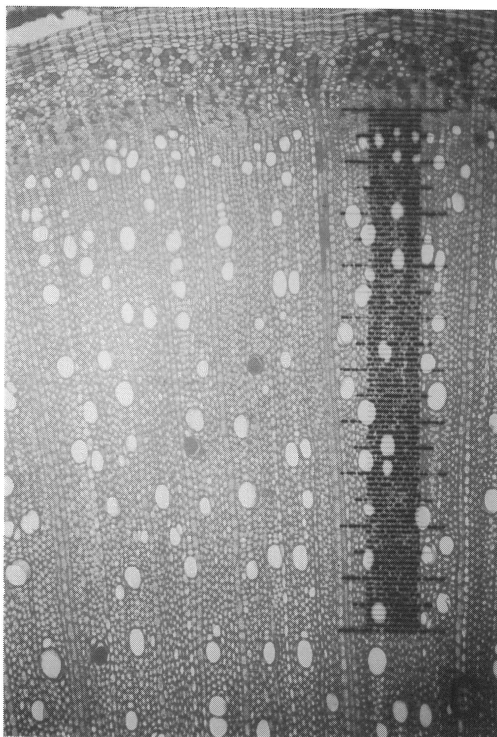
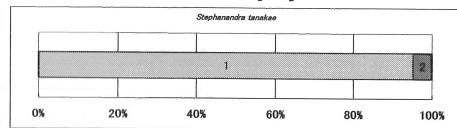
- Condition: dense
- Color: yellowish brown
- Proportion in one-year-old stem: 56.72%

C. Cross section of a three-year-old stem with an objective micrometer (1mm)

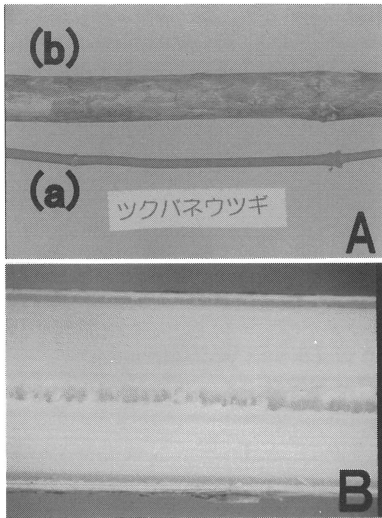
D. Cross section of a three-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: indistinct
- Pores: solitary
- Growth rings of 1, 2 and 3 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 23. *Stephanandra tanakae* (カナウツギ) (Rosaceae).



A. Stem morphology

- Bark color
 - (a) one-year-old stem: reddish brown
 - (b) three-year-old stem: brown

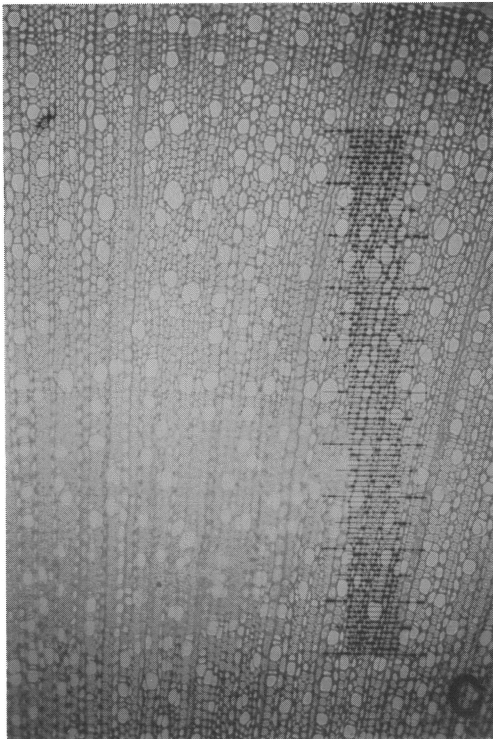
B. Pith in longitudinal section

- Condition: rough
- Color: yellowish brown
- Proportion in one-year-old stem: 64.17%

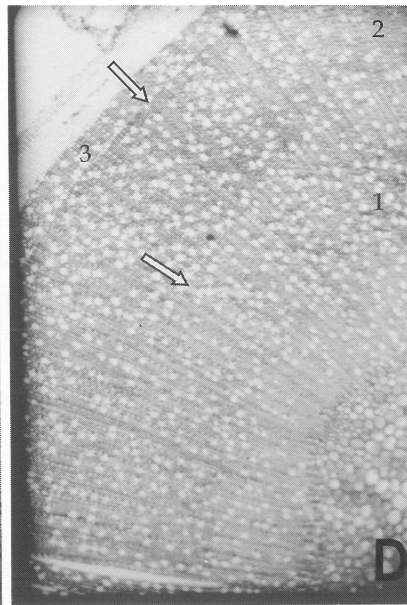
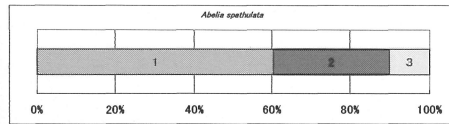
C. Cross section of a three-year-old stem with an objective micrometer (1mm)

D. Cross section of a three-year-old stem

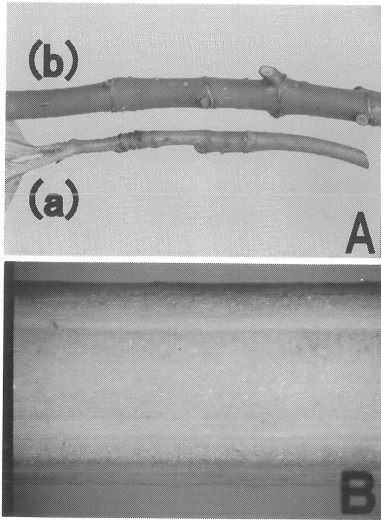
- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary
- Growth rings of 1, 2 and 3 are shown in the figure.



Proportion of growth rings in secondary xylem



App. 24. *Abelia spathulata* var. *spathulata* (ツクバネウツギ) (Caprifoliaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: green
- (b) six-year-old stem: green

B. Pith in longitudinal section

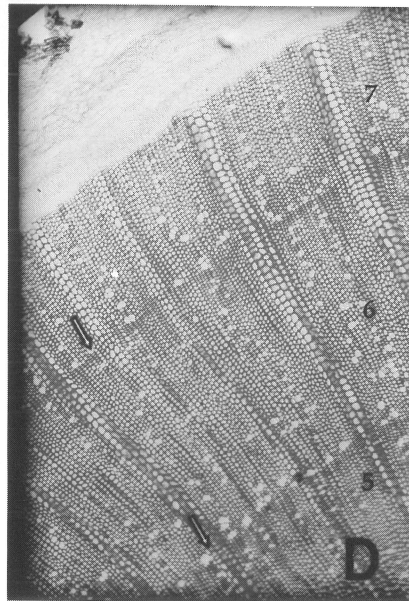
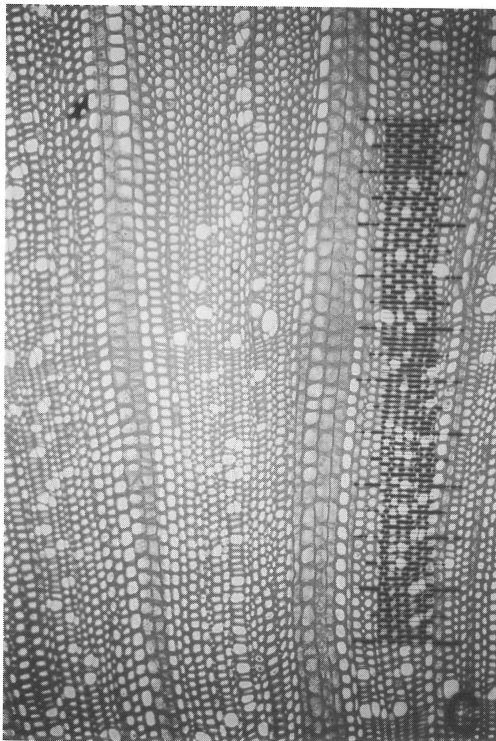
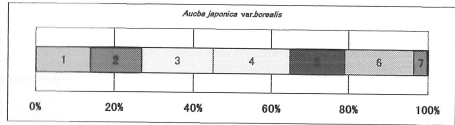
- Condition: dense
- Color: white
- Proportion in one-year-old stem: 72.92%

C. Cross section of a seven-year-old stem with an objective micrometer (1mm)

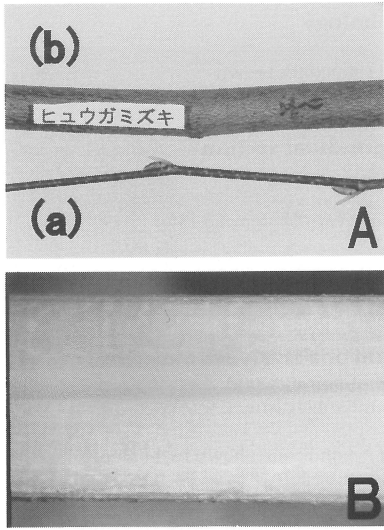
D. Cross section of a seven-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary
- Growth rings of 5, 6 and 7 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 25. *Aucuba japonica var. borealis* (ヒメアオキ) (Cornaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: reddish brown
- (b) three-year-old stem: reddish brown

B. Pith in longitudinal section

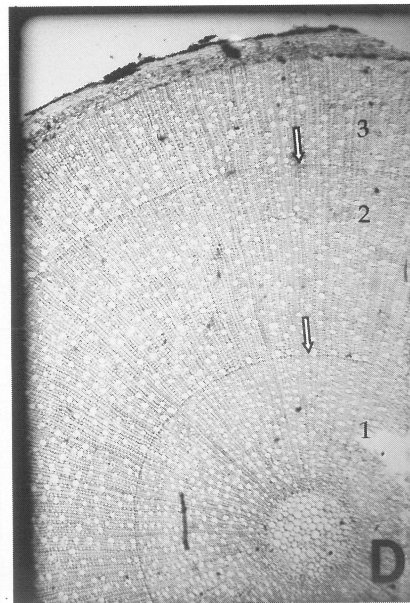
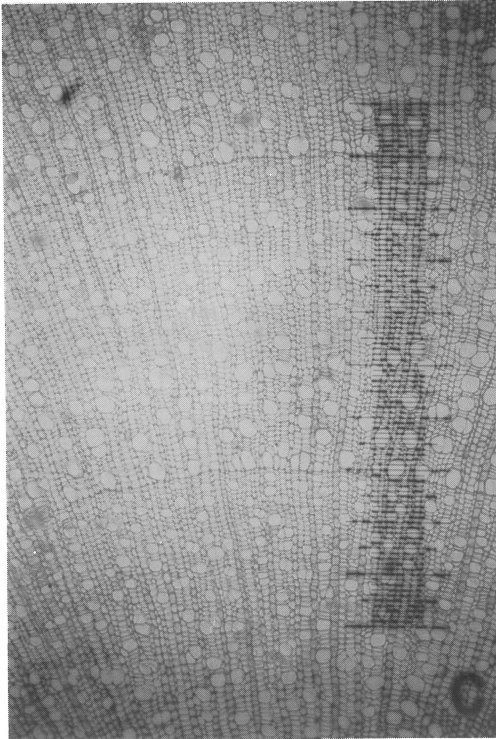
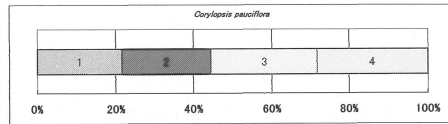
- Condition: dense
- Color: brown
- Proportion in one-year-old stem: 44.68%

C. Cross section of a three-year-old stem with an objective micrometer (1mm)

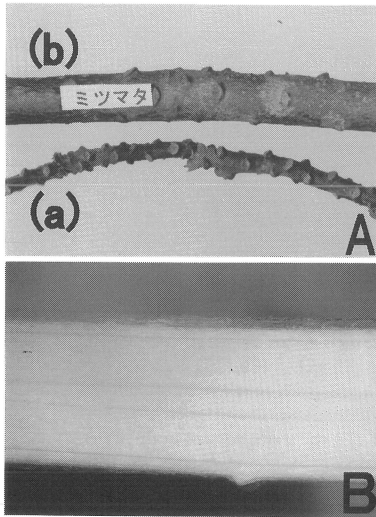
D. Cross section of a three-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary
- Growth rings of 1, 2 and 3 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 26. *Corylopsis pauciflora* (ヒュウガミズキ) (Hamamelidaceae).



A. Stem morphology

- Bark color
 - (a) one-year-old stem: dark brown
 - (b) five-year-old stem: dark brown

B. Pith in longitudinal section

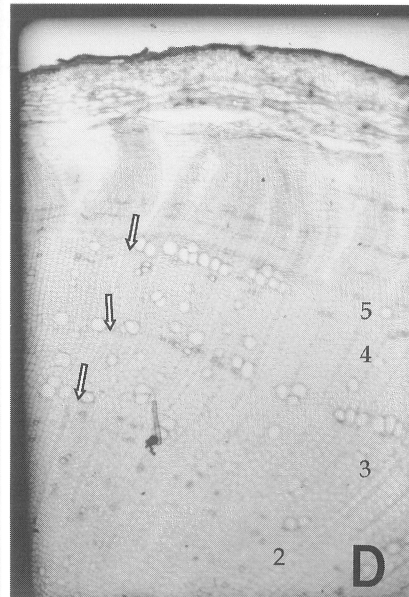
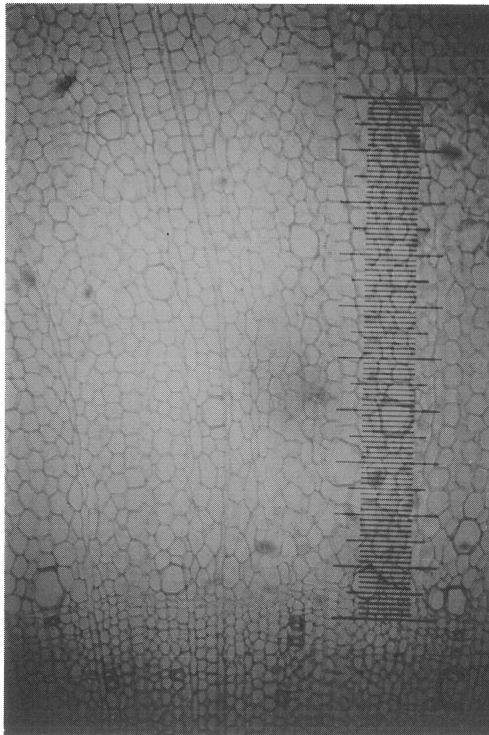
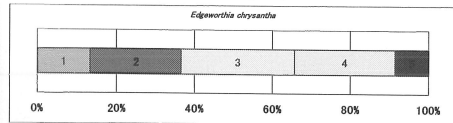
- Condition: dense
- Color: white
- Proportion in one-year-old stem: 25.13%

C. Cross section of a five-year-old stem with an objective micrometer (1mm)

D. Cross section of a five-year-old stem

- Porosity: semi-ring-porous wood
- Growth ring boundaries: distinct
- Pores: solitary
- Growth rings of 2-4 and 5 are shown in the figure.

Proportion of growth rings in secondary xylem in *Edgeworthia chrysantha*



App. 27. *Edgeworthia chrysantha* (ミツマタ) (Thymelaeaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: light brown
- (b) six-year-old stem: light brown

B. Pith in longitudinal section

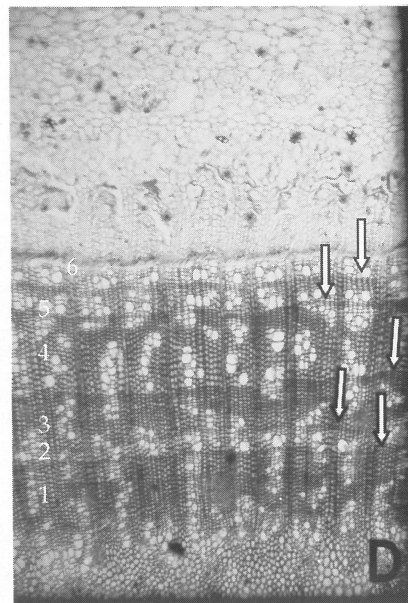
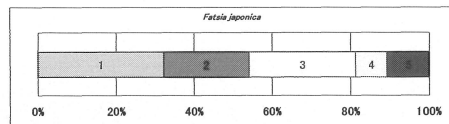
- Condition: dense
- Color: yellowish white
- Proportion in one-year-old stem: 77.80%

C. Cross section of a six-year-old stem with an objective micrometer (1mm)

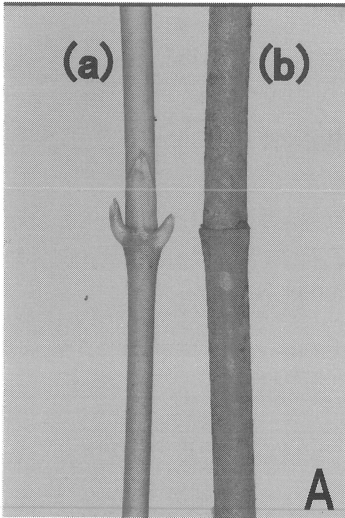
D. Cross section of a six-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: in clusters
- Growth rings of 1-5 and 6 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 28. *Fatsia japonica* (ヤツデ) (Araliaceae).



