ImmunoCAP®
Is it allergy?

Grass pollens

Allergy – Which allergens?

Thermo
SCIENTIFIC

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Grass Pollen Allergens

Familiar features of the grasses, or *Poaceae* (also known as *Gramineae*), include small, inconspicuous flowers, linear, sheathing leaves, and tufts or spikes. The grasses constitute a huge family, with around 8,000 species. Grasses are also very widespread, probably covering about 20% of the world's surface. They made a major contribution to the development of human culture, as they were certainly some of the first plants in cultivation, helping in the transition from hunting and gathering to agriculture about 10,000 years ago. *Triticum* (Wheat) and *Hordeum* (Barley) were prominent in the Middle Eastern Fertile Crescent, the "cradle of civilisation", from earliest recorded times. Grasses of far more types than the few whose seed is edible for humans served as forage and fodder for livestock and as tools for land alteration and reclamation. Property ownership and trade, and along with them the state, art, technology and so on, would probably not have developed without the value grasses added to land.

Allergen exposure

Today, much of the grass pollen that humans are exposed to has ornamental or incidental sources: lawns, parks, gardens and wasteland. The push for "green space" in cities and the spread of suburbs have been forces working against the distancing of people from grass exposure, distancing that would otherwise be a result of large-scale urbanisation. Ironically, some asthmatics who moved to arid regions like Arizona in the United States quickly found their environment becoming grass-filled again, from irrigation-fed proliferation of lawns. Moreover, the human population's recent dramatic growth has naturally been accompanied by increased demand for cheap, relatively easily produced food: grasses play a starring role in keeping the planet fed. The "green revolution" has resulted in higher-yield crops, with more grain produced per hectare; and also in deforestation, as more land has been brought under cultivation and converted into pasturage. All of this has placed more grass pollen in the air, a change which, depending on atmospheric conditions and the type of pollen, may have consequences even for people outside the immediate areas where the crops and pastures grow. (Maize pollen is unusually dense and can be expected to be found in lower concentrations in the atmosphere, but many other crops produce pollen that travels far more efficiently).

Among the major allergenic offenders among grasses are Rye grass, Timothy grass, Bermuda grass and Cocksfoot. But the epidemiological patterns are of course dependent not only on such factors as the size and weight of the pollen grains, the potency of the allergens and the distribution of plants, but also on the history of sensitisation in particular populations – including such diverse influences as cross-reactivity and migration. Clinical studies, despite much progess, will still have much to reveal in the future about grass pollen allergy.

Cross-reactivity

Figure 1 is an illustration of one probable set of relationships of the relevant grasses to each other. Though it is far from universally agreed on, this schema can be useful in beginning a discussion of cross-reactivity.

Cross-reactivity can be expected to roughly follow botanical relationships, but some unevenness in the patterns should be noted. Group 4 allergens, for example, may be a source of especially strong cross-reactivity within the *Pooideae* subfamily (1-3), but this appearance may, on the other hand, be a function of the importance of this subfamily in allergy, which perhaps causes it to be more intensively studied. Also outstandingly notable is the role of Group 1 and Group 5 allergens, with some of the studies pointing to the potential for strong cross-reactivity not only between tribes but sometimes even between subfamilies (4-9).

As might be expected, there is potential for cross-reactivity between the pollen of a particular grass and its edible grain, or even another grain. This has been supported by, for instance, immunological similarity not only between Rye pollen and Rye flour, but also between Rye pollen and Wheat flour (10).

The existence of panallergens such as profilin allow for much broader cross-reactivity, in this case extending to tree pollen, weed pollen and plant-derived foods of distantly related species. Among the pollens, Olive tree, Birch, Mugwort, Wall pellitory, Plaintain and Ragweed are prominent in studies of cross-reactivity with grass pollen; among foods and other substances, Apple, Celery, Melon, Carrot, Kiwi and Latex are significant in the same connection (11-20). Oral Allergy Syndrome may be involved (21).

Clinical experience

Clinically as well as epidemiologically, grass pollen allergy is one of the more nebulous and frustrating types of allergic disease. Without routine identification of the specific allergens affecting patients, to allow for avoidance strategies, many health professionals and patients alike have fatalistically accepted almost constant discomfort during the "allergy season". (This is approximately May to July in temperate climates of the Northern Hemisphere, and as long as March to November in the north's tropical and sub-tropical climates. In the Southern Hemisphere the pollen seasons are of course roughly reversed along with the seasons. In some grass-rich areas of southern Africa, the pollen season is 10 months long. A strategy almost as unsatisfactory as no treatment is chronic medication applied in a "shot-gun" fashion to deaden a group of symptoms: red, swollen, itchy, and/or watery eyes (conjunctivitis), sneezing, congenstion, runny nose, and/or nasal itching (rhinitis), and asthma. The classic term "hay fever" used to cover the syndrome invokes the picture of a mild and transitory problem, and the popular media have generally depicted grass pollens as causing something approximating "the sniffles" – a minor personal and social irritation. But the role grass pollens commonly play in allergic asthma and their importance in cross-reactivity show that they should be taken seriously and individually identified.

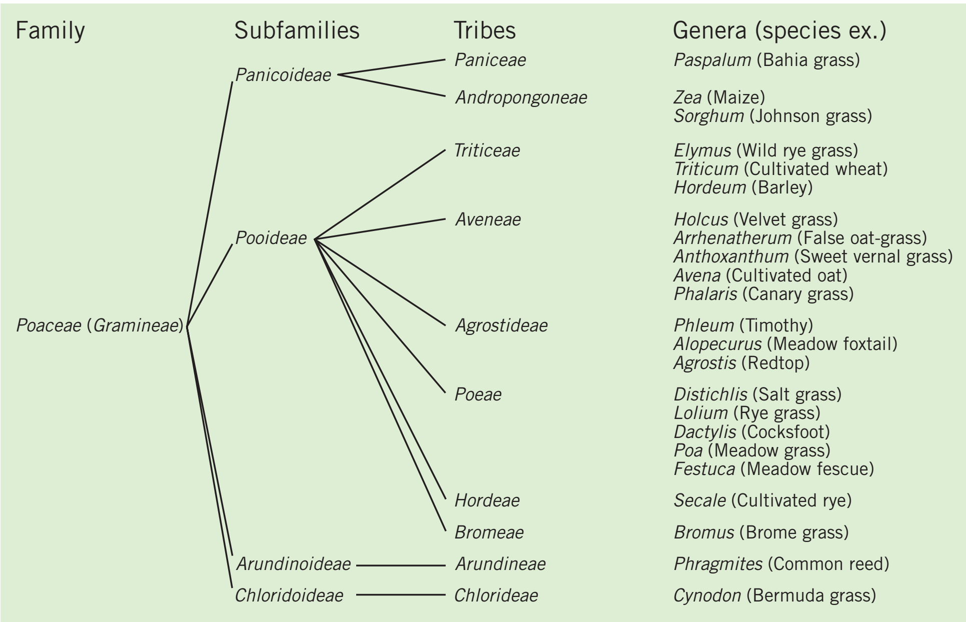

Figure 1. Grasses and their botanical relations, adapted from L Yman (24).

ImmunoCAP™ grass allergens available for IgE antibody testing

g17	Bahia grass *Paspalum notatum*
g201	Barley *Hordeum vulgare*
g2	Bermuda grass *Cynodon dactylon*
g11	Brome grass *Bromus inermis*
g71	Canary grass *Phalaris arundinacea*
g3	Cocksfoot *Dactylis glomerata*
g7	Common reed *Phragmites communis*
g14	Cultivated oat *Avena sativa*
g12	Cultivated rye *Secale cereale*
g15	Cultivated wheat *Triticum sativum*
g204	False oat-grass *Arrhenatherum elatius*
g10	Johnson grass *Sorghum halepense*
g202	Maize, Corn *Zea mays*
g4	Meadow fescue *Festuca elatior*
g16	Meadow foxtail *Alopecurus pratensis*
g8	Meadow grass, Kentucky blue grass *Poa pratensis*
g9	Redtop, Bentgrass *Agrostis stolonifera*
g5	Rye grass *Lolium perenne*
g203	Salt grass *Distichlis spicata*
g1	Sweet vernal grass *Anthoxanthum odoratum*
g6	Timothy grass *Phleum pratense*
g13	Velvet grass *Holcus lanatus*
g70	Wild rye grass *Elymus triticoides*
Mixes:	**gx1**
	gx2
	gx3
	gx4
	gx6

Allergen components – Recombinant / purified native

Timothy grass (*Phleum pratense*)	
g205	rPhl p 1 (recombinant)
g206	rPhl p 2 (recombinant)
g208	nPhl p 4 (native)
g209	rPhl p 6 (recombinant)
g210	rPhl p 7 (recombinant)
g211	rPhl p 11 (recombinant)
g212	rPhl p 12; profilin (recombinant)
g213	rPhl p 1, rPhl p 5b (recombinant)
g214	rPhl p 7, rPhl p 12 (recombinant)
g215	rPhl p 5b (recombinant)

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

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g17 Bahia grass

Paspalum notatum

Family:	*Poaceae* (*Gramineae*)
Subfamily:	*Panicoideae*
Tribe:	*Paniceae*
Common names:	Bahia Grass, Bahiagrass
Source material:	Pollen

A grass species producing pollen, which often induces hayfever, asthma and conjunctivitis in sensitised individuals.

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Allergen Exposure

Geographical distribution

Paspalum has about 400 species. *P. notatum* is native to southern Brazil, Uruguay, northern Argentina, and northwestern Paraguay, and is found in most Central and South American countries. It has been introduced as a turf and forage grass into East and West Africa, Australia, India, Japan, Mexico, and the southern and eastern United States.

Paspalum notatum is a sod-forming, deep-rooted, warm-season perennial grass. It spreads by short, stout, woody runners and by seed. The runners have many large, fibrous roots, which form dense, tough sods, even on drought-prone sandy soils. The leaf bases at the terminus of each rhizome usually have a purplish hue. The stems of *P. notatum* are ascending, usually ranging from 20 to 75 cm tall, and the dark green leaves are 4 to 10 mm wide and 6 to 25 cm long.

The inflorescences have 2 to several spicate branches 4-12 cm long, and each branch (or raceme) has 2 rows of spikelets, either paired or positioned with one slightly below the other. Flowering is between June and November in the Northern Hemisphere. (Bahia grass ripens progressively over the summer in the United States and at no time is all the seed mature.) Besides vegetative spread, some varieties can reproduce asexually by unfertilized yet viable seeds; the sexually reproducing varieties are wind-pollinated. The plant seeds prolifically during the summer.

Environment

Bahia grass is widely used for forage and for erosion control. It easily invades disturbed pastures, roadsides, and rights-of-way, but does not appear to invade intact, undisturbed, native systems.

Allergens

Multiple antigenic components have been detected, but no allergens from this plant have yet been characterised (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 *Poaceae*. Cross-reactivity between Bahia grass (g17), Johnson grass (g10) and Maize pollen (g202) can be expected, as they are closely related through the subfamily *Panicoideae* (2-3).

g17 Bahia grass

Martin *et al*. reported that Bahia grass shares allergenicity with Timothy, Meadow, rye, Redtop, Meadow fescue, and Sweet vernal grass, but also possesses unique allergens (4). More recent studies have not been able to confirm cross-allergenicity between Bahia and Timothy grass (5-6).

Pollen extracts of 2 trees, *Callistemon citrinis* (Bottlebrush) and *Melaleuca leucadendron* (Melaleuca), as well as the grass *Paspalum notatum* (Bahia) were analyzed for antigenic and allergenic cross-reactivity. Clinical studies demonstrated that 81% of patients who were skin test-positive to at least 1 of the pollens were also positive to the other 2. 63% of allergic individuals studied showed a high correlation between skin test results and the number of IgE-binding components analysed by immunoblotting. These IgE-reactive components were detected in the molecular weight range of 29-66 kDa. Each patient's serum had a unique IgE-binding pattern, indicating heterogeneity of immune response; however, common major determinants were detected by a large percentage of the allergic patients' sera (1).

Clinical Experience

IgE mediated reactions

Bahia grass is a significant aeroallergen, which can induce asthma, allergic rhinitis and allergic conjunctivitis (6-7).

In a study in which 38 subjects were challenged (25 nasally, 13 bronchially) with Bahia grass pollen extract, a positive Bahia intradermal skin test predicted a positive challenge to Bahia in all (11/11) of the nasal challenges and 75% (6/8) of the bronchial challenges. Specific IgE antibodies to Bahia pollen were detected by conventional RAST (greater than or equal to 2+) in 82% (14/17) of subjects with positive challenges and in 5% (1/20) of subjects with negative challenges (6).

Various studies around the world have demonstrated the importance of Bahia grass as an aeroallergen. In a study conducted in New South Wales, Australia, an association between Bahia grass and asthma in children was demonstrated (8). In Cartagena, Colombia, 28% of 99 subjects with acute asthma were found to be sensitised to Bahia grass (9). In 100 Thai patients with allergic rhinitis, 16% were positive in skin tests to Bahia grass pollen (10).

Aerobiological and clinical studies in Kuala Lumpur, Malaysia, have documented the importance of Bahia grass pollen in the exacerbation of asthma and allergic rhinitis (11).

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Hordeum vulgare

Family: *Poaceae* (*Gramineae*)
Subfamily: *Pooideae*
Tribe: *Triticeae*
Common names: Common Barley, Barleycorn, Malt
Source material: Pollen

Barley pollen g201 should be differentiated from the food Barley, f6.

A grass species producing pollen, which often induces hayfever, asthma and conjunctivitis in sensitised individuals.

Allergen Exposure

Geographical distribution

Barley is probably native from Afghanistan to northern India. It first came under cultivation 12,000 or more years ago. It is widely cultivated in temperate areas of the world for its edible seed. Because of its wide range of geographical distribution, Barley has accumulated a vast array of genetic variability.

Barley is the fourth most important cereal crop in the world after Wheat, Maize, and Rice. Russia is the largest producer of Barley, followed by Great Britain, France, the United States, then Canada and other countries.

Barley is an erect annual grass. Its stout, simple stem is hollow and jointed and can grow more than a metre high. The narrow, tapering leaves ascend the stem in two ranks, with some overlapping; and their bases form loose sheaths around the stem. The flowers are hermaphrodite (have both male and female organs) and are pollinated by wind. The flowers grow in bristly-bearded terminal spikes, producing eventually the elliptic, furrowed Barley grains. The time of flowering depends on the cultivar, and cultivars include winter-hardy varieties. The period from planting to harvest varies from 60 days to 4 months.

Basically, Barley can be divided into three types: two-rowed, with kernels in 2 lines; 4-rowed, with kernels in 4 lines; and 6-rowed, with kernels in 6 lines. Barley may also be divided up into three types based on the nature of the hulls, varying from tight to loose to non-existent.

Environment

Barley is not known in the wild. It may be found as a relict of cultivation but does not persist.

Barley is a staple food in the developing world, and is used in industrialized countries for animal feed and for speciality food products. Malt is a nutritious sweetener in various foods. It is also grown for distilling malt liquors and spirits, and is one of the primary components of beer. About half of the total US production is used for malting. Barley has many folk medicinal uses.

Unexpected exposure

Barley straw is used as bedding and packing material, for making hats and for the manufacture of cellulose pulp. It is a source of fibres for making paper, and a biomass for fuel, and it can be shredded and used as mulch.

g201 Barley

Allergens

Hor v 9 has been described as a barley pollen allergen (1).

Southern blots suggested that Hor v 9 allergens exist as multiple isoforms in Barley (2).

Potential cross-reactivity

This pantemperate tribe *Triticeae* is notable for its cereal genera: Wheat, Barley and Rye. The close relation speaks in favour of cross-reactivity between Wild rye grass g70, Cultivated wheat g15, Cultivated rye grass g12, Barley g201, and Couch grass (*Agropyron repens*) as well as Lymegrass (*Elymus arenarius*). An extensive cross-reactivity among the different individual species of the genus could be expected. There should be cross-reactivity with other members of the family *Poaceae*, particularly in the subfamily *Pooideae* (Rye grass (g5), Canary grass (g71), Meadow grass (g8), Timothy grass (g6), Cocksfoot (g3), Meadow fescue (g4), Velvet (g13), Redtop (g9), Meadow foxtail (g16), Wild rye grass (g70)) (3-4).

Sequence comparisons showed that the Hor v 9 cDNA clones were also homologous to Group 5 allergens of Timothy grass (*Phleum pratense*) pollen and Canary grass (*Phalaris aquatica*) pollen, and the Group 9 allergen of Rye grass (*Lolium perenne*) pollen (2).

The Barley pollen cDNA, and 3 other cloned allergens, Phl p 5, Phl p 5a (from Timothy), and Lol p 1b (from Rye grass), were demonstrated to have extensive nucleotide and amino acid sequence similarity to Poa p 9 isoallergens of Meadow grass (5).

Clinical Experience
IgE mediated reactions

Barley pollen can induce asthma, allergic rhinitis and allergic conjunctivitis.

In a French study, Barley pollen and Rye pollen were demonstrated using specific IgE tests to be the cereals that were the most prevalent sensitising allergens in children with grass pollinosis (6).

Aerobiological surveys have detected Barley pollen in the atmosphere of Madrid, Spain (7).

Other reactions

Flour made from the seed of Barley may result in symptoms of food allergy, occupational allergy, or allergy reactions to beer (8-10).

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Cynodon dactylon	
Family:	*Poaceae*
Subfamily:	*Chloridoideae*
Tribe:	*Chlorideae*
Common names:	Bermuda-grass, Bermudagrass, Scutch grass, Wire grass, Star grass, Bahama grass, Devil grass
Source material:	Pollen
Synonyms:	*Panicum dactylon*

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Allergen Exposure

Geographical distribution

Bermuda grass is found in much of Europe though not Scandinavia, in the USA, South Africa, Australia, India, and Japan. It probably originated in India. It is the dominant forage grass of Brazil. It is the most common tropical lawn grass, especially in dry areas, and an important pasture grass in the southern US. It is considered to be one of the most allergenic grasses.

Bermuda grass is a creeping, low-growing, evergreen perennial usually growing to 0.3 m by 0.5 m at a medium rate. It is one of about 9 species of the genus *Cynodon*. Reproduction is mostly by means of long runners on top of the ground, but also through seeds and a vast system of hard, sharp-pointed rhizomes beneath the ground. The grayish leaves on the erect stems are 1.5 to 10 cm long, while those on the runners and rhizomes are very short, scaly, and not leaf-like. Roots are formed at the joints, and frequent erect stalks are produced, about 10 to 45 cm high. There are 3 to 5 very narrow 2 to 6 cm finger-like flowering spikes at the tip.

The grass flowers in North America from April/May to September/October. Around the Mediterranean, blooming occurs from May to August, and in other regions of the world from February to December. The flowers are hermaphrodite (have both male and female organs) and are pollinated by wind. The seeds, like the flowers, are tiny, with as many as 4.4 million seeds in one kilogram. In drought, the plant dies above ground but will re-grow from rhizomes.

Bermuda grasses vary greatly in size, shape and colour, but the distinguishing characteristics of *Cynodon dactylon* are the conspicuous ring of white hairs of the ligule, the fringe of hairs on the keel of the lemma, and the gray-green appearance of the foliage.

