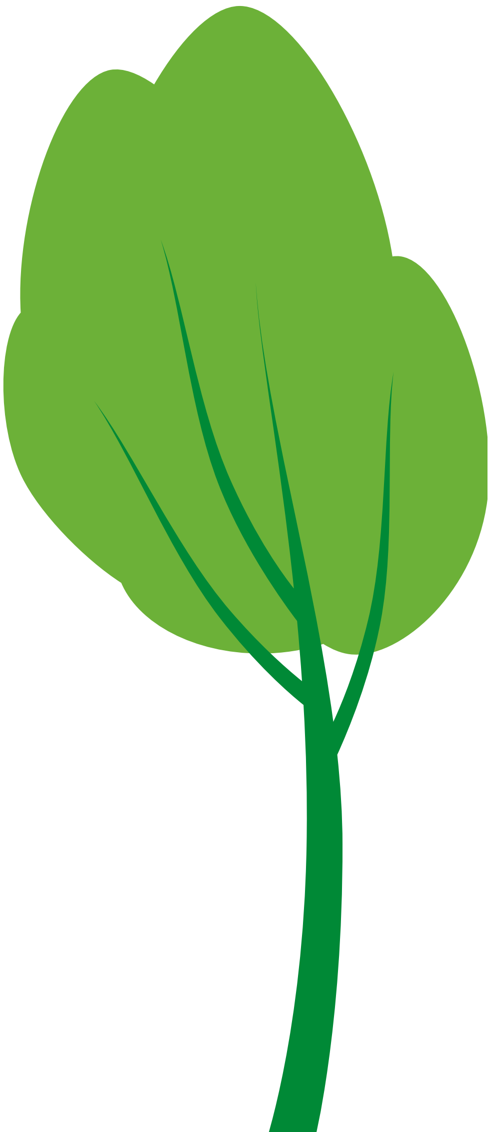
ImmunoCAP®
Is it allergy?

Tree pollens

Allergy – Which allergens?



Thermo SCIENTIFIC

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Tree pollen allergens

Trees are an important cause of pollen allergy. One reason for this is that they are both widespread and dense in the human environment, probably accounting for most of the world's pollen plants under cultivation. From ancient times they have been considered beautiful and in some cases sacred, and they have had a number of vital uses in human culture, producing not only food but material for shelter, fuel and implements. Trees are so congenial to most people that they are accompaniments to buildings (especially homes) almost wherever space, climate and soil allow. The intensely developed metropolis, and the impoverished, environmentally degraded rural village or urban slum in the developing world, are considered unwholesome in part because of the absence of trees.

As far as allergy is concerned, deforestation and urbanisation in the world overall are tendencies that need to be considered in balance against reforestation and suburbanisation in many industrialised countries – which are the main territory of allergy and the main focus of allergy studies. Also, the increasing preference in Europe, America and the Far East is to provide for "green space" in urban planning (while the newer cities of Australia and New Zealand have tended to be heavily "green" from the beginning), and trees are normally included. The public health benefits of trees' absorption of carbon dioxide from human activities are held to far outweigh any detriments from tree pollen. Tree pollen allergen exposure therefore remains high in the developed world, or is even increasing. Exacerbating the situation for pollen-allergic individuals is the preference for male trees as ornamentals, in order to avoid the trouble of harvesting or cleaning up from the ground the fruit of female trees. When a species is not self-fertilising, it is of course the male tree that produces the pollen, and this must be light, mobile pollen – with far greater allergenic potential.

The second reason for the importance of trees in allergy is their huge production of pollens. This must, however, be taken in the context of individual tree species: the gymnosperms or cone-bearing trees (mostly evergreens) are the biggest pollen shedders, but within this group the Pine is relatively benign, because its large pollen tends to fall straight down and not travel – but Cypresses, Junipers and Cedars are among the most troublesome of all allergenic trees. But the angiosperms or flowering trees (mostly deciduous) are also important, particularly Birch, Alder, Beech, Elm and Hazel. Because of human mobility and intervention in the environment, moreover, the allergy diagnosis and management that are necessitated by exposure to such allergens have been complicated. Olive trees, often planted for their fruit, now occur in many places where the climate is suitable (including southern Africa), not just in the Mediterranean. Cedars and Birches may still be considered characteristic of Japan and Scandinavia respectively, but this allows no firm deductions as to where specimens of these trees cannot have been introduced, beyond the most obvious places (Antarctica, the Congo basin, the Sahara, and a few others). The Eucalyptus was exclusive to Australia before colonial settlement of that continent, but is now one of the most widespread "alien" trees, and in many places a significant pest. The worldwide mix of trees is probably more diverse now than at any other time in human history, with all the problems this implies for dealing with allergy.

Allergen exposure

As far as allergenic trees are concerned, the "pollen season" can begin in early spring with the flowering of trees such as Birch, long before grass and weed pollens. On the other hand, some trees flower in autumn or twice a year, which can confuse expectations about pollen exposure. Rhinitis, asthma and conjunctivitis are typical in tree pollen allergy, and as with grass and weed pollen allergies, there is a tendency to accept discomfort and not pursue suitable diagnostic and management strategies, opting either for no treatment or possibly inappropriate chronic medication. But the influence of tree pollens on asthma, and important patterns of cross-reactivity, make it very desirable that tree pollen allergy be adequately addressed clinically.

Cross-reactivity

Cross-reactivity can be expected to roughly follow botanical relationships. The classification in figure 1 on the next page (representing widespread if not universal taxonomical opinion) shows some of the most common allergy provoking trees available for ImmunoCAP® testing.

The families of the *Fagales* order, here represented by *Betulaceae*, *Casuarinaceae*, *Fagaceae*, *Juglandaceae* and *Myricaceae*, are closely related and cross-reactivity can occur between members of different families within the order. The other orders contain a variety of non-related families where cross-reactivity can be expected only between members of the same family (1-13).

Broader cross-reactivity encompasses weed and grass pollens and plant-derived foods and other substances from distantly related species. Oral Allergy Syndrome, especially relating to Birch pollen, is a phenomenon that is of particular interest (14). To sketch a general pattern, Olive tree and Birch are most prominent in studies of cross-reactivity with, most strikingly, Mugwort, Wall pellitory, Plantain ragweed, Timothy, Rye, and Cocksfoot among the weeds and grasses; among foods and other substances, Apple, Celery, Melon, Carrot, Kiwi and Latex are most clearly significant in the same connection (15-24). It should be noted that the above is only a sampling of cross-reactivity among and beyond tree pollens.

Trees

Order	Family	Genus (species available on ImmunoCAP®)
Pinales	*Cupressaceae*	*Chamaecyparis* (Japanese cypress)
		Cryptomeria (Japanese cedar)
		Cupressus (Arizona cypress, Italian cypress)
		Juniperus (Mountain juniper, Red cedar)
		Libocederus (Cedar)
		Taxodium (Bald cypress)
	Pinaceae	*Picea* (Spruce)
		Pinus (Pine, White pine)
		Pseudotsuga (Douglas fir)
Arecales	*Arecaceae*	*Elaeis* (Oil palm)
		Phoenix (Date)
		Syagrus (Queen palm)
Fagales	*Betulaceae*	*Alnus* (Grey alder)
		Betula (Common silver birch)
		Carpinus (Horn beam)
		Corylus (Hazel)
	Casuarinaceae	*Casuarina* (Australian pine)
	Fagaceae	*Castanea* (Chestnut)
		Fagus (American beech)
		Quercus (Oak, Virginia live oak)
	Juglandaceae	*Carya* (Pecan, White hickory)
		Juglans (Walnut)
	Myricaceae	*Myrica* (Bayberry)
Malpighiales	*Salicaceae*	*Populus* (Cottonwood)
		Salix (Willow)
Malvales	*Malvaceae*	*Tilia* (Linden)
Saxifragales	*Salicaceae*	*Liquidambar* (Sweet gum)
Rosales	*Elaeagnaceae*	*Elaeagnus* (Russian olive)
	Moraceae	*Morus* (Mulberry, Red mulberry)
	Ulmaceae	*Celtis* (Hackberry)
		Ulmus (American elm, Cedar elm)
Myrtales	*Myrtaceae*	*Eucalyptus* (Eucalyptus)
		Melaleuca (Cajeput-tree)
Fabales	*Fabaceae (Leguminoseae)*	*Acacia* (Acacia)
		Cercidium (Paloverde)
		Cytisus (Scotch broom)
		Prosopis (Mesquite)
Sapindales	*Anacardiaceae*	*Schinus* (Peppertree)
	Sapindaceae	*Acer* (Box-elder)
		Aesculus (Horse chestnut)
Proteales	*Platanaceae*	*Platanus* (London plane)
Dipsacales	*Adoxaceae*	*Sambucus* (Elder)
Scrophulariales	*Oleaceae*	*Fraxinus* (European ash, White ash)
		Ligustrum (Privet)
		Olea (Olive)

Figure 1. Trees and their botanical relations, adapted from L Yman (8).

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Tree ImmunoCAP® Allergens available for IgE antibody testing

t19	Acacia (*Acacia longifolia*)
t5	American beech (*Fagus grandifolia*)
t73	Australian pine (*Casuarina equisetifolia*)
t37	Bald cypress (*Taxodium distichum*)
t56	Bayberry (*Myrica cerifera*)
t1	Box-elder (*Acer negundo*)
t212	Cedar (*Libocedrus decurrens*)
t45	Cedar elm (*Ulmus crassifolia*)
t206	Chestnut (*Castanea sativa*)
t3	Common silver birch (*Betula verrucosa*)
t14	Cottonwood (*Populus deltoides*)
t222	Cypress (*Cupressus arizonica*)
t214	Date (*Phoenix canariensis*)
t207	Douglas fir (*Pseudotsuga taxifolia*)
t205	Elder (*Sambucus nigra*)
t8	Elm (*Ulmus americana*)
t18	Eucalyptus, Gum-tree (*Eucalyptus spp.*)
t25	European ash (*Fraxinus excelsior*)
t2	Grey alder (*Alnus incana*)
t44	Hackberry (*Celtis occidentalis*)
t4	Hazel (*Corylus avellana*)
t209	Horn beam (*Carpinus betulus*)
t203	Horse chestnut (*Aesculus hippocastanum*)
t23	Italian/Mediterranean/ Funeral cypress (*Cupressus sempervirens*)
t17	Japanese cedar (*Cryptomeria japonica*)
t208	Linden (*Tilia cordata*)
t11	Maple leaf sycamore, London plane (*Platanus acerifolia*)
t21	Melaleuca, Cajeput-tree (*Melaleuca leucadendron*)
t20	Mesquite (*Prosopis juliflora*)
t6	Mountain juniper (*Juniperus sabinoides*)
t70	Mulberry (*Morus alba*)
t7	Oak (*Quercus alba*)
t223	Oil Palm (*Elaeis guineensis*)
t9	Olive (*Olea europaea*)
t219	Paloverde (*Cercidium floridum*)
t22	Pecan, Hickory (*Carya illinoinensis*)
t217	Peppertree (*Schinus molle*)
t213	Pine (*Pinus radiata*)
t210	Privet (*Ligustrum vulgare*)
t72	Queen palm (*Syagrus romanzoffiana*)
t57	Red cedar (*Juniperus virginiana*)
t71	Red mulberry (*Morus rubra*)
t54	Russian olive (*Elaeagnus angustifolia*)
t55	Scotch broom (*Cytisus scoparius*)
t201	Spruce (*Picea excelsa*)
t211	Sweet gum (*Liquidambar styraciflua*)
t218	Virginia live oak (*Quercus virginiana*)
t10	Walnut (*Juglans californica*)
t15	White ash (*Fraxinus americana*)
t41	White hickory (*Carya tomentosa syn. C. alba*)
t16	White pine (*Pinus strobus*)
t12	Willow (*Salix caprea*)
Mixes:	**tx1, tx2, tx3, tx4, tx5**
	tx6, tx7, tx8, tx9, tx10

Allergen components – Recombinant/ purified native

t215	rBet v 1 PR-10, Birch
t216	rBet v 2 Profilin, Birch
t220	rBet v 4 Birch
t221	rBet v 2, rBet v 4 Birch
t225	rBet v 6 Birch
t224	nOle e 1 Olive

Information regarding available allergen components can be found in “Allergy – Which allergens?, Native & recombinant allergen components”.

Acacia longifolia

Family: *Fabaceae*

Common names: Acacia tree, Wattle, Port Jackson, White sallow, Sydney golden

Source material: Pollen

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Allergen Exposure

Geographical distribution

Acacias are a characteristic feature of dry regions in India and the African savannah, where they are called umbrella trees because of their shape.

These trees are native to Australia, Africa and North and South America. They have been introduced in Portugal, Spain, France and Italy. *A. melanoxylon* is grown in large plantations in Australia, East Africa, South Africa and Brazil, where it is harvested for use in tanning leather.

Acacia flowers in early spring.

Environment

Acacia is a large genus, covering more than 1000 species, many with thorns and spines. The trees are small, evergreen and fast growing. They are planted for ornament but also for stabilising dunes and eroded slopes. They can also be a noxious alien type, crowding out indigenous plants.

Unexpected exposure

Acacia gum (Gum Arabic/Senegal gum/Sudan gum f297) is derived from this tree and may result in food allergy reactions (1-2). Acacia gum is the odourless, colourless, tasteless dried exudate from the stem of the Acacia tree.

Acacia bark and wood are pregnant with oils and terpenes and are considered a source of occupational allergens, especially in the tanning industry. Acacia oil is also used in the printing industry.

Allergens

To date no allergens have been characterised.

Potential cross-reactivity

Cross-reactivity between Acacia tree and Rye grass pollen allergens has been described (3). Cross-reactivity among members of the *Fabaceae* (Legume family) may be expected (4).

Date palm pollen (Phoenix dactylifera) has been shown to cross-react with antigens from Artemisia, Cultivated rye (*Secale cereale*), Timothy grass (*Phleum pratense*), Sydney golden wattle (*Acacia longifolia*) and Bermuda grass (*Cynodon dactylon*) pollen (5).

t19 Acacia

Clinical Experience

IgE-mediated reactions

Hayfever and asthma occur through exposure to the pollen (3,6-9). Rhinitis and asthma have been described in wood workers exposed to Acacia wood (10).

A study reviewed perennial and seasonal aeroallergen trends in the Middle East, and their effect on military personal serving in the region. It was reported that most of the countries have significant grass and weed pollen seasons from April to May and from September to October, respectively. Indigenous trees such as Date palm, Acacia, and Mesquite have specific pollen seasons during various periods anywhere from March through May. Mould allergens were perennial, with seasonal peaks, whereas House dust mite was common in humid coastal regions. The study concluded that seasonal and perennial allergens observed in the United States are also found in the Middle East (11). In an earlier study of 327 adult patients with diseases of suspected allergic origin who were examined in a hospital in the United Arab Emirates, skin prick testing showed that among the 244 patients (74.6%) with positive results, Acacia was positive in 25.6% (12). In a study of aeroallergens in sandstorm dust investigated in Riyadh, Saudi Arabia, the most abundant aeroallergens were, among others, Acacia, *Alternaria*, *Aspergillus* and Bermuda grass (13). In a study in Saudi Arabia, of 1,159 patients tested for sensitisation to inhalants, Acacia was positive in 29% (7).

In a Malaysian study of asthmatic patients with and without rhinitis, 7.9% were skin-prick-test-positive to *Acacia spp*. (14). In an earlier study in Kuala Lumpur, Malaysia, of 200 patients with asthma, 21.5% were sensitised to Acacia and 7.5% to *Melaleuca* pollen. In pollen collection, grass and Acacia pollen grains were the 2 most commonly found pollens (15). In Montpellier, in southern France, Acacia resulted in positive skin prick tests, though the pollen was almost absent from pollen counts (8). Studies have demonstrated sensitisation to other Acacia species, including to Cootamundra wattle (*A. baileyana*) along the Adriatic coast (16), *A. auriculiformis* in West Bengal, India (17), and in Thailand, where pollen from this tree was shown to result in vernal keratoconjunctivitis (18). An earlier study reported that of 100 Thai individuals with allergic rhinitis, 19% were skin-prick-positive for Acacia (6).

Among 107 patients with allergic rhinitis and/or asthma in Jakarta, Indonesia, 12.15% were shown to be sensitised to *A. auriculiformis* (19). Sensitisation to Acacia species was also demonstrated in Otaru, Japan (20). Occupational asthma has been reported due to Acacia species (21), and specifically to Blackwood (*A. Melanoxylon*) (22). *A. Melanoxylon* was also reported to cause occupational airborne contact dermatitis (23). Pollen from Sydney golden or the Mimosa tree (*A. floribunda*) was reported to be an occupational allergen in florists (24).

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t5 American beech

Fagus grandifolia	
Family:	*Fagaceae*
Common names:	American beech, Carolina beech, Gray beech, Red beech, Ridge beech, and White beech
Source material:	Pollen
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Allergen Exposure

Geographical distribution

The genus *Fagus* comprises 10 species of deciduous trees in the family *Fagaceae*, native to temperate Europe and North America. *Fagaceae* (Beech family), contains Beeches, Oaks, and Chestnuts.

Only American Beech is native to North America, ranging from southern Ontario to Nova Scotia, just west of the Mississippi to Texas, and south to the Gulf coast (1). In Europe this species is replaced with Common Beech (*F. sylvatica*). In Europe, Beech is indigenous only in England. Beech may be found in Armenia, Palestine, and Asia Minor. The southern beeches Nothofagus were previously thought to be closely related to beeches, but are now treated as members of a separate family, *Nothofagaceae*. They are found in Australia, New Zealand, New Guinea, New Caledonia and South America (2).

American Beech is a tall deciduous tree usually growing 20-25 m tall, although trees up to 40 m have been recorded. The crown is broad and the roots are wide spreading. The bark is smooth and blue- to light-grey. The leaves are yellow-green during the growing season. The 6 to 14 cm long leaves are leathery, oval, and yellow-green during the growing season. American beech leaves are finely toothed, whereas those of European beech have a wavy border (1).

The flowers are small single-sex (monoecious). The female flowers are borne in pairs. The male flowers are wind-pollinated catkins, produced in spring shortly after the new leaves appear. Male flowers occur in ball-like clusters on pendulous stalks. Female flowers are lesser in number, in leaf axils near the shoot tip. The Beech flowers in late spring. In the Northern Hemisphere, Beech pollen season extends from April to May. Beech trees are wind-pollinated. The European varieties shed more pollen than the native species. Beech pollen closely resembles oak pollen in morphology (1).

Beeches begin producing seed (fruit) when 40 years old, producing large quantities by 60 years of age. The fruit is a bur, usually containing two nuts. The fruit is a small, sharply three–angled nut 10-15 mm long, borne singly or in pairs in soft-spined husks 1.5–2.5 cm long, known as cupules (2). The pyramidal nuts are enclosed in pairs in a bristly husk. Seed is produced at 2- to 8-year intervals.

Beechnuts, called 'mast' in England, are valued for feeding farm animals and may be roasted and eaten by humans or used a coffee substitute. Although edible, the nuts are bitter with a high tannin content.

Environment

American Beech occurs occasionally in woods and is sometimes cultivated. Beech wood is used to make parquet flooring, wood pavement, bentwood furniture, veneer plywood, and railroad ties (1). Coal tar used to protect wood from rotting is made from beech wood. Creosote, made from Beech wood, is used medicinally. The wood may be used for fuel. Dyes are made from the leaves and bark.

Allergens

To date no allergens have been characterised.

Potential cross-reactivity

High cross-reactivity is often found among different species within the same family. There is a relatively high degree of cross-reactivity between species of the family *Fagaceae* (3), and an extensive cross-reactivity within the genus *Fagus* has been demonstrated (4). There is strong cross-reactivity between Oak and members of the Birch family, *Betulaceae* (5).

Partial identity between the major allergens of Birch, Beech, Alder, Hazel and Oak pollen extract has been demonstrated by means of, among others, *in vitro* specific IgE tests (6).

Clinical Experience

IgE-mediated reactions

In studies on patients with seasonal rhinitis, it was found that Birch, Beech, Alder, Hazel, bog-myrtle and Oak pollens are most important as causes of springtime hay fever (7-8). However, Beech pollen does not play the most significant role in causing hay fever.

Rhinitis and asthma caused by exposure to Beech wood dust in wood workers has also been described (9-11). Furthermore, exposure to Beech dust may lead to the development of sore throat and bronchial hyperresponsiveness (12).

In a study in Westchester County in the state of New York of skin prick tests to 48 aeroallergens in100 patients referred for allergic rhinitis, 65% had a positive SPT to at least 1 aeroallergen of which 16% were positive to Beech (13). In an earlier study of hypersensitivity toward prevalent tree pollens in the New York area, the highest prevalence of hypersensitivity was for Oak (34.3%), Birch (32.9%), Maple (32.8%), American Beech (29.6%), Hickory (27.1%), Ash (26%), Elm (24.6%), and Poplar (20.6%) (14).

In Japan, investigation of stored sera demonstrated IgE antibodies directed at American beech tree (15).

Fagus spp. pollen has been recorded in the air of Bilecik in Turkey (16) and in Lublin (eastern Poland) (17). The pollen of *Fagus spp*. has also been reported in the air of Zurich (18).

Other reactions

Occupational contact allergy from Beech wood has been described (19).

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t73 Australian pine

Casuarina equisetifolia

Family: *Casuarinaceae*

Common names: Australian pine, Common ironwood, Beefwood, Bull-oak, Whistling-pine, Horsetail tree

Source material: Pollen

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Allergen Exposure

Geographical distribution

Casuarina is a genus of 17 species in the family *Casuarinaceae*, native to Australia, southeastern Asia, and islands of the western Pacific Ocean. Once treated as the sole genus in the family, it has now been split into 3 genera (1). It is widely redistributed in southeastern China, India, and Australia (2). *C. equisetifolia*, *C. glauca*, and *C. cunninghamiana* were introduced to Hawaii, the West Indies, to Mexico by the middle to late 1800s, and to Florida shortly thereafter. *C. cunninghamiana* is also common in southern Spain (3). Most species are dioecious, but a few are monoecious.

Australian pine tree is an evergreen with native habitats typical of *Casuarina*, from Burma and Vietnam east to French Polynesia, New Caledonia, and Vanuatu, and south to Australia (the northern part of Northern Territory, north and east Queensland, and northeastern New South Wales). It is also found in India and parts of Africa. In West Africa it is known as the Filao Tree and is planted to prevent erosion of sandy soils (4).

Not to be confused with the Pine tree of the coniferous *Pinus* species, Australian pine tree is a Pine-like tree with a large, rather untidy, greyish-green crown. What appear at first to be Pine needles are in fact short twigs (0.5-1 mm in diameter, bearing minute scale-leaves in whorls of 6-8), and these are distinguished from Pine needles in that the former are jointed with several nodes and internodes. The fruit resembles a small cone, about 2 cm long and oval. Australian pine tree grows rapidly to 6-35 m within ten years (5).

Unlike most other species of *Casuarina* (which are dioecious), it is monoecious, with male and female flowers produced on the same tree. The flowers develop in small catkin-like inflorescences at the ends of shootlets; the male flowers in simple spikes 0.7-4 cm long, the female flowers on short peduncles. The pistillate flowers are found on lower side branches. All species are wind-pollinated. *C. equisetifolia* and *C. glauca* pollinate from February through May in the Northern Hemisphere, while *C. cunninghamiana* pollinates from September through December, and accounts for almost 80% of pollen in October in southern Spain (3,5).

The fruit is an oval woody structure 10-24 mm long and 9-13 mm in diameter. It superficially resembles a conifer cone, being made up of numerous carpels, each containing a single-winged seed 6-8 mm long.

t73 Australian pine

Casuarina species have variable degrees of salt tolerance and grow very rapidly, so that they are ideal for planting along sand dunes and as windbreaks to protect citrus orchards. They were therefore introduced into many countries (3). Australian pine tree and *C. cunninghamiana* were introduced into, among others, Argentina, China, Egypt, Israel, Iraq, Kenya, Mexico, South Africa and the southern United States (in particular Florida), and are now considered to be invasive species (1,3).

Environment

A Spanish study showed that in that country the pollen season for Pine in general is relatively short. The pollen dispersion period occurs during October and November. There is a diurnal pattern, with the most influential variables in dispersion being temperature, sunshine, and rainfall. The highest concentrations of pollen occurred between 12 a.m. and 2 p.m (6).

Australian pine tree was reported to be a significant contributor to the major tree pollen season (December through May) in the Tampa Bay area, Florida, as well as during a minor season (October and November) (7). Similarly, pollen from Australian pine tree has been recorded in the atmosphere of Darwin, Australia (8), and Argentina (9).

This tree is cultivated as an ornamental plant, for shade, as a windbreak, and for dune stabilisation. The wood is used for shingles, fencing, and firewood (1).

Allergens

To date no allergens have been characterised.

Potential cross-reactivity

Cross-reactivity with other members of this distinctive family may be expected. (10)

While there is strong cross-reactivity between *Betulaceae* and *Fagaceae*, there are no studies examining *Casuarinaceae* cross-allergenicity with other suborder members (11-12).

Through the use of rabbit antisera, no cross-antigenicity has been demonstrated between *Casuarina* and true conifers (13).

Clinical Experience

IgE-mediated reactions

Asthma and rhinitis occur in sensitised individuals. Skin prick tests and *in vitro* tests in these patients have confirmed IgE antibodies to Australian pine tree pollen (6).

In a study in Málaga, in southern Spain, sensitisation to Australian pine tree pollen was investigated in a nonatopic population of 210 with a previous history of autumn rhinitis or asthma. Six subjects tested positive, and of these, 5 were shown to have serum-specific IgE (RAST class > or = 2) to this pollen (6).

Australian pine pollen-specific IgE has been demonstrated in 6 of 14 (42%) subjects with a positive nasal challenge, and in 4 of 5 (80%) subjects with a positive bronchial challenge, confirming that Australian pine pollen is an aeroallergen (14).

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t37 Bald cypress

Taxodium distichum

Family: Some researchers claim that Bald cypress belongs to the family *Cupressaceae* (1-2), while others place it in a separate family, *Taxodiaceae*. A third opinion is that these are a single family

Common names: Bald cypress, Swamp Cypress

Source material: Pollen

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Allergen Exposure

Geographical distribution

Bald cypress is a deciduous conifer, growing in very wet, swampy, often submerged soils. It is native to humid climates where precipitation ranges from about 760 mm to 1630 mm. It is found from Delaware to south Florida, into Texas and Oklahoma, and north to Indiana. Planted as an ornamental in Europe, it is hardy into southern Canada (3-5). Ancient Bald cypress forests, with some trees more than 1,200 years old, once dominated swamps in the southeastern US (6). Existing trees can be around 500 years of age, and some exceed 40 m in height. Some consider pond cypress (*T. ascendens* and *T. mucronatum*) to comprise varieties of *T. distichum* (3,7-8).

Bald cypress is a large tree, usually reaching over 25 m in height, with a trunk diameter of 2-3 m, and a wide, buttressed, tapering trunk. The bark is light-brown, gray-brown or red-brown, shallowly vertically fissured and scaly, with a stringy texture. The trunk base is deeply ridged. The branches are upright and spreading. Buds are small and inconspicuous. Twigs near the end of the shoots persist, while those on the lower part of the stem are deciduous and fall with the leaves. The leaves are borne on deciduous branchlets that are spirally arranged on the stem but twisted at the base to lie in 2 horizontal ranks, 1-2 cm long and 1-2 mm broad (6). The deciduous needles are 10-19 mm long, soft, flat, and flexible. Leaflets are linear with entire margins. Foliage is soft and light-green with a feathery or plume-like appearance.

The roots send up short, tapering trunks, protruding out of the water or (less often) the ground and known as “cypress knees”.

Bald cypress is unusual in that it is a deciduous conifer, shedding its foliage during the winter months; hence the name “bald”.

The flowers are monoecious. Male and female strobili mature in about 12 months; they are produced from buds formed in the late fall, with pollination in early winter. Male catkins are at least 5 cm long and quite conspicuous during the winter months, arranged in narrow drooping clusters of 10 cm. The seed cones are green, maturing to gray-brown, globular and 2-3.5 cm in diameter. They have from 20 to 30 spirally arranged 4-sided scales, each bearing 1 or 2 (rarely 3) triangular seeds. The number of seeds per cone ranges from 20 to 40. The cones disintegrate when mature to release the large seeds. The seeds are 5 to10 mm long and are produced every year, but with heavy crops every 3 to 5 years (4).

In Tampa, Florida, in the USA, Oak, Pine, Australian pine, Bald cypress, Cedar, Bayberry and Mulberry contribute to the major tree pollen season, extending from December to May (9).

Environment

Bald cypress heartwood is very resistant to rot (and called "wood eternal"). It is prized for the construction of docks, warehouses, and bridges, as well as interior trim (4). Taxol, an anticancer drug first isolated from the bark of the yew tree (Taxus brevifolia), is also produced in Bald cypress by an endophytic fungus (*Pestalotiopsis microspora*). Bald cypress is also planted as an ornamental tree.

Allergens

No allergens have been characterised.

Potential cross-reactivity

Potential cross-reactivity for this tree has not been elucidated to date.

Clinical Experience

IgE-mediated reactions

Anecdotal evidence suggests that asthma and hayfever are possible following exposure to pollen from this tree; however, few specific studies on this have been reported to date (10).

Nasal and bronchial Bald cypress challenges verify this tree's ability to cause both allergic rhinitis and asthma. (10) In a study in which 57 nasal and bronchial provocation tests were performed with Bald cypress pollen extract on 41 subjects, a positive nasal response was elicited in 12 of 17 (71%) subjects with allergic rhinitis and positive Bald cypress pollen skin tests. A positive bronchial challenge was elicited in 2 of 10 asthmatics with positive Bald cypress pollen skin tests. Bald cypress-specific IgE was demonstrated in 7 of the 12 (59%) subjects with a positive nasal challenge, and in 1 of the 2 subjects with a positive bronchial challenge (10).

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t56 Bayberry

Myrica cerifera

Family: *Myricaceae*

Common names: Bayberry, Bay-rum tree, Candleberry, Sweet gale, Wax myrtle, Southern waxmyrtle, and Waxberry

Source material: Pollen

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Allergen Exposure

Geographical distribution

Bayberry is a member of the *Myrica* genus, consisting of about 35-50 species of small trees and shrubs in the family *Myricaceae*, order *Fagales*. Members of the genus are found in Africa, Asia, Europe, North America and South America, but not Australasia. Some authors split the genus into 2 genera on the basis of catkin and fruit structure, restricting *Myrica* to a few species and classing the others in *Morella* (1).

The species vary from 1 m shrubs to 20 m trees; some are deciduous, but the majority of species are evergreen. The plants can grow on soils that are very poor in nitrogen. Bayberry is a shrub or slender tree growing up to 12 m in height. The leaves are spirally arranged, simple, 2.5 to 12 cm long, lanceolate or wedge-shaped, shining or resinous, dotted on both sides, and with a crinkled or finely toothed margin. They have a fragrant odour when crushed.

The flowers are catkins, with male and female catkins borne on separate trees (dioecious reproduction), the male flowers in cylindrical yellow clusters and the female flowers in green, somewhat shorter clusters. The flowers appear in spring, generally before the leaves are fully expanded.

The fruit is a small drupe, which remains on the tree for several years and consists of clusters of round, 1-seeded, somewhat berrylike nuts covered with a greenish-white wax.

The wax coating on the fruit is indigestible to most birds, but a few species have adapted to be able to eat it. The seeds are then dispersed in the birds' droppings. The wax coating of several species of *Myrica*, including *Myrica cerifera*, is known as Bayberry wax, and was used in the past to make candles. The foliage of *Myrica* gale is a traditional insect repellent, used by campers to keep biting insects out of tents. Several species are also grown as ornamental plants in gardens. *Myrica* is used to spice beer and schnapps in Denmark.

Allergens

No allergens have been characterised.

Potential cross-reactivity

Unknown at present.

Clinical Experience

IgE-mediated reactions

Although allergy to pollen from Bayberry has not been commonly reported (2-3), the following studies are suggestive. Southern bayberry was reported to be the source of the fifth most common windborne tree pollen in Tampa, Florida, in the USA (3-4). In a study of 400 consecutive subjects evaluated for allergic respiratory symptoms in this area, 15% had positive skin prick tests to Bayberry pollen extract. When Bayberry pollen extract was used to perform 25 nasal and 22 bronchial challenges on 45 of these subjects, 12 of 13 (92%) subjects with allergic rhinitis and positive Bayberry pollen skin prick tests had positive nasal challenges. Four of 7 (57%) subjects with asthma and positive Bayberry pollen skin tests had positive bronchial challenges. Bayberry-specific IgE was present in the sera of 8 of 13 (62%) subjects with positive challenges, and absent in 15 of 18 (83%) subjects with negative challenges. Intradermal skin tests with Bayberry pollen extract were more predictive of provocation challenge results than was plate radioimmunoassay (3).

Other reactions

The stem bark of a close family member, *Myrica sapida*, has been shown to possess not only bronchodilator activity but also to decrease bronchial hyperresponsiveness in animal models (5).

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t1 Box-elder

Acer negundo

Family: *Sapindaceae*

Common names: Box elder, Maple ash, Ash maple, Ashleaf maple, Manitoba maple, Box elder maple, Western box elder, Black ash, California boxelder, Cutleaf maple, Cut-leaved maple, Negundo maple, Red river maple, Stinking ash, Sugar ash, Three-leaved maple

Not to be confused with the Elder t205 (*Sambucus nigra*) or the Grey alder t2 (*Alnus incana*)

Source material: Pollen

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Allergen Exposure

Geographical distribution

The Box elder tree belongs to *Acer* (Maple), a genus of trees and shrubs, variously classified in a family of their own, the *Aceraceae*, or (together with the *Hippocastanaceae*) included in the family *Sapindaceae*. There are approximately 125 species, most of which are native to Asia, but several occur also in Europe, northern Africa, and North America. The species *A. rubrum*, Red maple, appears on the Canadian flag (1-2).

Box elder is native to eastern and Midwestern North America. It has the broadest range of the North American Maples, and is found throughout eastern and central North America (2).

The Box elder is a small- to medium-sized tree, reaching heights of 10 to 15 m (up to 30 m in gardens), with a trunk diameter up to 1.2 m. It is usually fast-growing and fairly short-lived. It often has several trunks and can form impenetrable thickets (3). The trunk is relatively short and tapering, and the crown is spreading and bushy.

The bark is thin and pale gray to light brown when young, but on maturity becomes grayish-brown, scaly, and deeply grooved or deeply cleft into broad ridges. The shoots or twigs are bright green, often with a whitish (or pink or violet), shiny, waxy coating when young. The twigs usually have white lenticels. Unlike most other Maples (which usually have palmate leaves), this tree has pinnate leaves up to 10 cm long, with 3 to 7 elliptic to oval leaflets (usually 3) each. Some Maples have trifoliate leaves, but only the Box elder tree regularly displays more than 3 leaflets (3). The leaflets are 3 to 7 cm long, and all having irregularly toothed margins. Each leaflet is shallowly and irregularly lobed or notched, translucent light green in colour, smooth on the upper surface and paler on the underside, and in fall becoming yellow-green and brown (2-3).

Box elder is dioecious, with male and female flowers occurring separately but on the same tree. The flowers are small and appear in early spring on drooping racemes 10 to 20 cm long. The male flowers are in small bundles, and the female ones in clusters on drooping stalk-like structures. The flowers are greenish-yellow, without petals, and inconspicuous (2). Box elder flowers in the early spring, just before the leaves appear.

The most distinctive characteristic of the Maples is the fruit (seed), which comes in pairs (paired samaras) commonly known as "keys", each with a thin membranous wing. The fruits are borne in pairs of drooping, 15 cm-long pendulous clusters. The individual fruit consists of a wing with a single seed at the base, is 2.5 to 4 cm long, and reddish brown to yellowish. In the Northern Hemisphere it ripens from August through October and stays on the tree through winter.

Environment

The Box elder thrives in sunlight and in rich, moist soils and is often found in lowland sites near water. Box elder wood is used for low quality furniture, paper pulp, interior finishing, and barrel making. Syrup can be made from the sap (2).

Allergens

To date no allergens have been characterised.

Potential cross-reactivity

An extensive cross-reactivity among the different individual species of the genus could be expected (4). When researchers compared levels of IgE antibodies to *A. negundo* and *A.platanoides* (Norway maple) in individuals sensitive to the allergens of these, 88% of the patients showed a very high level of cross-sensitisation (5).

Clinical Experience

IgE-mediated reactions

Box elder pollen will result in asthma, hayfever and allergic conjunctivitis in susceptible individuals (5-6).

In a population in Missouri, USA, that was skin-tested with pollen from 12 wind-pollinated tree species, Box elder, Willow and Hickory elicited the most-intense allergic reactions; and Oak, Birch, Sycamore, Black walnut and Poplar, more-moderate reactions; allergens from Cottonwood, Maple, Elm and White ash were still less reactive. The authors stated that since Box elder is ubiquitous and produces a strongly positive reaction among adults in this region, it should be included among skin tests of those patients known to be allergic to early spring pollen (5).

In a study that evaluated the impact of different trees on asthma, and the association between daily hospitalisations for asthma and daily concentrations of different tree pollens in 10 large Canadian cities, it was reported that for an increase in daily tree pollen concentration, percent increases in daily hospitalisation for asthma were 2.63% for *Ulmus* (Elm), 2.45% for the group containing *Pinaceae* (Pine, Fir, Spruce), *Tsuga* (Hemlock) and *Larix* (larch, tamarack); 2.32% for the group containing *Quercus* (Oak) and *Castanea* (Chestnut), and 2.16% for *Acer* (Box elder and Maple) (7).

In a study in Morgantown, West Virginia, USA, whose purpose was to identify the frequency of positive skin tests to outdoor allergens among younger children who had asthma, a total of 687 children with asthma were evaluated. Children between 12 and 24 months of age had a 29% incidence of pollen sensitisation. Notably, 49% of 3- and 4-year-olds were sensitised to outdoor allergens. Primary sensitising pollens in this age group were Short ragweed, Box elder, and June grass (8).

In a study of 371 allergy patients tested serologically for hypersensitivity to prevalent tree pollens in the area surrounding New York, the highest prevalence of hypersensitivity was for Oak (34.3%), Birch (32.9%), and Box elder (32.8%) tree pollens (9).

Acer pollen has been recorded in aerobiological studies in southeastern Spain (10) and in Porto in Portugal (11), and has been reported to be a prominent pollen in Philadelphia, Pennsylvania, and suburban Cherry Hill, New Jersey (12).

Other reactions

The pollen of this and other species of Maple can cause airborne contact dermatitis (13).

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Libocedrus decurrens

Family: *Cupressaceae*

Common names: Cedar tree, Incense-cedar, White cedar, California incense-cedar

Synonym: *Calocedrus decurrens*

Not to be confused with:

Japanese cedar t17 (*Cryptomeria japonica*), family *Taxodiaceae*

Cedar elm t45 (*Ulmus crassifolia*), family *Ulmaceae*

Mountain cedar t6 (*Juniperus ashei*), family *Cupressaceae*

Eastern red cedar t57 (*Juniperus virginiana*), family *Cupressaceae*

Western red cedar (*Thuja plicata*), family *Cupressaceae*

Eastern white cedar (*Thuja occidentalis*), family *Cupressaceae*

Deodar cedar (*Cedrus deodara*), family *Pinaceae*, and other Cedar trees of genus *Cedrus*, family *Pinaceae*

Source material: Pollen

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Allergen Exposure

Geographical distribution

Libocedrus/Calocedrus is a genus of 2 to 3 species of coniferous trees in the family *Cupressaceae* (Cypress). The genus is related to the genus *Thuja* and has similar overlapping scale-leaves.

