The Biology of Canadian Weeds. 111.
Anthriscus sylvestris (L.) Hoffm.

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Darbyshire, S. J., Hoeg, R. and Haverkort, J. 1999. **The biology of Canadian weeds. 111. *Anthriscus sylvestris* (L.) Hoffm.** Can. J. Plant Sci. **79**: 671–682. Wild chervil, *Anthriscus sylvestris* (L.) Hoffm. (Apiaceae), is a weed of perennial crops, old fields, disturbed areas and roadsides. Introduced from Eurasia, it is widely naturalized in eastern Canada from Newfoundland to Ontario and at two sites in British Columbia. It is a monocarpic short-lived perennial, reproducing by seed and budding from the root crown. Dense populations achieved through vegetative reproduction can exclude most other vegetation. The rust, *Puccinia pimpinellae* subsp. *pimpinellae*, was detected on a population of wild chervil from Quebec.

Key words: Wild chervil, *Anthriscus sylvestris*, weed biology

Darbyshire, S. J., Hoeg, R. et Haverkort, J. 1999. **Biologie des mauvaises herbes canadiennes. 111. *Anthriscus sylvestris* (L.) Hoffm.** Can. J. Plant Sci. **79**: 671–682. L' anthrisque des bois, *Anthriscus sylvestris* (L.) Hoffm. (Apiaceae), est une mauvaise herbe des cultures pérennes, des prés abandonnés, des milieux perturbés et des bords de route. Introduite d'Eurasie, elle est naturalisée dans l'est du Canada, de Terre-Neuve jusqu'en Ontario et aussi dans l'ouest, à deux localités de la Colombie-Britannique. C'est une espèce monocarpienne et vivace de courte durée. Elle se reproduit par graines et aussi par bourgeonnement au sommet de la racine. En raison du succès de ce mode de multiplication, l'espèce forme des populations denses qui peuvent éliminer toute autre forme de végétation. On a identifié la rouille *Puccinia pimpinellae* subsp. *pimpinellae* sur les plantes d'une population sauvage d'anthrisque des bois au Québec.

Mots clés: Anthrisque des bois, *Anthriscus sylvestris*, biologie des mauvaises herbes

1. Name

Anthriscus sylvestris (L.) Hoffm. — Synonyms: *Chaerophyllum sylvestre* L.; *Cerefolium sylvestre* (L.) Besser. — **wild chervil** (Alex et al. 1980); **anthrisque des bois** (Ferron and Cayouette 1964). Many other common names are given in the literature: wild beaked-parsley (Groh 1942), cow-parsley (Scoggan 1979), wild parsley (Marie-Victorin 1995), woodland beakchervil (Canada Weed Committee 1969), keck (Tutin 1980), persil d'âne, persil sauvage, persin and petrosine (Ferron and Cayouette 1964). Apiaceae (= Umbelliferae), carrot or parsley family, Ombellifères.

2. Description and Account of Variation

(a) *Description* — Monocarpic (producing fruit once) perennial rosette. Life history may vary depending on edaphic conditions or population characteristics as other authors have reported it as an annual (Hiroe 1979), a biennial or short-lived perennial (e.g. Cannon 1968; Lovett Doust 1980a; Hansson and Persson 1994) or a polycarpic (producing fruit more than once) perennial (e.g. Grime et al. 1988; Spalik and Woodell 1994). Thick tap root up to 2 m long (Fig. 1B). Flowering stem 0.3–1.5 m tall, branched, hollow, deeply furrowed, pubescent above, lower nodes with a fringe of longer hairs. Leaves with a triangular blade to 0.3 m long, 2–3 pinnately compound, lobes of leaflets often dentate, lowest primary leaf divisions smaller than the rest of the leaf. Petiole, axis and branches of leaves grooved or furrowed on the upper surface (Fig. 2). Leaf blades usually abaxially pubescent (especially on veins), sparsely pubescent or glabrous adaxially. Leaf sheaths clasping when young, usually somewhat inflated towards the base, often densely pubescent toward apex and margins.

Inflorescence a compound umbel, 20–60 cm in diameter, terminal and axillary (on second to fourth order branches) umbels made up of (8) 10–15 (20) umbellets (Fig. 1C), rays (3-) 6–12, glabrous, 1–4 cm long. Bracteoles 4–6, ovate to ovate-lanceolate, acute to aristate, ciliate, greenish or pinkish, reflexed at maturity. Pedicels about as long as bracteoles at anthesis and elongating with maturity, usually with a few short hairs (<0.2 mm) at the apex often forming an irregular ring (Fig. 1D). Flowers 3–6 mm in diameter (Fig. 1C), without an involucre, petals creamy white and notched, the outer flowers in the umbellets with larger petals toward the outside, sepals minute. Styles with an enlarged base (stylopodium), usually divergent. Anthers 0.3–0.5 mm. Fruit (Fig. 1D) with 2 mericarps (hereafter referred to as seeds), 5–10 mm long and 0.9–1.6 mm wide, greenish brown to

Abbreviations: **AYV**, anthriscus yellows virus; **PYFV**, parsnip yellow fleck virus

dark brown or black, shining, smooth or sometimes with scattered papillose bumps; commissures constricted; carpels subterete, tapering to a somewhat ribbed beak 1/4 to 1/3 the length of fruit, persistent stigmas slightly to widely divergent. Cotyledons linear-spathulate, tapered gradually at the base, without a distinct petiole.

(b) *Similar species* — The presence of small tooth-like hairs at the apex of most pedicels (Fig, 1D) will distinguish *A. sylvestris* from other species of Apiaceae in Canada. The seeds of the more delicate species *Anthriscus caucalis* M. Bieb. (bur chervil) are covered with hooked hairs and the pedicel apices have long hairs (about 0.3 mm). The foliage of *Myrrhis odorata* (L.) Scopoli (sweet cicely) is similar, but fragrant when crushed and the longer seeds (about 25 mm) are sharply angled. Sweet cicely is sometimes cultivated, but rarely escapes in Canada. The cultivated garden chervil (or chervil), *Anthriscus cerifolium* (L.) Hoffm., rarely escapes from cultivation and does not seem to persist in Canada. Its seeds are more elongate and narrow with the beak usually comprising about 1/3 the total length, and the bracteoles are lanceolate-linear.

