4. Identification Keys

How to use the keys

The objective of the identification key is to separate groups of species by using a few selected unambiguous and clearly visible features. Due to intraspecific anatomical variability, correct identification can only be achieved through comparison with illustrations and descriptions in the main section of the atlas. Some species were repeated two or more times in the key because of their not clear structure. The page numbers given in the key refers to the complete anatomical description of the species.

Coniferous woods are listed under the sections “Wood without vessels” and are separated by resin ducts presence or absence. Additional features are given to facilitate identification process: axial parenchyma, ray tracheids (“+”, present; “-”, absent), and cross-field pitting (S, small; L, large).

Dicotyledons wood and Monocotyledons plant body are grouped together under the section “Wood with vessels”. They are divided first by presence or absence of included phloem. In those species with successive cambia, phloem strands can be arranged in continuous tangential bands, or in single, scattered vascular bundles as seen in transverse section. Then species are then classified by raylessness and ray type (heterogeneous or homogeneous).

In woods without included phloem wood porosity is the first classification factor (ring-porous, semi-ring-porous, and diffuse-porous). Within each of the tree groups raylessness and ray width were then applied as grouping factors: rays are absent, exclusively uniseriate (90% or more), up to 3 cells wide, and more than 4 cells wide. Ray width classification in the identification key always refers to the larger rays. Ray type is also specified (heterogenous and homogenous). Within each of the resulting groups additional features are given for each specie in order to help identification. Those additional features refer to perforation plates (13, simple; 14, scalariform; 19, foraminate), helical thickenings (“+”, present; “-”, absent), and vessel groupings (9, vessels predominantly solitary; 10, vessels in radial multiples; 11, vessel clusters common).

Keys structure

A. Crivellaro, F. H. Schweingruber, *Atlas of Wood, Bark and Pith Anatomy of Eastern Mediterranean Trees and Shrubs*,
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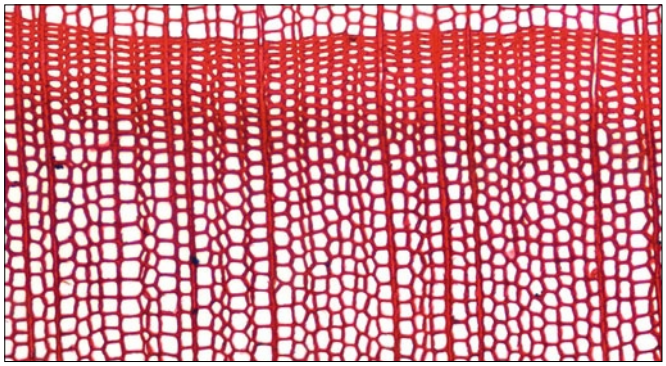
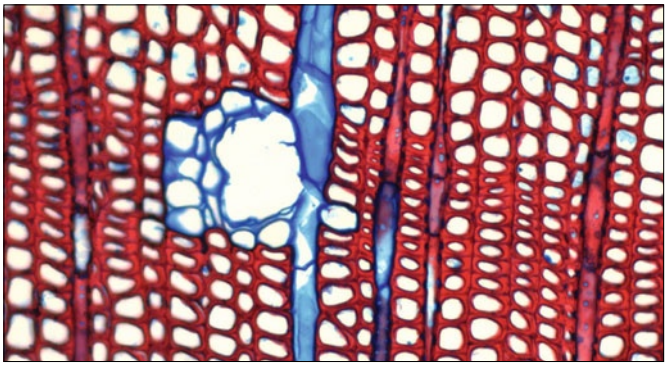
Wood without vessels (Gymnosperms)

The major mass of conifers wood consists of tracheids. Growth ring boundaries are usually distinct. Axial parenchyma is present in some species. Axial and radial resin canals are present or absent. Rays are mostly uniseriate.

Wood of a conifer without resin ducts.



Wood of a conifer with resin ducts.