The Incense-cedar tree is native to western North America, with the bulk of the habitat being in the USA: western Oregon, Nevada, and California. The tree also occurs in Mexico and in Western and Central Europe. The Incense-cedar is cultivated worldwide as an ornamental tree.

The Incense-cedar is a resinous, aromatic tree, generally 18 to 45 m tall but able to reach 60 m. The tree has an irregularly angled trunk with a diameter of up to 3 m, and a columnar crown. The bark is light- or reddish-brown and deeply and irregularly furrowed into ridges. The foliage is produced in flattened sprays with scale-like leaves 2 to 15 mm long; they are arranged in opposite decussate pairs, with the successive pairs closely and then distantly spaced, forming apparent whorls of 4; the facial pairs are flat, with the lateral pairs folded over their bases (1). The leaves are evergreen, shiny, with only inconspicuous stomata, and are aromatic when crushed. The wood of is soft, with a strong spicy-resinous fragrance.

Incense-Cedar is monoecious: both male and female flowers may be borne on the same tree. The flowers are 6 mm yellow-green strobili, borne on the ends of twigs from early September. The pollen is shed from late winter to early spring.

The seed cones are inconspicuous in spring, becoming pendent and red-brown to golden-brown in colour when they mature in late summer. The seed cones are 20 to 35 mm long, with 4 (rarely 6) scales arranged in opposite decussate pairs; each outer pair of scales bears 2 winged seeds, the inner pair(s) usually being sterile and fused together in a flat plate (1). The pollen cones are 6 to 8 mm long. Seed dispersal begins in late August and lasts through October. Seeds of Incense-cedar are carried great distances by wind.

Although the large "Cedars" (actually, species of *Calocedrus*, *Chamaecyparis*, *Cupressus*, and *Thuja*) of western North America tend to look alike at first, the Incense-cedar is distinguished by the flattened vertical sprays of its foliage.

Environment

Incense-cedar heartwood is ideal for exterior use where moisture is present, and may be found as mud sills, window sashes, sheathing under stucco or brick veneer construction, greenhouse benches, fencing, poles, and trellises. Incense-cedar is also used as the primary material in the manufacture of pencils because it is soft and tends to sharpen easily without forming splinters.

It is a popular ornamental tree, grown particularly in cool-summer climates (notably eastern Britain and elsewhere in northern Europe, and in parts of the northern Pacific Northwest of North America), and admired for its very narrow columnar crown (1). This tree has become popular as an ornamental tree in Northern Italy where the pollen season is the winter (January and February) (2).

Allergens

To date no allergens have been characterised.

Potential cross-reactivity

Cross-reactions with other members of this family are possible (3). A high degree of cross-reactivity also occurs among the *Cupressaceae* and *Taxodiaceae* families (4).

Clinical Experience

IgE-mediated reactions

Anecdotal evidence suggests that Incense-cedar tree pollen can induce asthma, allergic rhinitis and allergic conjunctivitis; however, few studies have been reported to date (2,5).

A 40-year-old woman reported having experienced rhinitis and conjunctivitis since the age of 12 years. She experienced intense allergic symptoms while in close proximity to Incense cedar trees. A skin prick test and serum IgE antibody test for Cypress tree were both positive. A crude extract prepared from the cones of Incense cedar were used for a skin prick test which resulted in a very strong positive reaction. The IgE antibody concentration to Incense-cedar was 5.2 RAST arbitrary units. An Incense-cedar pollen challenge resulted in the immediate onset of sneezing, rhinorrhoea, nasal obstruction, redness of the conjunctiva, and tearing and itching of the eyes. A challenge with Cypress pollen extract was negative. (2)

Other reactions

Cases of dermatitis from Cedar wood pencils have been described (6), reactions may be due to the presence of thymoquinone, thymoquinol and carvacrol in the wood (7).

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Ulmus crassifolia

Family: *Ulmaceae*

Common names: Cedar elm, Texas cedar elm

Source material: Pollen

See also: Elm (White elm or American elm; *Ulmus americana*) t8

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Allergen Exposure

Geographical distribution

The Elm family, *Ulmaceae*, contains 6 genera, the most important being *Ulmus*, *Planera*, and *Zelkova*. (Hackberries [*Celtis spp*.] used to be included in the Elm family but are more closely related to *Urticaceae* and have been placed in a separate family, *Celtidaceae* (1)). There are about 45 species of Elms worldwide, found within the temperate Northern Hemisphere, with about 4 introduced species in the USA, and six native to the North American continent east of the Rocky Mountains. There are 25 species of *Ulmus* (1-3).

In the 1930's, Dutch elm disease devastated White elm trees in North America as well as in Europe. The disease, a fungal blight, was caused by the *Ascomycete Ophiostoma ulmi* and transmitted through the native Elm bark beetle *Hylurgopinus rufipes* (4). All Elms are susceptible to some degree to the fungus, in particular American elm (*U. americana*) and September elm (*U. serotina*). Chinese elm (*U. parvifolia*), Siberian elm (*U. pumila*) and Red or Slippery elm (*U. rubra*) are highly or modestly resistant (1,3).

Cedar elm is a deciduous tree native to south-central North America. It grows mainly in southern and eastern Texas, eastern Oklahoma, Arkansas and Louisiana, with small populations in western Mississippi, southwest Tennessee and northwestern Florida (5-7). It also occurs in northeastern Mexico. It is the most prevalent Elm in Texas. It typically grows well in flat river bottom areas referred to as Cedar elm flats.

The Cedar elm is a medium-sized to large tree, growing to 24-27 m tall, with a rounded crown. The trunk is about 75 cm in diameter. Twigs have corky wings. The leaves are small (2.5 - 5 cm long and 1.3 - 2 cm broad) and elliptical, with serrated edges, asymmetric leaf takeoff on either side of the leaf stem, and a leathery, sandpapery upper surface. Cedar elm has the smallest leaves of native North American Elms.

Elm flowers are produced in the late summer or early fall. They are greenish, small and inconspicuous, with a reddish-purple colour and short stalks at the leaf base. All Elms are wind-pollinated and are prolific pollen producers. Pollination is intense over a short period of time. Individual trees may release their pollen load over a 2 to 3 day period. Cedar elm pollinates from July into October (1). The fruit is a small winged samara 8 to 10 mm long, maturing quickly in late fall, after the flowering.

Environment

Elms are also grown for shade and ornament. Commercially, they are used in a variety of industries for their heavy, exceedingly hard wood.

Allergens

No allergens have been characterised.

Potential cross-reactivity

An extensive cross-reactivity among the different individual species of the genus could be expected, as well as to a certain degree among members of the family *Ulmaceae* (8). However, to date this has not been documented.

In a Spanish study, individuals with Melon allergy were found to have a higher prevalence of asthma and an increased frequency of sensitisation to several tree and weed pollens, predominantly *Ulmus* and *Ambrosia* (9).

Clinical Experience

IgE-mediated reactions

Intense hayfever, but not asthma, has been described (6,10). Although only sparse reports document sensitisation to pollen from this tree, anecdotal evidence from areas where the tree is commonly found suggests that allergic sensitisation is common following exposure to the pollen. Furthermore, because of the close family relationship with White elm tree, which induces asthma, allergic rhinitis and allergic conjunctivitis (11,16), clinical inferences may be drawn. See White elm t8.

In a Canadian study that evaluated the impact of different trees on asthma, along with the association between daily hospitalisations for asthma and daily concentrations of different tree pollens in 10 large Canadian cities, it was reported that for an interquartile increase in daily tree pollen concentration, percent increases in daily hospitalization for asthma were 2.63% for *Ulmus* (12).

Aerobiology studies often do not draw distinctions among the various species of Ulmus, but this may not be problematic; considering the close relationship among species of Elm, cross-sensitisation or cross-reactivity to *Ulmus* is possible, and hence inferences can be drawn, including that individuals sensitised to Cedar elm may be affected in areas where White elm or other members of the genus produce pollen.

In Tampa, Florida, in the USA, where the major tree pollen season occurs from December through May, with a minor season occurring from October to November, Elm tree pollen is important during the minor season (13).

In Cordoba, Spain, aerobiology studies have reported pollen grains from the closely related species, Ulmus minor, in the air (14). In Siena, in central Italy, Elm tree pollen was found to be an important aeroallergen in March but not during the rest of the tree pollen season (15), whereas in Modena, in northern Italy, the Elm family contributed little pollen to the air (about 1% of the total recorded) (16). In aerobiology studies of 9 districts of northern China, the most common aeroallergens in spring were often *Ulmus*, *Populus* and *Salix* (17). Elm has also been reported to be an important tree pollen in Tehran, Iran (18).

Pollen concentrations in the atmosphere of Lublin (eastern Poland) were reported to be the highest for *Betula*, *Pinaceae* and *Alnus*; and the lowest for *Ulmus*, *Fagus* and *Corylus*. Signficantly, total pollen grains for Ulmus varied almost 2-fold between successive years (19). Pollen from the *Ulmus* species has been reported to be an important allergen in Zagreb, Poland (20).

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t206 Chestnut

Castanea sativa

Family: *Fagaceae*

Common names: Chestnut, European chestnut , Sweet chestnut

Source material: Pollen

See also: Sweet chestnut (*Castanea sativa*) f299

Not to be confused with Horse chestnut tree (*Aesculus hippocastanum*) t203

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Allergen Exposure

Geographical distribution

The Chestnut belongs to the *Fagaceae* family, which consists of 3 important genera: Beech (*Fagus*), Chestnut (*Castanea*), and Oak (*Quercus*).

The European chestnut in its natural form is a large, spreading, deciduous tree, growing to over 30 m tall. Mature leaves are 10-20 cm long, 3-7 cm broad, and have between 6 and 20 bristles on each of the deeply serrated margins. Both female and male flowers are borne on the current season's shoots in early summer to midsummer. The trees are cold-hardy and can withstand temperatures as low as -25 °C when dormant. The fruit (Chestnut) is a spiny husk containing 2 or 3 nuts. In the USA, the Chestnut pollen season extends from May to July. Chestnut trees are mainly insect-pollinated.

Several edible species of Chestnut are grown around the world, the 4 main species being Chinese chestnut (*Castanea mollissima*), European or Spanish or Sweet chestnut (*C. Sativa*), Japanese chestnut (*C. crenata*), and American chestnut (*C. dentata*, most of which have been destroyed through a blight). The nuts of all of these species are used as food in similar fashions (about which, see below).

In the USA, the Chestnut pollen season extends from May to July. Chestnut trees are insect-pollinated.

Environment

It is cultivated in groves for fruit and in coppices for wood. Up to 500,000 tonnes of Chestnuts are produced each year around the world, with the biggest proportion coming from the Northern Hemisphere. Chestnuts are consumed fresh, boiled, grilled or preserved in sugar (iced Chestnuts). Chestnut flour is also utilised. The tannin and the very hard wood of the tree are also used.

See Sweet chestnut f299 for allergen information on these nuts.

Unexpected exposure

European chestnut pollen has been shown to be present in honey and may thereby contribute to allergic reactions (1).

Allergens

In an examination of sera from 14 patients with established allergy to pollen of the European chestnut, 13/14 (92%) showed IgE binding to a 22 kDa protein in European chestnut pollen extract, 2/14 (14%) displayed additional binding to a 14 kDa protein, and

1/14 (7%) bound only to the 14 kDa protein. The 22 kDa protein was characterised and is now known as Cas s 1. The 14 kDa protein was identified as a profilin (2).

The following allergens have therefore been identified to date:

Cas s 1, a 22 kDa protein, a major allergen and a Bet v 1 homologue (group 1 *Fagales*-related protein) (2-4).

Cas s Profilin, a 14 kDa protein, a profilin (2).

Potential cross-reactivity

The Chestnut belongs to the *Fagaceae* family, which consists of 3 important genera: Beech (*Fagus*), Chestnut (*Castanea*), and Oak (*Quercus*). An extensive cross-reactivity among the different individual species of the *Fagaceae* family could be expected (5-6).

Cas s 1 shows significant amino acid sequence similarity and is antigenically closely related to the major Birch pollen allergen Bet v 1 (3). Cross-reactivity with other Bet v 1-related allergens, including Birch tree, occurs.

Profilin from pollen of the European chestnut would be expected to cross-react with other plants containing profilin (2,7).

Clinical Experience

IgE-mediated reactions

IgE-mediated allergy, resulting in hayfever and asthma, to pollen of the European chestnut represents an important cause of pollinosis in Mediterranean and sub-Mediterranean areas (8-14).

Skin prick tests to Chestnut pollen were positive in 17/47 patients with seasonal symptoms of allergy in a study conducted in Paris. Eight patients had total IgE levels above 300 kU/l, 15 were found to have IgE antibodies to the pollen, and 14 were positive on nasal provocation testing (9). In the southern part of Switzerland (Canton Ticino), where Chestnut pollens represent about 30% of the airborne pollens, 37% of 503 patients with allergic rhinitis were sensitised to European chestnut pollen (8).

It was found that 92% of 14 patients with established allergy to pollen of the European chestnut tree demonstrated specific IgE to the profilin allergen in this pollen. Fourteen percent displayed additional binding to a 14 kDa protein in the extract, and 1 (7%) bound only to this 14 kDa protein (2).

A study examined the impact of different trees on asthma, and the association between daily hospitalisations for asthma and daily concentrations of different tree pollens in 10 large Canadian cities, and found that as a result of an interquartile increase in daily tree pollen concentration, percent increases in daily hospitalisation for asthma were 2.32% for the group containing *Quercus* and *Castanea* (15).

In a study of 210 patients with a diagnosis of pollinosis who attended an allergy clinic based in Plasencia, Spain, a low prevalence of sensitisation to Chestnut tree of 7.1% was demonstrated. Sensitisation to other pollens was far more prevalanet: *Dactylis glomerata*, 80.4%; *Olea europea*, 71.9%; *Fraxinus excelsior*, 68%; *Plantago lanceolata*, 62.8%; *Chenopodium album*, 60.9%; *Robinia pseudoacacia*, 49%; *Artemisia vulgaris*, 43.8%; *Platanus acerifolia*, 36.6%; *Parietaria judaica*, 36.1%; *Populus nigra*, 32.3%; *Betula alba*, 27.6%; *Quercus ilex*, 21.4%, *Alnus glutinosa*, 20.9%; and *Cupressus arizonica*, 7.6%. Of the 15 patients sensitised to Chestnut pollen, 14 had seasonal rhinoconjunctivitis and asthma. Ten patients had IgE antibodies to Chestnut pollen. Chestnut pollen was shown to be present in this area in large amounts from the 23rd to the 28th week of the year (14).

Chestnut wood has also been shown to cause occupational asthma in wood workers (16).

Other reactions

Allergic reactions often occur following ingestion of the fruit (nut) of the Chestnut tree. See Sweet chestnut (*Castanea sativa*) f299.

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t3 Common silver birch

Betula verrucosa

Family: *Betulaceae*

Common names: Common Silver Birch, Common Birch, Birch, Birch tree

Synonym: *B. pendula*

Source material: Pollen

See also: rBet v 1 t215, rBet v 2 t216, rBet v 4 t220, rBet v 6 t225

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Allergen Exposure

Geographical distribution

Birches, *Betula spp*., are boreal and temperate trees and shrubs, with around 50 species worldwide and 12 species native to North America (1). River Birch (B. nigra) and White or Paper Birch (B. papyrifera) are common to North America, whereas Common Silver Birch (*B. verrucosa*) is the prevalent European species (2).

Common Silver Birch is native and common in most of Europe, northwest Africa and western Siberia, but absent in the southernmost parts of Europe. It is the most common tree found in Scandinavia and the Alps, and a potent pollen producer in those areas. (*B. pubescens*, similar to *B. Verrucosa*, is found in the more northern areas of Europe and particularly in the mountains, forming extensive woods. There are closely related species in East Asia and North America.) Because of climatic conditions characterised by mild winters and dry summers with sunny days, the vegetation of the Mediterranean area is normally different from that of central and northern Europe. But the pollen map of Europe and the Mediterranean is changing because of cultural factors such as the import of Birch and Cypress for urban parklands. Birch is spreading down into the Mediterranean area: to northern Italy, for example.

Common Silver Birch is a single-stemmed, deciduous tree up to about 25 metres tall. The bark is smooth and silvery white, but can become black and fissured into rectangular bosses. The leaves are alternate, ovate or triangular, and doubly serrate. Common Silver Birch flowers in late spring, usually at the same time as the leaves appear, but in North America it blooms early in spring and occasionally flowers again in late summer or fall. The bloom time is usually short. Birches are wind-pollinated, with pollen and seed catkins on the same tree. Male catkins are formed in late summer and appear in winter as stiff fingers on long shoots; they are elongated and pendulous in early spring. Birches shed enormous quantities of pollen in advance of the unfolding of the leaves: single catkins can produce 6 million grains. Birch has reproductive rhythms of high and low years for the abundance of pollen and subsequent seed. The rhythms are often modified by the influences of weather.

Environment

Birch occurs in woods, particularly where the soil is lighter. It often grows in heath lands and clearings and is also planted in gardens.

Annual pollen counts may vary from year to year by a factor of 400%. Pollen levels are determined by the weather, diversity of local flora, and the specific rhythms of pollination of particular taxa (3).

Unexpected exposure

Systemic anaphylaxis due to the ingestion of an undefined mixture of pollens, sold as a dietary supplement, has been described. Inhibition studies of the patient's serum showed results highly positive to grasses, Birch, Alder and Compositae, suggesting that the pollen mixture contained allergens capable of cross-reacting with the patient's IgE (4).

Allergens

Birch pollen contains at least 29 antigens (5). Allergens of molecular weights of 29.5, 17, 12.5, and 13 kDa had been isolated (6-7).

The following allergens have been characterised:

Bet v 1, a 17 kDa protein, a ribonuclease and a PR-10 protein (8-17).

Bet v 2, a 15 kDa, a profilin (11,15-25).

Bet v 3, a 24 kDa calcium-binding protein (19,26).

Bet v 4, a 9 kDa calcium-binding protein (20,27-29).

Bet v 5, a 35 kDa isoflavone reductase-related protein (30-32).

Bet v 6, a 30-35 kDa protein, PCBER (Phenylcoumaran benzylic ether reductase) (33).

Bet v 7, a 18 kDa protein, a cyclophilin (34).

Bet v 11 (39).

The following recombinant allergens have been expressed:

rBet v 1 (35).

rBet v 2 (25,36-38).

rBet v 3 (19,26).

rBet v 4 (20,28-29).

rBet v 5 (30).

rBet v 6 (11).

Bet v 1 displays a considerable degree of heterogeneity and consists of at least 20 isoforms (Bet v 1a to Bet v 1n), which differ in their IgE-binding capacity (8,17,30,39). Although the major allergen Bet v 1 recognises serum-IgE antibodies in up to 95% of Birch pollen-allergic indivuals (30), studies among patients from 6 countries report highly variable IgE sensitisation profiles in Birch pollen-allergic patients from various countries and regions (40).

Bet v 2, a profilin, has been reported as being recognised by IgE from about 10% to 38% of Birch pollen-allergic patients from Central Europe (41-42.) The percentage affected clearly depends on the geographic area; in Swedish and Finnish patients, approximately 5-7% were sensitised to Birch profilin, compared to 20-38% of patients in Central and Southern Europe (42). Similarly, in a study that reported that few Finnish (2%) and Swedish (12%) patients had IgE to Bet v 2, Bet v 2 reactivity was found to be more common in the other populations (20% to 43%) (40).

Bet v 3 is recognised by IgE from about 10% of Birch allergic patients (30).

Bet v 4 reacts with serum IgE from approximately 20% of individuals allergic to pollen (8,19-20,30,43).

rBet v 5 bound IgE from 32% (9/28) sera from Birch pollen-allergic patients with an IgE antibody level of at least 3.50 kU/l (30).

Bet v 7, a cyclophilin, was recognised by IgE antibodies in up to 20.8% of Birch pollen-allergic patients (34).

Significantly, Birch pollen-allergic individuals may not be sensitised to any of the major Birch pollen allergens.

Potential cross-reactivity

Cross-reactivity between pollens from species within the *Betulaceae* family or belonging to closely related families can be expected (44-47). *Fagales* pollens, *e.g.*, Birch (*Betula verrucosa*), Alder (*Alnus glutinosa*), Hazel (*Corylus avellana*), Hornbeam (*Carpinus betulus*) and Oak (*Quercus alba*), all contain 1 major Birch pollen-related allergen (43).

Amino acid sequence identities between the Cor a 1 isoforms from Hazel and Bet v 1 were between 71% and 73% (80.5-83% similarity); between Cor a 1 isoforms and Aln g 1 from Alder, there was 75.5-76.7% identity (83.6-85% similarity); and between Cor a 1 isoforms and Car b 1 from Hornbeam, 83.6-89.9% sequence identity (89.3-95% similarity) (48). Cas s 1 from European Chestnut shows significant amino acid sequence similarity and is antigenically closely related to Bet v 1 (49). Cross-reactivity has also been reported between Birch tree and other members of the *Fagales* family (such as Beech), and partial cross-reactivity between Birch and Ash pollens (50).

The most common manifestation of allergy to food in Birch pollen-allergic individuals is oral allergy syndrome and typically occurs in Birch tree pollen allergic individuals in Central and Northern Europe. Symptoms elicited are usually limited to the oropharyngeal system and are called "oral allergy syndrome". This is discussed in detail below.

Cross-reactivity has also been noted between Mugwort, Birch pollen allergy, and Celery (51-53), a phenomenon often referred to as "Birch-Mugwort-Celery syndrome" (54), or "Celery-Carrot-Birch-Mugwort-spice syndrome" when Carrot and Spices are included (55-59). Spices involved included Anise, Fennel, Coriander, and Cumin, all members of the *Apiaceae* family (60).

Bet v 1, the major allergen in Birch pollen, is a member of a group of defence proteins (PR-10) (61), which behave as major allergens in patients from Northern and Central Europe with allergy to plant foods associated with Birch pollen allergy. In these patients, the primary sensitisation seems to be produced through the inhalation route on exposure to Birch pollen. The most characteristic set of symptoms associated with sensitisation is oral allergy syndrome (OAS) (62). The major allergens in Apple, Pear, Apricot and Sweet Cherry are structural homologues to the Birch pollen major allergen Bet v 1 (63).

Bet v 2, a profilin, may result in cross-reactivity with other profilin containing pollens or food, including Hazelnut, Ragweed pollen, Mango, Mugwort pollen, Timothy grass pollen, Celery, Carrot, Peanut, Paprika, Anise, Fennel, Coriander, Cumin, Tomato and Potato (64-65).

Furthermore, profilin is present in Birch pollen, Peach and Apple, and this may result in cross-reactivity among these, even though the patients in question have never been exposed to Birch (66).

Bet v 3 and Bet v 4 are calcium-binding proteins, may result in cross-reactivity with other plants containing these panallergens.

Bet v 5, an isoflavone reductase-related protein, is a minor Birch pollen protein and may be responsible for pollen-related oral allergy to specific foods in a minority of patients with Birch pollen allergy (30,32).

Bet v 6, a pectin esterase (67), affecting approximately 10-15% of Birch pollen-allergic individuals, was reported to be cross-reactive with proteins of comparable size from Lychee, Mango, Banana, Orange, Apple, Pear and Carrot (68).

Clinical Experience

IgE-mediated reactions

Birch pollen is highly allergenic and is a significant cause of immediate hypersensitivity, in particular asthma and rhinoconjunctivitis, not only in Scandinavia, Europe, Canada, and the northern part of the United States but also in Japan, resulting in allergic reactions such as asthma, allergic rhinitis and conjunctivitis in adults and children (45-46,69-85).

Birch pollen is a significant cause of immediate hypersensitivity among susceptible subjects in temperate climates, affecting 5-54% of the population in Western Europe (86). The number of individuals allergic to plant pollen has been on a constant increase, especially in large cities and industrial areas. For example, in a Belgian study of patients suffering from respiratory allergy, the frequency of Birch pollen sensitisation significantly increased, from 13% in the period 1975-1979 to 34% in the period 1992-1995. In contrast, the frequency of house dust mite, Timothy grass pollen, and Mugwort pollen sensitisation remained almost unchanged. The increase was not associated with an increase in the Birch pollen count (87). An increased sensitisation to Birch has also been reported in the Netherlands (88).

Both adults and children may be affected. Immune response to Birch has been reported to occur in all children during the first 7 years of life, regardless of atopic status (89). It was documented that children exposed to high Birch pollen levels at 1 year were more likely to be sensitised to Birch pollen than those born in a year with a lower exposure, and more likely to have allergic asthma (90). Furthermore, exposure of the mother during pregnancy to high levels of Birch pollen was reported to result in a tendency towards increased risk of sensitisation to the same allergen, and increased symptoms of atopic disease in children with atopic heredity (91-92).

Furthermore, sensitisation to Birch may occur in new immigrants residing in an area highly populated with Birch trees. For example, among immigrants to Sweden, sensitisation to Birch, as documented by serum IgE antibodies and SPT, increased from 16% within 2.5 years to 53% after more than 10.5 years. More than 40% of the immigrants who had asthma, rhinoconjunctivitis, eczema, and urticaria were allergic to only Birch pollen, and 19% had oral allergy syndrome, suggesting that environmental factors rather than hereditary differences determine the IgE state (76).

Sensitisation to Birch tree pollens are heterogenous in character with individuals being sensitised to one or more Birch tree pollen allergens. In a retrospective Spanish study of pollen allergy caused by *Betula* in the area of Ourense, out of 222 patients diagnosed with pollen allergy, 41.89% were shown to have skin reactivity to *Betula alba* (10.75% were monosensitised); 30% suffered from an oral allergy syndrome to fruits; 41.93% of the patients with skin reactivity to *Betula* pollen had asthma, in comparison with 23.25% of the those with no sensitisation to *Betula* (93).

Because of the close relationship shared between *Betula* species, similar inferences can be drawn in countries where these species occur. For example, atmospheric surveys carried out in different parts of India showed that the closely related *Betula utilis* produced allergenically important pollen (94).

In Sapporo, Japan, the most common allergen responsible for pollen allergy was Birch, affecting 54 of 87 patients (62%) (95). In 392 patients with nasal allergy attending a clinic in Sapporo, 74 (18.9%) were Birch pollen-allergic. The authors reported that there had been a significant increase in Birch pollen allergy, compared with previous reports (96). A study reported that allergy to Japanese White Birch (*Betula platyphylla var. japonica*) is gradually increasing; this was especially marked in Sapporo and its neighborhood (97).

Birch pollen has been demonstrated to be a significant allergen in Sweden (98-100), Finland (101), Switzerland (102-103), Belgium (104), Austria (74), Germany (105), Spain (106), Greece (107), the Netherlands (108-110) the UK (111) and Japan (112). Birch pollen has been reported to be a major aeroallergen in Fairbanks area, Alaska, from early May to September (113-114).

The most common manifestation of allergy to food in Birch pollen-allergic individuals is oral allergy syndrome (115). Individuals with Birch allergy and oral allergy syndrome are more frequently allergic to Apple than to other foods (116-117). Rhinitis, itching, tingling and other mild reactions on the oropharyngeal mucosa were reported to be the most common complaints after eating raw Apples (in about 30% of patients with hypersensitivity to Birch pollen). Agioedema, urticaria and anaphylaxis were reported to be rare, "but must be noticed" (118). Other studies indicated an association of 70% between oral and pharyngeal reactions to vegetables and fruits on the one hand, and Birch pollen allergy on the other (11,119).

Of 171 Birch pollen-sensitised patients (having IgE antibody levels >0.7 kU_A/l), 22 (13%) were hypersensitive to Apple, 11 (6%) to Peach, and 6 (3.5%) to Kiwi fruit. The higher the IgE antibody level to Birch, the higher the prevalence of hypersensitivity to Apple and Peach were found to be (120).

In a study of 283 patients with clinical Birch pollen hypersensitivity, OAS was associated with more severe respiratory symptoms and with higher Birch-specific and total IgE levels; moreover, its onset was clearly related to the duration of Birch pollinosis. Significantly, this study suggests that about 15% of patients with Birch pollen hypersensitivity are not prone to OAS, and that their anti-Birch IgE might be directed against determinants that do not cross-react with food allergens (121). Furthermore, in Mediterranean areas, oral allergy syndrome (OAS) occurs independently of Birch pollinosis; moreover, on occasion it presents with no associated pollinosis (122). Also, IgE antibodies to Birch may be detected in patients with oral allergy syndrome even in geographical areas where Birch pollen is absent. The authors suggest that even in such areas measurement of IgE antibodies to Birch pollen is important for screening and diagnosing patients with oral allergy syndrome (123).

Importantly, allergens present in Peach and Apple may result in cross-reactivity between these 2 foods and Birch, even though patients have never been exposed to Birch (66). Further evidence for the cross-reactive relationship between Birch and Apple is demonstrated by the fact that 56% of patients allergic to Birch pollen and Apple improved in their fruit allergy if desensitised to Birch pollen (124).

Bet v 1 mainly results in mild symptoms of oral allergy syndrome. This is usually caused by Apple, Cherry, Peach and Plum but can also be observed with other allergens giving rise to generalised symptoms. Sensitisation to Bet v 2 is commonly associated with more-generalised symptoms, in particular urticaria and angioedema (55). In allergy that is not related to Birch pollen, oral allergy syndrome to *Rosaceae* foods may occur as a result of lipid transfer proteins, and, in contrast to the typical experience of Birch-*Rosaceae* cross-reactive patients, this kind of oral allergy syndrome is frequently accompanied by more severe and systemic reactions (125).

Symptoms of food allergy in Birch pollinosis patients are usually mild and restricted to the oral cavity. On the other hand, while allergy to a food, *e.g.*, Hazelnut, without concomitant pollinosis is less common, symptoms tend to be more severe and are often systemic (116).

Other reactions

Birch pollen-related foods have been reported to trigger atopic dermatitis in patients (126-128). In particular, immediate and delayed hypersensitivity to Birch pollen may result in worsening of atopic dermatitis during the Birch pollen season (77). Adult patients with hypersensitivity to Birch pollen and atopic dermatitis have been shown to have a worsening of their condition after oral challenge with Birch pollen-related foods.

Contact urticaria to fruit related to Birch sensitivity has been reported (129).

Children with Birch pollen-allergic rhinoconjunctivitis have been reported to exhibit an enhanced degree of gingival inflammatory reaction (130). Allergy and sensitivity to Birch pollen (and probably to other kinds of allergens) was reported to be an important risk factor for adenoid hypertrophy in children (131).

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t14 Cottonwood

Populus deltoides

Family: *Salicaceae*

Common names: Cottonwood, Poplar tree

Source material: Pollen

The botanical family Willow (*Salicaceae*) consists of *Populus* and *Salix*, the latter being true Willows. *Populus deltoides* is the common designation for species of trees in this genus, but in fact *Populus* can be divided into 3 distinct groups: Cottonwoods, Aspens and Poplars

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Geographical distribution

The botanical family *Salicaceae* consists of *Populus* and *Salix*, the latter being willows. *Populus* is a genus of between 30 and 40 species of flowering plants. Their native distribution covers most of the Northern Hemisphere, and 9 are native to North America (1). They do not occur in the Southern Hemisphere.

Cottonwood is a deciduous tree native to eastern North America. It is the fastest-growing native tree on that continent. In open areas, it typically has a large trunk that divides into upright branches near its base and ascends to form a broad, open, spreading crown. In plantations, it tends to have a tall, straight, and relatively branch-free bole and a small rounded crown. On good sites, 35-year-old trees may average 40 m in height, while trees 55 to 65 years old may be 53-58 m in height, with a trunk diameter up to 100 cm. The root system is quite expansive and can extend over 30 m from the trunk.

The bark is smooth and yellowish-gray, becoming dark gray and developing deep furrows with age. The leaves are finely toothed, triangular, dark green and shiny on top and paler underneath, with a long flattened stalk (1).

Cottonwood is dioecious: each tree is male or female, not both. Cottonwood flowers in early spring, with the exact time of pollen production depending on the region. Populus species are entirely wind-pollinated, as distinct from Willows, which are primarily insect-pollinated. Male catkins are 5 to 7 cm long. Propagation is mainly by airborne seed (”cotton”) from female trees, but detached branches can also take root (1). The cotton is produced in enormous quantities for about 2 weeks virtually every year, and can be windblown for miles from its origin.

Environment

Because of its extensive root system, the tree plays a major role in soil erosion control along rivers, streams, and lakes.

Allergens

To date no allergens from this plant have yet been characterised.

Potential cross-reactivity

Extensive cross-reactivity could be expected among species in the genus *Populus*, as well as with species of the genus *Salix*, such as Willow (2). Indeed, strong cross-reactivity between Cottonwood and Willow is shown by skin test correlations and P-K neutralization (1,3-7). Moderate cross-reactivity between *Salicaceae* and *Fagales* members is shown by P-K neutralization and passive hemagglutination inhibition (1,3-4).

Clinical Experience

IgE-mediated reactions

Pollen from the Cottonwood tree results in asthma, hayfever and allergic conjunctivitis (8). Estimates from Oklahoma and Colorado in the USA attributed 20% of all hayfever to Cottonwood (1,9-10). Lewis *et al.* showed skin test reactivity to Cottonwood in 60% of atopic patients from 7 different states (11).

Allergy to Cottonwood pollen has been shown to be among the 10 most important aeroallergies resulting in clinical symptoms in the Eastern Province of Saudi Arabia, where 38% of 1,159 patients were skin prick test-positive to Cottonwood pollen (12); and similar findings emerged from among 614 patients with respiratory allergies in Turkey (13). In a study in the United Arab Emirates, among 327 adult patients with respiratory, dermatologic and ophthalmologic diseases of suspected allergic origin, Cottonwood was found to be the third most prevalent sensitising allergen (33.1%) after Mesquite (45.5%) and Grass Mix (40.7%) (14).

A Hungarian study found that 6.8% of hayfever patients were sensitised to Cottonwood tree pollen; thus, in this group of patients, Cottonwood was not an important cause of hayfever (5); and the results were similar in an early 1975 study in St. Louis, Missouri, USA (15). In a study examining aeroallergen sensitisation rates among 209 children of the military in Texas who were undergoing skin testing for rhinitis, the most common allergens were found to be grasses, Alternaria, and Cottonwood (16).

Cottonwood pollen has been demonstrated to be a major aeroallergen during the pollen season in Tehran, where the season extends from the first week of February through the middle of October (17); the pollen is also a major aeroallergen in Fairbanks, Alaska (18). In other regions, Cottonwood pollen may not be a large component of the total aeroallergen measurement. In Madrid, Spain, the largest airborne presence (from 1979 to 1993) was for *Quercus spp.* (17%), followed by *Platanus spp.* (15%), *Poaceae spp.* (15%), *Cupressaceae spp.* (11%), *Olea spp.* (9%), *Pinus spp.* (7%), *Populus spp.* (4%), and *Plantago spp.* (4%). The predominant pollens from January to April were tree pollens (*Cupressaceae*, *Alnus*, *Fraxinus*, *Ulmus*, *Populus*, *Platanus*, and *Morus*) (19). *Populus* was the eighth-most-common allergenic pollen recorded in the atmosphere of Burgos, Spain (20), and the fourth-most-common in Toledo, Spain (21).

In a study of the impact of different trees on asthma, and of the association between daily hospitalisations for asthma and daily concentrations of different tree pollens in 10 large Canadian cities, statistically significant but small (<2%) effects were observed from *Populus* (Aspen, Poplar) (22).

Pollen from *Populus spp.* has been shown to be among the main contributors to aeroallergen load in the air of Vinkovci, in northeastern Croatia (23). In the city of Heraklion, Crete, pollen from *Populus spp.* was the sixth-most-prevalent atmospheric pollen (24). *Populus spp.* pollen was reported to be a significant atmospheric pollen in Zagreb, Croatia (25). In Plasencia, Spain, *Populus spp.* pollen was reported to be the ninth-most-prevalent pollen aeroallergen. Among 210 patients with a diagnosis of pollinosis, 32.3% were sensitised to *P. nigra* (26).

Similarly, pollen from the closely related White poplar, *P. alba*, has been reported to a significant allergen (27). The pollen of *P. alba* has been found to be prevalent by aerobiological studies in Turkey (28-29). In a study evaluating the clinical importance of Poplar allergy in subjects with seasonal allergy living in Ankara, Turkey, which has a high Poplar pollen load, allergy to P. alba pollen was reported to result in mild symptoms, while *Gramineae* (grass) pollen allergy contributed significantly to symptoms (30).

In a study of 371 allergy patients tested serologically for hypersensitivity to prevalent tree pollens in the area surrounding New York, 20.6% were sensitised to Poplar (31). In a study in Westchester County in the state of New York, skin prick tests to 48 aeroallergens in 100 patients referred for allergic rhinitis showed that 9% were sensitised to Cottonwood (32).

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Cupressus arizonica

Family: *Cupressaceae*

Common Names: Cypress, Arizona cypress, Arizona rough cypress, Cedro blanco

Synonyms: *C. Glabra, C. Arizonica var. glabra*

Source material: Pollen

See also: Italian/Mediterranean/ funeral cypress (*C. sempervirens*) t23

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Allergen Exposure

Geographical distribution

About 30 Arizona cypress tree varieties exist, recognised on the basis of distribution and of foliage, cone and bark characteristics.

Arizona cypress is the only Cypress native to the southwest of North America and has been widely exported, especially to Europe. It is a steeple-shaped, coniferous evergreen that can grow over 25 m tall. Its leaves are pale green to gray-blue. The small, inconspicuous yellow flowers are monoecious (individual flowers are either male or female, but both sexes can be found on the same plant) and are pollinated by wind. The brown bark peels in thin strips and turns gray with age.

The taller, greener, longer-lived but closely related and, where pollen allergy is concerned, very similar Italian funeral cypress tree is indigenous to the Mediterranean and has been introduced in places such as Australia, the US, New Zealand, Chile, China and India. It is the classic ornamental in cemeteries, a usage dating back to ancient times.

The Italian cypress tree is the most common Cypress in the countries around the Mediterranean, followed by the Arizona cypress, and their prevalence is reflected in the allergic impact of their pollen. In the USA, Mountain cedar (another member of the *Cupressaceae* family, in Europe existing only in the Balkans and the Crimea) is a major cause of seasonal allergy in the southwest (1-2), overshadowing the effects of Arizona cypress.

Environment

The Arizona cypress, like a number of other Cypresses (including Italian funeral cypress), is typically used as a windbreak, privacy screen or ornamental, or for erosion prevention. It is sometimes grown as a Christmas tree in the southern and western United States. The species can be found in coniferous woodlands on rough, very dry and very rocky soils.

Allergens

Allergens from the Arizona cypress tree have been isolated and characterised, and their diagnostic significance has been established (3). *Cupressaceae* pollen in general has 2 important characteristics: a low protein concentration and a high carbohydrate content.

t222 Cypress

The following allergens have been characterised:

Cup a 1, a 43-kDa protein, a major allergen, a pectate lyase (4-12).

rCup a 1 (8,12).

Cup a 2, a polygalacturonase (6,13).

Cup a 3, a thaumatin-like protein (14-16).

Cup a 4, a calcium-binding protein (14).

Cup a 1 was demonstrated to be a major allergen: 19 of 33 sera (57%) from patients allergic to Cypress showed significant reactivity to purified Cup a 1, (9) and 14 out of 17 to the native allergen (12).

Cup a 3, a 21 kDa thaumatin-like protein, is a major allergen (16).

Sixty-three percent of 104 Cypress-allergic patients were shown to have specific IgE against rCup a 3. The enhanced expression of Cup a 3 was reported to be dependent on the pollution in the area where the pollen was collected.

In a study investigating allergens of Italian funeral cypress and Arizona cypress, the former showed a wider diversity of allergens, whereas the latter showed a higher content of the major 43 kDa allergen (17).

