The biology and non-chemical control of Common Toadflax (*Linaria vulgaris* Mill.)

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Common Toadflax

(bride-weed, common linaria, flaxweed, yellow rod, yellow toadflax, wild snapdragon)
***Linaria vulgaris* Mill.**

Occurrence

Common toadflax is a native herbaceous perennial with a creeping rhizome according to Clapham *et al.* (1987) or persistent creeping roots according to Frankton & Mulligan (1970). It is common throughout Britain (Stace, 1997). Common toadflax occurs in hedgebanks, fields, waysides, woodland clearings and waste grassy places on dry, well-drained gravelly, sandy or chalky soils (Barker, 2001; Saner *et al.,* 1995). It often occurs at the road edge but is absent from the vegetation of the adjacent abandoned field (Dale *et al.,* 1965). In the UK, common toadflax is absent from meadows, pasture and wetlands (Grime *et al.,* 1988). In early surveys of Bedfordshire and Norfolk it was characteristic of chalky soils (Brenchley, 1913). Common toadflax was found as often among one crop as another but was rarely dominant (Brenchley, 1920). It has a good tolerance of heavy metal contamination. It thrives on nitrogen rich soils (Hanf, 1970).

Several subspecies have been described (Saner *et al.,* 1995). It has a variable growth habit depending on the soil type, shade level and grazing regime. It sometimes develops peloric flowers. Common toadflax can form hybrids with related species.

Common toadflax has a long tradition of medicinal use but is little used today (Barker, 2001). A yellow dye is extracted from the flowers (Morse & Palmer, 1925). The foliage is said to be toxic to stock but it rarely occurs in pasture in the UK (Grime *et al.,* 1988). In North America where common toadflax is a weed of pasture on the prairies, cattle usually avoid it but will eat it in a dried state (Saner *et al.,* 1995). It has been used to treat cattle that are unable to ruminate. Common toadflax leaves are said to have insecticidal properties.

Common toadflax is an overwintering host for the cucumber mosaic virus and the broad bean wilt virus.

Biology

Flower buds develop at the end of June and common toadflax flowers from July to October (Barker, 2001; Clapham *et al.,* 1987). The flowers are insect pollinated and self-incompatible so seed set can be unreliable (Grime *et al.,* 1988). However, a small proportion of seed can develop without cross-pollination (Saner *et al.,* 1995). Seed is produced from September onwards. There are 70 winged seeds in each ripe capsule. Seeds dehisce through pores in the seed capsule. Each flower head can produce 1,000 seeds. The average number of seeds per 9 stems is 2,280 (Stevens, 1932). The average seed number per plant is given as 8,700 (Hanf, 1970), 30,000 (Salisbury, 1961) and 31,500 (Stevens, 1957). The 1,000 seed weight is 0.14 g (Stevens, 1932).

Seed colour is variable from grey to black (Saner *et al.,* 1995). Darker seeds are heavier and more likely to be viable.

In Petri-dish tests of seed germination in the light and in darkness, there was around 67% germination in the light but none in the dark (Grime & Jarvis, 1976). In laboratory studies with dry-stored seed on moist paper or soil in the light, there was no germination at a constant 18-20^{o}C and only 5% at alternating temperatures of 20 to 30^{o}C or of 6 to 20 to 30^{o}C (Cross, 1930-33). Germination is promoted by chilling and alternating temperatures (Saner *et al.,* 1995). Germination is increased by a period of dry storage (Grime *et al.,* 1988).

Common toadflax seed can germinate when ripe but usually does so in spring (Saner & Müller-Schärer, 1994). There was no germination in the autumn after sowing in October of seed sown in a 75 mm layer of soil in open cylinders buried in the field and stirred at intervals, (Roberts, 1986). Emergence began in the following spring. The main periods of emergence were April-May and August to October. Seedlings never appeared in large numbers and flushes tended to follow cultivations. There was a gradual decrease in seedling emergence over the 5-year period of the study.

Seeds germinate shallowly 0-2 cm deep in soil (Hanf, 1970).