A. Stem morphology

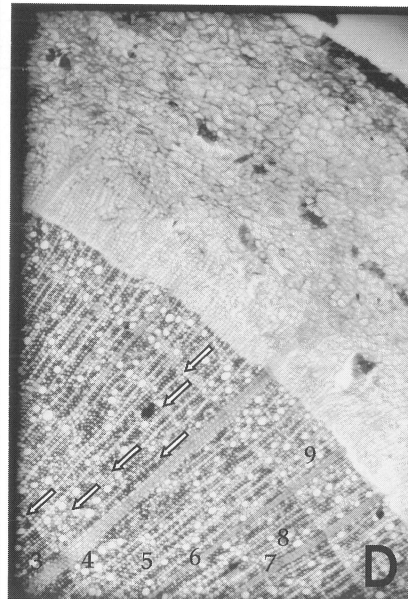
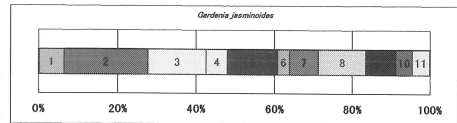
- Bark color
- (a) one-year-old stem: green
- (b) three-year-old stem: brown

C. Cross section of a nine-year-old stem with an objective micrometer (1mm)

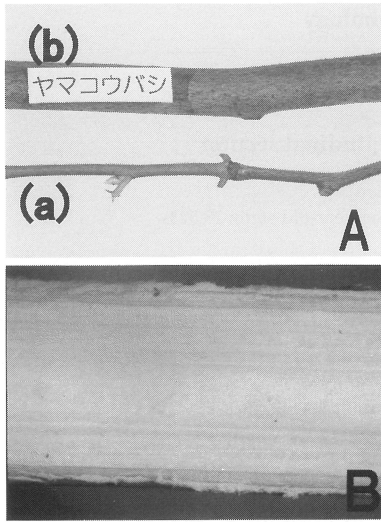
D. Cross section of a nine-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary
- Pith proportion in one-year-old stem: 77.78%
- Growth rings of 3-8 and 9 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 29. *Gardenia jasminoides* f. *jasminoides* (クチナシ) (Rubiaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: reddish brown
- (b) four-year-old stem: reddish brown

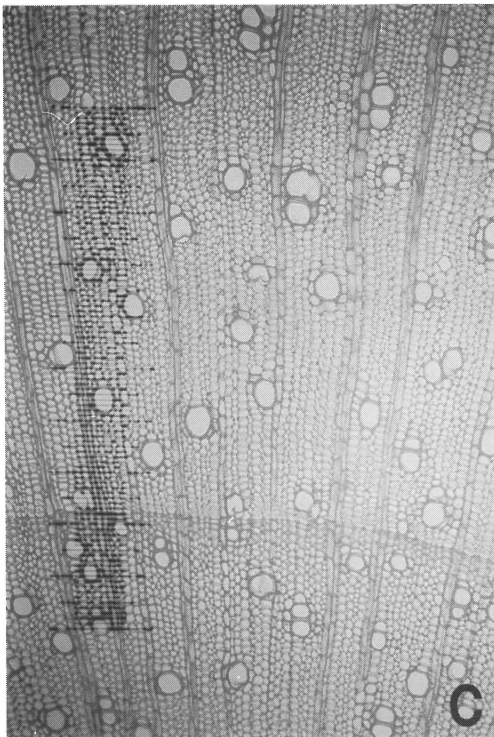
B. Pith in longitudinal section

- Condition: dense
- Color: white
- Proportion in one-year-old stem: 32.72%

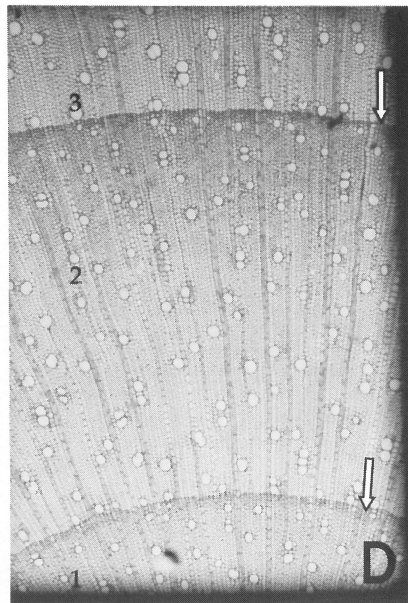
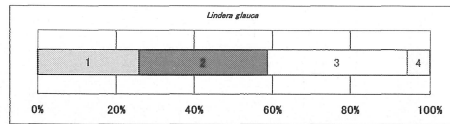
C. Cross section of a four-year-old stem with an objective micrometer (1mm)

D. Cross section of a four-year-old stem

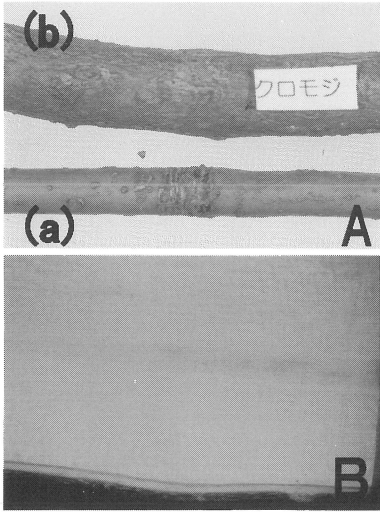
- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary, or in radial multiples
- Growth rings of 1, 2 and 3 are shown in the figure.



Proportion of growth rings in secondary xylem



App. 30. *Lindera glauca* (ヤマコウバシ) (Lauraceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: green
- (b) four-year-old stem: green and brown

B. Pith in longitudinal section

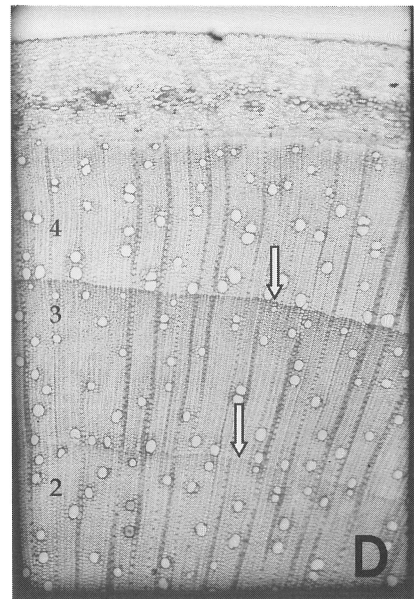
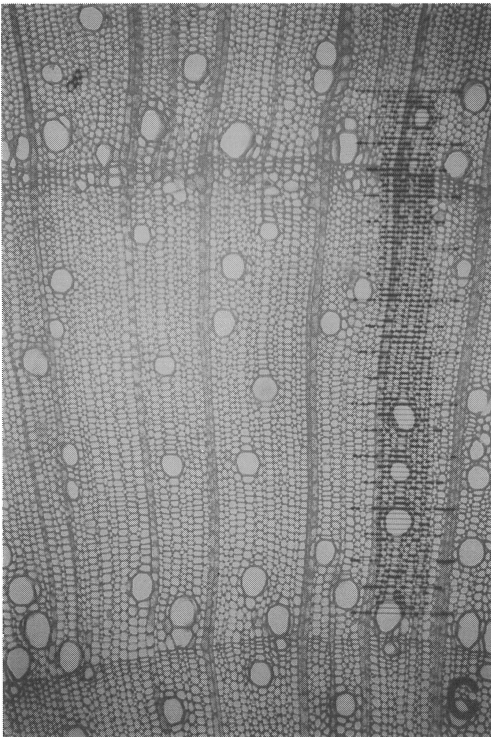
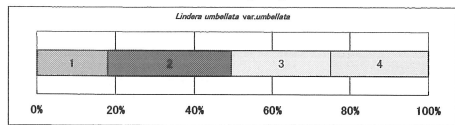
- Condition: dense
- Color: light brown
- Proportion in one-year-old stem: 73.52%

C. Cross section of a four-year-old stem with an objective micrometer (1mm)

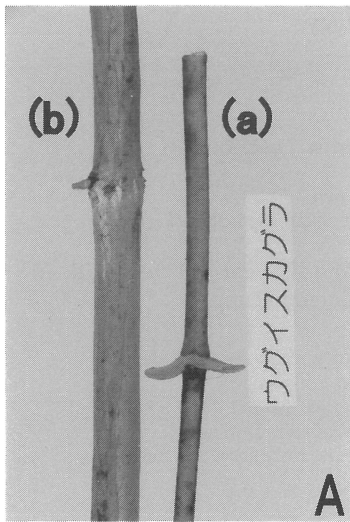
D. Cross section of a four-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary, or in radial multiples
- Growth rings of 2, 3 and 4 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 31. *Lindera umbellata* var. *umbellata* (クロモジ) (Lauraceae).



A. Stem morphology

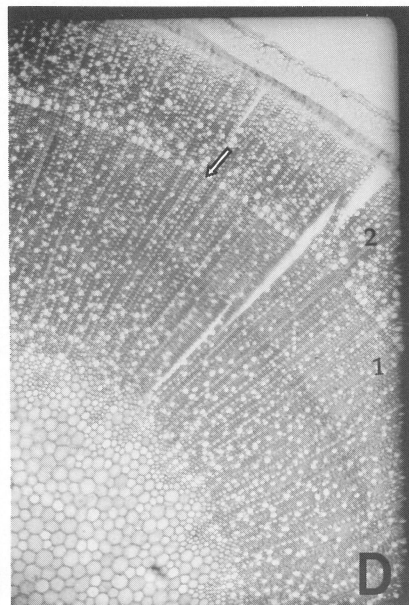
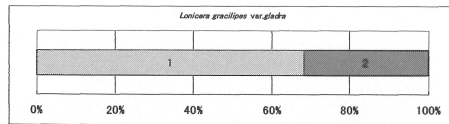
- Bark color
- (a) one-year-old stem: reddish brown
- (b) two-year-old stem: reddish brown

C. Cross section of a two-year-old stem with an objective micrometer (1mm)

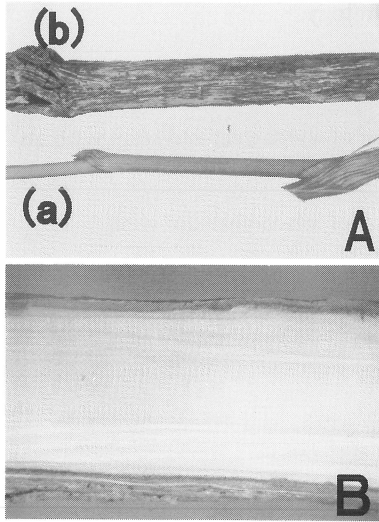
D. Cross section of a two-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary
- Pith proportion in one-year-old stem: 63.80%
- Growth rings of 1 and 2 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 32. *Lonicera gracilipes* (ウグイスカグラ) (Caprifoliaceae).



A. Stem morphology

- Bark color
 - (a) one-year-old stem: green
 - (b) six-year-old stem: brown

B. Pith in longitudinal section

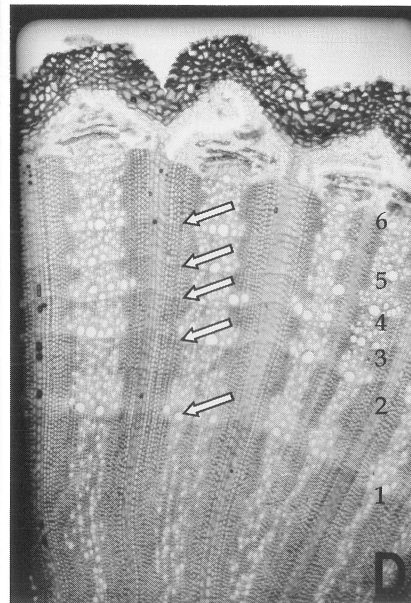
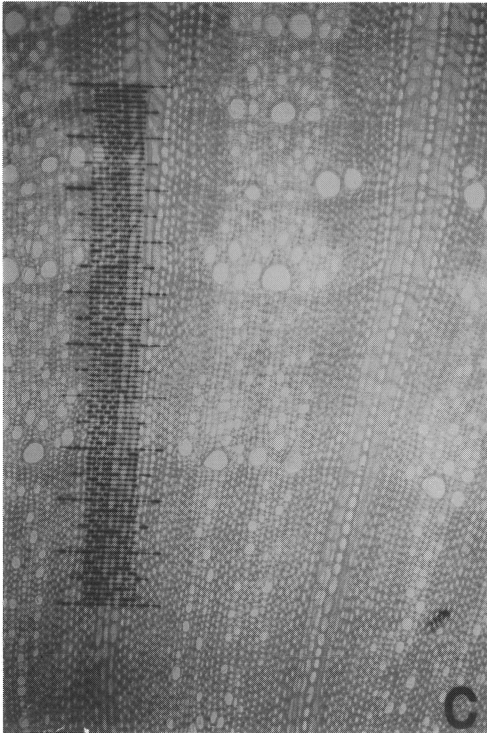
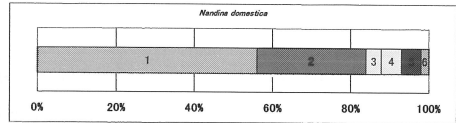
- Condition: dense
- Color: yellowish brown
- Proportion in one-year-old stem: 38.86%

C. Cross section of a six-year-old stem with an objective micrometer (1mm)

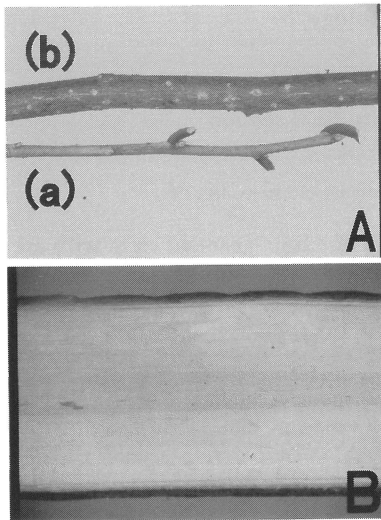
D. Cross section of a six-year-old stem

- Porosity: semi-ring-porous wood
- Growth ring boundaries: distinct
- Pores: solitary, or in radial multiples
- Growth rings of 1-5 and 6 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 33. *Nandina domestica* (ナンテン) (Berberidaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: grayish brown
- (b) three-year-old stem: khaki

B. Pith in longitudinal section

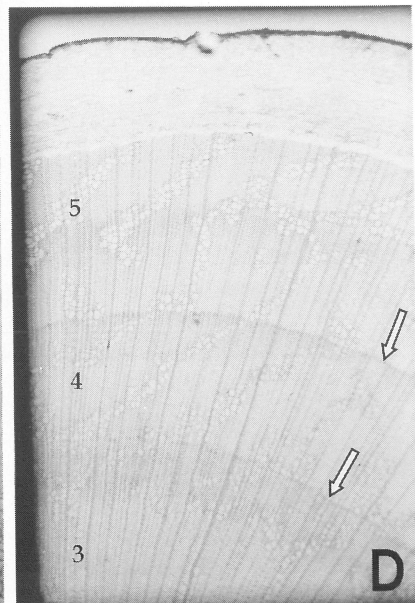
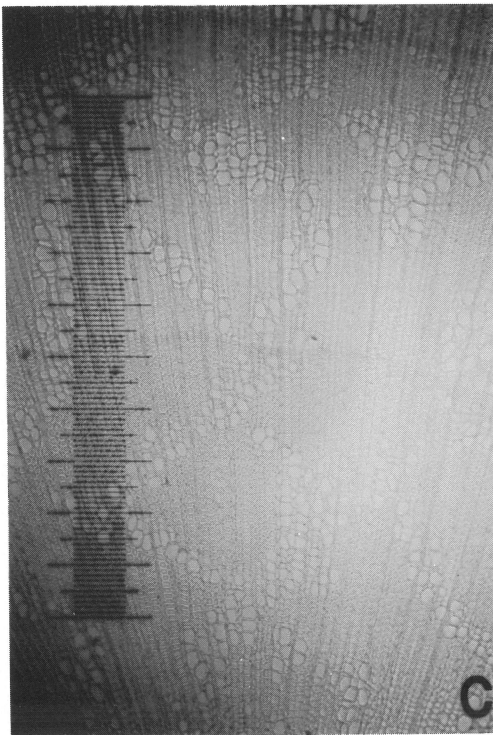
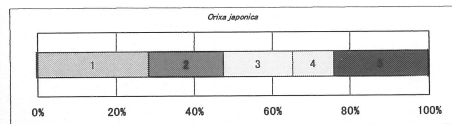
- Condition: rough
- Color: green
- Proportion in one-year-old stem: 48.92%

C. Cross section of a five-year-old stem with an objective micrometer (1mm)

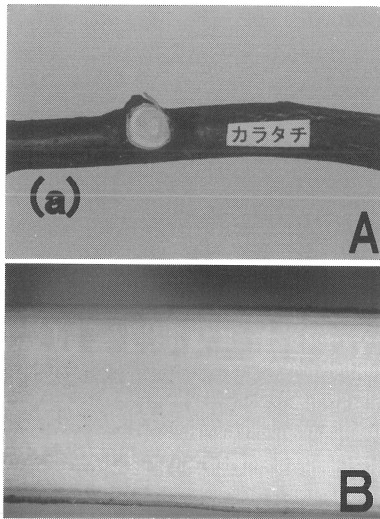
D. Cross section of a five-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: in clusters; in dendritic pattern
- Growth rings of 3, 4 and 5 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 34. *Oriza japonica* (コクサギ) (Rutaceae).