(c) I. *Taxonomic Problems* — The genus *Anthriscus* has had widely varying numbers of species recognized in treatments by different authors. Hiroe (1979) recognized only three species, Coulter and Rose (1900) estimated the genus contained about 13 species and Heywood (1971) and Tutin (1980) recognized about 20 species in the genus. Two other species have been introduced to Canada. Garden chervil, *A. cerifolium*, has been reported as a rare escape in Quebec and bur chervil, *A. caucalis*, is a common ruderal weed in southwestern British Columbia. The morphology of the mature fruits readily distinguishes these species (see the section "Similar species", above).

The wide-ranging populations of *A. sylvestris* are quite polymorphic. Groupings of plants with similar leaf shape and vestiture were recognized by Petersen (1914) in his analysis of polymorphism. Cannon (1968) recognized a complex of four closely related species in Europe (*A. sylvestris* (L.) Hoffm., *A. nitida* (Wahlenb.) Garcke, *A. nemorosa* (M. Bieb.) Sprengel and *A. fumarioides* (Waldst. & Kit.) Sprengel), distinguishing them by the colour and texture of the fruits and the shape and size of leaf divisions. Hruska (1982) described geographical and ecological differences between these species. Other authors have expressed reservations on recognizing these taxa at a specific rank (Hedge and Lamond 1972) or have considered various segregates as subspecific taxa of *A. sylvestris* (Townsend 1984). *Anthriscus nitida* is said to differ from *A. sylvestris* in its habitat (cold, shaded mountain valleys) and in the presence of the sesquiterpene lactone, grilactone (Muckensturm et al. 1978). Canadian material all seems to belong to *A. sylvestris* sensu stricto, although rarely individuals with greenish mature fruits (rather than dark brown to black), or prominant tubercles on the fruit (rather than smooth fruits) are seen.

(c) II. *Genetic variation* — Populations of *A. sylvestris* occurring in northern regions of Britain have largely glabrous and more dissected leaves and larger seeds than southern populations (Clapham 1953; Tutin 1980).

Mulligan (1961) reported a chromosome count of $2n = 16$ from a population of *A. sylvestris* in the Ottawa region. This count has also been reported from several European populations (Cannon 1968; Hruska 1982). Bolkhovskikh et al. (1969) list 13 other references for $2n = 16$. Tamamschian (1933) reported $2n = 18$ from Russian material.

3. Economic Importance

(a) *Detrimental* — In North America it is considered a problematic weed in Nova Scotia (Anonymous 1996), Ontario and Washington State (Roché 1991) where it is primarily a weed of perennial forage crops and pastures. It is considered a weed in Sweden (Hansson and Persson 1994), Norway (Jakobsons 1975b), Britain (Oswald 1986), The Netherlands (van Mierlo and van Groenendael 1991), Germany (Schulz et al. 1973), Finland, New Zealand, Norway, Spain, Sweden, United States and Yugoslavia (Holm et al. 1979). In Sweden it is invading hay meadows, probably due to changing grazing and cutting practices (Hansson and Persson 1994), and nature reserves where it is increasing at the expense of other species.

Rapid growth of the broad leaves in the spring forms a canopy which crowds out grasses and legumes growing below (Wagner 1967). Populations in Nova Scotia, where aboveground foliage was removed by mowing and/or herbicide application, showed large bare soil patches around the tap roots long after the control action. This suggests some residual allelopathic effect may be preventing the re-establishment of surrounding vegetation.

(b) *Beneficial* — Although *A. sylvestris* is reported to be occasionally cultivated in gardens, *A. cerefolium* is more frequently planted and used as a herb similar to parsley. Watt and Breyer-Bradwijk (1962) reported a number of herbal remedy uses of *A. sylvestris*. In Lesotho, a lotion is extracted and used as a refreshing bath; in Russia, it is used as an abortifacient and remedy in childbirth; in Europe, the powdered plant is used as a dressing for wounds. The roots have been used as a medicinal under the name "qianhu" in China (Kozawa et al. 1978). A number of attributes and medicinal uses are listed by Fournier (1947), but he warns that some of the ascribed properties may be due to confusion with other similar species in the Apiaceae family.

Pratt (1895) reported that the somewhat aromatic foliage of wild chervil is eaten in some parts of Britain, but claims that the roots are poisonous and can be fatal. Courchet (1882), on the other hand, stated that the roots and young shoots are sometimes eaten. Church (vide Clapham 1953) stated that it is used as a pot herb in Britain. The flowers are said to yield a good yellow dye (Pratt 1895).

