The biology and non-chemical control of Creeping Buttercup (*Ranunculus repens* L.)

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Creeping buttercup

(devil's guts, granny threads, ram's claws, sitfast, sitsicker, tether-toad)
***Ranunculus repens* L.**

Occurrence

Creeping buttercup is a native perennial weed common in damp meadows, pastures, gardens, lawns and waste places on a wide range of soils but mainly on wet, heavy land, moderately rich in nutrients (Clapham *et al.*, 1987; Long, 1938; Copson & Roberts, 1991). Climatic conditions do not limit the distribution of creeping buttercup. It is found throughout the UK and is recorded up to 3,400 ft (Stace, 1997; Salisbury, 1961). It has been found in prehistoric deposits. It can tolerate both waterlogging and moderate droughts (Lovett-Doust *et al.*, 1990; Harper, 1957). It can withstand compaction, trampling and disturbance, and is found in gateways and on paths even in woodland. In early surveys of Bedfordshire and Norfolk it was distributed on most soils but seldom found on chalk (Brenchley, 1913). On arable land it is commoner on neutral and clay soils, less so on acid soils (Harper, 1957). It is found on the peat of upland grassland but not on dry lowland peat. It is rarely found on chalk grassland except where the ground has been disturbed e.g. by rabbits. It can be particularly abundant on heavy garden soil.

Creeping buttercup is associated with heavily-grazed short swards (Gibson, 1996a). Buttercups are serious weeds of old pastures and hay meadows (Harper & Sagar, 1953). In a survey of seeds in pasture soils in the Netherlands in 1966, creeping buttercup was common in the sward and in the soil seedbank (Van Altena & Minderhoud, 1972). In damp meadows creeping buttercup forms large colonies on heavy soil (Harper, 1957). It increases with poor drainage, and in ridge and furrow pasture it often forms bands along the bottom of the furrows. It is an efficient pioneer species capable of rapid colonisation of areas disturbed by man such as gardens, building sites, dredged riverbanks, cleared ditches etc. Creeping buttercup is also an efficient colonist of disturbed arable habitats such as cornfields where it can establish and spread rapidly even in relatively dry conditions. It was relatively common in a survey of weeds in spring cereals in NE Scotland in 1985 (Simpson & Carnegie, 1989). In unsown set-aside land in Scotland, creeping buttercup was the second most frequently recorded species and constituted the highest ground cover (Fisher *et al.*, 1992). Creeping buttercup appeared to be discouraged by root crops (Brenchley, 1920).

Creeping buttercup is the most widely distributed of the common buttercups. A number of varieties have been described that differ in habit and flower colour (Harper, 1957). The plant is very plastic and its morphology and growth reflect the habitat (Lovett-Doust *et al.*, 1990). Stolon formation is linked to soil fertility. In close turf stolons are few, in open ground long stolons are produced for rapid colonisation (Harper, 1957).

It can cause diarrhoea if eaten by sheep and cattle but is normally avoided. Nevertheless it is sometimes browsed by stock, possibly due to the lower content of ranunculin than in other buttercups making it less unpalatable (Sarukhán & Harper, 1973). It normally has a creeping habit under intense grazing but makes erect growth when left ungrazed and it can then withstand competition from taller grasses in hay crops. Increased nitrogen promotes stolon branching and this affects the shoot:root ratio. It is also said to deplete the land of potassium and may have an allelopathic effect on neighbouring plants.

Biology

Creeping buttercup flowers from May to August and seeds freely (Long, 1938). The flowers are insect pollinated, some selfing occurs but flowers are predominantly cross pollinated. Only a few plants flower and then they only have 1-5 flowers. Flower heads contain 25-30 seeds (achenes) (Salisbury, 1961). A flowering shoot yields 140 seeds (Hanf, 1970). Average seed production is 687 seeds per plant. The seed number of an average plant is 227 (Pawlowski *et al.*, 1970).

Ripe seeds are highly dormant and may need an after-ripening period to break dormancy (Harris *et al.*, 1998). In laboratory studies diurnal fluctuations in temperature with an amplitude of $1^{o}C$ promoted germination in the light (Thompson *et al.*, 1977). Soil temperature and moisture level determine the level of emergence (Harris *et al.*, 1998). The time to the onset of emergence decreases with increasing temperature above a base temperature of $0^{o}C$. Germination normally occurs in late spring (April-May) but a few seeds germinate in the autumn if conditions are mild and wet, and odd seedlings emerge sporadically throughout the year (Harper & Sagar, 1953). Differences have been noted between the pattern of emergence of seeds from arable populations of creeping buttercup and those from wasteland (Harris *et al.*, 1998). Field emergence in plots cultivated at monthly, 3 monthly and yearly intervals or not at all extended from March to November (Chancellor, 1964). The main peaks of emergence were March to June and August to September. The least number of seedlings emerged from the uncultivated plots. Seed sown in a 75 mm layer of soil in cylinders sunk in the field and stirred periodically, emerged mainly from February to June and August to October but there was some emergence throughout the year (Roberts & Boddrell, 1985). Seed germinates at 5-30 mm depth in soil (Hanf, 1970).