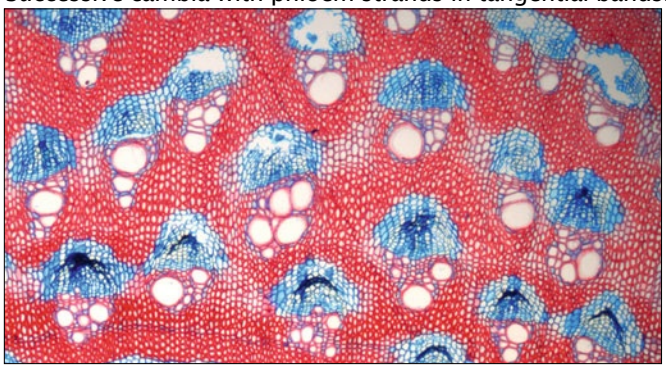


	Axial parenchyma	Ray tracheids	Cross-field pitting	Species	pg.
Without resin ducts	+	-	S	*Cupressus sempervirens*	54
	+	-	S	*Juniperus excelsa*	56
	+	-	S	*Juniperus foetidissima*	58
	+	-	S	*Juniperus oxycedrus*	60
	+	-	S	*Juniperus phoenicea*	62
	-	-	S	*Taxus baccata*	76
	-	+	S	*Cedrus brevifolia*	64
	-	+	S	*Cedrus libani*	66
With resin ducts	-	+	S	*Pinus brutia*	68
	-	+	L	*Pinus nigra*	72
	-	+	S	*Pinus halepensis*	70
	-	+	S	*Pinus pinea*	74

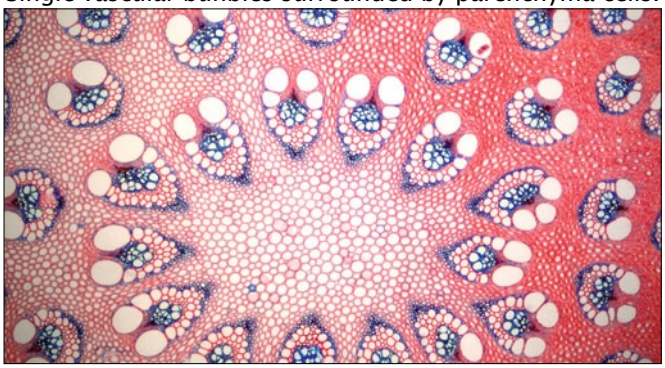
Wood with vessels and with included phloem

Species with successive cambia are separated by phloem strands arranged in continuous tangential bands, or in single, scattered vascular bundles as seen in transverse section.
We are aware about the great anatomical variability within plants with successive cambia.

Successive cambia with phloem strands in tangential bands.



Single vascular bunbles surrounded by parenchyma cells.