The plant is palatable to and grazed by cattle (Wagner 1967; Hansson and Persson 1994; Pratt 1895). Pratt (1895) stated that it is a favourite food and sometimes gathered as a forage for rabbits and cows. In Germany, Wagner (1967) reported that although young foliage is relished by livestock it is of low nutritional value and reduces milk production and quality when composing a high proportion of the feed. Wagner (1967) recommends upper field population limits of
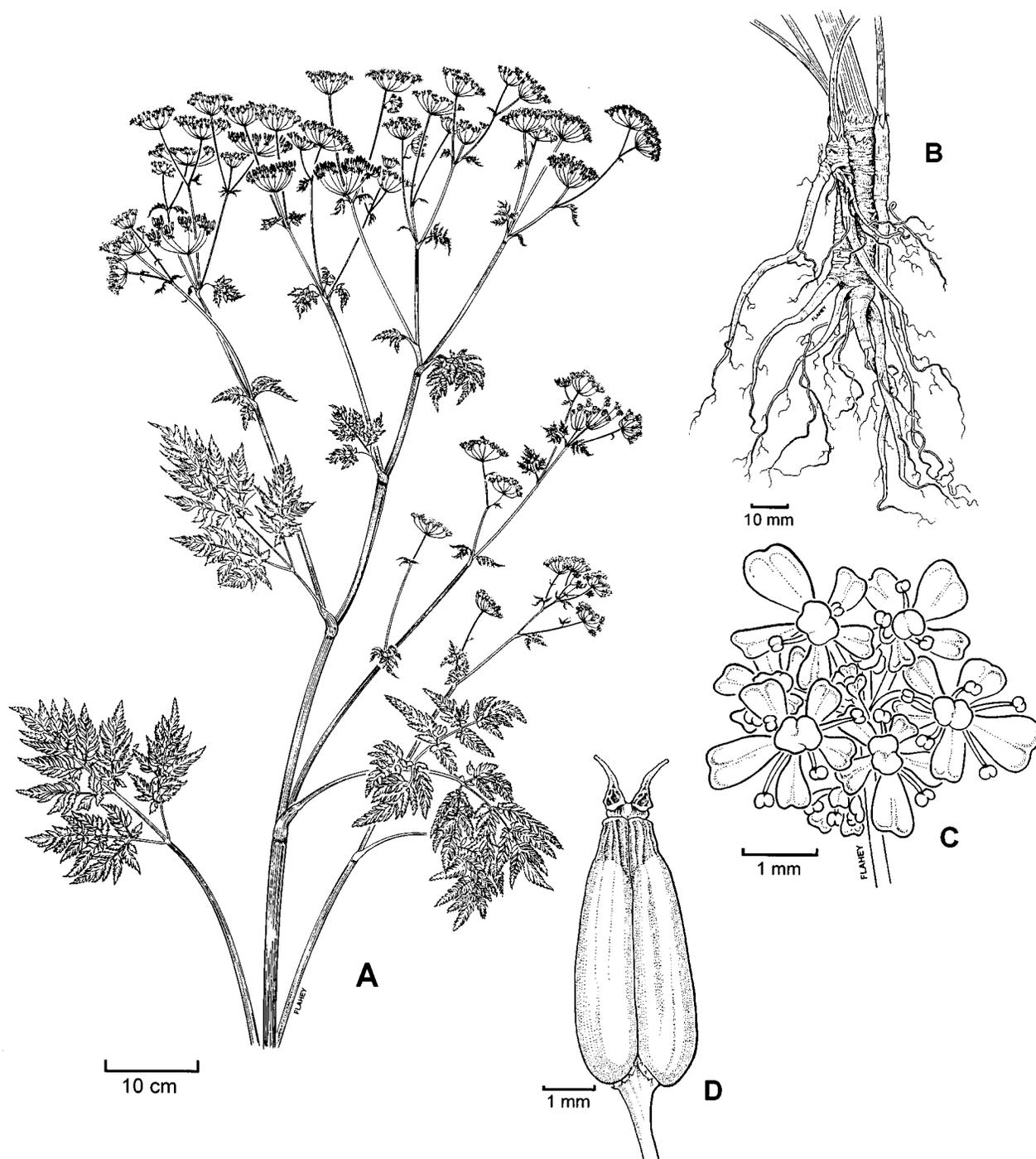
Fig. 1. *Anthriscus sylvestris* A) shoot, B) tap root showing side rosettes, C) umbellet, D) fruit.

20 plants m^{-2} for fodder and silage production and 5 plants m^{-2} for hay production. In Nova Scotia the young foliage is readily browsed by cattle.

(c) *Legislation* — In North America *A. sylvestris* is currently listed as a noxious weed in the state of Washington (WAC 16-750-005, Class A noxious weed, 1989), in Nova Scotia (O.I.C. 96-630, N.S. Reg. 139/96. Schedule "A" Class

Number One), in British Columbia's Fraser Valley (Part II, Schedule A, B.C. Reg. 66/85) and in Grey County, Ontario (By-law 3373-92 under Section 10 of the Ontario Noxious Weed Act, 1992).

4. Geographic Distribution
All three species of *Anthriscus* occurring in Canada have been introduced from Eurasia. The distribution of *A.*

Fig. 2. A plant of *Anthriscus sylvestris* grown in the greenhouse and showing small plantlets budding from the root crown. Pot diameter = 152 mm.

sylvestris in eastern Canada (Fig. 3) is scattered through eastern Newfoundland, Nova Scotia, southern New Brunswick, southern Quebec and southern Ontario. In eastern North America the distribution is known to extend as far south as Roan Mountain on the Tennessee–North Carolina border (Mellichamp et al. 1988). It is also known from Stanley Park in Vancouver and between Chilliwack and Abbotsford, British Columbia. A localized weed in Washington state (Roché 1991; Roché et al. 1993), it invades moist pastures and roadsides in the Palouse region. Hultén and Fries (1986) provide a map of the Old World distribution indicating a range throughout Europe (rare in the south), north Africa and temperate Asia as well as its introduction to South Africa. A similar distribution is given on the map by Meusel et al. (1978), although the temperate Asian range is considered to be that of the segregate species *A. nemorosa*. These authors also indicate a wide distribution in east-central Africa and introduction to Iceland.

5. Habitat

In general wild chervil is a plant of moderately disturbed habitats and edges, in moist or mesic sites. It can form dense colonies in ditches, dykes, road verges, meadows, hay fields, stream banks and hedge rows. It is found at lower frequencies in pastures, open woodlands or waste land. Wagner (1967) reported it as occurring in nutrient-rich, mesic to moderately damp meadows in Germany. Lundqvist

(1977) stated that it occurs in lowland coniferous forests and mountainous deciduous forests in northern Sweden. Grime et al. (1988) stated that, in Britain, it is present on arable land only as seedlings and is absent from wetlands, although Clapham (1953) stated that it occurs in brackish marshes in Britain. Hruska (1982) describes favourable natural habitats in Europe as being shaded, cool stations with moderately damp soil rich in organic matter. Anthropogenic habitats such as forest edges, roadside ditches, irrigation canals, mown fields, etc., provide similar environmental features.

The other two species of *Anthriscus* introduced to Canada, *A. cerefolium* and *A. cacaulis*, are found in drier, sunnier habitats. They are frequently found in settled areas where the soil is disturbed, dry or abandoned (Hruska 1982).

(a) *Climatic Requirements* — In Sweden, Hansson and Persson (1994) found that there was a greater variation in the year-to-year population size than could be induced by experimental conditions of cutting regimes and/or nitrogen supplement. They speculated that this was due to climatic factors, and correlated growth rates, seed production and abundance in their study populations to precipitation.

