Literature review of the biology of *Clematis vitalba* (old man’s beard)

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## CONTENTS

Distribution .................................................. 3
Plant communities ............................................ 4
Taxonomy and nomenclature ................................... 4
Genetics .......................................................... 6
Floral morphology and anatomy ............................... 6
Sexual reproduction and seed morphology .................... 8
Germination ...................................................... 11
Vegetative morphology .......................................... 13
Plant anatomy .................................................... 14
Stem regeneration ................................................ 16
Biomass ............................................................ 17
Light requirements .............................................. 17
Nutrition ......................................................... 18
Pathology ........................................................ 19
Entomology ....................................................... 20
Chemical constituents and toxicology ....................... 21
Palaeoecology .................................................... 24
Uses of *Clematis vitalba* .................................... 24
Chemical control ................................................. 24
References ....................................................... 26
**DISTRIBUTION**

**Natural range**

*Clematis vitalba* is native to Europe. It has a wide natural range from the Netherlands south to North Africa and as far east as the Caucasus. In Britain it is native to Wales and England, from Denbigh, Stafford, and South Yorkshire southwards (Clapham et al., 1962). Fitter (1978) shows that *C. vitalba* is abundant in the south of England and from the north of France southwards. It is less frequent in northern Europe. *C. vitalba* grows in profusion in the forest of Yugoslavia and northern Greece (R.E. Brockie pers. comm.).

Sankey (1966) describes the natural distribution of *Clematis vitalba* as continental-southern, ranging as far as North Africa. Ellenberg (1974) classified *C. vitalba* as having an oceanic-suboceanic distribution covering the greater part of central Europe. The best correlation with *C. vitalba* distribution appears to be July mean temperature (Fitter 1978).

**Naturalised range**

*Clematis vitalba* is naturalised in Ireland (Fitter 1978, Clapham et al., 1962, Perring and Walters 1962); Scotland (Fitter 1978, Perring and Walters 1962); Poland (Boratynski 1974); Denmark (Hansen 1972); Oregon, North America (Chambers and Dennis 1973); North-eastern United States (Rudolf 1974); South Australia (Jessop 1983); and New Zealand (Allan 1940). Thus, *C. vitalba* has been introduced into countries bordering its natural range as well as those more distant.

In New Zealand *C. vitalba* is present from Puhoi (north of Auckland) to Stewart Island. The greatest concentrations are in Nelson, Marlborough, Wellington, Wanganui, and Manawatu regions. *C. vitalba* is absent from Northland, Coromandel, western Bay of Plenty, Taupo, East Cape, and Fiordland. Elsewhere there are isolated infestations, mainly along rivers (Atkinson 1984,
Keating and Challis 1985).

**PLANT COMMUNITIES**

Ellenberg (1974) places *Clematis vitalba* as a species which characteristically occurs in the Prunetalia association of the Querco-Fagetea class. In Holland, *C. vitalba* is a component of two vegetation types - tall herb vegetation and woodland and shrub associations (Runhaar et al. 1987). Jurko and Kontris (1984) have described a new forest community - *Clematidi vitalbae - culti - Pinetum nigrae*. This community comprises man-made stands of *Pinus nigra* with *Clematis vitalba* as an abundant physiognomic dominant. The stands are on limestone bedrock.

**TAXONOMY AND NOMENCLATURE**

*Clematis vitalba* is the lectotype of genus *Clematis* (Godley 1977), group Rectae, Section Vitalba (Fish 1970), tribe Clematidea, family Ranunculaceae, order Ranales (Hutchinson 1973). The Ranunculaceae is predominantly herbaceous but *Clematis* with soft wood and broad medullary rays is regarded as advanced (Hutchinson 1973). The genus comprises approximately 250 species of mainly temperate distribution (Willis 1973).

Fish (1970), states that *Clematis* is a rather heterogeneous group apparently containing several lines of development that represent reduction in different flower parts at different rates; *C. vitalba* has flowers with a greatly reduced number of relatively primitive carpels.

Using *Clematis vitalba* as a representative of Ranunculaceae Grund et al. (1981) determined that, based on amino acid sequences, there are strong relationships between Ranunculaceae, Rosaceae, and Fabaceae. Also, *Anemone nemorosa* and *C. vitalba* were more closely related than other members of the Ranunculaceae studied (i.e., *Aquilegia vulgaris*, *Consolida ajacis*, *Eranthis hyemalis*).
Several varieties of *C. vitalba* have been recorded: *C.v. var crenata* (Jord.) Rouy et Fouc (Koeva-Todorovska and Nenova 1980) from Bulgaria; *C.v. var timbali* (Lousley 1969) from near Thorley, England; *C.v. var syriaca* Boiss (Wichmann 1964) from Lebanon and Palestine; and *C.v. var integrata*. These varieties are not recognised in modern floras and they probably represent phenotypic responses to habitat (P.J. Garnock-Jones pers. comm.). Within New Zealand *C. vitalba* from the Clutha Valley looks consistently different from *C. vitalba* from elsewhere (pers. obs.).

