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Intriguing World of Weeds

Wild Parsnip (*Pastinaca sativa*): A Troublesome Species of Increasing Concern

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Although many of us fondly associate parsnips with a rustic, home-cooked meal, there is also a wild variety that is increasingly causing problems as a weed in North America. The cultivated variety is a subspecies of *Pastinaca sativa* (*Pastinaca sativa* ssp. *sativa*) and contains lower amounts of the problematic furanocoumarins than the wild version. Wild parsnip (*Pastinaca sativa* L. PAVSA) is an introduced facultative biennial from Eurasia. It has spread throughout the United States and southern Canada and is now colonizing old fields, railroad embankments, roadsides, and waste areas. Wild parsnip contains furanocoumarins, which deter herbivores from eating its foliage. These compounds can also cause phytophotodermatitis in humans and livestock, a condition that results in patches of redness and blisters on the skin when they come into contact with the sap or ingest parts of the plant in the presence of sunlight. Few people, including medical professionals, recognize the plant or associate it with the burns it causes. Recently, wild parsnip has received increasing attention as expanding populations have resulted in more frequent human and livestock contact with the plant. This article reviews important aspects of the etymology, distribution, history, biology, and management of wild parsnip. A key objective of this review is to raise awareness of the potential health problems caused by wild parsnip and to stimulate research that will lead to effective management of this increasingly problematic species.

Etymology

Wild parsnip is an herbaceous biennial (or more correctly, a monocarpic perennial) within the Apiaceae (Umbelliferae) (carrot, parsley) (Zomlefer 1994), subfamily Apioideae, tribe Peucedaneae, and subtribe Ferulinae (Peucedaninae) based on Drude's (1897–1898) classification of the Apiaceae (Downie et al. 1998). However, Theobald (1971) noted that *Pastinaca* shares most floral and fruit anatomical characteristics with members of the genus *Heracleum*, which are classified in the Tordyliinae subtribe. This taxonomic similarity suggests distinct differences within the subtribes of the Peucedaneae. In the United States and Canada, there are 94 known genera and 440 species of Apiaceae (Zomlefer 1994). Wild parsnip is the only known species within the *Pastinaca* genus in the United States and Canada (S. J. Darbyshire, personal communication; Menemen and Jury 2001). Worldwide, there are eight species (Table 1) and four subspecies (Table 2) in the *Pastinaca* genus (Menemen and Jury 2001).

The four subspecies of wild parsnip are found across Eurasia. *P. sativa* L. ssp. *sativa* is widely cultivated throughout the Northern Hemisphere; ssp. *urens* [Req. ex Godron] Çelak. and ssp. *sylvestris* [Mill.] Rouy and Camus are distributed in several countries including France, Georgia, Italy, Russian Federation, Switzerland, and Ukraine; and ssp. *latifolia* [Duby] DC., is endemic to Corsica (Menemen and Jury 2001; USDA ARS 2006). These latter three species are not known to be present in the United States or Canada.

Within the Apiaceae, some of the most economically important species are vegetables including carrot (*Daucus carota* L.), celery (*Apium graveolens* L.), celeriac (*A. graveolens* L. var. *rapaceum* [Mill.] DC.), and fennel (*Foeniculum vulgare* Mill. var. *dulce* Battandier [Trabut]). All of these crops are used for their swollen roots or leaf bases, which are present by the end of the first growing season. There are also several economically important herbs in the Apiaceae including anise (*Pimpinella anisum* L.), caraway (*Carum carvi* L.), chervil (*Anthriscus cerefolium* [L.] Hoffm.), coriander (*Coriandrum sativum* L.), dill (*Anethum graveolens* L.), lovage (*Levisticum officinale* Koch.), and parsley (*Petroselinum crispum* [Mill.] Nym.) (Zomlefer 1994).

The Latin name *Pastinaca* is said to be derived from the Latin word *pastino*, "to prepare the ground for planting of the vine" (Fernald 1950), but could also originate from the Latin word *pastus*, meaning "food," referring to the edible root. The epithet *sativa* means "sown," indicating that the plant has been cultivated (Menemen and Jury 2001). Common names of wild parsnip include: parsnip (USDA NRCS 2006), bird's nest, hart's-eye, heeltrot, hockweed, madnip (Klaber 1942), queen weed, and tank (Jaques 1959). Synonyms of *Pastinaca sativa* L. include *Pastinaca sativa* L. var. *pratensis* Pers., *Peucedanum sativum* S. Wats. (French 1971), *Pastinaca sylvestris* L., and *Pastinaca sativum* (L.) Bentham ex Hooker fil. There is confusion in the taxonomy of wild parsnip. Bailey (1951) refers to the cultivated parsnip as *P. sativa* L. and to the wild parsnip as *P. sativa* L. var. *sylvestris* DC., whereas Clapham et al. (1962) consider *P. sativa* L. to be the wild parsnip. Somner and Jillson (1967) refer to the cultivated parsnip as *P. sativa* L. var. *hortensis* and to the wild parsnip as *P. sativa* L. var. *pratensis* Pers. The differences between the cultivated and wild parsnips appear quite obscure.