A recent study reported that a large number of the sera from Arizona cypress-allergic individuals that are reactive with the major allergen, Cup a 1, recognise carbohydrate epitopes only. IgE antibodies from these sera was able to induce histamine release from basophils, and the authors suggest that they might play a functional role in the clinical symptoms of allergy (12). A large portion of the IgE reactivity of *Cupressaceae*-allergic subjects was reported to be associated with sugar moieties of *C. arizonica*, which appear to be shared by bromelain and phospholipase A2 (7).

Potential cross-reactivity

An extensive cross-reactivity among the different individual species of the genus could be expected, and in fact there is a great deal of evidence that it occurs (18-19).

Intense cross-reactivity has been reported between Italian funeral cypress tree, Arizona cypress tree and Mountain cedar tree (20). For example, for *in vivo* diagnosis of Cypress allergy, Mountain cedar tree pollen extract demonstrated a sensitivity of 95%, a specificity of 100%, a negative predictive value of 96%, and a positive predictive value of 100%. (1) While Italian funeral cypress tree and Arizona cypress tree are commonly encountered in Mediterranean regions, Mountain juniper tree is, in Europe, present only in the Balkans and the Crimea, but is a major cause of allergy in the USA.

C. arizonica and *C. sempervirens* extracts are highly cross-reactive at the IgE level and have a number of common epitopes. Two major IgE-reactive components of approximately 43 kDa and 36 kDa have been shown to be present in both (21). The 2 have complementary allergenic composition: *C. sempervirens* shows a wider diversity of allergens, whereas *C. arizonica* shows a higher content of the major 43 kDa allergen (17). The cross-reactivity between these 2 family members was reported to be due to the presence of periodate-sensitive as well as -resistant epitopes (22).

Extensive cross-reactivity also occurs with other family members. These include Prickly juniper tree (*J. oxycedrus*), Japanese cypress tree/False cypress tree (*Chamaecyparis obtusa*), and Western Red cedar tree (*Thuja plicata*) (10).

Recombinant Cup a 1, the major allergen of *C. arizonica* pollen, was shown to be highly homologous with the major allergens of Mountain cedar (Jun a 1), Japanese cypress (Cha o 1) and Japanese cedar (Cry j 1). The study, indicating different IgE reactivity with the glycosylated and non-glycosylated protein, suggests the importance of carbohydrate moieties in the IgE binding site (8).

Pollen from *Juniperus oxycedrus* (Prickly juniper tree) has also been shown to have wide cross-reactivity with other family members (23). Recombinant Jun o 2, one of the allergens from this pollen, was shown to have significant sequence similarity to calmodulins. Immunoblotting inhibition tests showed that *J. oxycedrus*, *J. ashei*, *C.*

arizonica, C. sempervirens, Parietaria judaica, Olea europaea, and Lolium perenne pollen extracts were able to inhibit IgE binding to rJun o 2 at different concentrations (24). The implication is that if a close cross-reactivity can be expected between *J. oxycedrus* and other members of the *Cupressaceae*, then there is a possibility that individuals allergic to *Pareitaria judaica* and other members of the *Urticaceae* (*e.g.*, stinging nettle) could be cross-reactive to trees from this species.

Similarly, a study reported that a high inhibition of IgE binding on Olive pollen extract was exhibited by Birch, Mugwort, Pine, and Cypress pollens, suggesting the presence of proteins having common epitopes that can be recognised by sera from Olive-allergic individuals (25).

Cup a 2 belongs to the polygalacturonase protein family. Polygalacturonases are major pollen allergens in *Cupressaceae* trees (6), Polygalacturonases have also been identified in grass pollen (group 13 grass allergens) and in London plane tree pollen (Pla a 2) (26).

Cup a 3, a thaumatin-like stress-activated protein, has homology with a similar allergen found in Mountain cedar tree (Jun a 3), Cherry (Pru a 2), Apple (Mal d 2), and viral-infected Tobacco leaves (16). The amino acid sequence of Cup a 3 was found to have a high degree of homology to Jun a 3 (16).

The similarities of amino-acid sequences and some complex glycan stuctures have been suggested as explaining the high degree of cross-reactivity between the *Cupressaceae* and *Taxodiaceae* families (9).

Clinical Experience

IgE-mediated reactions

Arizona cypress, in common with the other members of the *Cupressaceae* family, is an important source of allergens, causing winter respiratory allergies and commonly inducing symptoms of asthma, hayfever, and allergic conjunctivitis in sensitised individuals (8,23). Symptoms from the winter flowering may create confusion with symptoms from perennial allergens such as House dust mite (27). The *Cupressaceae* pollen season has gained an earlier onset as a result of the vastly wide distribution of *C. arizonica*, which pollinates in January and February and partially overlaps with the very highly cross-reacting *C. sempervirens*, which pollinates from February to the end of March (28). In a study over an 8-year period (1982-1989) in southern Italy, *Cupressaceae* pollen was noted as being at the highest concentrations during winter and early spring. "Remarkable" fluctuations of *Cupressaceae* pollen counts were noted over a 2-year cycle (33).

To initially demonstrate the cosmopolitan nature of *C. arizonica* and of its effects, we can point to a report of a 37-year-old man from Lithuania working in Switzerland who presented with typical symptoms of allergic rhinoconjunctivitis that appeared in spring. A detailed history revealed that the patient was working in a building of a United Nations agency surrounded by a park with numerous Arizona cypress trees. Skin-specific IgE for *C. arizona* was strongly positive (29).

In general, species of the *Cupressaceae* family (genera *Cupressus*, *Juniperus*, *Chamaecyparis*, *Callitris*, *Thuja* and *Libocedrus*) are a very important cause of allergies (especially oculo-rhinitis) in various geographical areas, especially North America, Japan, and Mediterranean countries such as France, Italy and Israel (30). Of particular importance is the wide diffusion in these countries of trees belonging to the genus *Cupressus*, especially *C. sempervirens* and *C. arizonica* (4). Cypress allergy has been reported since 1945 (31). *C. arizonica* and *Juniperus sabinoides*, or Mountain cedar, are key causes of respiratory allergies in Texas and the southwestern United States. In Australia, the culprit species is predominantly *C. sempervirens*. In Japan, the major pollen allergen source is the Japanese cedar (*Cryptomeria japonica*), a member of the closely related family of *Taxodiaceae*.

Clinical and aerobiologic studies show that the pollen map of Europe is changing as a result of cultural factors (*e.g.*, wider international travel and evolving environmental management). During the last 30 years, *C. arizonica* has been widely used for reforestation, for wind and noise barriers, and ornamentally in gardens and parks. *C. sempervirens* and *C. arizonica* are common in southern Italy and France, *C. alba* is present in most parts of Italy, and *C. lasoniana* is used in the UK as a fast-growing evergreen (32). Of the *Cupressaceae*, the most widespread genus in southern Italy was found to be *Cupressus*, represented in particular by *C. arizonica* Green and *C. Sempervirens L*. The authors noted that the employment of these trees for reforestation and garden ornamentation had increased considerably in the last 40 years (33). An increase in the reactivity to *Cupressaceae* pollens has been described as well, possibly because the allergenic load is becoming greater. Air pollution may have contributed to this increase (30).

From the Mediterranean region comes the most dramatic evidence of recent increases in reactivity to *Cupressaceae* pollen. For example, in a comparative study of *Cupressaceae*, the annual mean pollen concentration in Lyon-Bron, France (in a temperate region), went from 4.5 pollen grains per cubic metre of air at the beginning of the 1980s to 13.7 pollen grains at the beginning of the twenty-first century (an increase of more than 200%); and in Montpellier, France (in a Mediterranean region), the concentration went from 43 pollen grains per cubic metre of air to 72 pollen grains during the same period (34).

Similarly in Rome, the incidence of Cypress allergy increased from 9.3% to 30.4% in 3 years (35). In Italy, the annual sensitisation rate as demonstrated by skin-specific IgE to *C. sempervirens* increased from 7.2% in 1995 to 22% in 1998 (36). In another large-scale study, allergy to *Cupressaceae* pollen was also reported to be on the increase in recent years in Italy (27). In an epidemiological survey, conducted in 12 Italian centres, of 3,057 pollen-sensitised patients, the prevalence of skin reactivity to a panel of tree pollens was found to be 9.2% in northern, 28.2% in central, and 20.1% in southern Italy. Monosensitised patients represented only 14.7% of all *Cupressaceae*-sensitised patients, their average age being higher than that of the polysensitised ones (43.3 versus 35.86). The most frequent allergens, as shown by prick tests, were *Cupressus sempervirens* (90%) and *Cupressus arizonica* (88.9%). The authors concluded that pollen allergy to the *Cupressaceae* was on the increase in Italy (27).

Nevertheless, the prevalence of Cypress sensitisation appears to vary greatly, even though the data are consistently collected in geographical areas with abundant Cypresses. Some authors have stated that Cypress allergy is underestimated, as this is a winter pollen and pollen allergy may be characterised by symptoms mimicking "recurrent" viral infections (30,37). Other researchers have claimed that the prevalence of sensitisation is low in spite of the high allergenic pollen load in the areas studied (2,38). For instance, in the Western Ligurian Riviera, Cypresses are part of the spontaneous flora and are also cultivated and planted for ornamental and other gardening purposes. Of 1,735 patients, only 18 (1.04%) had skin reactivity Cypress. Of these 18 patients, only 5 were monosensitised, whereas the remaining 13 patients were polysensitised. Rhinoconjunctivitis was the more frequent symptom. In patients with polysensitisation, symptoms were not clearly related to the Cypress pollen season, but rather might have to do with other pollens. The *Cupressaceae* pollen counts were high during the pollen season, with an increasing trend during the previous 4 years. The data from this study show that the prevalence of sensitisation to Cypress, at least in this geographic region, is very low despite the large diffusion of pollens and the high pollen peaks. This contrasts partly with data reported in previous surveys (39). For instance, in a study performed in another area of the Ligurian Riviera (39), the rate of sensitisation was higher (2).

A possible explanation for the underestimation of the prevalence of Cypress allergy may be the difficulty of allergen extraction from the grains, which leads to the lack of good standardisation of the extracts. Another possible factor is genetic protection, especially in those populations in close contact with Cypresses during centuries (40).

The majority of studies evaluated either Cypress as a homogenous entity or Italian funeral cypress. This may have influenced the results of some studies. In a 4-year Italian study of 1,393 patients, utilising SPT to *C. sempervirens*, an incidence of Cypress allergy of approximately 10% was reported in the first 2 years, but rose to over 24% when *C. arizonica* pollen extract was added to the test. With further improvements in the testing, 35.4% of patients in the final year of the study were shown to be allergic to Cypress pollen. The study concluded that allergy to Cypress is under-evaluated as a result of its winter seasonal appearance, and that false-negative diagnosis may be made as a result of poor *in vivo* allergen extracts (37). The authors of another study concluded that the use of more than 1 extract of *Cupressaceae* and *Taxodiaceae* origin would increase the diagnostic sensitivity (27).

To examine individual regions outside Italy: Cypress pollen allergy is also very important in France. In a study of *Cupressaceae* pollen (*C. sempervirens*) and allergic individuals in Montpellier, the authors reported that individuals allergic to this pollen present with a high rate of conjunctivitis and a low rate of asthma (30).

Cypress allergy has also been reported in Spain, and Cupressaceae pollen is by far the most common pollen during the winter period (30%) in Cordoba. *Cupressaceae* pollen is the predominant pollen in areas such as Toledo, Barcelona and Madrid from January to April (11%), and it is the main cause of the so-called "winter allergic cold". The prevalence of positive skin prick tests to *C. arizonica* extract is 20% (41-44). In the study, the absence of monosensitisation was noted. Of adult pollen-allergic patients, 37% were allergic to *Cupressaceae*, as well as 18% of those with respiratory allergy (41).

In Israel, Italian funeral cypress grows naturally, but millions of these trees were also planted in recent times, as well as Arizona cypress and a variety of other family members. Researchers reported that pollen release in some regions may vary from one locality to another by a month, depending on prevailing winds, water availability and other microclimatic conditions (45). In another Israeli study, patients with Cypress allergy were reported to be symptomatic from February until April; 70% of them had rhinitis, 30% also asthma, and 18% conjunctivitis. Sensitisation to this pollen in hayfever patients varied from 26% in Tel Aviv to 32% in Netzer-Sireni and 24% in lower Galilee. In the monosensitised patients, anti-Cypress immunotherapy was successful (46).

Similarly, Arizona cypress pollen has increased in the air of Tucson, Arizona, due to "greening" of the area with ornamentals and barrier plants (47). There is, however, a remarkable shortage of allergy-related studies of this tree where it is indigenous, in the United States.

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t214 Date

Phoenix canariensis

Family: *Arecaceae*

Common names: Canary Island date palm tree

Source material: Pollen

See also: Date (the fruit of *Phoenix dactylifera*) f289

Not to be confused with the "true" Date palm tree (*Phoenix dactylifera*) which is cultivated for its fruit.

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Allergen Exposure

Geographical distribution

Phoenix canariensis is native to the Canary Islands in the Atlantic Ocean off northeast Africa. These Palms are popular landscape items around the world, particularly in coastal regions with Mediterranean climates.

Although there are many Palms that we call ”Date palms” (*e.g.*, Canary Island date palm, Pygmy date palm, Senegal date palm), *Phoenix dactylifera* is the true Date palm, cultivated for its delicious fruit.

The Canary Island date palm is a very large and imposing tree. It grows up to 20 m tall. The large trunk supports a huge crown of over 50 arching, pinnate leaves that may each measure 6 metres long. The leaves are deep green, shading to yellow stems where the leaflets are succeeded by vicious spines. The trunk is covered with diamond designs that mark the points of attachment of previously discarded leaves.

Palms have separate male and female plants. Flowers are mostly wind- pollinated, and the plant produces a large amount of pollen. Cream-coloured to yellow flowers are borne in summer on stalks about 2 m long. The heavy bunches of fruits (Dates) are yellow-orange or deep red, with edible, sweet but almost dry flesh. They are cylindrical to ellipsoid in shape and approximately 2 cm in size. They are edible but not very palatable.

Environment

These Palms occur in nearly frost-free climates around the world, and particularly in coastal regions.

Allergens

To date no allergens have been isolated from this plant.

Six major allergens have been isolated from Date pollen from the related species *P. dactylifera*: Pho d 1 (a 12 kDa protein), Pho d 2 (a 14.4 kDa protein), Pho d 3 (a 57 kDa protein), Pho d 4 (a 65-67 kDa protein), Pho d 5 (a 28-30 kDa protein), and Pho d 6 (a 37-40 kDa protein). The 12, 14.4, 57, and 65-67 kDa bands bind 80-93%, and the 28-30 and 37-40 kDa bands 60-80% of atopic sera (1). Due to its close relationship within the same genus, *P. canariensis* could be expected to contain similar allergens.

A more recent study reported that 30% (60 patients) were skin test-positive to Date palm profilin, Pho d 2, of the closely related species *P. dactylifera* (2).

Potential cross-reactivity

Extensive cross-reactivity among the different individual species of the genus could be expected (3).

RAST inhibition studies have demonstrated significant cross-reactivity between *P. canariensis* pollen and *P. dactylifera* pollen (4). Furthermore, allergens present in fruit of *P. dactylifera* have been reported to be cross-reactive with pollen allergens from the same Palm, and the study reported that Date fruit-sensitive as well as Date pollen-allergic patients' sera recognised the same group of Date fruit IgE-binding components (1).

Studies from India have reported cross-reactivity among the pollen of 4 species of important Palms in that region (*Areca catechu*, *Cocos nucifera*, *Phoenix sylvestris* and *Borassus flabellifer*) (5-6), suggesting cross-reactivity between these 4 palms and the closely related Date tree. Cross-reactivity among the 4 Palm pollen grains was also demonstrated by dot blotting and ELISA inhibition studies (7).

The closely related *P. dactylifera* contains a profilin allergen, Pho d 2, which was shown to have high sequence identity with other allergenic food and pollen profilins (8). Pollen from this Palm has been reported to show cross-reactivity with antigens from Artemisia, Cultivated rye (*Secale cereale*), Timothy grass (*Phleum pratense*), Sydney golden wattle (*Acacia longifolia*) and Bermuda grass (*Cynodon dactylon*) pollen. Cross-reactivity was also reported to exist between pollen from this palm and a number of foods implicated in oral allergy syndrome, but the authors stated that the clinical relevance of this needed to be elucidated (9).

Clinical Experience

IgE-mediated reactions

Asthma, allergic rhinitis, allergic conjunctivitis and contact urticaria may occur following contact with pollen from this tree (4).

An individual with asthma, rhinoconjunctivitis, and contact urticaria from pruning dried leaves from this Palm was described. A skin prick test and IgE antibody tests were positive. A bronchial provocation test with the pollen elicited a positive response (4).

In an Israeli study, pollen extracts of 12 varieties of Palm and 9 of Pecan were tested on 705 allergic patients living in 3 cities and 19 rural settlements. Sensitivity to extracts of Date palm pollen and Pecan tree pollen was much higher among residents of rural than of urban communities. There was a relationship between the abundance of these trees in a region and the incidence of positive skin prick tests to their pollen. Pollen levels decreased with increasing distance from the trees, and were low at approximately 100 m from a source (10). In view of the significant cross-reactivity among members of this species, the findings of this study would be relevant to areas where *P. canariensis* is grown.

In a study based in West Bengal, India, it was reported that 18 common airborne types of pollen were detected, and that they induced sensitisation in susceptible individuals: the closely related species *P. sylvestris* (Sugar date palm) was shown to result in sensitisation in 43% of 475 individuals tested (11).

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t207 Douglas fir

Pseudotsuga taxifolia

Family: *Pinaceae*

Common names: Douglas fir tree, Oregon pine, Yellow fir

Source material: Pollen

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Allergen Exposure

Geographical distribution

Of the 6 species of *Pseudotsuga*, 2 are native to North America, 1 to Mexico, and 4 to Asia and parts of Europe.

The Douglas fir is a tall evergreen timber tree, with short needles and egg-shaped cones similar to those of a Fir tree, but it is not a true Fir. Douglas fir attains a height of 30 to 90 m. The trees have irregularly whorled branches. The foliage is feathery-soft and not sharp. Colour varies from silver to heavy bluish-green. Branchlets are nearly smooth, but not as smooth as the branches of Firs.

Flowers are monoecious (individual flowers are either male or female, but both sexes are found on the same plant) and bloom in May. The fruit is a pendulous cone with 3-lobed bracts extending beyond the cone scales. The fruit is very distinctive and when present is the best identification feature.

Environment

This is the most important timber tree of western North America, and is also widely planted in parts of Europe. The timber is usually called Oregon pine or Yellow fir.

Allergens

No allergens from this plant have yet been characterised.

Potential cross-reactivity

An extensive cross-reactivity among the different individual species of the genus could be expected (1).

Clinical Experience

IgE-mediated reactions

Anecdotal evidence suggests that asthma, allergic rhinitis and allergic conjunctivitis, similar to reactions caused by other members of this family, are possible following exposure to pollen from this tree; however, few specific studies have been reported to date.

The Douglas fir is not an important allergen in urbanised communities, except those situated close to Douglas fir plantations, where the prevalence of atopic sensitisation to pollen from this tree is expected to be high.

Other reactions

The tussock moth caterpillar, occurring in forested areas of Oregon, was associated with itching of the skin and eyes, nasal discharge, cough, and, at times, respiratory difficulty in 41 of 428 individuals working in a forest (2).

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t205 Elder

Sambucus nigra

Family: *Adoxaceae*

Common names: Elder, Common elder, Elderberry

Source material: Pollen

Sambucus is the old Latin name for the European elderberry; *nigra* (black) may refer to the ripe fruit

(Not to be confused with the Box-elder t1 (*Acer negundo*) or the Grey alder t2 (*Alnus incana*)

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Large clusters of creamy-white flowers are produced in summer, followed in autumn by large bunches of shiny black Elderberries. The flowers are borne in large panicles, and are insect-pollinated. The flowers are small, white, and fragrant, in flat cymes. The fruits ripen in late fall and are usually purple-black, numerous, 4-6 mm in diameter. Only blue/black berries are medicinal; the red berries produced by some species are not medicinal.

Allergen Exposure

Geographical distribution

The Elder tree and other species of Sambucus comprise fast-growing small trees or large shrubs, 1-4 m tall. The leaves are compound and contain 5-11 leaflets, with finely or sharply toothed margins, 4-13 cm long and 2-6 cm wide.

Numerous species of Elder tree or Elderberry grow in Europe and North America. The Elder tree is native to south-eastern Canada and most of the United States except for the Great Basin and the Pacific Northwest, and is found in Britain, Europe, Iraq and Turkey.

Environment

Elder trees are usually found in floodplains or rich soil. In Europe they are often seen along fencerows and ditches and stream banks. Other areas these shrubs can be found in are hedgerows, scrub, woods, roadsides and waste places. Elderberry fruits are used for making pie, jam and wine.

Unexpected exposure

Fruits should not be eaten fresh in large quantities, as they are emetic. Elder flower extract, mostly from the European species *S. nigra*, is made into a drink. The leaves of American Elder are toxic.

Allergens

To date the following allergen has been characterised:

Sam n 1, a 33.2 kDa, ribosomal inactivating protein, found in the pollen, flower and fruit (1).

Thaumatin-like proteins (TLPs) have been isolated and characterized from fruits and leaves of Elder tree. Ripening berries accumulated a fruit-specific TLP during the final stages of maturation. The leaves expressed a TLP that closely resembled the fruit-specific homologue. These thaumatin-like proteins shared a high sequence similarity with group-5 pathogenesis-related proteins (2). The clinical relevance of this protein was not evaluated, nor whether the allergenicity of these TLPs is similar to that of other TLPs.

Potential cross-reactivity

An extensive cross-reactivity among the different individual species of the genus could be expected (3).

Clinical Experience

IgE-mediated reactions

Anecdotal evidence suggests that asthma, allergic rhinitis and allergic conjunctivitis are possible following exposure to pollen from this tree; however, few specific studies have been reported to date. Patients suffering from allergic rhinoconjunctivitis and dyspnoea during summer may exhibit these symptoms after contact with flowers or dietary products of the Elder tree. Nine patients with a history of summer hayfever were tested in a routine setting for sensitization to Elder. 0.6% of 3,668 randomly tested patients showed positive skin prick test and/or IgE antibodies to Elder (1).

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t8 Elm

Ulmus americana

Family: *Ulmaceae*

Common names: Elm, White elm, American elm

Source material: Pollen

See also: Cedar elm (*U. crassifolia*) t45

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Allergen Exposure

Geographical distribution

The Elm family, *Ulmaceae*, contains 6 genera, the most important being *Ulmus*, *Planera*, and *Zelkova*. (Hackberries [*Celtis spp*.] used to be included in the Elm family but are more closely related to *Urticaceae* and have been placed in a separate family, *Celtidaceae*). There are about 45 species of Elms worldwide, found in the temperate Northern Hemisphere, with about 4 introduced species to the USA, and 6 native to North America east of the Rocky Mountains. There are 25 species of *Ulmus* (1-3).

White elm can be found mostly in forests in central and eastern North America, where it represents a major source of pollen. White elm is native to North America and has a wide range, from all of the eastern states through the Central Plains (4).

The corresponding European species, Wych elm (*U. glabra*) and Smooth elm (*U. carpinifolia*), grow wild or cultivated throughout the north temperate regions. In the 1930s, Dutch elm disease devastated White elm trees in North America as well as in Europe. The disease, a fungal blight, was caused by the ascomycete *Ophiostoma ulmi* and transmitted through the native Elm bark beetle, *Hylurgopinus rufipes* (5). All Elms are susceptible to some degree to the fungus, especially American elm (*U. Americana*) and September elm (*U. serotina*). Chinese elm (*U. parvifolia*), Siberian elm (*U. pumila*) and Red or Slippery elm (*U. rubra*) are highly or moderately resistant (1,3).

White elm is a deciduous tree growing up to 40 m tall and is well known for its vase-shaped crown. The bark is furrowed and light- or dark-grey. The dark-green leaves are alternate, simple, and have doubly toothed margins.

The flowers appear in late winter or early spring as drooping, hairy, greenish-red clusters of 3 to 4 flowers, while other species of the genus flower in the fall. Oval and flat fruit are produced. These are up to 1.5 cm long and have papery wings.

Environment

White elm grows in woods and hedges and by roads and streams, occurring on moist uplands and bottomlands. In bottomlands, the trunk is more likely to be buttressed than in uplands. American elm was widely planted as an ornamental in urban settings because it was stress-tolerant, fast-growing, and beautiful.

Allergens

No allergens have yet been characterised.

Potential cross-reactivity

An extensive cross-reactivity among the different individual species of the genus could be expected, as well as to a certain degree among members of the family *Ulmaceae* (6). However, to date this has not been documented.

In a Spanish study, individuals with Melon allergy were found to be especially prone to sensitisation and asthma to several tree and weed pollens, predominantly *Ulmus* and *Ambrosia* (7).

Clinical Experience

IgE-mediated reactions

White elm pollen can induce asthma, allergic rhinitis and allergic conjunctivitis (8-9).

The importance of *Ulmaceae* pollen in asthma, allergic rhinitis and other allergy conditions has been demonstrated by numerous studies from around the world. In Washington, DC, the *Ulmaceae* have been shown to have 2 distinct pollinating times, with the later-flowering species of Elm pollinating from August through October, coinciding with Ragweed season. April is usually the month with the highest weekly average concentrations (10).

Elm tree pollen has also been demonstrated to be an important aeroallergen in Salamanca, Madrid, and Badajoz, Spain (11-13), and in 9 districts of northern China (22). In one district, Elm pollen was the dominant aeroallergen detected.

Elm tree pollen has also been shown to be an important aeroallergen in Tehran, Iran, where the pollen season extends from the first week of February through the middle of October (14).

In Siena, in central Italy, Elm tree pollen was found to be an important aeroallergen in March, but not during the rest of the tree pollen season (15); whereas in Modena, in northern Italy, the Elm family contributed little pollen to the air (about 1% of the total pollen recorded) (9). Similarly, Elm tree pollen was not shown to be an important aeroallergen in Missouri, USA (16). In Tampa, Florida, in the USA, where the major tree pollen season occurs from December through May, with a minor season occurring from October to November, Elm tree pollen is important during the minor season (17).

In a New York study of 371 allergy patients tested serologically for hypersensitivity to prevalent tree pollens in the surrounding area, the highest rate of hypersensitivity was to Oak (34.3%), Birch (32.9%), and Maple (32.8%) tree pollens, with a rate of 24.6% for Elm being recorded (18). In a Canadian study that evaluated the impact of different trees on asthma, along with the association between daily hospitalisations for asthma and daily concentrations of different tree pollens in 10 large Canadian cities, it was reported that for an interquartile increase in daily tree pollen concentration, percent increases in daily hospitalization for asthma were 2.63% for *Ulmus* (19).

Aerobiology studies often do not draw distinctions among the various species of *Ulmus*, but this may not be problematic; considering the close relationship among these species, cross-sensitisation or cross-reactivity is possible. Pollen concentration in the atmosphere of Lublin (in eastern Poland) was reported to be the highest for *Betula*, *Pinaceae* and *Alnus*; and the lowest for *Ulmus*, *Fagus* and *Corylus*. Signficantly, total pollen grains for *Ulmus* varied almost 2-fold between successive years (20). Pollen from the *Ulmus* species has also been reported to be an important allergen in Zagreb, Poland (21). In aerobiology studies of 9 districts of northern China, the most common aeroallergens in spring were often *Ulmus*, *Populus* and *Salix* (22).

IgE antibodies to Elm tree pollen were detected in pollen-allergic individuals with allergic rhinitis in Jena, Germany (8).

Other reactions

Delayed and prolonged contact urticaria as a result of contact with Elm tree has been reported (23).

t8 Elm

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t18 Eucalyptus, Gum-tree

Eucalyptus spp.

Family: *Myrtaceae*

Common names: Eucalyptus, Gum tree, Blue gum tree, Fever tree

Source material: Pollen

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Allergen Exposure

Geographical distribution

Members of the Eucalyptus species are quick-growing evergreen trees or shrubs. Some species can reach heights over 135 m. The stem and trunk bark of the Eucalyptus may be dappled in gray, green, russet, or cream and may peel in sheets. These trees have leathery, smooth, lance-shaped leaves, which are studded with glands containing a fragrant volatile oil with a distinctive aroma.

Eucalyptus originated in Australia. There are over 700 species of the tree, which now grows in almost all tropical and subtropical areas. It is found in North and South Africa, India, Southern Europe, California, and Mediterranean countries.

Their puffball-like flowers may be red or orange. They have no petals but instead numerous stamens arising from a capsule-like calyx, which give them their fluffy appearance. Eucalyptus flowers in the tropics almost year-round.

Environment

Eucalyptus thrives in any environment having a mean annual temperature not below 60 °F. Whole Eucalyptus forests have been planted in California and around the Mediterranean to help stem erosion. Eucalyptus has been planted in swampy areas, where its fast growth demands much water and performs a draining function.

Different species of Eucalyptus are grown for timber, paper, oil and gum production. The oils of the leaves and shoots are used for medicinal purposes: for example, as an ingredient in tablets for soothing sore throats. The oils may be divided roughly into 3 classes of commercial importance: (i) the medicinal oils, which contain substantial amounts of eucalyptol (also known as cineol); (ii) the industrial oils, containing terpenes; and (iii) the aromatic oils. Tannin is extracted from the bark of some varieties.

Allergens

No allergens from this plant have yet been characterised.

Potential cross-reactivity

A high degree of cross-reactivity among the different Eucalyptus species can be expected, and occasionally also between these and species of the genus *Melaleuca* (1).

Clinical Experience

IgE-mediated reactions

Eucalyptus is known to cause cutaneous diseases through its oil or pollens, and respiratory allergic diseases through its pollens. Eucalyptus pollen may result in symptoms of asthma, hayfever and conjunctivitis (2-4).

A 30-year-old woman with asthma and rhinoconjunctivitis was described. Her symptoms appeared to be exacerbated by Eucalyptus pollens and by ingestion of an infusion containing Eucalyptus. Specific IgE was positive for Eucalyptus pollens. The authors suggested that care should be taken in administering herbal medications in the case of asthmatic subjects (4).

Eucalyptus pollen has been shown to be an important airborne allergen in Taiwan, with 76% of 195 children aged between 5 and 15 years demonstrating specific IgE to this pollen in their serum (2). Specific assays to determine specific IgE to Eucalyptus pollen have been shown to be effective (3).

An aerobiological survey conducted in West Bengal, India, of 31 pollen types found that the pollens showing the strongest sensitising potential included *E. citriodora* (lemon-scented gum). Skin prick testing for sensitisation to this tree was positive in 89/260 (34.23%) (5). Similarly, in an "All India Coordinated Project on Aeroallergens and Human Health" undertaken to discover the quantitative and qualitative prevalence of pollens at 18 different centres in the country, it was found that the predominant airborne pollens included Eucalyptus (6).

An atmospheric survey of the eastern Mediterranean coast of Turkey found that the most prominent tree pollens were *Cupressaceae*, *Eucalyptus* and *Pinus*. The most common herb pollen was from the *Chenopodiaceae* family (7). Eucalyptus pollen has also been documented in pollen studies in central Argentina (8), southwestern Spain (9-10), and Athens, Greece (11).

Contact urticaria due to Eucalyptus pollen has been reported (12).

Other reactions

Eucalyptus oil is distilled from the fresh leaves of *Eucalyptus globulus* and other species. It may result in toxicity when ingested orally. A 6-year-old girl presented with slurred speech, ataxia and muscle weakness progressing to unconsciousness following the broad application of a home remedy for urticaria containing Eucalyptus oil (13).

Eucalyptus oil may result in allergic contact dermatitis (14).

Euproctis edwardsi, the mistletoe browntail moth, is a variety of hairy caterpillar widely distributed in southeastern Australia. Itching urticarial wheals and papular eruptions can follow contact with the caterpillars or their detached hairs. Infestation with *Euproctis edwardsi* can be minimised by removal of mistletoe from Eucalyptus trees (15).

A 46-year-old woman with vocal cord dysfunction precipitated by Eucalyptus odour exposure was described (16).

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t25 European ash

Fraxinus excelsior

Family: *Oleaceae*

Common names: European ash, Common ash, European common ash

Source material: Pollen

See also: White ash (*F. americana*) t15

There are 4 important genera in the *Oleaceae* family: Olive (*Olea*), Ash (*Fraxinus*), Lilac (*Syringa*), and Privet (*Ligustrum*)

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Allergen Exposure

Geographical distribution

Fraxinus is a genus of about 65 species, which are distributed in northern temperate regions. The hardy White ash (*Fraxinus Americana*), for example, is native and common in eastern North America and also thrives in Europe. The European ash (*Fraxinus excelsior*) is native to most of Europe, with the exception of northern Scandinavia and the southern Mediterranean. White ash tree (t15) needs to be differentiated from European ash tree (t25).

European ash is a broad, spreading, deciduous tree, capable of reaching 35 m in height. It is distinguished from other species of Ash in that it has black and not brown buds. The bark is light-grey (smooth in younger trees, rough and scaly in older specimens). The dark green leaves are 20-35 cm long, pinnate compound, with 9-13 leaflets. The leaflets have sharply toothed margins. The leaves of the European ash are often among the last to open in spring, and the first to fall in autumn in the event of an early frost. They usually drop off while still green, but on some cultivars may turn yellow first.

European ash is dioecious (male and female flowers are distinct but – most of the time, in this case - grow on separate trees). Unusually, a tree that is male one year can produce female flowers the next, and a female tree can become male. The unornamental, purple or greenish-white, petal-free springtime flowers (the female ones somewhat longer than the male ones) open before the leaves. Ash sheds copious pollen. The tree is entirely wind-pollinated. The pollen is carried as far as 110 m from the point of dispersion. Ash pollen load may vary extensively between years (1). In Europe, European ash flowers in April and May.

The fruits are 4-5 cm long, oblong, and winged (known as “Ash keys” because they hang in bunches). They turn brown and remain on the trees until the following spring, when they are blown off and carried away by the wind.

European ash tree pollen may often be overlooked as a cause of pollinosis, as the flowering season coincides with that of Birch. Because of the close family relationship with the Olive tree, the pollen is a significant cause of respiratory allergy through cross-reactivity. Observations from Switzerland suggest that European ash tree pollen may be, at least locally, as important as Birch in the elicitation of spring pollinosis (2).

Environment

European ash grows best on deep, well-drained, moist soils with other hardwoods. It is often utilised as a landscape tree and is commonly found in gardens and parks.

Unexpected exposure

Because of its high resistance to splitting and its flexibility, European ash wood is the traditional material for tool handles, tennis rackets and snooker cues.

The bark contains the bitter glucoside fraxin, the bitter substance fraxetin, and tannin, quercetin, mannite, and malic acid.

Extract of *Fraxinus excelsior* combined with other ingredients, *e.g.*, extracts of Trembling poplar tree (*Populus tremula*) and Goldenrod (*Solidago virgaurea*), has been used for the management of mild to moderate rheumatic complaints (3).

Allergens

European ash tree pollen contains Fra e 1, a major allergen related to the major Olive allergen Ole e 1; the panallergen profilin Fra e 2; a 2-EF-hand calcium-binding protein, Fra e 3; a pectinesterase-like molecule; and an allergen sharing epitopes with Group 4 grass pollen allergens (4).

Allergens characterised:

Fra e 1 (2,4-8).

rFra e 1 (5-6).

Fra e 2, a profilin (2,4).

Fra e 3, a calcium-binding protein (2,4).

Fra e 9, a 1,3-beta-glucanase (9).

Fra e 1 is a major allergen for Ash pollen-sensitised individuals in Northern and Central Europe. It belongs to the Olive tree Ole e 1-like family and has a high degree of cross-reactivity with other members (5). Approximately 70-80% of Ash pollen-sensitised individuals will have Fra e 1-specific IgE antibodies (2,6).

Approximately 75% of European ash-sensitised patients were shown to have IgE antibodies to rFra e 1, and 29 of 30 Ash-sensitised patients were shown to have positive SPT to rFra e 1 (6).

About 50% of Ash-allergic individuals have been shown to be sensitised to Fra e 2, a profilin, and in the same study, the calcium-binding protein Fra e 3 was shown to be a major allergen (4).

In a study evaluating the frequency of IgE-binding to Fra e 1 and pollen panallergens, Fra e 1 sensitisation was found in 100% of monosensitised patients (n = 6), 93% of oligosensitised patients (n = 16), but only 44% of polysensitised patients (n = 25). IgE antibodies against Fra e 2, Fra e 3, and carbohydrate epitopes in the 3 groups was found in 0/0/17%, 0/19/31%, and 32/72/60% of the patients, respectively. The study found that only 20% of positive SPT to European ash resulted from cross-sensitisation to pollen panallergens (2).

Potential cross-reactivity

The genus *Fraxinus* belongs to the family *Oleaceae*. It is closely related to Jasmine (*Jasminum*), Lilac (*Syringa*), Privet (*Ligustrum*), Forsythia (*Forsythia*) and Olive (*Olea*). An extensive cross-reactivity among the different individual species of the genus could be expected, as well as to a certain degree among members of the family *Oleaceae* (10). Indeed, cross-reactivity has been documented among Olive (*Olea europaea*), White ash (*Fraxinus americana*), Privet (*Ligustrum vulgare*), and Russian Olive tree (*Elaeagnus angustifolia*) pollen allergens (11). A high degree of cross-reactivity has also been demonstrated among Olive tree (*Olea europaea*), European ash (*Fraxinus exselsior*), Privet (*Ligustrum vulgare*) and *Phillyrea angustifolia*, although there was no 100% identity among these species (12). Similar results have been reported by other studies (2,13-15). Six common protein bands were found to be responsible for the cross-reactivity, with apparent molecular weights of 49.6, 40, 36.7, 19.7, 16.7, and 14 kDa (15). A study using recombinant Fra e 1 reported an 82%, 88%, and 91% identity with, respectively, Syr v 1 (Lilac tree), Ole e 1 (Olive tree), and Lig v 1 (Privet tree) (6). Further clarity on the relationship among the *Oleaceae* pollen allergens was achieved in a study evaluating the common epitope determinants in Olive and other *Oleaceae* pollens: European ash, Privet, Lilac, and Forsythia; 18- and 20-kDa proteins were present in each pollen except Forsythia. IgE antibodies to Forsythia was directed at 50- to 55-kDa protein bands (16).

A study comparing the profiles of Olive and Ash pollen allergens investigated the degree of cross-reactivity using Spanish and Austrian allergic patients selectively exposed to Olive or Ash pollen. Both groups exhibited an almost identical IgE-binding profile to both pollen allergens, with major reactivity directed against Ole e 1 and its homologous Ash counterpart, Fra e 1. Extensive cross-reactivity was demonstrated between Olive and Ash pollen allergens. However, whereas cross-reactions between profilins and calcium-binding allergens also occur between unrelated plant species, cross-reactivity to Ole e 1 was confined to plants belonging to the *Oleaceae*. The study concluded that Ole e 1 is a marker allergen for the diagnosis of Olive and Ash pollen allergy (7). As Fra e 1 has strong cross-reactivity with Ole e 1 (5), some authors have suggested that the cross-reactivity is so pronounced that immunotherapy with Ole e 1 would protect European ash-allergic individuals (15).

Since European ash pollen contains a profilin and a calcium-binding protein, and both are panallergens, cross-reactivity with other plants containing these protein families may result. In a study evaluating sera of 40 Ash pollen-allergic individuals, 30% had IgE antibodies to several high-molecular-weight Ash pollen allergens cross-reactive with Timothy grass and Olive pollen (4).

Ole e 9, an Olive tree pollen allergen and a 1,3-beta-glucanase, has been shown to have counterparts in pollen from European ash and Birch tree pollen, Tomato, Potato, Bell pepper, Banana and Latex (9). Specific cross-reactivity between Ash and Birch has been reported in a study (17).