According to Gilmour and Walters (1973) the classically correct (Greek root) pronunciation of *Clematis* is cleematis or claymatis: "Never, in any circumstances should it be pronounced clemaytis". The greek *klematis* means climbing plant (Collins English dictionary). The specific epithet *vitalba* means white vine, from the Latin *vitis* -vine, *alba* - white, and no doubt refers to the masses of white seeds which are prominent in winter.

*Clematis vitalba* has many common names. The standard common name in New Zealand is old man’s beard (Healy 1984) in reference to the silvery grey fruits (Bean n.d.). Traveller’s joy was a name invented by Gerard; who says this clematis is "esteemed for pleasure by reason of the goodly shadow and the pleasant sent or savour of its flowers. And because of its decking and adorning waies and hedges where people travel, thereupon have I named it Traveller’s joy" (Bean n.d.). Interestingly, an alternative derivation of this common name was proposed by a farmer south of Motueka: that a decoction of *C. vitalba* seeds taken before a long journey was known to prevent travel sickness (pers. comm.). This statement has not been confirmed from the literature.

Other common English names include virgin’s bower, mile-a-minute (for obvious reasons), European clematis, wild clematis (Mitchell 1975), hedge feathers (Fisk 1962), graybeard, crocodile, hag-rope, lovebird, birdwith, and willow wind (Sanecki 1974).

Grigson (1958) records 35 local names for *C. vitalba* within
England. The most widespread common names are old man's beard (14 counties) and honesty (10 counties). A group of common names - boy's bacca, gipsy's bacca, smoking cane, tom bacca, shepherds delight, and poor man's friend - have been derived from the practice of smoking cigar lengths of the stem. These cigars apparently draw well and do not burst into flame. Similar common names in German, French, and Dutch indicate that C.vitalba stems were smoked in these countries too.

The common names in France include clématide des haies (clematis of hedges) and herbe au gueux (beggar's plant). The latter name "originated from the use by beggars in Paris of the acrid juice of the plant to produce ulcerous wounds as a means of exciting pity" (Bean n.d.). In Germany, C.vitalba is known as die Waldrebe (literally - woodland vine). The Dutch name is bosrank (i.e., forest vine) and the Polish name is Powojnik pnacy (Boratynski 1974).

GENETICS

The chromosome number of C.vitalba is 2n = 16 (Clapham et al., 1962).

An investigation of successive 1 mm segments of C.vitalba roots revealed that in segment 1 (root tip) DNA content comprised equal proportions of 2C and 4C DNA (Olszewska and Osiecka 1984). 4C DNA progressively decreased and by segment 7, 2C DNA predominated. Within segment 1 the mitotic index was 6.5% (the highest recorded out of 30 species). However, the authors do not clarify what the broader significance of their results may be.

FLORAL MORPHOLOGY AND ANATOMY

The floral formula of C.vitalba is, in the standard format, K4 A∞ G∞. The calyx comprises four (sometimes five) free sepals, arranged spirally. The sepals are lanceolate, greenish-white in
colour, and are covered on both sides with short, soft hairs. There is no corolla. The androecium is hypogynous and comprises a large, but variable, number of spirally arranged stamens. The gynoecium is superior with a variable number of free carpels arranged spirally; ovary small, rounded, and unilocular surmounted by a slender style covered with white silky hairs; terminal 1 mm of style is stigmatic (James and Clapham 1935).

Variable numbers of carpels and stamens have been reported in the literature. James and Clapham (1935) record approximately 60 stamens and 15-35 carpels; Fish (1970) records 26 stamens and 12 carpels; Kennedy (1984) records approximately 50 stamens and approximately 30 carpels per flower.

C.vitalba has valvate sepals (Hutchinson 1955, Godley 1977).

Generally, within the Ranunculaceae nectar is produced from nectaries located at the base of the petals (Hickey and King 1981). C.vitalba is apetalous and therefore lacks nectaries. However, James and Clapham (1935) and Jones (1939) state that nectar is secreted from the filaments of the stamens. Jones (1939) illustrates drops of nectar exuding from the tissues of the filaments. Keener (1967) records that "nectar is secreted by certain hairs of the filaments" within Clematis subsection Integrifolia. Salisbury (1952) and Hutchinson (1955), on the other hand, state that the flowers of C.vitalba do not produce nectar.

The floral anatomy of C.vitalba has been investigated by Brouland (1936). The pedicels each contain six vascular bundles which then divide so that each of the four sepals receives three vascular traces. Each stamen has a single vascular trace and the vascular trace at the base of each carpel divides into a lateral and a median trace. The median trace extends into the style and the lateral trace supplies the basal fertile ovule. Brouland (1936) records that C.vitalba has four rudimentary ovules which are not vascularised.
pollen grains of *C.vitalba* are 20 µm long and are distinguished from other *Clematis* species by the furrow and the sculpturing of the outer two walls (Petrov and Borissova-Ivanova 1975). Roland and Roland (1968) and Roland (1971) have investigated the detailed structure of the ectexine, endexine, and intine of *C.vitalba* pollen.