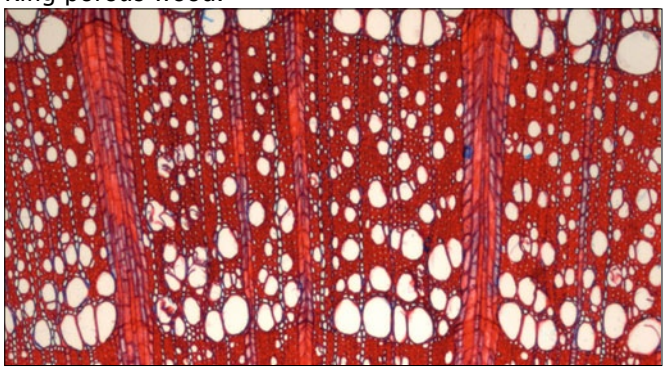


	Perforation plates	Helical thickenings	Vessels grouping	Species	pg.
Phloem strands in tangential bands					
Rays absent	13	-	11	*Atriplex semibaccata*	214
	13	-	11	*Salicornia fruticosa*	220
	13	-	9	*Sarcocornia perennis*	222
Phloem strands scattered and/or isolated					
Rays present					
Rays heterogeneous	13	-	9	*Convolvulus dorycnium*	248
	13	-	9	*Bosea cypria*	100
Rays homogeneous	13	-	10	*Convolvulus oleifolius*	250, 252, 254
Rays absent	13	-	11	*Arthrocnemum macrostachyum*	208
	13	-	11	*Atriplex halimus*	210
	13	-	11	*Atriplex portulacoides*	212
	13	-	11	*Noaea mucronata*	218
	13	-	10	*Suaeda aegyptica*	224
	13	+	11	*Halocnemum strobilaceum*	216
	13	+	11	*Suaeda vera*	226
	13	+	11	*Ruscus aculeatus*	90
	13	+	9	*Asparagus acutifolius*	86
	13	+	9	*Asparagus stipularis*	87
	13	+	9	*Arundo donax*	88
	13	+	9	*Phragmites australis*	89
	13	+	9	*Smilax aspera*	91

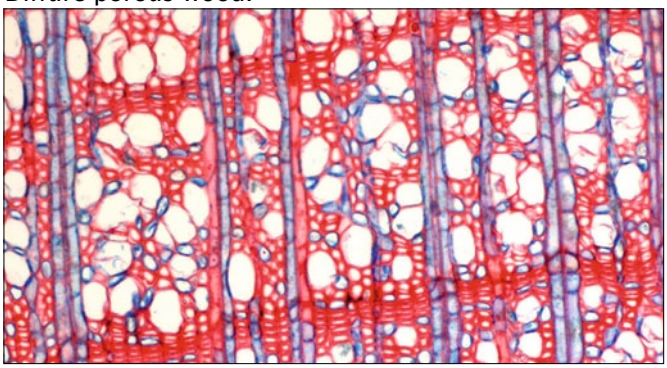
Wood with vessels and without included phloem

Wood with a great variation in type, size, form and arrangement of its cell types. Earlywood vessels can be much larger than those of the latewood (ring-porous woods), or vessels diameter can be uniform throughout the growth ring (diffuse-porous woods). Intermediate pattern is frequent (semi-ring-porous woods). Axial parenchyma and rays may or may not be present.

Ring-porous wood.



Diffure-porous wood.



	Perforation plates	Helical thickenings	Vessels grouping	Species	pg.
Ring-porous					
Rays exclusively uniseriate					
Rays heterogeneous	13	-	9	*Cyprinia gracilis*	126
	13	-	9	*Hypericum hircinum*	330
	13	+	9; 11	*Pterocephalus multiflorus*	262
Rays homogeneous	13	-	9	*Castanea sativa*	312
	13	-	9; 10	*Satureja thymbra*	378
	13	+	9	*Rubia tenuifolia*	512
Larger rays up to 3 seriate					
Rays heterogeneous	13	-	9	*Convolvulus oleifolius*	254
	13	-	9	*Salvia willeana*	376
	13	-	9	*Fraxinus angustifolia*	430
	13	-	9; 11	*Fraxinus ornus*	432
	13	-	11	*Capparis spinosa*	196
	13	-	11	*Teucrium divaricatum*	388
	13	+	9	*Acanthoprasium integrifolium*	334
	13	+	9; 11	*Cotinus coggygria*	102
	13	+	9; 11	*Hypericum confertum*	328
	13	+	11	*Pistacia atlantica*	104
	13	+	11	*Pistacia lentiscus*	106
	13	+	11	*Pistacia terebinthus*	108
	13	+	11	*Rhus coriaria*	110