(b) *Substrate* — In Canada it has been found growing on sandy, clay, loam or peaty soils in dry to moist-mesic sites. In Nova Scotia populations were found on soils with pH ranging from 4.1 to 6.7. Populations in Nova Scotia grow in
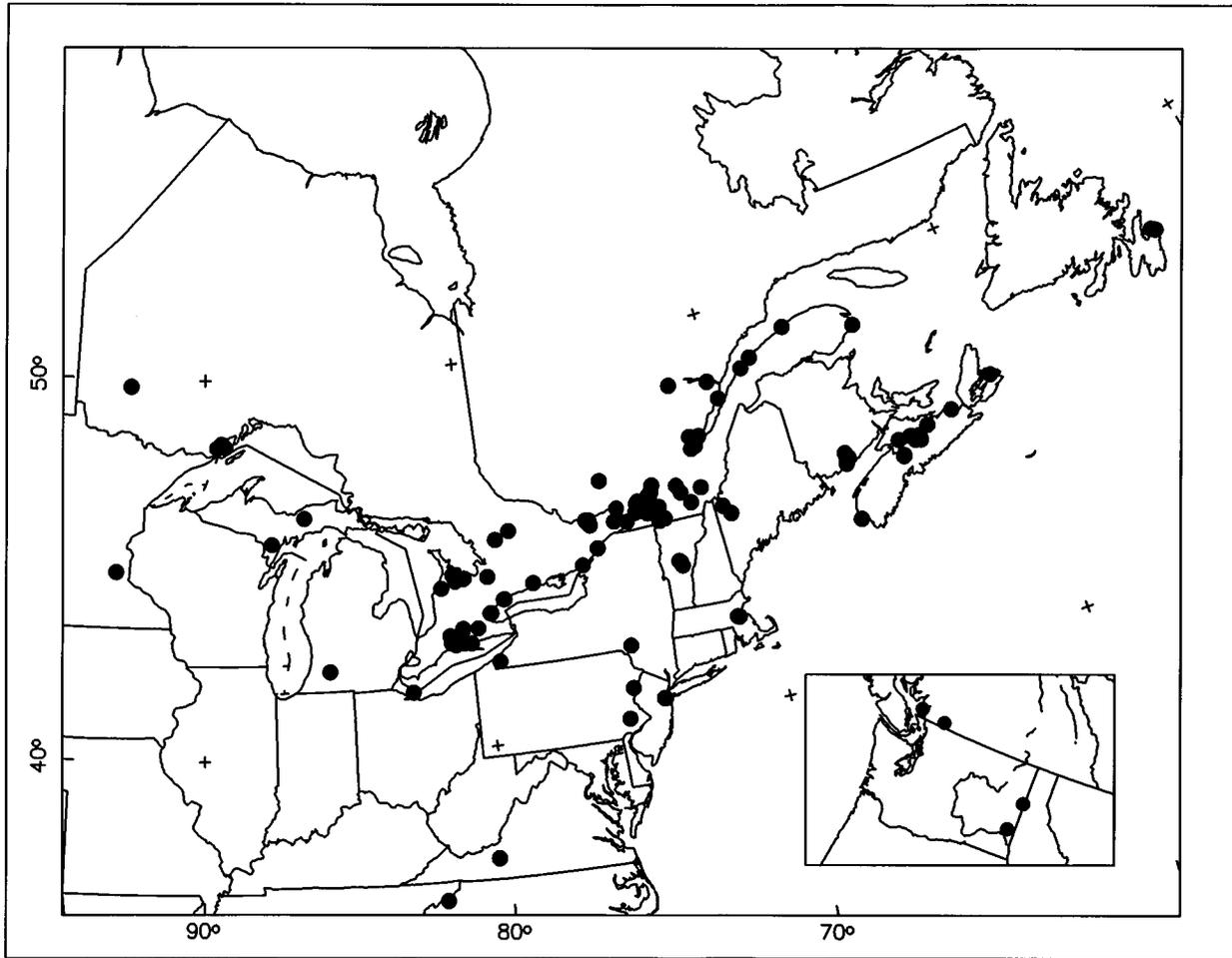
Fig. 3. Distribution of *Anthriscus sylvestris* in Canada and adjacent United States. Based on specimens examined and supplemented with some literature records for the United States. Specimens from the following herbaria were examined: ACAD, APM, CAN, DAO, HAM, LKHD, MT, NBM, NSAC, NSPM, QFA, TRT, UBC, UWO, WAT and V. Inset: southern British Columbia, Washington, northern Oregon and Idaho.

dyked pastures and on the dykes themselves, indicating a competitive ability in saline habitats. In England wild chervil is described as growing "on practically all soils" (Long and Percival 1910). Neutral to basic substrates support larger populations in Britain (Clapham 1953; Grime et al. 1988), although the plant does occur on somewhat acid soils as well. Grime et al. (1988) stated that it is intolerant of heavily droughted or waterlogged soils.

(c) *Communities in which the species occurs* — A summary of the habitats and communities in which *A. sylvestris* occurs in northern Europe and Scandinavia is found in Clapham (1953). In subalpine and "arctic" regions of Scandinavia it may form a major component of plant communities near the tree-line (Clapham 1953). Jakobsons (1975a) studied *A. sylvestris* in meadows of central Norway where plant communities were of the *Molinio-Arrhenatheratea* association, either dry enough to be arable or too moist to be used for purposes other than grazing with-

out improving drainage. Wild chervil is also common in this association in central Europe (Hruska 1982). Old World phytosociological associations in which wild chervil occurs were given by Horvat (1977) and Hruska (1982), including several where it forms a dominant component. Hada (1978) described the *Anthriscetum sylvestris* association, belonging to the *Aegopodion podagrariae* alliance, from the Czech Republic. Primarily an association found in roadside ditches, four other plant species were always found in the association, viz. *Heracleum sphondylium* L., *Arrhenatherum elatius* (L.) Presl, *Urtica dioica* L. and *Alopecurus pratensis* L.

