THE SECONDARY PHLOEM OF AMENTOTAXUS

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The systematic position of Amentotaxus is uncertain (Keng, 1969). It is placed either in the Taxaceae, Cephalotaxaceae, or in a separate family, the Amentotaxaceae (Kudo & Yamamoto, 1931; Li, 1963). The genus is held to represent only one species, i.e. A. argotaenia (Hance) Pilger (Kudo & Yamamoto), or four species, i.e. A. argotaenia (Hance) Pilger, A. cathayensis Li, A. formosana Li, and A. yunnanensis Li (Li, 1952), or three species, i.e. A. argotaenia (Hance) Pilger, A. formosana Li, and A. yunnanensis Li (Hu, 1964). Finally Chuang & Hu (1963) identify A. formosana Li with A. argotaenia (Hance) Pilger.

Because of all these different opinions, further investigations seem advisable. Although hampered by the lack of suitable material, Miller (1973) made a comparative study of the secondary xylem. He concluded that a) at the specific level taxonomic evaluation is not possible, or that b) Amentotaxus is monotypic. A comparative study of the secondary phloem is even more difficult, because fresh material is preferable for this purpose. The present investigation deals with the comparison of A. argotaenia (Hance) Pilger sensu stricto with some other representatives of the Taxaceae and Cephalotaxaceae.

MATERIAL

Twig material of A. argotaenia (Hance) Pilger sensu stricto was obtained from Hong Kong (Lantao Peak, Lantao Island) via Dr. D. K. Ferguson of the University of Antwerp. Using an increment borer with a diameter of 5 mm., fresh samples were taken from trees of Taxus baccata L., Torreya grandis Fortune, and Cephalotaxus harringtonia (Forbes) K. Koch. These trees in the Arboretum "De Dreyen" at Wageningen, had a diameter of approximately 15 cm. at breast height. Two stem samples of Austrotaxus spicata Compt. were obtained via Dr. A. M. W. Mennega and H. J. Miller from Sweden (Stockholm nr. 233) and Australia (D. F. P. 32.479).

RESULTS

The results of the investigation are shown in the following table.

TABLE 1. A comparison of Amentotaxus argotaenia with some genera of the Taxaceae and Cephalotaxaceae.