Description

Wild parsnip is a tall, stout, herbaceous plant with a long, thick, and deep taproot (Gleason and Cronquist 1991)

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Table 1. Key for type species: *Pastinaca* L. (adapted from Menemen and Jury 2001).

1. Leaves simple and glabrous on both sides	*P. lucida*
1. Leaves pinnate and hairy on both sides	
2. Petals pinkish	*P. zozimoides*
2. Petals yellow	
3. Bracts and bracteoles present	
4. Petals glabrous or subglabrous on dorsal surface	*P. hirsuta*
4. Petals hairy	
5. Leaves elliptic to ovate-triangular, mericarp elliptic to ovate, rays generally more than 10	*P. pimpinellifolia*
5. Leaves oblong to elliptic, mericarp elliptic to orbicular, rays generally less than 10	*P. armena*
3. Bracts and bracteoles absent	
6. Leaves 2-pinnate, rays unequal, brown veins absent	*P. fleischmanni*
6. Leaves 1-pinnate, rays equal or subequal, brown veins present	
7. Petals hairy, mericarp ovate, commisural surface waxy	*P. divaricata*
7. Petals glabrous or subglabrous, mericarp elliptic, commisural surface glabrous, very rarely waxy	*P. sativa*

(Figure 1). The plant is most often a biennial, but can behave as a monocarpic perennial (Baskin and Baskin 1979; Gleason and Cronquist 1991), thus dying after the production of flowers and seeds (Kline 1986). The roots can grow to a 1.5-m depth (Gleason and Cronquist 1991), and are funnel-shaped, white, aromatic, mucilaginous, sweet, and slightly acrimonius. The root has been a widely utilized esculent since early times (Hedrick 1919). Wild parsnip does not reproduce vegetatively (Hendrix and Trapp 1992). Rosettes grow near the soil surface and bear alternate, pinnately compound leaves, approximately 15 cm in length (Lorenzi and Jeffrey 1987). The plant requires 2 or more years to mature, at which time plants bolt, form a grooved aerial shoot and flower (Baskin and Baskin 1979). Lower leaves have longer petioles than the upper leaves, which are sometimes sessile. Each leaf has 5–15 oblong to ovate leaflets, which are 5–10 cm long and serrate or lobed (Gleason and Cronquist 1991).

Inflorescences are large, compound, determinate umbels, approximately 10–20 cm wide. Petals are yellow, usually with no bracts or bractlets, and sepals are minute or lacking. Flowers have 15–25 rays of unequal length and an appendicular axial structure termed the carpophore. Fruits are schizocarpic, glabrous, elliptic to obovate, strongly flattened dorsally (Gleason and Cronquist 1991), low-ribbed (Lorenzi and Jeffrey 1987), and 5–7 mm in length (Gleason and Cronquist 1991; Lorenzi and Jeffrey 1987). The fruits contain two mericarps, each with one seed (Hendrix et al. 1991) and consisting largely of tissues of an inferior ovary (Jackson 1933). Fruits are considered tonic and are said to be both carminatives, which aid in digestion, and emmenagogues, which induce menstrual flow (French 1971). The ploidy level of wild parsnip is $2n = 22$ (Gleason and Cronquist 1991). Wild parsnip is andromonoecious, with individual plants bearing both male and hermaphroditic flowers. The hermaphroditic flowers are protandrous, going through a staminate, then a pistillate stage (Nitao and Zangerl 1987), with little or no overlap between the stages (temporal dioecism), either within or between umbels, thus preventing cross pollinations between flowers of the same plant (Cruden and Hermann-Parker 1977).

Table 2. Key for subspecies: *Pastinaca sativa* L. (adapted from Menemen and Jury 2001).

1. Stem angled in transverse section and deeply sulcate	
2. Leaves with short hairs, stem glabrous or very sparsely scabridous hairy	ssp. *sativa*
2. Leaves with soft long hairs, stem densely covered with hairs	ssp. *sylvestris*
1. Stem in transverse section terete and striate	
3. Commissural vittae 2 hairs	ssp. *urens*
3. Commissural vittae 3–6 hairs	ssp. *latifolia*

Many species in the Apiaceae, including wild parsnip, can cause phytophotodermatitis (PPD) in humans if skin is exposed to the light-sensitizing sap of the species and ultraviolet (UV-A 320–380 nm) radiation. The reaction consists of a burning erythema beginning approximately 24 h after exposure, which may later blister. The inflammatory reaction may be mild enough to go undetected, but can also cause severe postinflammatory hyperpigmentation lasting weeks to months. Furanocoumarins (furocoumarins) are the photosensitizing chemical compounds found in the sap of wild parsnip and cause the phototoxic reaction (Berenbaum 1995). The sap of the plant is most irritating when the plant is in flower (Kennay and Fell 1990).