Environment

Bermuda grass occurs on waste places, roadsides, pastures and agricultural fields, in riparian areas adjacent to streams and marshes, and in the understory of open forests, orchards, and Pine (*Pinus spp.*) plantations. Unwanted spreading of the species is exacerbated by continued planting, as a turf and forage crop and especially for soil reclamation purposes. Bermuda grass is difficult to control once it has been nurtured and has become established.

Bermuda grass has no reported uses as a food, but is a folk remedy for a large number of ailments.

g2 Bermuda grass

Allergens

Bermuda grass pollen contains at least 12 IgE-binding proteins (1-2). Two of these allergens have been described as major allergens, since they reacted with IgE antibodies in more than 50% of sera in a study on 21 Bermuda grass-allergic individuals (3).

Cyn d 1, a major allergen, has been characterised and consists of 11 isoforms (4-8). This allergen may occur as a single 34 kDa protein or as a mixture of 34 and 29 kDa proteins (isoforms) (9).

Cyn d 7, a 12 kDa calcium binding protein (10-11).

Cyn d 12, a profilin (12).

Cyn d 1 only weakly precipitates allergens from other grass species in immunochemical studies, indicating that Cyn d 1 possesses some unique immunochemical properties. Four monoclonal antibodies of Bermuda grass have been shown to cross-react with pollen components from other grass species, especially *Poa pratensis* (Meadow grass) and *Dactylis glomerata* (Cocksfoot) (13).

Two isoallergens of Cyn d 1 isolated were designated Cyn d 1a and b. Cyn d 1a is a 32 kDa protein, and Cyn d 1b is a 31 kDa protein (14).

Approximately 10% of sera of Bermuda-allergic individuals showed IgE reactivity to Cyn d 7 (10).

A 46 kDa antigen of Bermuda grass pollen has been identified. The amino acid sequences of 4 internal peptide fragments were found to be 25-71% identical with those of cytochrome c oxidase III from Corn grass pollen (15). The clinical relevance has not yet been demonstrated.

Bermuda also contains species-specific allergen (16).

A cDNA clone coding for Birch pollen allergen, Bet v 4, a calcium-binding allergen, has significant sequence similarities extending outside the Ca^{2+}-binding sites with pollen-specific allergens of *Brassica* and Bermuda grass (17). The clinical relevance has not yet been demonstrated.

Potential cross-reactivity

The genus *Cynodon* comprises 9 species, which are geographically widely distributed and genetically diverse. Genetic relatedness among the species demonstrated that the strongest species similarities were between *C. aethiopicus* and *C. arcuatus*, *C. transvaalensis* and *C. plectostachyus*, and *C. incompletus* and *C. nlemfuensis* (18). Other studies have demonstrated complete cross-reactivity between Giant Bermuda grass extract and Bermuda grass (19).

There is not much cross-reactivity between Bermuda grass and temperate pasture grasses, due in part to the absence of Group 2, 3 and 5 antigens in the former. Cross-reactivity among the different individual species of the subfamily *Chloridoideae* could be expected (Bermuda, Buffalo, Windmill, and Grama grasses). (20-23). Extracts of Buffalo grass pollen were shown to significantly inhibit IgE binding to Buffalo grass, Kikuyu, Eragrostis and Bermuda, but 100% inhibition was never achieved, indicating that cross-reactivity existed but also that unique epitopes are present in Buffalo grass (24). A study reported a close allergenic relationship between Salt, Grama and Bermuda grasses. Johnson grass appeared to also share some allergenicity with Bermuda grass (25).

This grass contains Group 1 allergens, to which more than 95% of patients allergic to grass pollen possess IgE antibodies. These are highly cross-reactive glycoproteins exclusively expressed in the pollen of many grasses (26-28). Group 1 allergens are highly homologous, but not all of the antigenic epitopes are cross-reactive (29). For example, Group 1 allergens from 8 different clinically important grass pollens of the *Pooideae* (Rye grass, Canary grass, Meadow grass, Cocksfoot and Timothy grass), *Chloridoideae* (Bermuda grass) and *Panicoideae* (Johnson grass, Maize) were isolated, and IgE binding to an allergic human serum pool was conducted to determine the degree of antigenic and IgE-binding similarities. The highest IgE-binding similarity was observed between Cocksfoot and Rye grass (53%) and between Rye grass and Canary grass (43%). No IgE-binding similarity was observed between Maize and other grasses. The highest antigenic similarity was also observed between Rye grass and Cocksfoot grass (76%), and the lowest similarity between Maize (23%) and Bermuda (10%) (30). Monoclonal antibodies of Cyn d 1 (Bermuda grass) recognised cross-reactive epitopes on proteins from 8 other grasses including Rye grass, Timothy grass, Meadow grass and Johnson grass (14).

Bermuda grass contains a profilin, which may contribute to cross-reactivity in pollen- and food-allergic patients. Pollen that contains profilin has been demonstrated in *Phleum pratense* (Timothy), *Olea europaea* (Olive), *Cynodon dactylon* (Bermuda grass), *Parietaria judaica* (Wall pellitory), *Sorghum halepense* (Johnson grass), *Poa pratensis* (Meadow grass), *Ambrosia elatior* (a Ragweed), and *Helianthus annuus* (Sunflower) pollen (12,31,35).

A low degree of cross-reactivity was shown between Kikuyu grass and Bermuda grass (33).

IgG immunoblot analyses of Date Palm pollen (*Phoenix dactylifera L.*) showed varying degrees of cross-reactivity with Bermuda grass, but this cross-reactivity is generally of low intensity (34).

Clinical Experience

IgE mediated reactions

Bermuda grass pollen is a very common source of pollinosis throughout the world and is a potent inducer of asthma, allergic rhinitis and allergic conjunctivitis (35-37).

In northern New South Wales, Australia, an association between Bahia grass and asthma in children was reported, and between Bermuda grass and allergic rhinitis in adults (38).

Sandstorm dust has been shown to contain Bermuda grass pollen, and appears to be a prolific source of potential triggers of allergic and nonallergic respiratory ailments (39).

In Comarca Lagunera, Spain, of 101 patients with asthma, 70% were found to be highly sensitive to Cynodon dactylon on specific IgE determination (40).

Bermuda grass was shown to make a high contribution to overall pollen rain in the semiarid environment of Arizona (41). In children, the prevalence of physician-diagnosed asthma was 9.8% at age 6 (n = 948) and 15.5% at age 11 (n = 895). Specific IgE tests for Bermuda grass demonstrated that it was the most prevalent allergen among children with allergic rhinitis (42). A further study confirmed the high prevalence of Bermuda grass sensitisation and found that Bermuda grass pollen was also significantly associated with sinusitis (43). In Orange County, California, in 271 patients identified by a group of local allergy specialists, tree pollen allergens were the most prevalent sensitising agents, followed in declining order by weed pollens, molds, environmentals, and grass pollen extracts. However, Bermuda grass pollen elicited the highest positive rate, with 85% of the group positive to this allergen (44).

In Mexico, Bermuda grass is a prominent aeroallergen (45). In Monclova, Coahuila, 4.9% of 247 patients were shown to be sensitised to Bermuda grass pollen (46). In Oaxaca, specific IgE determination in 138 patients with asthma, rhinitis and sinusitis showed that Bermuda and Rye grass were the most prevalent sensitising allergens after House Dust Mite (47).

Bermuda grass was shown by serum-specific IgE determination to be the most prevalent sensitising pollen in asthmatic children in Taiwan, with 8% of the children positive to this allergen (48).

In 100 Thai patients with allergic rhinitis, specific IgE tests were positive in 17% (49). In Kuala Lumpur, Malaysia, Bermuda grass pollen was recorded in aerobiological and clinical studies, and reported to be the most allergenic of the grass pollens (50).

Kuwait is a desert country where the prevailing high temperatures, low humidity, and scant vegetation suggest a low prevalence of allergy. In a study of allergen-specific IgE among 505 young adult blood donors with a mean age of 28.4 years, the Pharmacia CAP-RAST test showed that Bermuda grass, House dust mite, and Goosefoot were the most prevalent sensitising allergens, with frequencies of 53.6%, 52.7%, and 50.9%, respectively, among the sensitised subjects (51). Furthermore, in 810 patients with extrinsic asthma or allergic rhinitis from Kuwait, specific IgE to Bermuda grass was detected in 54.6% of sera (52). Further studies confirmed the high prevalence of sensitisation. In 706 patients aged 6 to 64 years with allergic rhinitis, specific IgE to Bermuda grass was detected in 55.0% (53). In 553 asthmatics, serum-specific IgE to Bermuda grass was found in 62.9%. Bermuda grass was imported for the purpose of "greening" the desert (54).

Similarly, in 263 United Arab Emirate nationals with a respiratory disease suspected of being of allergic origin, 33% were sensitised to Bermuda grass (55). In Saudi Arabia, in both adults and children with asthma and/or allergic rhinitis, specific IgE determination found Bermuda grass to be one of the most common allergens (56-57). In the Eastern Province of Saudi Arabia, 29% of 1,159 patients were shown, through specific IgE tests, to be sensitised to Bermuda grass (58).

Bermuda grass has also been shown to be a prominent allergen in Africa. In Johannesburg and Cape Town, South Africa, Bermuda was shown by specific IgE tests to be one of the most prevalent sensitising allergens in children with asthma and allergic rhinitis (59-60).

In a general paediatric clinic in Zimbabwe, in 84 children aged below 12 years with atopic conditions, the commonest allergens identified were Dust Mite and Bermuda grass, as determined by specific IgE determination (61). In Nigeria, specific IgE tests confirmed that Bermuda grass was a major aeroallergen in both rural and urban asthmatics (62).

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g11 Brome grass

Bromus inermis

Family: *Poaceae* (*Gramineae*)
Subfamily: *Pooideae*
Tribe: *Bromeae*
Common names: Bromegrass, Smooth Brome, Rescue grass
Source material: Pollen

Not to be confused with *Bromus arvensis* – Field brome, a cool-season bunchgrass introduced from Europe in the late 1920's into the USA and used as cover crop and for green manure in parts of northeastern and north-central regions.

Other common species of the genus include:

B. arvensis, B. mollis, B. racemosis.

A grass species producing pollen, which may induce hayfever, asthma and conjunctivitis in sensitised individuals.

Allergen Exposure

Geographical distribution

Brome grass is native to Europe, China and Siberia. It was introduced into North America in the 1880's, where it has since been cultivated in the northern regions from Alaska and all the Canadian provinces and territories south to southern California and New Mexico, northern Oklahoma, and North Carolina. It extends from Northern Europe eastwards to China. It is also widely distributed in Argentina and elsewhere in South America.

Brome is a cool-season, sod-forming grass which resists trampling, making it excellent for grazing and soil conservation. It grows up to 1.2 m tall. It is the only grass with a sealed sheath. Usually in the middle of the leaf blade there is an impression of the letter "V" or "W", vertical on the leaf. The numerous blades, both basal and from the stem, are flat but rolled in the bud-shoot, 4 to 13 mm wide, 15 to 55 cm long, flat, tapering to a sharp point, and with scabrous margins.

The inflorescence is an open panicle from 6 to 17 cm long bearing 6- to 11-flowered spikelets that are pale green to slightly purple-tinged. In the Northern Hemisphere, Brome grass starts flowering in May and finishes in September. The seeds ripen from August to September. The flowers are hermaphrodite (have both male and female organs) and are pollinated by wind. Brome grass reproduces by seed, rhizomes, and tillers, but spread by seed is weak.

Two principle types of Brome are recognised, the northern and southern. The northern type is weakly rhizomatous, with leaves well up on the stem and short glumes. A few northern cultivars are actually bunchgrasses. The southern type is strongly rhizomatous, with leaves near the base of the stem and long glumes. Other notable differences are earlier spring growth of the southern type and more even growth of the northern type through the growing season.

Environment

Brome grass is found in riparian zones, valley bottoms, and a variety of dryland sites.

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 lesser degree among members of the subfamily *Pooideae* (1-2).

In an early study, Brome grass, Western Wheat, and Quack grasses demonstrated RAST inhibition patterns similar to the northern grasses (Timothy, Meadow grass, Rye, Redtop, Meadow Fescue, and Sweet Vernal grass) (3).

Inhibition studies of IgE antibody binding to Dac g 4 (*Dactylis glomerata* - Cocksfoot grass) with other pollen extracts confirmed the presence of cross-reactive allergens in *Secale cereale* (Cultivated Rye), *Lolium perenne* (Rye grass), *Festuca elatior* (Meadow Fescue), *Holcus lanatus* (Velvet grass), *Bromus arvensis* (Field Brome), *Poa pratensis* (Meadow grass), *Hordeum sativum* (Barley), and *Phleum pratense* (Timothy grass) (4). Considering the presence of Group 4 allergens in Field Brome, the probability of a similar Group 4 allergen being present in Brome grass is high. Group 4 grass pollen allergens are glycoproteins with a molecular weight of 50 to 60 kDa, which are present in many grass species. Almost 75% of patients allergic to grass pollen display IgE reactivity to Group 4 allergens, which hence can be regarded as major grass pollen allergens (5). Further, Phl p 4 homologes with similar molecular weights were detected in *Dactylis glomerata* (Orchard grass), *Festuca pratensis* (Meadow Fescue), *Holcus lanatus* (Velvet grass), *Poa pratensis* (Meadow grass), and *Lolium perenne* (Rye grass). Group 4 homologes are present in the various grass extracts, but to different extents (6).

Clinical Experience

IgE mediated reactions

Brome grass pollen can induce asthma, allergic rhinitis and allergic conjunctivitis.

Brome grass pollen has been recorded as an aeroallergen in the Western Cape, South Africa (7).

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g71 Canary grass

Phalaris arundinacea

Family: *Poaceae* (*Gramineae*)
Subfamily: *Pooideae*
Tribe: *Aveneae*
Common names: Reed Canary grass, Reed Canarygrass, Ribbon grass, Variegated grass
Source material: Pollen

Commonly recognised varieties include

Phalaris canariensis – Canary grass, Canarygrass (UK), Canary seed, Canaryseed, Canary bird seed;

Phalaris aquatica – Bulbous Canary grass, Harding grass, Hardinggrass (Canada), Toowoomba Canary grass (Australia);

Phalaris coerulescens – Blue canary grass.

A grass species producing pollen, which often induces hayfever, asthma and conjunctivitis in sensitised individuals.

Allergen Exposure

Geographical distribution

Canary grass, probably native to North America, is widely distributed in both North America and Europe in regions above the sub-tropics. The European cultivars for hay and forage have no clear distinguishing characteristics from apparently native plants.

Canary grass is a perennial that can grow as tall as 2.6 m but usually reaches a height of only 1.5 m. The sturdy, often hollow stems can have some reddish coloration near the top. Leaves are up to 30 cm long and 2 cm wide. The seed head is a compact, green or light-purple panicle that can vary in length from 7 to 40 cm. Panicles are on culms high above the leaves. The plant reproduces sexually by seed production, but mainly spreads vegetatively by means of dense, vigorous rhizome growth

The species flowers between April and September. The flowers are hermaphrodite (have both male and female organs) and are pollinated by wind. The plant is noted for attracting wildlife.

Environment

A wetland plant, this species typically occurs in soils that are saturated or nearly saturated for most of the growing season. Ideal conditions typically occur in roadside ditches, rights-of-way, river dikes and levees, shallow marshes, and meadows. It usually forms monotypic stands and is highly competitive with Timothy (*Phleum pratense*), Meadow grass (*Poa pratensis*), and Redtop (*Agrostis alba*). It is also cultivated as a ground cover, and some varieties are used ornamentally.

g71 Canary grass

Unexpected exposure

The leaves have been woven into hats and mats.

Allergens

Pha a 1, a 34 kDa protein, a major allergen (1).

Pha a 5, a major allergen existing in 4 isoforms (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 *Poaceae*, in particular grasses belonging to the *Pooideae* sub-family (Rye grass (g5), Canary grass (g71), Meadow grass (g8), Timothy grass (g6), Cocksfoot (g3), Meadow fescue (g4), Velvet grass (g13), Redtop (g9), Meadow foxtail (g16), Wild rye grass (g70)) (2-3).

This grass contains Group 1 allergens, to which more than 95% of patients allergic to grass pollen possess IgE antibodies. These are highly cross-reactive glycoproteins exclusively expressed in the pollen of many grasses (4-6). Group 1 allergens are highly homologous, but not all of the antigenic epitopes are crossreactive (7). For example, Group 1 allergens from 8 different clinically important grass pollens of the *Pooideae* (Rye grass, Canary grass, Meadow grass, Cocksfoot and Timothy grass), *Chloridoideae* (Bermuda grass) and *Panicoideae* (Johnson grass, Maize) were isolated, and IgE binding to an allergic human serum pool was conducted to determine the degree of antigenic and IgE-binding similarities. The highest IgE-binding similarity was observed between Cocksfoot and Rye grass (53%) and between Rye grass and Canary grass (43%). No IgE-binding similarity was observed between Maize and other grasses. The highest antigenic similarity was also observed between Rye grass and Cocksfoot grass (76%), and the lowest similarity between Maize (23%) and Bermuda (10%) (8).

Highly homologous Group 1 allergens have been demonstrated between Pha a 1 from Canary grass, Lol p 1 from Rye grass pollen (a deduced amino acid sequence identity of 88.8%), Hol l 1 from Velvet grass pollen (88.1%), and Phl p 1 from Timothy grass pollen (86.6%) (9). The major Timothy grass pollen allergen Phl p 1 also cross-reacts with most grass-, Corn- and monocot-derived Group 1 allergens (10). Monoclonal antibodies of Cyn d 1 (Bermuda grass) recognised cross-reactive epitopes on proteins from eight other grasses including Rye grass, Timothy grass, Meadow grass and Johnson grass (11).

Pha a 1 from Bulbous canary grass (*P. aquatica*) has been shown to have common allergenic components with other grasses. In a separate study, IgE binding of Pha a 1, Lol p 1 (Rye grass), and Cyn d 1 (Bermuda grass) was investigated in 24 sera of Bulbous canary grass-allergic individuals and found to occur in 19/24, 18/24, and 9/24, respectively. IgE binding to all three major allergens, or to both Pha a 1 and Lol p 1, occurred in 8/24 sera. The findings suggested that while the N-terminal sequence of Pha a 1 was identical to Lol p 1, there may be specific allergenic epitopes exclusive to this allergen that are important for allergenicity in southern Australia (12). As *P. aquatica* and *P. arundinacea* are closely related, this may apply to the latter grass pollen as well.

Canary grass pollen contains a Group 5 allergen. Almost 90% of grass pollen-allergic patients are sensitised against Group 5 grass pollen allergens. A monoclonal human IgE antibody has been shown to cross-react with Group 5A isoallergens from several grass and Corn species (13). Polymorphic forms of Pha a 5 from Canary grass have been shown to share significant sequence identity with other group 5 allergens from Rye grass, Timothy grass and Meadow grass pollens (1). Group 5 allergens have been detected in *Phleum pratense*, *Lolium perenne* (Rye grass), *Poa pratensis* (Meadow grass) and *Dactylis glomerata* (Cocksfoot) extracts. The major components in these fractions were found to be 25-28 kDa proteins, and IgE binding to these components was confirmed using a pool of grass-allergic sera (14).