	TAXUS BACCATA	Torreya Grandis	CEPHALOTAXUS HARRINGTONIA	AUSTROTAXUS SPICATA	AMENTOTAXUS ARGOTAENIA
C					
Sequence of alternating tg. layers of cells	sieve cells–crystal cells–sieve cells–	sieve cells– parenchyma cells–	sieve cells-1 (to 3) layers parenchyma	sieve cells– parenchyma	1 to 10 (often 5) layers of sieve cells–
ig. layers of cens	parenchyma cells-etc.	etc.	cells-etc.	cells-etc.	parenchyma cells-etc
Growth ring boundary Sieve cells:	inconspicuous	inconspicuous	indistinct	indistinct	indistinct
shape	fiber; rectangular in cross section	as in Taxus	as in Taxus	as in Taxus	as in Taxus
measurements	8–15 μm rd.	as in Taxus	as in Taxus	as in Taxus	6–12 μm rd.
	$10-25 \ \mu m \ tg.$	as in Taxus	as in Taxus	as in Taxus	$10-30 \mu\mathrm{m}$ tg.
	\pm 1250 μ m lg.	\pm 800 μ m lg.	\pm 900 μ m lg.	?	\pm 1600 μm lg.
sieve areas	in rd. walls;	as in Taxus;	as in Taxus;	as in Taxus;	as in Taxus;
	round to oval; 10–15 μm	rounded to angular;	rounded to angular;	rounded to angular;	rounded to oval;
collapsed from	third period	as in Taxus	as in <i>Taxus</i> as in <i>Taxus</i>	as in <i>Taxus</i> second period	as in Taxus
Albuminous cells	in the layers of	as in Taxus	as in Taxus	second period	second period
	phloem-parenchyma cells, mostly in lg.	as III I taans	as III I axus		
	strands				
Phloem-parenchyma cells: shape in conducting					
phloem	fiber; rectangular in cross section	as in Taxus	as in <i>Taxus</i>	as in Taxus	as in Taxus
	10–20 μm rd.	as in Taxus	as in Taxus	as in Taxus	8–15 μm rd.
	20–25 μm tg.	as in Taxus	as in Taxus	as in Taxus	10–30 μm tg.
shape in nonconducting					
phloem	fiber; oval to round	as in Taxus	as in Taxus	as in Taxus	fiber; oval in
	in cross section;				cross section;
	30–40 μm rd.				$25-45 \mu m \text{ rd.}$
					15–30 μm tg.
					,
number of cells per fiber		5-18	6–16	5–20	5–20
lg. measurements of cells	50-200 μm	70–180 μm	50–200 μm	50–200 μm	80–200 μm
	50–200 μm mainly in radial				
lg. measurements of cells	50-200 μm	70–180 μm	50–200 μm	50–200 μm	80–200 μm
lg. measurements of cells pits transverse walls	50–200 μm mainly in radial and transverse walls	70–180 μm as in <i>Taxus</i>	50–200 μm as in <i>Taxus</i>	50–200 μm as in <i>Taxus</i>	80–200 μ m as in $Taxus$
lg. measurements of cells pits transverse walls	50–200 μm mainly in radial and transverse walls	70–180 μm as in <i>Taxus</i> nodular fiber; round to	50–200 μm as in <i>Taxus</i>	50–200 μm as in <i>Taxus</i>	80–200 μ m as in $Taxus$ nodular
lg. measurements of cells pits transverse walls Sclereids:	50–200 µm mainly in radial and transverse walls nodular	70–180 µm as in <i>Taxus</i> nodular fiber; round to rectangular in cross	50–200 μ m as in $Taxus$ almost smooth	50–200 μm as in <i>Taxus</i> smooth	80–200 μ m as in $Taxus$
lg. measurements of cells pits transverse walls Sclereids: shape	50–200 µm mainly in radial and transverse walls nodular fiber; bone-shaped in cross section	70–180 µm as in Taxus nodular fiber; round to rectangular in cross section	50–200 μm as in <i>Taxus</i> almost smooth fiber; round to rectangular in cross section	50–200 μm as in <i>Taxus</i> smooth fiber; round to oval in cross section	80–200 μm as in Taxus nodular irregular; oval in cross section; almost no lumen
lg. measurements of cells pits transverse walls Sclereids: shape measurements	50–200 μm mainly in radial and transverse walls nodular fiber; bone-shaped in cross section 1250–3000 μm lg.	70–180 μ m as in $Taxus$ nodular fiber; round to rectangular in cross section 1000–2000 μ m. lg.	50–200 μ m as in $Taxus$ almost smooth fiber; round to rectangular in cross section 1000–1750 μ m lg.	50–200 μm as in <i>Taxus</i> smooth fiber; round to oval in cross section up to 1 cm. lg.	80–200 μm as in <i>Taxus</i> nodular irregular; oval in cross section; almost no lumen 1000–1750 μm lg.
lg. measurements of cells pits transverse walls Sclereids: shape measurements crystals	50–200 μm mainly in radial and transverse walls nodular fiber; bone-shaped in cross section 1250–3000 μm lg. in outer cell wall	70–180 μ m as in $Taxus$ nodular fiber; round to rectangular in cross section 1000–2000 μ m. lg. in outer cell wall	50–200 μ m as in $Taxus$ almost smooth fiber; round to rectangular in cross section 1000–1750 μ m lg. absent	50–200 μm as in Taxus smooth fiber; round to oval in cross section up to 1 cm. lg. absent	80–200 μm as in <i>Taxus</i> nodular irregular; oval in cross section; almost no lumen 1000–1750 μm lg. in outer cell wall