A. Stem morphology

- Bark color
- (a) four-year-old stem: green

B. Pith in longitudinal section

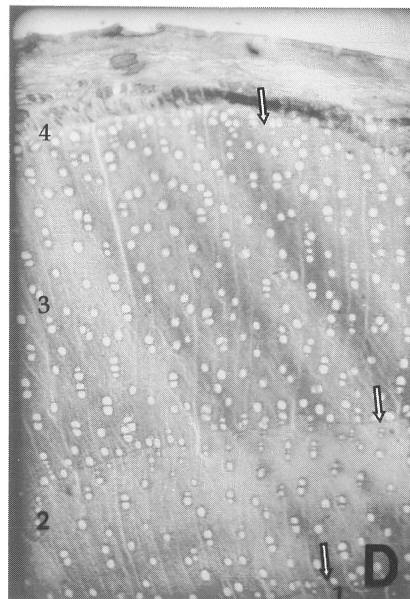
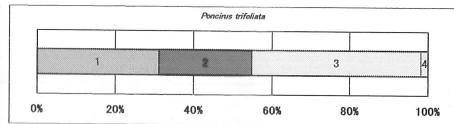
- Condition: dense
- Color: brown
- Proportion in one-year-old stem: 48.12%

C. Cross section of a four-year-old stem with an objective micrometer (1mm)

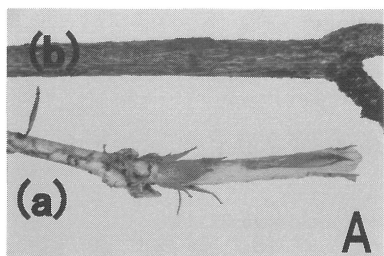
D. Cross section of a four-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary, or in radial multiples
- Growth rings of 1-3 and 4 are shown in the figure.

Proportion of growth rings in secondary xylem

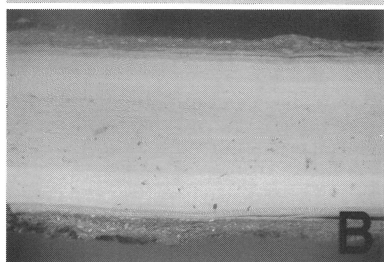


App. 35. *Poncirus trifoliata* (カラタチ) (Rutaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: green
- (b) four-year-old stem: dark brown



B. Pith in longitudinal section

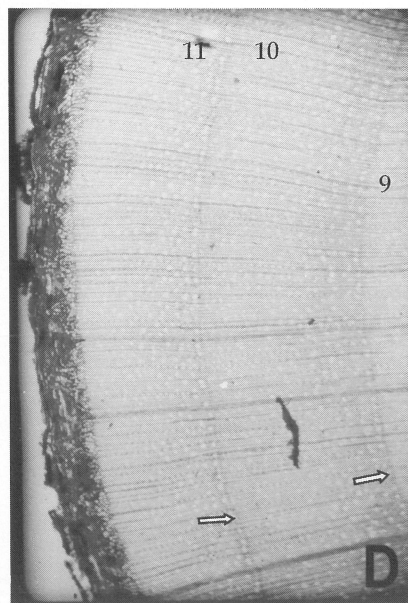
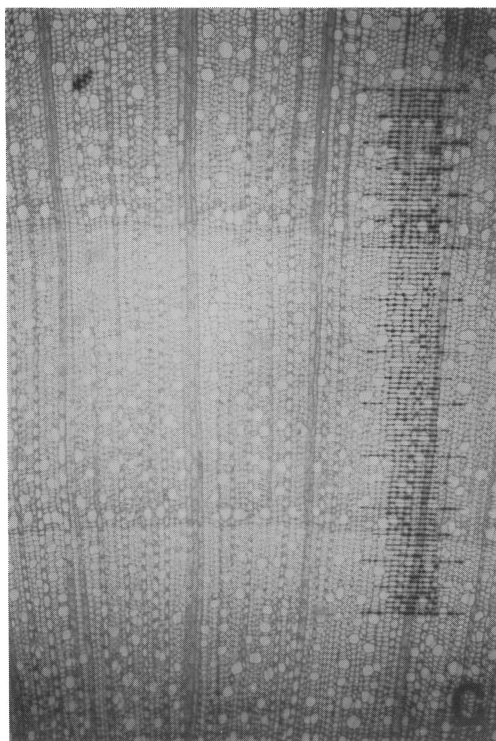
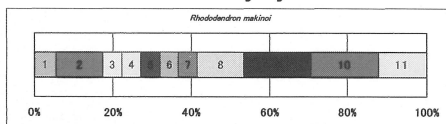
- Condition: dense
- Color: white
- Proportion in one-year-old stem: 61.64%

C. Cross section of a eleven-year-old stem with an objective micrometer (1mm)

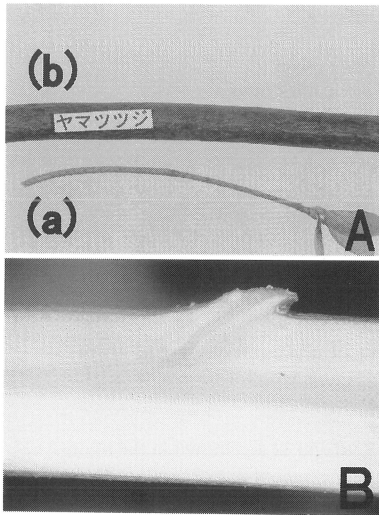
D. Cross section of a eleven-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary
- Growth rings of 9, 10 and 11 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 36. *Rhododendron makinoi* (ホソバシヤクナゲ) (Ericaceae).



A. Stem morphology

- Bark color
 - (a) one-year-old stem: brownish green
 - (b) five-year-old stem: dark brown

B. Pith in longitudinal section

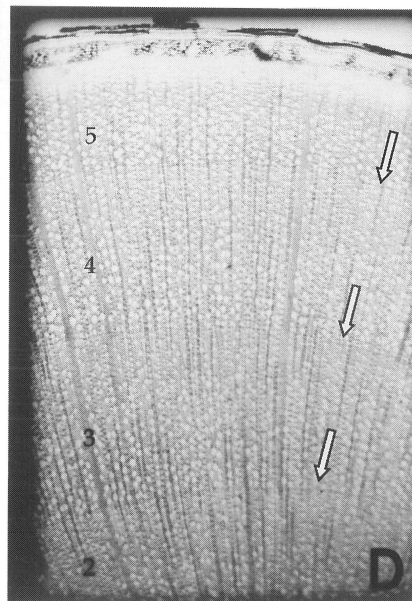
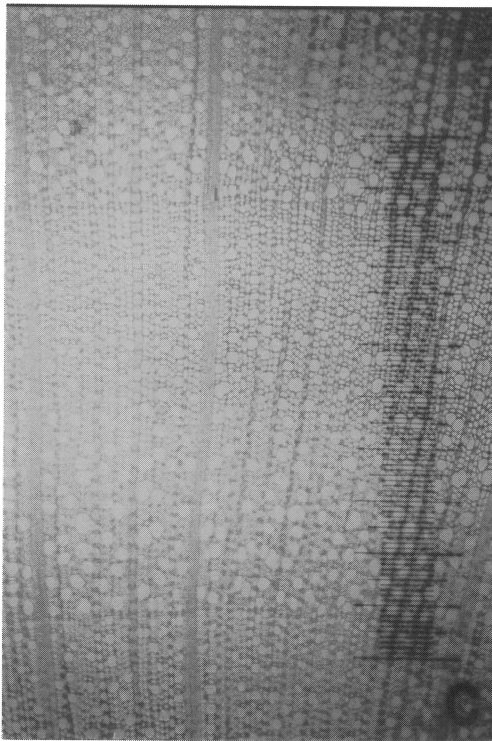
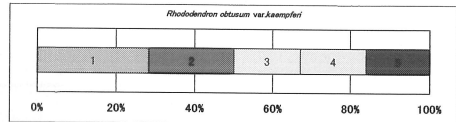
- Condition: dense
- Color: brown
- Proportion in one-year-old stem: 25.14%

C. Cross section of a five-year-old stem with an objective micrometer (1mm)

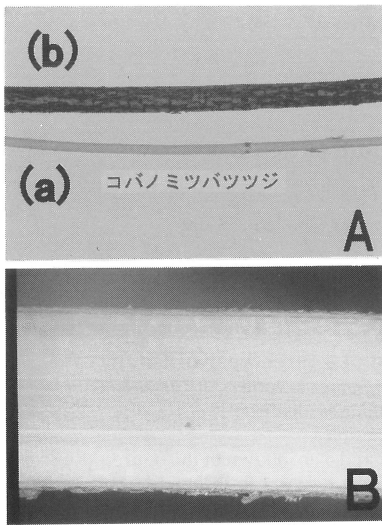
D. Cross section of a five-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary
- Growth rings of 2-4 and 5 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 37. *Rhododendron obtusum var. kaempferi* (ヤマツツジ) (Ericaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: brownish green
- (b) five-year-old stem: dark brown

B. Pith in longitudinal section

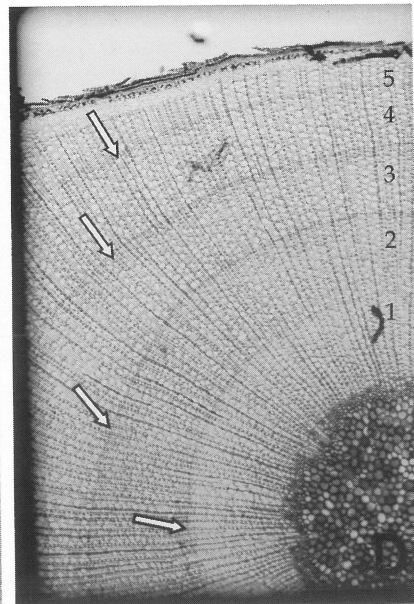
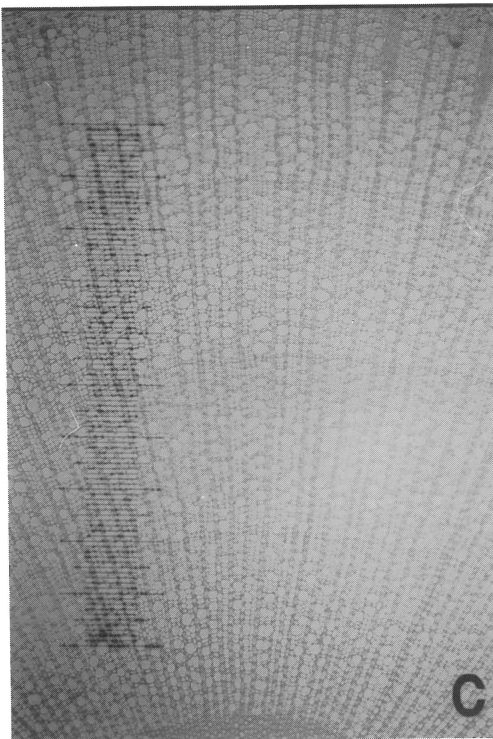
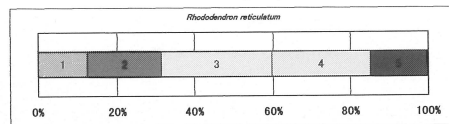
- Condition: dense
- Color: yellowish green
- Proportion in one-year-old stem: 55.88%

C. Cross section of a five-year-old stem with an objective micrometer (1mm)

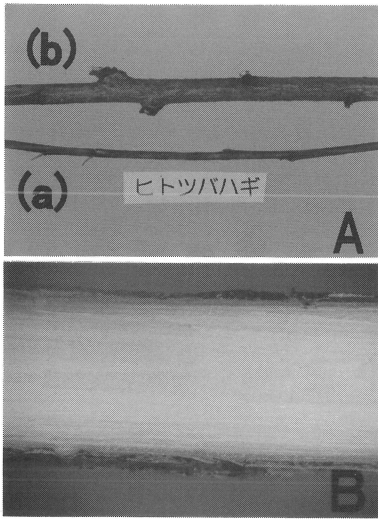
D. Cross section of a five-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary
- Growth rings of 1-4 and 5 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 38. *Rhododendron reticulatum* (コバノミツバツツジ) (Ericaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: brown
- (b) four-year-old stem: brown

B. Pith in longitudinal section

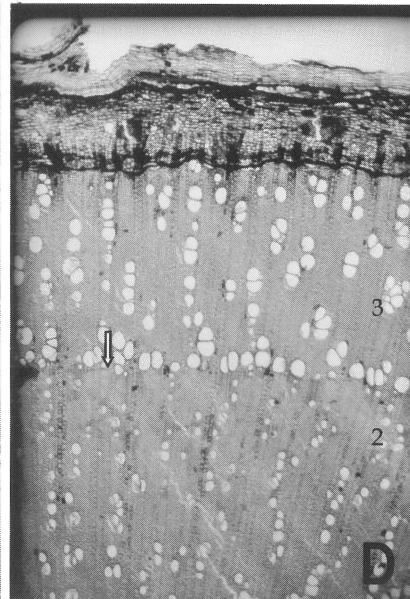
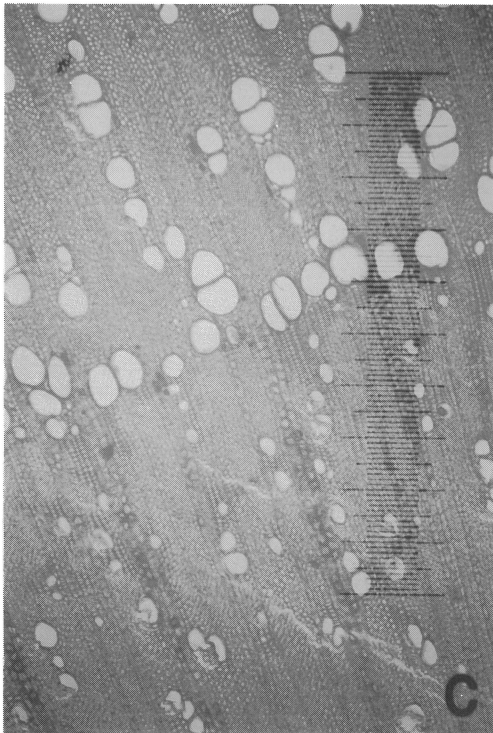
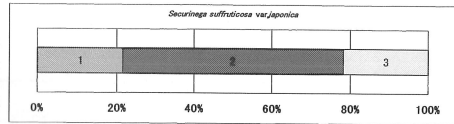
- Condition: dense
- Color: white
- Proportion in one-year-old stem: 38.70%

C. Cross section of a three-year-old stem with an objective micrometer (1mm)

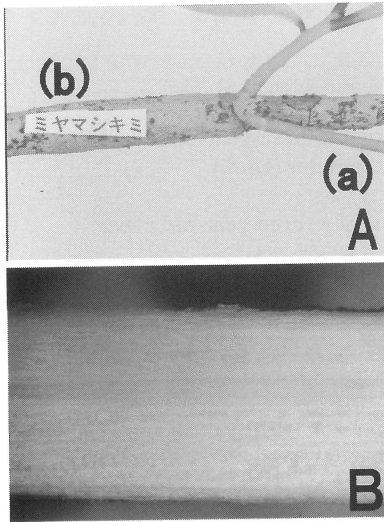
D. Cross section of a three-year-old stem

- Porosity: semi-ring-porous wood
- Growth ring boundaries: distinct
- Pores: in radial multiples
- Growth rings of 2 and 3 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 39. *Securinega suffruticosa* var. *japonica* (ヒトツバハギ) (Euphorbiaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: green
- (b) five-year-old stem: grayish brown