Sequence comparisons showed that the Hor v 9 cDNA clones (Barley pollen) were also homologous to Group 5 allergens of

Timothy grass (*Phleum pratense*) pollen and Bulbous canary grass (*Phalaris aquatica*) pollen, and to the Group 9 allergen of Rye grass (*Lolium perenne*) pollen (15).

Clinical Experience

IgE mediated reactions

Canary grass pollen often induces asthma, allergic rhinitis and allergic conjunctivitis (13).

Canary grass pollen has been found in aeroallergen studies in the Western Cape, South Africa (16).

Specific IgE measurements in sera from subjects sensitized to Wheat and Rye flour indicated that there is significant reaction with seed extracts of 12 cereals (Wheat, Durum wheat, Triticale, Cereal rye, Barley, Rye grass, Oats, Canary grass, Rice, Maize, Sorghum and Johnson grass) (17).

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g3 Cocksfoot

Dactylis glomerata

Family: *Poaceae* (*Gramineae*)
Subfamily: *Pooideae*
Tribe: *Poeae*
Common names: Cocksfoot grass, Cock's foot grass, Cock's-foot, Orchard grass
Source material: Pollen

Recognized varieties include
D. g. var. ciliata Peterm,
D. g. var. detonsa Fries.

A grass species producing pollen, which often induces hayfever, asthma and conjunctivitis in sensitised individuals.

Allergen Exposure

Geographical distribution

Of Eurasian temperate zone origin, Cocksfoot was introduced to the eastern United States in 1760. It is now found throughout most of US, except for desert or arctic regions, and also grows in the temperate regions of Africa (Kenya, Tanzania, Rhodesia, S. Africa), Australia (NSW, Victoria, and other areas of southern Australia) and South America (Brazil, Colombia, Venezuela, Argentina). It is widespread in Europe and temperate Asian regions such as Japan, where it is a major pollen source. It is one of the commonest grasses, and is widely used for forage and hay. It is one of the best grasses for cultivating in shady areas.

Cocksfoot is an evergreen perennial bunchgrass growing to 1.4 m tall and with a deep root system. The plant is non-rhizomatous, reproducing by seeds and tillers. It has erect, glabrous culms, and blades 10 to 60 cm long and 0.2 to 1.1 cm wide. The inflorescence is a panicle 8 to 20 cm long with 2 to 6 florets per spikelet, and the spikelets tightly clustered on one side of the blade. This arrangement has been compared to the foot of a cockerel.

In North America it flowers from April/May to August, and in Europe from June to September. The flowers are hermaphrodite (have both male and female organs) and are pollinated by wind. The seeds ripen from July to September.

Environment

The plant grows on roadsides, lawns, fields, ditch banks, meadows, and waste places, often in the wake of disturbance. It prefers woodland and other dappled shade, and even occasionally occurs in desert shrub communities. It is frequently planted for ground cover, soil stabilization and biomass, but especially for pasture and hay.

The plant is a folk remedy for treating tumours and kidney and bladder ailments.

Allergens

To date, many IgE-binding components have been isolated, major allergen groups identified, and allergens indicated by cross-reactive studies (1-8).

Dac g 1 (9-11).

Dac g 2 (12).

Dac g 3, a 14 kDa protein(13).

Dac g 4, a major 59 kDa protein (14-15).

Dac g 5 (16-17).

Dac g 3 is recognised by more than 60% of sera from *Dactylis glomerata* pollen-allergic individuals (13).

In the *Dactylis glomerata* plant, allergenic components are most highly concentrated in the pollen, but are also present in the leaves and show traces in the stems (18).

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 *Poaceae*; and is especially likely for members of the subfamily *Pooideae* (Rye grass (g5), Canary grass (g71), Meadow grass (g8), Timothy grass (g6), Cocksfoot (g3), Meadow fescue (g4), Velvet grass (g13), Redtop (g9), Meadow foxtail (g16), Wild rye grass (g70)) (19-20).

This grass contains Group 1 allergens, to which more than 95% of patients allergic to grass pollen possess IgE antibodies. These are highly cross-reactive glycoproteins exclusively expressed in the pollen of many grasses (21-23). Group 1 allergens are highly homologous, but not all of the antigenic epitopes are crossreactive(24). For example, Group 1 allergens from 8 different clinically important grass pollens of the *Pooideae* (Rye grass, Canary and Meadow grass, Cocksfoot and Timothy grass), *Chloridoideae* (Bermuda grass) and *Panicoideae* (Johnson grass, Maize) were isolated, and IgE binding to an allergic human serum pool was conducted to determine the degree of antigenic and IgE-binding similarities. The highest IgE-binding similarity was observed between Cocksfoot and Rye grass (53%) and between Rye grass and Canary grass (43%). No IgE-binding similarity was observed between Maize and other grasses. The highest antigenic similarity was also observed between Rye grass and Cocksfoot grass (76%), and the lowest similarity between Maize (23%) and Bermuda (10%) (25).

The major Timothy grass pollen allergen Phl p 1 also cross-reacts with most grass-, Corn- and monocot-derived Group 1 allergens, including Dac g1 (26). Monoclonal antibodies of Cyn d 1 (Bermuda grass) recognised cross-reactive epitopes on proteins from eight other grasses, including Cocksfoot, Rye grass, Timothy grass, Meadow grass and Johnson grass (27).

T-cell lines specific for Phl p 1 (the Group I allergen of Timothy grass, *Phleum pratense*) from the sera of 9 patients allergic to grass pollen displayed IgE binding with grass pollen extracts from *Dactylis glomerata* (Cocksfoot), *Poa pratensis* (Meadow grass), *Lolium perenne* (Rye grass), *Secale cereale* (Cultivated rye), and selected amino acid sequence-derived peptides. Cross-reactivity studies revealed cross-reacting and non-cross-reacting T-cell epitopes (28).

Immunological identity between recombinant Dac g 2 (from Cocksfoot grass) and Lol p 1 and Lol p 2 (both from Rye grass) has been demonstrated. Similar cross-identity was observed with pollen extracts from 3 other grass species: *Festuca rubra* (Red fescue), *Phleum pratense* (Timothy grass) and *Anthoxanthum odoratum* (Sweet vernal grass). Recombinant Dac g 2 was recognised by species- and group-cross-reactive human IgE antibodies in 33% (4/12) of sera randomly selected from grass-sensitive individuals and in 67% (14/21) of sera from patients receiving grass pollen immunotherapy (12).

A sequence identity of 65% was found between Dac g 3 allergen and Lol p 3 (Rye grass), suggesting that these allergens are homologues. Computer analyses showed that, in spite of a high degree of sequence homology, even closely related allergens such as Dac g 3 and Lol p 3 have dissimilar predictive secondary structures and different potential antigenicity (13).

Cocksfoot grass also contains a Group 4 allergen. Group 4 grass pollen allergens are glycoproteins with a molecular weight of 50 to 60 kDa, which are present in many grass species. Almost 75% of patients allergic to grass pollen display IgE reactivity to Group 4 allergens, which hence can be regarded as major grass pollen allergens (29). Phl p 4 represents a trypsin-resistant major Timothy grass pollen allergen with immunologic similarities to the major Ragweed allergen Amb a 1 and therefore must be considered an important cross-reactive component in grass pollen and weed pollen allergy (29). Inhibition studies of IgE antibody binding to Dac g 4 (*Dactylis glomerata* - Cocksfoot grass) and to other pollen extracts confirmed the presence of cross-reactive allergens in *Secale cereale* (Cultivated rye), *Lolium perenne* (Rye grass), *Festuca elatior* (Meadow fescue), *Holcus lanatus* (Velvet grass), *Bromus arvensis* (Field brome), *Poa pratensis* (Meadow grass), *Hordeum sativum* (Barley), and *Phleum pratense* (Timothy grass) (14).

Phl p 4 homologes with similar molecular weight were detected in *Dactylis glomerata* (Cocksfoot grass), *Festuca pratensis* (Meadow fescue), *Holcus lanatus* (Velvet grass), *Poa pratensis* (Meadow grass), and *Lolium perenne* (Rye grass). Group 4 homologes were present in the various grass extracts, but to different extents (15).

Cocksfoot grass pollen also contains a Group 5 allergen. Almost 90% of grass pollen-allergic patients are sensitised against Group 5 grass pollen allergens. Group 5 allergens have been detected in Timothy grass, Rye grass, Meadow grass and Cocksfoot extracts. The major components in these fractions were found to be 25-28 kDa proteins, and IgE binding to these components was confirmed using a pool of grass-allergic sera (30).

The variability of cross-reactivity of IgE antibodies to Group 1 and 5 allergens in *Dactylis glomerata* (Cocksfoot), *Festuca rubra* (Red fescue), *Phleum pratense* (Timothy grass), *Anthoxanthum odoratum* (Sweet vernal grass), *Secale cereale* (Cultivated rye), *Zea mays* (Maize), and P*hragmites communis* (Common reed) to IgE antibodies against Lol p I or Lol p V (from Rye grass) was investigated by means of RAST-inhibition. The degree of cross-reactivity was demonstrated to be highly variable. Individual sera were not always equally cross-reactive to all pollen species. A high degree of cross-reactivity for Group 1 allergens did not necessarily imply the same for Group 5. Group 1 and Group 5 representatives were found to be present in all 8 species (31).

An inhibition test has shown that the reactivity of the IgE antibody specific for Olive tree pollen antigen was inhibited dose-dependently by an extract of Cocksfoot grass pollen. These findings show that there is a reaction in some patients with grass pollinosis that might be induced by Olive tree pollen (32).

Sera from 3 patients with confirmed allergy to Melon, Cocksfoot and English Plantain pollens revealed that several distinct protein bands were shared by the 3 extracts at 14, 31, and a spectrum between 40 and 70 kDa, approximately. Extracts of Melon, Plantain and Cocksfoot showed that all allergens of Melon blotting were almost completely inhibited by grass and *Plantago* pollen extracts, supporting the theory that there are structurally similar allergens, and that all allergenic epitopes of Melon are present in these pollens (33-34).

Sera from subjects diagnosed as allergic to White cypress pine, Italian cypress, Rye grass or Birch pollen were shown to have IgE antibodies that reacted with pollens from these 4 species and from Cocksfoot, Couch grass, Lamb's quarters, Wall pellitory, Olive, Plantain and Ragweed. The authors conclude that the presence of pollen-reactive IgE antibodies may not necessarily be a true reflection of sensitising pollen species (35).

Four monoclonal antibodies raised to Cyn d 1 (Bermuda grass) were shown to cross-react with pollen components from other grass species, especially Meadow grass and Cocksfoot (27).

An early study suggested that Birch, Cocksfoot, Mugwort and Ragweed pollen might have shared allergens with an extract of Apple pulp (36).

g3 Cocksfoot

Clinical Experience

IgE mediated reactions

Cocksfoot grass pollen is a very common allergen inducing asthma, allergic rhinitis and allergic conjunctivitis (37-39).

In 187 patients in Madrid, Spain, with rhinitis and/or seasonal asthma, 92% were shown to have specific IgE to Cocksfoot pollen (40).

In a Polish study, 22 patients with seasonal allergic rhinitis between 13 and 53 years of age were examined for specific IgE to 5 grass and 3 weed pollens. The most common sensitisation was to Meadow fescue (*Festuca elatior*), Meadow grass (*Poa pratensis*) and Cocksfoot (*Dactylis glomerata*) (41).

Cocksfoot grass has also been reported to be an important aeroallergen in Greece. In Athens, the most prevalent aeroallergen in patients with allergic rhinitis as shown by specific IgE determination was to *Dactylis glomerata* (Cocksfoot), *Parietaria* (Pellitory), *Olea europea* (Olive), *Dermatophagoides* (House dust mite) and several moulds (42).

Similarly, in Turkey, as shown by specific IgE tests on 614 respiratory-allergic patients, Cocksfoot grass was among important grass pollens (43).

Cocksfoot grass is a very important aeroallergen in Japan, resulting in a high prevalence of sensitisation as determined by specific IgE determination (44-47). In 226 children attending an allergy clinic, overall average sensitisation rates were 38.5% for *D. glomerata*. Among children aged 12 or more, sensitisation rates for *D. glomerata* were much higher (56.3%) (48). Cocksfoot grass pollen was also shown to be a major cause of seasonal allergic rhinitis in a farming community in central Japan where Cocksfoot grass was planted for Apple farming (49).

In Thailand, 18% of 100 patients with allergic rhinitis were shown by specific IgE determination to be sensitised to Cocksfoot grass (50).

One study indicated that Dactylis glomerata pollen is a trigger for or exacerbates atopic eczema (51).

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Phragmites communis

Family:	*Poaceae* (*Gramineae*)
Subfamily:	*Arundinoideae*
Tribe:	*Arundineae*
Common names:	Reed grass, Reed
Source material:	Pollen
Synonyms:	*Phragmites australis, P. vulgaris, Arundo phragmites, Arundo vulgaris*

A grass species producing pollen, which may induce hayfever, asthma and conjunctivitis in sensitised individuals.

Allergen Exposure

Geographical distribution

The Common reed is native to Eurasia and Africa, but is now widespread through much of the world, including the United States, Mexico, the West Indies, Chile, Argentina, and Australia.

Common reed is a tall, warm-season, bamboo-like, perennial sod-forming grass. The culms are erect, rigid, smooth, and hollow. They may be nearly 2.5 cm in diameter and from 2 to 4 m tall, occasionally up to 6 m, terminating in a 30 cm-long, densely flowered, tawny or purplish panicle. The plant has stout, creeping, extensive rhizomes, often also stolons. Roots grow down to a depth of about 1 m. The leaf-blades, arising from the culm, are broad, flat, 1.5 to 6 dm long, 1 to 6 cm broad, glabrous, green or glaucous, with the sheaths overlapping.

The flowers develop later than in most other grasses, and blooming often coincides with that of common weeds such as *Artemisia* or other members of the *Asteraceae* (*Compositae*), in the late summer to fall. The spikelets are 10 to 17 mm long, and the florets are exceeded by the hairs of the rachilla. The seeds ripen from late to mid-fall. The flowers are hermaphrodite (have both male and female organs) and are pollinated by wind.

Environment

It grows in marshes, swamps and other wet wastelands, and along streams, lakes, ponds and ditches. It is often weedy and very difficult to eradicate, as the stoloniferous rhizomes may reach 10 m or more in length. But for the same reason it may be planted to stabilize stream banks.

Reeds are very commonly used for thatching and for making partitions, fences, coarse mats, carrying nets, baskets, rope, sandals, pens, brooms, lattices, and arrows.

The shoots, roots, stems, leaves and seeds have culinary uses, and are more recently harvested for cellulose. Young reeds provide animal forage and green manure. The leaves, flowers and stems are used medicinally, and in ornamental arrangements.

Unexpected exposure

It is converted into alcohol (for use as a fuel), fertilizer, rayon, insulation, plaster, cork substitute, upholstery filler, boards and paper. A light-green dye is obtained from the flowers.

g7 Common reed

Allergens

No allergens from this plant have yet been characterised.

Common reed appears to contain Group 1, Group 2 and Group 5 allergens (1-2).

Potential cross-reactivity

An extensive cross-reactivity among the different individual species of the genus could be expected, as well as to a lesser degree among members of the closely related subfamily *Bambusoideae* (Bamboo, Rice), and the family *Poaceae* (grasses) (3-4).

Natural pollen extracts from *Anthoxanthum odoratum* (Sweet vernal grass), *Avena sativa* (Cultivated oat), *Cynodon dactylon* (Bermuda grass), *Lolium perenne* (Rye grass), *Phragmites communis* (Common reed), *Poa pratensis* (Meadow grass), *Secale cereale* (Cultivated rye grass), *Triticum sativum* (Cultivated wheat), and *Zea mays* (Maize/Corn) were characterised regarding their allergen contents by means of specific antibodies and by IgE immunoblot inhibition with recombinant allergens from Phl p 1, Phl p 2, Phl p 5, and Bet v 2 using sera of 193 European, American, and Asian subjects. Immunologically detectable Group 5 and Group 2 allergens were found in all these species except for *C. dactylon* and *Z. mays* (1).

Group 1 and Group 5 allergens were shown to be present in *Dactylis glomerata* (Cocksfoot), *Festuca rubra* (similar to Meadow fescue), *Phleum pratensis* (Timothy grass), *Anthoxanthum odoratum* (Sweet vernal), *Secale cereale* (Cultivated rye), *Zea mays* (Maize/Corn), and *Phragmites communis* (Common reed). Cross-reactivity of IgE antibodies against Lol p 1 or Lol p 5 to these grasses was investigated by means of RAST-inhibition, and the degree of cross-reactivity was demonstrated to be highly variable. Individual sera were not always equally cross-reactive to all pollen species. A high degree of cross-reactivity for Group 1 allergens did not necessarily imply the same for Group 5 (2).

Clinical Experience

IgE mediated reactions

Common reed pollen can induce asthma, allergic rhinitis and allergic conjunctivitis.

Common reed grass is a common aeroallergen in the Western Cape, South Africa (5).

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g14 Cultivated oat

Avena sativa

Family:	*Poaceae (Gramineae)*
Subfamily:	*Pooideae*
Tribe:	*Aveneae*
Common names:	Cultivated oats, Common oat
Source material:	Pollen

Cultivated oat (*Avena sativa*) g14 must be differentiated from False oat grass (*Arrhenatherum elatius*) g204 and Oats (*Avena sativa*) f7, the food.

A grass species producing pollen, which often induces hayfever, asthma and conjunctivitis in sensitised individuals.

Allergen Exposure

Geographical distribution

Oats are of uncertain origin, but probably originated in Europe from two species of Wild oats (*A. fatua L.*) and Wild Red oats (*A. sterilis L.*). Oats are now cultivated throughout the temperate zones of the world. The major growing areas are the USA, southern Canada, the USSR and Europe, particularly around the Mediterranean.

Oats are an erect, tufted annual grass, growing to 1.2 m. The culms are smooth or scabrous beneath the panicle. The leaves are 15 to 30 cm long and 0.6 to 1.2 cm wide, with loose sheaths. The spikelets, usually 2-flowered, are up to 2.5 cm long, and the kernel is 0.6 to 0.8 cm long, narrow, with nearly parallel sides, and hairy.

Oats are in flower between early spring and early summer, and the seeds ripen between late summer and mid-autumn, depending on the environment. The flowers are hermaphrodite (have both male and female organs). Self-pollination is normal, but cross-pollination by wind also occurs.

Environment

Oats may escape cultivated fields and are found in dry wasteland, alien crops and meadows, especially on heavier soils.

Oats are used as a cereal, or in making biscuits, sourdough, etc., but usually not bread. Oats are also one of basic ingredients of whisky, and a coffee substitute. An edible oil obtained from the seed is used in the manufacture of commercial breakfast cereals.

Unexpected exposure

The straw has a wide range of uses, such as for biomass, fibre, mulch, paper-making, building board and thatching, and as a stuffing and bedding material. The hulls can serve as a filter in breweries.

Allergens

No allergens from this plant have yet been characterised.

Cultivated oat appears to contain Group 1, Group 2 and Group 5 allergens (1-2).

g14 Cultivated oat

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 *Poaceae*, especially in the subfamily *Pooideae* (Rye grass, Canary grass, Meadow grass, Cocksfoot and Timothy grass) (3-4).