	Perforation plates	Helical thickenings	Vessels grouping	Species	pg.
(Larger rays up to 3 seriate)					
(Rays heterogeneous)	13	+	11	*Celtis tournefortii*	194
	13	+	11	*Genista fasselata*	298
	13	+	11	*Phlomis cypria* subsp. *cypria*	360
	13	+	11	*Phlomis cypria* var. *occidentalis*	362
Rays homogeneous					
	13	-	9	*Fraxinus angustifolia*	430
	13	+	9; 11	*Teucrium creticum*	384
	13	+	11	*Robinia pseudoacacia*	308
Larger rays more than 4 seriate					
Rays heterogeneous	19	-	9	*Ephedra nebrodensis*	82
	13	-	9	*Aristolochia sempervirens*	124
	13	-	9	*Onosis spinosa* subsp. *leisosperma*	306
	13	-	9	*Quercus infectoria* subsp. *veneris*	324
	13	-	9	*Rubus sanctus*	500
	13	-	9; 11	*Rubus discolor*	498
	13	-	9; 11	*Vitis vinifera*	568
	13	-	11	*Hedera helix*	122
	13	-	11	*Astragalus echinus* subsp. *echinus*	292
	13	-	11	*Morus nigra*	416
	13	-	11	*Clematis vitalba*	454
	13	+	9	*Rosa micrantha*	496
	13	+	9; 1	*Prunus armeniaca*	476
	13	+	9; 11	*Celtis australis*	192
	13	+	9; 11	*Elaeagnus angustifolia*	266
	13	+	9; 11	*Morus alba*	414
	13	+	9; 11	*Prunus dulcis*	482
	13	+	9; 11	*Rosa canina*	492
	13	+	9; 11	*Rosa damascena*	494
	13	+	9; 11	*Ailanthus altissima*	538
	13	+	11	*Pistacia atlantica*	104
	13	+	11	*Berberis cretica*	154
	13	+	11	*Celtis tournefortii*	194
	13	+	11	*Lonicera japonica*	200
Rays homogeneous	13	-	9	*Quercus cerris*	318
	13	-	9	*Quercus infectoria* subsp. *veneris*	324
	13	+	11	*Cercis siliquastrum*	296
	13	+	11	*Robinia pseudoacacia*	308
	13	+	11	*Ulmus canescens*	562

	Perforation plates	Helical thickenings	Vessels grouping	Species	pg.
Semi-ring-porous					
Rays exclusively uniseriate					
Rays heterogeneous	13	-	9	*Lomelosia cyprica*	258
	13	-	9	*Lavandula stoaechas*	340
	13	-	9	*Salix alba*	526
	13	-	9	*Lycium schweinfurtii*	452
	13	-	9; 11	*Cistus salvifolius*	236
	13	-	9; 11	*Fumana thymifolia*	240
	13	-	9; 11	*Micromeria chionistrae*	342
	13	-	9; 11	*Micromeria myrtinifolia*	346
	13	-	9; 11	*Polygonum equisetiforme*	450
	13	-	9; 11	*Thymelaea hirsuta*	558
	13	-	11	*Micromeria microphylla*	344
	13	-	11	*Asperula cypria*	506
	13	+	9; 11	*Thymelaea tartoriaria*	560
	13	+	11	*Pterocephalus multiflorus* subsp. *multiflorus*	260
Rays homogeneous	13	-	9	*Helianthemum obtusifolium*	242
	13	-	9	*Origanum dubium*	354
	13	-	9	*Teucrium micropodioides*	394
	13	-	9	*Thymus intiger*	398
	13	-	9	*Lycium schweinfurtii*	542
	13	-	9; 11	*Satureja thymbra*	378
	13	-	11	*Origanum cordifolium*	352
	13	+	9	*Teucrium kyreniae*	392
	13	+	9	*Rubia tenuifolia*	512
	13	+	11	*Teucrium cyprium*	386
	13	+	11	*Teucrium kotschyannum*	390
Larger rays up to 3 seriate					
Rays heterogeneous	19	-	9	*Ephedra foeminea*	80
	14	+	9; 11	*Corylus avellana*	158
	14	+	9; 11	*Viburnum tinus*	98
	13	-	9	*Cistus creticus*	228
	13	-	9	*Cistus ladanifer*	230
	13	-	9	*Helianthemum stipulatum*	244
	13	-	9	*Prasium majus*	366
	13	-	9	*Salvia willeana*	376
	13	-	9	*Callistemon lanceolatus*	418
	13	-	9	*Syringa vulgaris*	438
	13	-	9	*Crataegus mongyna*	470
	13	-	9	*Pyracantha coccinea*	484
	13	-	9	*Pyrus syriaca*	490
	13	-	9	*Citrus aurantium*	514
	13	-	9	*Origanum majorana*	356
	13	-	9	*Salvia fruticosa*	372
	13	-	9	*Pyrus communis*	486