6. History
The first report of the genus in Canada was that of Lindsay (1878) under the name *Anthriscus vulgaris* Persoon (= *A. caucalis*) as introduced near Bedford, Nova Scotia. A specimen in Lindsay's herbarium is cited, but was not located during this study. Neither has a specimen been located by

other workers (Roland and Smith 1969). There is a report of a specimen collected by H. H. Lyman at Montreal in 1879 (Rousseau 1968), which also has not been subsequently located. These specimens may be lost or destroyed, or the records may have been based on a mis-identifications. The earliest specimen of *A. sylvestris*, in Canada (located in this study) is that of James Fletcher from St. John, New Brunswick, in 1904 (Groh 1942). From specimens examined at various herbaria the earliest dates from other provinces are: Newfoundland, 1949 (DAO); Nova Scotia, 1971 (NSPM); Quebec, 1908 (DAO); Ontario, 1930 (CAN, WAT); and British Columbia, 1964 (CAN). The first collection of chervil, *A. cerefolium*, as a ruderal weed in Quebec was made by F. F. Forbes at Matane in 1904.

Marie-Victorin (1995) states that in about 1925, wild chervil went through a population explosion in the Montreal area. It is now a common ruderal weed in southwestern Quebec and adjacent Ontario.

7. Growth and Development

(a) *Morphology* — In late April and early May, linear-lanceolate cotyledons appear followed quickly by the compound true leaves with lobed leaflets. By the end of June seedlings have about six leaves while older, mature plants form a dense canopy of leaves about 0.3–0.4 m high and begin to flower. The fruits mature in late June and July. By August the flowering stems senesce and the brown stalks overtop the canopy of green basal leaves. Seeds fall gradually from the mature plants through late July, August and September and some may persist on the dead stems through the winter.

The pattern of vegetative reproduction, budding from the root crown, allows chervil to achieve dense populations with minimal seedling recruitment. Young plantlets are formed early in the growing season and usually remain attached to their parent root stalk throughout the year. By the end of the first year the tap root is well formed and can provide considerable resources for initiation of growth the following spring.

(b) *Perennation* — Vegetative reproduction is accomplished with the production of side rosettes from buds in the leaf axils at the caudex of the tap root (Figs. 1B, 2). van Mierlo and van Groenendael (1991) found that if the flowering stem is cut as it reaches its maximum height the production of side rosettes is stimulated. Abundant budding at the apex of tap roots was observed in Nova Scotia populations after stems were cut or sprayed with dicamba (1.2 kg ha^{-1}). The buds develop a taproot and the new plantlets separate from the main tap root as they mature (Figs. 1B, 2). Sometimes side rosettes will flower without developing a tap root (van Mierlo and van Groenendael 1991).

Overwintering structures include a short caudex and the attached roots (Lovett Doust 1980a).

(c) *Physiological data* — Aboveground seedling growth is slow, relative to tap root growth, because of the early allocation of photosynthate to the root stock as reserves for the following season's growth (Grime et al. 1988). Seasonal decline in growth rate is slowest for the tap root due to an increasing proportion of assimilate being stored in the root (van Mierlo and van Groenendael 1991). Imhoff and Kühbauch (1980) found assimilate translocation to the roots predominated during the rosette stage and late flowering stage.

Kurihara et al. (1978) and Kurihara and Kikuchi (1979) isolated and characterized a number of essential oils, phytoserols, fatty acids and flavonoids from *A. sylvestris*. The high levels and diversity of volatile monoterpene compounds secreted by flowers and the variation in proportions of enantiomeric forms suggest that *A. sylvestris* and other Apiaceae have complex enzyme systems to generate these compounds (Borg-Karlson et al. 1994).

(d) *Phenology* — Seeds germinate in early spring (Roberts 1979). In the Ottawa area, germination occurs from mid to late April. Flowering is size dependent, usually occurs after 3 to 4 yr, and is followed by plant death (van Mierlo and van Groenendael 1991; Hansson and Persson 1994). In nutrient-rich environments flowering can occur in the second year of plant growth (van Mierlo and van Groenendael 1991; Hansson 1994). van Mierlo and van Groenendael (1991) found that certain conditions must be met for flowering of mature plants to occur under field conditions. Plants with a minimum dry weight of 1.5 g need to be vernalized to induce formation of flower primordia and stem elongation.

(e) *Mycorrhizae* — Grime et al. (1988) reported that *A. sylvestris* is non-mycorrhizal.

8. Reproduction

(a) *Floral biology* — As with most members of the Apiaceae, *A. sylvestris* attracts a wide range of unspecialized insect pollinators. The large number of small flowers arranged in comparatively flat heads, the copious, exposed nectar and broad stylopodium are features that facilitate visitation and feeding for many kinds of insects with unspecialized mouth parts. In fact, specialized nectar feeders, such as Lepidoptera, tend to be uncommon visitors to the Apiaceae (Lubbock 1890). Müller (1883) reported a variety of Diptera, Coleoptera and Hymenoptera visiting flowers for nectar and that a few Diptera and Hymenoptera visit for pollen. He also observed that honey bees (*Apis mellifera*) sometimes visit *A. sylvestris*. Knuth (1908) gives a long list of insect visitors to European populations from the orders Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera and Neuroptera. Chagnon (1936) reported adults of a species of the Cerambycid (Coleoptera) genus *Stenocorus* (under the name *Toxotus trivittatus*) as commonly visiting flowers of wild chervil in Quebec. Borg-Karlson et al. (1994) reported a high proportion of Diptera among the insect visitors. Relatively few of the insect visitors listed by Knuth and Müller are more than casual pollen vectors.

The volatile compounds emitted by flowers (and leaves) of *A. sylvestris* and five other species of Apiaceae were studied by Borg-Karlson et al. (1994) and distinct species-specific fragrances were found. High levels of monoterpene hydrocarbons were found in species-specific proportions,

sabinene, myrcene and α-pinene being the main components in *A. sylvestris*. Analysis of nitrogenous components showed that *A. sylvestris* secreted higher levels of these compounds than other sympatric Apiaceae studied, with isovaleraldoxime being the major constituent.