Natural pollen extracts from *Anthoxanthum odoratum* (Sweet vernal grass), *Avena sativa* (Cultivated oat), *Cynodon dactylo*n (Bermuda grass), *Lolium perenne* (Rye grass), *Phragmites communis* (Common Reed), *Poa pratensis* (Meadow grass), *Secale cereale* (Cultivated rye grass), *Triticum sativum* (Cultivated wheat), and *Zea mays* (Maize/Corn) were characterised regarding their allergen contents by means of specific antibodies and by IgE immunoblot inhibition with recombinant allergens from Phl p 1, Phl p 2, Phl p 5, and Bet v 2 using sera of 193 European, American, and Asian subjects. Immunologically detectable Group 5 and Group 2 allergens were found in all these species except for *C. dactylon* and *Z. mays* (1).

A high degree of cross-reactivity for Group 1 allergens did not necessarily imply the same for Group 5 (2).

Pollen from 10 agricultural plant species was surveyed for the presence of proteins cross-reactive with Group 1, Group 4 and Group 9 allergens. Barley (*Hordeum vulgare*), Maize (*Zea mays*), Rye (*Secale cerale*), Triticale (*Triticosecale cereale*), Oats (*Avena sativ*a), Canola (*Brassica napus*) and Sunflower (*Helianthus annus*) pollens contained numerous allergen-cognate proteins (5).

Cross-reactivity between Cultivated oat pollen and Oat seed has not been established as yet.

Clinical Experience

IgE mediated reactions

Cultivated oat pollen can induce asthma, allergic rhinitis and allergic conjunctivitis.

Specific IgE determination demonstrated that Oat pollen may be an occupational allergen among dairy farmers (6).

Other reactions

Oats, the seed of Cultivated oat, may result in food allergy. See Oats (*Avena sativa*) f7. Feathers and Oat chaff have been used as bedding materials, and may result in allergic symptoms in children and infants (7).

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g12 Cultivated rye

Secale cereale

Family:	*Poaceae (Gramineae)*
Subfamily:	*Pooideae*
Tribe:	*Triticeae*
Common names:	Rye
Source material:	Pollen
Synonyms:	*Triticum cereale*

There is a need to differentiate between Cultivated rye grass pollen (*Secale cereale*) g12, the foodstuff Rye (*Secale cereale*) f5, Rye grass (*Lolium perenne*) g5, and Wild rye grass (*Elymus tricoides*) g70.

A grass species producing pollen, which often induces hayfever, asthma and conjunctivitis in sensitised individuals.

Allergen Exposure

Geographical distribution

Probably native to the Mediterranean or southwestern Asia, but now widely cultivated in the temperate regions of the world, Rye can be grown in a wider range of environmental conditions than any other small grain. Winter rye is the most winter-hardy of all cereals. Rye is cultivated in Central and Eastern Europe, Russia and North America, often where conditions are unfavorable for Wheat. Less than 50% of the Rye grown in the US is harvested for grain, with the remainder used as pasture, hay, or as a cover crop.

Rye is a hardy, tufted annual grass, 1 to 1.5 m tall, with a blue-green cast and an extensive root system. The leaves are 1.2 cm or less broad, 7.5 to 15 cm long, smooth or slightly scabrous, and pointed; the leaf sheaths are long and loose. A 7 to 15 cm bushy spike is the flower head. The spikelets contain 2 fertile florets; the kernels are oblong, 0.8 cm long, and light-brown,

It is in flower from May to July (in the Northern Hemisphere), giving rise to the well-known "smoke" when the Rye pollen is released in great masses. The seeds ripen from August to September. The flowers are hermaphrodite (have both male and female organs) and are pollinated by wind.

Environment

The plant grows in cultivated beds and requires full sunlight. It is also used as a pasturage grass, grazed in the fall or spring and then allowed to head-out and mature. It may be a weed in Wheat fields, and may escape along roadsides and to waste places, but never becomes established outside cultivation.

Rye is widely cultivated for its grain and as valuable spring forage. A common cereal, Rye is used-especially in northern Europe-to make bread, cakes, etc. The seed can be sprouted and added to salads. Malt, a sweet substance produced by germinating the seed, is used as a sweetening agent and in making beer and whisky.

g12 Cultivated rye

Unexpected exposure

The straw is used as a fuel or as a biomass in industry. It is quite strong and can also be used in archery targets, mushroom compost, bedding, thatching, for paper making, weaving mats and hats, and as a packing material for nursery stock, bricks and tiles. It is often dried for commercial flower arrangements.

Allergens

Cultivated rye pollen contains more than 30 proteins that can be shown to be allergens in terms of their IgE binding in sera from Rye pollen-allergic individuals. Nine were determined to be major allergens. Using Western Blot, 17 allergens were isolated, 3 of them major allergens (1).

To date, only Sec c 5 has been characterised (2). Group 1, 4 and 5 allergens have been inferred from studies on cross-reactivity between grasses. Although other allergens have not yet been fully characterised, a 28 kDa allergen has been isolated (3), and allergens of 33 kDa, 48 kDa and 67 kDa detected (4).

Potential cross-reactivity

This pantemperate tribe *Triticeae* is notable for its cereal genera: Wheat, Barley and Rye. The close relation speaks in favour of cross-reactivity between Wild rye grass g70, Cultivated wheat g15, Cultivated rye grass g12, Barley g201, and Couch grass (*Agropyron repens*) as well as Lymegrass (*Elymus arenarius*). An extensive cross-reactivity among the different individual species of the genus could be expected. There should be cross-reactivity with other members of the family *Poaceae*, particularly in the subfamily *Pooideae* (Rye grass (g5), Canary grass (g71), Meadow grass (g8), Timothy grass (g6), Cocksfoot (g3), Meadow fescue (g4), Velvet (g13), Redtop (g9), Meadow foxtail (g16), Wild rye grass (g70)) (5-6).

Phl p 1, a major allergen of Timothy grass, harbours multiple T-cell epitopes. Species-specific and cross-reacting T-cell epitopes were reported to exist among Group 1 grass allergens, which include *Secale* (7).

Inhibition studies of IgE antibody binding to Dac g 4 from *Dactylis glomerata* (Cocksfoot grass) with pollen extracts confirmed the presence of cross-reactive allergens in *Secale cereale* (Cultivated rye), *Lolium perenne* (Rye grass), *Festuca elatior* (Meadow fescue), *Holcus lanatus* (Velvet grass), *Bromus arvensis* (Field brome), *Poa pratensis* (Meadow grass), *Hordeum sativum* (Cultivated barley), and *Phleum pratense* (Timothy grass) (8).

Natural pollen extracts from *Anthoxanthum odoratum* (Sweet vernal grass), *Avena sativa* (Cultivated oat), *Cynodon dactylon* (Bermuda grass), *Lolium perenne* (Rye grass), *Phragmites australis* (Common reed), *Poa pratensis* (Meadow grass), *Secale cereale* (Cultivated rye), *Triticum sativum* (Cultivated wheat), and *Zea mays* (Maize/Corn) were characterized regarding their allergen contents by means of specific antibodies and by IgE immunoblot inhibition with recombinant allergens from Phl p 1, Phl p 2, Phl p 5, and Bet v 2 using sera of 193 European, American, and Asian subjects. Immunologically detectable Group 5 and Group 2 allergens were found in all these species except for *C. dactylon* and *Z. mays* (9).

Pollen from 10 agricultural plant species was surveyed for the presence of proteins cross-reactive with Group 1, Group 4 and Group 9 allergens. Barley (*Hordeum vulgare*), Maize (*Zea mays*), Rye (*Secale cerale*), Triticale (*xTriticosecale cereale*), Oat (*Avena sativa*), Canola (*Brassica napus*) and Sunflower (*Helianthus annus*) pollens contained numerous allergen-cognate proteins (10).

Cross-reactivity between Rye pollen and Rye seed has not been studied in detail. In a 1984 study, crossed line immuno-electrophoresis showed that some of the Rye pollen antigens were immunological partially identical to antigens of Wheat flour and Rye flour (11).

Clinical Experience

IgE mediated reactions

Cultivated rye grass pollen can induce asthma, allergic rhinitis and allergic conjunctivitis (1-2).

In an early French study, Barley pollen and Rye pollen were reported to be important sensitising allergens in children with grass pollinosis, as determined by specific IgE studies (12).

The importance of grass pollen as a cause of hay fever in the South Plain of Hungary was studied. Of 642 patients with seasonal allergic rhinitis, 261 who experienced allergic rhinitis in May and June, when the daily pollen count of grass pollen was at its highest, were examined for specific IgE to various grasses. In this study 84% were positive to *Poaceae* grasses, and 63% to Secale (13).

In Saudi Arabia, Cultivated rye pollen was shown to be one of the most abundant aeroallergens in sandstorm dust (14).

Other reactions

Antifreeze proteins, which are proteins that have the ability to retard ice crystal growth, have been identified as the most abundant apoplastic proteins in cold-acclimated Winter rye leaves. All tests indicated that these antifreeze proteins are similar to members of three classes of pathogenesis-related proteins, namely endochitinases, endo-beta-1,3-glucanases, and thaumatin-like proteins(15). Chitinases have also been isolated from Rye seed (16), but the relationship between these and the chitinases from Rye leaves has not yet been determined.

Rye infested with a fungus called ergot was responsible for several epidemics in medieval times.

g12 Cultivated rye

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g15 Cultivated wheat

Triticum sativum

Family: *Poaceae* (*Gramineae*)
Subfamily: *Pooideae*
Tribe: *Triticeae*
Common names: Wheat, Bread wheat, Common wheat
Source material: Pollen
Synonyms: *T. vulgare, T. aestivum*

In various countries, several species of *Triticum* are cultivated, among which is *Triticum sativum* (*Triticum vulgare*), the species most generally raised in the US and Europe. It has two varieties, *Triticum aestivum*, or Spring wheat, and *Triticum hybernum*, or Winter wheat.

See Wheat f4 for allergy to the food.

A grass species producing pollen, which often induces hayfever, asthma and conjunctivitis in sensitised individuals.

Allergen Exposure

Geographical distribution

Cultivated wheat is of uncertain origin, perhaps coming from the Middle East. It is known only under cultivation. This cereal is widely cultivated in temperate countries and in cooler parts of tropical countries. Next to Rice, it is the world's most widely used grain. Wheat covers about 50% of the total area sown with grain crops in Europe. Important areas of cultivation include Argentina, Belgium, Britain, Canada, China, India, Japan, Peru, Spain, Turkey, the US, southern former USSR and southwestern Australia.

Cultivated wheat is an annual grass. The root is fibrous. The stem is simple, round, smooth, erect, hollow or pithy, and up to 1.5 m tall. The leaves are flat, narrow, veined, roughish above, 20 to 38 cm long, and about 1.3 cm broad. The flowers are borne on a 4-cornered terminal spike, 5 to 7.5 cm in length, with a tough rachis. The spikelets are broad-ovate, 2- to 5-flowered, slightly overlapping, and pressed close to the rachis. The grains are loose.

Cultivated winter wheat flowers from June to July (in the Northern Hemisphere), and Spring wheat flowers in late summer. The flowers are hermaphrodite (have both male and female organs) and are pollinated by wind.

Environment

Wheat is grown in cultivated beds, usually as a crop but sometimes for pasturage. It is not known in the wild.

The seed can be cooked as a whole grain but it is more usually ground into a powder and used as a flour for making bread, fermented foods, pasta, cakes, biscuits, etc. The grain also is the source of alcoholic beverages. Bran from the flour milling is also an important livestock feed; the germ is a valuable addition to feed concentrate. Some Wheat is cut for hay.

Wheat is used as a shampoo and is a folk remedy.

Unexpected exposure

The straw has many uses: e.g., as a biomass, for fuel, thatching, mulch. mats, carpets, baskets, packing material, cattle bedding, and paper manufacturing.

g15 Cultivated wheat

Allergens

Cultivated wheat pollen contains a 1,3-beta-glucanase allergen (1).

No other allergens from this pollen have yet been characterised, although many have been characterised from the seed.

Potential cross-reactivity

The pantemperate tribe *Triticeae* is notable for its *cereal* genera: Wheat, Barley and Rye. The close relation speaks in favour of cross-reactivity between Wild rye grass g70, Cultivated wheat g15, Cultivated rye g12, Barley g201, and Couch grass (*Agropyron repens*) as well as Lymegrass (*Elymus arenarius*). An extensive cross-reactivity among the different individual species of the genus could be expected. There should be cross-reactivity with other members of the family *Poaceae*, particularly in the subfamily *Pooideae* (Rye grass (g5), Canary grass (g71), Meadow grass (g8), Timothy grass (g6), Cocksfoot (g3), Meadow fescue (g4), Velvet (g13), Redtop (g9), Meadow foxtail (g16), Wild rye grass (g70)) (2-3).

Many varieties of Wheat are cultivated, such as Durum and Polish wheat. All are closely related, and therefore have a high cross-reactivity to each other. *Triticum* and species of *Secale* have a tendency to hybridise, making it difficult to identify the genera.

Natural pollen extracts from *Anthoxanthum odoratum* (Sweet vernal grass), *Avena sativa* (Cultivated oat), *Cynodon dactylon* (Bermuda grass), *Lolium perenne* (Rye grass), *Phragmites australis* (Common reed), *Poa pratensis* (Meadow grass), *Secale cereale* (Cultivated rye grass), *Triticum sativum* (Cultivated wheat), and *Zea mays* (Maize/Corn) were characterized regarding their allergen contents by means of specific antibodies and by IgE immunoblot inhibition with recombinant allergens from Phl p 1, Phl p 2, Phl p 5, and Bet v 2 using sera of 193 European, American, and Asian subjects. Immunologically detectable Group 5 and Group 2 allergens were found in all these species except for *C. dactylon* and *Z. mays* (4).

Ole e 9, the major Olive tree pollen, is a 1,3-beta-glucanase, a member of the "pathogenesis-related" protein family. Ole e 9 is involved in the allergic responses of 65% of patients sensitised to Olive pollen. It has a 39% sequence identity with the 1,3-beta-glucanase from Wheat (1).

Clinical Experience

IgE mediated reactions

Cultivated wheat pollen is a predominant cause of asthma, allergic rhinitis and allergic conjunctivitis (5).

Other reactions

A male athlete suffered complete respiratory arrest following a run through a Wheat field, which had caused Wheat pollen to be released. He had multiple wheals on both legs and complained of severe breathlessness before collapsing. It is possible that the symptoms were triggered either by the running itself, inhalation of allergens other than Wheat pollen, skin abrasions caused by contact with Wheat stalks, or a combination of these factors (6).

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g204 False oat-grass

Arrhenatherum elatius

Family:	*Poaceae* (*Gramineae*)
Subfamily:	*Pooideae*
Tribe:	*Aveneae*
Common names:	Tall oat-grass, Onion Couch
Source material:	Pollen

There are two subspecies or varieties: one has swollen bases in the main shoots, like small onion bulbs, and is sometimes called "Onion Couch"; the other lacks these swellings.

A grass species producing pollen, which often induces hayfever, asthma and conjunctivitis in sensitised individuals.

Allergen Exposure

Geographical distribution

False oat-grass is native to Europe and was brought to the United States early in the last century. It is now grown widely, for making hay and for grazing, in the central and northern states. World distribution includes the former USSR, East Asia, and Africa.

It is a hardy, upright perennial bunchgrass growing up to 180 cm high, with many leaves scattered along the stems. The seed head resembles that of Oats: hence the name. The leaf blades, rolled in the bud shoot, are flat, linear, up to 50 cm long and 10 mm wide, and sometimes sparsely hairy.

The inflorescence is a panicle, green to purple, shining, erect or nodding, oblong or ovate, contracted, and up to 35 mm wide and 60 cm long. The hermaphrodite (containing both male and female organs) florets number 1 to 3 per spikelet. Incomplete (male) florets also occur at the base of the inflorescence. False oat-grass flowers from November in the Southern Hemisphere.

Environment

Often found in dry meadows or pastures, but very seldom in wild situations.

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 *Poaceae*, particularly in the tribe *Aveneae* (Sweet vernal grass (g1), Cultivated oat (g14), Velvet grass (g13), Canary grass (g71)) (1-2).

g204 False oat-grass

Clinical Experience

IgE mediated reactions

False oat-grass pollen may induce asthma, allergic rhinitis and allergic conjunctivitis.

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g10 Johnson grass

Sorghum halepense

Family:	*Poaceae* (*Gramineae*)
Subfamily:	*Panicoideae*
Tribe:	*Andropogoneae*
Common names:	Johnsongrass, Sorghum
Source material:	Pollen
Synonyms:	*S. controversum, S. miliaceaum, Holcus halapensis*

Do not confuse this plant with its close relation *S. bicolor* (Common wild sorghum).

A grass species producing pollen, which often induces hayfever, asthma and conjunctivitis in sensitised individuals.

©University of South Carolina Herbarium. Photo: Linda Lee

Allergen Exposure

Geographical distribution

Johnson grass is a robust perennial native to North Africa, South Asia, and southern Europe, in a range from 55°N to 45°S. It has been reported as a weed in 30 crops in 53 countries, and in all major agricultural areas in the world. Introduced to the United States around 1830 from Turkey, it occurs in most states and as far north as Ontario.

Johnson grass is a warm-season graminoid. It differs from other Sorghum species in being a perennial that spreads by vigorous, extensive rhizomes, which can be as much as 1 cm in diameter and 2 m long. Stems are typically 0.5 to 1.5 m high, occasionally reaching heights of 3 to 3.5 m. Its purplish panicles are 10 to 50 cm long with sessile spikelets 4.5 to 5.5 mm long, and the numerous slender leaves are 10 to 50 cm long. The awned, ovoid seeds are brown.

Growth is very vigorous, and 2 or 3 crops of hay may be harvested in a season. The flowering times are highly variable, as they depend crucially on temperature. In the Mediterranean area, Johnson grass flowers between June and August. In other parts of Europe the season is from July to September. In the US, it usually flowers from May to July or in the extreme south from December to January. The flowers are hermaphrodite (have both male and female organs) and are pollinated by wind. Johnson grass recolonises by its large quantity of seed as well as by its creeping rhizomes.

Environment

Johnson grass grows in sandy and rugged soils. It is cultivated for livestock feeding around the Mediterranean. It can be found in cultivated beds but more often invades open or scrubby places such as irrigation ditches, waste and disturbed areas, roadsides, and crop fields; especially places subjected to unnatural frequent flooding. It often becomes a troublesome weed, difficult to eradicate.

Though Johnson grass is primarily a hay and pasture grass, humans eat the seed raw or cooked. It can be used whole in a similar manner to that of rice or millet, or it can be ground into a flour and used as a cereal in making bread, cakes, etc. In some places the root is used as a substitute for sarsaparilla. Johnson grass is used as a folk remedy.

Allergens

Sor h 1 (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 *Poaceae*. Cross-reactivity among Bahia grass (g17), Johnson grass (g10) and Maize pollen (g202), which are related through the sub-species *Panicoideae*, is likely (2-3).