James and Clapham (1935) state that the inflorescences of *C.vitalba* comprise "opposite pairs of cymes, dichasial below and monochasial above, in the axils of foliage leaves, with small bracts and bracteoles". Jones (1939) also states that the inflorescence of *C.vitalba* is cymose, in the axils of foliage leaves: "The main axis of the inflorescence ends in a flower, and in the axils of the two prophylls of this flower there arise one-branched monochasias". Other writers have erroneously described the inflorescences of *C.vitalba* as axillary panicles (e.g., Bean n.d., Hutchinson 1955, Mitchell 1975, Kennedy 1984).


**SEXUAL REPRODUCTION AND SEED MORPHOLOGY**

Insect pollination of *C.vitalba* has been recorded by James and Clapham (1935) who state that short-tongued bees and flies take pollen and lick the nectar from the stamen filaments, and by Clapham et al. (1962) who state that pollen-collecting bees and pollen-eating flies especially syrphids, visit the flowers.

Fertilisation of *C.vitalba* has not been documented but embryology is described by Fish (1970). The carpels of *C.vitalba* contain one basal, fertile ovule and 2-4 distal, sterile ovules. Development in the fertile ovule proceeds via a linear tetrad of megaspores derived initially from a subepidermal archesporial cell. The three micropylar megaspores degenerate and the
chalazal megaspore (embryo sac initial) proceeds to form an 8-nucleate embryo sac (3 mitotic divisions). The sterile ovules are ategmic and lack vascular tissue. Division of the megaspore mother cell to four nuclei is not followed by cytokinesis, resulting in a 4-nucleate coenomegaspore. The nuclei fuse in pairs, giving rise to a secondary 2-nucleate embryo sac with diploid nuclei (tetrasporic development). The nuclei divide by mitosis forming a secondary 4-nucleate embryo sac. Following this an 8-nucleate embryo sac is formed, with the egg apparatus at the micropylar end. These sterile ovules persist until after fertilisation of the functional ovule.

Souèges (1910) states that carpels of Clematis species contain one basal fertile ovule with usually five sterile ovules arranged vertically in the conical space at the base of the style. Brouland (1936) records that C.vitalba has four rudimentary ovules. Vesque (1878) describes early cell divisions in the fertile ovule.

The fruit of C.vitalba is an achene - "a small, dry, indehiscent, one-seeded, seed-like fruit or carpel in which the covering does not adhere to the seed" (Chute 1930). The ovary enlarges during and after flowering and the style lengthens considerably (James and Clapham 1935).

Berestets’ka (1984) found that two lines of evolution of the protective layers around the seeds have occurred in Clematis. In C.vitalba the thickness of each tissue layer in the pericarp and spermoderm has been reduced but the pericarp is lignified and protects the seed. (In the other line it is the spermoderm which is lignified).

The hairs on the style of C.vitalba lengthen as the fruit matures and when the fruit is dry the hairs project from the style at a wide angle (120° - van Gardingen 1986). In wet weather, the hairs lie parallel to the style (Paturi 1976). The hairs bend hygroscopically and this is possible because of a cell wall cushion, situated on the outer side of the hair base, which
exhibits a perpendicular orientation of cellulose fibrils (Sitte 1973). Cellulose fibrils are helically orientated in secondary walls of the style hairs; the direction of the textural helix reverses at irregular distances along the hair and the helical pattern is determined early in hair development, long before hair growth is completed (Sitte 1973).

These style hairs assist detachment from the parent plant as well as dissemination by wind, water, and animals. The fruits are used in the construction of many nests (Mitchell 1975, Atkinson 1984). Mark Ogle (pers. comm.) states that *C. vitalba* seeds were found in two sparrow’s nests in the attic of a house in Wanganui. Mark also looked at nests of blackbird, thrush, silvereye and grey warbler but did not find any *C. vitalba* seeds. Atkinson (1984) states that it is probable that *C. vitalba* seeds are dispersed by water. Wind-dispersal is well documented (James and Clapham 1935, Salisbury 1952, Sitte 1974, Paturi 1976, van Gardingen 1986).

As well as assisting dispersal, the style hairs also enable the fruit to lodge into a crack in the soil thereby enhancing the chances of successful germination. Paturi (1976) describes this process: "Having landed somewhere on the ground, the fruit begins to move, bending with the variations in atmospheric humidity. As its plumed end easily catches in the grass or in bumpy ground, the seed end then sweeps to and fro, combing the ground for a crack in which it can settle, and which will later afford it enough stability and moisture for growth. If the seed end is lodged and the feathery end is still caught somewhere, the alternating hydraulic movements cause the seed to turn on the spot. Its sharp end with the fine barb-bristles is thereby screwed like a drill into the ground and firmly secured". Paturi (1976) illustrates the hygroscopic movements of the awn with time-lapse photography.

Van Gardingen (1986) estimates that 17,650 viable seeds are produced for every 0.5 m² of *C. vitalba* canopy.
Rudolf (1974) states that seed dispersal usually occurs within one month after ripening. Fruits are brown when ripe. Rudolf gives fruit ripening dates as July to September in the north-eastern United States and as September to October in France. Lhotská (1974) records that in Czechoslovakia fruits of *C.vitalba* ripen from the end of September. In New Zealand fruits ripen from late April in Christchurch (van Gardingen 1986) or from mid March at Taihape (West 1986).