B. Pith in longitudinal section

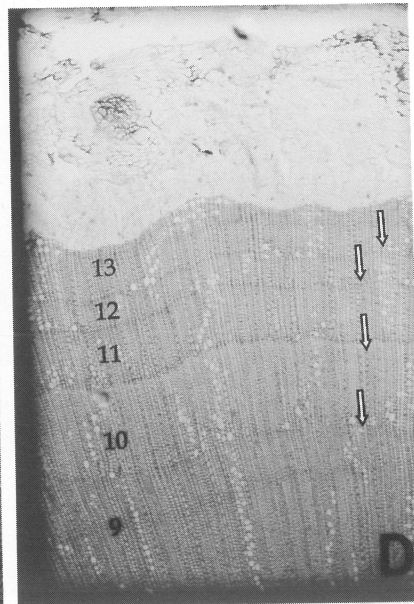
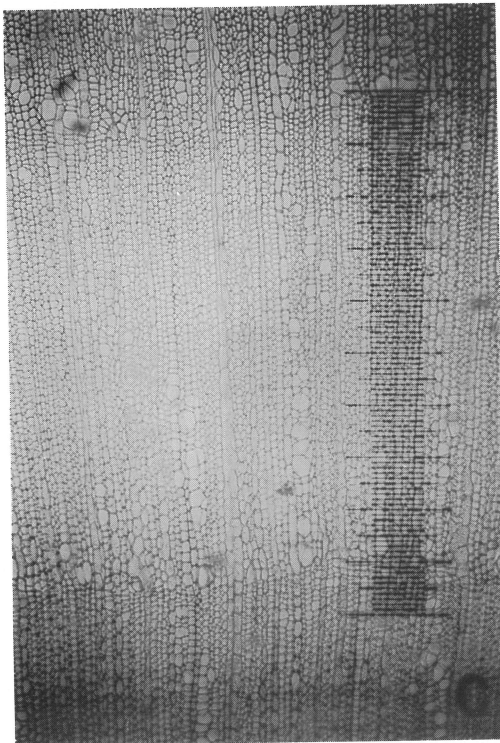
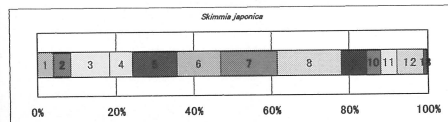
- Condition: dense
- Color: brown
- Proportion in one-year-old stem: 79.00%

C. Cross section of a thirteen-year-old stem with an objective micrometer (1mm)

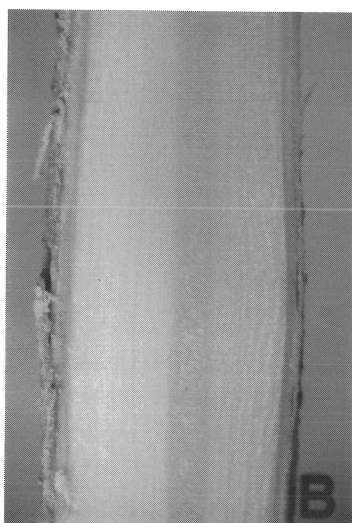
D. Cross section of a thirteen-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary, or in radial multiples; in radial files
- Growth rings of 9-12 and 13 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 40. *Skimmia japonica* var. *japonica* (ミヤマシキミ) (Rutaceae).



B. Pith in longitudinal section

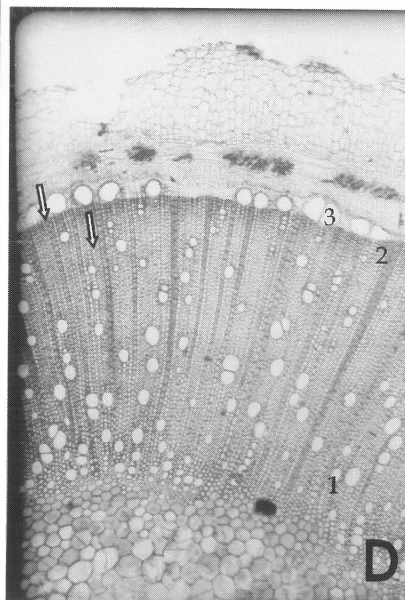
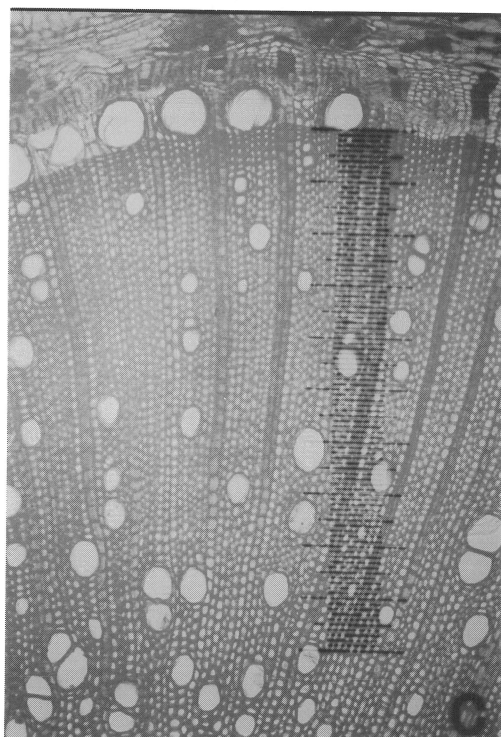
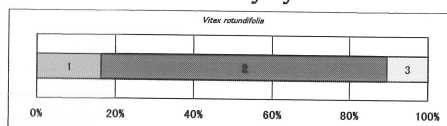
- Condition: dense
- Color: green
- Proportion in one-year-old stem: 84.25%

C. Cross section of a three-year-old stem with an objective micrometer (1mm)

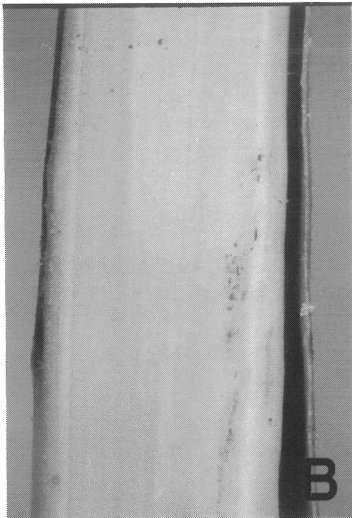
D. Cross section of a three-year-old stem

- Porosity: semi-ring-porous wood
- Growth ring boundaries: distinct
- Pores: solitary, or in radial multiples
- Growth rings of 1, 2 and 3 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 41. *Vitex rotundifolia* (ハマゴウ) (Verbenaceae).



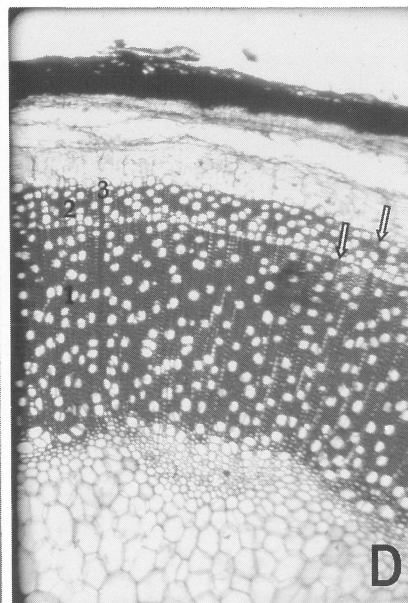
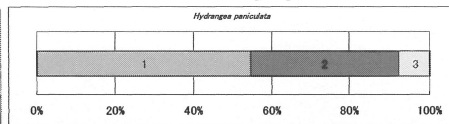
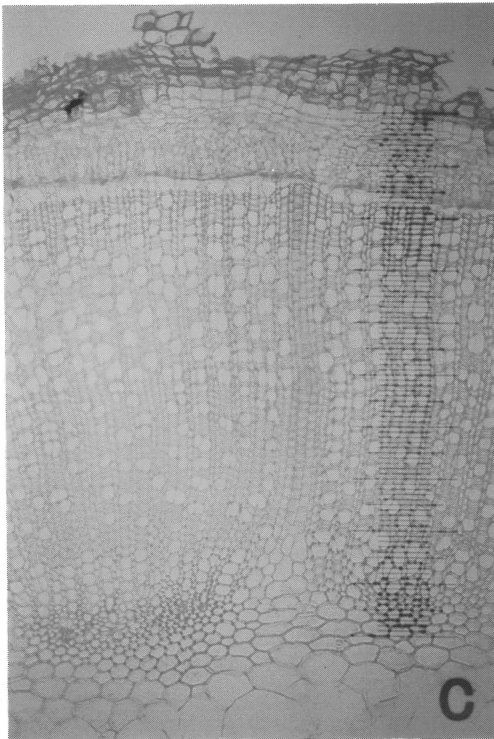
B. Pith in longitudinal section

- Condition: dense
- Color: light brown
- Proportion in one-year-old stem: 86.78%

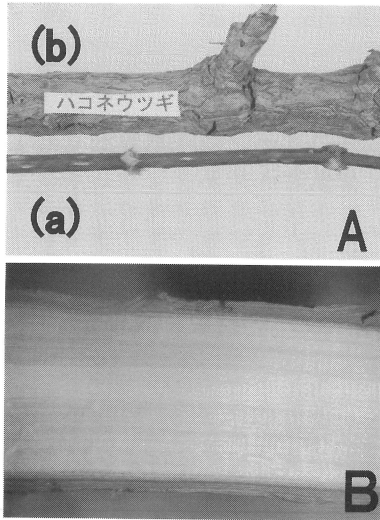
C. Cross section of a three-year-old stem with an objective micrometer (1mm)

D. Cross section of a three-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary
- Growth rings of 1, 2 and 3 are shown in the figure.



App. 42. *Hydrangea paniculata* (ノリウツギ) (Saxifragaceae).



A. Stem morphology

- Bark color
 - (a) one-year-old stem: brown
 - (b) four-year-old stem: grayish brown

B. Pith in longitudinal section

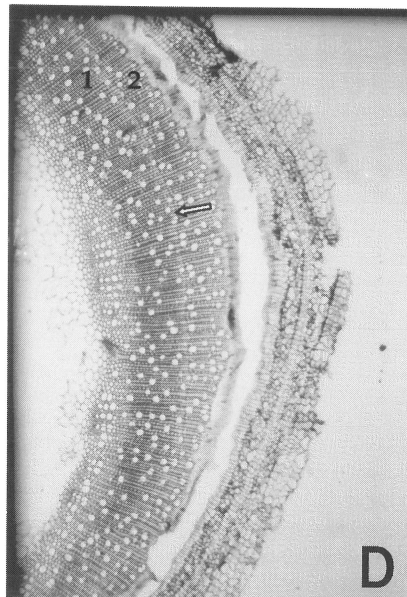
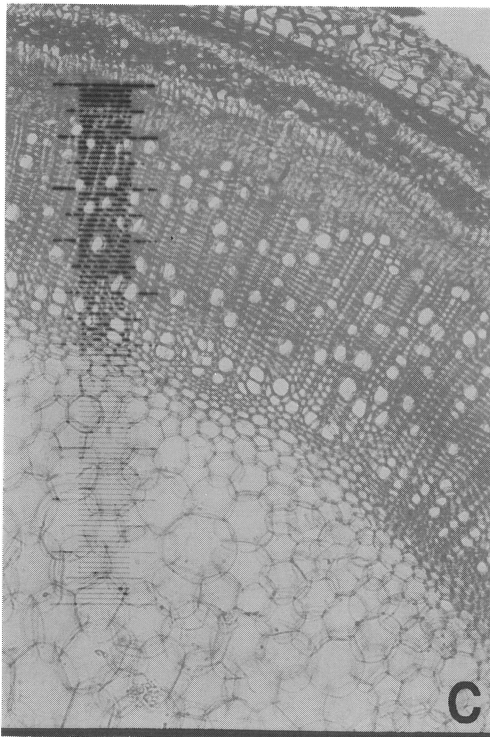
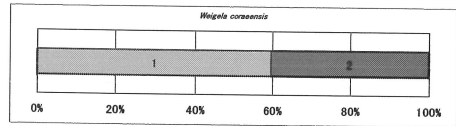
- Condition: dense
- Color: white
- Proportion in one-year-old stem: 80.00%

C. Cross section of a two-year-old stem with an objective micrometer (1mm)

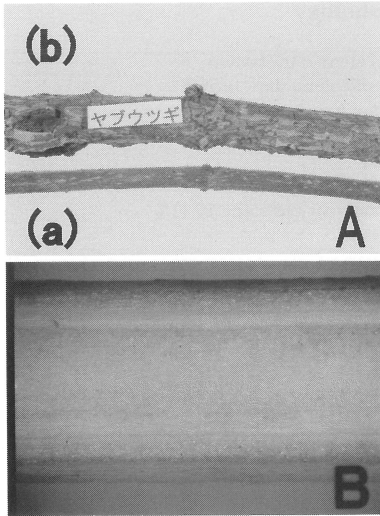
D. Cross section of a two-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary
- Growth rings of 1 and 2 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 43. *Weigela coraeensis* (ハコネウツギ) (Caprifoliaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: brownish black
- (b) four-year-old stem: brownish black

B. Pith in longitudinal section

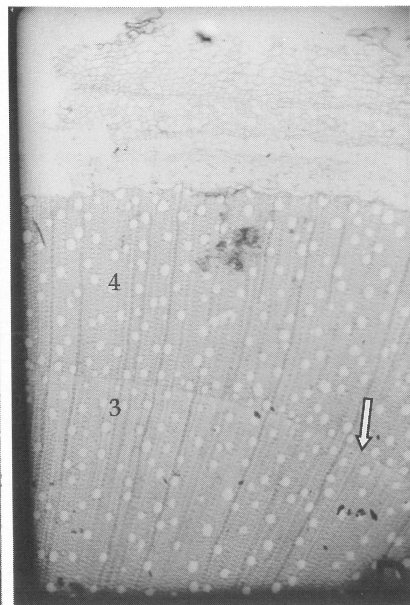
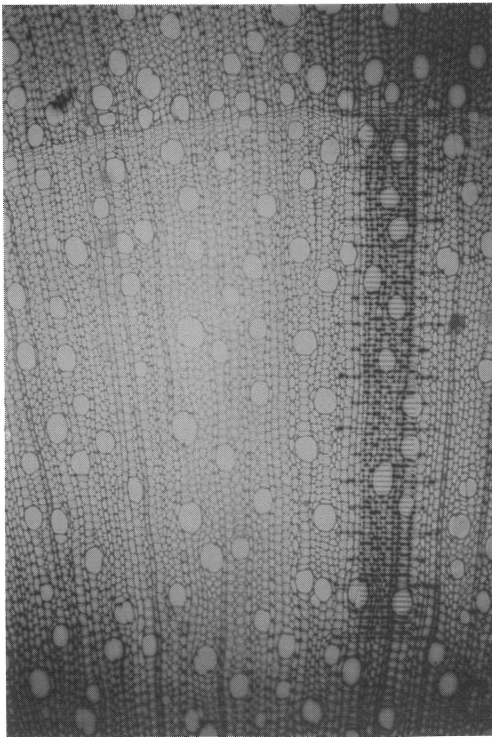
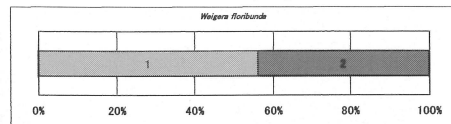
- Condition: dense
- Color: white
- Proportion in one-year-old stem: 45.58%

C. Cross section of a four-year-old stem with an objective micrometer (1mm)

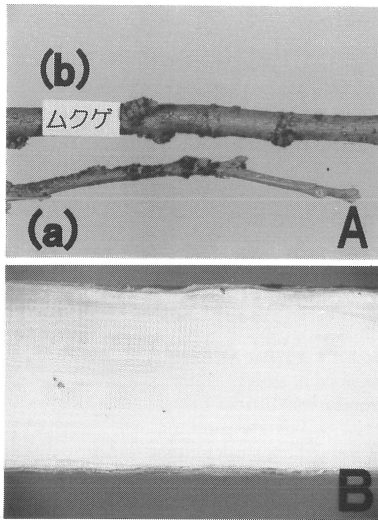
D. Cross section of a four-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary
- Growth rings of 3 and 4 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 44. *Weigera floribunda* var. *floribunda* (ヤブウツギ) (Caprifoliaceae).