Seedlings establish readily in open ground and often occur in patches or clumps. There may be rapid colonization of bare soil but seedlings are rare in grassland or other established vegetation (Lovett-Doust *et al.*, 1990; Lovett Doust, 1981a). Soil moisture level is important and it is the influence of the water table on germination and early seedling growth that determines the distribution of creeping buttercup along the furrow bottoms in ridge and furrow grassland (Harper & Sagar, 1953). Seedlings are frost tolerant (Salisbury, 1962b).

Creeping buttercup has a short swollen stem base, long stout adventitious roots and strong, leafy, epigeal stolons that root at the nodes. Daughter plants (ramets) form in the axils of the stolon leaves. Creeping buttercup overwinters as a small leafy rosette. In spring, new leaves develop and later the buds low down in the rosette grow out into strong, above ground runners that root at the nodes. These stolons begin to develop at or just before flowering in May to June. Stolon production goes on into late summer (Lovett-Doust *et al.*, 1990). The production of daughter rosettes continues through

July and August as the stolons extend (Lovett Doust, 1981a). The stolon internodes wither and rot in the autumn leaving the daughter rosettes as independent units. The process is accelerated if trampling by stock breaks up the plants (Sarukhán & Harper, 1973). The plants overwinter as a few leaves (Hill, 1977; Zimdahl, 1993).

Sometimes the plants do not flower in the first year or flowering is delayed until later in the year, up to October. The parent plant dies after flowering, the overwintering unit being the stolon-borne daughter plants that have developed roots and leaf rosettes but have not flowered (Clapham *et al.*, 1987). Over the winter, growth slows due to the cold but in a mild period growth may continue for a while (Harper, 1957). The main flush of growth is in June and July (Grime *et al.*, 1988). The density of rosettes reaches a peak in July and August that is twice the density in winter (Lovett Doust, 1981a). The annual mortality of rosettes ranges from 30 to 70% and the calculated time for a complete turnover of the rosette population is 3 to 16 years in open woodland and 2 to 10 years in grassland.

The number of leaves borne by a rosette varies throughout the season, reaching a maximum in June-July and falling to its lowest value in October-November (Lovett Doust, 1981b). But this may depend on the habitat. In a study of the plasticity of creeping buttercup, clones from different habitats in Ireland; marsh, ruderal and turlough (submerged from October to May), were grown under identical conditions (Lynn & Waldren, 2001). Leaf number peaked at end of May then declined from mid-June to mid July. Clones varied in leaf number. Leaf number determined the number of primary stolons that were formed. The peak of primary stolon formation was in mid-July, few were produced after this because of leaf die-back. The decline in the leaves of the mother rosette may be due to reserves going to the daughter plants on the stolons. The number of potential daughters depends on the branching of the stolons. Branching to produce secondary and tertiary stolons declined in low nitrogen conditions. Some plants spread widely others remained relatively compact, but there was considerable plasticity. Peak flowering occurred at end of May but some clones carried on into June. Only 20% of plants flowered and most of these had only 1 to 5 flowers. Those from ruderal habitats tended to flower most, possibly because seed production has greater benefits in disturbed habitats.

Persistence and Spread

Seed dormancy is enforced by burial leading to high populations of buried seeds in soil. Creeping buttercup forms large seedbanks in soil and seeds can remain viable for several years (Weber, 2003). Seeds have been recorded in enormous numbers in the soil beneath pastures even though the plant may be poorly represented in the vegetation (Chippindale & Milton, 1934; Champness & Morris, 1948). Creeping buttercup seed constituted 36% of the seedbank in a pasture ploughed after 22 years (Chancellor, 1978). Up to 12,000 seeds per m^2 to 15 cm depth have been recorded (Lovett-Doust *et al.*, 1990). The annual decay rate of seed in soil has been measured at 38% (Sarukhán, 1970). There is usually considerable persistence of creeping buttercup seed after cultivation of grassland (Harper, 1957). In Belgium, it was one of the main species that remained in the seedbank of a reclaimed heath that was under arable cropping since 1924 and under grassland from the 1960s (Stieperaere & Timmerman, 1983).

Thompson *et al.* (1993) suggest that based on seed characters, creeping buttercup seed should persist for longer than 5 years in soil. Seed longevity in soil is 5 to 7 years (Guyot *et al.,* 1962). Seed buried in mineral soil at 13, 26 or 39 cm depth and left undisturbed retained 51, 55 and 48% viability respectively after 20 years (Lewis, 1973). Seed buried in a peat soil at 26 cm for 20 years retained 17% viability. Seed recovered from excavations and dated at 80 years old was found to germinate (Ødum, 1974). Seeds survive 3 years of dry storage (Harper, 1957). Seed stored under granary conditions had 18% viability after 1 year but was not viable after 20 years storage.