Clinical Experience

IgE-mediated reactions

European ash is a common cause of asthma, allergic rhinitis and allergic conjunctivitis (2,11,18), in particular in Central and Northern Europe, as has been recognised in recent years (2,4). The tree is regarded as contributing to important health problems (12,19). In patients living near Strasbourg, Ash pollen induces nearly 4% of the total sensitisation of the allergic population (6). The relevance of Ash pollen as a cause of sensitisation may have been undervalued because of the overlapping of the tree's pollination period with the pollination of other better-documented trees, such as Birch (20).

A Spanish study was carried out in the Basque region, with the aim of demonstrating the importance of European ash tree pollen as a triggering factor in the allergic symptoms shown in early spring. In an area where European ash trees are common but Olive trees are not present, 48 pollen-allergic patients were selected and classified into 3 groups in accordance with their predominant sensitisation: Olive tree pollen-allergic patients (O), grass-allergic patients (G) and Olive tree pollen- + grass-allergic patients (M). A hundred percent of O patients, 40% of M patients and 16% of G patients reported early symptoms, coinciding with the flowering of Ash, when grass pollen was not yet present. Conjunctival challenge tests with Ash and Olive pollen extracts were positive in 70% and 100% respectively in O patients, 50% and 78% in M patients, and 31% and 58% in G patients. Conjunctival challenge tests with Olive tree pollen extract in patients who suffered from early symptoms were positive with lower concentrations of the extract. The patients with early symptoms had a higher rate of positive skin prick tests with Ash pollen and had significantly higher levels of IgE antibodies to European ash pollen than did late-symptomatic patients. The study concluded that Ash pollen can be considered a potential cause of hayfever in areas where it is present in considerable amounts (21).

In an eastern Austrian study of 5,416 consecutive patients sensitised to various pollens, approximately 17.6% were shown to have skin reactivity to Ash (2). Ash tree pollen has also been demonstrated to be an important aeroallergen in Zurich, Switzerland, contributing greatly to the overall pollen count (22).

The daily pollen concentration measured in the atmosphere over a 6-year period in Badajoz, in southwestern Spain, demonstrated that pollen from *Fraxinus* species was among the most important aeroallergens (23). In Madrid, Spain, pollen from *Fraxinus* species was shown to be among the dominant pollens from January to April (24). In Cordoba, Spain, SPT was carried out on 1,500 pollen-allergic patients with an extract of *Fraxinus* pollen, and 59% were positive. The great majority of the patients were polysensitive; only 8% were found to be monosensitive (25).

In Plasencia, Spain, aerobiological studies reported that, although the most common pollens detected were *Quercus*, *Poacea*, *Olea*, *Platanus*, *Pinus*, *Cupresaceae*, *Plantago*, *Alnus*, *Populus*, and *Castanea*, in 210 patients with a diagnosis of pollinosis, 68% were sensitised to European ash tree pollen. The percentages of sensitisation were the following: *Dactylis glomerata*, 80.4%; *Olea europea*, 71.9%; *Fraxinus excelsior*, 68%; *Plantago lanceolata*, 62.8%; *Chenopodium album*, 60.9%; *Robinia pseudoacacia*, 49%; *Artemisia vulgaris*, 43.8%; *Platanus acerifolia*, 36.6%; *Parietaria judaica*, 36.1%; *Populus nigra*, 32.3%; *Betula alba*, 27.6%; *Quercus ilex*, 21.4%; *Alnus glutinosa*, 20.9%; *Cupressus arizonica*, 7.6%; and *Castanea sativa*, 7.1% (26).

Pollen from this species was also shown to be important in Mexico City (27), Sivrihisar, Turkey (28), and Vinkovci in northeastern Croatia (29).

In St. Louis, Missouri, USA, in a study using SPT for pollen from 12 wind-pollinated tree species, it was reported that the closely related White ash had sensitised some individuals but was less reactive than other tree species (30).

Although Ash tree pollen may not be a major component of aeroallergens in a given community, individuals who are Olive tree pollen-allergic may also be found to be sensitive to Ash tree pollen as a result of cross-reactivity. In a study of 503 patients with allergic rhinitis in the southern part of Switzerland (Canton Ticino), patients were evaluated by SPT for sensitisation to common allergens. The authors suggested that out of the 54% who were positive to Olive tree, a great many would be allergic to Ash tree pollen (31). Similarly, in a study of Olive tree pollen allergy, almost all patients exhibited concomitant skin sensitivity to both Ash and Olive pollen (15).

Other reactions

Rhinitis and occupational asthma from exposure to Ash wood dust has been reported (32). A study described an 18-year-old man who worked in a furniture factory and reported rhinitis and asthma after exposure to Ash wood dust. A bronchial provocation test induced a dual asthmatic response. Intradermal testing with Ash wood extract elicited an immediate positive response. IgE antibodies to Ash wood were found in the patient's serum (33).

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Alnus incana

Family: *Betulaceae*

Common names: Grey alder, Speckled alder

Source material: Pollen

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Allergen Exposure

Geographical distribution

The *Fagales* order consists of trees from the *Betulaceae* family (Grey alder and Birch tree), along with Hazel, Hornbeam, Oak, and Chestnut tree.

Grey alder is the most widely distributed Alder in Europe and western North America.

Grey alder is a rapidly growing, deciduous, multi-stemmed shrub or small tree, which tends to form thickets. It has a long trunk and a narrow crown. The Alder typically grows between 2 and 5 m in height but may reach 12 m. The bark is thin, smooth, and green-grey, greyish-brown, or reddish-brown. Trees often produce adventitious roots from near the base of the stem. The leaves are broadly elliptic or ovate, and dull green on both sides. The leaves remain green until they are dropped in the fall.

Flowering generally begins during March or April, with seeds ripening from September to November. The flowers occur in catkins and are monoecious (individual flowers are either male or female, but both sexes are found on the same plant). Alders are wind-pollinated and produce clouds of yellow pollen. The cones remain on the plants for about a year after the seeds are shed, aiding in identification during winter. The fruit is a small, single-seeded nutlet, with narrow lateral wings.

Environment

Grey alder seldom grows at a distance from water. It is typically found bordering streams, rivers and mountain springs, on moist lowlands and in swamps. It invades gaps and clearings in forests and thrives there.

Allergens

More than 30 allergens have been detected in *Alnus* pollen, mainly from analysis of *A. glutinosa* (1-6).

No allergens have been characterised from Grey alder tree (*A. incana*), but the following allergens have been characterised from *A. glutinosa*:

Aln g 1, a 17 kDa protein, a Bet v 1 homologue (Group 1 *Fagales*-related protein) (7-12).

Aln g 4, a 9.4 kDa protein, a polcalcin, a calcium-binding protein (12-15).

Aln g Profilin (16).

Potential cross-reactivity

An extensive cross-reactivity among the different individual species of the genus, *e.g.*, between *A.incana* and *A. glutinosa*, could be expected (17).

Studies of cross-reactivity have mostly concerned *A. glutinosa*, but as a result of the close relationship between this species and *A. incana*, their cross-reactivity is most likely similar. Close cross-reactivity has been demonstrated among Birch, Alder and Beech pollen (18), as well as among Birch, Alder and Hazel (as a result of the common Bet v 1 homologous allergens Aln g 1, Bet v 1 and Cor a 1) (4,7,9,19-20). Cross-reactivity has also been demonstrated among Birch, Alder, Hornbeam, Hazel, European chestnut and Oak (16,21-22). Aln g 1 and Bet v 1 from Birch tree have a 86.8% homology (8). Cor a 1 isoforms from Hazel pollen have been reported to have a 75.5-76.7% identity (83.6-85% similarity) with Aln g 1 (23).

Alder tree contains a calcium-binding protein, which may result in cross-reactivity with other pollens containing calcium-binding protein, *e.g.*, Timothy grass, Rye grass, Birch tree, Olive tree, Mugwort, and Ragweed (24).

Patients sensitised to Japanese hop pollen have been reported to have a higher prevalence of skin prick tests for, among other pollens, those of Sunflower, Bermuda grass, Orchard grass, Alder tree, Birch tree, and Poplar tree (25).

Clinical Experience

IgE-mediated reactions

Alder pollen is a significant cause of asthma, allergic rhinitis and allergic conjunctivitis, in particular in springtime in Middle and Northern Europe, and in conjunction with Birch and Hazel pollen (26-31). The majority of studies have assessed either the *Alnus* species in general or *A. glutinosa* specifically; however, the close relationship between *A. incana* and other *Alnus* species, including *A. glutinosa*, suggests that a number of inferences can be drawn.

Allergy to Alder is important in Northern European countries and is increasing in Southern Europe. Alder has been reported to be a significant cause of sensitisation or allergy in a wide range of geographic locations, including Genoa (a northern Mediterranean area in Italy) (31), southern Finland (32), Fairbanks, Alaska (33), Spain (34-36), Norway (37), Australia (37), and Switzerland (38-39). In central Italy, the pollination period stretches from February to mid-October. Pollen from the Alder is particularly high in the month of March (40). Alder has also been reported to be relevant in Japan (41-42); however, *Alnus sieboldiana Matsumura* may be the predominant species (43).

Studies have reported on Alder pollen in Warsaw, Poland (44), Sweden (29), the Philippines (45), and Tehran, Iran (46). In Plasencia, Spain, *Alnus* was the eighth-most-prominant pollen found in an aerobiological study. Of 210 patients with a diagnosis of pollinosis, 20.9% were sensitised to *Alnus glutinosa* (47). Alder pollen has been documented in aerobiological studies in Worcester, in the West Midlands, United Kingdom (48), and Rochester, Minnesota, USA (49).

In an "All India Coordinated Project on Aeroallergens and Human Health" study evaluating the prevalence of pollen allergens at 18 different centres in the country, the allergenically important pollens included *Alnus* (50). However, in India a number of other *Alnus* species occur, including *Alnus nitida*, an important sensitiser in Delhi patients (51).

As the amount of measurable pollen is highly dependant on geographic and climatic conditions, it varies considerably among different regions of a country, as documented in Switzerland, as well as among different countries and continents (52). In the southern part of Switzerland, among 503 patients with allergic rhinitis tested by skin prick for sensitisation to common allergens, 33% were sensitised to Alder tree pollen (27).

A study determined the impact of different trees on asthma and explored the association between daily hospitalisations for asthma and daily concentrations of different tree pollens in 10 large Canadian cities. In correlating interquartile increases in daily tree pollen concentration with percent increases in daily hospitalisation for asthma, a statistically significant but small (<2%) effect was observed for *Alnus* (53).

In Poznań, Poland, symptoms of patients with positive skin prick tests to *Alnus* pollen allergens were the following: 51% pollinosis, 43% atopic dermatitis, 4% asthma, 1% chronic urticaria and 1% eczema. Serum-specific IgE for *Alnus* was class 5 or 6 in 20.5%. The authors considered that *Alnus* pollen is generally mildly allergenic, but that the amount of *Alnus* pollen released into the atmosphere in places such as Poznań may increase its impact on the population and make it one of the more important aeroallergens present (54).

Alder pollen was reported to be a significant aeroallergen in Zagreb, Croatia. Patients with monosensitisation to Birch pollen had the most severe symptoms in April. In the patients with poylsensitisation to Alder, Hazel and Birch pollen who were cross-reactive, initial symptoms occurred as early as February, with abrupt exacerbation in March and April. The most severely affected patients were those allergic to Birch, Hazel, Alder, grass and Ragweed pollen, who had symptoms throughout the year, with exacerbation in spring and the late summer months (55).

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t44 Hackberry

Celtis occidentalis

Family: *Ulmaceae*

Common names: Hackberry, Northern hackberry

Source material: Pollen

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Allergen Exposure

Geographical distribution

The *Ulmaceae* consist of the Elms and Hackberries. Hackberry (*Celtis*) is a genus of about 60-70 species of deciduous trees or shrubs widespread in southern Europe, southern and eastern Asia, southern and central North America, and south to central Africa. They are found in both temperate and tropical climates. Hackberries are fast-growing and relatively long-lived, growing in a variety of soils.

Hackberry (*C. occidentalis*), a tree native to the USA, grows 10-13 m in height. Southern hackberry, also native to the USA and the largest Hackberry, grows to 20-25 m in height. There are 5 native North American tree species and 2 shrubs. Nettle tree, *C. australis*, is a tree or shrub found in Europe and used for its edible fruit, yellow dye from the bark, and wood for whip-handles and walking-sticks (1).

The trees have broad crowns with ascending, arching branches. The leaves are single and alternate, 5 to 15 cm long, serrated and asymmetric at the base. The bark is scaly and coarsely ridged. Both male and female flowers are found on a tree (monoecious reproduction). The flowers are inconspicuous and appear about the same time as the leaves. Male flowers are longer and fuzzy. Female flowers are greenish and more rounded. Pollen anthesis is from April through May in the Northern hemisphere. Pollen is shed in large amounts.

The fruit is a berry-like, pitted drupe 6-10 mm in diameter, on a single stalk, persisting in winter, and dispersed by birds and mammals (1). It is edible in many species, with a dryish consistency but a sweet taste, reminiscent of a date.

Older taxonomies classified the suborder *Urticineae* as a separate order, *Urticales*, which contained Elm in *Ulmaceae*, Mulberry in *Moraceae*, Nettle in *Urticaceae*, and Hemp and Hops in *Cannabaceae*. Hackberries used to be included in *Ulmaceae* along with Elm, but are now regarded as more closely related to *Urticaceae* and have therefore been placed in a separate family, *Celtidaceae* (2). However, in the APG II system Hackberry has been placed in the Hemp family (*Cannabaceae*).

Environment

The closely related species *C. sinensis* was introduced to the southeastern region of Queensland, Australia, and has had a destructive affect on indigenous plant communities. Its pollen has been identified as an allergen source (3).

Tala (*C. tala*) is a tree or shrub widely distributed in the central part of Argentina, flowering from September through December and reported to be an important cause of hayfever, affecting up to 44% of patients (4-5). Asthma has not been described in connection to it (1).

In Italy, in a study evaluating *Ulmaceae* airborne pollen at the Modena Geophysical Observatory monitoring station, 5 pollen types were identified: *C. australis*, *Ulmus glabra*, *Ulmus laevis*, *Ulmus minor*, and *Ulmus minor/laevis*. However, the family contributed little pollen to the air (about 1% of the total pollen recorded), *Ulmus* and *Celtis* contributing 0.9% and 0.04%, respectively. The highest levels of *Celtis* were during the afternoon (6).

Allergens

No allergens have yet been characterised.

Potential cross-reactivity

Allergic reactions may be expected due to the extensive cross-reactivity that has been posited among the different species of the genus *Ulmus* (represented by White Elm tree) (7). However, there is very little cross-reactivity data on Elm and Hackberry (8).

Clinical Experience

IgE-mediated reactions

Although *C. tala* was reported over 4 decades ago to be an important cause of hayfever in Argentina, affecting up to 44% of patients (5-6), very few studies have evaluated the significance of this tree pollen in allergy. *C. occidentalis* and other species of *Celtis* are generally included in decades-old lists of hayfever plants or of plants with potentially causing hayfever (9-10). The most important Hackberry for hayfever was reported to be *C. occidentalis* (11). Asthma has not been described in this connection (1).

A study that examined aeroallergen sensitization rates in allergic rhinitis affected military children in Texas, found that of 345 children who has been tested for a 51-allergen panel, 80.3% had at least 1 positive test result, and the average number of positive test results was 11.4. The most common allergens were grasses, *Alternaria*, and Cottonwood. Thirty-two of 51 allergens were positive in 20% or more children. Almost 30% were skin prick test positive for Hackberry (12).

Recently, reports were published of the high prevalence of Hackberry pollen in Argentina (13-14), but the studies were not correlated with clinical reports.

The closely related species *C. sinensis* was introduced to the southeastern region of Queensland, Australia, and its pollen has been identified as an allergen source (15).

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t4 Hazel

Corylus avellana

Family: *Betulaceae*

Source material: Pollen

See also: Hazelnut f17

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Allergen Exposure

Geographical distribution

The Hazel tree is native to all of the British Isles and Europe, and to West Asia and North Africa. It has been naturalised in other parts of the world.

The Hazel is a deciduous tree growing to 6 m, but some cultivars are small shrubs or grow in hedges. The tree often develops numerous upright stems from the roots, creating a thicket. The bark is pale brown or grey-brown, and smooth on older stems. The 7.5 – 10 cm-long green leaves mature to a dark green, becoming reddish in autumn.

The Hazel tree is monoecious (individual flowers are either male or female, but both sexes can be found on the same plant). The male catkins open in late winter or early spring in bunches of bright yellow, drooping "lamb tails". The female flowers are almost inconspicuous and appear on the same branches as tiny pink-red tufts. The tree is wind-pollinated. The fertilised flowers develop into clusters of 2 cm nuts, which turn brown in October.

Environment

The tree's natural habitat is woods and hedgerows, and particularly the slopes of hills.

The tree produces the well-known Hazelnut.

Allergens

Hazel tree pollen contains at least 40 distinct antigens (1-2).

The following allergens have been characterised:

Cor a 1, a 17.4 kDa protein, a Bet v 1 homologue (a Group 1 *Fagales*-related protein) (3-8).

Cor a 2, a 14 kDa protein, a profilin (3-4,8-10).

Cor a 10, a 70 kDa protein, a luminal-binding protein (3,11-12).

Cor a 1 and Cor a 2 are found both in Hazel pollen and in Hazelnut (9).

Serum IgE antibodies from all of 25 patients with type I allergic reactions to tree pollens and intolerance to Hazelnuts bound to Cor a 1, and 16% bound to Cor a 2, Hazel pollen profilin. Similar proteins were found in Hazelnuts (9).

The major allergen Cor a 1, a 17-kDa protein, has been isolated from Hazel pollen. Four Cor a 1 isoforms have been determined, which display different antigenic and allergenic properties. The sequence identities between these isoforms and Bet v I, the major Birch pollen allergen, were shown to have 80.5 - 83% similarity (6).

Potential cross-reactivity

An extensive cross-reactivity among the different individual species of the genus could be expected (13).

Cor a 1 has a 80.5 - 83% similarity to allergens of other trees of the order *Fagales*: Bet v 1, the major Birch pollen allergen; Aln g 1, the major allergen from Grey alder tree; and Car b 1, the major allergen from Hornbeam tree (1). Approximately 95% of patients allergic to tree pollens from the order *Fagales* display IgE binding to these allergens (1,7,14-16).

Further evidence for clinical cross-reactivity in this family is the finding that the allergens of Birch (Bet v 1), Alder (Aln g 1), Hazel (Cor a 1), and Hornbeam (Car b 1) are confined to shared epitopes (17).

Cross-reactivity has also been demonstrated among members of the *Fagales* family (Birch, Alder, Hazel, and Beech) and members of the *Oleaceae* family (Ash, Olive, Lilac, and Privet) (18).

As an antigenic relationship between Hazel pollen and Hazelnut exists, cross-reactivity can be expected (19). This relationship has been clarified by a study in which specific IgE from 25 patients displaying type I allergic reactions to tree pollen and intolerance to Hazelnuts bound to Cor a 1 in all of the subjects, and to the 14 kDa Hazel pollen profilin in 16%. IgE binding to proteins of comparable molecular weights in Hazelnut extracts (18 kDa and 14 kDa) was found, suggesting that proteins similar to Cor a I and Hazel profilin might also be expressed in Hazelnuts (9).

Clinical Experience

IgE-mediated reactions

Hazel pollen is important, resulting in asthma, hayfever and allergic rhinitis in Hazel pollen-allergic individuals, in particular in early spring (19-22).

Hazel pollen has been shown to be an important cause of pollinosis in Switzerland (23-24), Sweden (25), Germany (26, Romania (27), and Italy (28). High Hazelnut pollen levels have been recorded during March in Siena, in central Italy (29), and in Rabka, Poland (30). In Jena, Germany, specific IgE tests for 10 tree pollens demonstrated that Hazel tree pollen was among the most important causes of spring hayfever (31).

In Genoa, a northern Mediterranean area in Italy, among 3,473 patients suffering from seasonal respiratory allergy who were SPT to 1 or more pollens, 16% were STP-positive to *Betulaceae* and/or *Corylaceae* pollens. These patients had winter or early spring hayfever, with a high incidence of asthma (32).

A study determined the impact of different trees on asthma and explored the association between daily hospitalisations for asthma and daily concentrations of different tree pollens in 10 large Canadian cities. In correlating interquartile increases in daily tree pollen concentration with percent increases in daily hospitalisation for asthma, researchers observed a statistically significant but small (<2%) effect for *Corylus* (33).

Hazelnut pollen has been detected in aerobiological studies in Zagreb, Croatia (34-35); Lublin, Poland; Skien, Norway (36); and Crete (37) and Thessaloniki, Greece (38).

In a study of 5,080 asthmatic children, aged 1 to 18 years, evaluated at an allergy clinic in Istanbul, 6% (345 cases) were sensitised to Hazelnut pollen (39).

A French study suggests that Hazel pollen allergy may result in aggravation of winter respiratory symptoms. A group of patients is described who experienced exacerbation of allergic symptoms due to Alder pollen and Hazel pollen but not to infectious coryza (40).

Other reactions

A 62-year-old Turkish farmwoman, who had been collecting large amounts of green and brown Hazelnut leaves for use as fuel, was reported to have developed cough, respiratory distress and intermittent fever. The authors state that continual antigen exposure to mould from Hazelnut husks resulted in allergic alveolitis (41).

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t209 Horn beam

Carpinus betulus

Family: *Betulaceae*

Common names: Horn beam, Hornbeam, European hornbeam

Source material: Pollen

The Horn beam, Birch (*Betula verrucosa*), Alder (*Alnus incana*), and Hazel (*Corylus avellana*) all belong to the order *Fagales*

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Allergen Exposure

Geographical distribution

The Horn beam is a sturdy deciduous tree superficially resembling Beech. It is native to Britain and the temperate regions of Western, Central and Southern Europe, and it is found eastward as far as western Russia and the Ukraine.

The Horn beam grows15-25 m in height. The trunk is smooth and steel-grey, sometimes with a rippled, muscular appearance. The dark-green leaves are heavily textured, with deeply impressed veins. The leaves become golden-yellow to chartreuse in colour during autumn. The tree can reach 150 years in age.

Horn beam produces flowers from April to May. The flowers are monoecious (individual flowers are either male or female, but both sexes can be found on the same plant), and the male and female flowers appear in pendulous catkins in May after the leaves. The tree is wind-pollinated.

The fruit (seed) is a small 7-8 mm-long, light-brown, ribbed nutlet, partially surrounded by a 3-pointed leafy involucre 3-4 cm long. It ripens from October to November.

Environment

Horn beam grows in woodlands and hedgerows.

The tree produces extremely hard, white, close-grained wood.

Allergens

To date, the following allergens have been characterised:

Car b 1, a 17 kD Bet v 1 homologue (1-7).

Car b 2, a profilin (3).

Car b CBP, a calcium-binding protein (3,8).

Potential cross-reactivity

An extensive cross-reactivity among the different individual species of the genus could be expected (9). Indeed, Birch (*Betula verrucosa*), Alder (*Alnus glutinosa*), Hazel (*Corylus avellana*), and Horn beam (*Carpinus betulus*) all belong to the order *Fagales*, and a high degree of homology of their 4 major allergens has been indicated (10). This is mostly due to pollen from these trees containing allergens that share IgE epitopes with Bet v 1 and Bet v 2 (3-4,6,11).

The deduced amino acid sequences in Car b 1 from Horn beam pollen show pronounced homology with Bet v 1, the major allergen from *Betula verrucosa* (White birch) pollen (2,7).

Homologues to Bet v 1, the major Birch pollen allergen, are also present in members of the *Fagaceae*, *Rosaceae* and *Apiaceae* families (12-14).

As Horn beam tree pollen contains profilin and calcium-binding proteins, cross-reactivity may occur with other pollens containing these panallergens (3,8).

The Horn beam tree contains an N-glycan carbohydrate structure. It is theorised that carbohydrate structures are another potential source of immunological cross-reaction among allergens such as Kentucky blue grass (*Poa pratensis*), Rye (*Secale cerale*), Rye grass (*Lolium perenne*), Short ragweed (*Ambrosia elatior*), Giant ragweed (*Ambrosia trifida*), Birch (*Betula alba*), Horse chestnut (*Aesculus hippocastanum*), Olive (*Olea europaea*) and snake-skin pine (*Pinus leucodermis*) pollen (15).

Patients with Type I allergy to *Fagales* pollens frequently show adverse reactions to fruits and vegetables, in particular to Apple and to Hazelnut (16).

Clinical Experience

IgE-mediated reactions

Anecdotal evidence suggests that asthma, allergic rhinitis and allergic conjunctivitis are possible following exposure to pollen from this tree; however, no specific studies have been reported to date.

Although the Horn beam is not as prevalent as other *Fagales* trees, *i.e.*, Birch (*Betula verrucosa*), Alder (*Alnus glutinosa*), and Hazel (*Corylus avellana*), it should be borne in mind that these trees are highly cross-reactive (11-12). Similar clinical patterns can be expected with all members of the *Fagales* family. *Fagales* allergy can be found in Birch-free areas and can be caused by exposure to other *Fagales* species (17). Pollen from Horn beam can therefore be regarded as an important aeroallergen.

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t203 Horse chestnut

Aesculus hippocastanum

Family: *Sapindaceae*

Common names: Horse chestnut tree, Common horse chestnut

Source material: Pollen

Not to be confused with Chinese chestnut tree (*Castanea mollissima*) or European or Spanish or Sweet chestnut (*Castanea sativa*) t206

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Allergen Exposure

Geographical distribution

The Horse chestnut tree is native to Europe and particularly common in the Balkans (northern Greece and Albania), and has become naturalised in Britain. It is now cultivated throughout temperate zones, including Mexico, Turkey and the USA.

Horse chestnut is a large, deciduous tree growing 17 to 30 m in height at a fast rate. The bark is mostly dark grey and brown, but exfoliates in plates on older branches and the trunk to reveal showy orange bark underneath. The leaves are large, with 5 to 7 toothed leaflets.

The tree flowers in May, and the seeds ripen in September. The flowers are borne on large, upright panicles; these flowers are white with a yellow blotch at the centre that fades to red after pollination. The flowers have a delicate honey-like scent, are hermaphrodite (have both male and female organs) and are pollinated by insects. The fruits produced are in pale-green capsules, which are covered with blunt spikes. The fruits mature in September and October. These prickly green nut cases containing shiny, brown, inedible Chestnuts are known as “conkers”.

Environment

The tree is found naturally in woodlands but can be planted in gardens and streets.

Unexpected exposure

The roasted seed is used as a coffee substitute or cooked and eaten. The seed is rich in saponins. The seeds have also been used as a decongestant, expectorant and tonic. Saponins in the seeds are used as a soap substitute. Saponins are toxic.

Allergens

No allergens from this plant have yet been characterised.

Potential cross-reactivity

An extensive cross-reactivity among the different individual species of the genus could be expected (1).

Clinical Experience

IgE-mediated reactions

Anecdotal evidence suggests that asthma, allergic rhinitis and allergic conjunctivitis are possible following exposure to pollen from this tree; however, few specific studies have been reported to date (2-3).

Sensitisation to Horse chestnut tree pollen is common where the tree is growing. In an Austrian study, IgE antibodies to Horse chestnut pollen were found in 12.6% of urban children, compared to 1.9% of control subjects recruited from a rural area. Horse chestnut-specific IgE levels were highest in highly atopic pollen-allergic children, in particular those also sensitised to the Plane tree (2).

Other reactions

Contact dermatitis to the extract of Horse chestnut has been reported (4).

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t23 Italian/Mediterranean/Funeral cypress

Cupressus sempervirens

Family: *Cupressaceae*

Common names: Italian funeral cypress, Mediterranean cypress

Source material: Pollen

See also: Cypress (*C. arizonica*) t222

Not to be confused with other trees of the *Cupressaceae* family: Juniper, Mountain cedar/Mountain juniper, Japanese cypress/False cypress, Western red cedar, Eastern red cedar, Eastern white cedar

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Allergen Exposure

Geographical distribution

Italian funeral cypress grows wild in the Mediterranean area and is distributed eastward to Iran, Greece and Israel. It is planted as an ornamental in Australia, New Zealand, Chile, and India, along the Rhone valley in France, and in Britain. *Cupressaceae* is the most widely distributed of all gymnosperm families, occurring in diverse habitats on all continents except Antarctica.

Cupressus sempervirens is an evergreen tree, forming a tall, dark-green column 12 to 20 m in height and normally no more than 1 m wide. The tree has a perfect conical shape with a pointed crown. The leaves are scale-like and along with the branches form tight, thick foliage. The tree is resinous, aromatic and monoecious. Some species live well over 3,000 years.

Italian cypress flowers from March to April. The flowers are inconspicuous. Pollination usually occurs in late winter or spring. In certain areas, *e.g.*, Israel, pollen dispersal starts in January and peaks in March or April (1). (Pollination may occur any time from late summer to early winter for some species of Cupressaceae.) The fruit is oval in shape, dry and hard, and brown in colour. Seed maturation occurs in late summer or autumn. The seeds in the cones may remain on the tree for several seasons.

Environment

Cypress grows in dry areas, where it has adapted well. *C. sempervirens* is cited very often in classical literature, and was planted as an ornamental. It has often been cultivated in cemeteries, a tradition dating back to the time when the Greeks made wreaths of Cypress to place on the heads of their sacrificial animals, which could be offerings to the dead.

Italian cypress is often used for framing gardens, as an accent around large buildings, or in other formal landscapes. The wood may be used for fence posts.

Allergens

Seventeen IgE-binding proteins in the molecular weight range 14-96 kDa have been isolated. A protein of approximately 42 kDa reacted with 81.3% of the sera of allergic subjects (2). *C. sempervirens* shows a wider diversity of allergens than does *C. arizonica*, which, however, shows a higher content of the major 43 kDa allergen (3).

The following allergens have been characterised:

Cup s 1, a pectate lyase (4-5).

Cup s 3 (4,6-7).

Cup s 8, a profilin (8).

Potential cross-reactivity

Intense cross-reactivity exists among Italian funeral cypress tree, Arizona cypress tree and Mountain juniper tree, as well as other members of the *Cupressaceae* family (9-10).

Recombinant Cup a 1 (*C. arizonica*) has been shown to be highly homologous with the major allergens of Mountain cedar (Jun a 1), Japanese cypress (Cha o 1) and Japanese cedar (Cry j 1), confirming the cross-reactivity of conifer pollens (11-12). By inference, Italian funeral cypress tree pollen would share cross-reactivity with these allergens.

Cry j 2 may confer cross-allergenicity among *Taxodiaceae* and *Cupressaceae* (13).

Italian funeral cypress tree pollen has been shown to have common epitopes with Olive, Birch, Mugwort, Pine, and Cypress pollens (14).

Cross-reactivity has also been demonstrated among White cypress, Pine, Italian cypress, Rye grass, Birch, Cocksfoot, Couch grass, Lamb's quarters, Wall pellitory, Olive, Plantain and Ragweed (15).

Podocarpus gracilior (Yellowood) and *Callitris verrucosa* contain allergens that cross-react with Italian funeral cypress tree pollen (16).

Complex glycan structures have been identified among the causes of the high degree of cross-reactivity between the *Cupressaceae* and *Taxodiaceae* families (17).

In a Spanish study examining sensitivity of patients with asthma and/or rhinoconjunctivitis to *Cupressaceae* pollen using skin prick tests, all the *Cupressus*-sensitive patients were found to be positive to *Olea* and *Fraxinus*, compared to 77% and 51% in the 2 *Cupressus*-negative groups (18).

Cross-reactivity between Italian funeral cypress pollen and Peach as a food has been reported in seven individuals. Symptoms of oral allergy syndrome, urticaria or angioedema occurred immediately following the ingestion of Peach: lip pruritus and oedema (n = 3), urticaria (n = 3) and angioedema (n = 1). Italian funeral cypress pollen and Peach were shown to share a common allergen of 45 kDa (19).

Clinical Experience

IgE-mediated reactions

Pollen from Italian funeral cypress can cause asthma, hayfever and conjunctivitis (20-23).

The prevalence of sensitisation to Italian funeral cypress pollen in patients with hayfever may be as high as 24%-32%, depending on the region. In an Israeli study, 13% of all those found to be sensitive to this pollen were monosensitised. In this group of patients, 70% had rhinitis, 30% also had asthma, and 18% had conjunctivitis. Symptoms lasted from February until April (1). Some authors suggest that hayfever due to *Cupressaceae* pollen sensitivity has become a public health priority (24).

In Japan, where Cypress tree pollen is a prominent aeroallergen, the efficacy of using specific IgE assays has been demonstrated (25). In a Japanese study evaluating the relationship of various specific IgE in the serum to 12 inhalant allergens in patients with allergic conjunctivitis during various times of the year, it was found that the highest sensitisation rate for those affected in spring was 68.8% for Cedar pollen, followed by Cypress pollen at 59.4% (26).

Italian funeral cypress has been identified as the cause of an increasing number of cases of late-winter and early-spring pollinosis in Mediterranean countries (27). In Latium, a region in central Italy, out of 1397 residents with complaints related to upper- or lower-respiratory-tract disorders or conjunctival disease, 243 (17.4%) were skin prick-positive to *C. sempervirens* extract, and 47 (19.3%) of this group were monosensitised. All the subjects monosensitised to Cypress pollen had symptoms from January through April. The authors assert that sensitisation to

C. sempervirens has increased from 7.2% in 1995 to 22% in 1998 (28). Sensitisation to pollen from this tree has also been recorded in Madrid, Spain (29). In a Greek study of individuals with respiratory allergy, it was demonstrated that 12.7% were sensitised to Cypress pollen (30).

Further studies have confirmed the allergenicity of Cypress pollens. In a study conducted on a rural Kibbutz community (Netzer Sereni) in Israel, the most prevalent causes of atopy were House dust mite (28.9%), Sagebrush (16.5%), grasses (18.2%), Pecan (13.2%) and Cypress (11.1%) (31). In Madrid, Spain, the highest average airborne concentration from 1979 to 1993 was of *Quercus spp*. (17%), followed by *Platanus spp*. (15%), *Poaceae spp*. (15%), *Cupressaceae spp*. (11%), *Olea spp*. (9%), *Pinus spp*. (7%), *Populus spp*. (4%), and *Plantago spp*. (4%). Cypress tree pollen occurred predominantly from January to April (32).

In a study in Izmir, Turkey, of patients with seasonal respiratory allergy, 65 (14.3%) of 455 were skin prick-positive to Italian funeral cypress pollen (33.) Only 1 patient was monosensitised. Of 154 patients with rhinitis and asthma in a study in Casablanca, 20.78% were sensitised to Italian funeral cypress pollen (34).

Aerobiological studies have confirmed the relevance of pollen from this tree in the atmosphere of Eskisehir, Turkey (35); Badajoz, Burgos and Plasencia, Spain (36-38); the island of Crete (39); and Clermont-Ferrand, France (40).

While Italian funeral cypress and Arizona cypress are commonly encountered in Mediterranean regions, Mountain cedar in Europe is present only in the Balkans and the Crimea. This tree is a major cause of allergy in the USA (41).

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Cryptomeria japonica

Family: *Cupressaceae* (old tax. *Taxodiaceae*)

Common names: Japanese cedar, Sugi tree (Japanese)

Synonym: *Cupressus japonica*

Source material: Pollen

Japanese cedar tree should not be confused with the incense-cedar tree (*Libocedrus decurrens*) or with Cedar trees of the genus *Cedrus*

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Allergen Exposure

Geographical distribution

Japanese cedar, also called Sugi tree, is an evergreen growing 30 to 50 metres tall. Its needles shift from a pale opal in the summer to a bright red toward the autumn.

Japanese cedar is native to Japan and the coastal provinces of China, and is often cultivated in Europe and North America.

The male Japanese cedar tree flowers between February and April. However, Japanese children born during the winter months of November to January and exposed to Japanese cedar pollen within the first 6 months of life demonstrated an increased risk of sensitisation and of especially severe sensitisation to this pollen, as determined by IgE antibodies (1). As male Sugi flowers disperse a small amount of pollen in early January, some Japanese cedar pollinosis patients will experience allergic symptoms as early as January (2).

Environment

Japanese cedar grows in woods, often in pure stands, favoring rich, deep soils in places sheltered from strong winds. It is the most important timber tree in Japan, where about a third of the area under cultivation is devoted to it.

Allergens

The following allergens have been characterised:

Cry j 1, a 45-50 kDa protein, a pectate lyase, a major allergen (3-16).

Cry j 2, a polygalacturonase, a major allergen (4,17-22).

Cry j 3, a 27 kDa protein, a thaumatin, a PR-5 protein (23-25).

Cry j 4, a calcium-binding protein (26).

Cry j IFR, an isoflavone reductase (27).

Cry j Chitinase (28).

(In addition to the allergens characterised to date, a number of other antigenic proteins have been isolated but not characterised, including proteins of 7, 15 and 20 kDa (29)).

Cry j 1 and Cry j 2 are major allergens. However, concentrations of these allergens vary greatly in pollen from different individual Japanese cedar trees (18). Most basically, there are 2 varieties of Japanese cedar trees: the popular diploid and the less popular triploid. These trees are not very different morphologically. In a comparison of the major allergens Cry j 1 and Cry j 2, the triploid tree pollen extract was shown to have lower concentrations of both. The pollen from this variety may thus be less allergenic (30).

The IgE-binding frequency of Cry j 3 in the sera of patients allergic to Japanese cedar pollen was estimated at 27% (27/100). Cry j 3 may play a crucial role in cross-reactivity and oral allergy syndrome (23).

Cry j IFR, an isoflavone reductase-like protein, has similarity to the Birch pollen allergen Bet v 6 (previously known as Bet v 5). However, in contrast to Bet v 6, which has been reported to be a minor allergen, recombinant Cry j IFR exhibited 76% IgE binding frequency (19/25) in Japanese cedar pollen-allergic patients (27).

A class IV chitinase has been isolated from Japanese cedar pollen. The purified protein displayed the ability to bind IgE from all patients tested (31/31) (28).

Potential cross-reactivity

Japanese cedar (Cry j 1) has been shown to be very similar to the major allergens of Mountain cedar (Jun a 1), Japanese cypress (Cha o 1) and *Cupressus arizonica* (Cup a 1), and this is thought to throw light on the cross-reactivity of conifer pollens (31-33). These results have been confirmed by specific IgE inhibition assays.

In Japan, many patients with pollinosis have IgE antibodies to pollen of both Japanese cypress and Japanese cedar. The sequences of Cha o 1 and Cry j 1, the major allergens of Japanese cypress and Japanese cedar pollens, respectively, are 80% identical (7). The presence of both T cells reactive to T cell epitopes common to Cha o 1 and Cry j 1 and T cells specific to T cell epitopes unique to Cha o 1 in patients with pollinosis contributes to symptoms continuing after the Cedar pollen season in March and into the Cypress pollen season in April (34).

Jun a 1 is a glycoprotein highly homologous with Japanese cedar pollen glycoallergen, Cry j 1 (10).

Since it is unlikely that many patients in the United States were sensitised through Japanese cedar, they were probably sensitised with similar tree pollen allergens such as Cup s 1 and Jun a 1, which cross-reacted with Cry j 1. A study investigated human IgE epitopes of Cry j 1 and succeeded in identifying a common linear epitope (35).

Cry j 2, a polygalacturonase, has a high sequence identity with Cha o 2 from Japanese cypress tree (36-37). Data suggests that conserved homologues of Cry j 2 confer cross-allergenicity among *Taxodiaceae* and *Cupressaceae* (19).