This grass contains one of the Group 1 allergens, which are glycoprotein isoallergens shared by many species of grass (4). Group 1 allergens are highly homologous, but not all of the antigenic epitopes are crossreactive (5). For example, Group 1 allergens from 8 different clinically important grass pollens of the *Pooideae* (Rye grass, Canary grass, Meadow grass, Cocksfoot and Timothy grass), *Chloridoideae* (Bermuda grass) and *Panicoideae* (Johnson grass, Maize) were isolated, and IgE binding to an allergic human serum pool was conducted to determine the degree of antigenic and IgE-binding similarities. The highest IgE-binding similarity was observed between Cocksfoot and Rye grass (53%) and between Rye grass and Canary grass (43%). No IgE-binding similarity was observed between Maize and other grasses. The highest antigenic similarity was also observed between Rye grass and Cocksfoot grass (76%), and the lowest similarity between Maize (23%) and Bermuda (10%) (6).

A study to explore common antigenic/allergenic components of 5 important grass pollens of India, a tropical country, was conducted. In India, to explore cross-reactivity, intradermal tests and specific sera IgE tests were performed with pollen extracts of *Cenchrus* (English bunch grass), *Cynodon* (Bermuda grass), *Imperata* (Cottonwool grass), *Pennisetum* (Kikuyu), and *Sorghum* (Johnson grass) in patients with nasobronchial allergy. Among 133 patients, *Cynodon* extract elicited markedly positive skin reactivity in most patients, followed by *Pennisetum*, *Imperata*, *Cenchrus*, and *Sorghum*. ELISA inhibition experiments showed different degrees of cross-reactivity among the grass pollens studied (7).

On the basis of RAST inhibition tests, Johnson grass appeared to share allergenicity with both Northern grasses (Timothy, Meadow, Rye, Redtop, Meadow fescue, and Sweet vernal) and Bermuda grass (8).

Clinical Experience

IgE mediated reactions

Johnson grass pollen often induces asthma, allergic rhinitis and allergic conjunctivitis in sensitised individuals (7).

Farmers exposed to grain Sorghum and grain Sorghum dust were more likely to experience respiratory symptoms like cough or chest tightness, as well as an acute febrile illness, than were farmers exposed to other types of grain (9).

In Thailand, specific IgE tests with 14 selected local aeroallergens on 100 asthmatic children aged 0-16 years demonstrated Johnson grass to be a common aeroallergen, with 14% of the study group sensitised to it (10). In 100 older patients with allergic rhinitis, Johnson grass was shown to be the most prevalent aeroallergen, with 21% of this group positive on specific IgE determination (11).

Johnson grass is also a common aeroallergen in Turkey, as demonstrated by specific IgE testing of 614 respiratory-allergic patients (12).

In Cape Town, South Africa, pollen from Johnson grass was reported to be a clinically important allergen (13).

Other reactions

RAST of sera from subjects sensitised to Wheat and Rye flour indicates that significant cross-reactions occur between seed extracts of 12 cereals (Wheat, Durum wheat, Triticale, Cereal rye, Barley, Rye grass, Oats, Canary grass, Rice, Maize, and Johnson grass) (14). A common allergen between Johnson grass pollen and Johnson grass seed has not been demonstrated to date.

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g202 Maize, Corn

Zea mays

Family:	*Poaceae (Gramineae)*
Subfamily:	*Panicoideae*
Tribe:	*Andropogoneae*
Common names:	Maize, Corn
Source material:	Pollen

Maize/Corn pollen (*Zea mays*) g202 must be differentiated from the food Maize/Corn (*Zea mays*) f8.

A grass species producing pollen, which may induce hayfever, asthma and conjunctivitis in sensitised individuals.

Allergen Exposure

Geographical distribution

The original habitat is obscure; it was probably South America or Mexico. The plant is now grown anywhere in the world where summers are reasonably warm. Corn is one of the most commonly grown foods. It is the staple cereal of the human diet in Central and tropical South America and in many parts of Africa. It is extremely important in livestock rearing, food processing and other commercial activities in developed countries.

The plant is a single-stemmed annual, grown from one seed, though sucker shoots (which may produce seed) rise from the base. The single stalk, terminating in the tassel or staminate flowers, can grow to over 3 m at a fast rate. The smooth leaves, usually drooping, usually green, can be over half a metre long.

The 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 female flowers are borne on a receptacle, termed "ear", which arises at a leaf axil near the mid-point along the stem. Normally 1 to 3 or more such ears develop. The flower organs, and later the grain kernels, in more or less longitudinal rows, are enclosed in several layers of papery tissue, termed husks. Strands of "silk", actually the stigmas from the flowers, emerge from the terminals of the ears and husks at the same time the pollen from the terminal tassels is shed. In the Northern Hemisphere it is in flower between July and October, and the seeds ripen between September and October. The grains are variable as to size, shape, and colour.

Sweet corn is distinguished from field corn by the high sugar content of the kernels at the early "dough" stage, and by wrinkled, translucent kernels when dry.

Environment

The plant is found in cultivated beds, and does not grow wild except when escaping cultivation in a very limited way.

Maize is eaten straight off the cob or processed in a variety of ways.

Unexpected exposure

Maize pollen may be used in herbal therapies. The stalks, cobs, grains and oil have many agricultural and industrial uses.

g202 Maize, Corn

Allergens

Zea m13, an allergen having significant sequence homology with a number of pollen- or anther-specific proteins from monocot and dicot plants, as well as with recently described allergens from Olive and Rye grass, has been isolated. The recombinant Zea m13 fusion protein reacted with serum IgE from grass pollen-allergic patients, indicating that Zea m13 and homologous proteins represent a family of conserved plant allergens (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 *Poaceae*, and is especially likely among Bahia grass (g17), Johnson grass (g10) and Maize pollen (g202), related through the sub-family *Panicoideae* (2-3).

However, Maize pollen in several studies has shown lower degree of cross-reactions than other grasses. (See below).

This grass contains one of the Group 1 allergens, which are glycoprotein isoallergens shared by many species of grass (4). Group 1 allergens are highly homologous, but not all of the antigenic epitopes are crossreactive (5). For example, Group 1 allergens from 8 different clinically important grass pollens of the *Pooideae* (Rye grass, Canary grass, Meadow grass, Cocksfoot and Timothy grass), *Chloridoideae* (Bermuda grass) and *Panicoideae* (Johnson grass, Maize) were isolated, and IgE binding to an allergic human serum pool was conducted to determine the degree of antigenic and IgE-binding similarities. The highest IgE-binding similarity was observed between Cocksfoot and Rye grass (53%) and between Rye grass and Canary grass (43%). No IgE-binding similarity was observed between Maize and other grasses. The highest antigenic similarity was also observed between Rye grass and Cocksfoot grass (76%), and the lowest similarity between Maize (23%) and Bermuda (10%) (6).

Maize pollen appears to also contain a Group 5 allergen. Almost 90% of grass pollen-allergic patients are sensitised against Group 5 grass pollen allergens. A monoclonal human IgE antibody has been shown to cross-react with Group 5A isoallergens from several grass and Corn species; however, no reactivity was observed with Maize (7).

The cross-reactivity of IgE antibodies to Group 1 and Group 5 allergens has been shown to be highly variable in 8 grass pollen species. Cross-reactivity of IgE antibodies against Lol p I or Lol p V (both from Rye grass pollen) to *Dactylis glomerata* (Cocksfoot), *Festuca rubra* (Red fescue), *Phleum pratensis* (Timothy grass), *Anthoxanthum odoratum* (Sweet vernal grass), *Secale cereale* (Cultivated rye), *Zea mays* (Maize/Corn), and *Phragmites communis* (Common reed) was investigated by means of RAST-inhibition. Within a group of sera the degree of cross-reactivity was demonstrated to be highly variable. Individual sera were not always equally cross-reactive to all pollen species. A high degree of cross-reactivity for Group 1 allergens did not necessarily imply the same for Group 5. Group 1 and Group 5 representatives were found to be present in all 8 species (8). Later studies have shown contradictory results, and *Zea mays* may in fact not contain a Group 5 allergen (nor a Group 2 allergen) (9).

Clinical Experience

IgE mediated reactions

Z. mays pollen is found in lower concentrations in aerobiological studies because of its density. Nevertheless, individuals exposed to this pollen may have asthma, allergic rhinitis and allergic conjunctivitis induced (10-12).

In a study of 101 patients with asthma living in Comarca Lagunera, Spain, specific IgE determination tests demonstrated that 57% of the group were sensitised to Maize pollen (10). *Z. mays* pollen was also shown by specific IgE tests to be an important pollen among 614 respiratory-allergic patients in Turkey (13).

In 468 asthmatic children in Johannesburg, South Africa, the commonest allergens on specific IgE testing included Maize/Corn pollen (14).

Other reactions

Thirty-three Navajo patients were seen in a private allergy consultation practice in Flagstaff, Arizona. Skin test and historical data were available from 9 atopic patients to evaluate hypersensitivity reactions to oral Corn pollen used in Navajo ceremonials. Six of the 9 patients had positive skin test reactions to Corn pollen and 4 of these 6 reported symptoms from oral Corn pollen. The symptoms included various combinations of oral and ear itching, sneezing, cough, and wheezing (15).

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Festuca elatior

Family: *Poaceae* (*Graminae*)
Subfamily: *Pooideae*
Tribe: *Poeae*
Common names: English Bluegrass
Source material: Pollen
Synonyms: *Festuca pratensis*

Fescues are of two basic types, Meadow fescue (*F. elatior, syn. F. pratensis*) and Tall fescue (*F. arundinacea*), with some confusion existing between their taxonomical designations. Tall fescue is more persistent and more heavily yielding, so that it is now the dominant type. But their very close morphological similarity and habitat justify a simultaneous consideration of the plants as allergens.

A grass species producing pollen, which often induces hayfever, asthma and conjunctivitis in sensitised individuals.

Allergen Exposure

Geographical distribution

Fescue is a temperate-climate grass native to northern Europe and western Asia. It has been introduced and grows well in cool climates of the US, but is more common in Europe. It has been introduced in similar climates worldwide. It is a valuable pasture grass, used to a lesser extent for hay and as an all-purpose turf grass.

Tall fescue is a robust, coarse-textured, bunch-type perennial. The erect stems can reach over a metre high. The main difference in Meadow fescue is its much smaller height, typically less than half a metre. The 3 to 8 mm-wide and 10 to 50 cm-long leaf blades are upright, rolled when young, coarse on the upper surface and smooth underneath, succulent, and with rasplike margins and prominent veins. The leaves radiate from a central clump, and the sheaths of inferior leaves are purple-red.

The panicle-like inflorescence is up to 20 cm long. It spreads during flowering and contracts afterwards. The spikelets, green or faintly purple, are 3- to 11-flowered. The florets are hermaphrodite (have both male and female organs). The plant is wind-pollinated. Fescue flowering season is from May to July in the Northern Hemisphere, and from October to April in Australia. Fescue tends to be a solitary plant: it does not spread rapidly because of its lack of underground stolons or rhizomes.

Environment

Fescues grow best in open and damp sites such as roadsides, creeks, swampy verges and open paddocks, as well as in meadows and pastures. Tall fescue's deep, extensive root system makes it suitable also for drought-prone sites.

g4 Meadow fescue

Allergens

Meadow fescue contains at least 24 antigens, of which 12 have been shown to bind IgE antibodies in sera from patients with well-established allergic rhinitis (1). A number of allergens have been isolated and characterised.

Fes p 1 (2).

Fes e 1-B.

Fes e 2-B.

Fes p 4, a 60 kDa protein (3-4).

A carbohydrate moiety appears to be involved in IgE binding to Fes p 4 (3).

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 *Poaceae*, and in particular within the subfamily *Pooideae* (Rye grass (g5), Canary grass (g71), Meadow grass (g8), Timothy grass (g6), Cocksfoot (g3), Meadow fescue (g4), Velvet (g13), Redtop (g9), Meadow foxtail (g16), Wild rye grass (g70)) (5-6).

This grass contains Group 1 allergens, to which more than 95% of patients allergic to grass pollen possess IgE antibodies. These are highly cross-reactive glycoproteins exclusively expressed in the pollen of many grasses (2,7,8). Group 1 allergens are highly homologous, but not all of the antigenic epitopes are crossreactive(9). For example, Group 1 allergens from eight different clinically important grass pollens of the *Pooideae* (Rye grass, Canary grass, Meadow grass, Cocksfoot and Timothy grass), *Chloridoideae* (Bermuda grass) and *Panicoideae* (Johnson grass, Maize) were isolated, and IgE binding to an allergic human serum pool was conducted to determine the degree of antigenic and IgE-binding similarities. The highest IgE-binding similarity was observed between Cocksfoot and Rye grass (53%) and between Rye grass and Canary grass (43%). No IgE-binding similarity was observed between Maize and other grasses. The highest antigenic similarity was also observed between Rye grass and Cocksfoot grass (76%), and the lowest similarity between Maize (23%) and Bermuda (10%) (10). Highly homologous Group 1 allergens have been demonstrated between Pha a 1 from Canary grass, Lol p 1 from Rye grass pollen (a deduced amino acid sequence identity of 88.8%), Hol l 1 from Velvet grass pollen (88.1%), and Phl p 1 from Timothy grass pollen (86.6%) (11). The major Timothy grass pollen allergen Phl p 1 also cross-reacts with most grass-, Corn- and monocot-derived Group 1 allergens (12). Monoclonal antibodies of Cyn d 1 (Bermuda grass) recognised cross-reactive epitopes on proteins from eight other grasses, including Rye grass, Timothy grass, Meadow grass and Johnson grass (13).

Meadow fescue grass also contains a Group 4 allergen. Group 4 grass pollen allergens are glycoproteins with a molecular weight of 50 to 60 kDa, which are present in many grass species. Almost 75% of patients allergic to grass pollen display IgE reactivity to Group 4 allergens, which hence can be regarded as major grass pollen allergens(14). Inhibition studies of IgE antibody binding to Dac g 4 (*Dactylis glomerata* - Cocksfoot grass) with other pollen extracts confirmed the presence of cross-reactive allergens in *Secale cereale* (Cultivated Rye), *Lolium perenne* (Rye grass), *Festuca elatior* (Meadow fescue), *Holcus lanatus* (Velvet grass), *Bromus arvensis* (Field brome), *Poa pratensis* (Meadow grass), *Hordeum sativum* (Barley), and *Phleum pratense* (Timothy grass) (15). Further, Phl p 4 homologes with similar molecular weights were detected in *Dactylis glomerata* (Cocksfoot grass), *Festuca pratensis* (Meadow fescue), *Holcus lanatus* (Velvet grass), *Poa pratensis* (Meadow grass), and *Lolium perenne* (Rye grass). Group 4 homologes are present in the various grass extracts, but to different extents (3).

Immunological identity has been demonstrated between recombinant Dac g 2 (Cocksfoot grass) and Lol p 1and Lol p 2 (both from Rye grass). Similar cross-identity was observed with pollen extracts from three other grass species: *Festuca rubra* (Red fescue), *Phleum pratense* (Timothy grass) and *Anthoxanthum odoratum* (Sweet vernal grass). Recombinant Dac g 2 was recognized by species- and group-cross-reactive human IgE antibodies in 33% (4/12) of sera randomly selected from grass-sensitive individuals and in 67% (14/21) of sera from patients receiving grass pollen immunotherapy (16). As *Festuca rubra* is probably very cross-reactive with *F. elatior*, these findings by inference probably apply to the latter. This is supported by a study in which a monoclonal antibody against major Rye grass pollen that bound to the 28 to 30 kDa allergen showed binding to similar polypeptides in Meadow fescue (17).

Clinical Experience

IgE mediated reactions

Meadow fescue pollen is a common inducer of asthma, allergic rhinitis and allergic conjunctivitis (18).

In a Polish study, 22 patients between 13 and 53 years of age with seasonal allergic rhinitis were examined for specific IgE to 5 grass and 3 weed pollens. The most common sensitisation was to Meadow fescue (*F. elatior*), followed by Meadow grass (*Poa pratensis*), and Cocksfoot (*Dactylis glomerata*) (18).

In Norway, in 770 patients with seasonal and perennial nasal symptoms, pollens from Timothy grass, Meadow foxtail, Meadow grass and Meadow fescue were found to be very important causative factors (19).

Other reactions

Fescue grass is often infected with an endophyte, *Acremonium coenophialum*, which produces several classes of plant/fungal alkaloids. These are responsible for toxicosis problems in animals ingesting this grass, resulting in a syndrome called Fescue toxicosis (20). These pyrrolizidine alkaloids (in particular in Tall fescue) may be excreted in cow's milk and pose a hazard to children ingesting milk (21).

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Alopecurus pratensis

Family:	*Poaceae* (*Graminae*)
Subfamily:	*Pooideae*
Tribe:	*Agrostideae*
Common names:	Meadow Fox-tail
Source material:	Pollen

A grass species producing pollen, which may induce hayfever, asthma and conjunctivitis in sensitised individuals.

Allergen Exposure

Geographical distribution

This plant is native to non-Mediterranean Europe and temperate Asia, and perhaps also to non-desert parts of North Africa. It is cultivated for forage in Australia, New Zealand and North America.

A long-lived, tufted perennial grass, with short rhizomes and short ascending stolons, it grows to over a metre in height. The leafblades, mostly basal, and rolled when young, are abundant, flat, dark-green, smooth and up to 30 cm long and 8 mm wide. At the top of the shoot, spikelets are packed into a cylindrical 3 to 8 cm-long loose or compact spike-like panicle narrowing to a fairly sharp point. The 1-flowered spikelets are grayish but turn straw-coloured with age.

Meadow foxtail is one of the first grasses to begin growth in the spring, and in mild climates it can grow throughout the winter season. In colder Northern Hemisphere climates it blooms from April to July. The flowers are hermaphrodite, having both male and female organs. The stamens are first yellow then become orange. It is not considered to be a major pollen-producer. Reproduction is through the abundant tiny seed.

Alopecurus pratensis may be distinguished from *Phleum pratense* by its more scabrous blade margins, absence of cilia on the collar and absence of notches on the ligule.

Environment

Meadow foxtail grows in wet meadows and pastures and other marshy places, and in old orchards.

g16 Meadow foxtail

Allergens

Meadow foxtail grass contains at least 24 antigens, of which 12 have been shown to bind IgE antibodies in sera from patients with well-established allergic rhinitis (1).

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 *Poacea*e, in particular in the subfamily *Pooideae* (Rye grass (g5), Canary grass (g71), Meadow grass (g8), Timothy grass (g6), Cocksfoot (g3), Meadow fescue (g4), Velvet (g13), Redtop (g9), Meadow foxtail (g16), Wild rye grass (g70)) (2-3).

Clinical Experience

IgE mediated reactions

Meadow foxtail grass pollen may induce asthma, allergic rhinitis and allergic conjunctivitis.

In Norway, in 770 patients with seasonal and perennial nasal symptoms, pollens from Timothy, Meadow foxtail, Meadow grass and Meadow fescue were found to be very important causative factors (4).

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Poa pratensis

Family:	*Poaceae* (*Gramineae*)
Subfamily:	*Pooideae*
Tribe:	*Poeae*
Common names:	Smooth Meadow-grass, Kentucky Blue grass, Kentucky Bluegrass
Source material:	Pollen

Poa pratensis naturally hybridizes with several other species within the genus, including *P. secunda*, *P. arctica*, *P. alpina*, *P. nervosa*, *P. reflexa*, and *P. palustris*. Most of the 200 species of the genus *Poa* are distributed in the cold and temperate regions of the world.

A grass species producing pollen, which often induces hayfever, asthma and conjunctivitis in sensitised individuals.