Many members of the Apiaceae, including other weedy species, such as wild carrot (*Daucus carota* L.), poison hemlock (*Conium maculatum* L.), spotted water hemlock (*Cicuta maculata* L.), and giant hogweed (*Heracleum mantegazzianum* Sommier and Levier) share similar characteristics with wild parsnip. Distinguishing features of wild parsnip, however, include its yellow flowers, pinnately compound stem leaves that are divided into at least five coarsely-lobed leaflets, and its distinctive parsnip odor (Alex 1992; Kennay and Fell 1990) (Figure 1).

Several features help distinguish between species in the genus *Pastinaca* (Table 1). Leaves that are simple and glabrous on both sides, characteristics only of *P. lucida*, differentiate it from the other *Pastinaca* species, which have pinnate leaves that are hairy on both sides. Other distinguishing characteristics include leaf shape and the degree to which they are pinnatifid, the presence or absence of bracts and bracteoles, petal color and hairiness, the number and length of rays, and the presence or absence of brown veins. *P. sativa* has once pinnate leaves that are hairy on both sides, lacks bracts and bracteoles, has yellow, glabrous or subglabrous petals, equal or subequal rays, and brown veins. Furthermore, *P. sativa* ssp. *sativa* can be differentiated from other subspecies by close examination of the stem and the presence of hairs on leaves (Table 2).

Distribution and Habitat

Wild parsnip is widely distributed in Europe and temperate Asia, where it originated. It is found in many countries including Belgium, France, Georgia, Germany, Italy, the