Wong Nam (1987) records the weight of one-year-old seeds as 2.58 mg per seed and of fresh seeds as 2.49 mg per seed. The fruits were collected from vines in March and the pericarps were removed before weighing.

**GERMINATION**

The seeds of *C.vitalba* (and other species) have dormant embryos and require pre-chilling (stratification) to stimulate germination (USDA 1948, Rudolf 1974). Pre-chilling has been done at 1-5°C in moist sand for 2-5 months. Field sowing responses of *C.vitalba* indicate that warm plus cold stratification may be required. Germination of untreated seeds was < 1% after 2 months (Rudolf 1974).

Lhotská (1974) illustrates the under-developed nature of the embryo of *C.vitalba* when fruits are first ripe. During the course of after-ripening on the parent vine the embryo grows. Seeds collected in mid winter took almost 2 months to germinate whereas those collected in spring germinated in less than one month. Thus, the winter-collected seeds continued after-ripening in the soil (Lhotská 1974). Germination of seeds was more rapid under alternating temperatures but final percentage germination was similar for seeds germinated under alternating (8-12/18-25°C) and constant cold temperatures (7-10°C). There was very little or no germination at temperatures of 20-22°C and 32°C (Lhotská 1974).
McClelland (1979) found that 83% of seeds germinated when kept in the dark. However, van Gardingen (1986) found that germination in total darkness was minimal but that when seeds were exposed to light for a short period germination increased significantly and was greater than in seeds exposed to 16 hours light per day. She concludes that there is a light requirement for germination of C.vitalba seeds and suggests that McClelland may have inadvertently exposed the seeds in his total darkness treatment to light while monitoring germination. Tucker (1979) determined that C.vitalba seeds germinated better under alternating temperatures. Ungerminated seeds transferred from constant to alternating temperatures did not germinate. The constant temperatures used by Tucker were similar to the warm temperature (20-22°C) of Lhotska (1974) in which very little germination was recorded. Kennedy (1984) provides a summary of Tucker’s results.

Grime et al. (1981) recorded 50% germination of C.vitalba after stratification at 5°C for 2 months. Also, van Gardingen (1986) determined that chilling significantly reduced the time to 50% germination and that increasing the period of chilling increased the germination rate. Van Gardingen (1986) found that seeds collected and stored dry in a paper bag still had high germination rates after 20 months. In contrast, seeds buried in the soil had 1.3% viability after 4 months and were completely inviable after 7 months. She used giberellic acid (GA₃) 10⁻⁴ M to break the dormancy of C.vitalba seeds but spraying seeds with a giberellin inhibitor had no effect on germination.

Wong Nam (1987) examined the effect of different types of litter on C.vitalba germination. Seedlings germinated from above or below totara (Podocarpus totara) litter grew significantly less than those from titoki (Alectryon excelsus), rewarewa (Knightia excelsa), pine (Pinus radiata), kahikatea (Dacrycarpus dacrydioides), mahoé (Melicytus ramiflorus), or rimu (Dacrydium cupressinum) litter treatments. Wong Nam (1987) found that seeds collected from vines after one year germinated and grew more rapidly than those from recently ripened fruits collected in
March. These results support those of Lhotská (1974). Total germination of one-year-old seeds was lower, however (Wong Nam 1987). In general, *C.vitalba* seeds were capable of germinating from above or below litter of a wide range of types - from the large, thick leaves of rewarewa to the fine litter of rimu or kahikatea. Emerging shoots of *C.vitalba* have a negative thigmotrophic response i.e., shoots grow parallel to obstacles until they can grow vertically. Roots of seedlings were capable of penetrating leaves and organic components of potting mix (Wong Nam 1987). Wong Nam suggests that thick layers of litter may act as a mulch, preventing germination of *C.vitalba* by moderating soil temperatures, attenuating light, and aggravating soil anaerobic conditions. In her experiments seeds germinated readily from beneath a 1.5 cm thick layer of litter. Wong Nam indicates that further experiments on the effect of litter depth would be profitable.

VEGETATIVE MORPHOLOGY

*Clematis vitalba* is a woody climber that can attain a considerable size and age - over 40 years (Salisbury 1952). The bark of mature stems is thick, grey, and stringy and the nodes where the opposite leaves arise are thickened (Mitchell 1975). The young stems are deeply ridged and furrowed longitudinally. They are dark purple and bright, pale green and are covered in small silky white hairs, especially near the apex.

*Clematis vitalba* is deciduous. Leaves of mature vines are opposite and comprise five leaflets which are variable in shape, usually rounded or sub-cordate at the base and generally ovate-acuminate (Clapham *et al* 1962, Mitchell 1975). Leaflets are entire or toothed. It often appears that leaves exposed to full sun are entire and those in the shade are toothed (pers. obs.) but many exceptions to this generalisation can be found.
Young leaves are covered in short, silky, white hairs which become more sparse as the leaves mature. On older leaves, sparse hairs can be found more commonly on the undersides, along veins (Mitchell 1975). Although *C. vitalba* is deciduous, it appears that the leaf blades drop off but the lignified petioles can remain attached to the branches for two seasons (Darwin 1865). *Clematis vitalba* is a petiole-climber (Schimper 1903). The petioles of the leaves bend in tight coils around anything of adequately small diameter. According to Mitchell (1975) the petioles seem to react only to a diameter which enables the coil to have three or four turns and, since the petioles are 8-10 cm long, this means that they bind to objects with diameters around 1 cm, including other stems from their own plant.