A. Stem morphology

- Bark color
 - (a) one-year-old stem: dark brown
 - (b) eleven-year-old stem: dark brown

B. Pith in longitudinal section

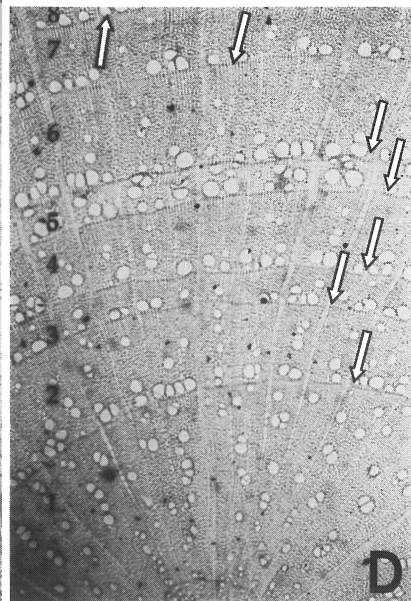
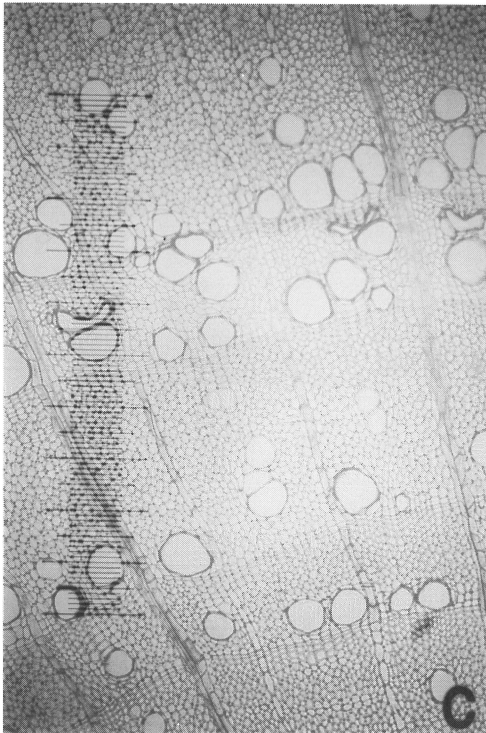
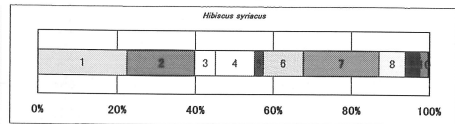
- Condition: dense
- Color: white
- Proportion in one-year-old stem: 19.11%

C. Cross section of an eleven-year-old stem with an objective micrometer (1mm)

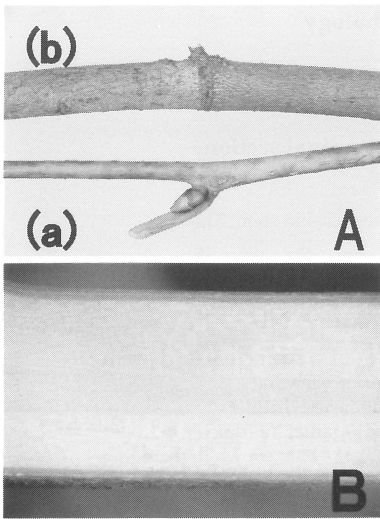
D. Cross section of an eleven-year-old stem

- Porosity: semi-ring-porous wood
- Growth ring boundaries: distinct
- Pores: solitary
- Growth rings of 1-7 and 8 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 45. *Hibiscus syriacus* (ムクゲ) (Malvaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: green
- (b) five-year-old stem: brown

B. Pith in longitudinal section

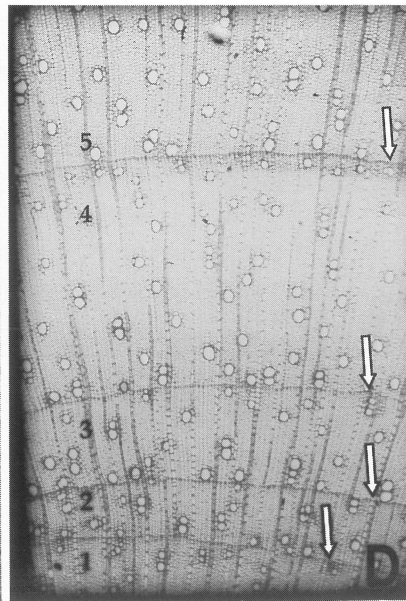
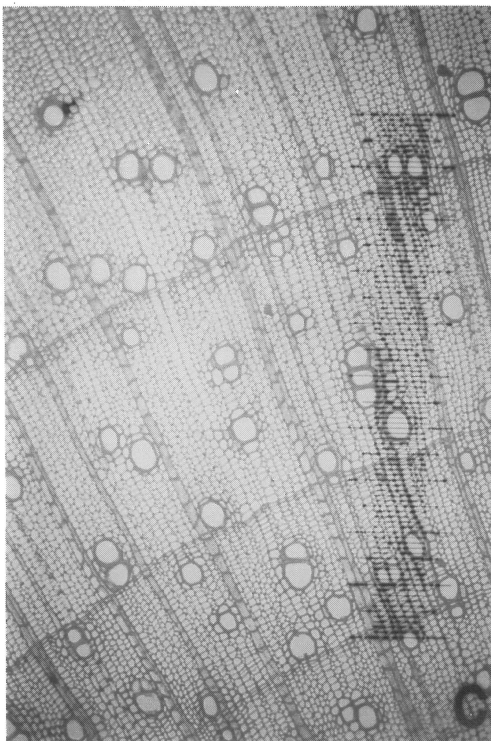
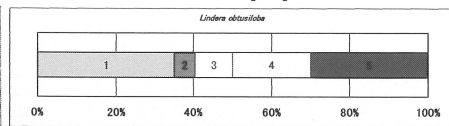
- Condition: dense
- Color: white
- Proportion in one-year-old stem: 33.22%

C. Cross section of a four-year-old stem with an objective micrometer (1mm)

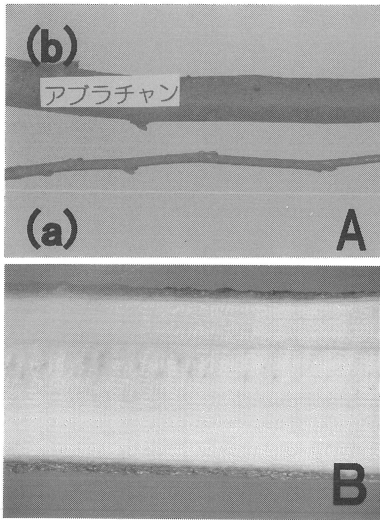
D. Cross section of a five-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary, or in radial multiples
- Growth rings of 1-4 and 5 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 46. *Lindera obtusiloba* (ダンコウバイ) (Lauraceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: reddish brown
- (b) four-year-old stem: reddish brown

B. Pith in longitudinal section

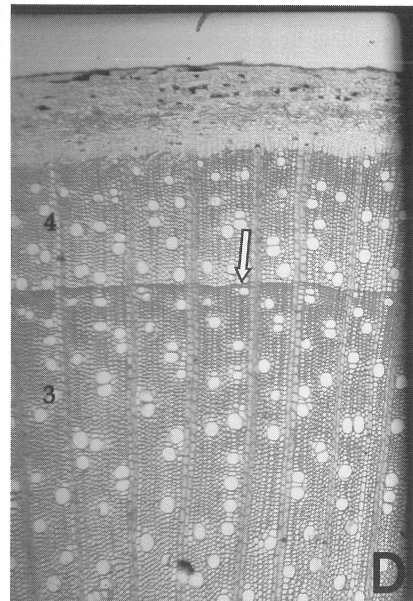
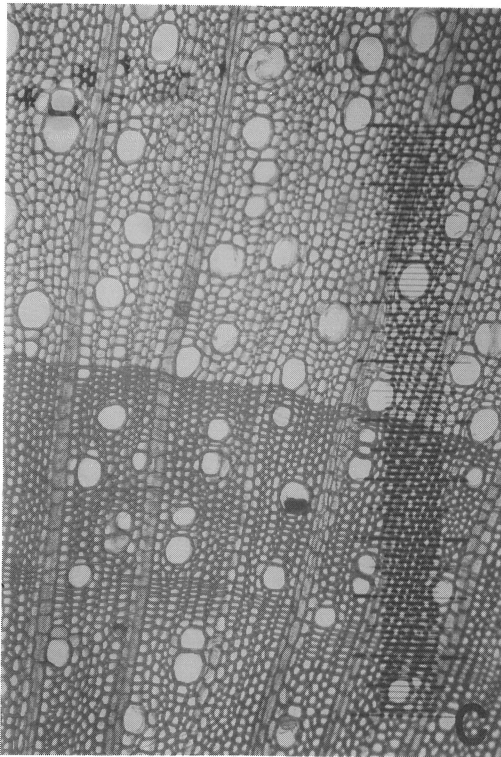
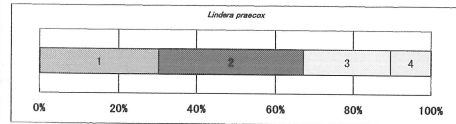
- Condition: dense
- Color: white
- Proportion in one-year-old stem: 33.60%

C. Cross section of a four-year-old stem with an objective micrometer (1mm)

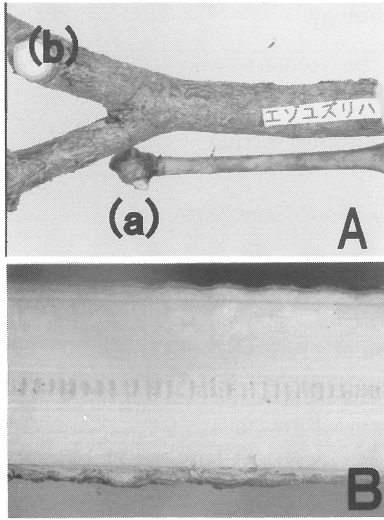
D. Cross section of a four-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary, or in radial multiples
- Growth rings of 3 and 4 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 47. *Lindera praecox* (アブラチャン) (Lauraceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: green
- (b) seven-year-old stem: brown

B. Pith in longitudinal section

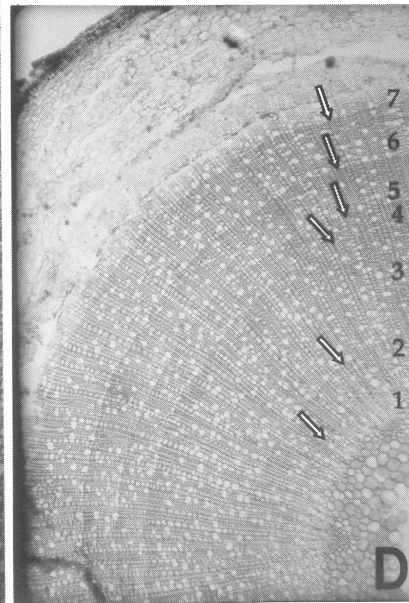
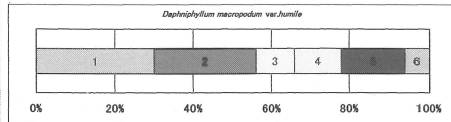
- Condition: rough
- Color: yellowish brown
- Proportion in one-year-old stem: 60.46%

C. Cross section of a seven-year-old stem with an objective micrometer (1mm)

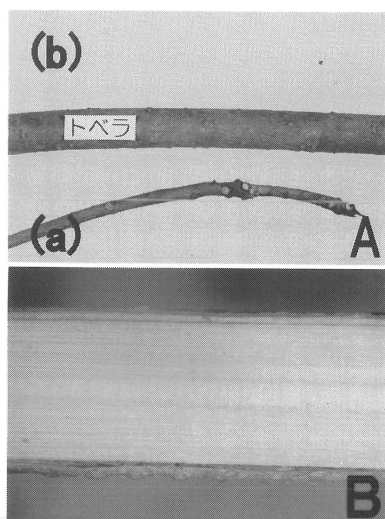
D. Cross section of a seven-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: indistinct
- Pores: solitary
- Growth rings of 1-6 and 7 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 48. *Daphniphyllum macropodum* var. *humile* (エゾユズリハ) (Euphorbiaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: reddish brown
- (b) three-year-old stem: reddish brown

B. Pith in longitudinal section

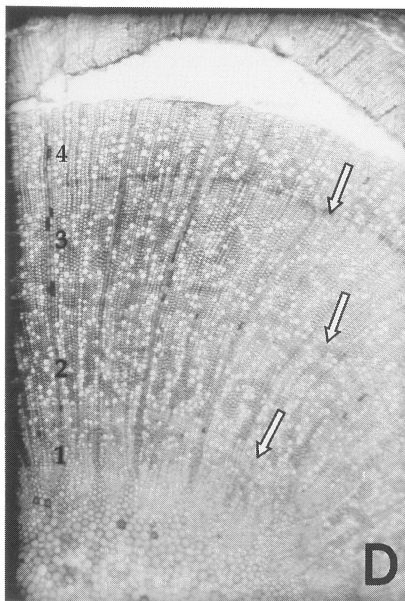
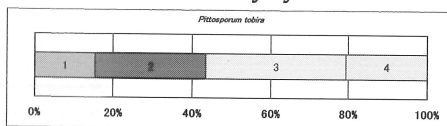
- Condition: dense
- Color: white
- Proportion in one-year-old stem: 76.13%

C. Cross section of a four-year-old stem with an objective micrometer (1mm)

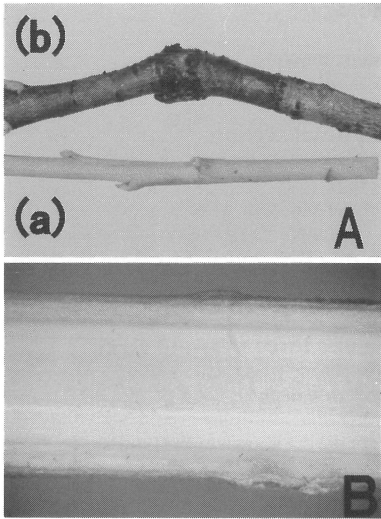
D. Cross section of a four-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: indistinct
- Pores: solitary, or in radial multiples
- Growth rings of 1-3 and 4 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 49. *Pittosporum tobira* (トベラ) (Pittosporaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: yellowish green
- (b) five-year-old stem: reddish brown

B. Pith in longitudinal section

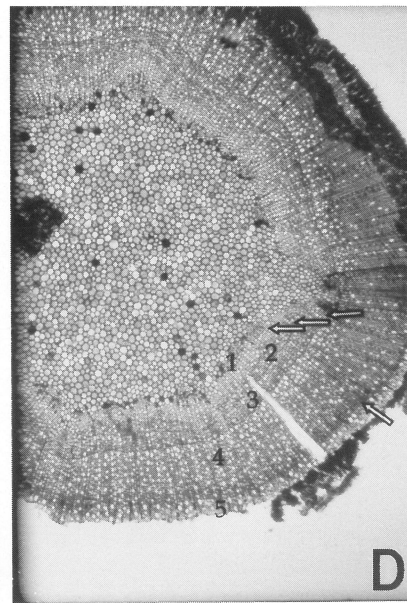
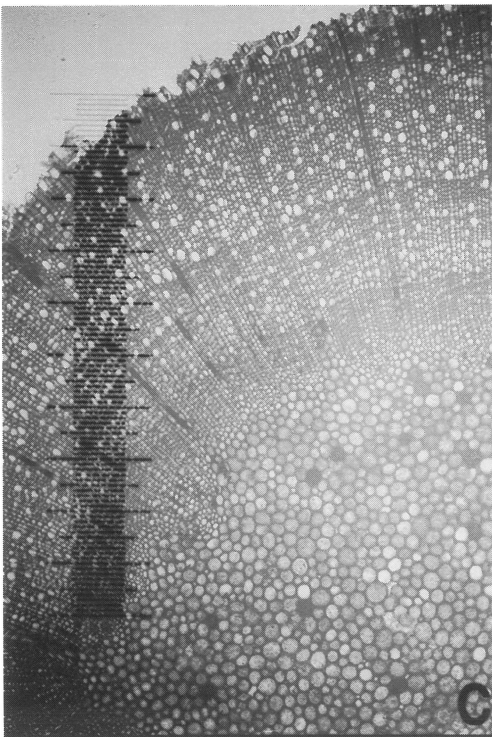
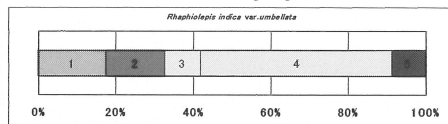
- Condition: dense
- Color: light brown
- Proportion in one-year-old stem: 78.57%

C. Cross section of a five-year-old stem with an objective micrometer (1mm)

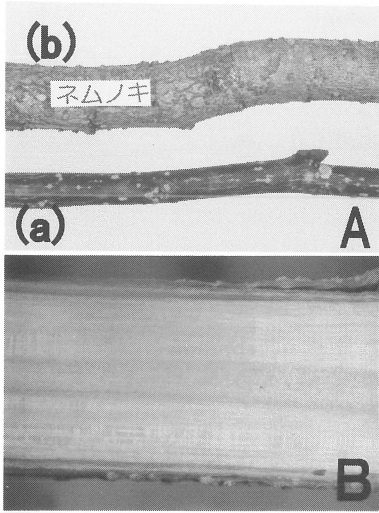
D. Cross section of a five-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary
- Growth rings of 1-4 and 5 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 50. *Raphiolepis umbellata* var. *integerrima* (シヤリンバイ) (Rosaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: brownish black
- (b) three-year-old stem: light brown