Japanese cedar pollinosis is among the most widespread diseases in Japan. Cross-reactivity between Japanese cedar pollen and Tomato fruit was demonstrated through inhibition studies (38). A potential allergen responsible may be Cry j 2, a polygalacturonase, which has a 40% identity with the polygalacturonase from Tomatoes.

A class IV chitinase was isolated from Japanese cedar pollen. It may result in various degrees of cross-reactivity with other plants containing this allergen, *e.g.*, latex (28).

Cross-reactivity has also been demonstrated between the pollen of *Cupressus sempervirens* (Italian funeral cypress tree t23) and that of Japanese cedar (39).

Clinical Experience

IgE-mediated reactions

Japanese cedar pollen is the most common allergen causing seasonal pollen allergy in Japan (40-42). It is the most common cause of seasonal allergic rhinitis (39,43-44) and contributes significantly to sinusitis (45) and rhinoconjunctivitis during spring (46-47). It is a risk factor for bronchial asthma in Japanese adult asthmatics (48). Pollen from this tree also affects the severity of atopic dermatitis (49-50) and is an important factor in oral allergy syndrome (51-52).

Population-based surveys in Japan in 2004 yielded a prediction that the prevalence of Japanese cedar pollen allergy among adolescents was 28.7% in metropolitan areas and 24.5% in the general population of urban areas. The prevalence increased 2.6-fold between 1980 and 2000, and the prevalence differed considerably according to age and degree of urbanisation (53). In a nationwide Japanese epidemiological survey of allergic rhinitis through questionnaires mailed to 9,471 otorhinolaryngologists and their families (17,301 subjects), Cedar pollen allergy was found to be 17.3%. The prevalence was higher on the Pacific coast and in central districts of Japan, compared to districts on the Sea of Japan and the Inland Sea, and the prevalence was lower in either high or low altitudes. Morbidity was highest in the suburbs, followed by urban residential areas and downtown locations (54). Based on another nationwide survey, conducted shortly after the peak pollen season, of 10,920 subjects from 12 regions in Japan, the estimated prevalence of Japanese cedar pollen allergy was 13.1%. Nasal symptoms were more severe than eye symptoms, and 62.5% of the respondents had severe or moderate interference with daily activities (55).

In a more recent study in Wakayama Prefecture in Japan, among 759 first-year university students the prevalence of various allergic diseases was found to be 37.9%. The prevalence of rhinitis, including pollinosis, was 31.0%, while that of atopic dermatitis was 26.2% and that of bronchial asthma was 11.3%. The rate for IgE antibodies against Japanese cedar pollen was 48.6%, compared to 44.2%, 29.6%, and 28.9% for Dermatophagoides farinae, Timothy grass and house dust, respectively (40).

Measurements in the Japanese population of IgE antibodies to Japanese cedar pollen indicate high levels of sensitisation, with a prevalence of 30.9% when a serum level of 0.7 kU/L or higher was considered positive. The prevalence was higher in males and highest in the 20-29 years age group (56). The number of patients with Japanese cedar pollinosis was reported to be increasing, having extended up to about 15% of the Japanese (57-58).

A study that investigated the prevalence of sensitisation to Japanese cedar pollen in allergic and non-allergic children from infancy to adolescence found that of 243 children with allergic diseases and 137 children without allergic diseases, 47.1% with allergic diseases and 19.9% without allergic diseases had IgE antibodies to Japanese cedar pollen (> or = 2). The youngest child sensitised to this pollen was a 23-month-old boy with atopic dermatitis. The proportion of children who were born from January to March was significantly higher in the Japanese cedar pollen-sensitised group than in the non-sensitised group (59).

Further studies have confirmed the high rate of sensitisation to this pollen (60). Among 226 children visiting a Japanese paediatric allergy clinic from 1996 to 1999, 53.1% were sensitised to Japanese cedar pollen, and sensitisation was higher in children aged 12 or more (68.8%) (61).

The highest frequency of Japanese cedar pollen allergy appears to occur among residents living alongside roads with heavy automobile traffic. This has been attributed to the elution of Japanese cedar pollen allergens from pollen grains and their adsorptive concentration onto hydrophobic and hydrophilic substances such as pollution from cars (62).

Pollen counts of Japanese cedar are increasing (63). Significant increases in the sensitisation to Japanese cedar pollen have occurred over the last 30 years, from 12.5% to 54.4% in asthma patients, and from 35.1% to 81.5% in allergic rhinitis patients (64). Based on subjective symptoms, it has been documented that as many as 21 to 62% of patients with Japanese cedar pollinosis have pollinosis symptoms before the start of pollen season, but these reports may contain overestimates due to inaccurate diagnosis of Japanese cedar pollinosis (65-66). In a study measuring Japanese cedar-specific IgE of stored 15-year-old sera of 88 patients and comparing the results with those from a similar group of 91 current patients, Japanese cedar-specific IgE of Class 2 or more was demonstrated in 65.9% of the current patient group, compared with 46.6% for the former one. There was no significant difference between these 2 groups for children aged 6 or younger (67).

Among 76 Japanese children less than 6 years of age with symptoms of asthma and atopic dermatitis, 27.6% had IgE antibodies to Japanese cedar pollen, as measured with ImmunoCAP®. The youngest child was a 1-year-, 8-month-old boy. Of a further 27 children attending the otorhinolaryngology clinic with complaints of rhinorrhoea and/or eye symptoms, cough, snoring, or epistaxis, approximately 40% were found to be sensitised to Japanese cedar and/or *Cupressaceae* pollen alone (68).

t17 Japanese cedar

Japanese cedar pollen is a cause of allergic rhinitis and allergic conjunctivitis. Allergic rhinitis can interfere with cognitive function, can impair work productivity, and may cause work absences. Authors have suggested that clinicians should pay more attention to ocular symptoms as well as nasal symptoms and improve patients' quality of life in order to reduce productivity losses (69). Among patients with allergy-like symptoms seen at an ophthalmology and otolaryngology department in a Japanese hospital in 2001, 134 (87.0%) had allergic conjunctivitis, and in 2002 the number was 126 (90.6%). Approximately 22% were shown to have IgE antibodies for Japanese cedar (70). In another Japanese study evaluating the relationship between IgE antibodies to 12 inhalant allergens and allergic conjunctivitis in autumn and spring, it was found that the highest positive rate was 68.8%, for Japanese cedar pollen, followed by Cypress pollen (59.4%) in the spring group (71). A study of rhinoconjunctivitis in 641 patients with allergic rhinitis in Hakodate, Japan, reported that 21.2% of patients were sensitised to Japanese cedar pollen (72).

In 267 patients with allergic rhinitis, 73.8% tested positive for Japanese cedar, as determined by specific IgE determination (73).

In a study, the purified Cedar pollen allergen Cry j 1 was instilled in the left eye of 9 patients with Japanese cedar pollinosis who had no nasal or ocular symptoms. The allergen provoked not only ocular symptoms but also nasal symptoms in 77.8% of patients. Symptoms were itching and hyperaemia of the palpebral conjunctiva, and the itching lasted for more than 5 hours (45).

Japanese cedar pollen plays a role in atopic dermatitis. Among children with atopic dermatitis, a statistically significant correlation was demonstrated between the severity of atopic dermatitis and the presence of Japanese cedar pollen; *i.e.*, those with CP tended to have more-severe atopic dermatitis (37). In a study in the Yokohama region or Japan, of 337 outpatients with skin allergy, specific IgE for Japanese cedar was found in 73.7% (244 cases) (74). Atopy patch testing with Japanese cedar pollen extract was used to investigate patients with atopic dermatitis whose condition is exacerbated by contact with Japanese cedar pollen. In a study of 74 patients with atopic dermatitis and 5 patients with Japanese cedar pollinosis, 21 of the 74 patients (30%) had a history of exacerbation every spring after contact with Japanese cedar. Of these patients, 68% were sensitised to Japanese cedar pollen. The authors suggested that atopy patch testing with Japanese cedar pollen extract appears to be a useful method for investigating trigger factors for eczematous skin lesions in a subgroup of patients with atopic dermatitis (46).

Among 97 patients with atopic dermatitis, 48.5% showed aggravation of dermatitis during the pollination season, and 85% of them had Japanese cedar pollinosis. This particular study suggested that some other factors, *e.g.*, Japanese cedar pollen-specific T cells, might play an important role in addition to Japanese cedar pollen-specific IgE (75).

A study also suggested that Japanese cedar pollens play an important role in the aggravation of infantile atopic dermatitis in spring by inducing IL-5 production (76).

Airborne contact dermatitis after contact with Japanese cedar pollen has also been reported. A scratch-patch test, scratch test and specific IgE were performed in 13 patients with skin symptoms suspected to be of Japanese cedar pollen origin, and 5 patients with Japanese cedar pollinosis. All 13 patients with contact dermatitis showed a positive scratch-patch reaction to Japanese cedar pollen extract, compared to 20% of the patients with Japanese cedar pollinosis but no eruptions (77).

Oral allergy syndrome may be associated with Japanese cedar tree pollen allergy, but less with Japanese cedar than with Orchard grass, Short ragweed and Alder tree pollen. Furthermore, in Japanese studies of Japanese cedar, childhood oral allergy syndrome does not consistently accompany pollen allergy, compared to the pattern seen in adults. Among the frequent food allergens is Kiwi fruit, followed by Tomato, Orange and Melon (78). In a study of 23 patients with Japanese cedar pollen allergy and oral allergy syndrome, with ages ranging from 5 to 62, the responsible fruits included Melon, Apple, Peach, and

Kiwi fruit. Most patients with OAS exhibited hypersensitivity to more than 2 foods. Significantly, 13 of 20 patients were shown to have IgE antibodies to Apple, whereas 17 patients had no IgE antibodies to Melon, and only 2 patients had IgE antibodies to Kiwi and 1 patient to Peach. The study concluded that evaluation of IgE antibodies to Birch pollen and Apple may be useful for diagnosing oral allergy syndrome in patients with Japanese cedar pollinosis (47).

Japanese cedar pollen is also a common sensitising allergen in other areas where the tree is grown. A Korean study reported a 9.7% sensitisation rate in the urban population and a 1.3% sensitisation rate in the rural population (79).

Importantly, symptoms may persist even after the end of the pollen season. Cry j 1 was still detected in house dust collected 2 weeks after airborne Japanese cedar pollen had disappeared. The authors postulate that some late symptoms of Japanese cedar pollinosis may have been caused by pollen which had attached to clothes and been brought indoors (80).

Other reactions

A 42-year-old-man with Japanese cedar pollen allergy reported repeatedly experiencing dyspnoea after drinking Tomato juice during the Japanese cedar pollen season. Swelling of the oral and nasal mucosa and congestion of the conjunctiva were observed. IgE antibody tests were positive for Tomato and Japanese cedar pollen. A challenge test using Tomato juice was positive. Common antigenicity was found between Tomato and Japanese cedar pollen. The dyspnoea may have reflected the feeling of pharyngeal narrowing (81).

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Tilia cordata

Family: *Malvaceae*

Common names: Basswood, European lime, Small-leaved European linden, Small-leaved lime, Small-leaved linden

Source material: Pollen

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Allergen Exposure

Geographical distribution

Tilia is native to England and Wales, the south of Scotland, most of Western Europe except southern Spain, Italy and Greece, and parts of the USA. Fifty species of *Tilia* occur from the north temperate regions downward; they are widely distributed in Europe, Asia and North America, and are found as far south as Indochina and Mexico. Seven species are found on the North American continent. The European species is often used as a street, park or lawn tree. *Tilia cordata* is the most common species of *Tilia*.

Tilia cordata is a common deciduous shade or specimen tree, very symmetrical in shape, pyramidal to oval in outline, densely dark-green and shiny-foliaged in summer. The heart-shaped leaves turn yellow or yellow-green in autumn. The tree grows 20 to 27 m in height, or up to 38 m in optimal conditions. The trunk is reddish-brown and very smooth when young, darkening and developing prominent ridges and deep furrows when older. The leaves are alternately arranged, rounded to triangular-ovate, 3 and 8 cm long and broad, and mostly hairless except for small tufts of brown hair in the leaf vein axils (1).

The small, creamy-yellow, moderately fragrant hermaphrodite flowers are produced in clusters of 5 to 11 and appear around June (in the Northern Hemisphere), on lime-coloured, elongated and curving bracts. Linden pollen extends from May to July. Linden in the USA is thought to be mainly insect-pollinated and is believed to lack allergenic activity for this reason, whereas in Europe, where pollination is considered to occur by wind as well, the pollen is regarded as allergenic.

The fruits are small, round, 6 to 7 mm-long and 4 mm-broad nutlets with a rough surface; initially pale green, they occur in clusters hanging from the pale yellow bracts, maturing in autumn to a light tan colour and persisting into early winter. The nutlets are downy at first, become smooth at maturity, and, unlike *T. platyphyllos*, are not ribbed.

Environment

The tree grows wild in woods and on cliffs, and is also domesticated as an ornamental. Sugar can be made from the sap, and beekeepers regard the flowers as a good source of nectar. In Europe the flowers are dried to make tea. Linden is also the source of jute.

t208 Linden

Allergens

No allergens from this plant have yet been characterised.

Assessment of serum of a 21-year-old individual allergic to Linden tree demonstrated several protein bands, mainly at approximately 50 kDa, but also at approximately 23 and 10 kDa (2).

Potential cross-reactivity

Cross-reactivity among the different species of the genus could be expected (3). Weak cross-reactivity was reported to exist between Linden tree and London plane tree (*Platanus acerifolia*) (1).

Clinical Experience

IgE-mediated reactions

Linden pollen can cause asthma, allergic rhinitis and allergic conjunctivitis (1-4).

Nasal, ocular, palatine, aural and pharyngeal pruritus, conjunctival hyperaemia, sneezing and night cough have been reported in a 21-year-old female. Symptoms occurred every June and were related to the flowering of a Linden tree near her house. A bronchial provocation test was negative. A skin pick test and a conjunctival provocation test were positive and the IgE antibody level was 27.7 kU_A/l (1).

A study assessing the aeroallergen sensitisation in an allergic population in Portugal found that high pollen counts could explain the early sensitisation occurring, even in young children. Linden tree was found to be one of the most representative aeroallergens, resulting in sensitisation in 11.4 % of 557 paediatric (< or = 15 years old) patients. Other aeroallergens were grasses (44.9 %), *D. pteronyssinus* (32.5 %), *D. farinae* (29.1 %), *Olea europea* (27.5 %), *Parietaria judaica* (23.4 %), Cat dander (16.1 %), *Artemisia vulgaris* (17.6 %), *Robinia pseudoacacia* (12.2 %), *Platanus acerifolia* (11.4 %), moulds (11.2 %), *Plantago lanceolata* (10.6 %), Dog dander (10.4 %), and *Pinus radiata* (7.5 %) (5).

Sensitisation to the closely related *T. platyphyllos* has been reported among children with respiratory allergy in the Trakya region of Turkey (6).

Other reactions

Occupational contact dermatitis with rhinoconjunctivitis due to *T. cordata* and colophonium exposure in a cosmetician has been reported (7). Contact urticaria has been reported (8).

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Platanus acerifolia

Family: *Platanaceae*

Common names: Maple leaf sycamore, London plane tree, American sycamore

Synonyms: *P. hispanica, P. hybrida*

Source material: Pollen

This is a somewhat variable species. It is often considered to be a hybrid of *P. orientalis* and *P. occidentalis*

Not to be confused with the Maple tree (*Acer spp.*), *i.e.* Box-elder (*A. negundo*)

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Allergen Exposure

Geographical distribution

The London plane, easily recognised by the bark, which exfoliates in large flakes, is renowned as a street tree, particularly in Europe. The origin of this hybrid is uncertain. It is found planted from southern and central Europe to western Asia, North America, South Africa, Australia and New Zealand, especially in urban areas. In America the tree probably crossed with a native variety and thus looks different from the European species. Over half of the trees on London streets are Plane trees, and Philadelphia has over 500,000.

The London plane is a large deciduous tree in a spreading form, with heavy, slightly drooping branches, reaching 21 – 30 m in height, and normally with a single stem clear of branches to a considerable height. The bark is mottled cream, grey, olive, and light-brown and usually but not always flakes in patches, creating a dappled appearance. The trunk may look rugged.

The triangular-ovate ”maple-like” leaf is medium- to dark-green, paler on the underside, and mat to glossy on the top. The leaves turn yellow-brown in autumn.

The green flowers are monoecious (individual flowers are either male or female, but both sexes can be found on the same plant) and appear in April in the Northern Hemisphere. The tree is wind-pollinated, and the pollen is thought to be very allergenic.

The seeds/fruits are syncarps of achenes, about 2.5 cm in diameter. They change from green to brown in October and persist into winter.

Environment

The tree is found in woodland and gardens and lining streets.

Allergens

Allergens of 17-18 kDa, 22 kDa, 43 kDa and 52 kDa have been isolated (1- 4). The 17-18 kDa protein has been identified as Pla a 1 and appears to be a major allergen (3). The 43 kDa protein, now identified as Pla a 2, and the 52 kDa one were found to have IgE-binding prevalences of 83 and 42%, respectively (4).

To date, the following allergens have been characterised:

Pla a 1, an 18 kDa protein, an invertase inhibitor (5-8).

Pla a 2, a 43 kDa protein, a polygalacturonase (4,6,9).

Pla a 3, a 10 kDa lipid transfer protein (4,10).

Pla a Profilin (5,11-12).

Pla a 1 is recognised by up to 92% of monosensitised London plane tree-allergic patients and 83% of polysensitised patients (4,7).

Pla a 2 is involved in the allergic responses of 84% of patients with London plane tree pollen allergy and represents 52% of the total IgE-binding capacity of London plane tree extract (9).

In the Mediterranean area, Pla a 3 is a minor allergen (27.3%) in London plane pollen-allergic patients without food allergy, and a major allergen (63.8%) in London plane pollen-allergic patients with Peach allergy (10).

Potential cross-reactivity

An extensive cross-reactivity among the different individual species of the genus could be expected (13).

Pla a 3, a lipid transfer protein, is a major cross-reactive allergen in Plane pollen-allergic patients with Peach allergy (10).

Other studies have indicated cross-reactivity between London plane pollen and food, but the cross-reactive allergen was not described. In a study of 56 patients allergic to food, skin prick tests demonstrated a positive correlation between London plane pollen and Hazelnut, Peanut, Banana and Celery. Inhibition studies confirmed strong cross-reactivity between London plane pollen and Hazelnut and Banana, and intermediate cross-reactivity with Celery and Peanut (14).

Similarly, in a study assessing the possible association of oral allergy syndrome with London plane tree pollen allergy, of 720 patients evaluated, 61 (8.48%) were sensitised to pollen from this tree. Food allergy was observed in 32 (52.45%) of the 61 patients sensitised to this tree's pollen. The food allergens most frequently implicated were Hazelnut, Peach, Apple, Peanut, Maize, Chick pea and Lettuce. The authors suggested that oral allergy syndrome in these patients may have been caused by primary respiratory sensitisation to London plane tree pollen, and that profilin may be the responsible allergen (15).

More recently, IgE reactivity to profilin was studied using a pool of sera from 23 patients with London plane pollen allergy and food allergy. Inhibition assays conducted with Hazelnut, Apple peel, Peanut, Chick pea and Peanut extracts demonstrated cross-reactivity, but neither the profilin nor Pla a 1 nor Pla a 2 could explain the strong cross-reactivity demonstrated (11).

Further evidence for cross-reactivity between London plane tree pollen and foods was that London plane tree-specific immunotherapy resulted in a significant decrease in food allergy in 16 adult patients with allergy to Hazelnut, Walnut, Lettuce, Peach, Cherry and London plane tree pollen (16).

In a study of individuals presenting for the first time to any of the 6 allergy clinics in Spain with respiratory and/or cutaneous symptoms, among 1,734 individuals, the prevalence of sensitisation to Tomato was found to be 6.52% (113 patients). Of these Tomato-sensitised subjects, only 16% reported symptoms with Tomato, but 97% were sensitised to inhalant aeroallergens, including 84% to pollens (mainly *Artemisia vulgaris* and *Platanus hybrida*), with differences in the average profiles between Northern and Southern clinics. Most of the sensitised subjects were asymptomatic, but some patients reported symptoms although they had no skin test sensitivity (17).

A polygalacturonase was isolated from Lily pollen and displayed significant similarity to allergens in other plants, including Phl p 13 of Timothy grass and Pla a 2 of London plane tree (18).

Cannabis sativa leaf extract has been shown to share a degree of cross-reactivity with Tomato, Peach and Mugwort, and a lesser degree with London plane tree pollen (19).

Clinical Experience

IgE-mediated reactions

Plane trees are an important source of airborne allergens in many cities of the United States and Western Europe (7). and exposure to London plane tree pollen can induce asthma, allergic rhinitis and allergic conjunctivitis (20-22); systemic reactions have occurred during immunotherapy (23).

Initially, London plane tree pollen was not thought to contribute much to the prevalence of atopic sensitisation, even though the pollen had been detected in the atmosphere, but recent studies have shown that pollen from this tree is an important cause of pollinosis.

In a study in Madrid, Spain, among 187 patients with a history of rhinitis and/or seasonal asthma, a 56% prevalence of positive skin-prick tests to *Platanus* was found, surpassed (not necessarily in this order) only by the effects of pollen from the grasses *Dactylis glomerata* (Cocksfoot), *Trisetum paniceum* (Common wild oats) (92%), and Olive tree (63%). Aerobiological sampling of the pollen content of the air in Madrid revealed that 14.9% of this content consisted of *Platanus*. Specific IgE confirmed sensitisation to this allergen (24).

In an earlier study in Madrid, among 47 patients with spring-summer pollinosis symptoms who were seen at an allergy clinic, skin-prick tests to *Platanus* were positive in 33 of the 39 patients first seen with seasonal symptoms during *Platanus* pollen season, and only in 3 of the 8 patients without symptoms during *Platanus* exposure. Twenty-two of the 33 *Platanus*-positive skin-test patients also had a positive ELISA result. The average 24-hour rhinitis symptom scores of the 39 patients first seen with seasonal symptoms from March through April showed significant correlation with *Platanus* pollen counts. (3) The authors concluded that *Platanus* pollen was an important cause of pollinosis in this area.

High levels or this aeroallergen and its clinical importance have also been demonstrated in studies from Cape Town, South Africa, where *Platanus* pollen is abundant in September (25), from Zurich, Switzerland (26), from Balikesir, Turkey (27), and from Salamanca, Spain (28). Pollen from this tree was also demonstrated to be an important aeroallergen in Montpellier, in southern France, where the highest prevalence of allergy was to grass pollen, followed by *Plantain*, *Parietaria*, *Oleaceae*, London plane and *Cupressaceae* pollen; the prevalence of sensitisation among the entire group ranged from 13% to 36% of pollen-allergic patients (29).

In Plasencia, Spain, where Castanea sativa (European chestnut tree) is a major source of pollen, it was nevertheless demonstrated that of 210 patients with pollen allergy, 36.6 % were sensitised to *Platanus acerifolia* (30). In a study of 371 skin prick-tested paediatric patients in Cova da Beira, an interior region of Portugal, 11.4% were found positive for *Platanus acerifolia* (31). In Madrid, Spain, the second-most-abundant airborne aeroallergen, after pollen of *Quercus spp*., was pollen from *Platanus spp*. In skin prick tests, the prevalence of positive reactions to London plane tree pollen was 52% (32). London plane tree pollen was also reported to be an important aeroallergen in Seville, Spain (33).

Importantly, London plane-allergic individuals may be concomitantly allergic to foods (11,15). (See Potential cross-reactivity above.)

Other reactions

Allergic contact dermatitis from contact with the London plane tree has also been reported (34).

t11 Maple leaf sycamore, London plane

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t21 Melaleuca, Cajeput-tree

Melaleuca leucadendron

Family: *Myrtaceae*

Common names: Melaleuca tree, Cajeput tree, Weeping tea tree, White wood tree, Punk tree, Tea tree

Source material: Pollen

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Allergen Exposure

Geographical distribution

The Melaleuca is a tall-growing tree, native to eastern Australia, Myanmar (Burma), New Guinea, the Solomon Islands, and the East Indies. It is also planted elsewhere in the tropics and is rather common in greenhouses. The species *Melaleuca alternifolia*, one type of Tea tree, is unique to Australia and native to New South Wales.

The Melaleuca tree grows 20 to 33 m in height and has a slender crown. The tree is usually single-trunked but may develop multiple trunks. The most striking feature is its almost pure-white papery bark, peeling off in sheets. The leaves are greyish-green, 4 to 10 cm long, 2 cm wide, and stiff. The leaves are very aromatic.

Its beautiful flowers bloom whitish-pink or purple. They have prominent ivory-white stamens and are produced on bottlebrush-like spikes 16 cm long. Dust-like seeds are enclosed in rounded, tightly clustered, greyish-brown woody capsules produced along the stems. In Australia, Melaleuca flowers from October to December; in California and Florida, from June to November.

Environment

The trees grow along creek banks. Some species have weeping foliage; others are stiffer in appearance.

Melaleuca oil (Cajuput oil) is distilled from the fresh leaves and twigs. The oil is obtained from several species besides *Melaleuca leucadendron*. Similar oil, Tea tree oil, is usually extracted from a family member, *Melaleuca alternifolia*. Melaleuca oil is used in medicine and for a variety of other purposes. The principal constituent of the oil is cineol. Solid terpineol is also present, and several aldehydes such as valeric, butyric and benzoic.

The spongy bark was used by the Aborigines of Australia to make shields and canoes, for roofing and as timber.

Allergens

Multiple antigenic components between 29-66 kDa have been detected, but the allergens have not yet been catergorised (1).

Potential cross-reactivity

An extensive cross-reactivity among the different individual species of the genus could be expected (2).

Clinical studies demonstrated that 81% of the patients who were skin test-positive to pollen from *Callistemon citrinis* (bottlebrush), *M. leucadendron*, or Bahia grass (*Paspalum notatum*) were also positive to the other 2 (1).

RAST inhibition analysis has demonstrated cross-reactivity between the closely related *Melaleuca quinquenervia* and bottlebrush (*Callistemon citrinis*) (3).

Clinical Experience

IgE-mediated reactions

Melaleuca pollen can induce asthma, allergic rhinitis and allergic conjunctivitis (1,4-5).

In a study in Darwin, Australia, that correlated daily average ambient pollen and fungal spore concentrations with hospital admissions for allergic respiratory disease, the association was the strongest in the case of *Myrtaceae* pollen (this being dominant tree taxa in the region) (5-6).

In an early study, pollen extracts of the trees *Callistemon citrinis* (bottlebrush) and Melaleuca, as well as of Bahia grass, were analysed for antigenic and allergenic cross-reactivity. Clinical studies demonstrated that 81% of the patients who were skin test-positive to at least 1 of the pollens were also positive to the other 2 (1).

In a study of the closely related Paperbark tea tree (*M. quinquenervia*), a 2-year aeroallergen survey and skin test results from 1,017 subjects were reviewed. Ninety-seven of 1,017 subjects were at 2+ or greater in intradermal tests. One of 6 double-blind nasal challenges and 1 of 4 single-blind bronchial challenges using extract from this tree were positive in subjects with positive skin tests. The study concluded that the Paperbark tea tree is not a significant source of aeroallergens (7).

In a Malaysian study of 200 patients attending a clinic, of the 29.5% who were asthmatic with positive SPT reactions, 21.5% had reactions to 1 or more of the grass pollens, 21.5% to Acacia pollen and 7.5% to Melaleuca pollen (3).

Other reactions

Tea tree oil (Melaleuca oil) is an essential oil, distilled predominantly from the leaves of the Australian plant *Melaleuca alternifolia*. This species is unique to Australia and native to New South Wales. Allergic contact dermatitis to tea tree oil is well recognised and is becoming increasingly common in Australia (8-10).

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t20 Mesquite

Prosopis juliflora

Family: *Fabaceae*

Common names: Mesquite, Common mesquite, Prairie mesquite, Algarroba

Source material: Pollen

Mesquite tree has been described under a number of now-invalid scientific names, including *Mimosa juliflora*

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Allergen Exposure

Geographical distribution

Mesquites belong to the *Fabaceae* (Legume) family. There are about 44 species of Mesquite found throughout the world. They occur most frequently in warmer and semi-arid regions of North and South America (especially Argentina), Africa, India, and southwestern Asia. Three of the most common Mesquites are native and characteristic shrubs of the southwestern US and Louisiana: Honey mesquite (*P. glandulosa*), Screwbean mesquite (*P. pubescens*), and Velvet mesquite (*P. velutina*) (1-2). Mesquite (*P. juliflora*) is native to Mexico, South America and the Caribbean. It has been introduced into Asia, Australia and elsewhere. All 4 are deciduous and have characteristic bean pods that have long been used by humans, wildlife and livestock as a food source.

Mesquite is a deciduous shrub or small tree typically reaching a height of 5-10 meters, and characterised by 22-cm bean-like pods. Mesquite bark is dull red and somewhat rough. The green-brown stem is sinuous and twisted, with axial thorns situated on both sides of the nodes and branches. The leaves are bipinnately compound and nearly hairless. The leaflets have short to nonexistent stalks and are dark green. Straight 2.5 cm spines arise in pairs from leaf axils. Seedpods are 10-22 cm long, yellow-green, flattened and narrowed between the seeds, ending in a point, and either straight or curved; they occur in drooping clusters (2).

Mesquite flowers in early summer. Its flowers are small, green-yellowish spikes without any particular fragrance, and yet attractive to bees. Honey mesquite's flowers are creamy-yellowish to green and sweet-smelling. They are densely packed in cylindrical clusters. In India, *P. juliflora* flowers twice a year, in February-March and August-September (3). Pollen may be produced in large quantities. Pollination is by both insects and wind.

Mesquite in several varieties (4) has been used for reclamation of desert lands and as a wood resource, with the end result that its easily dispersed and far-traveling pollen is an abundant and significant source of allergens (5- 7).

Environment

This tree can be found in warm climates in the desert, alongside desert washes and streams, on plains and hillsides, and often in thickets. Mesquites are widely used as ornamental shade trees throughout the Southwest because they need little or no watering and can survive on limited rainfall.

Unexpected exposure

Mesquite wood is used chiefly for firewood. The wood is also used for fence posts, tool handles, furniture, and to create aromatic charcoal for barbecuing. Liquid smoke for meat flavouring is manufactured from Honey mesquite sawdust. Honey mesquite provides an excellent source of nectar for honey bees. Native Americans used the seedpods, with or without the seeds, as flour, the root fiber for rope, and the wood for utensils, posts, and fuel (2).

Allergens

Mesquite pollen has been shown to contain at least 13 antigenic proteins. Early studies reported antigens varying from 10 to 81 kDa, with the most allergenic fraction being a 20 kDa protein. Other proteins of 13, 20, 27.5, 41, 55.5 and 81 kDa have been detected (8-15). Other authors, in evaluating pooled serum from 10 Mesquite-allergic individuals, detected allergenic bands of 11, 16, 17, 18, 20, 27, 30, 36, 44, 56, 71, and 99 kDa. An additional IgE response by a 64 kDa band not present on the gel was detected on the blot, resulting in a total of 13 blot bands. The remaining kDa gel band produced only a slight image when blotted (16). In an Indian study of 38 Mesquite-sensitised individuals, the patients' pooled sera demonstrated 16 IgE binding components, with components of 24, 26, 29, 31, 35, 52, 58, 66 and 95 kDa recognised by more than 80% of individual patients' sera (17).

To date, only one Mesquite allergen has been partly characterised:

Pro j 20kD (9-10,12,18).

Using serum IgE of Mesquite-allergic individuals, 59 and 66 kDa proteins were isolated from the pollen, wood and wood smoke of Mesquite. The authors commented that more allergens of Mesquite pollen were present but did not give further descriptions (19).

Potential cross-reactivity

Cross-reactivity among members of the legume family (*Fabaceae*) may be expected but has not yet been investigated. Significant cross-reactivity between members of genus is probable (20).

Cross-inhibition assays have shown a close relationship among Mesquite pollen, *Ailanthus excelsa*, *Cassia siamea* and *Salvadora persica*. IgE binding components of 14, 41, 52 and 66 kDa were shared allergens, whereas those of 26 and 29 kDa were specific to *P. juliflora* (17).

In a study investigating cross-reactivity of Mesquite tree pollen with plant-derived foods, *in vitro* cross-reactivity of Mesquite pollen with Lima bean was evaluated. Of 110 patients with asthma, rhinitis or both who were tested intradermally 20, showed marked positive reactions with Mesquite pollen extract. Of these, 12 patients showed elevated IgE antibodies to Mesquite pollen extract alone, and 4 to both Lima bean and the pollen extract. Lima bean extract could inhibit IgE binding to Mesquite in a dose-dependent manner. Immunoblot and immunoblot inhibition demonstrated the presence of 20, 26, 35, 66 and 72 kDa shared IgE-binding components between the 2 extracts. Histamine release, peripheral blood mononuclear cells proliferation, and interleukin (IL)-4 levels also suggested allergenic cross-reactivity (21). Whether Mesquite is cross-reactive with other *Phaseolus* species was not investigated.

Clinical Experience

IgE-mediated reactions

Mesquite pollen may induce asthma, rhinitis and conjunctivitis in sensitised individuals (5,22-24).

Mesquite is a major cause of allergic disease in the southwestern United States (3,5, 6,23, 25), Mexico (16,26-27), Saudi Arabia (28-31), South Africa (32), Kuwait (6,33-34), the United Arab Emirates (UAE) (35-36), and India (17-18,37-38).

Mesquite pollen is a potent allergen capable of evoking immediate hypersensitivity reactions in a susceptible population remote from the plant source. One study reports that 62% of 100 consecutive patients attending an allergy clinic were shown to be positive to Mesquite pollen, as confirmed by IgE antibody tests, despite the absence of the plant within a 50-mile radius (5). Asthmatics may experience a dual response: an acute immediate (IgE mediated) as well as a late response (39).

In Tucson, Arizona, a city that has a high prevalence of allergic rhinitis and asthma, pollen from the Mesquite tree has been noted to be among the major causes (23). In a report on sensitisation to Mesquite pollen in Charleston, South Carolina, USA, 1,598 out of 4,361 patients were said to be sensitised to Mesquite pollen, even though most of them had no known direct exposure to Mesquite (16).

In a study in Comarca Lagunera, Mexico, skin prick tests on 101 patients with asthma reported sensitisation to Mesquite tree in 57% (28).

The practices that "green" the desert have some unintended consequences, including the promotion of allergen sensitisation to imported plants. In a study from Kuwait on 706 patients aged 6 to 64 years who had allergic rhinitis, specific IgE to Mesquite tree was found in 50.3% (35). In a study of 553 asthmatics in Kuwait with sensitisation to common aeroallergens, as measured by serum-specific IgE, it was found that the 3 most prevalent sensitising pollens were from *Chenopodium* (70.7%), Bermuda grass (62.9%), and Mesquite tree (62.7%), all of which are horticultural plants imported for the purpose of "greening" the desert (6).

In a Saudi Arabian study of 473 allergic patients suffering from bronchial asthma in 4 geographical regions, a total of 76.1% in Qassim, 37.5% in Gizan, 29% in Abha, and 11% in Hofuf reacted positively to Mesquite pollen extract (4). In a study in Saudi Arabia of 84 children with allergic rhinitis, skin testing with common allergens found that Cat fur, Bermuda grass and Mesquite were the most common allergens. Symptoms of recurrent rhinosinusitis, otitis media with effusion, and tonsil and adenoid infection were commonly noticed among them (31). Similarly, a study in the Eastern Province of Saudi Arabia of 1,159 patients with positive skin prick tests to inhalants, 46% of natives and 32% of North American expatriates were positive to this allergen (32). Mesquite tree pollen may also be carried in sandstorm dust, as demonstrated in a study conducted in Riyadh, Saudi Arabia, which reported that Mesquite tree pollen was one of the most abundant aeroallergens (30) . Among 263 United Arab Emirates nationals with a respiratory disease suspected of being of allergic origin, 23.5% were sensitised to pollen from Mesquite trees (37). In a study of 327 adult patients with respiratory, dermatologic and ophthalmologic diseases of suspected allergic origin who attended a hospital based in the United Arab Emirates and were evaluated for aeroallergen sensitisation, skin prick testing showed that 45.5% were sensitised to Mesquite (36).

A study reviewing perennial and seasonal aeroallergen trends in the Middle East, and their effect on military personnel serving in the area, reported that most of the countries have significant grass and weed pollen seasons, and that Mesquite tree is as relevant as in the USA among these personnel (40).

In India, where the Mesquite tree is common, a Delhi study reported that Mesquite pollen was the most significant pollen sensitising agent, with 34.7% of patients being sensitised to it (41). An earlier study employed intradermal tests with Mesquite pollen extract on respiratory allergy patients from the Bikaner (arid) and Delhi (semi-arid) areas in India, and elicited positive skin reactions in 71/220 of the patients (17).

A study cautioned that when commercial Mesquite tree pollen extract results in an isolated positive skin test result, this may be a false positive result, and that in some patients the allergen extract apparently has the ability to cause direct mast cell degranulation (42).

Other reactions

Individuals with marked hypersensitivity to Mesquite pollen should be aware that honey might contain Mesquite pollen, as demonstrated by a report of a patient who was extremely sensitive to Mesquite pollen and experienced anaphylaxis after ingesting honey containing this pollen (43).

Mesquite wood charcoal has been widely promoted for the unique taste it imparts to broiled food. In a study comparing 13 Mesquite charcoal with 17 gas-flame broiler cooks, the prevalence of respiratory symptoms among workers exposed to Mesquite charcoal smoke was greater to a statistically significant degree. Unidentified high-molecular-weight saturated and unsaturated aliphatic hydrocarbons were present in air samples from the environments of the Mesquite broiler cooks, but not in air samples from the environments of the gas-flame broiler cooks (44).

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Juniperus sabinoides

Family: *Cupressaceae*

Common names: Mountain juniper, Mountain cedar, Ashe juniper

Synonym: *J. ashei*

Source material: Pollen

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Allergen Exposure

Geographical distribution

The genus *Juniperus* is widely distributed in the Northern Hemisphere. Mountain juniper is native to southwestern North America and is particularly common in Texas. It is found in northeastern Mexico and in the United States only as far north and east as southern Missouri. It colonises grasslands and becomes a pest.

Mountain juniper is a drought-tolerant, evergreen large shrub or small tree, up to about 6 metres in height. The feathery foliage grows in dense sprays and is bright green in colour. The 2-5 mm-long aromatic leaves are scale-like and produced on rounded shoots.

Mountain juniper flowers in winter (December and January). It is a dioecious species, with male pollens and female flowers occurring on different trees. The seed cones are globose to oblong, 3-6 mm long, soft, pulpy and berry-like; green at first, but becoming purple with maturity at about 8 months after pollination. Most species of Juniper produce copious amounts of pollen that can be carried long distances by the wind. Juniper is among the most significant allergenic offenders in the Cypress family. Juniper pollen is very buoyant and is smaller and more allergenic than Pine pollen. A Juniper with berries (a female tree) will not produce pollen.

Environment

It occurs in rocky soils in canyons and ravines and around rim-rocks and breaks and can live as long as 2 000 years. Its reddish-brown wood makes for long-lasting exteriors.

Allergens

In addition to those in Mountain juniper pollen, allergens have been detected in Mountain juniper wood and berry. No allergen was detected in the leaves, and no allergen in smoke from burning male and female trees (1).

The following major allergens have been characterised:

Jun a 1, a 42 kDa protein, a pectate lyase (2-13).

Jun a 2, a 43 kDa protein, a polygalacturonase (2,14).

Jun a 3, a 30 kDa protein, a thaumatin-like PR-5 protein (2,8,15-19).

The major Mountain juniper allergen, Jun a 1, contains conformational as well as linear IgE epitopes (2).