Flower development is centripetal with the outer flowers in umbellets developing first, the outer umbellets of an umbel developing before inner ones and the primary umbel in an inflorescence developing first (Webb 1981). As in most species of Apiaceae, *A. sylvestris* is andromonoecious (male and hermaphrodite flowers on the same plant). Hermaphrodite flowers are protandrous (stamens maturing before pistils), but flowers with mature stamens or mature pistils may be found mixed in the same umbel at the same time. This is due to the outer, primarily hermaphrodite flowers, maturing earlier than the central, primarily staminate, flowers within both umbels and umbellets (Lovett Doust 1980b). The proportion of male flowers increases in umbels of higher order (Knuth 1908; Lovett Doust 1980b; Tutin 1980; Spalik and Woodell 1994). In Britain, Lovett Doust (1980b) found proportions of male flowers from the first to fourth order umbels to be 37, 50, 82, and 100%, although fourth order umbels were not always found. Spalik and Woodell (1994), also working in Britain, found 31, 57, 83 and 97% male flowers, respectively.

(b) *Seed production and dispersal* — Seed ripens in late June through July and disperses slowly. Production is from 800 (Fournier 1947) to 10 000 (Keller et al. 1934) seeds per plant. The seeds have no obvious dispersal mechanism. Floatation experiments in both fresh and salt water indicated that mature seeds sink rapidly and are unlikely to be dispersed by water. Dead stems, however, contain many air spaces. Seeds attached to dead stems that are broken late in the season can float in water for several days. Observations in Nova Scotia and elsewhere suggested that the wide dispersal of seeds is primarily mediated by human activity, either by attachment to machinery or by soil transportation.

(c) *Viability of seeds and germination* — In Britain, Roberts (1979) reported an average seed viability of 79% when freshly gathered seeds were sown in outdoor pots and followed over a 5-yr period. As in many species of Umbelliferae, *A. sylvestris* produces a proportion of seeds which, although having well-formed endosperm and appearing normal, lack embryos and are incapable of germination (Flemion and Hendrickson 1949). The percentage of seeds lacking embryos may vary considerably from year to year. The lack of embryos in apparently normal and mature dill (*Anethum graveolens* L.) seed has been attributed largely to feeding of *Lygus* bugs (Flemion et al. 1949). In European populations no persistent seed bank is established, with the vast majority of seeds germinating the year after production and only a few the year after (Roberts 1979; Grime et al. 1988; van Mierlo and van Groenendael 1991). In one population from Nova Scotia, where seed development was controlled by cutting for 4 yr, substantial numbers of seedlings continued to appear for several years. Seeds require a cold period (about 3 mo at, or below, 5°C) to break dormancy

(Kurth 1967; Janiesch 1971) and for post-dehiscence maturation as the embryos continue to take up endosperm nutrients after seed dehiscence (van Mierlo and van Groenendael 1991). Seed germination shows a slight optimal range of 8–15°C, is slowed by high diurnal temperature fluctuations and is not affected by red/far-red light ratios (van Mierlo and van Groenendael 1991).

9. Hybridization

In Europe a complex of four species (or subspecies) overlaps in range. Cannon (1968) states that there is no obvious evidence of hybridization between taxa in regions of sympatry.

10. Population Dynamics

Populations of *A. sylvestris* growing in suitable habitats increase rapidly and are invasive (Hruska 1982). In southern Germany Schulz et al. (1973) observed that wild chervil populations increased in meadows which are heavily treated with organic fertilizers and, along with *Heracleum sphondylium*, comprised up to 50% of the plant cover (roughly up to 25 plants m^{-2}). van Mierlo and van Groenendael (1991) found *A. sylvestris* dominating communities in nutrient-rich moderately disturbed grasslands in The Netherlands. Wagner (1967) states that meadows in southern Germany are often white with the blossoms of wild chervil in the spring. In what he called a sparsely covered meadow Wagner (1967) counted an average of 18 plants m^{-2}.

Large numbers of seedlings are seen only in areas where soil is cleared or substantially disturbed. In the Netherlands, van Mierlo and van Groenendael (1991) reported seedling recruitment in dense stands of *A. sylvestris* initially varied from 80 to more than 1000 m^{-2}. By the end of the growing season, seedlings had declined to about 6% of their initial numbers and the density was considerably less than that of the mature plants. In one population studied the proportion of flowering plants originating directly from seed was 21%, while the remaining 79% of flowering plants originated from vegetatively produced side rosettes (van Mierlo and van Groenendael 1991). In sites of dense vegetation, sexual reproduction was relatively less important than vegetative reproduction. A similar situation has been observed in Canadian populations where most recruitment in established populations is from vegetative propagation except in highly disturbed areas.

van Mierlo and van Groenendael (1991) found that each adult plant produced an average of two side rosettes in excess of 1.5 g dry weight by the end of the flowering season under field conditions.

11. Response to Herbicides and other Chemicals

Williams (1984) stated that *A. sylvestris* is resistant to most herbicides and generally this seems to be the case, at least for the "old chemistry" herbicides. Dichlorprop (3 kg ha^{-1}) applied at early flowering and chlorfurecol-methyl (1.5 kg ha^{-1}) plus maleic hydrazide (3 kg ha^{-1}) applied in the spring gave good control in Britain (Williams 1984). In central Norway, mecoprop and dichlorprop (6 kg ha^{-1}) reduced

populations, although the addition of dicamba (0.5 kg ha^{-1}) did not increase the effect (Jakobsons 1975a). In Germany, good control was achieved with picloram and a combination of maleyl and hormone herbicides and SYS 67 Prop (6–9 L ha^{-1}) was found to be effective only on young plants (Walkowiak 1969). The best control with 2,4 DP (6.0 L ha^{-1}) was achieved in the early part of the growing season when plants were transferring the majority of assimilate to the root (Imhoff et al. 1980). In the greenhouse, increasing effectiveness was observed on chlorosis of mature plants with applications of metsulfuron-methyl (5 g ha^{-1}), chlorsulfuron (15 g ha^{-1}) and a mixture of the two (Oswald 1986). One hundered and twenty-eight days after spraying, vigorous regrowth occurred in the metsulfuron-methyl treatment, slight regrowth with chlorsulfuron and no regrowth with the mixture. Young plants (approximately 6 wk growth in greenhouse pots) were eradicated using chlorsulfuron or the mixture, but a small residue was left 63 d after spraying with metsulfuron. No regrowth of the treated young plants was observed.