B. Pith in longitudinal section

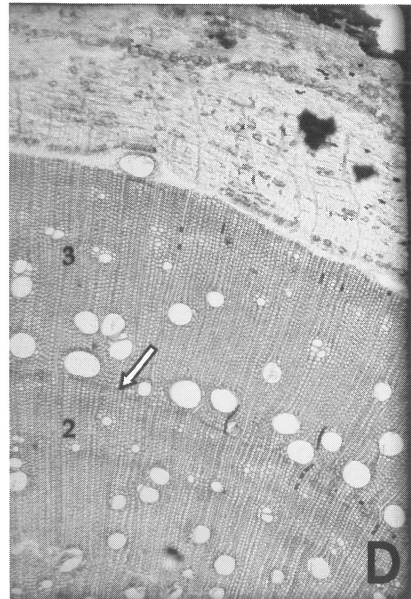
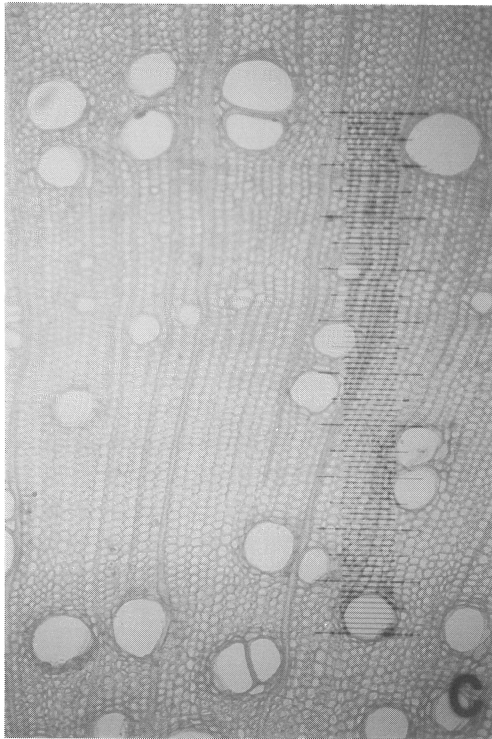
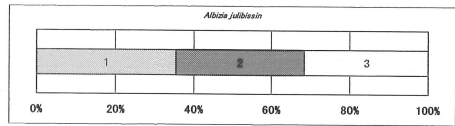
- Condition: dense
- Color: yellowish white
- Proportion in one-year-old stem: 41.87%

C. Cross section of a three-year-old stem with an objective micrometer (1mm)

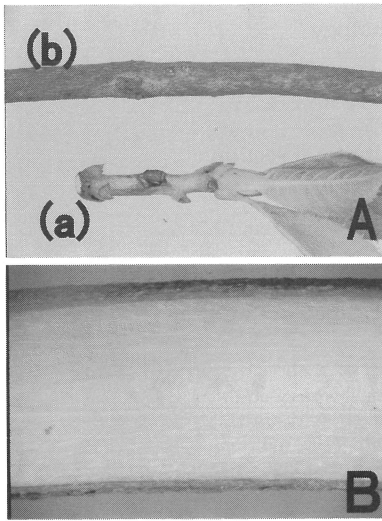
D. Cross section of a three-year-old stem

- Porosity: semi-ring-porous wood
- Growth ring boundaries: distinct
- Pores: solitary, or in radial multiples
- Growth rings of 2 and 3 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 51. *Albizia julibrissin* (ネムノキ) (Leguminosae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: yellowish green
- (b) four-year-old stem: brown

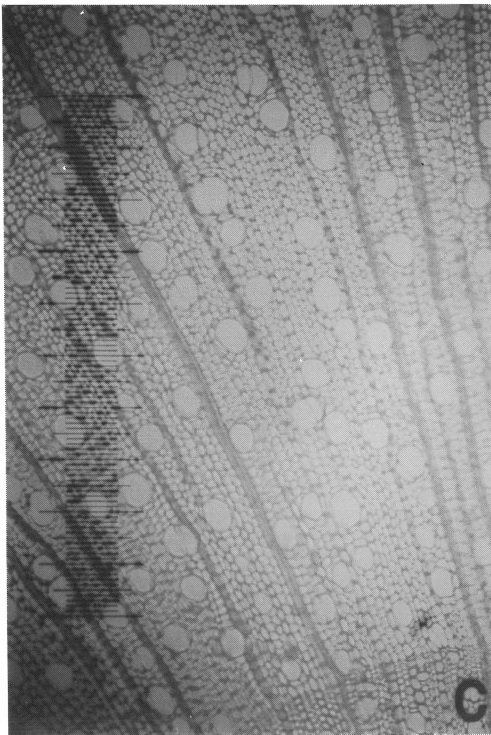
B. Pith in longitudinal section

- Condition: dense
- Color: yellowish brown
- Proportion in one-year-old stem: 63.04%

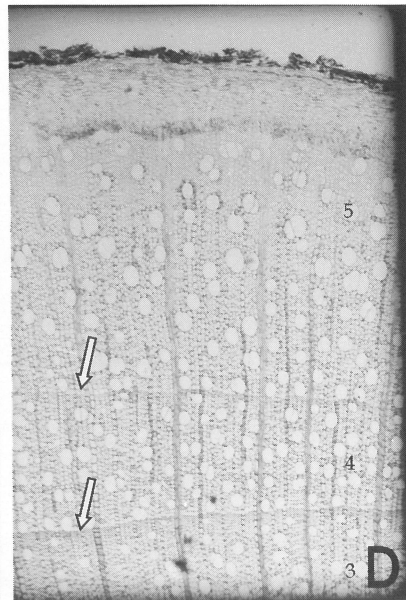
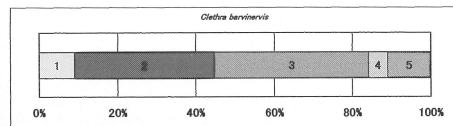
C. Cross section of a five-year-old stem with an objective micrometer (1mm)

D. Cross section of a five-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary
- Growth rings of 3, 4 and 5 are shown in the figure.



Proportion of growth rings in secondary xylem



App. 52. *Clethra barbinervis* (リョウブ) (Clethraceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: green
- (b) fourteen-year-old stem: brown

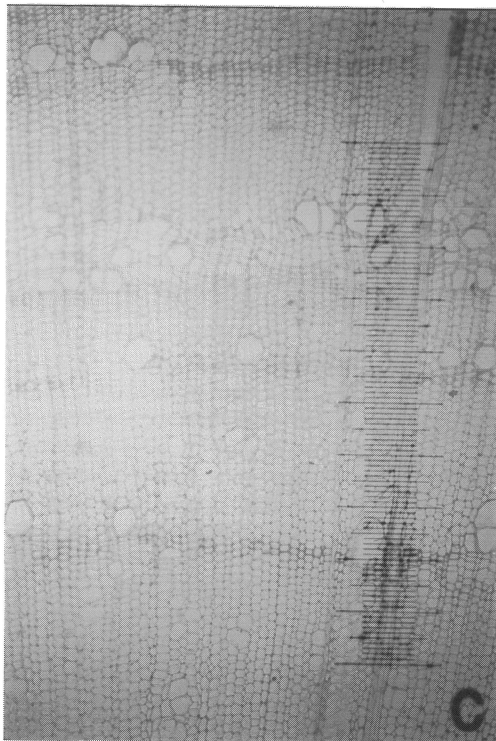
B. Pith in longitudinal section

- Condition: dense
- Color: yellowish white
- Proportion in one-year-old stem: 84.24%

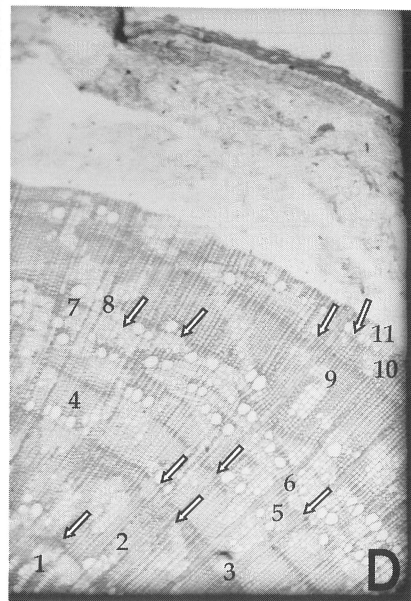
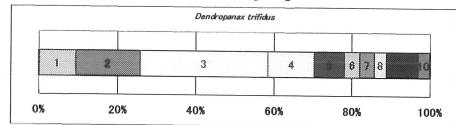
C. Cross section of a eleven-year-old stem with an objective micrometer (1mm)

D. Cross section of a eleven-year-old stem

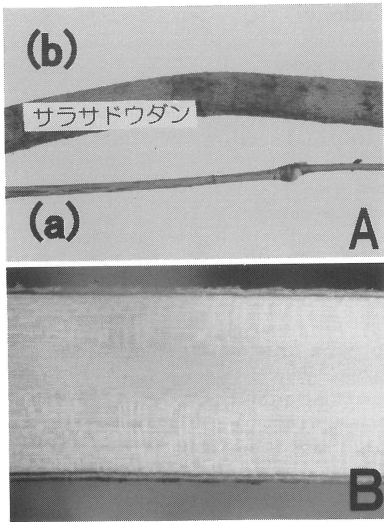
- Porosity: semi-ring-porous wood
- Growth ring boundaries: distinct
- Pores: solitary, or in radial multiples
- Growth rings of 1-10 and 11 are shown in the figure.



Proportion of growth rings in secondary xylem



App. 53. *Dendropanax trifidus* (カクレミノ) (Araliaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: green
- (b) six-year-old stem: dark brown

B. Pith in longitudinal section

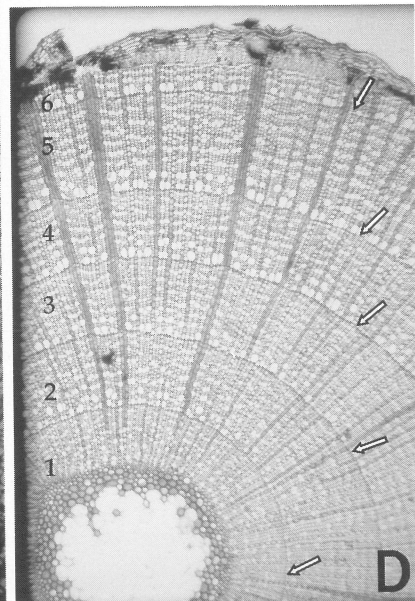
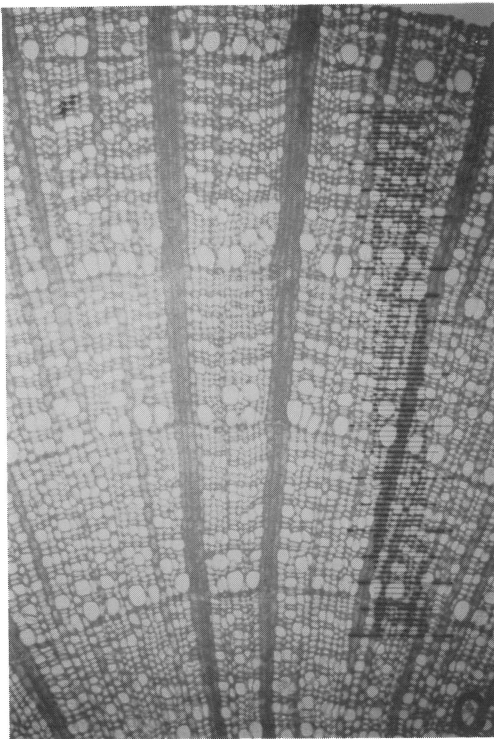
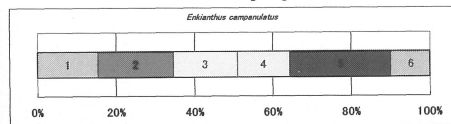
- Condition: dense
- Color: yellowish brown
- Proportion in one-year-old stem: 56.46%

C. Cross section of a six-year-old stem with an objective micrometer (1mm)

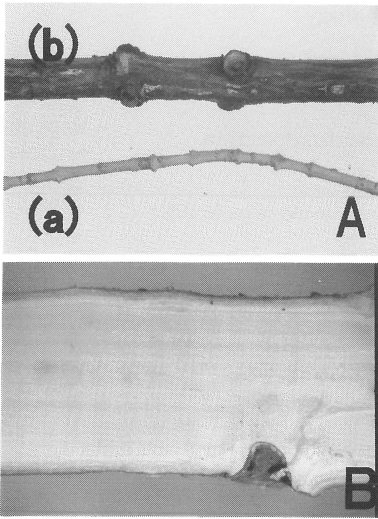
D. Cross section of a six-year-old stem

- Porosity: semi-ring-porous wood
- Growth ring boundaries: distinct
- Pores: solitary, or in clusters; in tangential lines
- Growth rings of 1-5 and 6 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 54. *Enkianthus campanulatus* var. *campanulatus* (サラサドウダン) (Ericaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: green
- (b) five-year-old stem: black

B. Pith in longitudinal section

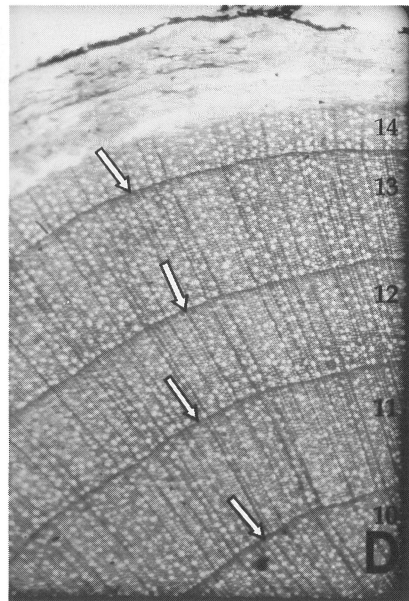
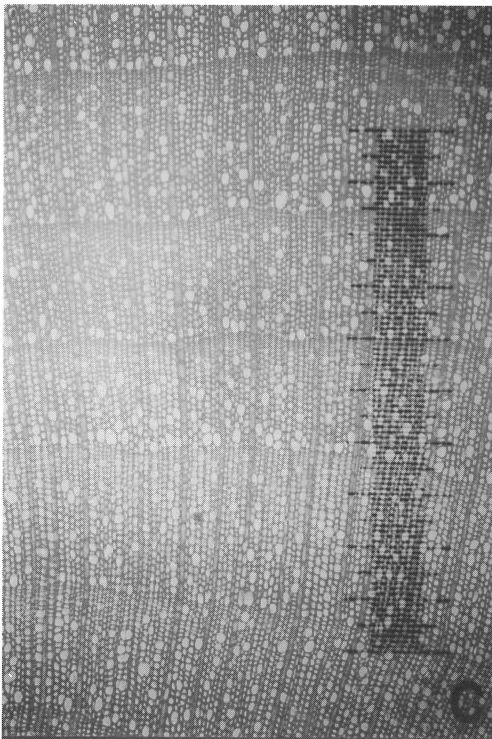
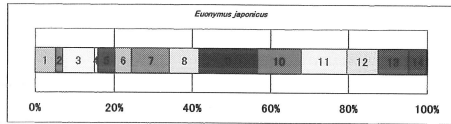
- Condition: dense
- Color: light brown
- Proportion in one-year-old stem: 68.21%

C. Cross section of a fourteen-year-old stem with an objective micrometer (1mm)

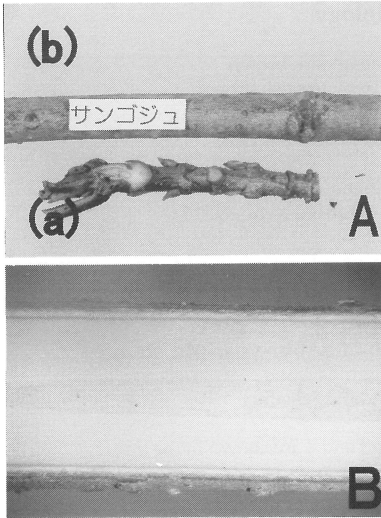
D. Cross section of a fourteen-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary
- Growth rings of 10-13 and 14 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 55. *Euonymus japonicus* (マサキ) (Celastraceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: reddish brown
- (b) three-year-old stem: grayish brown