Jun a 3, a thaumatin-like protein, is a member of the pathogenesis-related plant protein family. These proteins are modulated by stress, and therefore variable levels of Jun a 3 may be produced and alter the allergenic potency of pollens produced under different environmental conditions (18).

Potential cross-reactivity

A high degree of cross-reactivity could be expected among the different species of the family *Cupressaceae* (20), in particular among Mountain juniper tree, Italian funeral cypress tree and Arizona cypress tree (21). But in Europe, Juniper (*J. communis*) seldom causes sensitisation in atopic individuals.

Twelve *Cupressaceae* (including Mountain juniper) and the *Taxodiaceae* member Japanese cedar were shown to be extensively cross-reactive. In particular, a Mountain juniper major allergen, gp40 (Jun a 1), was shown to be cross-reactive with 40 to 42 kDa proteins of the other *Cupressaceae* and with the Japanese cedar major allergen of 46 kDa (22).

Jun a 1, a major Mountain juniper allergen, is highly homologous with the major Japanese cedar allergen Cry j 1 (2,9,11,20,23) and other Cedar major allergens including Jun v 1 of eastern red cedar (22). Although Jun a 1 and Jun v 1 are highly homologous and cross-reactive, another pair of allergens, Jun a 3 and Jun v 3, are not cross-reactive (24-25). Jun a 1 has an amino acid sequence similar to that of the major allergen Cha o 1 from Japanese cypress (*Chamaecyparis obtusa*) (2).

Jun a 2, another major allergen of Mountain juniper pollen, is highly homologous to Cry j 2 (70.7 %) and Cha o 2 (82.0%), major allergens of Japanese cedar tree (*Cryptomeria japonica*) and Japanese cypress tree (*Chamaecyparis obtuse*) pollen, respectively. IgE antibodies in sera of Japanese pollinosis patients bind not only to Cry j 2 and Cha o 2 but also to Jun a 2, strongly suggesting that Jun a 2 is an allergen of Mountain cedar pollen and that allergenic epitopes of these 3 proteins are similar (14).

Jun a 3, a thaumatin-like pathogenesis-related protein (PR-5), has a high homology with Cup a 3 from Arizona cypress tree. (26) Jun a 3 has also been shown to be closely related to a thaumatin-like protein in Banana. The presence of these common epitopes offers a molecular basis for positing cross-reactivity between aeroallergens and fruit allergens containing this allergen (15,27).

Clinical Experience

IgE-mediated reactions

Mountain juniper pollen causes asthma, hayfever and allergic conjunctivitis, in particular during winter months (28-29). Mountain juniper is the leading cause of respiratory allergy in South Texas (22) and is also a significant aeroallergen in Tulsa, Oklahoma (30). In Tulsa, the pollen has been recorded during December and January over the past 20 years; the nearest upwind sources for this pollen are tree populations growing in southern Oklahoma and central Texas, at distances of 200 km and 600 km, respectively. Researchers have argued that long-distance dispersal of *J. ashei* pollen into the Tulsa area showed a strong correlation with the trajectories of winds blowing across southern populations before travelling north towards eastern Oklahoma (31). As individuals allergic to Mountain juniper are often allergic to the close relative *J. virginiana* (eastern red cedar), the allergy symptoms starting in the winter may extend into spring, since the pollination of *J. virginiana* follows that of *J. ashei*.

In central Texas, where pollen from this tree causes severe respiratory tract allergy during the winter months, 34% of 234 unselected Mountain juniper-allergic patients were found to be allergic only to Mountain juniper, while 66% were allergic to Mountain juniper and other aeroallergens. Sensitised individuals appear to require much longer exposure to Juniper pollen before developing Mountain juniper pollen allergy, and they develop allergic disease at a later age (39 years, on average) when compared to patients with multiple allergies. Significantly, the authors noted that many of the Mountain juniper-allergic patients who had only allergic rhinitis were sensitive only to Mountain juniper pollen. The authors suggested that Mountain juniper pollen may be unique in causing allergic rhinitis in patients who have no other sensitivities (29,32). The authors suggested also that a possible explanation may lie in the carbohydrate nature of the main allergen of the Mountain juniper pollen, which may facilitate allergen transport through the respiratory tract mucosa and subsequent sensitisation (32).

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Morus alba

Family: *Moraceae*

Common names: White mulberry, Silkworm mulberry

Source material: Pollen

See also: Red mulberry (*Morus rubra*) t71

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Allergen Exposure

Geographical distribution

The Mulberries, comprising about 10 species, are monoecious or dioecious trees or shrubs. The origins of the Mulberry tree (*M. alba*) are mainly in China, Japan, Thailand and Malaysia. The tree is now found throughout the world. Only 2 species are native to North America, but several others have been introduced.

The Mulberry is a deciduous tree growing 18 to 20 m in height, with a wide-spreading, round top. The trunk is light grey. The green leaves may be unlobed, mitten-shaped, or 3-lobed.

The trees bear the staminate and pistillate flowers on different branches of the same tree or on different trees; these flowers are minute, and the staminate ones are in cylindric spikes up to 2 cm long (1). The tree flowers in spring and is wind-pollinated, and the pollen is dominant in its region. The pollen is highly allergenic. The seeds (fruits) ripen from summer. The fruit is an aggregate, 1 to 5 cm long, white becoming pink and then purplish to nearly black.

Environment

These trees are extensively grown in locations such as China, Southern Europe and India for their leaves as food for silkworms. Mulberries are popular for street planting and as garden and roadside ornamentals in the eastern US, Europe, and other places. Having escaped, trees often appear growing wild on roadsides and along fencerows.

The fruits may be eaten raw or cooked. The wood is valued for sporting goods due to its elasticity and flexibility when steamed.

Allergens

No allergens from this plant have yet been characterised.

Potential cross-reactivity

An extensive cross-reactivity among the different individual species of the genus, as well as a certain degree of cross-reactivity within the family *Moraceae* (including Breadfruit, *Ficus spp.* [Weeping fig], Fig, India rubber plant, and Jackfruit) could be expected (2).

Clinical Experience

IgE-mediated reactions

Mulberry pollens can induce asthma, allergic rhinitis and allergic conjunctivitis (3-4).

A study from Tuscon, Arizona, USA, concluded that Mulberry pollen is an important allergen associated with asthma and allergic rhinitis in children raised in a semiarid environment (5). In the tropical area of Caracas, Venezuela, Mulberry tree pollen was shown to be a frequently encountered aeroallergen (6).

Further studies, including from Spain and India, have shown Mulberry tree pollen to be an important aeroallergen (7-13). In a study of 30 patients in Santander, Spain, aged between 13 and 69 years, who suffered seasonal rhinoconjunctivitis symptoms and who had always lived in the area, it was found that 27% tested positive to *Plantago*, 20% to *Quercus*, and 13% to Mulberry tree pollen (14).

Mulberry pollen has also been recorded in the atmosphere of Didim, in southwestern Turkey (15). In a study conducted in the city of Heraklion, located in the center of the northern shore of the island of Crete, pollen from Moraceae was the seventh most prevalent pollen recorded (16). In a study of the pollen spectrum in La Plata, Argentina, 79 pollen types were represented. The most prevalent 10 pollens included pollen from Mulberry tree (17).

Airborne contact urticaria due to Mulberry pollen has been reported. (18)

Other reactions

Asthma and allergic rhinitis as reactions to the fruit of the Mulberry tree have been documented (19). Mulberry leaves have hypoglycaemic, hypotensive, diuretic and hypolipidaemic effects in diabetic patients (20).

The tree's unripe fruit and milky sap are reported to result in stomach upset and hallucinations, but this is not substantiated by all authors.

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t7 Oak

Quercus alba

Family: *Fagaceae*

Common names: Oak, White oak, Forked-leaf white oak, Fork-leaf oak

Source material: Pollen

See also: Virginia live oak (*Quercus virginiana*) t218

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Allergen Exposure

Geographical distribution

Oaks, making up the genus *Quercus*, are abundant hardy trees of deciduous forests in North America, Europe, and Asia. There are approximately 500 to 600 species worldwide, 250 in the Western Hemisphere, more than 150 in Mexico, and 70 in the United States and Canada (1-2). Oak trees are subject to a good deal of variation (3-4); for example, there are 2 principal varieties of *Q. robur*, which are often regarded as separate species.

However, Oaks are generally classified into 1 of 2 types, White or Red. Among species, the White oak (*Quercus alba*) is the most common. It is widespread in northeastern America. Related species are distributed widely over the Northern Hemisphere and are found in Java and the mountains of Mexico and South America.

The White oak is a medium-sized to large spreading deciduous tree, commonly reaching 18 to 24 m in height. Individuals may grow to more than 30 m in height and exceed 1.5 m in diameter. White oak is slow-growing and may live up to 600 years. The flowers are of 2 kinds: the male, in drooping catkins 2.5 to 8 cm long; and the female, appearing later, either singly or in pairs on short stalks, and producing as fruit an acorn 1.5 to 2.5 cm long. Acorns are generally borne in pairs.

Oaks are wind-pollinated. Flowering generally occurs in spring, when the new leaves are elongating, but varies according to latitude, weather conditions, and the genetic composition of individual trees. In the Northern Hemisphere, flowering can occur at any time from late March to May or June. Three distinct waves of flowering (early, middle, and late) have been reported. Pollen is generally shed within 3 days, but light winds can accelerate shedding, and prolonged rainy weather can delay it. Oaks shed copious amounts of pollen, more than any other plant, but it generally travels less than 200 m. Oak pollens are problematic throughout most of the US.

Environment

White oak grows in rich uplands and moist bottomlands, along streams, and on hummocks, sinks, sandy plains, and dry, gravel slopes. It occurs on all upland aspects (except for ridge tops with shallow soil) and slope positions. White oak is absent on poorly drained flats, and on very wet bottomlands.

Plants may bear seed as early as 20 years of age, but generally bear fruit between 50 and 200 years of age. White oak produces good acorn crops at erratic intervals. Unlike Red oak acorns, which take 2 years to mature on the tree, White oak acorns grow from flower to maturity in a single growing season.

White Oak is an important source of wood for furniture, veneer, paneling, and flooring. Corks are made from the thick, spongy bark of the Cork oak, which occurs in the Mediterranean region. Several species yield tannins, which are used in the leather-tanning industry, and others yield dyes from their bark. White oak is currently the major source of wood for whiskey barrels.

Acorns were traditionally an important food source for many Native American peoples. White oak acorns have been described variously as sweet and edible and as slightly bitter. The acorns were boiled to remove bitter tannins. Oils obtained from pressed acorns were used to alleviate pain in the joints.

Allergens

Studies suggest that White oak pollen contains multiple proteins that are potentially allergenic (5). Apparently, not all species of Oak are equally allergenic: *Q. ilex* pollen, although produced in considerable quantities, was not found to cause allergies in one study (6).

The following allergens have been characterised:

Que a 1, a 17 kDa protein, a group 1 *Fagales* protein (7-11).

Que a CBP, a calcium-binding protein (12).

Que a Profilin, a profilin (9).

Que a 1 was purified from Oak pollen extract and evaluated in 16 subjects sensitised to Oak pollen. nQue a 1 showed a 58-74% sequence identity with other pathogenesis-related class 10 allergens. All subjects were sensitised to Que a 1 and Bet v 1, and 2 to profilin (11).

Potential cross-reactivity

Some of the pollen allergens in the various species of Oak cross-react with each other, while others are unique to their own species.

In Sapporo, Japan, many Birch pollen-allergic patients complained of typical symptoms after the Birch pollen season. This has been attributed to Birch pollen-allergic individuals being affected by Oak pollinosis due to cross-reactivity between Birch and Oak pollen (13).

Natural Birch, Alder, Horn beam, Hazel, and Oak pollen contain allergens that share IgE epitopes with recombinant Bet v 1 and recombinant Bet v 2. A combination of recombinant Bet v 1 and Bet v 2 accounted for 82% of tree pollen-specific IgE in a European study. Most of the tree pollen-specific IgE antibodies were directed against rBet v 1 (9). Similarly, patients' IgE cross-reactivity between Birch and related tree pollen allergens has been shown to be between 75% (Oak) and 95% (Alder, Hazel and Horn beam), demonstrating the clinical importance of these trees (10). Therefore, in regions where Oak tree is a dominant or significant aeroallergen, tests for sensitisation to Birch, Alder, Beech or other *Fagales* members may be positive as a result of cross-reactive mechanisms (14).

In inhibitory ELISA assays, IgE binding to ginkgo pollen was inhibited more than 80% by Oak, Rye grass, Mugwort, and Ragweed; 34% by Japanese hop; and 10% by rBet v 2 at 10 µg/ml (15).

Clinical Experience

IgE-mediated reactions

Oak pollen is a major cause of allergic rhinitis and asthma (16-19).

Oak pollen affects sensitised individuals throughout the world. In Madrid, Spain, the highest level of airborne pollen from 1979 to 1993 was from the *Quercus* species (17%) (19), and in Salamanca, Spain, the highest quantity of pollen was from Holm oak (20). Oak pollen has also been shown to be significant in Zurich (21), Mexico City (22), Japan (23), Korea (24), Tampa, Florida (25), the Iberian Peninsula (26), Didim, in southwestern Turkey (27), and Cape Town, South Africa (28).

A study examined the impact of different trees on asthma, and the association between daily hospitalisations for asthma and daily concentrations of different tree pollens in 10 large Canadian cities, and found that as a result of an interquartile increase in daily tree pollen concentration, percent increases in daily hospitalisation for asthma were 2.32% for the group containing *Quercus* and *Castanea* (29).

Exposure to Oak dust may also lead to the development of sore throat and bronchial hyperresponsiveness (30).

Occupational asthma and rhinitis due to Oak wood dust has been demonstrated in wood workers (31-32).

Determination of Oak-specific IgE antibodies have been documented to be a useful investigation in the case of Oak-allergic individuals (33-34).

Other reactions

Adverse reactions may occur to other components present in/on Oak wood. Oak processing workers have experienced allergic reactions to *Penicillium citrinum* (35).

A 28-year-old man developed multiple episodes of fever, cough, shortness of breath, and leukocytosis, features of hypersensitivity pneumonitis, several hours after cutting live Oak and Maple trees. Fungal cultures of wood chips from Oak and Maple trees were positive for *Penicillium* (3 species), *Paecilomyces spp*., *Aspergillus niger*, *Aspergillus spp*., and *Rhizopus spp*. (36).

The Oak processionary caterpillar (*Thaumetopoea processionea Lepidoptera*) is found living on Oak trees in several European countries. The larva develops poisonous hair (setae), filled with an urticating toxin that may on contact lead to severe dermatitis, conjunctivitis, and pulmonary affection, as described in more than 40 people, including young children, who developed symptoms after resting within 20 m of an infested Oak tree. Only a few people had touched the caterpillars; the setae causing the disease can be airborne (37-38).

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t223 Oil Palm

Elaeis guineensis

Family: *Arecaceae*

Common names: Oil palm, African oil palm, Palma Africana

Synonym: *Elaeis melanococca*

Source material: Pollen

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Allergen Exposure

Geographical distribution

Elaeis is a genus consisting of only 2 species of Palms. *Elaeis guineensis* originally occurred in Africa, and *Elaeis oleifera* in Central and South America. The trees are now cultivated throughout the tropics and sometimes grown as ornamentals in other parts of the world, in particular in southern Florida. Palm oil from this genus is the second most frequently consumed vegetable oil in the world.

The Oil palm can reach 25 m in height. Its trunk is stout, erect and ringed. The feathery, fibrous fronds are green and up to 5 m long and 20 cm wide, saw-toothed and broadened at the base, each with 100-150 pairs of leaflets. The plant is monoecious (having male and female inflorescences in separate clusters, but on same tree). The male flowers occur on short, furry branches 10-15 cm long. Female flowers, and consequently fruits, occur in clusters of 200-300. Fruits are plum-like, oblong in shape, 3.5 cm long and about 2 cm wide.

Environment

Both species of Oil palm grow in open situations, such as along streams, in swamps and on savannahs. They are also in extensive commercial cultivation.

Unexpected exposure

Palm kernel oil is used for the manufacture of soaps and candles, and more recently of detergents, margarine, cooking fats, mayonnaise, sweets and baked goods. It is an important industrial lubricant.

The pressed cake, after extraction of the oil from the kernels, is used as livestock feed. The leaves and other parts of the plant are used in thatching, building, mulching and manuring. The ash is sometimes used in soap-making.

Allergens

The following allergens have been characterised:

Ela g Profilin (1).

Ela g Bd 31kD (2-3).

Ela g Bd 31kD was strongly recognised by IgE in 3 Oil palm pollinosis patients, weakly in 1, and not at all in 2 (2).

Potential cross-reactivity

An extensive cross-reactivity among the different individual species of the genus could be expected, as well as among members of the family (4).

Clinical Experience

IgE-mediated reactions

Oil palm pollen may commonly induce symptoms of allergic rhinitis and asthma in sensitised individuals, especially in Malaysia and Singapore (5-6).

In an aerobiologic survey of Singapore, crude extracts of 23 major spore (fungal and fern) and pollen types were assessed in 231 patients with asthma and/or allergic rhinitis and 76 healthy controls by skin prick test and total and specific IgE tests. Extracts of Oil palm pollen were observed to have the highest frequency of positive reactions (40%). Positive responses to these extracts correlated with total serum IgE levels of the subjects and were significantly associated with the presence of atopic disease (2).

A total of 107 patients with allergic rhinitis and/or asthma in Jakarta, Indonesia, were evaluated via skin prick test: 32 children and 75 adolescents and adults; there were also 20 normal control volunteers. Sensitisation to Palm oil pollen was demonstrated in 22.43%. No difference was noted between children and adults in the allergic group (3).

A study of the prevalence of allergen sensitisation among asthmatics in Thailand (84 paediatric, 71 adult asthmatics) found that sensitisation to Oil palm pollen in child and adult asthmatics was 8.3% and 5.6%, respectively (7).

Other reactions

Allergy to the fruit of Oil palm is possible. In a study that identified sensitivity to a Coconut (*Cocos nucifera*) 7S globulin in 2 Coconut-allergic patients, the greatest similarity was to a protein from Oil palm, a species also belonging to the *Arecaceae* family. Cross-reactivity among Coconut, Walnut, and Hazelnut was demonstrated by inhibition studies in patient 2 (8).

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t9 Olive

Olea europaea

Family: _Oleaceae_

Source material: Pollen

See also: Olive f342

There are 4 important genera in the _Oleaceae_ family: Olive (_Olea_), Ash (_Fraxinus_), Lilac (_Syringa_), and Privet (_Ligustrum_).

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Allergen Exposure

Geographical distribution

Olea europaea, the Olive tree, has been recognised as one of the most important causes of seasonal respiratory allergy in the Mediterranean area (1) and in other parts of the world where this tree is now grown. The Olive tree is grown in many parts of the world. Its germplasm is very broad, with 250 varieties in Spain alone (2).

Olive tree probably originated in Asia Minor, spread to the Mediterranean region, and was then introduced into North America (especially California and Arizona), South America (Chile), Australia and South Africa. Although in North America Olive trees are found only in the Southwest, Ash and Privet are widespread, a detail of relevance to cross-reactivity (3). Countries and regions have distinct varieties of Olive. In Italy, varieties of Olea europaea differing between the northern and southern parts of the country may induce different IgE-mediated reactions (4).

The Olive tree is an evergreen growing to 10 m, with a broad, round crown and a thick and knotty trunk. The flowers are hermaphrodite (have both male and female organs). Pollination is by insects but also by wind when pollen is in abundance. The pollination period of _Olea_ varies. In Europe it may start as early as January, depending on the region (1). In southern Italy it lasts from early April to late June, and as one moves north, until July (4).

Olive pollen allergy is among the most significant pollinoses that depend on geographical location. Although the Olive tree is grown on 5 continents, more than 25% of the world's Olive tree cultivars are in Spain (5).

Environment

Olives grow in plantations and woods, and as scrub in dry, rocky places. Olive is famous for its fruits and oil, and its by-products are used in making soap. Olive wood is used in cabinet-making as well as in other woodworking and even in jewellery-making.

Allergens

The presence of at least 20 proteins with allergic activity has been demonstrated in Olive pollen (6).

The following allergens have been characterised:

Ole e 1, a 18.5-20 kDa protein, a trypsin inhibitor, a major allergen (5,7-22).

Ole e 2, a 15-18 kDa protein, a profilin (5,7,23-30).

Ole e 3, a 9.2 kDa protein, a 2-EF-hand calcium-binding protein (polcalcin) (5,7,27,31, 32-35).

Ole e 4, a 32 kDa protein, a major allergen (7,36-38).

Ole e 5, a 16 kDa protein, a superoxide dismutase. (7, 36, 37, 38, 39)

Ole e 6. a 5.5-5.8 kDa protein (5,7,40-42).

Ole e 7, a 9.9-10.3 kDa protein, a lipid-transfer protein, a major allergen (7,42-44).

Ole e 8, a 18.8 kDa protein, a calcium-binding protein with 4 EF-hand sites and very low prevalence (7,28,32,35,40,45-46).

Ole e 9, a 46.4 kDa protein, 1,3-beta-glucanase (5,7,28,47-53).

Ole e 10, a 10.8 kDa protein, a glycosyl hydrolase (5,7,25,52,54).

Ole e 11 (55).

Ole e 36kD (56).

Not all allergens are found in every Olive tree cultivar, and most allergens isolated and characterised to date are highly polymorphic. Olive cultivars display wide differences in the expression levels of many allergens and in the number and molecular characteristics of the allergen isoforms expressed (2,57). For example, in a study examining the various IgE-binding proteins of the pollen extracts of various Olive tree cultivars, 6 predominant IgE-binding bands, some of which appeared in all the cultivars, were found. Ole e 1 appeared in only 8 of the cultivars, but not in the 9 others (58). Other authors have shown similar results, and reported that significant variations in the average reactivity of allergic patients to skin prick tests were observed, depending on the cultivar in question (59). These differences are responsible for the important differences in the allergenic potency of the extracts and have implications for the diagnosis and therapy of Olive tree pollen allergy. The prevalence of many Olive pollen allergens is dependent on geographical location. Some of the Olive allergens have been revealed to be members of known protein families, whereas no biological function has been demonstrated for Ole e 1; while Ole e 4 and Ole e 6 are proteins without known homology to other allergens (40).

Although a number of Olive tree allergens are major allergens, sensitisation is nonetheless heterogeneous. For example, in a Spanish study of Olive pollen-allergic patients, 107 (90.7%) patients had a positive skin response to Ole e 1; 88 (74.6%) reacted to Ole e 2; 57 (47.9%) reacted to both Ole e 6 and Ole e 7; and 43 (37.8%) reacted to Ole e 3. Allergenic activity determined by ELISA to Ole e 1 was found in 84%; to Ole e 2 in 61.3%; to Ole e 3 in 31.9%; to Ole e 6 in 39.4%; and to Ole e 7 in 41.2% of patients. All patients had positive skin responses to at least 1 of the allergens tested (42).

Similar results have been demonstrated in other studies. Furthermore, the IgE response to certain Olive pollen allergens is modulated by the different clinical phenotypes of allergic disease and their relationship with the level of exposure to pollen and with genetic factors (25,55,60). In a study of 146 patients with seasonal rhinitis and/or asthma and a positive prick test to Olive tree pollen, 102 (69.9%) and 79 (54.0%) patients were shown to have a significant IgE antibody response against Ole e 2 and Ole e 10, respectively. There was a significant association between Ole e 2 and Ole e 10 sensitisation and with having asthma (25,61).

In a later study, the same authors demonstrated that patients from areas of intense Olive tree pollen exposure had a complex IgE antibody response to allergens of Olive pollen, which included 3 or more allergens in 75% of cases. The majority allergens were Ole e 1, Ole e 2, Ole e 7, Ole e 9, and Ole e 10. The existence of the antigen HLA-DR2 led to a higher risk of sensitisation to Ole e 10 and a greater trend towards the development of severe asthma, which increased in the presence of anti-profilin IgE. Thirty percent of patients suffering from Olive pollen allergy also presented with allergy to vegetable foods. Anti-Ole e 7 IgE was significantly associated with fruit anaphylaxis, and anti-profilin IgE was detected in 90% of patients with oral allergy syndrome (61).

Ole e 1 is the most frequent sensitising agent of all the Olive tree allergens, affecting more than 70% of the patients with sensitisation to Olive pollen, although other antigens, such as Ole e 4 and Ole e 7, have also been shown to be major allergens (7,9,40).

The 2 Olive tree pollen calcium-binding protein allergens, Ole e 3 and Ole e 8, do not have the same structural relationships. Ole e 3, a 2-EF-hand calcium-binding protein, and Ole e 8, a calcium-binding protein with 4 EF-hand sites, have been shown to have different sensitisation profiles: 34 (17%) and 16 (8.2%) of 195 sera from Olive tree pollen-allergic patients contained IgE antibodies against Ole e 3 and Ole e 8, respectively (35).

Sensitisation to Ole e 7 has been associated with a propensity to adverse reactions (62), and sensitivity to Ole e 10 with severe and persistent asthma (5,25).

Ole e 9, a 1,3-beta-glucanase, has been shown to be a major allergen, and has been found in the sera of 65% of patients with Olive pollinosis (47). Ole a 9 and Ole e 10 may play a role in pollen-latex-fruit syndrome (61).

A 36 kDa Olive pollen allergen has been isolated, but not characterised, and results in the sensitisation of 83% of Olive tree pollen-allergic patients. Extracts from Olive pollens collected in California demonstrated a much higher amount of the 36 kDa protein (approximately 16-fold higher) than did those from pollens of Spanish origin. The presence of similar allergens was detected in the closely related species *Syringa*, *Fraxinus*, and *Ligustrum* (56).

Potential cross-reactivity

A high degree of cross-reactivity has been demonstrated among Olive tree (*Olea europaea*), Ash (*Fraxinus exselsior*), Privet (*Ligustrum vulgare*) and *Phillyrea angustifolia* (a bush usually confined to certain areas of the Mediterranean), all members of the *Oleaceae* family, although there is no total shared identity among these 4 pollen species (63-64).

The Ole e 1-like family of proteins, which may evince cross-reactivity among members, comprises allergenic members from *Oleaceae*: Fra e 1 from European ash tree; Lig v 1 from Privet tree; Syr v 1 from Lilac tree; Pla l 1 from English plantain (*Plantago lanceolata*); Che a 1 from Goosefoot (*Chenopodium album*); Lol p 11 from Rye grass (*Lolium perenne*); and Phl p 11 from Timothy grass (*Phleum pratense*); as well as non-allergenic members such as BB18 from Birch tree (5,12,65-67). An 85.5 - 89.6% identity between Ole e 1 and Syr v 1 from *Syringa vulgaris* has been demonstrated (68).

A study comparing Olive and European ash pollen allergens, and investigating the degree of cross-reactivity in Spanish and Austrian allergic patients selectively exposed to Olive or Ash pollen, found an almost identical IgE-binding profile to both pollen allergens. A major reactivity was directed against Ole e 1 and its homologous Ash counterpart, Fra e 1. IgE inhibition experiments demonstrated extensive cross-reactivity between Olive and Ash pollen allergens. However, the study revealed that other panallergens, *e.g.*, profilin and calcium-binding allergens, also contribute to cross-reactivity between these plants and to other unrelated plant species (16).

The relevance of Ole e 1 cross-reactivity is indicated in various situations. For example, in northern and central Europe, where there are no Olive trees, 2 common genera of the *Oleaceae* family, *Fraxinus* and *Ligustrum*, occur. These have a low frequency of allergic sensitisation compared to *Olea*, but local tests for Olive pollen sensitisation may be positive. Similarly, the importance of cross-reactivity is demonstrated by a study in Michigan, USA, where in 103 atopic subjects, cross-reactivity among Olive tree, *Fraxinus*, Privet and Russian Olive tree pollens was demonstrated, even though the Olive tree does not grow in that area. Nineteen subjects were skin prick-positive to this allergen, confirming cross-reactivity (3).

Cross-reactivity between extracts of *Oleaceae* and some species of the *Poaceae* family has also been shown (69-70). The major allergen of *Plantago lanceolata* (English plantain) pollen, Pla l 1, has been shown to have significant sequence homology with the major Olive pollen allergen Ole e 1 (71).

Ole e 2, a profilin, can be expected to result in cross-reactions with other plants containing profilin. For example, IgE antibodies directed against the Date palm pollen allergen Pho d 2 showed strong cross-reactivity with other profilins, such as those from Olive tree and grass pollens (26).

Although lipid transfer proteins are reported to be panallergens with significant cross-reactivity, Ole e 7, a lipid transfer protein, has been reported to have limited similarity with other allergenic lipid transfer proteins from vegetable sources (Peach, Apple, Cherry, Apricot, Orange, Hazelnut) and therefore no significant cross-reactivity (5).

Ole e 9, a 1,3-beta-glucanase, may result in cross-reactivity with pollens or plants containing this panallergen, *e.g.*, Ash and Birch pollen, Tomato, Potato, Bell pepper, Banana and Latex (51).

Ole a 9 and Ole e 10 may play a role in pollen-latex-fruit syndrome (61).

As mentioned previously, a number of cross-reactive allergens may all contribute simultaneously. A study concluded that the high prevalence of Black locust tree/False acacia tree (*Robinia pseudoacacia*) pollen sensitisation in patients with pollinosis is likely to be due to cross-sensitisation to panallergens such as profilin, polcalcin, and 1,3-beta-glucanase from other common pollens, including Olive tree pollen (72).

A study to evaluate the associations between sensitisation to allergens of Olive tree pollen and confirmed plant-derived food allergy recruited 134 patients with allergy to Olive pollen. Only 40 reported adverse reactions to plant-derived food. Twenty-one (group A) were classified as having OAS, and 19 (group B) as having experienced anaphylaxis. In skin prick tests, sensitisation to Ole e 7 was more frequent in patients from group B. A total of 84 double-blind placebo-controlled challenges were performed, and 44% were positive. Among those who were skin prick test-positive, oral challenge confirmed the results in 68.42% for Peach, 50% for Pear, 71.42% for Melon, and 53.84% for Kiwi. In patients from group B, the following significant association with Olive tree pollen allergens were found: between positive skin prick tests for *Rosaceae* fruits and Ole e 3 and Ole e 7; *Cucurbitaceae* with Ole e 7; and *Actinidiaceae* with Ole e 3 (44).

Inhibition tests have found that the reactivity of the IgE antibody specific for Olive tree pollen antigen was inhibited dose-dependently by an extract of Orchard grass pollen. These findings suggest that in some patients with grass (*Gramineae*) pollinosis, this might be induced by Olive tree pollen (73).

A minimal-to-moderate cross-reactivity of Russian olive tree (*Elaeagnus angustifolia*) with Olive tree pollen was established, suggesting some cross-reactivity but not excluding co-sensitisation (74). Russian olive tree is not a member of the *Oleaceae* family.

An early study reported cross-reactivity among Olive, Privet, Rye grass, Couch grass and Bermuda grass pollen components but concluded that the presence of pollen-reactive IgE antibodies might not necessarily be a true reflection of the sensitising pollen species (75).

A high level of inhibition of the IgE binding of Olive pollen extract with Birch, Mugwort, Pine, and Cypress pollens was reported, suggesting that these extracts contain proteins that have common epitopes and thus can be recognised by Olive-allergic sera. The inhibition assays implied the presence of an allergen of 45 kDa (76).

In a Spanish study of *Cupressus* sensitisation, skin prick tests on 1532 patients with asthma and/or rhinoconjunctivitis demonstrated that of the *Cupressus*-sensitive patients, all also reacted positively to *Olea* and *Fraxinus*, compared to 77% and 51% in the 2 *Cupressus*-negative groups (77).

Cross-reactivity with *Zygophyllum fabago*, an herbaceous plant found widely in the Mediterranean area, has been described (78).

Clinical Experience

IgE-mediated reactions

Olive pollens can induce asthma, allergic rhinitis and allergic conjunctivitis in sensitised individuals (67,79-89).

The frequency of sensitisation to Olive tree pollen varies in the Mediterranean region from 12% in Sicily to 37% in Greece. (1, 90) In Greece, more than 37% of atopic individuals are sensitised to *Oleaceae* (91). Fifteen percent of atopic patients in southern France were found to be skin prick-positive to *Oleaceae* (92). In Italy, atopic sensitisation varied from 12.2% in Sicily to 30% in Apulia (93-97). In Naples, out of 4,142 patients examined consecutively over a 2-year period, 13.49% of adults and 8.53% of the children of all skin prick-positive patients were positive to *Olea* pollen allergens on skin prick testing (98). Less than 1.4% of children and 2.3% of adults were found to be monosensitised to Olive pollen (98). In a study of 507 asthmatic atopic children in the Chieti-Pescara area of Italy, skin prick tests found that 21% were sensitised to Olive tree pollen (99).

Sensitisation to Olive pollen has been reported in Israel (100-102). Positive skin reactions to Olive pollen among atopic patients of the Jewish population were shown to be high in number where Olive trees are abundant (66%), and fewer (29%) where the trees are scarce (102-103). In Spain, a study demonstrated that the frequency of sensitisation could vary greatly within the same country (104-105). Daily pollen measurements of the atmosphere showed pollen from the Olive tree to be among the most abundant pollen grains (106). Among 210 patients in the Plasencia area of Cáceres, Spain, who had a diagnosis of pollinosis, 71.9% were sensitised to Olive pollen, the second-most-prominent allergen after Cocksfoot grass (*Dactylis glomerata*) (80.4%) (107).

Sensitisation to Olive tree pollen has also been reported in Croatia (108), and in Cova da Beira, a central region of Portugal, where 371 paediatric patients were skin prick-tested and sensitisation to Olive tree pollen was found in 27.5% (109). Olive tree pollen has also been shown to result in sensitisation in Japan, where 16.3% of pollinosis patients were positive to this allergen (110). Skin prick tests for sensitisation to Olive tree pollen in the southern part of Switzerland (Canton Ticino) showed a high sensitisation rate of 54% (111).

The majority of studies demonstrate a higher prevalence of rhinoconjunctival symptoms than of asthma (1). Patients are more likely to be polysensitised than monosensitised to Olive tree pollen. Monosensitised individuals, children and adults, may have symptoms throughout the year without an apparent increase during the Olive pollination season (85,112).

In a Turkish study of 127 patients with respiratory allergic disease, 19 were found to be monosensitised to Olive pollen and 108 polysensitised. Of the monosensitised patients, 13 had allergic rhinitis only, while 6 had asthma as well. Of the polysensitised group, allergic rhinitis alone was present in 84, and was accompanied by asthma in 24 patients. Eleven patients with Olive tree sensitisation (57.9%) and 86 patients with polysensitisation (79.6%) had rhinitis symptoms throughout the year, irrespective of the Olive tree pollination season. Similarly, 3 of the monosensitised and 10 of the polysensitised patients with asthma had asthmatic symptoms during the pollination season and also after it (113).

Furthermore, studies in the south of Spain have demonstrated that patients exposed to extremely high Olive pollen levels display a different severity of allergy than in those exposed to normal levels, which makes it necessary to follow different treatment approaches (114).

Although Olive tree pollen allergy is broadly described in population studies, individuals working in Olive tree orchards and in laboratories are also prone. Occupational allergy was described in a researcher due to Ole e 9, an allergenic 1,3-beta-glucanase from Olive pollen. The 30-year-old researcher, involved in the study of Ole e 9-allergen and derivative recombinant products, developed nasoconjunctival pruritus, sneezing proxysms, rhinnorrhoea, conjunctival redness and palatal itching while handling fractions enriched with 35-55 kDa protein components of Olive pollen extract. He was asymptomatic during the Olive pollination season in Madrid. Skin prick tests were positive for Olive pollen and negative for other allergens tested. A single IgE-reactive band of 45 kDa was detected in the patient's serum, and immunoblotting was positive for purified Ole e 9-allergen. The authors point out that Ole e 9 is a major allergen in areas such as Jaen, Spain, whereas patients living in Madrid, which has lower pollen counts, are notably less sensitised to Ole 9, and they are always co-sensitised to Ole e 1 (48).

Other reactions

White mustard (*Sinapis alba*) is an entomophilic species of the *Brassicaceae* family. In a study of 12 Olive orchard workers with a history of rhinitis and/or bronchial asthma that occurred during weed management and/or the harvest, from January to March, all were sensitised to *S. alba* pollen extract and were positive on nasal challenge testing. The study concludes that *S. alba* pollen is a new occupational allergen for Olive farmers (115).

Allergic reactions have been reported to ingestion of or contact with the fruit of the Olive tree (116).

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t219 Paloverde

Cercidium floridum

Family: *Fabaceae*

Common names: Paloverde tree, Blue Paloverde

Synonym: *Parkinsonia florida*

Source material: Pollen

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Allergen Exposure

Geographical distribution

Blue paloverde is a spiny, small, deciduous tree with multiple stems, distributed throughout the Sonora Desert in the USA. Its range extends from central and southwestern Arizona into southeastern California.

Blue paloverde grows about 10 m tall. It has pinnately compound leaves. Inflorescences of Blue paloverde are 4 to 12 cm long, with 1 or more flowers. Flower and leaf production of Blue paloverde vary according to the amounts of precipitation received. Blue paloverde remains leafless throughout most of the year. Leaves are produced between mid-July and late November, depending on the summer rains. The fruits are flat legumes, each containing 1 to 8 flat seeds.

Blue paloverde typically flowers sporadically after rains from late March to May, but flowering may extend into July. Populations of Blue paloverde also may bloom from August to October.

Environment

Blue paloverde occurs in arid and semiarid climates characterized by high summer temperatures and highly variable rainfall. Blue paloverde grows predominantly in washes and beside culverts and bridges, but is also found in uplands. Blue paloverde fruits have been used by Native Americans for food. The Pima and Papago in Arizona cooked young Blue paloverde fruits and seeds and ground the seeds for porridge.

Unexpected exposure

Blue paloverde leaves and stems contain cyanogenic glycosides, alkaloids, and cinnamic phenolic acid.

Allergens

No allergens from this plant have yet been characterised.

Potential cross-reactivity

An extensive cross-reactivity among the different individual species of the genus could be expected (1).

Clinical Experience

IgE-mediated reactions

Anecdotal evidence suggests that asthma, allergic rhinitis and allergic conjunctivitis are possible following exposure to pollen from this tree; however, no specific studies have been reported to date.

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Carya illinoinensis

Family: *Juglandaceae*
Common names: Pecan tree, Hickory tree
Synonym: *C. pecan*
Source material: Pollen
See also: Pecan nut f201
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Allergen Exposure

Geographical distribution

The *Juglandaceae* family contains 2 important genera: Hickory/Pecan (*Carya*) and Walnut (*Juglans*).

The Pecan is a deciduous tree, usually 23 to 34 m tall but sometimes growing to over 50 m. The tree has a rather narrow crown and usually occurs in forests. Some Pecan trees are over 150 years old. They have compound leaves with lance-shaped leaflets. The bark is a pale gray or whitish brown, scaly, and deeply furrowed, and the twigs are hairy. The trees lose their leaves each year and bear sweet, edible nuts, deep brown in colour, that range from 2.5 to 5 cm in length.

The Pecan is native to North America. The range of Pecan covers the warmer temperate zone and subtropical areas. It is very common in the South and Southeast of the USA, but is also planted far beyond this range. In the USA, Texas is the largest producer of Pecan nuts, and is second only to Georgia in the production of hybrid (orchard-grown) varieties.

The Pecan has separate male and female flowers on the same tree (monoecious). Tiny pistillate flowers hang down in tassels. The tree flowers in spring, shedding enormous quantities of pollen. The pollen season extends from April to June in the Northern Hemisphere. Pollination occurs by wind. Although the pollen is very allergenic, it is large and does not travel far. However, in areas where the trees are cultivated commercially, heavy exposure to the pollen can cause allergy symptoms.