The roots of seedlings just 3 weeks old are able to develop adventitious root buds and can produce shoots if separated from the main plant (Nadeau *et al.,* 1992). The main shoot soon dies off or remains vegetative and numerous secondary shoots develop, all of which flower in the first year (Saner & Müller-Schärer, 1994). The adventitious flowering shoots develop on the taproot and lateral roots and by year 2 there may be 193 shoots spreading up to 46 cm from the parent plant (Salisbury, 1929). An extensive root system also develops during the 12 months after germination (Saner *et al.,* 1995). The main root may penetrate 1 m down into the soil (Saner & Müller-Schärer, 1994). Common toadflax regenerates from adventitious buds produced on the taproot and lateral creeping roots (Grime *et al.,* 1988; Saner *et al.,* 1995). It forms a web of superficial roots. The horizontal roots may be several metres long. The shoots are killed by frost but individual roots can live for at least 4 years and can withstand freezing to –15^{o}C. Plant shoots begin to make new growth in April.

Persistence and Spread

Seeds may persist in soil for several years (Grime *et al.,* 1988).

Common toadflax forms clonal patches but has a limited capacity to spread laterally by vegetative means (Grime *et al.,* 1988). Vegetative reproduction is possible from root fragments as short as 1 cm, and is common from 10 cm fragments (Saner *et al.,* 1995). Plants that develop from root fragments exhibit similar rates of shoot production in the first 12 weeks of growth to plants that develop from seedlings (Nadeau *et al.,* 1992).

Common toadflax has been spread as a contaminant of crop seed and in baled hay (Saner *et al.,* 1995). Seed may be dispersed by wind, water and ants. Despite being winged, 80% of seeds fall within 0.5 m of the parent and the rest within 2 m. The seeds are oily and can float for an extended period. Seeds have been recovered from

the crops of various birds. Seedlings have been raised from bird droppings (Salisbury, 1961).

Management

Control is by cutting, hoeing, pulling and removal of the creeping rootstocks during tillage (Long, 1938). Seedlings should be destroyed and as much as possible of the roots removed by spring cultivations (Morse & Palmer, 1925). Seedlings less than 2-3 weeks old are most susceptible to cultivations. Older plants should be hoed out to prevent seeding. Common toadflax is likely to be more of a problem under reduced tillage systems (Saner *et al.*, 1995). In a summer fallow, tillage should begin in June and be repeated at 3-4 week intervals. Cultivations should be shallow to avoid the spread of root fragments. Further cultivations should be made when the shoots have made 8-10 days regrowth. Sweep-type cultivators are recommended. It takes 2 years of cultivations to eliminate the weed, with 8-10 cultivations in year 1 and 4-5 in year 2. Mowing will prevent seeding but will not eliminate the weed..

Burning is not recommended for controlling common toadflax. It has a deep taproot and is thought to be tolerant to burning (Grime *et al.*, 1988). However, Saner *et al*, (1995) suggest that the superficial lateral root system is susceptible to root competition from other plants. Grasses will outcompete the weed in a properly managed grassland. Common toadflax is quickly able to colonize open sites where burning or overgrazing has reduced the other plants.

Seed production is reduced by plant competition (Saner *et al.*, 1995). Seeds also suffer predation by insects and this can have a drastic effect on seed numbers. The larvae of weevils of *Gymnetron* spp. develop inside the seed capsule while the adults feed on the buds, leaves and stem. The larvae of the sap beetle, *Brachypterolus pulicarius* L., develop inside the ovaries while the adults feed on the buds and young stem. Larvae of the moth, *Eupithecia linariata* Fabr., damage the flowers. Adults of the weevil, *Mecinus janthinus* Germ., feed on the shoots while the larvae burrow into the stem. The leaf feeding moth, *Calophasia lunula* Hufn., damages the foliage. Many of the insects have been introduced into North America as biocontrol agents for common toadflax.

Small root-mining moths, *Eteobalea* spp., overwinter as larvae on the roots and damage the plant throughout the growing season. Two species, *E. serratella and E. intermediella,* feed specifically on *Linaria* spp. and have similar behaviour but differ in the time of their main feeding periods (Saner & Müller-Schärer, 1994). The former has one generation per year and the latter has two. Eggs are laid at the base of the shoot and the emerging larvae burrow into the stem and move down into the root. They tunnel into the root cortex where most development takes place but the larvae return to the stem base to pupate. Both species overwinter as larvae. In pot studies root mining moths had little effect on plant survival. There was increased production of vegetative shoots after attack by *E. serratella* but seed production was reduced by 33%.

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