Allergen Exposure

Geographical distribution

Native to Europe and Asia, this grass now has worldwide distribution in temperate regions. It is probably the most important introduced grass in North America. It is best adapted for growth in cool, humid climates. In North America, though it occurs in every one of the United States, it is most prevalent in the northern half of the United States and the southern half of Canada. It is a highly palatable pasture grass and is also extensively used for lawns and turf. Numerous varieties are in commercial use. It is a major pollen-producer.

Meadow grass is a perennial, short to medium-tall, cool-season, sod-forming grass with shallow but dense rhizomes. The seed stems can reach over a metre in height. The abundant, terminally blunt leaves are primarily basally attached and are usually 10 to 30 cm long. The inflorescence is a panicle, green or purple, oblong, ovate or pyramidal, erect or slightly nodding, and open to contracted. There are 3 to 4 spikelets on a typical ultimate inflorescence branch, and 2 to 6 florets per spikelet.

Meadow grass germinates in late fall and winter and is one of the first grasses to resume growth in late winter or early spring. The flowers are hermaphrodite (have both male and female organs) and are pollinated by wind. Flowering time in the Northern Hemisphere is generally between May and July. Flowering is brief, usually under a week. This grass is a vigorous herbaceous competitor. Not only does it spread by rhizome expansion, but it also produces abundant tiny seed, which accounts for good seedling recruitment and establishment on disturbed sites.

Environment

Meadow grass grows in prairies and fields, mountain grasslands, mountain brushlands, mountain meadows, riparian woodlands, and open forests and woods. It is common along roadsides and on dunes, lawns, campgrounds, golf courses and ski slopes.

The seeds and the bases of the leaf stems are occasionally eaten by humans.

Allergens

P. pratensis contains at least 26 antigens, of which 14 resulted in IgE binding using sera from 11 patients with well-established hay fever (1). A number of allergens have been identified and characterised.

Poa p 1, and two isoforms, Poa p 1a (a 35.8 kDa protein) and Poa p 1b (a 33 kDa protein) (2-4).

Poa p 5 (5-6).

Poa p 9 (7).

Poa p 10.

Phl p 5-specific T cells have been shown to be highly heterogeneous, and to differentially recognize isoallergens (8).

A profilin also has been detected (9).

Appreciable trypsin inhibitory activity has been detected in *Parietaria*, *Olea*, *Ambrosia*, *Rumex*, *Chenopodium*, *Holcus* and *Poa spp*. These proteins of the serpin family of anti-proteinases were found to bind specific IgE antibodies from the serum of hay fever patients (10).

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 *Poaceae* and in particular grasses belonging to the *Pooideae* subfamily (Rye grass (g5), Canary grass (g71), Meadow grass (g8), Timothy grass (g6), Cocksfoot (g3), Meadow Fescue (g4), Velvet grass (g13), Redtop (g9), Meadow foxtail (g16), Wild rye grass (g70)) (11-12). Meadow grass is a very complex species, having several recognised forms highly cross-reactive to each other.

This grass contains Group 1 allergens, to which more than 95% of patients allergic to grass pollen possess IgE antibodies. These are highly cross-reactive glycoproteins exclusively expressed in the pollen of many grasses (13-15). Group 1 allergens are highly homologous, but not all of the antigenic epitopes are crossreactive (16). For example, Group 1 allergens from eight different clinically important grass pollens of the *Pooideae* (Rye grass, Canary grass, Meadow grass, Cocksfoot and Timothy grass), *Chloridoideae* (Bermuda grass) and *Panicoideae* (Johnson grass, Maize) were isolated, and IgE binding to an allergic human serum pool was conducted to determine the degree of antigenic and IgE-binding similarities. The highest IgE-binding similarity was observed between Cocksfoot and Rye grass (53%) and between Rye grass and Canary grass (43%). No IgE-binding similarity was observed between Maize and other grasses. The highest antigenic similarity was also observed between Rye grass and Cocksfoot grass (76%), and the lowest similarity between Maize (23%) and Bermuda (10%) (17). Highly homologous Group 1 allergens have been demonstrated between Pha a 1 from Canary grass, Lol p 1 from Rye grass pollen (a deduced amino acid sequence identity of 88.8%), Hol l 1 from Velvet grass pollen (88.1%), and Phl p 1 from Timothy grass pollen (86.6%) (18).

The major Timothy grass pollen allergen Phl p 1 also cross-reacts with most grass-, Corn- and monocot-derived Group 1 allergens, including Poa p 1 (19). Monoclonal antibodies of Cyn d 1 (Bermuda grass) recognised cross-reactive epitopes on proteins from eight other grasses, including Meadow grass, Rye grass, Timothy grass and Johnson grass (20).

T-cell lines specific for Phl p 1 (the Group 1 allergen of Timothy grass) from the sera of 9 patients allergic to grass pollen displayed IgE binding with grass pollen extracts from *Dactylis glomerata* (Cocksfoot), *Poa pratensis* (Meadow grass), *Lolium perenne* (Rye grass), *Secale cereale* (Cultivated rye), and selected amino acid sequence-derived peptides. Crossreactivity studies revealed cross-reacting and non-cross-reacting T-cell epitopes (21).

Inhibition studies of IgE antibody binding to Dac g 4 (*Dactylis glomerata* - Cocksfoot grass) with other pollen extracts confirmed the presence of cross-reactive allergens in *Secale cereale* (Cultivated rye), *Lolium perenne* (Rye grass), *Festuca elatior* (Meadow fescue), *Holcus lanatus* (Velvet grass), *Bromus arvensis* (Field brome), *Poa pratensis* (Meadow grass), *Hordeum sativum* (Barley), and *Phleum pratense* (Timothy grass) (22). Furthermore, Phl p 4 homologes with similar molecular weights were detected in *Dactylis glomerata* (Cocksfoot grass), *Festuca pratensis* (Meadow fescue), *Holcus lanatus* (Velvet grass), *Poa pratensis* (Meadow grass), and *Lolium perenne* (Rye grass). Group 4 homologes are present in the various grass extracts, but to different extents (23).

Meadow grass pollen also contains a Group 5 allergen. Almost 90% of grass pollen-allergic patients are sensitised against Group 5 grass pollen allergens. A monoclonal human IgE antibody has been shown to cross-react with Group 5A isoallergens from several grass and Corn species (24). Polymorphic forms of Pha a 5 from Canary grass have been shown to share significant sequence identity with other Group 5 allergens from Rye grass, Timothy and Meadow grass pollens (18). Another study verified the presence of group 5 allergens in Meadow grass, Timothy grass, Rye grass and Cocksfoot extracts. The major components in these fractions were found to be 25-28 kDa proteins, and IgE binding to these components was confirmed using a pool of grass-allergic sera (5).

Natural pollen extracts from *Anthoxanthum odoratum* (Sweet vernal grass), *Avena sativa* (Cultivated oat), *Cynodon dactylon* (Bermuda grass), *Lolium perenne* (Rye grass), *Phragmites australis* (Common reed), *Poa pratensis* (Meadow grass), *Secale cereale* (Cultivated rye grass), *Triticum sativum* (Cultivated wheat), and *Zea mays* (Maize/Corn) were characterized according to their allergen contents by testing with specific antibodies and by IgE immunoblot inhibition with recombinant allergens from Phl p 1, Phl p 2, Phl p 5, and Bet v 2 using sera of 193 European, American, and Asian subjects. Immunologically detectable Group 5 and Group 2 allergens were found in all these species except for *C. dactylon* and *Z. mays* (25).

Nine Lol p 1-specific T-cell clones were shown to exhibit cross-recognition of the recombinant *Poa pratensis* 9 (Poa p 9) allergen, indicating that these 2 major antigens of grass pollen share T-cell epitopes. Sequence comparisons of several allergenic molecules indicated that this cross-reactivity may be due to the presence of epitopes with structure(s) similar to the major T-cell epitope of Poa p 9 allergens, suggesting that the major grass pollen allergens share 1 or more cross-reacting T-cell epitopes (7). Further studies of 13 different grass pollens utilising immunoblotting of the proteins by means of anti-recombinant *Poa pratensis* (Poa p) 9 allergen antibodies indicated that Poa p 9-like proteins are present in 10 other grass pollens, albeit in variable amounts and polymorphic forms. There was a strong association between the Meadow grass extract and this recombinant allergen with respect to their inhibition of the binding of human IgE antibodies to allergens in grass pollen extracts. Taken together, these results suggest that the allergenic and antigenic epitopes of the Poa p 9-related proteins in some but not all grass pollens are similar in structure and specificities (26).

N-glycans have been isolated from Meadow grass (*Poa pratensis*), Cultivated rye (*Secale cerale*), Rye grass (*Lolium perenne*), Short ragweed (*Ambrosia elatior*), Giant ragweed (*Ambrosia trifida*), Birch (*Betula alba*), Hornbeam (*Carpinus betulus*), Horse chestnut (*Aesculus hippocastanum*), Olive (*Olea europaea*) and Snake-skin pine (*Pinus leucodermis*) pollen extracts. For grass pollens the major glycans detected were identical in properties. The authors state that these results are compatible with the hypothesis that the carbohydrate structures are another potential source of immunological cross-reaction between different plant allergens (27).

A 15 kDa allergen, a profilin, isolated from Celery, was found to be similar to an allergen in *Poa pratensis* (9).

g8 Meadow grass, Kentucky blue

Clinical Experience

IgE mediated reactions

Meadow grass pollen is a common inducer of asthma, allergic rhinitis and allergic conjunctivitis (28).

In a Polish study, 22 patients between 13 and 53 years of age with seasonal allergic rhinitis were examined for specific IgE to 5 grass and 3 weed pollens. The most common sensitisation was to Meadow fescue (*Festuca elatior*), followed by Meadow grass (*Poa pratensis*) and Cocksfoot (*Dactylis glomerata*) (28).

In Norway, in 770 patients with seasonal and perennial nasal symptoms, pollens from Timothy grass, Meadow foxtail, Meadow grass and Meadow fescue were found to be very important causative factors (29).

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Agrostis stolonifera

Family: *Poaceae* (*Gramineae*)
Subfamily: *Pooideae*
Tribe: *Agrostideae*
Common names: Water Bent grass, Creeping Bent, Creeping Bentgrass, Carpet Bentgrass; also see below
Source material: Pollen
Synonyms: *A. alba*

A general distinction is made between the "creeping" types that reproduce entirely or mainly by stolons, and the types for which seed is more important. There appears to be no consensus on all the details of this two-part classification, and we include all of the Redtops and Bentgrases in the same description, noting that the main difference is shape: some types are more prostrate. "Creeping" varieties are dominant.

Agrostis spp.

A. stolonifera x Agrostis tenuis – Cathedral or Victorian Bentgrass
A. capillaris L. – Colonial Bentgrass
A. tenuis – Highland Bentgrass
A. canina L. – Velvet Bentgrass
A. exarata – Spike Bentgrass
A. gigantea
A. palustris
A. filifolia

A grass species producing pollen, which often induces hayfever, asthma and conjunctivitis in sensitised individuals.

Allergen Exposure

Geographical distribution

Redtop is native to Eurasia and North Africa. It was probably introduced to North America prior to 1750, and has become naturalized throughout the southern Canadian provinces and most of the United States, Australia, New Zealand and South Africa. It is established in other temperate climates throughout the world as a turf but usually not a pasture grass.

The plants are rather fine-leaved, stoloniferous perennial grasses, sometimes mat-forming or tufted. (They can set seed in one growing season, thus sometimes functioning as an annual.) Culms are usually prostrate at least at the base, and up to 1 m long. The blades are flat to folded, 2 to 10 mm wide, and 2 to 18 cm long.

The panicle is open to somewhat narrow, green or purple (turning whitish after anthesis), and up to 40 cm long. The spikelets are densely clustered, with hermaphrodite (having both male and female organs) florets, 1 per spikelet. Flowering can be in the spring, summer or fall, depending on the plant variety and the conditions.

g9 Redtop, Bentgrass

Environment

Redtop is often cultivated as a member of the "lawn" family. It is one of the best wetland tame grasses. No other grass can adapt to so wide a range of soils and climatic conditions. Redtop is thus used in particular in golf and bowling greens. It is also a weed of woodlands, fields, forest openings, pastures, shrublands, prairies, sandhills, meadows, roadsides, waste areas, and the margins of marshes, bogs, ponds, vernal pools, streams and lakes. It is most commonly found in moist places, such as recently exposed sand and gravel bars, wet meadows, and the banks of streams. It also grows in salt marshes.

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 *Poaceae*, and particularly in the tribe *Agrostideae* (Meadow foxtail, Timothy grass). Redtop is cross-reactive to Timothy grass (g6), Meadow grass (g8), Cocksfoot (g3) and Rye grass (g5) (1-2).

Clinical Experience

IgE mediated reactions

Redtop pollen can induce asthma, allergic rhinitis and allergic conjunctivitis.

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Lolium perenne

Family: *Poaceae* (*Gramineae*)

Subfamily: *Pooideae*

Tribe: *Poeae*

Common names: Rye-grass, Perennial Rye Grass, Perennial Rye-grass, Perennial Ryegrass, Ray-grass, Annual Ryegrass

Source material: Pollen

There is a need to differentiate between Rye grass (*Lolium perenne*) g5, Cultivated rye (*Secale cereale*) g12, the foodstuff Rye (*Secale cereale*) f5, and Wild rye grass (*Elymus tricoides*) g70.

Some authors consider Italian Rye grass to be a variety or subspecies of Perennial rye grass. Recent genetic work indicates that they are distinct species, both possibly originating from a common ancestor, Wimmera rye grass (*L. rigidum*).

A grass species producing pollen, which often induces hayfever, asthma and conjunctivitis in sensitised individuals.

Allergen Exposure

Geographical distribution

It is native to Europe but has been introduced on all continents with temperate zones, and many islands. Rye grass has become a highly valued and productive cool-season forage, hay, lawn and erosion-control grass. It was the first meadow grass cultivated in Europe, and is considered the most important forage grass there.

Rye grass is a short-lived perennial, biennial or annual bunchgrass growing to as much as 1.5 m tall at a fast rate, and with a deeply fibrous root system. The plant is loosely to densely tufted (if loose, it forms dense tufts when grazed). The culms are erect, spreading, decumbent or (rarely) prostrate, sometimes rooting at the lowest nodes. The leaves are scattered along the culms. The leaf blades, folded in the young shoots, are 1 to 6 mm wide, 5.5 to 30 cm long, flat or folded, glossy, dark green and hairless. The tips of the leaves may be prowlike.

The inflorescence is a single spike, green or purple, erect, straight or slightly curved, symmetrical, fully exserted and up to 25 cm long. The spikelets alternate up the axis. The hermaphrodite (having both male and female organs) florets number 6 to 22 per spikelet. An incomplete (male) floret may also be present. Rye grass may remain in leaf all year, and may flower almost all summer; otherwise between May and July in the Northern Hemisphere. The flowers are pollinated by wind. Regeneration is by seed, probably dispersed by animals. Tillering can also be profuse.

g5 Rye grass

Environment

Ryegrass grows on disturbed sites, pastures, meadows, fields, lawns, roadsides, and even in clearings. Its usages in cultivation are mainly in mixtures.

The seed is used as a cereal and an emergency food. It is occasionally used in folk remedies for cancer, diarrhea, hemorrhage and malaria.

Allergens

Pollen from Perennial rye grass (*Lolium perenne*) is a major cause of type I allergies worldwide. It contains at least 32 antigens of which 13 could be bound by IgE by sera from 11 patients with well-established allergic rhinitis (1).

Lol p 1, a major allergen (2-5).

Lop p 2, a major allergen (6-7).

Lol p 3 (8).

Lol p 4 (9-10).

Lol p 5, and the isoforms Lol p 5A and Lol p 5C (11-12).

Lol p 9 (13).

Lol p 10, Cytochrome c (has very low allergenicity) (14).

Lol p 11, a soybean trypsin inhibitor (15).

Only single isoforms have been found to Lol p 1 (16).

Lol p 5C shares 95% amino acid sequence identity with Lol p 5A. Both isoforms demonstrated shared antigenic activity but different allergenic activities. Recombinant Lol p 5C demonstrated 100% IgE reactivity in 22 Rye grass pollen-sensitive patients. In comparison, recombinant Lol p 5A showed IgE reactivity in less than 64% of the patients (11).

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 *Poaceae*; and in particular among grasses belonging to the subfamily *Pooideae* (Rye grass (g5), Canary grass (g71), Meadow grass (g8), Timothy grass (g6), Cocksfoot (g3), Meadow fescue (g4), Velvet grass (g13), Redtop (g9), Meadow foxtail (g16), Wild rye grass (g70)) (17-18).

This grass contains Group 1 allergens, to which more than 95% of patients allergic to grass pollen possess IgE antibodies. These are highly cross-reactive glycoproteins exclusively expressed in the pollen of many grasses (19-21). Group 1 allergens are highly homologous, but not all of the antigenic epitopes are crossreactive (22). For example, Group 1 allergens from 8 different clinically important grass pollens of the *Pooideae* (Rye grass, Canary grass, Meadow grass, Cocksfoot and Timothy grass), *Chloridoideae* (Bermuda grass) and *Panicoideae* (Johnson grass, Maize) were isolated, and IgE binding to an allergic human serum pool was conducted to determine the degree of antigenic and IgE-binding similarities. The highest IgE-binding similarity was observed between Cocksfoot and Rye grass (53%) and between Rye grass and Canary grass (43%). No IgE-binding similarity was observed between Maize and other grasses. The highest antigenic similarity was also observed between Rye grass and Cocksfoot grass (76%), and the lowest similarity between Maize (23%) and Bermuda (10%) (23). Highly homologous Group 1 allergens have been demonstrated between Pha a 1 from Canary grass, Lol p 1 from Rye grass pollen (a deduced amino acid sequence identity of 88.8%), Hol l 1 from Velvet grass pollen (88.1%), and Phl p 1 from Timothy grass pollen (86.6%) (24). The major Timothy grass pollen allergen Phl p 1 also cross-reacts with most grass-, Corn- and monocot-derived Group 1 allergens (25). Monoclonal antibodies of Cyn d 1 (Bermuda grass) recognised cross-reactive epitopes on proteins from 8 other grasses, including Rye grass, Timothy grass, Meadow grass and Johnson grass (26).

T-cell lines specific for Phl p 1 (the Group 1 allergen of Timothy grass) from the sera of 9 patients allergic to grass pollen displayed IgE binding with grass pollen extracts from *Dactylis glomerata* (Cocksfoot), *Poa pratensis* (Meadow grass), *Lolium perenne* (Rye grass), *Secale cereale* (Cultivated rye), and selected amino acid sequence-derived peptides. Crossreactivity studies revealed crossreacting and non-crossreacting T-cell epitopes (27).

Rye grass also contains a Group 4 allergen. Group 4 grass pollen allergens are glycoproteins with a molecular weight of 50 to 60 kDa, which are present in many grass species. Almost 75% of patients allergic to grass pollen display IgE reactivity to Group 4 allergens, which hence can be regarded as major grass pollen allergens (28). Inhibition studies of IgE antibody binding to Dac g 4 (*Dactylis glomerata* – Cocksfoot grass) and to other pollen extracts confirmed the presence of cross-reactive allergens in *Secale cereale* (Cultivated Rye), *Lolium perenne* (Rye grass), *Festuca elatior* (Meadow fescue), *Holcus lanatus* (Velvet grass), *Bromus arvensis* (Field brome), *Poa pratensis* (Meadow grass), *Hordeum sativum* (Barley), and *Phleum pratense* (Timothy grass) (29).