B. Pith in longitudinal section

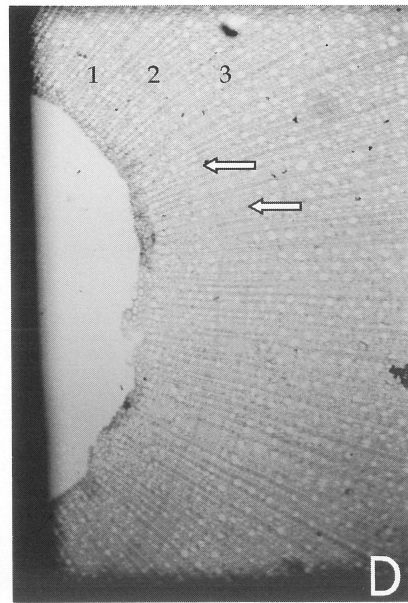
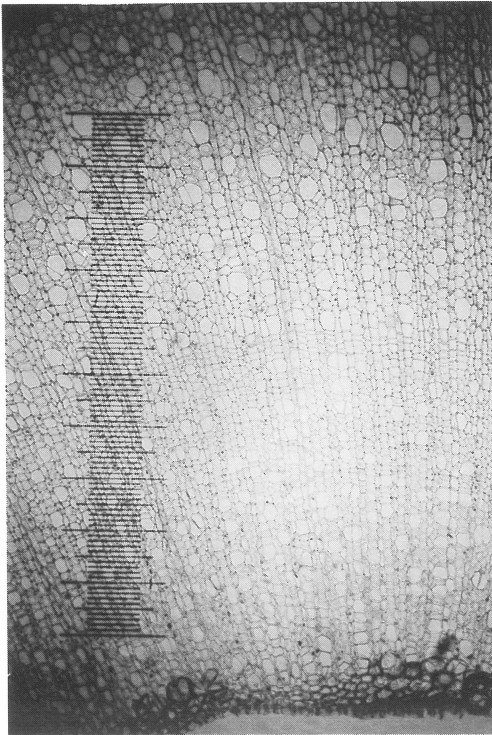
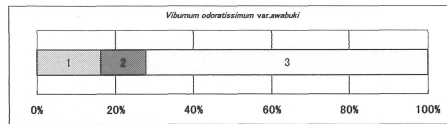
- Condition: dense
- Color: white
- Proportion in one-year-old stem: 70.90%

C. Cross section of a three-year-old stem with an objective micrometer (1mm)

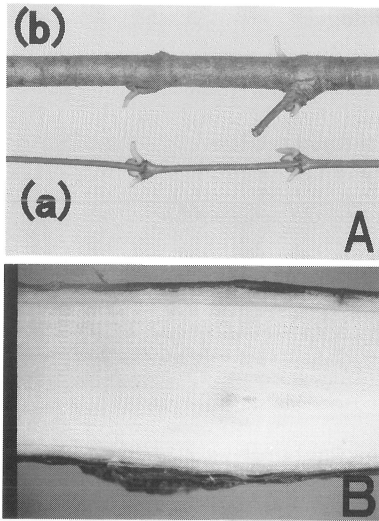
D. Cross section of a three-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: indistinct
- Pores: solitary
- Growth rings of 1, 2 and 3 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 56. *Viburnum odoratissimum* var. *awabuki* (サンゴジュ) (Caprifoliaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: dark brown
- (b) four-year-old stem: grayish brown

B. Pith in longitudinal section

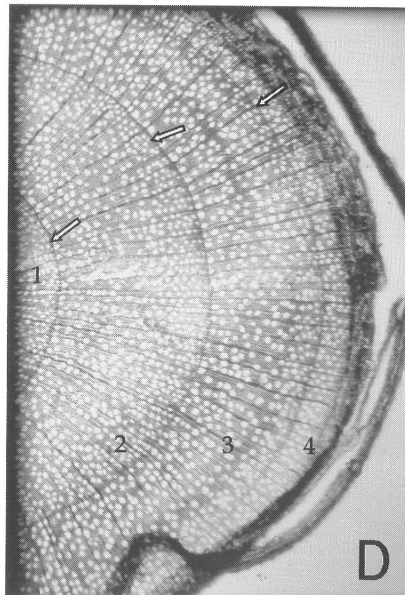
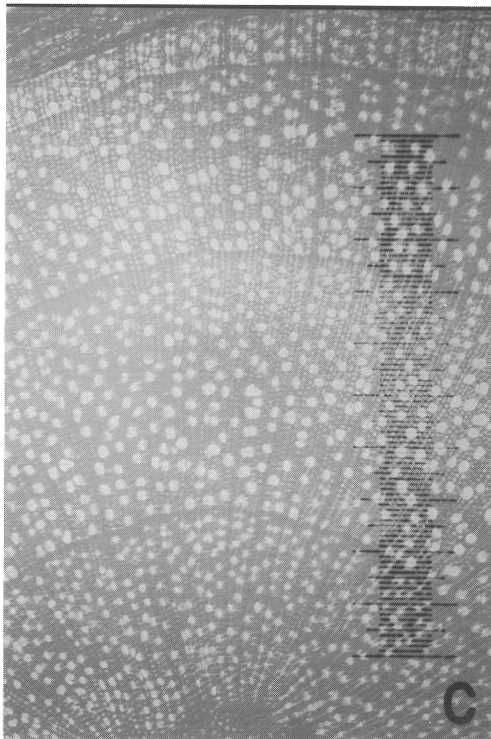
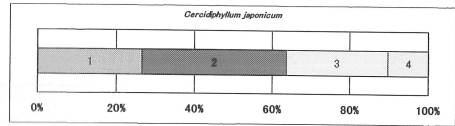
- Condition: dense
- Color: yellowish green
- Proportion in one-year-old stem: 35.21%

C. Cross section of a four-year-old stem with an objective micrometer (1mm)

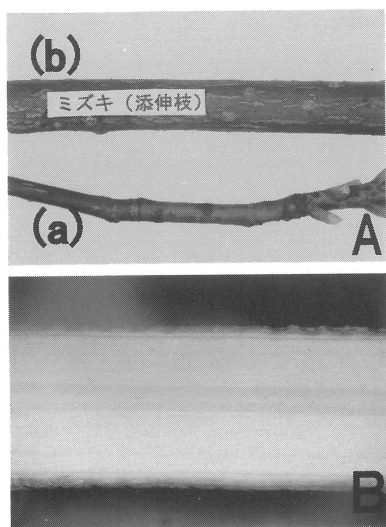
D. Cross section of a four-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary
- Growth rings of 1-3 and 4 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 57. *Cercidiphyllum japonicum* (カツラ) (Cercidiphyllaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: green
- (b) three-year-old stem: green

B. Pith in longitudinal section

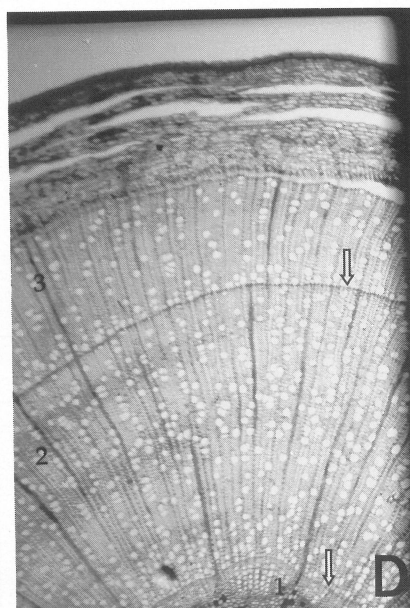
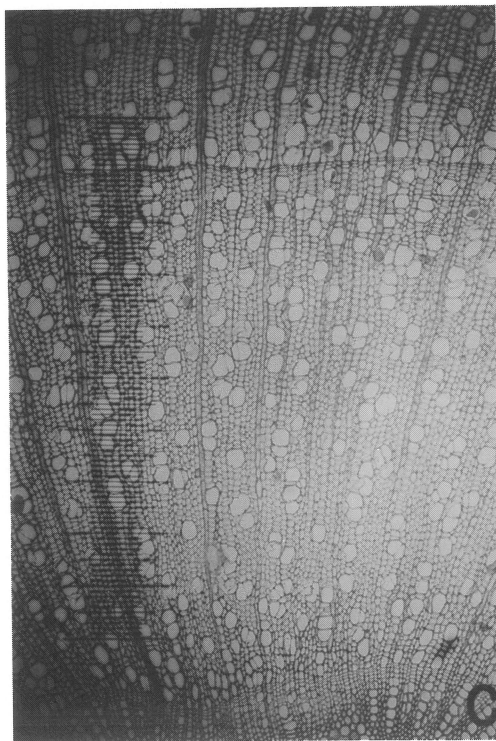
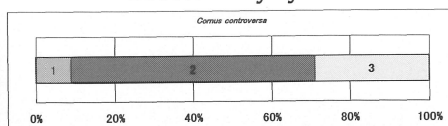
- Condition: dense
- Color: yellowish white
- Proportion in one-year-old stem: 78.21%

C. Cross section of a three-year-old stem with an objective micrometer (1mm)

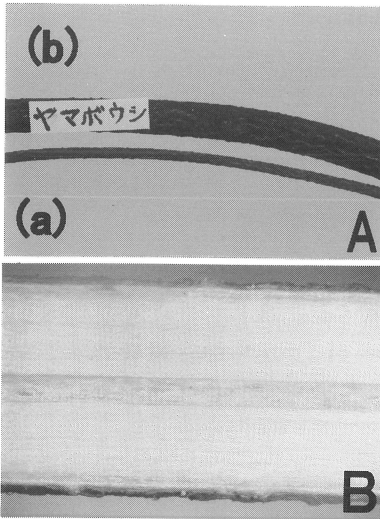
D. Cross section of a three-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary, or in radial multiples
- Growth rings of 1, 2 and 3 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 58. *Cornus controversa* (ミズキ) (Cornaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: reddish brown
- (b) twelve-year-old stem: dark brown

B. Pith in longitudinal section

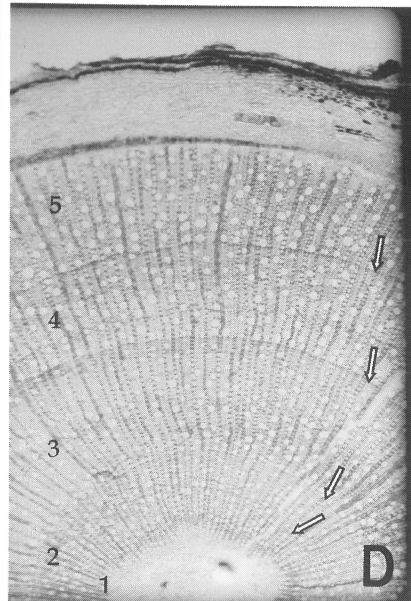
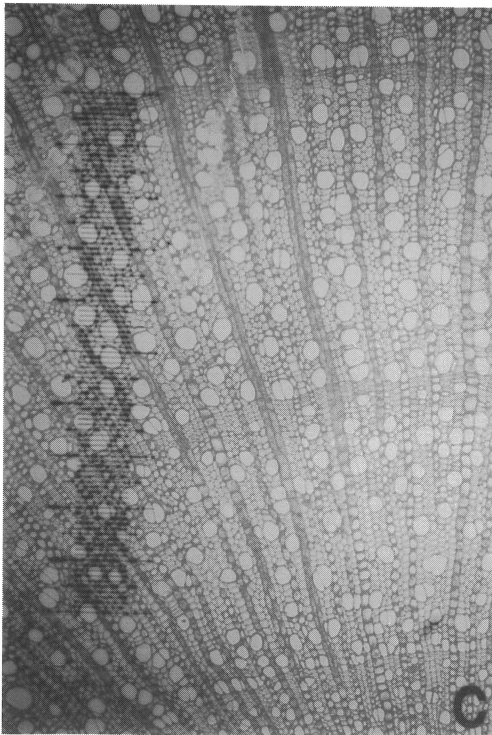
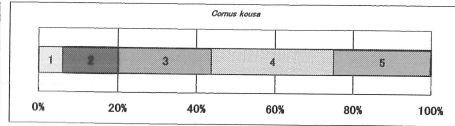
- Condition: dense
- Color: brown
- Proportion in one-year-old stem: 73.08%

C. Cross section of a five-year-old stem with an objective micrometer (1mm)

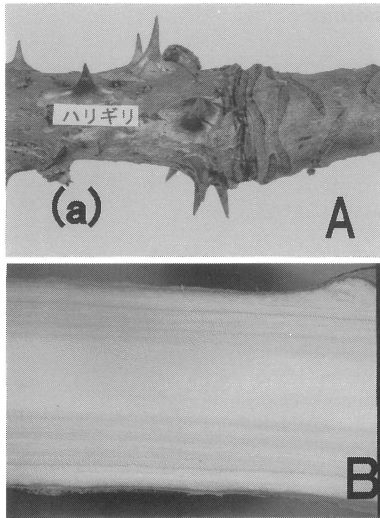
D. Cross section of a five-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary
- Growth rings of 1-4 and 5 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 59. *Cornus kousa* (ヤマボウシ) (Cornaceae).



A. Stem morphology

- Bark color
- (a) seven-year-old stem: grayish brown

B. Pith in longitudinal section

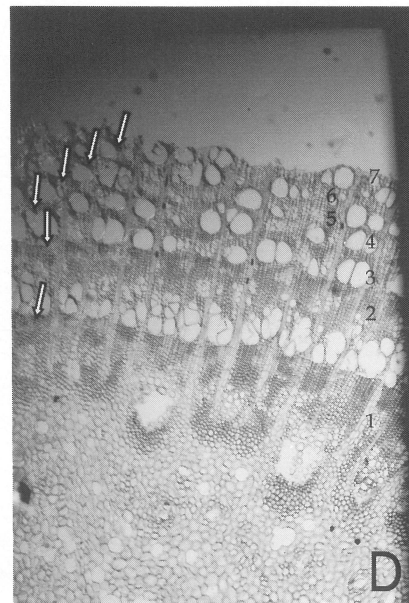
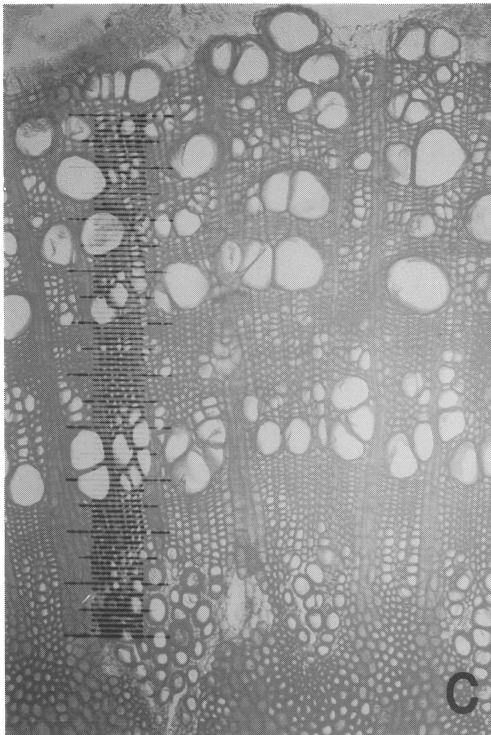
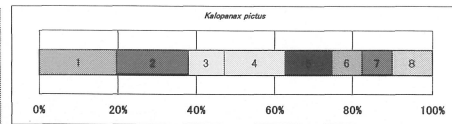
- Condition: dense
- Color: white
- Proportion in one-year-old stem: 92.59%

C. Cross section of a seven-year-old stem with an objective micrometer (1mm)

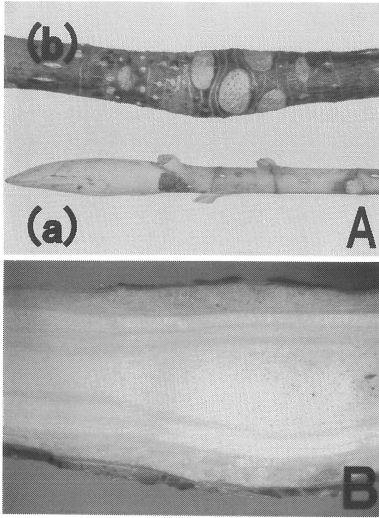
D. Cross section of a seven-year-old stem

- Porosity: semi-ring-porous wood
- Growth ring boundaries: distinct
- Pores: in clusters
- Growth rings of 1-6 and 7 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 60. *Kalopanax pictum* (ハリギリ) (Araliaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: green
- (b) seven-year-old stem: reddish brown

B. Pith in longitudinal section

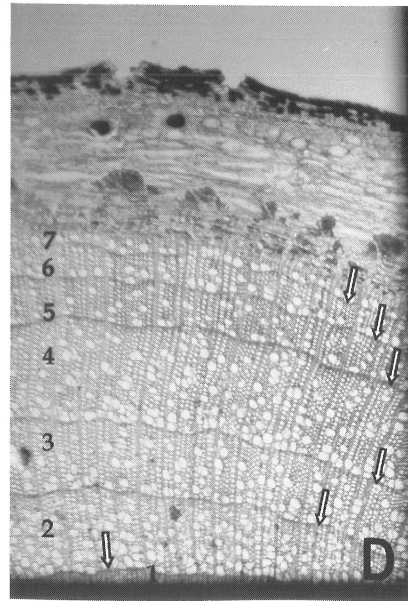
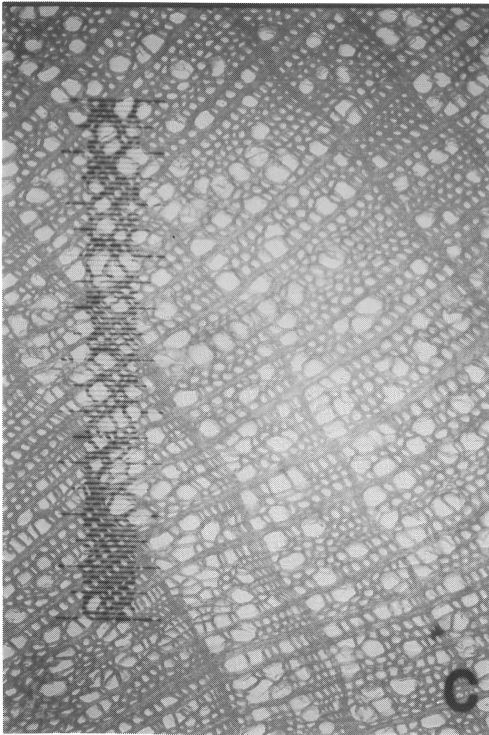
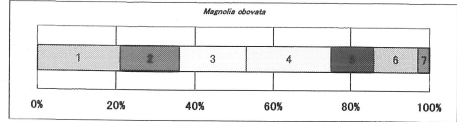
- Condition: dense
- Color: white
- Proportion in one-year-old stem: 79.80%

C. Cross section of a seven-year-old stem with an objective micrometer (1mm)

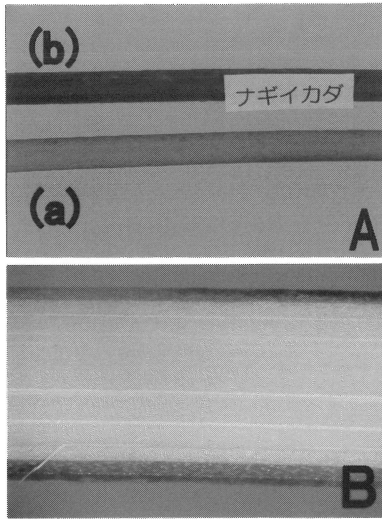
D. Cross section of a seven-year-old stem

- Porosity: diffuse-porous wood
- Growth ring boundaries: distinct
- Pores: solitary, or in radial multiples
- Growth rings of 1-6 and 7 are shown in the figure.