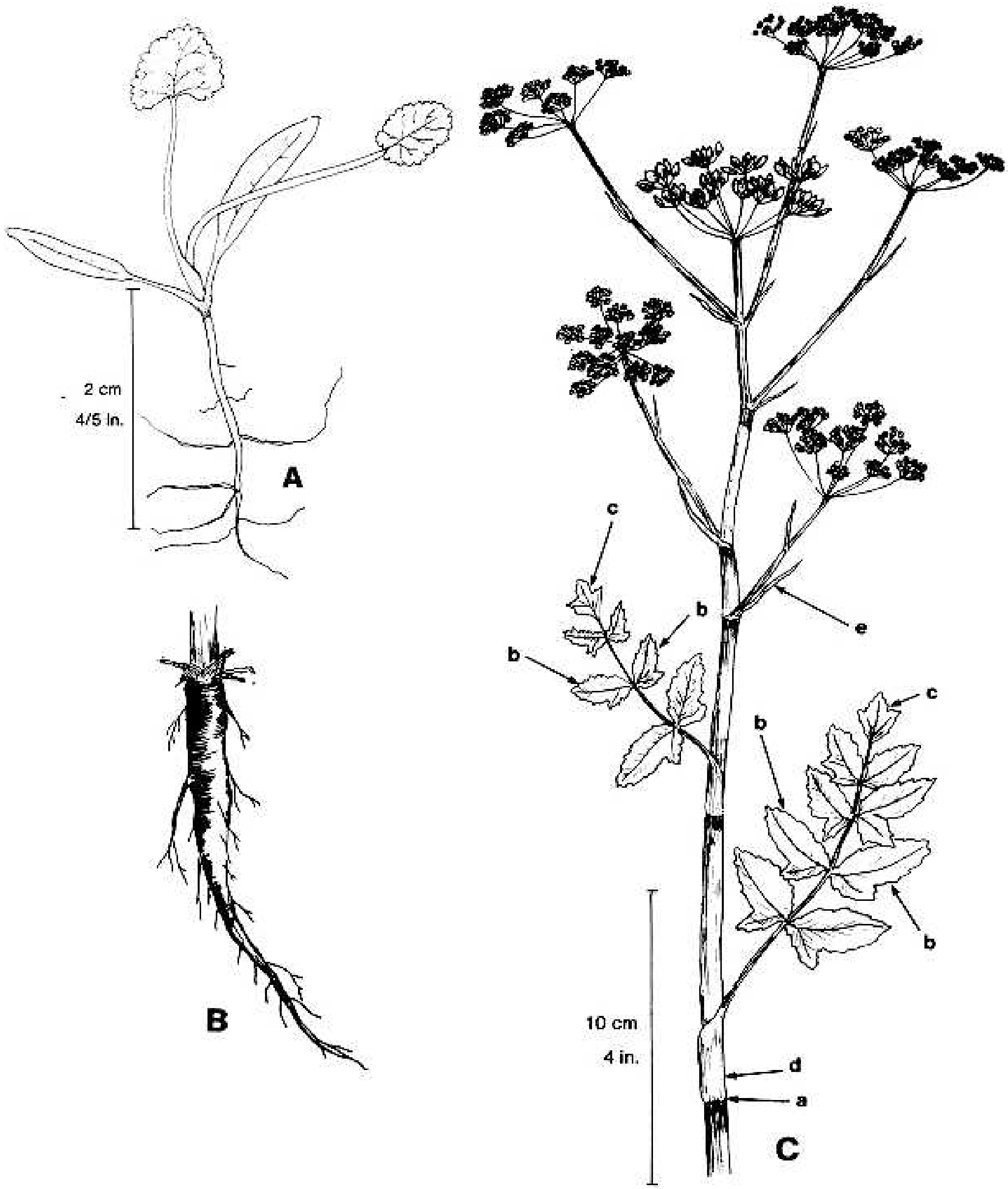

Figure 1. Wild parsnip, *Pastinaca sativa* L. (A) Seedling, (B) taproot, and (C) top of flowering stem. (a) Stems hollow except at the node, leaves alternate (one per node), pinnately compound with (b) two–five pairs of opposite, sharply toothed, and relatively broad, mitten-shaped leaflets and (c) a diamond-shaped leaflet at the tip; (d) leafstalks broad and completely encircling stem; uppermost leaves reduced to (e) narrow bracts with flowering branches in their axils. Drawings reprinted with permission from the Ontario Ministry of Agriculture, Food and Rural Affairs (Alex 1992).

Netherlands, Spain, Ukraine, and the United Kingdom, as well as Australia, Canada, and the United States (USDA ARS 2006). Wild parsnip is also widely naturalized in China and Japan (Hiroe 1958), New Zealand (USDA ARS 2006), and southern Africa and southern South America (USDA ARS 2006). In North America, wild parsnip is predominantly found in eastern regions, but it is widely naturalized across the United States. The species is distributed within 45 of the 50 United States (excluding Alabama, Florida, Georgia, Hawaii, and Mississippi). It is considered a noxious weed in Ohio (USDA NRCS 2006) and invasive in Kentucky, Nebraska, Tennessee, and Wisconsin (Haragan 1991; Hoffman and Kearns 1997; Stubbendieck et al. 1994). Wild parsnip is present in all of the Canadian provinces except the Northwest Territories and Nunavut (Darbyshire 2003). It is considered noxious in parts of Ontario (S. J. Darbyshire, personal communication), and is abundant in Quebec (Mulligan 1987). Cultivated parsnip (*Pastinaca sativa* L. ssp. *sativa*) is now grown worldwide (Schery 1972).

Wild parsnip is commonly found in waste areas, old fields, and along roadsides and railroad embankments. It grows best in rich, alkaline, moist soils, but can survive under poor soil conditions (Alex 1992; Fernald 1950; Gleason and Cronquist 1991; Schery 1972). Under summer drought conditions of Oxfordshire, U.K., Sternberg et al. (1999) found that the growth of wild parsnip plants in an old field increased and the growth of perennial grasses decreased. This tolerance to drought by wild parsnip may be due to its deep tap root, which allows access to water and nutrients from deeper soil layers (Tutin 1980).

History

Wild parsnip is an introduced plant native to Eurasia (Gleason and Cronquist 1991; Hedrick 1919; Hiroe 1958). This weedy species is native to regions between the western Mediterranean and the Caucasus Mountains (Rubatzky et al. 1999). According to Hedrick (1919), there is some doubt as to whether plants referred to as *Pastinaca* were cultivated in early times and also whether *Pastinaca* correctly refers to parsnip. Greek and Roman civilizations reportedly used *Pastinaca* as a food source, but they might have also been referring to carrots, highlighting the confusion in nomenclature between carrot and parsnip plants among early botanists. The Roman Emperor Tiberius (42 BC–AD 37) was apparently so fond of parsnips that he had them delivered to Rome annually from the Gelduba region on the Rhine in Germany, where they were thought to be grown to great perfection. Andrews (1958) clarifies the convoluted nomenclature surrounding the historical use of the word *pastinaca* and the uncertainty about whether these plants were cultivated or wild parsnips.

Although parsnip was likely cultivated long before 1542, when it was recorded in Germany, the root was unknown in Germany several years earlier in 1536. In 1552, parsnip was purportedly better known in kitchens than fat and was consumed especially by the poor (Hedrick 1919). The cultivated parsnip was widely grown in northern Europe by the 16th century (Rubatzky et al. 1999). In 1683, the parsnip was often used in England as a delicate and sweet food and was probably cultivated. It was observed on Margarita Island, Venezuela in 1564 and in Peru in 1604. The parsnip, likely referring to the cultivated subspecies, was introduced into North America by the earliest colonists and was cultivated in Virginia in 1609 and in Massachusetts in 1629, and was considered common by 1630. The species was also cultivated by Native Americans and was among the crops destroyed by General Sullivan in western New York in 1779 (Hedrick 1919). The natives used its roots as treatment for sharp pains, a root poultice on inflammations and sores, and tea in small quantities for "female disorders" (Foster and Duke 1990). It is probable that the cultivated parsnip escaped soon after its introduction in North America and reverted to its wild form. Distinguishing between the cultivated and wild populations of parsnip may be difficult, especially because the often-cited differences in leaf degree of hairiness characteristics do not appear consistent (S. J. Darbyshire, personal communication). However, Berenbaum et al. (1984) found the content of furanocoumarin in seeds differs between cultivated and wild parsnip plants.