Further, Phl p 4 homologes with similar molecular weights were detected in *Lolium perenne* (Rye grass), *Dactylis glomerata* (Cocksfoot grass), *Festuca pratensis* (Meadow fescue), *Holcus lanatus* (Velvet grass) and *Poa pratensis* (Meadow grass). Group 4 homologes are present in the various grass extracts, but to different extents (30).

Rye grass pollen also contains a Group 5 allergen. Almost 90% of grass pollen-allergic patients are sensitised against Group 5 grass pollen allergens. A monoclonal human IgE antibody has been shown to cross-react with Group 5A isoallergens from several grass and Corn species (31).

Polymorphic forms of Pha a 5 from Canary grass have been shown to share significant sequence identity with other Group 5 allergens from Rye grass, Timothy grass and Meadow grass pollens (24).

Group 5 allergens of Timothy grass (Phl p 5) bear T cell epitopes cross-reacting with Group 1 allergens of Rye grass (Lol p 1) (32). Group 5 allergens have also been detected in Timothy grass, Meadow grass and Cocksfoot extracts as well as in Rye grass. The major components in these fractions were found to be 25-28 kDa proteins, and IgE binding to these components was confirmed using a pool of grass-allergic sera (33).

Not all grass species appear to contain Group 5 allergens. Natural pollen extracts from *Anthoxanthum odoratum* (Sweet vernal grass), *Avena sativa* (Cultivated oat), *Cynodon dactylon* (Bermuda grass), *Lolium perenne* (Rye grass), *Phragmites australis* (Common reed), *Poa pratensis* (Meadow grass), *Secale cereale* (Cultivated rye grass), *Triticum sativum* (Cultivated wheat), and *Zea mays* (Maize/Corn) were characterised according to their allergen contents by tests with specific antibodies and by IgE immunoblot inhibition with recombinant allergens from Phl p 1, Phl p 2, Phl p 5, and Bet v 2 using sera of 193 European, American, and Asian subjects. Immunologically detectable Group 5 and Group 2 allergens were found in all these species except for *C. dactylon* and *Z. mays* (34).

Sequence comparisons showed that the Hor v 9 cDNA clones (Barley pollen) were also homologous to Group 5 allergens of Timothy grass (*Phleum pratense*) pollen and Canary grass (*Phalaris aquatica*) pollen, and the Group 9 allergen of Rye grass (*Lolium perenne*) pollen (35).

N-glycans have been isolated from Meadow grass, Cultivated rye, Rye grass, Short ragweed, Giant ragweed, Birch, Hornbeam, Horse chestnut, Olive, and Snake-skin pine pollen extracts. For grass pollens the major glycans detected were identical in properties. The authors state that these results are compatible with the hypothesis that the carbohydrate structures are another potential source of immunological cross-reaction between different plant allergens (36).

Nine Lol p 1-specific T-cell clones were shown to exhibit cross-recognition of the recombinant *Poa pratensis* 9 (Poa p 9) allergen, indicating that these two major antigens of grass pollen share T-cell epitopes. Sequence comparisons of several allergenic molecules indicated that this cross-reactivity may be due to the presence of epitopes with structure(s) similar to the major T-cell epitope of Poa p 9 allergens, suggesting that the major grass pollen allergens share cross-reacting T-cell epitopes (37).

Immunoblot IgE binding to Oilseed Rape pollen could be totally inhibited by Rye pollen (38).

A monoclonal antibody against major Rye grass pollen that bound to the 28 to 30 kDa allergen showed, through immunoblotting, binding to similar polypeptides in *Festuca elatior* (Meadow fescue) (39).

Although Canary grass has its own allergens, it shares some, resulting in cross-reactivity with Rye grass (40).

Clinical Experience

IgE mediated reactions

Rye grass pollen is a very common inducer of asthma, allergic rhinitis and allergic conjunctivitis (41-44). Sensitisation to Rye grass pollen has been reported throughout the world.

Late spring thunderstorms have been reported to trigger epidemics of asthma attacks (45). Various mechanisms for this have been postulated, including the release of starch granules from Rye grass pollen (46).

In-utero sensitisation of T cells due to inhalation of these allergens by the mother during pregnancy has been suggested (47).

Rye grass pollen was shown to be a very prominent sensitising allergen in the Netherlands (48) and in Germany (49).

In Switzerland, Rye grass is reported to be a major pollen responsible for allergic rhinitis during summer months (41,50). In the southern part of Switzerland, through the use of specific IgE tests in a sample of 503 consecutive patients suffering from allergic rhinitis, the most prevalent sensitivity was shown to be to grass pollens (72%), and to Rye grass (69%) (51).

Sensitisation to Rye grass is prevalent in Spain (52). In a study in Comarca Lagunera, 101 patients with asthma were found to be highly sensitive to pollen grains: Bermuda grass (70%), Goosefoot (69%), Russian thistle (63%), Rye grass (61%), and Maize (57%) (53).

In line with other European studies, sensitisation to Rye grass was shown to be very prevalent in Poland (54).

Sensitisation to Rye grass is very prevalent in Australia. A history of allergic rhinitis and allergy to Rye grass was reported to be a strong predictor for asthma exacerbation during thunderstorms in the spring (55). In 3 populations of schoolchildren aged 8-11 years and living in different climatic areas of New South Wales, specific IgE tests confirmed sensitisation to Rye grass (56).

Similarly, in a longitudinal study of a birth cohort of New Zealand children up to the age of 13 years, the association between specific IgE to various common allergens and the development of childhood asthma was explored. Of 714 children, 45.8% were sensitive to at least 1 of 11 allergens, the most common response being to Rye grass pollen (32.5%) (57).

In Cape Town, South Africa, pollen from Rye grass was detected in aeroallergen studies (58). In Egypt, in 68 randomly selected patients with asthma, specific IgE to Rye grass was determined to indicate a prominent sensitising allergen (59).

Rye grass sensitisation has also been reported from Turkey (60) and Mexico (61). In the latter, specific IgE determination in 138 patients with asthma, rhinitis and sinusitis showed that after House dust mite, the allergens to which sensitisation was most frequently present were Bermuda and Rye grass (62).

Other reactions

Although common allergens have not been detected to date in Rye grass pollen and seed, cross-reactivity between seeds of various cereals and grasses occurs. RAST of sera from subjects sensitised to Wheat and Rye flour indicated that there is significant reaction with seed extracts of 12 cereals (Wheat, Durum wheat, Triticale, Cereal rye, Barley, Rye grass, Oats, Canary grass, Rice, Maize, Sorghum and Johnson grass) (63).

Rye grass seed is comparable to Oats in nutritive value, and contains a prolamine and a gluten similar to Wheat gluten.

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g203 Salt grass

Distichlis spicata

Family: *Poaceae* (*Gramineae*)

Subfamily: *Pooideae*

Tribe: *Poeae*

Common names: Seashore Saltgrass, Inland Saltgrass, Alkali Saltgrass, Alkali-grass, Spike grass

Source material: Pollen

A grass species producing pollen, which may induce hayfever, asthma and conjunctivitis in sensitised individuals.

©University of South Carolina Herbarium. Photo: Linda Lee

Allergen Exposure

Geographical distribution

Salt grass is, within its specialised saline and alkaline environments, widely distributed across the western United States and Canada: from Saskatchewan to eastern Washington, and south to California, Texas, and Mexico.

Distichilis spicata is a tough, warm-season perennial grass species that grows 10 to 60 cm tall and spreads through extensive scaly rhizomes. The small blue-green to gray-green leaves are sharp pointed, coarse, and spread along the entire rigid stem, on opposite sides of which they stand erect, in two rows. They turn golden brown at the end of the growing season. The species is easy to recognize even in the winter because the leaves, though dry, remain attached.

Plants are dioecious (male and female flowers are on separate plants). The male panicle often extends above the leaves, but the female panicle is normally enclosed within the leaves. Panicles of both sexes are 4 to 8 cm long with only a few spikelets. The tan, flattened and overlapping spikelets contain about five flowers each. Saltgrass is a poor seed producer. Reproduction is mainly vegetative; plants spread through a well-developed system of rhizomes.

Environment

It grows on beaches, along estuary margins, at the edges of desert palm oases, in salt and brackish coastal marshes “where it can form large monocultures” and in other low, moist saline or alkaline environments.

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 *Poaceae*, especially in the tribe *Poeae* (Cocksfoot (g3), Meadow fescue (g4), Rye grass (g5), Meadow grass (g8)) (1-2).

g203 Salt grass

Clinical Experience

IgE mediated reactions

Salt grass pollen can induce asthma, allergic rhinitis and allergic conjunctivitis.

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g1 Sweet vernal grass

Anthoxanthum odoratum

Family: *Poaceae* (*Gramineae*)
Subfamily: *Pooideae*
Tribe: *Aveneae*
Common names: Sweet Vernal grass, Large Sweet Vernal grass, Sweet grass, Spring grass
Source material: Pollen

A grass species producing pollen, which often induces hayfever, asthma and conjunctivitis in sensitised individuals.

Allergen Exposure

Geographical distribution

Native to Eurasia, this grass is now widely naturalised in temperate North America and other temperate regions of the world, such as Australia, western North Africa, Asia Minor, northern Asia and Japan. It is a very variable species, grown for hay and as a pasture grass.

Sweet vernal grass is a perennial with short rootstocks and tufted stems usually 30 to 60 cm long, erect or spreading. The shoots are aromatic (coumarin-scented), like new-mown hay. When eaten it has a taste similar to a caramel. The leaves, distributed along the stems, are rolled in the bud-shoot. They are 2 to 9 mm wide, 2 to 30 cm long, flat, bright-green (sometimes purplish at the base), and hairy (with hairs of variable length), especially near the base. The margins are scabrous or smooth, and the tips acute, flat or hooded.

The inflorescence is a spike-like, terminal cylindrical panicle, straw-coloured, green or purple, contracted (5 to 18 mm wide) and 3 to 8 cm long. The spikelets are 6.5 to 10 mm long. The florets, 1 per spikelet, become shiny and golden-brown at maturity.

In the Northern Hemisphere it is in flower from April to June, and the seeds ripen from May to July. In the Southern Hemisphere flowering is from September to February and fruiting in and after November. The scented flowers are hermaphrodite (have both male and female organs) and are pollinated by wind. The tiny seeds are dispersed by wind, water and animals.

Environment

Sweet vernal grass is found in meadows, pastures, sand dunes, hayfields, roadside verges and in many other grassy situations, and also in cultivated beds. It invades disturbed areas, preventing the reestablishment of native species.

The whole plant (especially the flowering stems) is anticoagulant, antispasmodic and stimulant. It is normally applied only externally. It has even been used as a folk remedy for hay fever. A tea is made from the fresh or dried leaves. The leaves and dried flowers are used as a strewing herb.

g1 Sweet vernal grass

Unexpected exposure

The leaves are woven into baskets and used in potpourri.

Allergens

Ant o 1, a 34 kDa protein (1).

Ant o 5 (2).

The presence of Group 1, Group 2 and Group 5 grass family allergens is inferred from cross-reactivity studies in grasses (3-4).

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 *Poaceae*, and is especially likely for members of the subfamily *Pooideae* (Rye grass (g5), Canary grass (g71), Meadow grass (g8), Timothy grass (g6), Cocksfoot (g3), Meadow fescue (g4), Velvet grass (g13), Redtop (g9), Meadow foxtail (g16), Wild rye grass (g70)) (5-6).

One study was designed to estimate the percentage of IgE directed to common, cross-reactive, or both types of epitopes shared by recombinant pollen allergens Phl p 1, Phl p 2, and Phl p 5 from Timothy grass, Bet v 2 from Birch tree, and natural pollen extracts from 9 different monocots (Sweet vernal grass, Cultivated oat, Bermuda grass, Rye grass, Common reed, Meadow grass, Cultivated rye, Cultivated wheat, Maize) by using sera from different populations. IgE to recombinant pollen allergens accounted for a mean 59% of grass pollen-specific IgE. With the exception of Bermuda grass and Maize, this could be attributed to the presence of immunologically detectable Group 2 and Group 5 allergens (3).

Another study demonstrated immunological identity between recombinant Dac g 2 (from Cocksfoot grass) and Lol p 1 and Lol p 2 (both from Rye grass). Similar cross-identity was observed with pollen extracts from 3 other grass species: *Festuca rubra* (Red Fescue), *Phleum pratense* (Timothy grass) and *Anthoxanthum odoratum* (Sweet vernal grass). Recombinant Dac g 2 was recognised by species- and group-cross-reactive human IgE antibodies in 33% (4/12) of sera randomly selected from grass-sensitive individuals and in 67% (14/21) of sera from patients receiving grass pollen immunotherapy (4).

In an evaluation of the cross-reactivity among various grasses (Cocksfoot, Red fescue, Timothy, Sweet vernal grass, Cultivated rye, Maize, and Common reed), within a group of sera, the degree of cross-reactivity was demonstrated to be highly variable. A high degree of cross-reactivity for Group 1 allergens did not necessarily imply the same for Group 5, although Group 1 and Group 5 representatives were found to be present in all these species. It was demonstrated that within this group of grass species significant quantitative and qualitative differences exist with respect to Group 1 and Group 5 allergens (7).

Clinical Experience

IgE mediated reactions

Sweet vernal grass pollen can induce asthma, allergic rhinitis and allergic conjunctivitis (8-10).

The sensitivity to pollens in 125 patients with rhinitis and/or asthma symptoms living in the Eskisehir region, central Turkey, was assessed using a test for specific IgE determination. In 100 pollen-allergic patients, *Poaceae* sensitivity was the most common (69%), the most prevalent allergen being Sweet vernal grass (45%). Sensitivity to grass pollen between urban and rural individuals was similar (72.2% versus 71.4%) (9).

In 184 Costa Rican patients with allergic rhinitis tested for sensitivity to *Poaceae* species, the highest positive specific IgE tests were for Sweet vernal grass (83.2%), *Panicum maximum* (Guinea grass) (82.1%), *Panicum mole* (Panic grass, syn. *Panicum hallii*) (78.3%), and Velvet grass (77.7%) (10).

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g6 Timothy grass

Phleum pratense

Family: *Poaceae* (*Gramineae*)
Subfamily: *Pooideae*
Tribe: *Agrostideae*
Common names: Timothy, Herd's Grass, Cat's Tail
Source material: Pollen

Synonyms: *P. nodosum*, *P. parnassicum*

The two commonly recognised varieties are

P. Pratense var. pratense
P. Pratense var. nodosum.

A grass species producing pollen, which often induces hayfever, asthma and conjunctivitis in sensitised individuals.

Allergen Exposure

Geographical distribution

Timothy grass is native to Europe, North Africa and northern Asia, and has been introduced and widely cultivated as a hay and pasture grass in North and South America, South Africa and Australia. It is one of the world's most common grasses and one of the most common sources of animal fodder. It grows best in cooler, humid climates.

Timothy grass grows to 1 m tall. It is a clump-forming, rather short-lived perennial with characteristic long, cylindrical, spike-like, somewhat purplish to silvery flower heads on wiry stems. The stem often bends at the lower nodes. Sheaths are open with edges inrolled. Leaf blades are 4 to 10 mm wide, flat and tapering. The leaf blades on the mid- to upper-flowering stem are much shorter (3 to 10 cm long) than the sheaths.

Timothy grass flowers from early summer to midsummer. Just before or during flowering is the usual time for hay cutting, a circumstance that may reduce pollen exposure. The flowers are hermaphrodite (have both male and female organs). The plant is wind-pollinated. The seeds produced are among the smallest seeds of the common pasture species. The plant reproduces mainly from seed, but vegetative reproduction also occurs.

Phleum pratense is sometimes confused with *Agrostis alba* (a Redtop or Bentgrass) but can be distinguished by its white and more opaque ligule with a notch at either side and without hairs on the back. The presence of cilia on the shoulder and the less conspicuous ridging of the upper surface of the blade are also diagnostic.

Environment

Timothy grass is widespread in fields and meadows, and on roadsides. It is sown in pastures for forage, and is very common in hay. This most extensively cultivated of meadow grasses escapes freely and becomes established in natural meadows and waste places.

g6 Timothy grass

Allergens

The protein content of Timothy grass pollen varies from season to season, which may impact on the total allergen load that sensitised individuals are exposed to (1). In addition, pollen freshly collected on rural meadows and near high-traffic roads demonstrates a striking difference according to origin, with higher allergen release rates from rural meadow pollen grains (2).

P. pratense contains at least 28 antigens, of which 15 have been shown to bind to IgE (3). A number of major allergens have been detected (4).

Phl p 1, a major Group 1 allergen (5-6).

Phl p 4 (7-8).

Phl p 5, a major Group 5 allergen (9-10).

Phl p 6, a 11-12 kDa protein (11-12).

Phl p7, a calcium-binding protein (13-14).

Phl p 12, a 14.2 kDa protein, a profilin (an earlier name is Phl p 11) (15-17).

Phl p 13 (8,18).

Two Group 1 allergens, isoforms of Phl p 1, have been detected, and comprise 37 and 35 kDa components (19).

Phl p 5 is the dominant allergen of *P. pratense*, and consists of 2 isoforms having apparent molecular weights of 38 kDa (Phl p 5a) and 32 kDa (Phl p 5b). Each isoform is split into at least 4 isoallergens (20). Furthermore, Phl p 5-specific T cells are highly heterogeneous. Individual T-cell clones, and individual patients, differentially recognise isoallergens (21).

More than 70% of the patients allergic to Timothy grass pollen exhibit IgE-reactivity against the high-molecular-mass fraction between 50 and 60 kDa of Timothy grass pollen extracts. One allergen from this fraction is Phl p 4, and another Phl p 13. Using sera of 306 subjects allergic to grass pollens, specific IgE-binding to both Phl p 4 and Phl p 13 was demonstrated for more than 50% of subjects. There were clear differences in the immunological properties of Phl p 4 and Phl p 13 (7).

In an Austrian study, Phl p 6 reacted with serum IgE from 75% of 171 grass pollen-allergic patients (11).

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 *Poaceae*, in particular grasses belonging to the subfamily *Pooideae* (Rye grass (g5), Canary grass (g71), Meadow grass (g8), Timothy grass (g6), Cocksfoot (g3), Meadow fescue (g4), Velvet grass (g13), Redtop (g9), Meadow foxtail (g16), Wild rye grass (g70)) (22-23).

This grass contains Group 1 allergens, to which more than 95% of patients allergic to grass pollen possess IgE antibodies. These are highly cross-reactive glycoproteins exclusively expressed in the pollen of many grasses (24-26). Group 1 allergens are highly homologous, but not all of the antigenic epitopes are crossreactive (27). For example, Group 1 allergens from eight different clinically important grass pollens of the *Pooideae* (Rye grass, Canary grass, Meadow grass, Cocksfoot and Timothy grass), *Chloridoideae* (Bermuda grass) and *Panicoideae* (Johnson grass, Maize) were isolated, and IgE binding to an allergic human serum pool was conducted to determine the degree of antigenic and IgE-binding similarities. The highest IgE-binding similarity was observed between Cocksfoot and Rye grass (53%) and between Rye grass and Canary grass (43%). No IgE-binding similarity was observed between Maize and other grasses. The highest antigenic similarity was also observed between Rye grass and Cocksfoot grass (76%), and the lowest similarity between Maize (23%) and Bermuda grass (10%) (28).