*C. vitalba* stems frequently hang like a curtain along the forest edge. The climbing front is at the top of the plant amongst the forest foliage. Thus, *C. vitalba* does not strangle its host, unlike many other climbers which are stem twiners e.g., supplejack (*Ripogonum scandens*).

As Salisbury (1952) states, the first-formed leaves of the seedling are simple. An illustration of the seedling of *C. vitalba* at the one-leaf stage is given in Muller (1978). Further aspects of seedling morphology are described in the second part of this report.

Illustrations of *C. vitalba* foliage etc. are given by Ross-Craig (1948) and Hutchinson (1955). Robinson (1985) illustrates *C. vitalba* stems and growth habit.

**PLANT ANATOMY**

Smith (1927, 1928) describes in detail the stem anatomy of *Clematis vitalba*. Basically, *C. vitalba* stems contain 12 vascular bundles. The stem is hexagonal in cross-section with the six larger bundles in the ridges and the six smaller bundles in the furrows. At the nodes the six leaf-trace strands run through two
internodes before losing their identity. The vascular arrangement of the root is diarch (Smith 1928).

Décamps (1974) describes the stomata of *C.vitalba* as typically Ranunculaceous and structurally simple.

Schnettker (1976) describes and illustrates shoot development (i.e., differentiation of the procambium) of *C.vitalba*. She also describes the nodal vascular system. Schnettker (1977) describes in detail the position of leaf-traces in the stem vascular system. Each leaf has three vascular strands. The leaf arrangement is decussate and the vascular strands alternate. Schnettker (1978) deals with the development of the vascular patterns in the root and hypocotyl-cotyledon region of *Clematis vitalba*.

Sieber and Kučera (1980) state that *C.vitalba*, like many other lianes, is characterised by two main features: the extraordinary water conducting capacity of the vascular system, and the flexibility of the stem. They also describe the characteristic hexagonal shape of the stem and how this is derived. The wood is ring-porous. Annual rings are narrow and indistinct except in fast growing individuals and the secondary xylem comprises rays (12.8%), ground tissue (axial parenchyma and fibres - 22.2%) and vessels (65.0%). The high percentage of vessels in *C.vitalba* together with a high transport velocity explains the extraordinary water-conducting capacity of the vascular system (Sieber and Kučera 1980). They state that the secondary rays are distinctly narrower and shorter than the primary rays.

Kučera and Bosshard (1981) illustrate the formation of a pith cavity in young stems of *C.vitalba*. They suggest that lysigenic degradation of the pith parenchyma may cause the cavity. They state that the aging process of the xylem appears to be due to a partial dehydration of the older vessels; neither tyloses nor heartwood formation could be found. Water content of the stem decreases with increasing stem diameter. Kučera and Bosshard
(1981) also noted black staining in the central portion of the stem which was related to fungal attack.

Kennedy (1984) records that growth rings are absent or indistinct. However, Sieber and Kučera (1980) state that the wood is ring porous and that the annual rings are narrow and indistinct except in fast-growing individuals. Kučera and Bosshard (1981) also refer to Jahrringen (annual rings) in *C. vitalba*. Tucker (1979) demonstrated that annual rings are produced by *C. vitalba* in New Zealand and that climate exerts an effect on ring width.

Van Gardingen (1986) illustrates sun and shade leaves of *C. vitalba*. Shade leaves are thinner and the palisade cells are shorter. In sun leaves the mesophyll cells are more tightly packed.

**STEM REGENERATION**

Smith (1927, 1928) states that roots arise from stem internodes rather than nodes. Adventitious roots originate from the fascicular cambium of the stem; the axis of the root initial follows a radius of the stem and growth proceeds through the medullary ray. Rooting can be induced at the node by etiolating (i.e., reducing the starch reserves) the stem (Smith 1928). McClelland (1979) suggested that stem fragments comprising only one node were too small to support bud development, and that stem volume probably determines the regenerative capacity of *C. vitalba*. Van Gardingen (1986) planted sections of young, woody stems with two nodes each in a sand/loam mixture but after eight months there was no regrowth - all stems were dead. Yet, stems of the same age when attached to a living plant produced roots and shoots freely from the nodes.
Markham (1939) states that if *C. vitalba* is "allowed to grow at will over trees it is capable of becoming fully 50ft high, and the great thongs which form the base of the twining growths will be as thick as a man's arm". Grigson (1958) comments that *C. vitalba* "can twist and choke trees to death, and turn a south-country copse into an Amazonian forest", and according to Fisk (1962), *Clematis vitalba* is "a vigorous climber covering up to thirty feet or more in a single season". All of these comments indicate that *C. vitalba* is capable of growing as vigorously in the south of England as it does in New Zealand.