Biology and Ecology

First-year growth of wild parsnip begins in early spring, and lasts until late autumn. Maximum growth occurs during the summer months. In more northern regions of its North American distribution, fully expanded leaves die during the winter, but in more southern areas (e.g., Kentucky) a few leaves survive the winter. During especially cold winters, plants may lose all leaves. Growth resumes in late February or early March in Kentucky, with plants bolting in early April. Flowering typically occurs from mid-May to mid-June in Kentucky (Baskin and Baskin 1979) but can take place through October in some regions of the United States (Lorenzi and Jeffrey 1987). In Canadian populations, flowering takes place between July and October (Mulligan 1987).

Wild parsnip requires vernalization to flower and, although long days are not required for flower initiation, long days and short nights (8-h light period plus 2 h of light in the middle of the dark period), rather than short days and long nights (10-h light period) induce plants to flower more quickly (Baskin and Baskin 1979).

In a Kentucky old-field wild parsnip population, root-crown diameters (RCD) of flowering plants in May ranged from 0.5 to 3.9 cm. Having large rosettes at the end of a growing season is more likely to lead to flowering during next season than small rosettes (Gross 1981). Monocarpic biennials, such as wild parsnip, often must attain a critical size (RCD of at least 0.5 cm) by the end of autumn to be induced (i.e., vernalization and/or photoperiod) to flower the following spring (Baskin and Baskin 1979; Harper and Ogden 1970). If this critical size is not attained by the end of the growing season, vegetative growth will resume the following spring, but plants will not flower. Interestingly, some plants may not flower until the fifth growing season (Baskin and Baskin 1979). This delay in flowering may be due to age-related changes in old fields (Gross and Werner 1982; Holt 1972). Younger, more frequently disturbed old-fields may provide a more conducive environment for wild parsnip growth than older fields. In southern Michigan older old-fields, wild carrot seedling emergence and rosette survival is lower than in younger old-fields. Monocarpic perennials likely respond to intraspecific and interspecific densities, which increase over time, with shifts in size distributions. These plants undergo delayed reproduction rather than suffer fertility reductions typical of obligate annuals (Holt 1972).

Plants in the Apiaceae are generally considered quite uniform morphologically. Across the family, self-fertility appears to be the rule, and self-sterility is an unusual exception. Members of the Apiaceae typically have unspecialized flowers that attract generalist pollinators such as thrips (Thysanoptera). This floral uniformity may have been an adaptation to primitive, unspecialized pollinators (Bell 1971).

Despite the high degree of floral uniformity across the Apiaceae, there are, however, subtle differences between the genera including the stylopodia, exposed nectar, and pollination strategy. The carpophore is the central part of the ovary and is a specialized fruit structure associated with the type of fruit and fruit dissemination found in the Apiaceae. The structure is specific to the Apioideae, and within this subfamily it varies considerably histologically and in its development. Jackson (1933) provides a complete description of the carpophore of wild parsnip. Furthermore, wild parsnip has been reported to attract a higher percentage of Coleopteran visitors compared with other members of the Apiaceae. The higher percentage of visits by Coleoptera indicates a trend toward a more specialized pollinator–plant relationship in wild parsnip (Bell 1971).

Wild parsnip seeds typically remain attached to the dead but erect inflorescences, with seed dispersal usually taking place between early August and late November (Baskin and Baskin 1979). Dispersal occurs primarily by wind, and the flattened seeds of wild parsnip allow adequate dissemination. In an Illinois old-field wild parsnip population, plants produced an average of 1.9 g of seed per plant, with each seed weighing approximately 2 mg. On average, 975 seeds were produced per plant (Zangerl and Berenbaum 1997). Mean seed weight for a Swedish population was 3.12 mg, ranging from 1.23 to 5.27 mg. The median dispersal distance traveled by seeds was 3.05 m, with one especially light seed dispersing 13.9 m away from the seed source (Jongejans and Telenius 2001).