In another study, highly homologous Group 1 allergens have been demonstrated between Pha a 1 from Canary grass, Lol p 1 from Rye grass pollen (a deduced amino acid sequence identity of 88.8%), Hol l 1 from Velvet grass pollen (88.1%), and Phl p 1 from Timothy grass pollen (86.6%) (29). The major Timothy grass pollen allergen Phl p 1 also cross-reacts with most grass-, Corn- and monocot-derived Group 1 allergens (5). Monoclonal antibodies of Cyn d 1 (Bermuda grass) recognised cross-reactive epitopes on proteins from eight other grasses, including Rye grass, Timothy grass, Meadow grass and Johnson grass (30).

T-cell lines specific for Phl p 1 (the Group 1 allergen of Timothy grass) from the sera of 9 patients allergic to grass pollen displayed IgE binding with grass pollen extracts from Cocksfoot, Meadow grass, Rye, Cultivated rye, and selected amino acid sequence-derived peptides. Cross-reactivity studies revealed cross-reacting and non-cross-reacting T-cell epitopes (31).

Timothy grass also contains a Group 4 allergen. Group 4 grass pollen allergens are glycoproteins with a molecular weight of 50 to 60 kDa, which are present in many grass species. Almost 75% of patients allergic to grass pollen display IgE reactivity to Group 4 allergens, which hence can be regarded as major grass pollen allergens (7). Phl p 4 represents a trypsin-resistant major Timothy grass pollen allergen with immunologic similarities to the major Ragweed allergen Amb a 1 and therefore must be considered an important cross-reactive component in grass pollen and weed pollen allergy (7). Inhibition studies of IgE antibody binding to Dac g 4 (*Dactylis glomerata* - Cocksfoot grass) and to other pollen extracts confirmed the presence of cross-reactive allergens in *Secale cereale* (Cultivated rye), *Lolium perenne* (Rye grass), *Festuca elatior* (Meadow fescue), *Holcus lanatus* (Velvet grass), *Bromus arvensis* (Field brome), P*oa pratensis* (Meadow grass), *Hordeum sativum* (Barley), and *Phleum pratense* (Timothy grass) (32).

Oilseed rape pollen proteins were capable of quenching IgE binding to Timothy grass pollen proteins of >/=60 kDa, suggesting that grass pollen Group 4 allergens cross-react with the 27 to 69 kDa cluster in Oilseed rape pollen (33).

Timothy grass pollen also contains a Group 5 allergen. Almost 90% of grass pollen-allergic patients are sensitised against Group 5 grass pollen allergens. Group 5 allergens have been detected in Timothy, Rye grass, Meadow grass and Cocksfoot extracts. The major components in these fractions were found to be 25-28 kDa proteins, and IgE binding to these components was confirmed using a pool of grass-allergic sera (10).

A monoclonal human IgE antibody has been shown to cross-react with Group 5A isoallergens from several grass and Corn species (9). Polymorphic forms of Pha a 5 from Canary grass have been shown to share significant sequence identity with other Group 5 allergens from Rye grass, Timothy grass and Meadow grass pollens (29).

Group 5 allergens of Timothy grass (Phl p 5) bear T cell epitopes cross-reacting with Group 1 allergens of Rye grass (Lol p 1) (34).

The variability of cross-reactivity of IgE antibodies to Group 1 and 5 allergens in 8 grass pollen species was examined. Cross-reactivity of IgE antibodies against Lol p I or Lol p V (from Rye grass) to *Dactylis glomerata* (Cocksfoot), *Festuca rubra* (Red fescue), *Phleum pratense* (Timothy grass), *Anthoxanthum odoratum* (Sweet vernal grass), *Secale cereale* (Cultivated rye), *Zea mays* (Maize), and *Phragmites communis* (Dust Mite) was investigated by means of RAST-inhibition. Within a group of sera the degree of cross-reactivity was demonstrated to be highly variable. Individual sera were not always equally cross-reactive to all pollen species. A high degree of cross-reactivity for Group 1 allergens did not necessarily imply the same for Group 5. Group 1 and Group 5 representatives were found to be present in all 8 species (35).

Sequence comparisons showed that the Hor v 9 cDNA clones (Barley pollen) were also homologous to Group 5 allergens of Timothy grass pollen and Canary grass (*Phalaris aquatica*) pollen, and the Group 9 allergen of Rye grass (*Lolium perenne*) pollen (36).

Timothy grass contains a Group 13 allergen. Group 13 comprises major allergens in the grasses, allergens which have molecular masses of 50 to 60 kDa, are detectable in many common grasses, and show IgE cross-reactivity among themselves (18).

Timothy grass contains a calcium-binding protein, to which Group 13 allergens share similarities that may result in cross-reactivity (13).

Timothy grass also contains a profilin, which is in part responsible for the T-cell-mediated immunological response in patients allergic to Phl p. The response is very specific, since Phl p profiling-specific T-cell lines did not show cross-reactivity with a highly homologous profilin from Wall Pellitory (15). A study reported that binding to Camomile was inhibited in variable degrees by extracts from Celery roots, Anise seeds and pollen from Mugwort, Birch and Timothy grass, but the allergen was shown not to be a profilin (37).

Bahia and Timothy grass have in some studies been shown not to be cross-reactive (38-39).

Timothy grass seem to share allergens with Kiwi extract (40).

Mugwort, Ragweed, and Timothy grass pollen also share IgE binding epitopes with glycoprotein Latex allergens. The presence of common epitopes might in part explain clinical symptoms in pollen-allergic patients on contact with Latex. Any previously known panallergen was not detected (41).

Monoclonal antibodies specific for the major Mugwort pollen allergen Art v 1, approximately 60 kDa in size, were shown to result in a reduction of IgE binding to components of a similar molecular weight present in Timothy grass. The allergen was reported to be distinct from Bet v 1 and profilin and hence may represent a novel cross-reactive allergen in Oral Allergy Syndrome (42).

Immunological identity has been demonstrated between recombinant Dac g 2 (from Cocksfoot grass) and Lol p 1 and Lol p 2 (both from Rye grass), and similar cross-identity was observed with pollen extracts from 3 other grass species: *Festuca rubra* (Red fescue), *Phleum pratense* (Timothy grass) and *Anthoxanthum* odoratum (Sweet vernal grass) (43).

Clinical Experience

IgE mediated reactions

Allergy to Timothy grass pollen has been reported widely. Timothy grass is one of the most important causes of allergic rhinitis, asthma and allergic conjunctivitis during summer in cool temperate climates (39,44-45).

A European Community respiratory health survey reported that adults who had lived on farms as children were less frequently sensitised to Timothy grass, and were at lower risk of having nasal symptoms in the presence of pollen in general (46).

Timothy grass is a very prevalent aeroallergen in the Mediterranean countries, including Spain (47-49). In Salamanca, in a study in a Birch- and Ragweed-free area, 97.9% of patients allergic to pollens were sensitised to Timothy and Rye grass (50). The strongest associations between bronchial hyper-reactivity and specific IgE responses were seen with Timothy grass (51)

Timothy grass has also been shown by specific IgE determination to be an important allergen in the Netherlands (52).

In Sweden, in specific IgE tests on 7,099 adult patients with asthma and/or rhinitis, 44% of patients were positive, decreasing from 61% in patients 14-20 years old to 18% in patients 61-70 years old. Timothy grass, Cat and Birch were the most prevalent allergens. Of these patients, 65% were sensitised against several allergens, and 35% had a mono-allergy, most frequently to Timothy grass (70%) (53).

In Norway, in 770 patients with seasonal and perennial nasal symptoms, pollens from Timothy grass, Meadow foxtail, Meadow grass and Meadow fescue were found to be very important causative factors (54).

Timothy grass pollen was reported as the most prevalent sensitising allergen in Estonia, with 4.8% of 1,519 schoolchildren aged 10-12 years sensitised to this grass (55).

Similarly in Turkey, in a study of 1,149 patients with asthma from 5 major cities, the most common grass allergen to which patients were sensitised was Timothy grass, the prevalence varying from 4 to 19% (56).

In Japan, Timothy grass has been shown by specific IgE and other investigations to be a very prevalent allergen (57-58). In 107 patients with nasal allergies in Sapporo, RAST was positive for Timothy grass in 22.4%.

Timothy pollen is also an important aeroallergen in Thailand. In 100 patients with allergic rhinitis, sera-specific IgE to Timothy grass was raised in 16% (59).

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Holcus lanatus

Family:	*Poaceae* (*Gramineae*)
Subfamily:	*Pooideae*
Tribe:	*Aveneae*
Common names:	Yorkshire Fog
Source material:	Pollen

A grass species producing pollen, which often induces hayfever, asthma and conjunctivitis in sensitised individuals.

Allergen Exposure

Geographical distribution

Velvet grass is native and common to most of Europe, though it is absent in the northernmost regions. It now has a worldwide distribution including temperate regions in western Eurasia, the former USSR, and Australia. It was introduced in North America, where it is occasionally cultivated as meadow. The name Velvet grass perhaps comes from the appearance its pale purple flower heads make when growing amassed in an open field. In many countries *H. lanatus* is considered a weed and only of minor importance for grazing.

This perennial bunchgrass may, on the other hand, be named for the soft, whitish hairs (of two distinct lengths) on the stem, leaves and even inflorescence branches. The leaves, mostly basal and with distinct-textured leaf sheaths that can have a purplish colour, are up to 20 cm long and 10 mm wide; the stem and flower spikes provide additional height, typically up to 60 cm but occasionally higher.

The inflorescences are silvery to green to purplish, paniculate, erect or nodding, open or contracted, often oblong or ovate, sometimes almost spike-like, 8 to 15 cm long, and occasionally enclosed within the uppermost sheath. The spikelets number 2 to 3 on a typical ultimate inflorescence branch. There are typically 2 to 3 white hermaphrodite florets per 4 to 4.5 mm-long spikelet. There are occasional rudimentary or incomplete florets (male, without ovarian structure). Velvet grass flowers in late summer. The propagation is via seed, which is dispersed by wind. As with most bunchgrasses, this species tolerates fires and regenerates rapidly from basal shoots.

Environment

It invades moist disturbed sites rapidly, overwhelming native species and forming dense stands in upland pastures, open woods, fields and grasslands, and along roadsides.

The flowers can be used in both fresh and dried arrangements.

g13 Velvet grass

Allergens

Hol l 1, a 34 kDa protein (1).

Hol l 5, a 30 kDa protein, a major allergen (1,2).

Only single isoforms have been found to Hol l 1 (3).

The major Group I allergen of Velvet grass bears at least four different IgE-binding epitopes, which were individually recognized by sera from different patients (4).

A Group 4 grass allergen homologue to Phl 4 (Timothy grass) was also detected in this grass pollen (5).

Two isoforms of Hol l 5 have been detected and designated rHol l 5.01 and rHol l 5.02. A high similarity exists between them (78% identity) and to Group 5 allergens and their isoforms found in other grass species (6).

Appreciable trypsin inhibitory activity has been detected in *Parietaria*, *Olea*, *Ambrosi*a, *Rumex*, *Chenopodium*, *Holcus* and *Poa spp*. These proteins of the serpin family of anti-proteinases were found to bind specific IgE antibodies from the serum of patients with allergic rhinitis (7).

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 *Poaceae*, especially in the subfamily *Pooideae* (Rye grass (g5), Canary grass (g71), Meadow grass (g8), Timothy grass (g6), Cocksfoot (g3), Meadow fescue (g4), Velvet grass (g13), Redtop (g9), Meadow foxtail (g16), Wild rye grass (g70)) (8,9).

Velvet grass contains Group 1 allergens, to which more than 95% of patients allergic to grass pollen possess IgE antibodies. These are highly cross-reactive glycoproteins exclusively expressed in the pollen of many grasses (10-12). Group 1 allergens are highly homologous, but not all of the antigenic epitopes are crossreactive (13). Highly homologous Group 1 allergens have been demonstrated between Pha a 1 from Canary grass, Lol p 1 from Rye grass pollen (a deduced amino acid sequence identity of 88.8%), Hol l 1 from Velvet grass pollen (88.1%), and Phl p 1 from Timothy grass pollen (86.6%) (14).

Velvet grass also contains a Group 4 allergen. Group 4 grass pollen allergens are glycoproteins with a molecular weight of 50 to 60 kDa, which are present in many grass species. Almost 75% of patients allergic to grass pollen display IgE reactivity to Group 4 allergens, which hence can be regarded as major grass pollen allergens (15). Inhibition studies of IgE antibody binding to Dac g 4 (*Dactylis glomerata* – Cocksfoot grass) with other pollen extracts confirmed the presence of cross-reactive allergens in *Secale cereale* (Cultivated rye), *Lolium perenne* (Rye grass), *Festuca elatior* (Meadow fescue), *Holcus lanatus* (Velvet grass), *Bromus arvensis* (Field brome), *Poa pratensis* (Meadow grass), *Hordeum sativum* (Barley), and *Phleum pratense* (Timothy grass) (16). Further, Phl p 4 homologes with similar molecular weights were detected in *Dactylis glomerata* (Cocksfoot grass), *Festuca pratensis* (Meadow fescue), *Holcus lanatus* (Velvet grass), *Poa pratensis* (Meadow grass), and *Lolium perenn*e (Rye grass). Group 4 homologes are present in the various grass extracts, but to different extents (17).

Velvet grass pollen also contains a Group 5 allergen. Almost 90% of grass pollen-allergic patients are sensitised against Group 5 grass pollen allergens. Many other grasses have been shown to contain group 5 allergens (14,18).

Clinical Experience

IgE mediated reactions

Velvet grass pollen can induce asthma, allergic rhinitis and allergic conjunctivitis (19).

In 184 Costa Rican allergic rhinitis patients tested for sensitivity to *Poaceae* species, the highest numbers of positive specific IgE tests were for *Anthoxatum odoratum* (83.2%), *Panicum maximum* (82.1%), *Panicum mole* (78.3%), and *Holcus lanatus* (77.7%) (19).

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g70 Wild rye grass

Elymus triticoides

Family:	*Poaceae* (*Gramineae*)
Subfamily:	*Pooideae*
Tribe:	*Triticeae*
Common names:	Wild Rye, Beardless Wildrye, Creeping Wildrye, Alkali Ryegrass
Source material:	Pollen
Synonyms:	*Leymus triticoides*

There is a need to differentiate between Cultivated rye pollen (*Secale cereale*) g12, the foodstuff Rye (*Secale cereale*) f5, Rye grass (*Lolium perenne*) g5, and Wild rye grass (*Elymus triticoides*) g70.

A grass species producing pollen, which often induces hayfever, asthma and conjunctivitis in sensitised individuals.

Allergen Exposure

Geographical distribution

This grass is native to and widespread in western North America, from Washington State to California and east to Montana. It often forms large clumps in the wild, but is also grown for forage and ground cover (especially for erosion control in low- and medium-elevation saline and alkali areas). In Europe the closely related species Lymegrass (*E. arenarius*) is common in the dunes along the coasts.

Wild rye grass looks like a cross between Bermuda grass and Salt grass. It is a cool-season perennial, forming extensive creeping rhizomes. The stems are upright, hollow, usually unbranched, and up to 1.2 m tall. Blades are up to 10 cm long, about 1 cm wide, flat to involute, at least somewhat stiff, and rough to the touch. The inflorescences are spikes up 25 cm long, mostly 2 per node, with spikelets containing 3 to 8 flowers each.

It flowers between June and August, and the seeds ripen from September to October. The flowers are hermaphrodite (have both male and female organs) and are pollinated by wind. Seeds germination (requiring cold) is poor. Seedlings are weak and compete poorly with weeds and other grasses in the early developmental stages. However, once established, the grass is very rhizomatous and maintains stands for many years.

This grass is unlike most others in the genus *Elymus* in its very slender and short spikes, its long-creeping rhizomes, and its paired spikelets.

Environment

Wild rye grass grows in meadows, damp ravines, river flats and sand dunes, often in salty areas; erosion-prone slopes and cultivated beds.

The seed can be ground into flour and used to make to make bread, cakes, or porridge. (The hairs on the seed must be removed, traditionally by singeing, before consumption.)

g70 Wild rye grass

Unexpected exposure

The leaves are used for making mats, rope, paper, baskets, etc.

Allergens

No allergens from this plant have yet been characterised.

Potential cross-reactivity

This pantemperate tribe *Triticeae* is notable for its cereal genera: Wheat, Barley and Rye. The close relation speaks in favour of cross-reactivity between Wild rye grass g70, Cultivated wheat g15, Cultivated rye grass g12, Barley g201, and Couch grass (*Agropyron repens*), as well as Lymegrass (*Elymus arenarius*). An extensive cross-reactivity among the different individual species of the genus could be expected. There should be cross-reactivity with other members of the family *Poaceae*, particularly in the subfamily *Pooideae* (Rye grass (g5), Canary grass (g71), Meadow grass (g8), Timothy grass (g6), Cocksfoot (g3), Meadow fescue (g4), Velvet (g13), Redtop (g9), Meadow foxtail (g16), Wild rye grass (g70)) (1,2).

Clinical Experience

IgE mediated reactions

Wild rye grass pollen can induce asthma, allergic rhinitis and allergic conjunctivitis.

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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.

gx1

Cocksfoot	*Dactylis glomerata* (g3)	page 25
Meadow fescue	*Festuca elatior* (g4)	page 51
Rye grass	*Lolium perenne* (g5)	page 65
Timothy grass	*Phleum pratense* (g6)	page 79
Meadow grass, Kentucky blue	*Poa pratensis* (g8)	page 57

gx2

Bermuda grass	*Cynodon dactylon* (g2)	page 13
Rye grass	*Lolium perenne* (g5)	page 65
Timothy grass	*Phleum pratense* (g6)	page 79
Meadow grass, Kentucky blue	*Poa pratensis* (g8)	page 57
Johnson grass	*Sorghum halepense* (g10)	page 43
Bahia grass	*Paspalum notatum* (g17)	page 9

gx3

Sweet vernal grass	*Anthoxanthum odoratum* (g1)	page 75
Rye grass	*Lolium perenne* (g5)	page 65
Timothy grass	*Phleum pratense* (g6)	page 79
Cultivated rye	*Secale cereale* (g12)	page 35
Velvet grass	*Holcus lanatus* (g13)	page 87

gx4

Sweet vernal grass	*Anthoxanthum odoratum* (g1)	page 75
Rye grass	*Lolium perenne* (g5)	page 65
Common reed	*Phragmites communis* (g7)	page 31
Cultivated rye	*Secale cereale* (g12)	page 35
Velvet grass	*Holcus lanatus* (g13)	page 87

gx6

Bermuda grass	*Cynodon dactylon* (g2)	page 13
Rye grass	*Lolium perenne* (g5)	page 65
Johnson grass	*Sorghum halepense* (g10)	page 43
Brome grass	*Bromus inermis* (g11)	page 19
Velvet grass	*Holcus lanatus* (g13)	page 87
Bahia grass	*Paspalum notatum* (g17)	page 9

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