Environment

The Pecan tree is an important crop tree cultivated for its timber and edible nuts. Pecan orchards in the southern US produce more than 250 million pounds of Pecan nuts in an average year. Four-fifths of the Pecan harvest is sold as shelled nuts.

Unexpected exposure

Although the wood is brittle, it is valuable for flooring, furniture and panelling. Oil from the nuts is an ingredient in processed foods, is used in the manufacture of cosmetics and soap, and is a drying agent in paints.

Allergens

No allergens from this plant have yet been characterised.

Potential cross-reactivity

Cross-reactivity could be expected between species of the genus *Carya* and, to a moderate degree, to those of the genus *Juglans*, *e.g.*, Walnut tree (1).

t22 Pecan, Hickory

Clinical Experience

IgE-mediated reactions

Pecan tree pollen is considered to be highly allergenic, resulting in allergic rhinitis, conjunctivitis and asthma (2).

In an Israeli study, 705 allergic patients living in 3 cities and 19 rural settlements were tested for sensitivity to Date palm pollen and Pecan tree pollen. Sensitivity to the pollen extracts of Date palm and Pecan tree was much higher among residents of rural than of urban communities, with a clear relationship between the abundance of these trees in a region and the incidence of positive skin prick tests to their pollen. Sensitivity was frequent in those close to commercial Date or Pecan plantations. In general, sensitivity to Date pollen extracts was lower than to extracts of Pecan pollen. Pollen levels decreased with increasing distance from the trees, and were low at approximately 100 m from a source (3).

In an Israeli study of 395 participants comprising 78.2% of a rural community, 11.6% were skin-prick test positive to Pecan tree pollen, and they constituted 25.4% of the atopic population. Of those who were found atopic to 1 or more allergens, 50.3% had symptoms, whereas the parallel figure for those atopic to Pecan pollen was 76.1%; 58.7% of the Pecan-atopic participants had hayfever, 43.5% had asthma, and 31.5% had both hayfever and asthma. Of the Pecan atopics, 65.2% had clinical symptoms coinciding only with the Pecan pollen season, and an additional 10.9% had perennial symptoms. The measurement of Pecan tree pollen during this period, May, showed that the pollen grains comprised 70% of the total airborne grains (2).

Further studies in Monclova, Mexico, (4) and in a rural kibbutz community (Netzer Sereni) in Israel (5) have confirmed the allergenicity of Pecan tree pollen. Of 247 patients evaluated in Monclova, Mexico, 4.8% were skin test-positive for Pecan pollen (6). Pollen from this tree has also been documented in aerobiological surveys in Caxias do Sul in southern Brazil (7).

In a study in St. Louis, Missouri, USA, skin test results indicated that Box elder, Willow and Pecan elicited the highest number of allergic reactions (8). Three hundred and seventy-one allergy patients were tested serologically for hypersensitivity to prevalent tree pollens in the area surrounding New York. The highest prevalences of hypersensitivity were for Oak (34.3%), Birch (32.9%), Box elder (32.8%), and Pecan tree (27.1%) tree pollens (9). In a study that examined aeroallergen sensitisation rates in children of the military in Texas undergoing skin testing for rhinitis, of 209 patients, 27.8% were skin test-positive for Pecan tree pollen (10).

Other reactions

Some plants rooted near or under Hickory/ Pecan trees tend to yellow, wilt, and die. This occurs because these trees produce a non-toxic, colourless chemical called hydrojuglone. Hydrojuglone is found in the leaves, stems, fruit hulls, inner bark and roots. When exposed to air or soil compounds, hydrojuglone is oxidized into juglone, which is highly toxic. However, Hickory, Pecan tree and English walnut produce juglone in small amounts, as compared to Black walnut.

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t217 Peppertree

Schinus molle

Family: *Anacardiaceae*

Common names: Brazil peppertree, California pepper tree, Molle, Pepper tree, Peruvian peppertree, Schinus, Peruvian mastic tree, American pepper, False pepper

Source material: Pollen

Not to be confused with the West African peppertree (*Xylopia aethiopica*)

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Allergen Exposure

Geographical distribution

Peppertree is a member of the family *Anacardiaceae*, which includes plants in the genus *Rhus* (*syn. Toxicodendron*; poison ivy, Sicilian sumac tree, poison oak, poison sumac), *Anacardium* (Cashew nut), *Mangifera* (Mango), *Schinus* (Peppertree, piru), and *Pistacia* (Pistachio).

The Peppertree is native to Brazil, Peru, Uruguay, Paraguay, and North Argentina. It has become naturalised in semi-tropical and tropical parts of the United States, and has been planted in many parts of the world.

The Peppertree is an evergreen reaching 6 to 12 m in height, with light, weeping foliage. It has a rounded crown with drooping branches, an effect much like that of Weeping willow. The trunk is short, with bark that is light-brown, peeling, and rough-textured, becoming gnarled and furrowed with an attractive, irregular branching pattern as the tree ages. A milky sap, turning to sticky latex, forms if the bark is damaged. The leaves are light-green and are slightly curved at the tip, with a peppery smell if crushed. The Pepper tree has shallow roots that crack pavements and damage sewers.

The scented flowers are dioecious (individual flowers are either male or female, but only one sex is to be found on any one plant). Drooping 10 to 15 cm-long clusters of tiny yellowish-white flowers appear in summer, followed by clusters of rose-coloured, 6 mm, dry, shiny berries appearing in autumn on female trees and remaining attached in winter.

The Peppertree was introduced as an ornamental into Florida, USA, where it has become an invasive tree (1).

Environment

The tree grows in forests and gardens and has been planted along streets and highways.

Allergens

No allergens from this plant have yet been characterised.

Potential cross-reactivity

An extensive cross-reactivity among the different individual species of the genus, and to a certain degree among members of the family *Anarcardiaceae* (including Cashew nut, Mango, Pistachio nut, poison ivy and poison sumac), could be expected (2).

Cross-reactivity has been demonstrated between Mango tree pollen and Peppertree pollen (3).

Clinical Experience

IgE-mediated reactions

Pollens from the Peppertree can induce asthma, allergic rhinitis and allergic conjunctivitis (3).

In a study of 71 subjects of both sexes, aged from 14 to 40 years, 31% were found to be sensitised to Peppertree pollen, as measured by skin prick testing. All subjects who tested positive were sensitised to Mango tree pollen (*Magnifera indica*) as well (3).

Other reactions

Virtually all parts of this tree, including the trunk, leaves, and fruit, have been used in home medicines from Mexico to South America. The dried and roasted berries are used as a Pepper substitute. The essential oil from the fresh leaves of *S. molle* has been shown to be efficacious against a range of bacteria (4).

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t213 Pine

Pinus radiata

Family: *Pinaceae*

Common names: Pine tree, Monterey pine, Radiata pine

Source material: Pollen

See also: White pine tree (*Pinus strobus*) t16

P. radiata should not to be confused with the Australian pine (*Casuarina equisetifolia*) t73 or White pine (*Pinus strobus*) t16

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Allergen Exposure

Geographical distribution

Pine tree is a common name for a family of coniferous trees, of widespread distribution in northern temperate areas. Of the 100 different species included in the genus, almost all are found in the Northern Hemisphere. *P. radiata* has become the most important in the Southern Hemisphere. Family members include the Douglas fir tree (*Pseudotsuga taxifolia*), the Spruce tree (*Picea excelsa*), and the White pine tree (*Pinus strobus*), which is native to northeastern North America. Pines can be divided into 2 groups, hard Pines and soft Pines.

The Pine tree is an evergreen reaching a height of 15-35 m, with upward-pointing branches and a rounded top. The outer bark is narrowly ridged, and the inner bark is resinous. The leaves ("needles") are bright green, occur in clusters of 3, and are 10-15 cm long with blunt tips. They persist on the tree for approximately 3 years. Cones are 7.5-14 cm long, brown, egg-shaped, and usually set asymmetrically on a branch; they are attached at an oblique angle (1). The Pine tree can live for 90 years.

Most *Pinus* species flower in early summer. The male and female flowers are separate but on the same tree. Pollination occurs from January to February in the Northern Hemisphere, but may be extended due to high temperatures. The pollen count is often high, but the pollen grains are large; this is a possible reason for the low induction of sensitisation. Cones are produced annually. They may remain closed for several years, depending upon temperature and humidity.

Environment

Pines grow in a wide range of habitats, from sea level to altitudes of 2,400 m in Europe. The climate where Pine trees grow best is humid with mild temperatures year-round. The optimum soil is an acidic, deep, sandy loam with a clay layer.

Allergens

To date, 5 allergenic proteins have been detected: of 82 kDa, 67 kDa, 54 kDa, 44 kDa, and 38 kDa (2).

Potential cross-reactivity

A high cross-reactivity among *P. nigra*, *P. sylvestris*, *P. radiata* and *P. strobus* has been demonstrated using ImmunoCAP® RAST inhibition (3).

IgE studies have demonstrated that pollen extracts from Olive, Birch, Mugwort, Pine, and Cypress contain proteins that share common epitopes recognisable by sera from Olive-allergic individuals (4). The possibility of cross-reactivity between *Pinus* and Rye grass (*Lolium perenne*) has also been suggested (2). Enzyme immunoassay inhibition studies have revealed that leached *P. radiata* pollen proteins could partially inhibit serum IgE binding to Rye grass-specific IgE. This provides preliminary evidence for allergen cross-reactivity between these 2 unrelated species (5).

Importantly, allergy to Pine nuts (*P. edulis*) can occur with no symptoms of sensitisation to Pine pollen. Immunoblot experiments have demonstrated the presence of IgE antibodies in serum against several components of Pine nuts and pollen, and some cross-reacting components were found. The authors of this study suggest that development of Pine pollinosis may require a longer period of exposure to allergens, but that given the cross-reactivity between Pine nut and Pine pollen extracts, co-sensitisation to these 2 allergens is possible (6).

Clinical Experience

IgE-mediated reactions

Pine tree pollen may cause asthma, allergic rhinitis and allergic conjunctivitis.

Pinus pollen allergy has been generally considered to be rare and clinically insignificant. Although Pine pollen is released in large quantities, IgE-sensitisation to it occurs in only 1.5% to 3% of atopic patients, according to studies from northern Arizona and France (7-8). This has been thought to be due to the large size of the pollen from this tree.

However, a Spanish study suggests that Pine tree pollen is a significant pollen aeroallergen and should be considered in assessment of pollen-allergic individuals. In the study, *Pinus* pollen (in this instance, *P. pinaster* and *P. radiata*) was shown to be among the predominant pollens in an area of Spain. The majority of patients were monosensitisated to *Pinus* pollen and suffered from seasonal rhinoconjunctivitis (9). The sensitising Pine pollen seemed to depend on which species of Pine tree was present in the vicinity.

In the city of Vigo, Spain, several patients have tested positive for *Pinus* pollen extract in skin tests, and some were monosensitive. An aerobiological study conducted in this region showed that *Pinus* has high quantitative importance in the airborne pollen spectrum of the city, constituting 13%-20% of the total annual pollen. Data also demonstrated that the tree has a very long pollination period, from the middle of January until May. At the end of the pollination period, there was a final increase in *Pinus* pollen concentrations, coinciding with the pollination of *P. silvestris*, which is more abundant in mountainous areas far from the city (10).

In a study in Portugal of aeroallergen sensitisation in an allergic paediatric population of 557 patients, sensitisation to *P. radiata* was found in 7.5% (11). Other studies have demonstrated *Pinus* pollen to be a significant contributor to pollen in the air. In Vinkovci, in northeastern Croatia, *Pinus* pollen was among the top 10 contributors of 58 pollen types studied (12). *Pinus* pollen has been found to be the fifth-most-prevalent pollen in the air in Plasencia, Spain (13). Similarly, in studies in Estepona, on the "Costa del Sol" of southern Spain, *Pinus* pollen was found to be a significant contributor to the pollen count (14).

In an aerobiology study in Zagreb, Croatia, *Pinus* pollen was also reported to be a significant pollen (15). In a study in Split on the Croatian Adriatic, high pollen concentrations from the closely related genus member *P. halepensis* were demonstrated (16). An atmospheric survey of the east-Mediterranean coast of Turkey found that the most prominent tree pollens were *Cupressaceae*, *Eucalyptus*, and *Pinus*. The most common herb pollen was from the *Chenopodiaceae* family (17).

In an Indian study, the All India Coordinated Project on Aeroallergens and Human Health, undertaken to evaluate the prevalence of aeroallergens at 18 different centres in the country, it was found that *Pinus* pollen was among the predominant airborne pollens (18).

In contrast to the rarity of sensitisation from Pine pollen, workers processing Pine in sawmills showed a very high frequency of IgE sensitisation to the extract of Pine wood dust. This frequency was significantly greater than that of the sensitisation to Oak in workers processing Oak (19). Airborne allergic contact dermatitis from Pine dust has been documented (20).

Occupational asthma, lung function deficits, and elevated levels of respiratory symptoms may occur in workers exposed to wood dust, but these symptoms may not necessarily be IgE-mediated, as other naturally occurring substances in Pine trees may be operative (21). Reactions to these substances may be either IgE-mediated or irritant in nature.

In a study of Pine sawmill workers, results showed that exposure to green Pine sawdust may be a risk factor for atopy. Both green and dry dust were associated with obstructive as well as restrictive pulmonary effects (22).

Other reactions

Colophony (or rosin), usually derived from Pine trees, is a complex mixture of over 100 compounds and has many domestic, industrial and commercial applications. Exposure to colophony and modified colophony is common, though not as common as previously, because of replacement of the substance by plastics in many instances. Allergic reactions are usually of the delayed type. Colophony is, in particular, among the top 10 causes of contact dermatitis (23), and among the most common causes of occupational asthma (24).

Allergic reactions to a caterpillar (*Thaumetopoea pityocampa*) have been documented among occasional visitors to Pine tree plantations, and in particular among Pine forest workers. Dermatitis and ocular lesions may occur through an IgE, mechanical or toxic route. Allergists should take this insect into consideration when evaluating adverse reactions to Pine tree (25).

Allergic alveolitis from Pine sawdust has been reported (26).

In a study of workers in the Danish furniture industry, sensitisation to Pine wood dust was demonstrated with Pine-specific IgE tests in 11 exposed and 3 non-exposed subjects. In the group with clinically defined asthma, 8 (5.4%) individuals were shown to have Pine-specific IgE, compared with 6 (1.8%) in the group without asthma. In the groups with and without respiratory symptoms, 13 (3.8%) and 1 (0.7%) subjects, respectively, had Pine-specific IgE (27).

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t210 Privet

Ligustrum vulgare

Family: *Oleaceae*

Common names: Privet tree, Wild privet, Common privet, European privet

Source material: Pollen

There are 4 important genera in the *Oleaceae* family: Olive (*Olea*), Ash (*Fraxinus*), Lilac (*Syringa*), and Privet (*Ligustrum*)

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Allergen Exposure

Geographical distribution

The genus *Ligustrum* (Privet) comprises around 20 species, subspecies and varieties. Seven of these species are native to India, and others to Europe, Asia, and northern Africa. Privet trees are naturalised in Australia and the eastern half of North America. They are now used extensively as ornamentals in urban environments.

The Privet is a semi-evergreen or deciduous shrub growing 3 to 5 m in height. The smooth bark is grey-brown. The plant is highly branched but quite irregular in shape if not sheared. The stems are stiff and erect, with grey-brown bark spotted with small brown lenticels. Leaves are dark-green and turn purplish in autumn.

It flowers from June to July in the Northern Hemisphere. The 2.5 to 7.5 cm white flowers are hermaphrodite (have both male and female organs) and are pollinated by insects. They are produced in panicles 3 to 6 cm long; each flower is creamy-white, with a tubular base and a 4-lobed corolla (4 petals) 4 to 6 mm in diameter. The flowers produce a strong, sweet fragrance that many people find unpleasant (1). The flowers are often sheared off in early summer, which releases their strong odour. The fruit is a glossy blackberry 8 mm in size, and ripens from September to October. The berries are poisonous to humans but readily eaten by birds.

Environment

The tree is found in woodland, sunny edges, and dappled shade, and is grown as a hedge. The related *L. ovalifolium* is a very popular garden-separating hedge.

This tree has been used in basketry, to make ink and dye, and for charcoal. A yellow dye is obtained from the leaves, and a bluish-green to black one from the berries.

Allergens

Privet pollen contains allergens of approximately 20, 18-19, 40 and 70 kDa (2-3), but only Lig v 1 (4-8) has been characterised to date.

A profilin has been isolated (9).

Potential cross-reactivity

An extensive cross-reactivity among the different individual species of the genus could be expected, as well as to some degree among members of the *Oleaceae* family (10).

The main allergen of Olive tree (*O. europaea*), Ole e 1, has been shown to be present in other species of the *Oleaceae* family: White ash (*Fraxinus excelsior*), Privet (*L. vulgare*), and Lilac (*Syringa vulgaris*) (4). Allergens with apparent molecular weights of 49.6, 40, 36.7, 19.7, 16.7, and 14 kDa seem to be relevant (11). Studies have demonstrated that Lig v 1 plays a major role in cross-reactivity among these trees. Recombinant Fra e 1 from White ash tree has been shown to exhibit 82%, 88%, and 91% identity with

Syr v 1 from Lilac tree, Ole e 1 from Olive tree, and Lig v 1 from Privet tree, respectively (12). These results are consistent with those of other authors (3,6-7,13). Further studies have confirmed the high degree of cross-reactivity among these 3 plants, and *Phillyrea angustifolia*, a common bush, although the allergens in the 4 species were not identical (14).

Che a 1 from Goosefoot grass has a sequence similarity of 27 to 45% with known members of the Ole e 1-like protein family (15). The significance of this potential cross-reactivity was not evaluated.

A profilin has been inferred from a study of Che a 2 and was shown to have high degrees of inhibition with profilin from pollen of other plants, *e.g.*, Russian thistle (91%), Olive (96%), Privet (95%), Ash (95%), Lilac (93%), and Birch (94%) (9).

Profilin may be responsible for evidence of cross-reactivity between Privet tree pollen and other pollens where the responsible allergen was not identified.

In 103 atopic subjects in Michigan, USA, cross-reactivity among Olive tree, White ash, Privet and Russian olive tree pollen was demonstrated, even though the Olive tree does not grow in that area. Nineteen subjects were skin-prick positive to this allergen, confirming the cross-reactivity (16).

It has been reported that pollen from the Olive tree and Privet are cross-reactive with grass pollen from the *Poaceae* family (2).

Clinical Experience

IgE-mediated reactions

Privet pollen can induce asthma, allergic rhinitis and allergic conjunctivitis (17).

Privet is said not to be an important allergenic plant, as pollination is mainly by insects and pollen is not found in high levels in the air. However, as studies have demonstrated the high degree of cross-reactivity among Privet and other commonly occurring highly allergenic trees of the *Oleaceae* family, including Olive (*Olea*), Ash (*Fraxinus*), and Lilac (*Syringa*) (14), pollen-allergic individuals should be investigated for possible sensitisation to this allergen.

Authors have argued that, while Privet pollen may not account for high levels of the annual total of daily pollen concentrations measured in a city, in areas where these trees are widely used as ornamentals, the amounts accumulating may be high enough to cause allergy symptoms. Released Privet pollen grains have a short dispersal range, as a result of both the entomophilous nature of the plant and the large size of the pollen grains. In areas where Olive trees are prevalent, the last stages of the flowering period of Privet may overlap with the flowering period of Olive trees, and because the 2 pollen types share allergens, there may be a cross-reaction between Olive tree pollen and Privet pollen. It is therefore useful to test for Privet pollen sensitisation in areas where it is found concurrent with Olive tree (18). In Northern and Central Europe, where the Olive tree is not extensively cultivated, and where White ash tree and Privet are grown, positive specific IgE sensitisation tests for Olive tree may in fact indicate Privet sensitisation, as a result of cross-reactivity (17,19).

In a New Zealand study of 20 subjects, airway responsiveness (PD_{20} histamine) was shown to be significantly greater during the Privet flowering season. Symptom scores and bronchodilator use were higher, and peak expiratory flow rates lower, during the Privet-flowering season, but the changes were small and not statistically significant. Seventeen subjects had bronchial challenge studies performed on them; there were no isolated early responses, but 6 had late asthmatic responses. Eleven had no airway bronchial constrictor responses to challenge with either of the 2 local varieties of Privet. The authors pointed out that, although significant increases in airway responsiveness occur during the Privet flowering season, only a portion of this highly select group had a constrictor response to direct challenge (20).

A number of studies have demonstrated the presence of Privet pollen in the air of a city or region: in Salamanca in Spain (21), Huelva in southwestern Spain (with Privet pollen comprising 86% of the pollen measured) (22), and Tucson, Arizona (23). Authors have pointed out that in warmer regions of North America, many newly introduced plants, including Privet, Olive tree and Schinus, are cultivated widely, while others have become aggressive naturalised weeds (24).

Other reactions

Consumption of the fruit may result in vomiting (25).

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Syagrus romanzoffiana

Family: *Arecaceae*

Synonyms: *Arecastrum romanzoffianum*, *Cocos plumose* (previous nomenclature), *Syagrus romanzoffianum*

Source material: Pollen

Not to be confused with other commonly grown Palms: Mexican fan palm (*Washingtonia robusta*), California fan palm (*Washingtonia filifera*), and the Date palm (*Phoenix dactylifera*)

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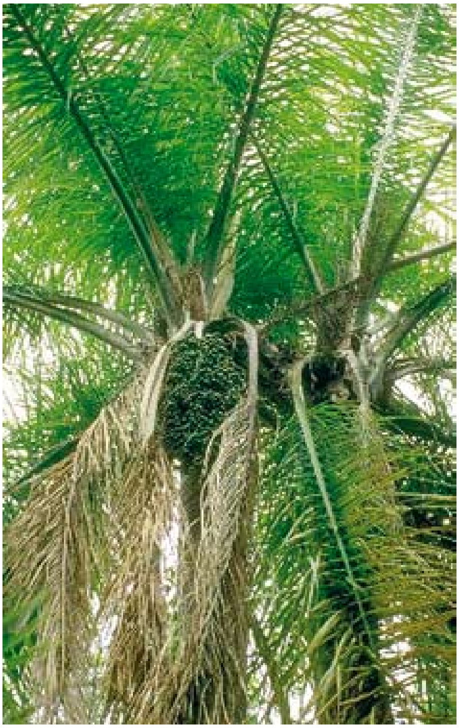

Allergen Exposure

Geographical distribution

Syagrus is a genus of 30 to 42 species of the family *Arecaceae* (Palms). These are native to South America, with a single species endemic to the Lesser Antilles. The genus is closely related to the *Cocos* or Coconut genus, and many *Syagrus* species produce edible seeds similar to the Coconut.

The Queen palm is a graceful, fast-growing Palm, native to Brazil, Paraguay and northern Argentina. It is now often found planted in courtyards, rows or groves in tropical climates all over the world. It is popular because it does not drop litter as Fan and Date palms do.

The Queen palm is an evergreen that can grow to 17 m. The single trunk is exceptionally straight, with a smooth bark banded with dark and light grey. The leaves are graceful and arching, whereas King Palm leaves are rather rigid. The leaves are grey-green in colour, pinnate, and arranged in a whorled pattern. The leaves typically grow 3.3 to 5 m long.

The small flowers are cream to yellow in colour. Succulent, indehiscent, 2.5 cm date-like fruits, green to orange in colour, are produced from summer to early winter.

Allergens

No allergens from this plant have yet been characterised.

Potential cross-reactivity

An extensive cross-reactivity among the different individual species of the genus could be expected, as well as to a certain degree among members of the family *Arecaceae* (1).

Clinical Experience

IgE-mediated reactions

Anecdotal evidence suggests that asthma, allergic rhinitis and allergic conjunctivitis, similar to reactions caused by other members of this family, are possible following exposure to pollen from this tree; however, few specific studies have been reported to date.

t72 Queen palm

The objective of a study was to examine aeroallergen sensitisation rates among children of the military in Texas who were undergoing skin testing for rhinitis, and to investigate the timing of atopic development in relation to perennial and seasonal allergens. A total of 345 children underwent testing to a 51-allergen panel. A total of 80.3% had at least 1 positive test result, and the average number of positive test results was 11.4. The most common active allergens were grasses, *Alternaria*, and Cottonwood. Thirty-two of 51 allergens were positive in 20% or more children. Sixteen percent of the children were skin prick-positive for Queen palm (2).

The daily pollen concentration in the atmosphere of Badajoz, in southwestern Spain, over a 6-year period demonstrated the presence of *Arecaceae spp*. (3).

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Juniperus virginiana

Family: *Cupressaceae*

Common names: Eastern red cedar, Eastern red cedar, Red cedar juniper, Red savin, Eastern juniper, Red juniper, Pencil cedar, Carolina cedar

Source material: Pollen

See also: Mountain juniper (*Juniperus sabinoides* syn. *J. ashei*) t6

To be differentiated from the following "Cedar" trees:

Western red cedar tree (*Thuja plicata*)

Eastern white cedar (T*huja; Thuja occidentalis*)

Cedar tree (Incense cedar; *Libocedrus decurrens*) t212

Japanese cedar tree (Sugi tree; *Cryptomeria japonica*) t17

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Allergen Exposure

Geographical distribution

The *Cupressaceae* family (16 genera and 140 species) is widely distributed throughout the world. The Cypresses are composed of 6 genera, and all are rather closely related: *Cupressus* (Cypresses), *Juniperus* (Junipers), *Thuja* (White cedars or *Arborvitae*), *Libocedrus* (Incense cedar), *Chamaecyparis*, and *Callitris*. They are distinguished by their small opposite or whorled leaves, which are usually scale-like, and their small pistillate cones with few scales. The pollen grains of this group are extremely uniform and spheroidal in form.

The Italian cypress tree (*Cupressus sempervirens*) is the most abundant plant in the Mediterranean area, followed by the Arizona cypress. The *Juniperus* genus is represented by Red cedar (*J. virginiana*), Mountain cedar (*J. ashei*), Prickly juniper (*J. oxycedrus*), and Juniper berry (*J. communis*).

There are approximately 60 species of Juniperus shrubs and small trees scattered throughout the Northern Hemisphere and the high mountains of the tropics. Red cedar (*J. virginiana*) is native to North America east of the Great Plains, from southeastern Canada to the Gulf of Mexico. Red cedar is a form of Cypress tree, not a true Cedar (genus *Cedrus*) but a variety of Juniper. Red cedar is the most abundant Juniper in all of the eastern United States and southeastern Ontario, appearing in fields and pastures and dry rocky places (1). Further west, it is replaced by the related Rocky Mountain juniper (*J. scopulorum*), and to the southwest by Mountain cedar tree (Ashe juniper) (*J. ashei*). (2).

In the USA, Mountain cedar (*J. sabinoides*) is a major cause of seasonal allergy in Texas and elsewhere in the Southwest. In Europe, this species is present only in the Balkan peninsula and the Crimean mountains (3-4).

Red cedar is a dense, evergreen, slow-growing tree that on poor soil may never become more than a bush. It grows about 5-20 m in height, with a trunk 30-100 cm in diameter. The bark is reddish-brown, thin, and fibrous, and peels off in narrow strips. The heartwood is bright purple-red to dull red; the sapwood is white. The sapwood develops a brownish tint in winter in the north and is sometimes used in windbreaks or screens.

Leaves are of 2 types: sharp, spreading, needle-like juvenile leaves 5-10 mm long, and tightly pressed scale-like adult leaves 2-4 mm long; they are arranged in opposite decussate pairs, or occasionally in whorls of three. The juvenile leaves are found on plants up to 3 years old and as scattered shoots on adult trees, usually in shade (2).

The seed and pollen cones are found on separate trees (dioecious reproduction). The seed cones are 3-7 mm long and berry-like, with fleshy scales, and ripen into dark purple-blue with a white wax cover, giving an overall sky-blue colour (though the wax often rubs off). They contain 1 or 2 (rarely up to 4) seeds and are mature in 6-8 months from pollination. The fruit is ornamental when produced in quantity. Birds eating the fruit may "plant" it along farm fences and in abandoned fields.

The pollen cones are 2–3 mm long and 1.5 mm broad, shedding pollen in late winter or early spring. Pollination is entirely by wind. *J. virginiana* is a weak pollen producer compared with the notorious Mountain cedars (*J. ashei* and *J. scopulorum*), with their enormous pollen loads. However, it is still a significant cause of early spring hayfever, and occasionally asthma, in the southeastern states (1).

Environment

Red cedar wood is highly aromatic. It is used for pencils, posts, veneers, panelling, and clothes chests. Its oil may be used for the essence of soap and for use in microscopy. Red cedar and its oil were found to be effective for killing and repelling house dust-mites. (5) Juniper berries have a sweetish, resinous taste and are used for flavouring foods or gin.

Allergens

The following allergens have been characterised:

Jun v 1, a pectate lyase (6-7).

Jun v 3, a thaumatin, a PR-5 protein (6-7).

Jun v 4 (7).

Jun v 1 was shown to be highly homologous to the allergens of the Cedar pollens. Jun v 3 was also shown to be highly homologous to its counterpart in Mountain cedar (Jun a 3), but with some epitope differences. The findings of the study suggested that mutations in the genes or post-translational modifications may explain why Red cedar pollen is reported to be less allergenic than those of other members of the *Cupressaceae* and *Taxodiaceae* families (7).

Potential cross-reactivity

The group 1 allergens of other "Cedar" trees are reported to be a major cause of pollen hypersensitivity in several geographic areas, and allergens from several taxa have been shown to cross-react. Although cross-reactivity of Red cedar has not been elucidated, an inference of cross-reactivity with other pollens may be made from knowledge of its closely related genus member, Mountain cedar. For example, cross-reactivity has been reported between the group 1 allergen from Mountain cedar (Jun a 1) and Japanese cedar (Cry j 1) (8). High cross-reactivity (75-90% homology) has been reported between Cup a 1 (*C. arizonica*), Cha o 1 of Japanese cypress (*Chamaecyparis obtuse*) and Jun a 1, the major allergen of Mountain cedar; all have an active pectase lyase site (9). The authors concluded that the high degree of homology of Jun a 1 with Cha o 1 and Cry j 1 may explain the cross-reactivity of conifer pollens (10).

Similarly, Cup a 3 from *C. arizonica*, a thaumatin-like, pathogenesis-related protein (11), was shown to have a high homology with Jun a 3 from Mountain cedar (12).

Clinical Experience

IgE-mediated reactions

Although only sparse reports document sensitisation to Red cedar, anecdotal evidence suggests that asthma and hayfever are possible following exposure to pollen from this tree. Red cedar has been reported to be a significant cause of early spring hayfever, and occasionally asthma, in the southeastern states of the USA (1).

"Cedar" pollens may also be significant allergens in areas where they are prevalent but their effects have not been suspected. Red cedar and White cedar (*Thuja occidentalis*) are common plants in western New York

State. In an examination of skin test results from 158 patients with asthma, rhinitis, or both, 102 had positive skin tests to at least 1 pollen. Among those, 52 patients (51%) had positive skin tests to at least 1 of the Cedar pollens. Patients sensitive on skin testing to Cedar pollen were very likely to be sensitive to deciduous tree, grass, or Ragweed pollen. The authors stated that sensitivity on skin testing to indigenous Cedar pollens was common in this region and therefore could be clinically significant (13).

Other reactions

Juniper tar (cade oil) is distilled from the wood of the Prickly juniper tree (*J. oxycedrus*) and contains etheric oils, triterpene and phenols. It is used for many purposes in folk medicine. An individual who ingested a spoonful of homemade Juniper tar developed fever, severe hypotension, renal failure, hepatotoxicity, and severe cutaneous burns on the face. (14) Whether a similar result would occur from Red cedar is unknown.

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t71 Red mulberry

Morus rubra	
Family:	*Moraceae*
Source material:	Pollen
See also:	Mulberry (*M. alba*) t70

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Allergen Exposure

Geographical distribution

Trees and shrubs of *Moraceae* are primarily tropical, with temperate trees represented by Morus, Broussonetia, and Maclura (1).

The Mulberries, comprising about 10 species, are monoecious or dioecious trees or shrubs. They bear the staminate and pistillate flowers on different branches of the same tree or on different trees; these flowers are minute, and the staminate ones are in elongated cylindric spikes (2). The origins of the Mulberry tree (*M. alba*) are in China, Japan, Thailand and Malaysia. The tree is now found throughout the world. Only 2 species are native to North America, but several others have been introduced.

The Red mulberry (*M. rubra*), closely related to the Mulberry or White mulberry tree (*M. alba*), is native to eastern North America, from southernmost Ontario and Vermont south to southern Florida and west to southeast South Dakota and central Texas (3-4). The White mulberry (*M. alba*) is a native of China, where it is grown for feeding silkworms. It is also widely cultivated in the United States and Canada, occurring in fruit-bearing and ornamental varieties (2). Paper mulberry, *B. papyrifera* is native to Asia but grown elsewhere, including the USA. *M. alba* and *B. papyrifera* have a predilection for warmer regions, extending to the US West Coast (1).

Red mulberry is a medium-sized deciduous tree, growing 10-15 m tall and with a trunk up to 50 cm in diameter. It may, rarely, reach 20 m in height. The leaves are variable but usually alternate, 7-14 cm long, 6-12 cm broad, simple, broadly cordate, with a shallow notch at the base, unlobed on mature trees, often with 2-3 lobes on young trees, and with a finely serrated margin (1,3). Red mulberry leaves are a deeper bluish green, and *M. alba* a lighter green (1.2).

Female and male flowers are found on dense catkins, on the same or separate trees. Pollination for most Mulberries is in April and May, beginning in March in the southern states, and later, extending into June, in the northern states (1,4-5). Each male flower has 4 stamens bent inward in the bud but straightening elastically and becoming exserted at maturity. They shed large amounts of pollen, which is occasionally the cause of hayfever.

The fruit is a compound cluster of several small drupes, similar in appearance to a Blackberry but somewhat elongated, 2-3 cm long, red ripening to dark purple, edible and very sweet. The fruit ripens in June or July.

Allergens

No allergens have yet been characterised.

Potential cross-reactivity

An extensive cross-reactivity among the different individual species of the genus could be expected (6) but is largely unstudied (7). *Morus* members are felt to be essentially identical based on skin test similarities, and *B. papyrifera* pollen was reported to "interact almost perfectly" with other Mulberry pollens (1-2).

Clinical Experience

IgE-mediated reactions

Mulberry tree was reported to induce severe hayfever, but asthma was not reported (2,8). Anecdotal evidence suggests that asthma and hayfever are possible following exposure to pollen from this tree; however, no specific studies have been reported to date.

Mulberry has been reported to be a major problem in Tucson, Arizona, a city that has a high prevalence of allergic rhinitis and asthma (9).

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t54 Russian olive

Elaeagnus angustifolia

Family: *Elaeagnaceae*

Common names: Russian olive, Russian silverberry, Oleaster, Silverberry

Source material: Pollen

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Allergen Exposure

Geographical distribution

The Russian olive tree is a member of the family *Eleagnaceae*. The tree is native to Europe and western Asia. The genus *Elaeagnus* comprises roughly 40 species of shrubs and small trees. Only Silverberry, *Elaeagnus comutata*, is native to North America; it is found primarily in eastern Canada. Buffaloberries, *Shepherdia spp*., are other native *Elaeagnaceae* family members found across Canada and extending down into the western United States (1-3).

The Russian olive tree was introduced into North America in the late 1800s. It was frequently planted on the Great Plains in rows for windbreaks (1), and was subsequently naturalised into the wild. The tree has invaded zones along watercourses in many arid and semiarid regions of the world. It is also used as an ornamental tree in many European cities for its gray foliage and tolerance of salty soil (4).

It is a tall shrub or small tree, 5 to 8 m in height, erect or (frequently) leaning, twisted, or distorted. It has low branches and an open crown. The branches are reddish brown, with 2- to 5-cm thorns. The leaves are alternate, 5 to 8 cm long, narrow, and light-green on top. The stems, buds, and the under surface of the leaves have a dense covering of minute, silvery to rust-coloured scales (5).

The flowers are 4-lobed, 1 cm long, yellow within and silvery gray outside, and very fragrant and rich in honey. They are produced in clusters of 1-3. The fruit is a small cherry-like drupe, 1-1.5 cm long, orange-brown and covered in silvery scales (5). The fruit is edible and sweet, with a dryish, mealy texture.

Although the tree is pollinated mainly by insects, Russian olive pollen can be identified in air samples, especially during the May to June pollination season, and skin test positivity to *Elaeagnus* has been demonstrated in hayfever patients in both the Midwest and West of the US (1,4).

In Madrid, Spain, the pollination of Russian olive occurs from May to June, coinciding with the pollination period of Olive trees and grasses. Pollen counts of Russian olive at local pollen stations may be low, but must be considered in the context of the relatively large size of the pollen in comparison with other allergenic pollens such as grass or Olive (4). Although a city or other area may not be widely planted with this tree, the local distribution of the pollen may severely affect sensitised individuals.

Environment

In Europe, the fruits, called ”Trebizond grapes,” are dried and used in cake-making. The wood is hard and fine-grained (1).

Allergens

In a study of 134 patients in Madrid, major IgE-binding bands in Russian olive extract, with molecular weights of 37, 43, 63.7 and 77.4 kDa, were recognised in 40%, 65%, 50% and 45% of patients, respectively (4).

No allergens have been characterised to date.

Potential cross-reactivity

In 103 Michigan residents with symptoms suggestive of allergic rhinitis or asthma, who were skin-tested with Olive tree (*Olea europaea*) pollen extract, 19 had positive reactions. As the Olive tree is not present in this area, an evaluation was made as to whether these findings were the result of cross-reactivity among the tree pollen allergens from Olive, Ash (*Fraxinus americana*), Privet (*Ligustrum vulgare*), and Russian olive. On ELISA testing, 11 of the 19 skin-test-positive patients were Olive positive, 8 were positive to Ash, 7 to Privet and 10 to Russian olive, and inhibition studies demonstrated that all 3 of these tree pollens were capable of inhibiting the binding of IgE in a dose-response fashion. Several proteins common to Olive, Ash, and Privet were demonstrated. Of the 12 Olive skin-test-positive patients contacted, 75% confirmed exposure to 1 or more of the studied trees in their yards (6).

In a study conducted in Madrid, Spain, all patients with a positive skin test to Russian olive were also positive to Olive; but not all Olive-positive patients were positive to Russian olive. In inhibition studies, the Russian olive extract was not able to inhibit Olive, whereas an Olive extract inhibited Russian olive by up to 41%, establishing minimal to moderate cross-reactivity between Olive tree and Russian olive tree, but not excluding cosensitisation. The presence of Ole e 1- and Ole e 4-like allergens in Russian olive tree extract was confirmed (4,7).

Clinical Experience

IgE-mediated reactions

Although only sparse reports document sensitisation to Russian olive tree, anecdotal evidence suggests that asthma and hayfever are possible following exposure to pollen from this tree (1,4-5).

In a study of 134 patients in Madrid with rhinoconjunctivitis and/or asthma, 73 (30.5%) were found to have a positive skin test to Russian olive tree, and all were positive to Olive (*Olea europaea*) as well. A nasal challenge with Russian olive tree was positive in 3 of 6 patients with a positive skin test to both pollens, and negative in 5 patients with a positive skin test to Olive tree only (4).

It has been suggested that a positive skin test to Olive pollen in regions where Olive trees are not present may be due to a sensitisation to Russian olive or other cross-reactive pollens (5).