Wild parsnip produces progressively smaller seeds on primary, secondary, and tertiary umbels. Secondary seeds weigh approximately 73%, and tertiary seeds weigh about 50% of primary seeds (Hendrix 1984) and seed biomass is positively correlated with embryo length over the full range of seed sizes (Hendrix et al. 1991). Although larger seeds are generally thought to have increased germination, emergence, and survival relative to smaller seeds, Hendrix and Trapp (1992) suggest that smaller wild parsnip seeds may provide a survival advantage during relatively short drought periods compared with larger seeds of the same species. Wild parsnip seeds exhibit morphological dormancy (Baskin and Baskin 1998) and dormant seeds have been found to survive no more than 4 yr in the soil (Kennay and Fell 1990). Baskin and Baskin (1979) studied the seed germination characteristics of an old-field wild parsnip population in Kentucky and found that seeds collected in September and October and incubated at 30/15 C had the highest germination levels, ranging from 55% (dark-incubated) to 73% (light-incubated). Stratification for 12 wk at 5 $\pm$ 2 C reduced the temperature requirement for germination regardless of whether seeds had been subjected to a light or dark treatment. Although some mature seeds can germinate during summer and autumn (4%) or winter (4 to 13%), germination is much higher in early spring (79%) when more optimal temperature and soil moisture conditions generally prevail. Seedlings in the old-field Kentucky site suffered high mortality, with less than 1% of seedlings surviving to maturity (Baskin and Baskin 1979).

Wild parsnip plants contain at least seven classes of secondary compounds, including terpenes, flavonoids, polyacetylenes, coumarins, and furanocoumarins (Berenbaum 1985). Some of the compounds are phenylpropanoids, such as myristicin, which, when combined with xanthotoxin, is synergistically toxic to some insects (Berenbaum 1985); monoterpenes, which are attractants for pollinators and antimicrobial agents (Harrewijn et al. 1994); sesquiterpenes, which are known to be toxic and deterrents to insects; and fatty-acid esters, which are toxic to the larvae of some lepidopterans (Zangerl and Berenbaum 1990, 1993). Furanocoumarins are ubiquitous within the Apiaceae. These defensive compounds have antifeedant and phototoxic properties that protect against a wide range of herbivores (Berenbaum 1991). Furthermore, all aboveground wild parsnip tissues contain the furanocoumarins xanthotoxin, bergapten, and imperatorin. The furanocoumarins angelicin and sphondin are present in the reproductive parts of some individuals. The distribution of furanocoumarins is correlated with nitrogen allocation; reproductive structures contain more than 10 times the amount of nitrogen and furanocoumarins contained in vegetative structures. Thus, furanocoumarin concentration on a percentage dry-weight basis is particularly high in the buds and seeds (Berenbaum 1981). Nitao and Zangerl (1987) and Zangerl et al. (1997) found increasing concentrations of furanocoumarins with increasing maturity of wild parsnip floral structures.

Furanocoumarin concentrations generally vary within wild parsnip populations. Berenbaum et al. (1984) found that the furanocoumarin content of seed collected from a roadside wild parsnip population in Illinois averaged 37.92 $\pm$ 2.43 μg/seed, ranging from 17.0 to 60.1 μg/seed, and relative proportions of individual furanocoumarins ranged from 2- to over 20-fold. Cultivated seed obtained from various commercial seed companies had significantly lower furanocoumarin content, averaging 13.74 $\pm$ 0.96 μg/seed, and ranging from 8.5 to 22.2 μg/seed. This difference may be due to selection for lower furanocoumarin content in cultivated plants to reduce photosensitization risks during handling. When plants escaped cultivation, furanocoumarin levels likely increased as selection pressure by herbivores and pathogens on wild parsnip in natural populations increased (Berenbaum et al. 1984). Zangerl and Berenbaum (1997) demonstrated that seed production in wild parsnip is negatively correlated with furanocoumarin concentration.

Furanocoumarins can act as phytoalexins, and therefore increase in concentration when in the presence of a pathogenic agent. When experimentally infected with fungi, the concentration of furanocoumarins increases in parsnip and when infected with *Ceratocystis fimbriata*, xanthotoxin inhibits the growth of this fungus (Berenbaum 1991). Similarly, following either mechanical or insect damage, foliar concentrations of furanocoumarins rapidly increase, typically several fold (Zangerl 1990; Zangerl et al. 2002). Furanocoumarins are both deterrents and toxins to a range of insects, particularly herbivorous insects (Berenbaum 1991). The presence of furanocoumarins is associated with high-light environments and nutrient-rich soils (Zangerl and Berenbaum 1987); thus, furanocoumarin-containing plants may grow preferentially in high-light conditions in part due to the production of higher levels of these defensive constituents under such conditions (Berenbaum 1991). UV light increases the toxicity of furanocoumarins in most cases, but deterrency is apparent even without UV light (Berenbaum 1991). Insects that feed on furanocoumarin-containing plants have adapted methods to reduce the toxicity of the compounds. Some insects avoid feeding on the plants during the day, thus avoiding the photosensitizing effects of UV light on furanocoumarins (Berenbaum 1990), whereas other insects that feed exclusively on furanocoumarin-containing plants have developed specialized methods for metabolizing and excreting the furanocoumarins (Cohen et al. 1989; Lee 1989; Nitao 1990).