In Germany, some control of *A. sylvestris* was achieved by using 2,4 DP (as an ester at 4.0 L ha^{-1} or as a salt at 6.0 L ha^{-1}) applied at the time of the first hay cut on 4 May (Wagner 1967). Assessment on 21 June, during the second growth phase of *Anthriscus*, showed population densities of 0.7 plants m^{-2} in the sprayed area and 18 plants m^{-2} in the control. Application of 2,4,5 T (3.0 L ha^{-1}) had no effect on *A. sylvestris*, although it did eliminate cow-parsnip (*Heracleum sphondylium*) and significantly controlled common yarrow (*Achillea millefolium* L.).

Applying chlorflurenol (CF 125) or 2,4 DP to pastures in Germany reduced wild chervil during the treatment year Schulz et al. (1973). After treatment with CF 125 at 3, 6 and 9 L ha^{-1}, wild chervil biomass was reduced to an average of 11, 3 and 3% of that of the control plots and plant density was reduced to an average of 20, 6 and 5%, respectively. Populations rebounded in the two years following, however, with average biomass at 57, 47 and 41% (year 1) and 74, 52 and 57% (year 2), and average plant density at 64, 53 and 41% (year 1) and 75, 49 and 45% (year 2). Results varied greatly between the replicate test sites, with some populations showing substantial biomass and plant density increase at all application rates in the years following application. Treatment with 2,4 DP (6 L ha^{-1}) provided better long-term suppression with an average biomass of 14% (year 1) and 37% (year 2) and an average plant density of 14% (year 1) and 31% (year 2) that of the untreated plots.

Preliminary herbicide screening trials on Nova Scotia populations showed variable results, with dichlorprop/2,4-D (2.4 kg ha^{-1}), clopyralid (0.36 kg ha^{-1}) or dicamba (1.1 kg ha^{-1}) being the most effective. Triclopyr (1.9 kg ha^{-1}), 2,4-D (2.3 kg ha^{-1}), MCPA (1.4 kg ha^{-1}) and dicamba/MCPA/mecoprop (0.6 kg ha^{-1}) provided poor control. In a series of experiments at Harbour Centre, Nova Scotia, five herbicides were applied with a boom sprayer in May to a third year forage crop of 70% Timothy (*Phleum pratense* 'Climax'), 15% red clover (*Trifolium pratense*) and 15% alsike clover (*Trifolium hybridum*). Treatments of dicamba

(1.2 kg ha^{-1}), clopyralid (0.2 kg ha^{-1}), triclopyr (1.5 kg ha^{-1}), dicamba + 2,4-D amine (1.2 + 1.1 kg ha^{-1}), and 2,4-D amine kg ha^{-1} were applied in a randomized complete block design having four replications. Densities of chervil in the range of 0.6–1.2 m^{-2} were observed in each of the 10 m^{-2} plots. Results were variable, but 6 wk after application no significant difference was observed amongst treatments with respect to number of wild chervil plants or biomass. At the same site, a dose response experiment was conducted with five rates of dichlorprop/2,4-D (Estaprop 582): 1.188, 1.783, 2.375, 2.969 and 3.563 kg ha^{-1}. None of the dosages resulted in significant control of wild chervil. A further experiment in the same forage field examined herbicide effects on root budding and stand reduction. This consisted of 17 treatments in a randomized complete block design, having three replications. Treatments consisted of dichlorprop/2,4-D (2.38 kg ha^{-1}), clopyralid (0.3 kg ha^{-1}), dicamba (2.21 kg ha^{-1}), and mecoprop (1.30 kg ha^{-1}). Herbicides were applied when the majority of the plants in the community were at the following growth stages: vegetative, pre-bloom, full bloom, mow at pre-bloom and spray regrowth (approximately 3 wk). Results are summarized in Table 1.

Vidme (see Jakobsons 1975b) found NaCl (150–200 kg ha^{-1}) used on pastures early in the season would eliminate 95% of *A. sylvestris* without serious damage to grasses. In Nova Scotia, *A. sylvestris* grows abundantly and spreads along dykes exposed to relatively high levels of salt. Only a small proportion of the population, however, occurs beyond the outside toe of the dykes.

Heavy manure from natural bird colonies or grazing livestock results in luxuriant growth (Clapham 1953). Large supplements of nitrogen from liquid manure or livestock waste can promote prolific growth (Wagner 1967).

12. Response to other Human Manipulations

Standard European control practices have involved repeated cutting prior to seed set to reduce populations of *A. sylvestris* (Long and Percival 1910). The effectiveness of cutting, however, differed in various studies. Some studies have shown an increase in populations (Koblett 1979; Hansson 1994), population decrease (Grime et al. 1988; Parr and Way 1988; van Mierlo and van Groenendael 1991) or little significant effect (Hansson 1994; Hansson and Persson 1994). Cutting of adult vegetative plants prior to flowering reduced seedling recruitment, depleted tap root reserves, delayed flowering, extended plant life and decreased plant mortality (Hansson 1994). Cutting at flowering, however, induced production of side rosettes and stimulated flowering in other, more mature side rosettes. Total biomass was not affected by cutting in Hansson's study (Hansson 1994) because of a compensatory increase in nutrient allocation to side rosettes. Likewise, population increases observed in some cutting experiments may be due to increased side rosette formation as well as reduction of competition for some resources (Hansson and Persson 1994). Cutting may also stimulate side rosettes to flower in their second year, a reaction which is reinforced by high nitrogen levels (Hansson 1994). Multiple cutting (three to six times a year) may afford some control, at least in a short term of 3–4 yr.