On the other hand, Lousley (1969) has a photograph of the typical habit of *C. vitalba* in southern England showing only a small to moderate biomass. Pollard et al. (1974) state that *C. vitalba* is a characteristic hedge plant which "appreciates" a regular trim with a brushing hook or a cutter bar.

In England, *C. vitalba* can penetrate 6 m or occasionally over 9 m into the crowns of trees. Large plants can lie over and smother young trees and shrubs. In scrubland or hedgerows this is relatively unimportant but in young forestry plantations the physical blanketing of *C. vitalba* can be very serious (Mitchell 1975).

Tucker (1979), working in New Zealand, recorded a maximum biomass of 547.4 g/m² in early January at Pohangina Scenic Reserve. The total biomass was made up of old stems (50.0%), leaves (27.1%), new stems (16.5%), and roots (5.4%).

**LIGHT REQUIREMENTS**

Ellenberg (1974) describes *C. vitalba* as a half-light plant, mostly growing in full light but also in the shade. Walter (1979) states that *C. vitalba* occurs only in forest canopy gaps.
Thus, \textit{C. vitalba} seems to have a requirement for relatively high light levels.

Van Gardingen (1986) conducted a shading experiment and found that plants were not significantly affected by moderate levels of shading (45\% full light) but at lower light levels (14\% full light) total biomass was reduced. \textit{C. vitalba} has some ability to adapt to relatively low light conditions, by increasing leaf area, but would be limited to areas where light intensity is greater than 15-20\% full light.

In a series of physiological experiments, van Gardingen (1986) determined that \textit{C. vitalba} is a sun-adapted plant. It has a high light saturation value of 1500-200 \textmu mol m$^{-2}$ s$^{-1}$ for assimilation and for stomatal conductance. It responds strongly to increasing atmospheric dryness with stomatal closure. Stomatal opening of plants transferred from low to high light intensity took 20 minutes—a rate which is too slow to respond to brief sunflecks. Van Gardingen concludes that \textit{C. vitalba} is characteristic of a light-demanding plant with adaptations to minimise water loss.

**NUTRITION**

In England, \textit{Clematis vitalba} is limited to calcium-rich soils but on the Continent it is found in a much wider range of soils. Sankey (1966) describes \textit{C. vitalba} as a "physical calcicole" i.e., soil physical conditions adequate for successful growth are provided by calcium-rich soils and the influence of calcium carbonate is subordinate.

In New Zealand, attempts to correlate the distribution of \textit{C. vitalba} with calcium-rich soils have failed (P. Lawrence, pers. comm.). However, near Wellington, \textit{C. vitalba} grows well on the relatively fertile Western Hutt hills but on the infertile Eastern Hutt hills it is restricted to colluvial soils.
Ellenberg (1974) states that in central Europe *C. vitalba* is found on weakly acid to weakly basic soils but never on strongly acid soils. It usually grows on soils rich in mineral nitrogen. In Holland, Runhaar *et al.* (1987) indicate that *C. vitalba* grows on moist soils with moderate nutrient availability.

**PATHOLOGY**

**Fungal pathogens**

*Uredo puawhananga* commonly infests *Clematis vitalba*. It was first recorded by Baylis (1954) from specimens collected at Upper Hutt by Arthur Healy. *U. puawhananga* was originally identified on native species of *Clematis*.

Ridley (1988) isolated the loculoascomycete *Nodulosphaeria erythrospora* on *Clematis vitalba* growing in Wellington.

Semina and Beskaravainaya (1978) found that *C. vitalba* can pass on immunity to powdery mildew (*Erisyphe communis f. clematidies*) to subsequent generations. Wichmann (1964) reports *Ascochyta clematidina* (*Sphaeropsidales*) on *Clematis vitalba*. Two rust species which affect *C. vitalba* overseas are *Puccinia rubigo-vera*, in Italy, which is also pathogenic to wheat; and *Puccinia clematidis-secalis*, in France, which is also pathogenic to rye.

**Viral pathogens**

Bellardi *et al.* (1985) isolated tobacco streak virus (TSV) from *C. vitalba* in Italy. Infected plants showed yellow mosaic and vein-yelllowing symptoms. Rana *et al.* (1987) isolated a distinct strain of tobacco streak virus (TSV/Cle) from *C. vitalba* in Yugoslavia. Some plants were symptomless whereas others showed chlorotic spots or yellow netting of the leaves. TSV/Cle was seed transmitted (70%).

Specimens of *C. vitalba* collected in New Zealand, from Akaroa and
Rai Valley, have shown similar symptoms to those recorded above for tobacco streak virus. However, attempts to transmit the suspected virus to other plants (including some used by the above authors) have failed (A.D. Thomson pers. comm.).

**ENTOMOLOGY**

Gourlay (1954) records adults of Fuller’s rose weevil, *Pantomorus godmani*, on *Clematis vitalba* in Nelson in April 1953. The more recent name for this generalist weevil is *Asynonychus cervinus* (Spiller and Wise 1982).