	Perforation plates	Helical thickenings	Vessels grouping	Species	pg.
(Larger rays up to 3 seriate)					
(Rays heterogeneous)	13	-	9; 11	*Pyrus malus*	488
	13	-	10	*Nicotiana glauca*	544
	13	-	11	*Ptilostemon chamapeuce*	152
	13	-	11	*Capparis spinosa*	196
	13	-	11	*Convolvulus dorycnium*	248
	13	-	11	*Anagyris foetida*	288
	13	-	11	*Teucrium divaricatum* subsp. *canescens*	388
	13	-	11	*Prosopis farcta*	408
	13	+	9	*Hippocrepis emerus*	304
	13	+	9	*Ziziphus spina-christi*	462
	13	+	9	*Cotoneaster nummuralis*	466
	13	+	9	*Crataegus azarolus*	468
	13	+	9	*Cydonia oblonga*	474
	13	+	9	*Citrus limon*	516
	13	+	9; 11	*Ostrya carpinifolia*	160
	13	+	9; 11	*Prunus avium*	478
	13	+	9; 11	*Artemisia arborescens*	134
	13	+	9; 11	*Arbutus andrachne*	268
	13	+	9; 11	*Spartium junceum*	310
	13	+	9; 11	*Hypericum confertum* subsp. *stenobotrys*	328
	13	+	9; 11	*Phlomis brevibracteata*	358
	13	+	9; 11	*Sorbus cretica*	504
	13	+	11	*Arbutus unedo*	270
	13	+	11	*Calycotome villosa*	294
	13	+	11	*Genista fasselata*	298
	13	+	11	*Lavandula angustifolia*	338
	13	+	11	*Phlomis cypria* subsp. *cypria*	360
	13	+	11	*Phlomis cypria* subsp. *occidentalis*	362
	13	+	11	*Phlomis lunariifolia*	364
	13	+	11	*Rosmarinus officinalis*	368
	13	+	11	*Salvia dominica*	270
Rays homogeneous	13	-	9	*Sideritis cypria*	382
	13	-	9; 11	*Odontites linkii*	440
	13	-	9; 11	*Plocama calabrica*	508
	13	+	9; 11	*Pterocephalus multiflorus* subsp. *obtusifolium*	262
	13	+	9; 11	*Spartium junceum*	310
	13	+	9; 11	*Teucrium creticum*	384
Larger rays more than 4 seriate					
Rays heterogeneous	14	-	9; 11	*Styrax officinalis*	548
	13	-	9	*Aristolochia sempervirens*	124
	13	-	9	*Dittrichia viscosa*	140
	13	-	9	*Phagnalon rupestre*	150
	13	-	9	*Erica arborea*	274