lg. measurements of cells pits transverse walls Sclereids: shape measurements	50–200 μm mainly in radial and transverse walls nodular fiber; bone-shaped in cross section 1250–3000 μm lg. in outer cell wall irregular in tg. layers;	$70{\text -}180~\mu{\rm m}$ as in $Taxus$ nodular fiber; round to rectangular in cross section $1000{\text -}2000~\mu{\rm m}$. lg. in outer cell wall irregular in tg.	50–200 μm as in Taxus almost smooth fiber; round to rectangular in cross section 1000–1750 μm lg. absent in tg. layers, some-	50–200 μm as in Taxus smooth fiber; round to oval in cross section up to 1 cm. lg. absent in long tg. layers,	80–200 μm as in <i>Taxus</i> nodular irregular; oval in cross section; almost no lumen 1000–1750 μm lg. in outer cell wall scattered,
lg. measurements of cells pits transverse walls Sclereids: shape measurements crystals	50–200 μm mainly in radial and transverse walls nodular fiber; bone-shaped in cross section 1250–3000 μm lg. in outer cell wall irregular in tg. layers; every 3 or 4 [2 – ∞]	70–180 μ m as in $Taxus$ nodular fiber; round to rectangular in cross section 1000–2000 μ m. lg. in outer cell wall irregular in tg. layers; every 1 or	50–200 μm as in <i>Taxus</i> almost smooth fiber; round to rectangular in cross section 1000–1750 μm lg. absent in tg. layers, sometimes 4 cells wide;	50–200 μm as in Taxus smooth fiber; round to oval in cross section up to 1 cm. lg. absent	80–200 μm as in <i>Taxus</i> nodular irregular; oval in cross section; almost no lumen 1000–1750 μm lg. in outer cell wall
lg. measurements of cells pits transverse walls Sclereids: shape measurements crystals arrangement	50–200 μm mainly in radial and transverse walls nodular fiber; bone-shaped in cross section 1250–3000 μm lg. in outer cell wall irregular in tg. layers; every 3 or 4 [2 – ∞] period	70–180 μ m as in $Taxus$ nodular fiber; round to rectangular in cross section 1000–2000 μ m. lg. in outer cell wall irregular in tg. layers; every 1 or 2 period	50–200 μm as in <i>Taxus</i> almost smooth fiber; round to rectangular in cross section 1000–1750 μm lg. absent in tg. layers, sometimes 4 cells wide; every 3 or 4 period	smooth fiber; round to oval in cross section up to 1 cm. lg. absent in long tg. layers, every 2 period	80–200 μm as in <i>Taxus</i> nodular irregular; oval in cross section; almost no lumen 1000–1750 μm lg. in outer cell wall scattered, single
lg. measurements of cells pits transverse walls Sclereids: shape measurements crystals	50–200 μm mainly in radial and transverse walls nodular fiber; bone-shaped in cross section 1250–3000 μm lg. in outer cell wall irregular in tg. layers; every 3 or 4 [2 – ∞] period mainly in radial walls	$70{\text -}180~\mu{\rm m}$ as in $Taxus$ nodular fiber; round to rectangular in cross section $1000{\text -}2000~\mu{\rm m}$. lg. in outer cell wall irregular in tg. layers; every 1 or 2 period as in $Taxus$	50–200 μm as in <i>Taxus</i> almost smooth fiber; round to rectangular in cross section 1000–1750 μm lg. absent in tg. layers, sometimes 4 cells wide; every 3 or 4 period as in <i>Taxus</i>	smooth fiber; round to oval in cross section up to 1 cm. lg. absent in long tg. layers, every 2 period as in <i>Taxus</i>	80–200 μm as in Taxus nodular irregular; oval in cross section; almost no lumen 1000–1750 μm lg. in outer cell wall scattered, single as in Taxus
lg. measurements of cells pits transverse walls Sclereids: shape measurements crystals arrangement	50–200 μm mainly in radial and transverse walls nodular fiber; bone-shaped in cross section 1250–3000 μm lg. in outer cell wall irregular in tg. layers; every 3 or 4 [2 – ∞] period	70–180 μ m as in $Taxus$ nodular fiber; round to rectangular in cross section 1000–2000 μ m. lg. in outer cell wall irregular in tg. layers; every 1 or 2 period	50–200 μm as in <i>Taxus</i> almost smooth fiber; round to rectangular in cross section 1000–1750 μm lg. absent in tg. layers, sometimes 4 cells wide; every 3 or 4 period	smooth fiber; round to oval in cross section up to 1 cm. lg. absent in long tg. layers, every 2 period	80–200 μm as in <i>Taxus</i> nodular irregular; oval in cross section; almost no lumen 1000–1750 μm lg. in outer cell wall scattered, single
lg. measurements of cells pits transverse walls Sclereids: shape measurements crystals arrangement pits first present from originated from	50–200 μm mainly in radial and transverse walls nodular fiber; bone-shaped in cross section 1250–3000 μm lg. in outer cell wall irregular in tg. layers; every 3 or 4 [2 – ∞] period mainly in radial walls the 4 period on	$70-180~\mu m$ as in $Taxus$ nodular fiber; round to rectangular in cross section $1000-2000~\mu m$. lg. in outer cell wall irregular in tg. layers; every 1 or 2 period as in $Taxus$ the 2 period on	50–200 μm as in <i>Taxus</i> almost smooth fiber; round to rectangular in cross section 1000–1750 μm lg. absent in tg. layers, sometimes 4 cells wide; every 3 or 4 period as in <i>Taxus</i> the 3 period on phloem-parenchyma	smooth fiber; round to oval in cross section up to 1 cm. lg. absent in long tg. layers, every 2 period as in <i>Taxus</i> the 2 period on phloem-parenchyma	80–200 μm as in Taxus nodular irregular; oval in cross section; almost no lumen 1000–1750 μm lg. in outer cell wall scattered, single as in Taxus the 4 period on