Mammalian toxicity to furanocoumarins, in the absence of UV light, is low, with an LD_{50} of 300 to 600 mg/kg body weight in rats and mice for oral or intraperitoneally injected zanthotoxin or imperatorin (Ivie 1978). An oral dose of 1 mg/kg body weight in humans, in the presence of UV light, can be harmful. Furanocoumarins are rapidly digested and excreted, which may explain the low mammalian toxicity (Berenbaum 1991). Ivie (1978) provides a review of furanocoumarin photosensitization in livestock and poultry.

As wild parsnip plants mature, soluble protein and fatty acid content decreases, and fatty-acid composition changes from linolenic acid in buds to petroselinic acid in fruits (Zangerl et al. 1997). *Pastinaca* and *Heracleum* are two genera in the Apiaceae that produce the essential oils, esters octyl acetate and octyl butyrate (Bicchi et al. 1990), which are found exclusively in the reproductive tissues of the plants and may be insect attractants (Zangerl et al. 1997).

Across the Apiaceae, hybridization is rare (Bell 1971). According to Keeler et al. (1996), the cultivated parsnip does not hybridize with congeners and no congeners are reported to exist as weeds. The crop does not outcross with wild relatives, and there are no known hybrids of wild parsnip with other species. Wild parsnip and cultivated parsnip are often referred to by the same name, although some taxonomists place wild and cultivated parsnips in different subspecies, varieties, or forms (Tutin et al. 1968). The cultivated and wild parsnips are considered conspecific, and wild plants may be recent escapes (Gleason and Cronquist 1991). There is no evidence in the literature to support or refute hybridization between the strains (Tutin et al. 1968).

Current and Potential Uses

There is confusion on whether wild parsnip roots are suitable for human consumption. French (1971) reported that roots of *Pastinaca sativa* are edible and are considered a food source for many animals, but it is unclear whether this was a reference to the wild or cultivated parsnip. Although Alex (1992) reported that the roots of wild parsnip are edible, Baskin and Baskin (1979), and Tutin et al. (1968) considered wild parsnip inedible for humans. Schery (1972) maintained that a sweet flavor in the root develops after cold exposure, therefore suggesting it suitable for eating. Ivie et al. (1981) found three photoactive, mutagenic, and photocarcinogenic psoralens, the linear series of furanocoumarins (Berenbaum 1991), in cultivated parsnip before and after cooking for a total concentration of about 40 ppm. As cooking (boiling or microwave) does not destroy the chemicals, humans are exposed to considerable levels of psoralens when they consume parsnip. The toxicological consequences of consuming high levels of psoralens have not been determined (Ivie et al. 1981).

Dating at least as far back as 968 AD, sunlight and plants containing furanocoumarins have been used to treat skin disorders such as leprosy and leucoderma (Berenbaum 1991). It has recently been shown that photochemotherapy (psoralen [P] + ultraviolet A radiation [UVA] = PUVA) is an effective and safe therapy for humans with mycosis fungoides, a lymphoma of the skin (Herrmann et al. 1995). PUVA has also been used to effectively treat psoriasis, but this treatment increases the risk of malignant melanoma (Stern et al. 1997). However, the PUVA photochemotherapy procedure remains one of the most common treatments in dermatology (Bethea et al. 1999).

Wild parsnip has been widely used in research investigating the insecticidal properties of its defensive compounds, particularly furanocoumarins (Arnason et al. 1992). Work with this plant has also provided new insights into fundamental studies of ecological and evolutionary aspects of plant–herbivore interactions. Furanocoumarins are also of interest to dermatologists and other medical practitioners, including veterinarians, because of the severe phototoxic reactions they can cause in humans and animals following contact or ingestion in the presence of sunlight. The ability of furanocoumarins to bind to DNA has led to their use by biochemists interested in better understanding the structure and function of DNA (Berenbaum 1995). There is an abundance of information available in the literature concerning the chemistry of wild parsnip and the ecological function of many of its constituent chemicals. Furthermore, the phytochemistry of the plant is simpler than other members of the Apiaceae (Zangerl et al. 1997), making it an especially suitable target for research.

Weediness

Based on the Holm et al. (1979) definition for determining the severity of a weed problem, wild parsnip is a weedy plant in the United States, South America, and New Zealand and is considered common, in Argentina, Canada, and the former Soviet Union, as listed in Bridges (1992) (Keeler et al. 1996). Although wild parsnip is a competitive weed, more aggressive growth by other species can often displace wild parsnip from some habitats (Kennay and Fell 1990). Nonetheless, this plant has become a major problem along roadsides and old fields, especially where agricultural production has been abandoned. Reports from beekeepers in several counties in New York have raised concerns about wild parsnip, which honeybees do not visit. In many old-fields, this plant is outcompeting and displacing populations of goldenrod (*Solidago* spp.) and other important plants used by bees for honey production (K. Carnes, personal communication).