	Perforation plates	Helical thickenings	Vessels grouping	Species	pg.
(Larger rays more than 4 seriate)					
(Rays heterogeneous)	13	-	9	*Rubus sanctus*	500
	13	-	9	*Tamarix tetragyna*	554
	13	-	9; 11	*Rubus discolor*	498
	13	-	9; 11	*Citrus sinensis*	518
	13	-	9; 11	*Tamarix smyrnensis*	552
	13	-	9; 11	*Tamarix tetrandra*	556
	13	-	11	*Hedera helix*	122
	13	-	11	*Hirtellina lobelii*	146
	13	-	11	*Convolvulus dorycnium*	248
	13	-	11	*Argyrolobium uniflorum*	290
	13	-	11	*Astragalus echinus* subsp. *echinus*	292
	13	-	11	*Sarcopoterium spinosum*	502
	13	+	9	*Prunus domestica*	480
	13	+	9; 11	*Helichrysum italicum*	142
	13	+	9; 11	*Prunus dulcis*	482
	13	+	9; 11	*Rosa damascena*	494
	13	+	11	*Lithodora hispidula*	164
	13	+	11	*Lonicera japonica*	200
	13	+	11	*Nepeta trodii*	350
	13	+	11	*Tamarix dalmatica*	550
Larger rays more than 4 seriate					
Rays homogeneous	13	-	9	*Juglans regia*	332
Diffuse-porous					
Wood rayless	13	-	9	*Alyssum troodi*	178
	13	-	9	*Arabis purpurea*	182
	13	-	9	*Erysimum kykkoticum*	186
	13	-	9	*Silene galatea*	206
	13	-	9	*Frankenia hirsuta*	326
	13	-	9; 11	*Alyssum akamasicum*	172
	13	-	9; 11	*Dianthus cyprius*	202
	13	-	9; 11	*Onosma mitis*	170
	13	-	9; 11	*Arabis cypria*	180
	13	-	9; 11	*Salicornia fruticosa*	220
	13	-	9; 11	*Sarcocornia perennis*	222
	13	-	11	*Onosma fruticosa*	168
	13	-	11	*Arthrocnemum macrostachyum*	208
	13	-	11	*Atriplex halimus*	210
	13	-	11	*Atriplex portulacoides*	212
	13	-	11	*Atriplex semibaccata*	214
	13	-	11	*Noaea mucronata*	218
	13	+	9	*Silene fruticosa*	204
	13	+	9	*Plumbago europaea*	448
	13	+	9; 11	*Suaeda vera*	226
	13	+	11	*Onosma caespitosa*	166
	13	+	11	*Halocnemum strobilaceum*	216

	Perforation plates	Helical thickenings	Vessels grouping	Species	pg.
Rays exclusively uniseriate					
Rays heterogeneous	14	-	9; 11	*Viburnum opulus*	96
	13	-	9	*Helianthemum syriacum*	246
	13	-	9	*Calluna vulgaris*	272
	13	-	9	*Eucalyptus torquata*	424
	13	-	9	*Melaleuca armillaris*	426
	13	-	9	*Ziziphus lotus*	460
	13	-	9	*Salix alba*	526
	13	-	9	*Lycium schweinfurtii*	542
	13	-	9	*Fagonia cretica*	570
	13	-	9; 11	*Punica granatum*	402
	13	-	9; 11	*Fumana thymifolia*	240
	13	-	9; 11	*Convolvulus oleifolius* var. *oleifolius*	252
	13	-	10	*Euphorbia thompsonii*	280
	13	-	10; 11	*Thymelaea hirsuta*	558
	13	-	11	*Calamintha incana*	336
	13	-	11	*Micromeria microphylla*	344
	13	-	11	*Thymbra capitata*	396
	13	-	11	*Asperula cypria*	506
	13	+	10	*Dodonaea viscosa*	534
	13	+	11	*Lycium ferocissimum*	540
Rays homogeneous	14	-	10; 11	*Alnus orientalis*	156
	13	-	9	*Fumana arabica*	238
	13	-	9	*Helianthemum obtusifolium*	242
	13	-	9	*Scutellaria sibthorpii*	380
	13	-	9	*Teucrium micropodioides*	394
	13	-	9	*Thymus intiger*	398
	13	-	9	*Lycium schweinfurtii*	542
	13	-	9; 11	*Micromeria nervosa*	348
	13	-	9; 11	*Salvia lanigera*	374
	13	-	9; 11	*Aesculus hippocastanum*	532
	13	-	10	*Euphorbia hierosolymitan*	278
	13	-	10	*Populus alba*	522
	13	-	10	*Populus nigra*	524
	13	-	11	*Origanum cordifolium*	352
	13	+	9	*Teucrium kyreniae*	392
	13	+	9	*Plumbago europaea*	448
	13	+	9	*Cydonia oblonga*	474
	13	+	9	*Rubia laurae*	510
	13	+	9; 11	*Vinca major*	118
	13	+	11	*Teucrium cyprium*	386