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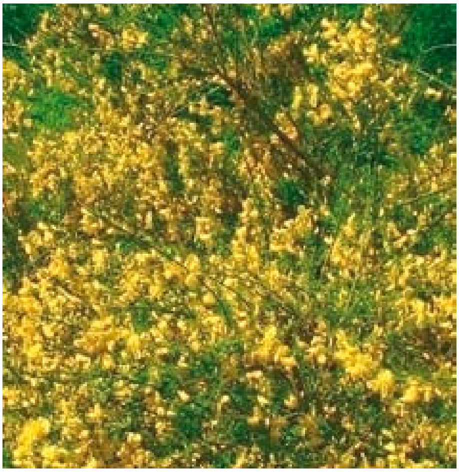
t55 Scotch broom



Cytisus scoparius

Family: *Fabaceae* (*Leguminosae*)

Common names: Scotch broom, Common broom, English broom, Broom tops, Irish tops, Basam, Bisom, Bizzom, Browme, Brum, Breeam, Green broom

Synonym: *Sarothamnus scoparius*

Source material: Pollen

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Allergen Exposure

Geographical distribution

Scotch broom is a perennial, leguminous shrub native to western and central Europe, from the Iberian Peninsula north to the British Isles and southern Scandinavia, and east to Poland and Romania (1). It has been introduced into several other continents outside its native range and is classified as a noxious invasive species in many countries, including the US (on the East Coast and in the Pacific Northwest), South Africa, Australia and New Zealand. It typically grows to 1-3 m tall, with main stems up to 5 cm thick. It has green shoots with small deciduous trifoliate leaves 5-15 mm long. Its long, slender, erect and tough branches grow in large, close fascicles, making it apt for broom-making.

In spring and summer, it is covered in profuse golden-yellow flowers 20-30 mm long and 15-20 mm wide. In late summer, its seed pods mature, becoming black, 2-3 cm long, 8 mm broad and 2-3 mm thick; they burst open, often with an audible crack, spreading seed.

There are 2 subspecies. Scotch broom is widely cultivated as an ornamental plant.

Environment

The twigs and branches are used for making brooms and also for basket-work. Parts of the plant have been employed medicinally, and are thought to be diuretic and cathartic.

Allergens

No allergens have been characterised.

Potential cross-reactivity

Unknown

Clinical Experience

IgE-mediated reactions

Anecdotal evidence suggests that asthma and hayfever are possible following exposure to pollen from this plant; however, no studies have been reported to date.

Other reactions

Attempts have been made to develop biological controls in affected areas, using Broom-feeding insects, *e.g.*, the psyllid *Arytainilla spartiophylla*, the beetle *Bruchidius villosus*, and the moth *Leucoptera spartifoliella* (1). Since allergic reactions have been reported to these insects, they should be considered as potential allergens in individuals thought to be allergic to pollen from this plant, but in whom specific investigations are negative.

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Picea excelsa

Family: *Pinaceae*

Common names: Spruce tree, Norway Spruce, Red Fir, European Spruce

Synonym: *P. abies*

Source material: Pollen

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Allergen Exposure

Geographical distribution

Spruce refers to trees of the genus *Picea*, a genus of about 35 species of coniferous evergreen trees in the Family *Pinaceae*, indigenous to the Northern Hemisphere. They are similar to the *Fir* genus. They can be distinguished by their whorled branches and conical form. Spruce trees are native to northern Europe, from Scandinavia to the Alps.

Spruces are evergreen trees with pyramidal habits, whorled branches, and scaly bark, and occur farther north than most trees. The trunk is grey-brown to red-brown, with irregular, close scales. The foliage is dark green. The branches are drooping, and often touch the ground. The leaves are 4-sided, somewhat curved, and spirally arranged, but are not sharply pointed. The needles are shed when 4–10 years old, leaving the branches rough with the retained sterigmata (an easy means of distinguishing them from other similar genera, where the branches are fairly smooth) (1).

Flowers are monoecious (individual flowers are either male or female, but both sexes can be found on the same plant) and are produced in May. Fruit is a pendant cone, 10 - 15cm long, with numerous persistent scales. Male and female cones are borne on the ends of the previous year's growth. The cone of the Norway Spruce is the largest of all Spruce cones.

Environment

These trees are common in woodlands, and occasionally planted as landscape trees in cities. Spruce is one of the most important woods for paper manufacture, as it has long wood fibres which bind together to make strong paper. Spruce wood, often called whitewood, is used for many purposes, ranging from general construction work and crates to highly specialised uses in wooden aircraft and many musical instruments, including guitars, mandolins, cellos, violins, and the soundboard at the heart of a piano (1). The leaves and branches, or the essential oils, can be used to brew spruce beer.

Allergens

No allergens from this plant have yet been characterised.

t201 Spruce

Potential cross-reactivity

An extensive cross-reactivity among the different individual species of the genus could be expected as well as to a certain degree between members of the family *Pinaceae* (2).

Clinical Experience

IgE-mediated reactions

Anecdotal evidence suggests that asthma and hayfever are possible following exposure to pollen from this tree; however, few specific studies on this have been reported to date.

Occupational asthma, lung function deficits, and elevated levels of respiratory symptoms in workers exposed to the wood dust have been demonstrated (3).

A 20-year-old man who had had flexural atopic eczema until 11 years of age, developed facial eczema and swelling 2 months after working at a sawmill as a forklift operator with fresh-sawn Finnish pine (*Pinus sylvestris*), Spruce (*Picea abies*) and European white birch (*Betula pendula*) timber. Patch testing was positive to *Myroxylon pereirae* resin, colophonium, abietic acid, fragrance mix, pine saw- dust and spruce sawdust (4).

In a study evaluating the impact of different trees on asthma, and the association between daily hospitalizations for asthma and daily concentrations of different tree pollens in 10 large Canadian cities, found an increase in daily tree pollen concentration, and percent increases in daily hospitalization for asthma were 2.45% for the group containing *Pinaceae* (Pine, Fir, Spruce) (5).

Major aeroallergens in Anchorage, Alaska, are Birch, Alder, Poplar, Spruce, Grass pollen and *Cladosporium* (6). Pollen from *Picea spp.* has been reported to be a significant airborne pollen in Zagreb, Croatia (7).

Other reactions

Occupational allergic contact dermatitis (8-9).

Plasters made from Spruce balsam may cause redness, itching papules, and/or sensitive skin, even pustules and ulcers (10).

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Liquidambar styraciflua

Family: *Altingiaceae*

Common names: Sweet gum tree, American sweetgum, Redgum

Source material: Pollen

Two forms of Sweet gum tree are recognised in horticulture: the round-lobed American sweet gum, *L. styraciflua forma rotundiloba*; and the Weeping American sweet gum, *L. styraciflua forma pendula*

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Allergen Exposure

Geographical distribution

Sweet gum is native to North America and to scattered locations in northeastern and central Mexico, Guatemala, Belize, El Salvador, Honduras, and Nicaragua. Sweet gum has been introduced into California as well as southwestern British Columbia (1-2). It is now found planted all over the world.

Sweet gum is a large, long-lived, deciduous hardwood tree that grows 15 to 45 m in height. The bark is grey-brown and deeply, irregularly furrowed into narrow, scaly plates or ridges. Young Sweet gum trees have long conical crowns, while mature trees have crowns that are round and spreading. The tree is easily recognised by the long-petioled, star-shaped leaves, which have 5 long-pointed, saw-toothed lobes. In autumn the leaves turn various shades of red and yellow.

Sweet gum flowers appear from March to May. The tree is monoecious (individual flowers are either male or female, but both sexes can be found on the same plant), with the male flowers in several clusters on an upright raceme, and the female flowers borne on a slender stalk. Both kinds of flower are small, green in colour, and inconspicuous.

The brown, ball-shaped fruits ("gumballs"), 2.5 to 4 cm in diameter, ripen from September to November and persist throughout the winter. Sweet gum produces an abundance of lightweight seed. The seed is winged and dispersed by wind, mainly within 60 m but sometimes travelling up to 180 m away.

Environment

Sweet gum grows best on alluvial clay and loamy soils of river bottoms, but tolerates a wide variety of conditions.

Sweet gum is valued as a lawn and park tree, and is quite showy in the fall (1). But the tree is primarily used for lumber, veneer, and plywood.

Medicinally, Sweet gum is known as "Copalm balsam"; the resinous gum is used extensively in Mexico and Europe as a substitute for storax. Ointments and syrups are made from it. It is also used as a perfuming agent in soap.

t211 Sweet gum

Allergens

No allergens from this plant have yet been characterised.

Potential cross-reactivity

An extensive cross-reactivity among the different individual species of the genus could be expected (3).

Clinical Experience

IgE-mediated reactions

Sweet gum tree produces great quantities of anemophilous pollen, and although anecdotal evidence of allergic sensitisation has been reported, few cases have been documented. Some authors have felt that Sweet gum is a minor cause of hay fever (4-5), whereas others (6) have commented on its profuse pollen production and presented data on significant skin sensitisation in 325 patients in Alabama, California, and Florida. Asthma has not been reported (1).

In a study in Westchester County in the state of New York, out of 100 patients referred for allergic rhinitis, 65% had a positive skin prick test to at least 1 aeroallergen out of 48 in the test panel. Sweet gum was positive in 16 (7).

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t218 Virginia live oak

Quercus virginiana	
Family:	*Fagaceae*
Common names:	Virginia live oak, Southern Live Oak, Live oak, bay live oak, scrub live oak, plateau oak, plateau live oak, escarpment live oak, Encino
Source material:	Pollen
See also:	Oak (*Q. alba*) t7

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Allergen Exposure

Geographical distribution

Oaks, making up the genus *Quercus*, are abundant hardy trees of deciduous forests in North America, Europe, and Asia. There are approximately 500 to 600 species worldwide, 250 in the Western Hemisphere, more than 150 in Mexico, and 70 in the United States and Canada (1-2).

Virginia live oak tree is native to the southeastern United States, from Virginia to Florida and west to Texas. It is also found in Cuba and in isolated locales in Mexico.

Live oak is a long-lived, nearly evergreen tree. It has a variety of forms, from shrubby or dwarfed to large and spreading, depending upon the site. It drops its leaves and grows new leaves within several weeks in the spring. In some areas it is in leaf all year. Trees grown in the open average 15 to 20 m in height. The bark is dark red-brown to grey and deeply furrowed longitudinally, with small surface scales, eventually becoming black and blocky. The 5 to 12.5 cm-long dark green leaves are thick, leathery and oval. The upper surface is lustrous, the lower pale and pubescent.

Virginia live oak tree flowers in early spring. The flowers, typical of Oaks, are on inconspicuous catkins, and are monoecious (individual flowers are either male or female, but both sexes can be found on the same plant). They are pollinated by wind. The countryside may become dusted with yellow pollen from this tree. Brownish-black acorns are produced, which are edible.

Environment

Virginia live oak is not as common as White oak. The natural habitat of the Live oak is woodlands.

Unexpected exposure

The acorns are used for coffee, oil and food, and various parts of the tree have been used for medicinal purposes.

t218 Virginia live oak

Allergens

No allergens from this plant have yet been characterised.

As an extensive cross-reactivity among the different individual species of the genus could be expected (3), Virginia live oak may have allergens similar to those of White oak. Studies suggest that White oak pollen contains multiple proteins that are potentially allergenic (4). These include a group 1 *Fagales* protein, a calcium-binding protein and a profilin. See Oak tree t 7.

Moreover, probably not all species of Oak are equally allergenic: *Q. ilex* pollen, although produced in considerable quantities, was not found to cause allergies in one study (5).

Potential cross-reactivity

Some of the pollen allergens in the various species of Oak cross-react with each other, while others are unique to their own species. No studies to date have examined the cross-reactivity between Virginia live oak and other plants, but assuming that an extensive cross-reactivity among the different individual species of the genus could be expected (3), studies involving White oak tree (*Q. alba*) are relevant.

In Sapporo, Japan, many Birch pollen-allergic patients complained of typical symptoms after the Birch pollen season. This has been attributed to Birch pollen-allergic individuals being affected by Oak pollinosis due to cross-reactivity between Birch and Oak pollen (6).

Natural Birch, Alder, Horn beam, Hazel, and Oak pollen contain allergens that share IgE epitopes with recombinant Bet v 1 and recombinant Bet v 2. A combination of recombinant Bet v 1 and Bet v 2 accounted for 82% of tree pollen-specific IgE in a study. Most of the tree pollen-specific IgE was directed against rBet v 1 (7).

In inhibitory ELISA assays, IgE binding to ginkgo pollen was inhibited more than 80% by Oak, Rye grass, Mugwort, and Ragweed; and 34% by Japanese Hop; and 10% by rBet v 2 at 10 µg/ml (8).

On the evidence of these studies, American patients allergic to Virginia live oak pollen can be expected to be affected by Oak species found in Europe and other parts of the world.

Clinical Experience

IgE-mediated reactions

Oak pollen is a major cause of asthma, allergic rhinitis and allergic conjunctivitis (9-12). Virginia live oak is not as common as White oak, but when it is grown in urban communities and near rural ones, it is an important allergen, and the prevalence of atopic sensitisation its pollen will be high.

Oak pollen affects sensitised individuals throughout the world. In Madrid, Spain, the highest level of airborne pollen from 1979 to 1993 was from the *Quercus* species (17%) (12), and in Salamanca, Spain, the highest quantity of pollen was from Holm oak (13). Oak pollen has also been shown to be significant in Zurich (14), Mexico City (15), Japan (16), Korea (17), Tampa, Florida (18), and Cape Town, South Africa (19).

Exposure to Oak dust may also lead to the development of sore throat and bronchial hyperresponsiveness (20).

Occupational asthma and rhinitis due to Oak wood dust have been demonstrated in wood workers (21-22).

Determination of IgE antibodies has been documented to be a useful investigation in the case of Oak-allergic individuals (23-24)

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t10 Walnut

Juglans californica

Family:	*Juglandaceae*
Common names:	California Black Walnut, California walnut, Jupiter's Nuts, Carya persica (Greek), Carya basilike (Greek)
Source material:	Pollen
See also:	Walnut (*Juglans spp.*) f256

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Allergen Exposure

Geographical distribution

The *Juglandaceae* family contains 2 important genera: Hickory/Pecan (*Carya*) and Walnut (*Juglans*)

The Walnut tree grows to a height of 12 to 20m, with a large, spreading, rounded top, and thick, massive stem. Some Walnut trees are 300 years old. Black Walnut is the tallest of the Walnuts, with the potential to reach 100 feet. The Walnut tree has compound leaves and consisting of small yellowish-green leaflets.

Walnut is the common name given to twenty species of deciduous trees in the genus Juglans, of which six species are native to the United States. Walnut is native to California, but about 15 related species occur in North and South America as well as in central and southern parts of Europe and Asia.

The Black Walnut is native to the eastern United States and is important for its timber and used in fine furniture rather than for its nut. The Common or English Walnut is native to areas stretching from the Balkans to China, but now widely grown in many other temperate areas, for nut production.

The flowers of separate sexes are borne upon the same tree and appear in early spring before the leaves. The Walnut tree flowers and produces pollen after 20 to 30 years of growth, in late spring to early summer. The pollen of all these trees is large and does not travel far. However, in areas where the trees are cultivated commercially, heavy exposure to the pollen can occur. Walnut pollen is generally considered to be moderately allergenic. The western species of Walnut (in California) is thought to be a more important cause of allergic sensitization than the Black Walnut. The Walnut fruit is a nut, borne singly or in pairs.

Walnut pollens are often the cause of inhalant allergies, and the nuts may cause food allergy.

Environment

It occurs in woods and on mountain slopes and may be cultivated in orchards for nut production.

Black Walnut heartwood is heavy, hard, strong, and durable, with a chocolate-brown color prized by furniture manufacturers and many other industries. The Black Walnut is much oilier and richer tasting than the English Walnut found in grocery stores.

Some plants planted near or under the Black Walnut tree tend to yellow, wilt, and die. This occurs because the Walnut tree produces a non-toxic, colorless chemical called hydrojuglone. Hydrojuglone is found in leaves, stems, fruit hulls, inner bark and roots. Several related trees such as English Walnut, hickories and pecan also produce juglone, but in smaller amounts compared to black Walnut.

Allergens

No allergens from this plant have yet been characterised.

Potential cross-reactivity

Cross-reactivity could be expected between species of the genus *Juglans*, and on a moderate level to the genus *Carya*, *e.g.*, Pecan tree (1).

The Walnut tree nut contains a lipid transfer protein allergen (LTP) (2-3). Whether a similar LTP allergen is present in Walnut tree pollen has not been determined yet. Cross-reactivity due to LTP allergens appears to be relevant only in foods, which are ingested, and not in pollens, which are inhaled.

Clinical Experience

IgE-mediated reactions

Anecdotal evidence suggests that asthma, allergic rhinitis and allergic conjunctivitis are common following exposure to pollen from Walnut tree; however, few specific studies have been reported to date (4-5).

A survey of the atmosphere of Bitlis, Turkey, reported that pollen from *Juglans spp*. was found (6).

Other reactions

Occupational allergic contact dermatitis to Walnut tree wood dust has been observed (7).

Asthma and rhinitis due to the related Central American walnut (*Juglans olanchana*) dust in a 48-year-old man. Intradermal tests were negative but inhalation with the extract resulted in immediate bronchospasm. Serum IgE antibodies werenot detected (8).

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t15 White ash

Fraxinus americana

Family: *Oleaceae*

Source material: Pollen

See also: European ash tree (*F. excelsior*) t25

There are 4 important genera in the *Oleaceae* family: Olive (*Olea*), Ash (*Fraxinus*), Lilac (*Syringa*), and Privet (*Ligustrum*)

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Allergen Exposure

Geographical distribution

Fraxinus is a genus of about 65 species, which are distributed in the northern temperate regions. The hardy White ash is native and common in eastern North America. It also thrives in Europe.

White ash is a tall, deciduous, long-lived tree, growing to a height of between 18 m and 40 m. The trunk is long, straight and free of branches for most of its length, and the crown is narrow and pyramidal when the tree is grown in a mixed stand. Specimens grown in the open have a short trunk with a rounded crown. The bark is ash-grey to brown, with a diamond pattern. The leaves are compound and 20 to 38 cm in length. Winged fruits hang in bunches throughout the winter and are shaped like keys.

White ash is dioecious (male and female flowers are distinct and grow on separate trees). Clusters of yellow-orange flowers appear in April and May, the male flowers blooming first, long before the leaf buds appear. Pollen season may start as early as January. Ash sheds copious amounts of pollen. Ash is entirely wind-pollinated. The pollen is carried by wind as far as 110 m from the point of dispersion.

Environment

White ash grows best on deep, well-drained, moist soils along with other hardwoods. Ash is an important timber tree, having light and elastic wood. The US exports Ash timber all over the world. White ash was used as snakebite preventive.

Allergens

No allergens have been characterised to date.

However, from the closely related European ash tree (*F. excelsior*), the following allergens have been isolated to date: Fra e 1, Fra e 2 (a profilin), Fra e 3 (a calcium-binding protein), and Fra e 9 (a 1,3-beta-glucanase) (1).

Potential cross-reactivity

An extensive cross-reactivity among the different individual species of the genus could be expected, as well as to a certain degree among members of the family *Oleaceae* (2).

Cross-reactivity among the pollen allergens of Olive (*Olea europaea*), White ash (*Fraxinus americana*), Privet (*Ligustrum vulgare*), and Russian olive tree (*Elaeagnus angustifolia*) has been documented (3). A high degree of cross-reactivity has also been demonstrated among Olive tree (*Olea europaea*), European ash (*F. exselsior*), Privet (*Ligustrum vulgare*) and *Phillyrea angustifolia*, although there was no 100% identity among these species (4). These results are consistent with those of other authors (5). A study using recombinant Fra e 1 from the closely related European ash (*F. exselsior*) reported an 82%, 88%, and 91% identity with, respectively, Syr v 1 (*Lilac tree*), Ole e 1 (Olive tree), and Lig v 1 (Privet tree) (6), suggesting possible cross-reactivity between pollen from this tree and these pollens.

Cross-reactivity is also known to occur among members of the *Fagales* family (Birch, Alder, Hazel, and Beech) and among members of the *Oleaceae* family (Ash, Olive, Lilac, and Privet); a study reports on specific cross-reactivity between Ash and Birch (7).

Clinical Experience

IgE-mediated reactions

Pollens from White ash can induce asthma, allergic rhinitis and allergic conjunctivitis (1,3,8-9).

Pollen from the Ash tree is an important aeroallergen. In a European study of 5,416 consecutive patients sensitised to various pollens, 17.6% had a positive skin-prick test to Ash (1.)

Ash tree pollen has also been demonstrated to be an important aeroallergen in Zurich, Switzerland, contributing greatly to the overall pollen count (10). Although Ash tree pollen may not always be a major component of aeroallergens, because of cross-reactivity individuals who are Olive tree pollen-allergic may be found to be sensitive to Ash tree pollen. Thus, among 503 patients with allergic rhinitis in the southern part of Switzerland (Canton Ticino) who were tested by skin prick for sensitisation to common allergens, of the 54% who were positive to Olive tree, a great many would be allergic to Ash tree pollen (11).

The daily pollen concentration measured in the atmosphere over a 6-year period in Badajoz, in southwestern Spain, demonstrated pollen from *Fraxinus* species to be among the most important aeroallergens (12). In Madrid, Spain, pollen from *Fraxinus* species was shown to be among the dominant pollens from January to April (13). In Cordoba, Spain, skin-prick tests were carried out on 1,500 pollen-allergic patients with an extract of *Fraxinus* pollen, and 59% were positive. The great majority of the patients were polysensitive; only 8% were found to be monosensitive (14).

Pollen from this species was also shown to be important in Mexico City (15), Sivrihisar, Turkey (16), Vinkovci in northeastern Croatia (17), and Mar del Plata, a city in Argentina (18). The presence of pollen from this tree was also demonstrated in an aerobiological study of 10 large Canadian cities (19).

In a study of 371 allergy patients tested serologically for hypersensitivity to prevalent tree pollens in the area surrounding New York, 26% were found to be sensitised to Ash (20). In a population in St. Louis, Missouri, USA, who were skin-tested with pollen from 12 wind-pollinated tree species, White ash was found to have sensitised some individuals, although it was shown to be less reactive than other tree species (21).

Rhinitis and occupational asthma from exposure to Ash wood dust have been reported (8,22).

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Carya tomentosa

Family:	*Juglandaceae*
Common names:	White Hickory, Mockernut hickory, Mockernut, Whiteheart hickory, Hognut, and Bullnut
Synonym:	*C. alba*
Source material:	Pollen
See also:	Pecan (*C. pecan*) t22

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Allergen Exposure

Geographical distribution

White hickory, closely related to the Pecan (Hickory) tree (*Carya pecan*), is a member of the *Juglandaceae* (Walnut) family and is the most abundant of the Hickories. The *Carya* or Hickory genus comprises 17 species, of which 15 are found in the United States, 1 in Mexico and 1 in southern China. In the United States, Hickories are found principally in the eastern states and not in the Pacific states (1).

The Hickories are similar to the Walnut in that they are tall spreading trees with smooth gray bark and large deciduous pinnate leaves; but they generally have fewer leaflets than the Walnut does. The bark becomes rough or scaly on mature trees.

White hickory is native to the USA. It is long-lived, sometimes reaching the age of 500 years (2). It is monoecious; male and female flowers are produced on the same tree, appearing after the unfolding of the leaves. The staminate flowers are borne in long pendent catkins that, unlike those of the Walnut, are branched. The catkins are about 10 to 13 cm long and may be produced on branches from axils of leaves of the previous season or from the inner scales of the terminal buds at the base of the current growth. The female flowers appear in short spikes on peduncles terminating in shoots of the current year. Flowers bloom from April to May, depending on latitude and weather. Usually the male flowers emerge before the female flowers. Hickories produce very large amounts of pollen in the late spring, often in amounts equal to those from Walnuts, and the pollen is dispersed by the wind.

Fruits, solitary or paired, are globose, about 2.5 to 9.0 cm long, and with a short neck-like base; they ripen in late summer. The fruit has a thick, 4-ribbed husk 3 to 4 mm thick that usually splits from the middle to the base. The nut is distinctly 4-angled, with a reddish-brown, very hard shell 5 to 6 mm thick, containing a small edible kernel. The seed is dispersed in late summer to autumn.

Environment

The wood is used for fuel and for products where strength, hardness, and flexibility are needed.

Allergens

No allergens have been characterised.

Potential cross-reactivity

Cross-reactivity could be expected between species of the genus *Juglans* and of the genus *Carya*, *e.g.*, White hickory and Pecan tree.

t41 White hickory

Clinical Experience

IgE-mediated reactions

Anecdotal evidence suggests that asthma and hayfever are possible following exposure to pollen from this tree; however, no specific studies on this have been reported to date. The most important Hickory causing hayfever and asthma is Pecan (*C. pecan*) (2). Hayfever from Pecan is often described, especially in areas where it is cultivated (3). Because of the close family and genus relationship between White hickory and Pecan, results of studies on the latter may be applicable to the former. See Pecan tree t22.

The pollen of the other Hickories is also known to cause hayfever where the trees are abundant (2,4). Other species of *Carya* may be involved, *e.g.*, the Shagbark (or Shellbark) hickory (*C. ovata*), Nutmeg hickory (*C. myristicaeformis Nutt*) and Pignut hickory (*C. glabra*) (2-3). In hayfever studies, the various species are generally not distinguished from each other because their pollens are believed to inter-react more or less perfectly (2).

In a study of 371 allergy patients tested serologically for hypersensitivity to prevalent tree pollens in the area surrounding New York over the years 1993-2000, the highest prevalence of hypersensitivity was for Oak (34.3%), Birch (32.9%), and Maple (32.8%) tree pollens. Lower prevalences were observed for Beech (29.6%), Hickory (27.1%), Ash (26%), Elm (24.6%), and Poplar (20.6%) trees (5).

In an earlier study in St. Louis, Missouri, USA, a population was skin-tested with pollen from 12 wind-pollinated tree species. Pollen extracts of Box elder, Willow and Hickory elicited the strongest allergic reactions; Oak, Birch, Sycamore, Black walnut and Poplar more-moderate reactions; while allergens from Cottonwood, Maple, Elm and White ash were less reactive (6).

Sensitisation to the close genus member *C. pecan* has been demonstrated in Israel (7) and Mexico (8-9).

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t16 White pine

Pinus strobus

Family: *Pinaceae*

Common names: White pine, Eastern white pine, Northern white pine, Weymouth pine

Source material: Pollen

See also: Pine (*P. radiata*) t213

Not to be confused with the Australian pine tree (*Casuarina equisetifolia*) t73

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Allergen Exposure

Geographical distribution

Of the 100 different species included in the genus *Pinus*, almost all are found in the Northern Hemisphere, with 36 in North America. White pine is native to North America but is now found also in France, Mexico and Guatemala. Commercial cultivation was attempted in Europe but was given up because of a fungus disease.

White pine is a large, tall, evergreen conifer with an irregular or flattened dense crown. It can grow to 20 m tall in 40 years. White pine commonly reaches 200 years of age and may exceed 450 years. The bark is smooth and gray-green when young, becoming with age gray-brown and deeply furrowed, with broad ridges of irregularly rectangular, purple-tinged scaly plates. The distinctive whorled branching and 5 blue-green needles in each fascicle are characteristic of this tree. The needles turn chartreuse to golden-brown in autumn and abscise immediately.

White pine flowers are monoecious (male and female flowers are distinct but grow on the same tree), with staminate (male) flowers in clustered yellow catkins, and pistillate (female) flowers in pink immature cones. Pollen is shed between early April and the end of June, depending on latitude. The pollen count is often high. Cones ripen and seeds are dispersed from August through September, about 2 years after cone initiation. White pine begins producing cones when 5 to 10 years old. The winged seeds are about 2 cm long and are dispersed primarily by wind, up to 60 m within a stand and more than 210 m in the open.

Environment

White pine occurs in forests, is often planted for timber, and survives dry, sandy soils or mountainous conditions. This Pine is becoming rare because a severe fungus disease often infects it.

Allergens

No allergens from this plant have yet been characterised.

Potential cross-reactivity

An extensive cross-reactivity among the different individual species of the genus could be expected (1).

A high cross-reactivity among *Pinus nigra*, *P. sylvestris*, *P. radiata* and *P. strobus* has been demonstrated in inhibition studies (2).

As extensive cross-reactivity exists between Pine tree (*P. radiata*) and White pine tree (*P. strobes*), the following cross-reactivity patterns should be considered applicable to White pine tree.

IgE antibody studies have demonstrated that pollen extracts from Olive, Birch, Mugwort, Pine, and Cypress contain proteins that share common epitopes recognisable by sera from Olive-allergic individuals (3). Enzyme immuno-assay inhibition studies have revealed that leached *P. radiata* pollen proteins could partially inhibit serum IgE binding to Rye grass-specific IgE. This provides preliminary evidence for allergen cross-reactivity between these 2 unrelated species (4). The possibility of cross-reactivity between *Pinus* and Rye grass (*Lolium perenne*) has also been suggested (5).

Importantly, allergy to Pine nuts can occur with no symptoms of sensitisation to Pine pollen. Immunoblot experiments have demonstrated the presence of IgE antibodies in serum against several components of Pine nuts and pollen, with the presence of some cross-reacting components. The authors of this study suggest that development of Pine pollinosis may require a longer period of exposure to allergens, and that given the cross-reactivity between Pine nut and Pine pollen extracts, co-sensitisation to these 2 allergens could be possible (6).

Clinical Experience

IgE-mediated reactions

Pinus pollen can induce asthma, allergic rhinitis and allergic conjunctivitis (7-9).

Pinus pollen allergy has been generally considered to be rare. Although Pine pollen is released in large quantities, IgE-sensitisation to it has been found to occur in only 1.5% - 3% of atopic patients in a northern Arizona private allergy practice, and in French studies (7-8).

This study reports that the incidence of positive skin testing to White pine in New England patients with spring seasonal allergic rhinitis was 6/61 (6%). Two of 4 patients challenged intranasally had a positive challenge (10).

A Spanish study suggests that Pine tree pollen is a significant aeroallergen and should be considered in investigations of pollen-allergic individuals. In this study, *Pinus* pollen (*Pinus pinaster* and *Pinus radiata*) was shown to be among the dominant pollens in an area of Spain. The majority of the patients were monosensitisated to *Pinus* pollen and suffered from seasonal rhinoconjunctivitis (9). The sensitising Pine pollen would in all instances depend on which species of Pine tree is present in the vicinity.

Other studies have shown that Pine tree pollen may be a significant aeroallergen. Airborne pollen contributors were measured in 2 locations in the USA, in Pennsylvania and New Jersey, separated by 11 km. Prominent airborne pollen included *Pinus* pollen. Tree, grass, and weed pollen season extended from mid-March to mid-June (11). In a study of aeroallergen sensitisation rates in children of the military in Texas, of 345 children who were skin prick-tested to a 51-allergen panel, 6.4% were positive to Pine (12).

In Burgos, Spain, *Pinus spp.* pollen was frequently detected in aerobiological studies (13). Pollen from *Pinus spp.* has also been documented in Portugal, with significant levels recorded in certain parts of the country (14-15). *Pinus spp.* pollen has also been documented in Trieste, Italy, with the level of this pollen being shown to correlate negatively with the winter severity (16).

As extensive cross-reactivity exists between Pine tree (*P. radiata*) and White pine tree (*P. strobes*), the latter should be found to generate similar clinical patterns to those the former generates.

Other reactions

Allergic contact dermatitis to White pine sawdust has been described (17). Contrary to the rarity of sensitisation to Pine pollen, workers processing Pine in sawmills showed a very high frequency of IgE sensitisation to the extract of Pine wood dust. This frequency was significantly greater than that of the sensitisation to Oak of workers processing Oak. (18) Airborne allergic contact dermatitis from Pine dust has been documented (19).

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t12 Willow

Salix caprea

Family:	*Salicaceae*
Common names:	Willow, Goat willow, Great sallow, Pussy willow
Source material:	Pollen

The family *Salicaceae* contains the genera *Populus* (Aspens, Cottonwoods, and Poplars) and *Salix* (Willow)

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Willow is a deciduous shrub or small tree, usually attaining between 3 m and 15 m in height. It may grow in the form of a large and upright shrub or a multi-stemmed small tree. The bark is yellowish-brown, becoming dark brown as the tree grows older. The green leaves are oblong and irregularly toothed.

Willow is among the first trees flowering in spring. The flowers are dioecious (individual flowers are either male or female, but only a single sex is to be found on any one plant) and appear in catkins. The male Willow produces white, 2.5 – 5 cm-long flowers on a bottlebrush-like catkin. The catkins are produced early in the spring, often before the leaves, or as the new leaves open. Pollination is by insects.

The fruit is a small, cylindrical, beaked capsule containing numerous tiny (0.1 mm) seeds. The seeds are furnished with long, silky, white hairs, which allow the seeds to be widely dispersed by the wind (2).

Allergen Exposure

Geographical distribution

The family *Salicaceae* contains the genera *Populus* (Aspens, Cottonwoods, and Poplars) and *Salix* (Willow). The genus *Salix*, which contains around 400 species of deciduous trees and shrubs, comprises Willows, sallows and osiers (1). They are found primarily on moist soils in cold and temperate regions of the Northern Hemisphere. Most species are known as Willow, but some narrow-leaved shrub species are called osier, and some broader-leaved species are called sallow. Some willows (particularly arctic and alpine species) are low-growing or creeping shrubs (2).

Willows are cool-climate trees and are common in most of Europe, North America, western temperate Asia, and northeast Africa. In eastern Asia they are replaced by related species. The tree is uncommon in the tropics.

Environment

Willow occurs in wet environments, such as riverbanks and lake shores, and in drier sites where bare soil becomes available due to ground disturbance. Willow bark is used as an herb. The wood is light and firm and yields salicine (salicylates), which is used in headache tablets and muscle-pain ointments.

Allergens

No allergens from this plant have yet been characterised.

Potential cross-reactivity

The family *Salicaceae* contains the genera *Populus* (Aspens, Cottonwoods, and Poplars) and *Salix* (Willow). Extensive cross-reactivity between the species in the genus *Salix* and in the genus *Populus* can be expected (3-4). This has been demonstrated between Cottonwood and Willow (5). Through P-K neutralisation and passive hemagglutination inhibition, moderate cross-reactivity between members of *Salicaceae* and of *Fagales* has been shown (6).

Ole e 9, a major Olive tree pollen allergen, shows 39%, 33%, and 32% sequence identity with 1,3-beta-glucanases from Wheat, Willow, and *Arabidopsis thaliana*, respectively (7). Whether the 1,3-beta-glucanases from Willow were allergenic was not evaluated for.

Clinical Experience

IgE-mediated reactions

Willow tree pollen can induce asthma, allergic rhinitis and allergic conjunctivitis (2,8-11). As a close relationship exists between this Willow and other species, these species, where they commonly occur, may also induce allergic symptoms (12-13).

Willow tree pollen is an important aeroallergen in many parts of the world. This has been demonstrated in Turkey and other parts of the eastern Mediterranean region (6), at the Rabka health resort in Poland (14), and in Switzerland (5). Pollen from *Salix spp*. was reported to play a role in allergic rhinitis in Eskisehir, Turkey (10). In another Turkish study of 614 respiratory-allergic patients, Willow, Poplar, Olive and Cypress pollens were among important inhalant allergens causing skin test positivity (6). Other aerobilogical studies from various regions in Turkey have documented the presence of *Salix spp*. pollens in the air (15-18).

Pollen extracts of Box elder, Willow and Hickory elicited the largest number of allergic reactions in a Missouri, USA, population skin-tested with pollen from 12 wind-pollinated tree species (7). *Salix* pollen was also recorded in Anchorage, Alaska (19).

Measurement of daily pollen concentration over a 6-year period in Badajoz, in southwestern Spain, demonstrated high levels of Willow pollen, along with the pollen of another family member, *Populus* (20). A study of the common airborne pollen allergens in the city of Salamanca, Spain, also confirmed the presence of *Salix* pollen in the air (21).

Willow pollen (and the pollen of the family member Cottonwood) has been demonstrated to be an important aeroallergen in Tehran, with the pollen season extending from the first week of February through the middle of October (22).

In 9 districts of northern China, the most common aeroallergens included the pollen of Willow and its family member *Populus* (23); the findings were similar in Seoul, Korea, where the pollen from these trees was recorded from March to May (24).

Other reactions

Phytodermatitis due to contact with Willow has been documented (25).

Anaphylaxis has been described in a 32-year-old atopic patient after the ingestion of a pollen compound prepared in an herbalist's shop. A few minutes after ingestion, generalised pruritus, diffuse erythema, facial oedema, cough, hoarseness and dysphonia occurred. The patient was shown to be sensitised to pollens from *Artemisia vulgaris*, *Taraxacum officinalis* and *Salix alba*, which were found in the preparation (26).

As Willow bark contains acetylsalicylic acid, adverse reactions to the ingestion of herbal products made from Willow bark may be attributed to allergy to Willow when in fact the allergy is to acetylsalicylic acid (27).

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Mixes

These tests consist of a mixture of different allergens, related or unrelated. For specific information about the included allergens consult the separate descriptions.

tx1

Box-elder	*Acer negundo* (t1)	page 24
Common silver birch	*Betula verrucosa* (t3)	page 35
Oak	*Quercus alba* (t7)	page 122
Elm	*Ulmus americana* (t8)	page 62
Walnut	*Juglans california* (t10)	page 168

tx2

Box-elder	*Acer negundo* (t1)	page 24
Oak	*Quercus alba* (t7)	page 122
Elm	*Ulmus americana* (t8)	page 62
Cottonwood	*Populus deltoides* (t14)	page 45
Pecan, Hickory	*Carya pecan* (t22)	page 139

tx3

Mountain juniper	*Juniperus sabinoides* (t6)	page 115
Oak	*Quercus alba* (t7)	page 122
Elm	*Ulmus americana* (t8)	page 62
Cottonwood	*Populus deltoides* (t14)	page 45
Mesquite	*Prosopis juliflora* (t20)	page 110

tx4

Oak	*Quercus alba* (t7)	page 122
Elm	*Ulmus americana* (t8)	page 62
Maple leaf sycamore, London plane	*Platanus acerifolia* (t11)	page 103
Willow	*Salix caprea* (t12)	page 178
Cottonwood	*Populus deltoides* (t14)	page 45

tx5

Grey alder	*Alnus incana* (t2)	page 73
Hazel	*Corylus avellana* (t4)	page 80
Elm	*Ulmus americana* (t8)	page 62
Willow	*Salix caprea* (t12)	page 178
Cottonwood	*Populus deltoides* (t14)	page 45

tx6

Box-elder	*Acer negundo* (t1)	page 25
Common silver birch	*Betula verrucosa* (t3)	page 35
American beech	*Fagus grandifolia* (t5)	page 14
Oak	*Quercus alba* (t7)	page 122
Walnut	*Juglans californica* (t10)	page 168

Mixes

tx7

Olive	*Olea europaea* (t9)	page 128
Willow	*Salix caprea* (t12)	page 178
White pine	*Pinus strobus* (t16)	page 175
Eucalyptus, Gum-tree	*Eucalyptus spp.* (t18)	page 65
Acacia	*Acacia longifolia* (t19)	page 11
Melaleuca, Cajeput-tree	*Melaleuca leucadendron* (t21)	page 108

tx8

Box-elder	*Acer negundo* (t1)	page 24
Common silver birch	*Betula verrucosa* (t3)	page 35
Hazel	*Corylus avellana* (t4)	page 80
Oak	*Quercus alba* (t7)	page 122
Maple leaf sycamore, London plane	*Platanus acerifolia* (t11)	page 103

tx9

Grey alder	*Alnus incana* (t2)	page 73
Common silver birch	*Betula verrucosa* (t3)	page 35
Hazel	*Corylus avellana* (t4)	page 80
Oak	*Quercus alba* (t7)	page 122
Willow	*Salix caprea* (t12)	page 178

tx10

Grey alder	*Alnus incana* (t2)	page 73
Common silver birch	*Betula verrucosa* (t3)	page 35
Hazel	*Corylus avellana* (t4)	page 80
White ash	*Fraxinus americana* (t15)	page 170

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