In dry conditions creeping buttercup flowers and sets seeds, in wet conditions it tends to increase by stolons (Salisbury, 1962a). Creeping buttercup relies predominantly on vegetative reproduction to maintain established populations. Studies in grassland have shown seedling mortality to be greater than 60% while more than 80% of vegetative propagules survived (Sarukhán, 1970). Plants produce extensive stolons that root at the nodes (Long, 1938). In an open fertile habitat the stolons may grow up to 1.5 m in length (Grime *et al.,* 1988). The roots are long and stout. The stolons spread rapidly where the vegetation is opened up by poaching or puddling, mole activity and where grass has been killed (Harper, 1957). A large proportion of adult plants are replaced each year in late summer by new vegetative units (Sarukhán & Harper, 1973). While populations of creeping buttercup in grassland have a high turnover of individual rosettes, population density remains remarkably stable (Soane & Watkinson, 1979). Recruitment is mainly through establishment of new rosettes from rooted stolon nodes, rarely from seedling establishment. The life expectancy of a rosette is 1.2 to 2.1 years. Local dominance of a few clones is likely unless seedling establishment occurs occasionally to maintain some genetic diversity.

In a survey of weed seed contamination in cereal seed in drills ready for sowing on farm in spring 1970, creeping buttercup seed was found in 2% of samples (Tonkin & Phillipson, 1973). Most of this was home saved seed. In a survey of seed contamination of grass and clover seed in 1960-61, creeping buttercup was found in 4.3, 12.8 and 1.8% of perennial ryegrass seed samples tested of English, Irish and Danish origin and 2.2 and 15.3% of samples of Italian ryegrass of English and Irish origin respectively (Gooch, 1963). It was found in 2.3% of meadow fescue, 1.6% of red fescue and 4% of white clover seed samples of English origin tested. In clover and grass seed samples tested in Denmark for the period 1966-69, 1955-57, 1939 and 1927-28, creeping buttercup seed was a contaminant in 1.4, 4.2, 8.2 and 7.4% of samples respectively (Olesen & Jensen, 1969).

Most of the seeds fall around the parent but some are eaten by birds (Harper, 1957). Seeds are dispersed by the wind and in the droppings of birds and farm animals (Lovett-Doust *et al*., 1990). Seed has been found in cattle and horse droppings (Salisbury, 1961). Seeds eaten by earthworms have been recovered from worm cast soil (McRill, 1974). Seeds are also carried in mud on tyres and boots. Seedlings have been raised from the excreta of various birds. Viable seeds have been found in the droppings of house sparrows (Harper, 1957). Seed is eaten by partridge, pheasant and pigeon but is less likely to survive digestion in these birds. The seeds are also predated by voles and mice (Sarukhán, 1974). Some rodents carry off and store the seeds.

Management

Creeping buttercup is controlled by frequent and vigorous cultivations in hot weather (Long, 1938). Deep ploughing may kill plants if burial is deeper than 6 inches. The plants are able to survive and emerge from shallower depths. Destruction of a grass sward by ploughing provides conditions for rapid spread especially if a spring crop is sown that takes time to establish (Harper, 1957). Two fallow crops may be taken in succession to clean the land, and mustard can be sown as a smother crop (Morse & Palmer, 1925).

In grassland, small patches can be removed manually and repeated cutting may reduce plant vigour (Weber, 2003). Heavily grazed swards are characterised by the presence of certain weeds including creeping buttercup (Gibson, 1996b). Intense grazing prevents seed set (Lovett-Doust *et al*., 1990). Rosette density increases with grazing but not with mowing. Plants may be weakened by cultivation but can regenerate after damage. Loosened plants and runners should be gathered up to prevent re-rooting. In pasture, creeping buttercup increases under tight spring grazing by sheep and decreases under lenient grazing (NERC, 2006). Meadows should be well harrowed in spring to drag out the creeping runners (Morse & Palmer, 1925). A dressing of lime may help on sour land. If the buttercup is very abundant it is best to plough and thoroughly clean up the field using one or more root crops before putting down to grass again using pure seed.

In roadside verges, creeping buttercup frequency increases with cutting frequency but is particularly favoured by cutting twice a year (Parr & Way, 1988).

The plant is attacked by a number of grazing animals and pests including nematodes, thrips, aphids and various other insects (Harper, 1957; Lovett-Doust *et al*., 1990). Various fungi also occur on the plant. Seeds and leaves are eaten by partridges and pheasants. Seeds are also eaten by wood pigeons. Chickens and geese readily eat the leaves. Creeping buttercup tolerates rabbit grazing but growth may become more prostrate (Gillham, 1955).

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