	Perforation plates	Helical thickenings	Vessels grouping	Species	pg.
Larger rays up to 3 seriate					
Rays heterogeneous	14	-	9	*Buxus sempervirens*	188
	14	-	9	*Cornus sanguinea*	256
	14	-	9	*Laurus nobilis*	398
	14	+	9; 11	*Corylus avellana*	158
	14	+	9; 11	*Viburnum tinus*	98
	13	-	9	*Cistus creticus*	228
	13	-	9	*Cistus parvifolius*	234
	13	-	9	*Helianthemum stipulatum*	244
	13	-	9	*Helianthemum syriacum*	246
	13	-	9	*Convolvulus oleifolius var. desertii*	250
	13	-	9	*Diospiros kaki*	264
	13	-	9	*Ricunus communis*	282
	13	-	9	*Alhagi graegorum*	284
	13	-	9	*Alhagi maurorum*	286
	13	-	9	*Laurus nobilis*	398
	13	-	9	*Ficus carica*	410
	13	-	9	*Eucalyptus gomphocephala*	422
	13	-	9	*Myrtus communis*	428
	13	-	9	*Ziziphus ziziphus*	464
	13	-	9	*Crataegus mongyna*	470
	13	-	9	*Crataegus* x *sinaica*	472
	13	-	9	*Pyracantha coccinea*	484
	13	-	9	*Pyrus syriaca*	490
	13	-	9	*Citrus aurantium*	514
	13	-	9; 11	*Nerium oleander*	116
	13	-	9; 11	*Glycirrhiza glabra*	300
	13	-	9; 11	*Origanum majorana*	356
	13	-	9; 11	*Oleae europaea*	434
	13	-	9; 11	*Pyrus communis*	486
	13	-	9; 11	*Pyrus malus*	488
	13	-	9; 11	*Lantana camara*	564
	13	-	10	*Suaeda aegyptiaca*	224
	13	-	10	*Nicotiana glauca*	544
	13	-	10; 11	*Cichorium spinosum*	138
	13	-	11	*Sambucus nigra*	94
	13	-	11	*Ptilostemon chamapeuce*	152
	13	-	11	*Ceratonia siliqua*	190
	13	-	11	*Phillyrea latifolia*	436
	13	-	11	*Rhamnus alaternus*	456
	13	-	11	*Withania somnifera*	546
	13	+	9	*Cistus monspelliensis*	232
	13	+	9	*Hippocrepis emerus*	304
	13	+	9	*Ziziphus spina-christi*	462
	13	+	9	*Cotoneaster nummuralis*	466
	13	+	9	*Crataegus azarolus*	468
	13	+	9	*Citrus limon*	516

	Perforation plates	Helical thickenings	Vessels grouping	Species	pg.
(Rays heterogeneous)	13	+	9	*Vitex agnus-castus*	566
	13	+	9	*Zygophyllum album*	572
	13	+	9; 11	*Schinus terebinthifolia*	114
	13	+	9; 11	*Acer pseudoplatanus*	530
	13	+	9; 11	*Artemisia arborescens*	134
	13	+	9; 11	*Lonicera etrusca*	198
	13	+	9; 11	*Arbutus andrachne*	268
	13	+	9; 11	*Sorbus cretica*	504
	13	+	10	*Plumbago auriculata*	446
	13	+	10	*Dodonaea viscosa*	534
	13	+	10; 11	*Schinus molle*	112
	13	+	11	*Arbutus unedo*	270
	13	+	11	*Lavandula angustifolia*	338
	13	+	11	*Salvia dominica*	370
	13	+	11	*Rhamnus lycioides*	458
	13	+	11	*Ruta chalepensis*	520
Rays homogeneous	13	-	9	*Convolvulus oleifolius* var. *desertii*	250
	13	-	9	*Eucalyptus camaldulensis*	420
	13	-	9	*Phytolacca pruinosa*	442
	13	-	9; 11	*Acacia saligna*	406
	13	-	9; 11	*Odontites linkii*	440
	13	-	11	*Alyssum cypricum*	176
	13	+	9; 11	*Acer pseudoplatanus*	530
Larger rays more than 4 seriate					
Rays homogeneous	13	-	9	*Quercus ilex*	322
	13	-	11	*Ambrosia maritima*	132
	13	+	9	*Acer obtusifolium*	528