lg. measurements of cells pits transverse walls Sclereids: shape measurements crystals arrangement pits first present from originated from Crystal cells	50–200 μm mainly in radial and transverse walls nodular fiber; bone-shaped in cross section 1250–3000 μm lg. in outer cell wall irregular in tg. layers; every 3 or 4 [2 – ∞] period mainly in radial walls the 4 period on crystal cells	$70-180~\mu m$ as in $Taxus$ nodular fiber; round to rectangular in cross section $1000-2000~\mu m$. lg. in outer cell wall irregular in tg. layers; every 1 or 2 period as in $Taxus$ the 2 period on crystal cells	50–200 μm as in <i>Taxus</i> almost smooth fiber; round to rectangular in cross section 1000–1750 μm lg. absent in tg. layers, sometimes 4 cells wide; every 3 or 4 period as in <i>Taxus</i> the 3 period on phloem-parenchyma cells	smooth fiber; round to oval in cross section up to 1 cm. lg. absent in long tg. layers, every 2 period as in <i>Taxus</i> the 2 period on phloem-parenchyma cells	80–200 μm as in Taxus nodular irregular; oval in cross section; almost no lumen 1000–1750 μm lg. in outer cell wall scattered, single as in Taxus the 4 period on crystal cells
lg. measurements of cells pits transverse walls Sclereids: shape measurements crystals arrangement pits first present from	50–200 μm mainly in radial and transverse walls nodular fiber; bone-shaped in cross section 1250–3000 μm lg. in outer cell wall irregular in tg. layers; every 3 or 4 [2−∞] period mainly in radial walls the 4 period on crystal cells present first oblique,	$70-180~\mu m$ as in $Taxus$ nodular fiber; round to rectangular in cross section $1000-2000~\mu m$. lg. in outer cell wall irregular in tg. layers; every 1 or 2 period as in $Taxus$ the 2 period on crystal cells	50–200 μm as in <i>Taxus</i> almost smooth fiber; round to rectangular in cross section 1000–1750 μm lg. absent in tg. layers, sometimes 4 cells wide; every 3 or 4 period as in <i>Taxus</i> the 3 period on phloem-parenchyma cells	smooth fiber; round to oval in cross section up to 1 cm. lg. absent in long tg. layers, every 2 period as in <i>Taxus</i> the 2 period on phloem-parenchyma cells	80–200 μm as in Taxus nodular irregular; oval in cross section; almost no lumen 1000–1750 μm lg. in outer cell wall scattered, single as in Taxus the 4 period on crystal cells
lg. measurements of cells pits transverse walls Sclereids: shape measurements crystals arrangement pits first present from originated from Crystal cells Phloem rays: direction	50–200 μm mainly in radial and transverse walls nodular fiber; bone-shaped in cross section 1250–3000 μm lg. in outer cell wall irregular in tg. layers; every 3 or 4 [2 − ∞] period mainly in radial walls the 4 period on crystal cells present first oblique, afterwards radial	70–180 μm as in Taxus nodular fiber; round to rectangular in cross section 1000–2000 μm. lg. in outer cell wall irregular in tg. layers; every 1 or 2 period as in Taxus the 2 period on crystal cells present radial	so-200 μm as in Taxus almost smooth fiber; round to rectangular in cross section 1000–1750 μm lg. absent in tg. layers, sometimes 4 cells wide; every 3 or 4 period as in Taxus the 3 period on phloem-parenchyma cells absent radial	smooth fiber; round to oval in cross section up to 1 cm. lg. absent in long tg. layers, every 2 period as in Taxus the 2 period on phloem-parenchyma cells absent	80–200 μm as in Taxus nodular irregular; oval in cross section; almost no lumen 1000–1750 μm lg. in outer cell wall scattered, single as in Taxus the 4 period on crystal cells present first oblique, afterwards radial