Management Options

Cultural and Mechanical Control. Mowing can be an effective control method against wild parsnip, but timing is critical. Poorly timed mowing can increase the number of seedlings and the percentage of plants surviving to maturity. Lorenzi and Jeffrey (1987) suggested that heavily infested areas should be mowed as soon as the flower stalks appear in order to prevent seed production. Wild parsnip density declined over a 6-year period in unmowed versus mowed plots of a Wisconsin prairie that were allowed to burn when routine prescribed burns took place. Therefore, natural succession may, in some cases, be an effective way of controlling wild parsnip. Mowing likely favored the dominance of wild parsnip by allowing light to reach young plants that were too short to be removed by the mower, and by reducing the density and height of competitor species such as Canada goldenrod (*Solidago canadensis* L. var. *scabra* Torr. and Gray) (Kline 1986).

Wild parsnip does not appear to be a problem in cropping systems that involve consistent crop rotations and cultivation (Lorenzi and Jeffrey 1987). In pastures, scattered plants can be controlled by cutting them below the basal leaves or by hand pulling, which is easiest after adequate rain or during drought (Kennay and Fell 1990; Lorenzi and Jeffrey 1987). Infested areas should be plowed and rotated to a cultivated crop for 2 yr. Cultivation may help prevent establishment of new seedlings, stimulate seed germination, and prevent seed production, if timed appropriately (Lorenzi and Jeffrey 1987). According to the "Vegetation Management Guideline for *Pastinaca sativa*" written for the Illinois Nature Preserves Commission, after spring burndown, wild parsnip plants are often the first to emerge and scattered plants can therefore be detected and controlled on the spot. Burning is not recommended as a successful control method for wild parsnip because it allows rosettes to develop, even though periodic burning helps maintain the vigor of native plants and allows them to more effectively compete with wild parsnip. Given that seed longevity in soil is relatively short (≤4 yr), plants may be more easily controlled if seed production is prevented for several years (Kennay and Fell 1990).

Biological Control. There are no biological control agents currently available for wild parsnip. Berenbaum (1981) found eight insect herbivores associated with a population of wild parsnip in Tompkins County, New York. These included an umbel-feeder (*Depressaria pastinacella* Dup.), a leaf-miner (*Phytomyza pastinacae* Hendel), a leaf-roller (*Agonopterix clemensella* Chambers), four seed-feeders (*Orthops scutellatus* Uhl., *Lygus lineolaris* (Palisot de Beauvois), *Plagiognathus politus* Uhl., and *Plagiognathus obscurus* Uhl.), and a sap-feeder (*Philaenus spumarius* L.). *D. pastinacella*, *P. pastinacae*, *A. clemensella*, and *O. scutellatus* are host-specific to members of the Apiaceae (Berenbaum 1981).

Pastinaca and *Heracleum* are the principal host plants of the parsnip webworm (*D. pastinacella*) (Berenbaum and Zangerl 1991), an insect that has been found to feed almost exclusively on the floral parts of wild parsnip. The webworm feeds on developing flowers and seeds, and then pupates in stems of wild parsnip (Gorder and Mertins 1984). The webworm is not affected by the furanocoumarins found in wild parsnip, nor those found in other species of the Apiaceae (Kenji 1987). Although the webworm selects parthenocarpic fruit having lower concentrations of furanocoumarins (Zangerl et al. 1991), this insect is able to metabolize almost all of the furanocoumarin xanthotoxin, a compound that is toxic to many polyphagous herbivores (Kenji 1987). Wild parsnip has few other insect enemies apart from the webworm, the greater part of which are specific to parsnip and related plants (Berenbaum 1981) and likewise, the webworm has few other hosts, all of which are very closely related and chemically similar to wild parsnip. Wild parsnip and the parsnip webworm have coevolved and have reportedly attained an evolutionary stalemate in their race to arms. Until environmental conditions change or new resistance traits evolve, this interrelationship will prevail (Berenbaum et al. 1986). This insect has been reported to severely damage individual wild parsnip plants, but is unlikely to decimate entire stands, therefore making it an unlikely candidate for biological control of this weed (Eckardt 2006).

Cultivated parsnip is susceptible to powdery mildew (*Erysiphe heraclei* Schleich. ex DC.), which is common especially under hot, dry conditions, and to alternaria blight (*Alternaria dauci* (Kuhn) Groves and Skolko), which can cause seedling mortality and plant death especially under hot, moist conditions (OEPP/EPPO 1994). Given the similarities in taxonomy and physiology between the cultivated and wild parsnip, these fungi are likely to infect wild parsnip as well. Wild parsnip is susceptible to viruses causing leaf chlorosis, mottling, curling, or no symptoms at all. These viruses include parsnip leafcurl virus, *Heracleum* latent virus, celery yellow spot virus, parsnip yellow fleck virus, the crinkle leaf strain of celery mosaic virus, nucleorhabdovirus, coriander feathery redvein virus, luteovirus, and parsnip mosaic virus. Some viruses have been listed here, but a full account of viruses that attack wild parsnip can be found on the Universal Virus Database of the International Committee on Taxonomy of Viruses (ICTVdb) Web site (Büchen-Osmond 2002).

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