Table 1. Response of wild chervil to herbicide application timed at various growth stages and cutting regimes

Treatment	Field Rate (kg a.i. ha⁻¹)	Growth Stage & cutting regime	Buds/plant	% reduction in plant density
Dichlorprop	2.34	Vegetative	0.57*abc*	69*bcd*
Clopyralid	0.30	Vegetative	0.96*abc*	50*d*
Dicamba	2.21	Vegetative	0.20*bc*	83*abc*
Mecoprop	1.30	Vegetative	0.58*abc*	93*ab*
Dichlorprop	2.34	Pre-bloom	0.19*bc*	88*ab*
Clopyralid	0.30	Pre-bloom	0.49*bc*	84*abc*
Dicamba	2.21	Pre-bloom	0.60*abc*	61*cd*
Mecoprop	1.30	Pre-bloom	0.47*bc*	77*abc*
Dichlorprop	2.34	Full bloom	1.33*abc*	77*abc*
Clopyralid	0.30	Full bloom	0.76*abc*	62*cd*
Dicamba	2.21	Full bloom	0.44*bc*	61*cd*
Mecoprop	1.30	Full bloom	0.056*c*	88*ab*
Dichlorprop	2.34	Mow pre-bloom, spray regrowth	1.02*abc*	78*abc*
Clopyralid	0.30	Mow pre-bloom, spray regrowth	0.67*abc*	90*ab*
Dicamba	2.21	Mow pre-bloom, spray regrowth	2.56*a*	89*ab*
Mecoprop	1.30	Mow pre-bloom, spray regrowth	1.40*abc*	96*a*
Control	–	–	2.17*ab*	-

a–c Means in the same column followed by the same letter are not significantly different ($P < 0.05$; least significant difference).

A 1997 mowing experiment at Brooklyn, Nova Scotia, was conducted at four different life stages to determine any timing effects on vegetative reproduction. The trial consisted of five treatments in a randomized complete block design, having three repetitions. Plant numbers were counted and recorded for each of the 10-m² plots. Plots were mowed using a gas-powered line cutter at a variety of growth stages, including vegetative, pre-bloom, full bloom, seed set and an unmowed control. Plots were examined on 12 September and no significant difference in root budding was observed for any of the treatments.

In Sweden, where cattle have been excluded from meadows, particularly for fall grazing, *A. sylvestris* populations have increased (Hansson and Persson 1994). Wagner (1967) suggests that grazing while plants are in a strong spring growth stage is advantageous. Spring grazing of young foliage in Nova Scotia has helped to decrease *A. sylvestris* populations.

Cutting of flowering plants early in the season, while the flowering stem is immature, results in the production of a secondary inflorescence from an axiallary bud of one of the old leaves, but if flowering stems are cut as they reach their maximum height, no secondary flowering stem is produced (van Mierlo and van Groenendael 1991).

13. Response to Parasites

(a) *Insects and other non-domestic animals* — No data are available for *A. sylvestris* in Canada; however, the larvae of a number of Lepidoptera have been reported feeding on *A. sylvestris* in Finland, including *Amphipyra tragopoginis*, *Autographa bractea*, *Diachrysia chrysitis*, *Odezia atrata*, *Perizoma didymatum* and *Xylena exsoleta* (Savela 1996). Two additional species, *Agonopterix heracliana* and *Depressaria sordidatela*, have been reported to feed on unidentified species of *Anthriscus* (Savela 1996). Carter and Hargreaves (1986) report *Idaema dimidiata* feeding on *A. sylvestris*, *A. cacaulis* and other herbaceous plants in Europe.

Three European aphid species are reported to be specific on *A. sylvestris*: *Dysaphis anthrisci* (alternates with *Malus domestica* (Borkh.) Borkh. [= *M. pumila* P. Miller] as the winter host), *D. hirsutissima* and *Aphis brohmeri* (Stroyan 1963; Heie 1986). In addition, *Dysaphis crataegi* is reported as rarely occurring on *A. sylvestris* (Stroyan 1963) and *Semiaphis anthrisci* is found on a number species of Apiaceae including *A. sylvestris* (Patch 1939). Cook and Davies (1994) reported the aphid *Myzus persicae* feeding on the petioles of *A. sylvestris* in Britain. This and four other polyphagous species (*Myzus certus*, *Aulacorthum circumflexum*, *Cavariella aegopodii* and *Hyadaphis foeniculi*) have been reported to occur on *Anthriscus cerefolium* in British Columbia (Forbes and Chan 1989).

Two species of nematodes (*Ottolenchus ranunculaceus* and *O. pratensis*) have been reported to occur on *A. sylvestris* in Russia (Sumenkova 1987).

(b) *Microorganisms and viruses* — Parsnip yellow fleck virus (PYFV) is a semi-persistent, aphid-transmitted, RNA virus (Murant 1974; Hemida and Murant 1989a) that occurs naturally in a number of species in the Apiaceae (Hemida and Murant 1989b) and in a few species in other families (Murant 1974). Known vectors of this virus are the polyphagous aphids *Cavariella aegopodii* and *C. pastinacae* (Murant 1974) and its transmission is dependent on the presence of the helper anthriscus yellows virus (AYV) in the vector (Murant and Goold 1968; Elnagar and Murant 1976). Two serotypes are reported, one attacking parsnip (*Pastinaca sativa* L.), celery (*Apium graveolans* var. *dulce* (P. Mill.) DC.) and cow parsnip (*Heracleum sphondylium*) and another attacking carrot (*Daucus carota* L.), coriander (*Coriandrum sativum* L.) and *A. sylvestris*. The primary range of the *Anthriscus* serotype is *Anthriscus* and *Coriandrum* (Hemida and Murant 1989b). van Dijk and Bos (1985) studied the cause and epidemiology of spring viral dieback of cultivated carrots in the Netherlands and identified the pathogen as the *Anthriscus* strain of PYFV transmitted by the aphid *C. aegopodii*.

Anthriscus yellows virus has been isolated from *A. sylvestris*, *A. cerefolium* and *Coriandrum sativum* by Murant and Goold (1968). It is a phloem-limited RNA virus, which is transmitted by the aphid *Cavariella aegopodii* in a semi-persistent manner.

The rust *Puccinia pimpinellae* (Str.) Röhling subsp. *pimpinellae* was collected by the senior author from material growing in Alymer, Quebec (specimens at DAOM). This rust has been reported on other Apiaceae, but not previously detected on *Anthriscus*.

(c) *Higher plant parasites* — None reported.

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