lg. measurements of cells pits transverse walls Sclereids: shape measurements crystals arrangement pits first present from originated from Crystal cells Phloem rays: direction width	50–200 μm mainly in radial and transverse walls nodular fiber; bone-shaped in cross section 1250–3000 μm lg. in outer cell wall irregular in tg. layers; every 3 or 4 [2 − ∞] period mainly in radial walls the 4 period on crystal cells present first oblique, afterwards radial uniseriate	70–180 μm as in Taxus nodular fiber; round to rectangular in cross section 1000–2000 μm. lg. in outer cell wall irregular in tg. layers; every 1 or 2 period as in Taxus the 2 period on crystal cells present radial uniseriate	so-200 μm as in Taxus almost smooth fiber; round to rectangular in cross section 1000–1750 μm lg. absent in tg. layers, sometimes 4 cells wide; every 3 or 4 period as in Taxus the 3 period on phloem-parenchyma cells absent radial uniseriate, sometimes biseriate	smooth fiber; round to oval in cross section up to 1 cm. lg. absent in long tg. layers, every 2 period as in Taxus the 2 period on phloem-parenchyma cells absent	80–200 μm as in Taxus nodular irregular; oval in cross section; almost no lumen 1000–1750 μm lg. in outer cell wall scattered, single as in Taxus the 4 period on crystal cells present first oblique,
lg. measurements of cells pits transverse walls Sclereids: shape measurements crystals arrangement pits first present from originated from Crystal cells Phloem rays: direction width height in cells	50–200 µm mainly in radial and transverse walls nodular fiber; bone-shaped in cross section 1250–3000 µm lg. in outer cell wall irregular in tg. layers; every 3 or 4 [2−∞] period mainly in radial walls the 4 period on crystal cells present first oblique, afterwards radial uniseriate 1–16	70–180 μm as in <i>Taxus</i> nodular fiber; round to rectangular in cross section 1000–2000 μm. lg. in outer cell wall irregular in tg. layers; every 1 or 2 period as in <i>Taxus</i> the 2 period on crystal cells present radial uniseriate 1–13	so-200 μm as in Taxus almost smooth fiber; round to rectangular in cross section 1000–1750 μm lg. absent in tg. layers, sometimes 4 cells wide; every 3 or 4 period as in Taxus the 3 period on phloem-parenchyma cells absent radial uniseriate, sometimes biseriate 1–15	smooth fiber; round to oval in cross section up to 1 cm. lg. absent in long tg. layers, every 2 period as in Taxus the 2 period on phloem-parenchyma cells absent almost radial uniseriate 1–10	80–200 μm as in Taxus nodular irregular; oval in cross section; almost no lumen 1000–1750 μm lg. in outer cell wall scattered, single as in Taxus the 4 period on crystal cells present first oblique, afterwards radial uniseriate 1–4
lg. measurements of cells pits transverse walls Sclereids: shape measurements crystals arrangement pits first present from originated from Crystal cells Phloem rays: direction width	50–200 μm mainly in radial and transverse walls nodular fiber; bone-shaped in cross section 1250–3000 μm lg. in outer cell wall irregular in tg. layers; every 3 or 4 [2 − ∞] period mainly in radial walls the 4 period on crystal cells present first oblique, afterwards radial uniseriate	70–180 μm as in Taxus nodular fiber; round to rectangular in cross section 1000–2000 μm. lg. in outer cell wall irregular in tg. layers; every 1 or 2 period as in Taxus the 2 period on crystal cells present radial uniseriate	so-200 μm as in Taxus almost smooth fiber; round to rectangular in cross section 1000–1750 μm lg. absent in tg. layers, sometimes 4 cells wide; every 3 or 4 period as in Taxus the 3 period on phloem-parenchyma cells absent radial uniseriate, sometimes biseriate	smooth fiber; round to oval in cross section up to 1 cm. lg. absent in long tg. layers, every 2 period as in Taxus the 2 period on phloem-parenchyma cells absent almost radial uniseriate	s0–200 μm as in Taxus nodular irregular; oval in cross section; almost no lumen 1000–1750 μm lg. in outer cell wall scattered, single as in Taxus the 4 period on crystal cells present first oblique, afterwards radial uniseriate

CONCLUSIONS

Amentotaxus argotaenia (Hance) Pilger sensu stricto differs from the other investigated species in the following characteristic features: the axial system is, for the greater part, composed of sieve cells. They constitute tangential bands 1 to 10 (often 5) cells wide, alternating regularly with tangential layers of phloem-parenchyma cells 1 cell wide; sclereids, originated from either phloem-parenchyma cells or crystal cells, lie scattered in the nonconducting phloem, irregular, thus not in tangential layers; the rays are 1 to 4 cells high; the sieve cells are rather long. These differences in the characteristics of the secondary phloem are not sufficient to decide whether Amentotaxus should be placed in the Taxaceae or in the Cephalotaxaceae, or even in a separate family, the Amentotaxaceae.

Additional investigations are advisable, but only if and when fresh

material is available.

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