Many insects have been recorded in association with *C.vitalba* (see Syrett 1984); many are host-specific. *Xylocleptes bispinus* is a stem-boring beetle which lives only in *Clematis vitalba*. The life history of this stem borer is described in detail by Wichmann (1964). Elmquist (1978) found larvae of the butterfly *Chloroclystis v-ata* on cultivated *C.vitalba* in Sweden. West (1980) records *C. vitalba* as a host of the moth *Sterrha vulpinaria* in Kent, England.

Buxton (1985) conducted a survey of insects associated with *Clematis vitalba* in England. Her study was undertaken to determine which insects could be effective biological control agents of *C.vitalba* in New Zealand. She suggests the following insects, in isolation or combined, may be suitable: *Horisme vitalbata* (Lepidoptera), *Melanthia procellata* (Lepidoptera), *Eupithecia haworthiata* (Lepidoptera), and *Xylocleptes bispinus* (Coleoptera). Buxton stresses that extensive host-specificity trials are required and that ecological relationships must be investigated before any of these insects are introduced into New Zealand (where there are eight native species of *Clematis*). Buxton states that "because *C.vitalba* is defined as a weed by virtue of its size, it is not necessary to completely eradicate the weed. Individuals can be allowed to survive providing growth is not sufficient to exclude light penetration to the native trees".
Horisme vitalbata and Melanthia procellata have leaf-eating larvae. These species are bivoltine (i.e., two generations per season) and the second generation, late in the growing season, is likely to reduce the long-term recovery potential of C.vitalba from earlier defoliation. Eupithecia haworthiata damages flowers. Xylocleptes bispinus is a stem-borer which preferentially invades the tissue of the nodes where it probably causes maximal disruption of nutrient and water transport.

Other insects which were associated with C.vitalba but did not appear to reduce the biomass to any extent were Hemistola chrysoprasaria (Lepidoptera), a defoliator; Phytomyza vitalbae (Diptera), a leaf-miner; Contarinia clematidis (Diptera), a gall former; and Eriophyes vitalbae (Eriophyiidae), a mite with unknown effect (Buxton 1985).

CHEMICAL CONSTITUENTS AND TOXICOLOGY

The most characteristic compound of the Ranunculaceae is ranunculin - a bitter, crystalline glycoside which is non-vesicant. Protoanemonin can be generated enzymatically (or by stem distillation) from ranunculin. Protoanemonin is a vesicant oil, volatile in steam, and has an acrid taste. Bruising of fresh plants liberates protoanemonin. This compound, the lactone of Y-hydroxylvinylacrylic acid, is the precursor of anemonin - a non-vesicant crystalline substance. Fresh plants of Clematis vitalba contain 0.27-0.91% of ranunculin. Ranunculin content may vary considerably within a species and this may be the result of genetic differentiation or of variations during development (Ruijgrok 1966).

Winter and Willeke (1951) showed that a maceration of C.vitalba leaves and roots had antibiotic effects on Escherichia coli, Staphylococcus aureus, and Bacillus subtilis. They determined that, on agar, the bacteriostatic effect extended 5-6 cm from the macerate, not by diffusion but by evaporation of the effective component and subsequent dissolution in agar. Winter & Willeke
found that an irreversible inactivation of the antibiotic from *C.vitalba* takes place and they suggest that protoanemonin is the active compound and that it degenerates, with time, to the inactive anemonin.

Protoanemonin is recorded as the toxin responsible for the death of grazing ruminants (Connor 1977). Moore (1971) records the death of a young cow as a result of poisoning by *C.vitalba*. However, Long (1917) reports that asses and goats can eat large quantities of this plant in the spring when it is less poisonous. Cattle have been observed to eat *C.vitalba* in the Rai valley, Marlborough, also in spring (pers. obs.). Taylor (1981) records that, in New Zealand, *C.vitalba* spreads into fields but is usually controlled by grazing animals "in spite of a burning taste".

Sanecki (1974) states that *C.vitalba* has diuretic and diaphoretic actions which are most potent when extracts are made from the leaves prior to flowering. *C.vitalba* was apparently used in Pliny’s time for cleaning leprous sores and has more recently been employed against psora and in scalp treatment.

According to Long (1917), when eaten in quantity, young shoots of *C.vitalba* are diurectic and violently purgative, causing dysentery, and, in rare cases, death. Applied to the exterior it is irritating and even vesicatory – see derivation of the common name "herbe aux gueux" (p. 6).

Bianchi *et al.* (1978) record the death of a human from pericardial perforation of a gastric ulcer consequent upon the presence of a large phytobezoar (23 x 11 x 9 cm) of *Clematis vitalba* (Other items in the man’s stomach were bits of plastic, sponge, cloth, paper, ribbons, broom corn, and a peach stone!).

Ulubelen (1970) recorded antitumor activity of *C.vitalba* and determined a number of compounds by chromatography. The compounds included sistosterol (= B-sistosterol and campestrol), chlorogenic acid, and caffeic acid.
Chirva et al. (1971) discovered free triterpenoids - hederagenin and oleanolic acid - and about 50% saponins in the roots of *Clematis vitalba*. They also discovered eight glycosides - vitalbosides A-H. Vitalbosides F-H contain the unusual monosaccharide ribose. Table 1, from Chirva et al. (1971), outlines the components of the vitalbosides. Kintya et al. (1974a) subsequently determined that vitalboside D is split, on acid hydrolysis, into glucose, arabinose, rhamnose, and ribose. Kintya et al. (1974a) give the structure of vitalboside D. Kintya et al. (1974b) illustrate the structure of vitalboside G and state that the sugars glucose, arabinose, ribose, and rhamnose are present in a ratio of c. 3:1:1:3.