Proportion of growth rings in secondary xylem



App. 61. *Magnolia obovata* (ホオノキ) (Magnoliaceae).



A. Stem morphology

- Bark color
- (a) one-year-old stem: green
- (b) two-year-old stem: dark green

B. Pith in longitudinal section

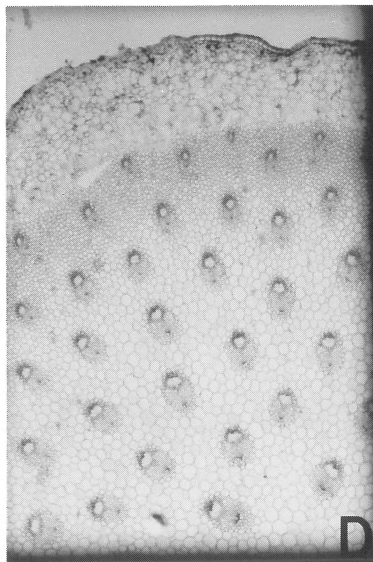
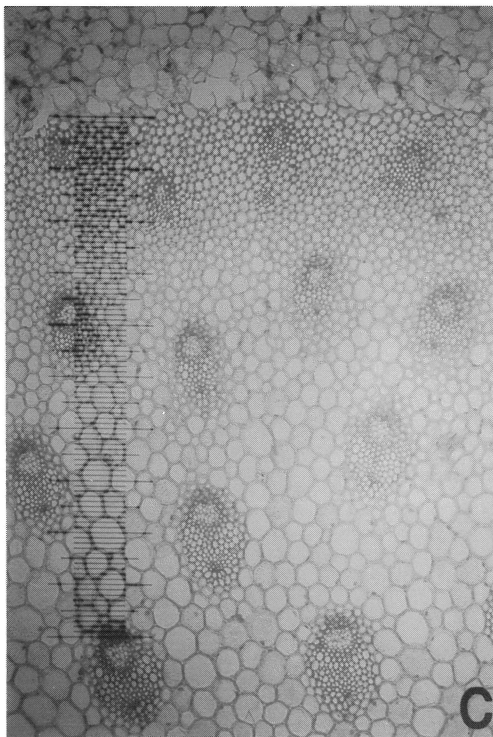
- Condition: dense
- Color: yellowish green

C. Cross section of a two-year-old stem with an objective micrometer (1mm)

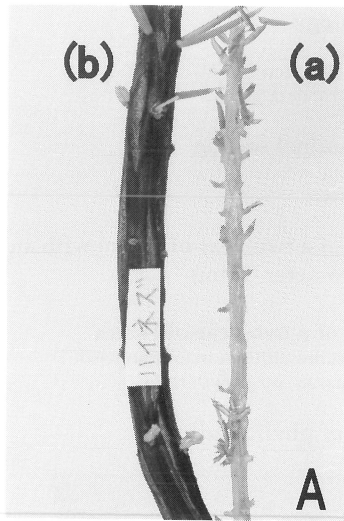
D. Cross section of a two-year-old stem

- Porosity: vessel bundles diffused in ground tissue
- Growth ring boundaries: no growth rings

E. Cross section of phyllocladium



App. 62. *Ruscus aculeatus* (ナギイカダ) (Liliaceae).



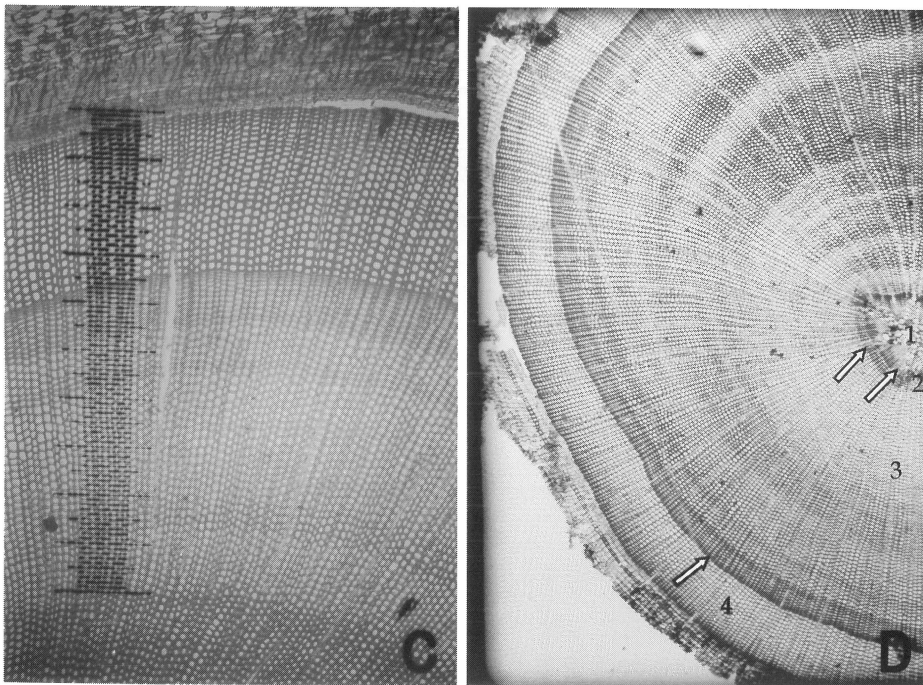
A. Stem morphology

- Bark color
 - (a) one-year-old stem: yellowish green
 - (b) four-year-old stem: brown

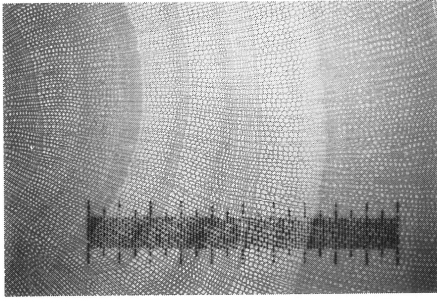
C. Cross section of a seven-year-old stem with an objective micrometer (1mm)

D. Cross section of a four-year-old stem

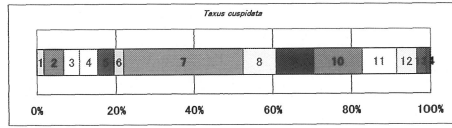
- Porosity: no pores (conifer)
- Growth ring boundaries: distinct
- Pith proportion in one-year-old stem: 64.71%
- Growth rings of 1-3 and 4 are shown in the figure.



App. 63. *Juniperus conferta* var. *conferta* (ハイネズ) (Cupressaceae).

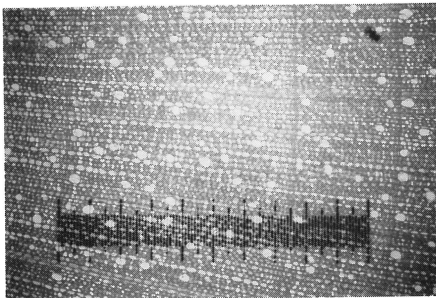


Proportion of growth rings in secondary xylem

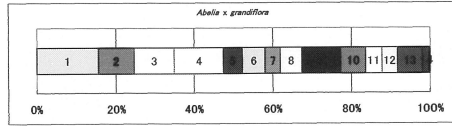


Cross section of a thirteen-year-old stem with an objective micrometer (1mm)

App. 64. *Taxus cuspidata* var. *nana* (キャラボク) (Taxaceae).

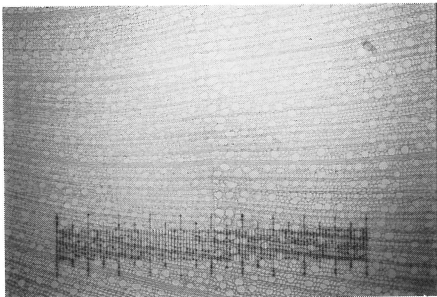


Proportion of growth rings in secondary xylem

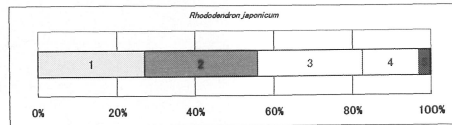


Cross section of a fourteen-year-old stem with an objective micrometer (1mm)

App. 65. *Abelia* × *grandiflora* (ハナヅノツクバネウツギ) (Caprifoliaceae).

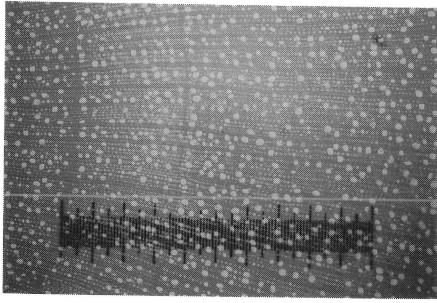


Proportion of growth rings in secondary xylem



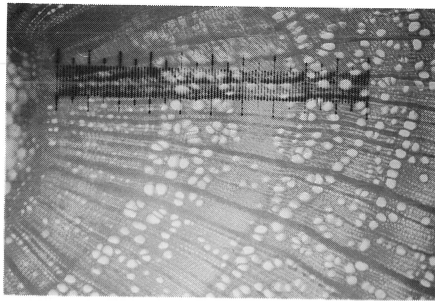
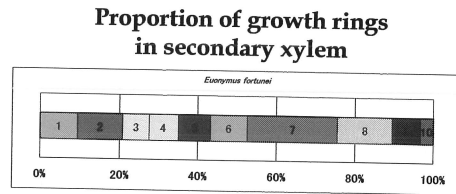
Cross section of a five-year-old stem with an objective micrometer (1mm)

App. 66. *Rhododendron japonicum* (レンゲツツジ) (Ericaceae).



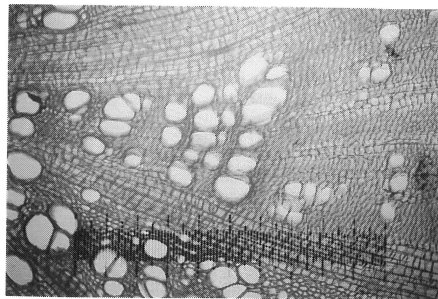
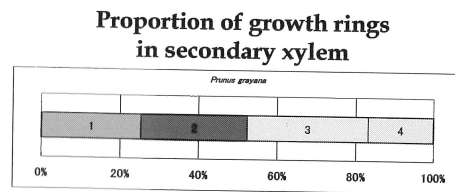
Cross section of a four-year-old stem
with an objective micrometer (1mm)

App. 67. *Euonymus fortunei* (ツルマサキ) (Celastraceae).



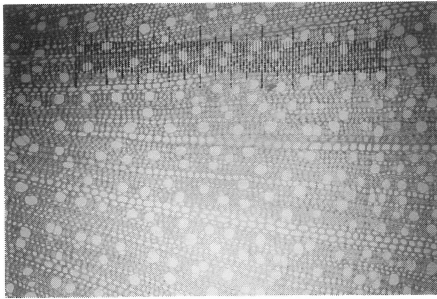
Cross section of a four-year-old stem
with an objective micrometer (1mm)

App. 68. *Prunus grayans* (ウワミズザクラ) (Rosaceae).

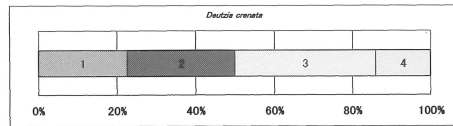


Cross section of a four-year-old stem
with an objective micrometer (1mm)

App. 69. *Rubus trifidus* (カジイチゴ) (Rosaceae) root.

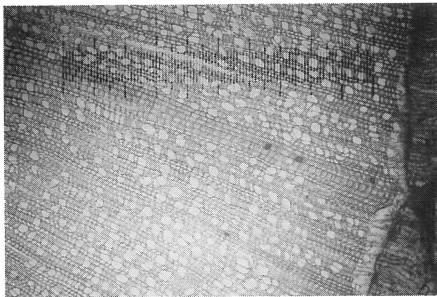


Proportion of growth rings
in secondary xylem

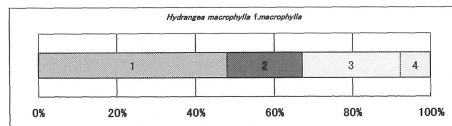


Cross section of a four-year-old stem
with an objective micrometer (1mm)

App. 70. *Deutzia crenata* (ウツギ) (Saxifragaceae).

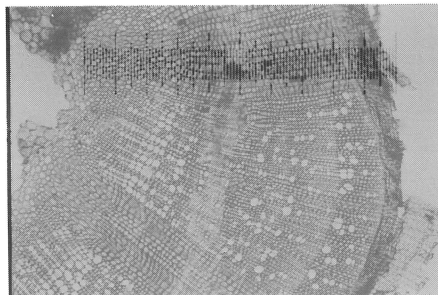


Proportion of growth rings
in secondary xylem



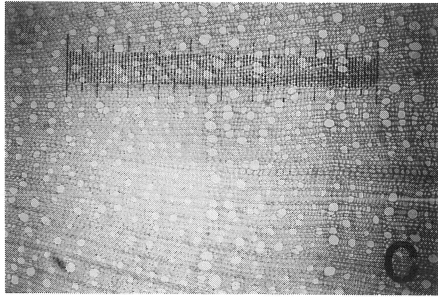
Cross section of a four-year-old stem
with an objective micrometer (1mm)

App. 71. *Hydrangea macrophylla* (アジサイ) (Saxifragaceae).

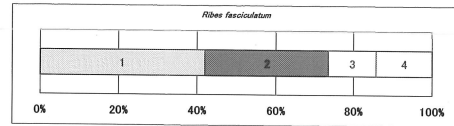


Cross section of a five-year-old stem
with an objective micrometer (1mm)

App. 72. *Hydrangea petiolaris* (ツルアジサイ) (Saxifragaceae).

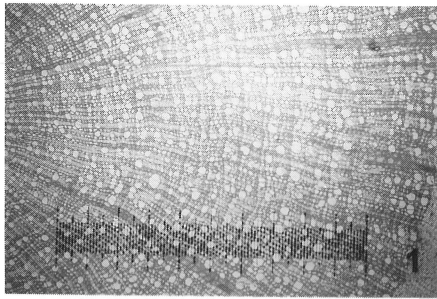


Proportion of growth rings
in secondary xylem

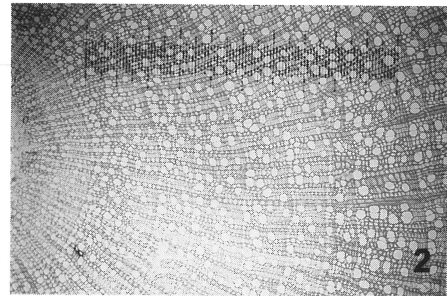


C. Cross section of a four-year-old stem
with an objective micrometer (1mm)

App. 73. *Ribes fasciculatum* (ヤブサンザシ) (Saxifragaceae).



1. Cross section of a mature stem with
an objective micrometer (1mm)



2. Cross section of a young stem starting
to bloom with an objective micrometer
(1mm)

App. 74. *Cornus kousa* (ヤマボウシ) (Cornaceae) mature stem and young stem.