Table 1. Vitalbosides of *C.vitalba* and their components

<table>
<thead>
<tr>
<th>Glycoside</th>
<th>Aglycone</th>
<th>Carbohydrate composition of the glycosides</th>
</tr>
</thead>
<tbody>
<tr>
<td>vitalboside</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>oleanolic acid</td>
<td>glucose,</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td>glucose, arabinose, rhamnose, (traces)</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>glucose, arabinose, rhamnose,</td>
</tr>
<tr>
<td>D</td>
<td>hederagenin</td>
<td>glucose, arabinose, rhamnose, ribose,</td>
</tr>
<tr>
<td>E</td>
<td></td>
<td>rhamnose</td>
</tr>
</tbody>
</table>

**PALAEOECOLOGY**

*C.vitalba* fruit have been recorded from the Hoxnian interglacial (mid-Pleistocene) at Clacton, Essex (Godwin 1975). Leaves of *C.vitalba*, probably from this interglacial period, have been collected at Stoke Newington, Middlesex (Reid 1899). There is a Flandrian record of *C.vitalba* charcoal dated at 6,300 B.P. from Oakhanger, Hampshire (Rankine et al. 1960). The charcoal was associated with Mesolithic artifacts. The authors state that *C.vitalba* "is a plant which might have considerable use to early
man, but it is not a plant of acid soils such as these. The nearest place where it could have grown is on the chalk about 3 miles distant".

USES OF CLEMATIS VITALBA

The "billoway mass" of seed heads produced in autumn is often used as decoration for harvest festivals in England (Fisk 1962). Also in England, pliable stems of C.vitalba are used for basket making.

Colville et al. (1979) have demonstrated that carbonised wood of C.vitalba provides an ideal matrix for bone regeneration in mammals. The wide vessels, characteristic of this species are the main attribute allowing bone regeneration.

CHEMICAL CONTROL

Ehlers (1965) found that C.vitalba was resistant to a mixture of amitrole and dalapon which suppressed most other weeds in conifer plantations. Fort (1975) reports that C.vitalba becomes a problem in vineyards where 2,4-D is used repeatedly but that it is controlled by aminotriazole. Harranger et al. (1964) found that C.vitalba growing in hedgerows was unaffected by either dormant shoot treatment or summer-green treatment with 2,4,5T and 10% fuel oil. However, Pécheur (1967) states that 2,4,5-T plus picloram controls C.vitalba in scrubby vegetation. He states that this vine is resistant to 2,4,5-T alone. Fryer and Makepeace (1978) state that 2,4,5-T as a foliar spray will control C.vitalba but that further applications may be necessary on larger vines. Wittering (1974) includes "Clematis" in a general list of climbers which might need to be controlled in forests in Britain.

In an Aglink produced by the Ministry of Agriculture and Fisheries, Popay (1986) outlines various methods of control.
Isolated plants can be removed manually or cut back and treated with 2,4,5-T in diesel. Larger infestations can be sprayed with Tordon 50-D, Tordon Brushkiller DS, Garlon 520, Versatill, or Roundup. Roundup is the only one of these chemicals that has no residual action in the soil. It is also the only chemical registered for use on C.vitalba. The usual technique for ground-based spraying is to cut all stems at a convenient height and spray the regrowth from the cut stems during the growing season.

Downard (1986) found that Tordon Brushkiller and Garlon 520 applied to vine bases in autumn were 100% effective. High volume autumn applications, covering all foliage, of Tordon Brushkiller, Versatill, and Roundup also had 100% kill rate. Aerial spraying in summer with Tordon Brushkiller (60-90% kill) and Versatill (30-80% kill) was less effective.

Van Gardingen (1986) investigated the effectiveness of wooden plugs soaked in herbicide and implanted in holes drilled in C.vitalba stems. Herbicides used were glyphosate (Roundup), dicamba, 2,4,5-T ester (Broadside), and 2,4,5-T/picloram (Tordon Brushkiller). Whereas 2,4,5-T had little effect on large vines, 2,4,5-T/picloram had killed vines completely after 3 days. Dicamba led to vine death over a period of two months and glyphosate seriously damaged the vines but they were not dead after two months.

Partly-cut stems of six-month and twelve-month old seedlings were treated with the same concentrated herbicides. Van Gardingen (1986) found that 2,4,5-T was the most effective herbicide. All seedlings were dead within 70 days. 2,4,5-T/picloram killed all of the younger seedlings but only 50% of the older ones. Dicamba and glyphosate killed only 50% of the younger seedlings and none of the older seedlings. All plants were adversely affected by these herbicides but many recovered. The symptoms displayed by the plants when treated with each herbicide are described in detail by van Gardingen (1986).
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