# Capeweed: Effects and Management in Western Australia

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## Abstract

Capeweed (Arctotheca calendula) is a common weed of crops, pastures and rangelands across southern Australia. It is competitive with grain, legume and oilseed crops, although it has some value in pastures. Herbicide resistance and fast growth in the vegetative phase makes its management more difficult than that of some other broadleaf weeds. It can be partially managed by grazing, and this paper suggests that integrated grazing (livestock) and crop systems might offer a good control option while increasing the long term sustainability of whole farm agroecological systems.

## Background

Capeweed, also called Cape Dandelion (Letsela & Turner, 2002), is native to the Cape region of South Africa (Arnold, Ozanne, Galbraith, & Dandridge, 1985), but has become naturalised in many regions around the world, including California, New Zealand, and southern Australia ("Factsheet - Arctotheca calendula," 2015). Capeweed was first introduced into Australia in 1830 (Arnold et al., 1985). By 1900 it was widespread in pasture areas of southern Australia, and by the 1970s it accounted for around 30 - 50% of the pasture dry matter in grazing areas of Western Australia (Arnold et al., 1985). Between 1997 and 2008, it increased in frequency in south-west Western Australia by 7%, although it was not of increased concern to farmers over that period (Borger et al., 2012). It is currently present in all states and territories of Australia ("Factsheet - Arctotheca calendula," 2015), where it is regarded as an ecological and agricultural weed.

Although not as detrimental as some weeds affecting Western Australia, capeweed is of some significance for both crop and livestock production. Its impact is greater for crop production, and since the main agricultural enterprise of the ‘grain belt’ region of south-west Australia is winter rain-fed cereal and oilseed crops (Michael, Borger, MacLeod, & Payne, 2010), it is of some concern in that context. Capeweed competes effectively with cereal, oilseed, and leguminous crops, emerging before crops are sown and quickly growing large enough to compete for light as well as water and nutrients (Conning, Renton, Ryan, & Nichols, 2011). The small amounts of available summer rainfall in the grain belt region of Western Australia are sufficient for the growth of weeds such as capeweed, which then utilise water and nutrients that would normally be available to the sown winter crop (Michael et al., 2010). This effect is exacerbated by the changing climate, with a shift towards a drier growing season and more rain during the summer fallow (Michael et al., 2010). In Western Australia a wheat crop may have infestations of between seven and ninety capeweed plants per square metre, which can reduce wheat yield by up to 44% ("Section 6 Profiles of common weeds of cropping," 2014), causing significant losses to farmers.

Capeweed, like many summer weeds in the grain belt region of Western Australia, also acts as an alternate host for several insects and diseases. Capeweed is known to act as a host for a number of pests, including the light brown apple moth, as well as many other species of *Lepidoptera* ("Section 6 Profiles of common weeds of cropping," 2014). It also supports populations of blue green aphids (*Acyrthosiphon kondoi*), green peach aphid (*Myzus persicae*), red-legged earth mite (*Halotydeus destructor*), and cucumber mosaic virus, which is transmitted by aphids ("Section 6 Profiles of common weeds of cropping," 2014). The impact of capeweed on crop production is not merely that of its overt competition with crop plants for space and resources, but also its part in the ecological cycles of pests and pathogens of agriculture in Western Australia.

The impacts of capeweed on livestock production are mixed. Under some conditions, capeweed is implicated in nitrate or nitrite poisoning of livestock. This is most likely to occur when capeweed is growing in fertile soils, especially near stockyards or in areas where sheep or cattle are kept at high stocking rates, or after spraying with hormones or herbicides which increase nitrate content in the plants ("Section 6 Profiles of common weeds of cropping," 2014). On light or medium textured soils, such as those often found in poorer pastures in many regions of Western Australia, capeweed is unlikely to contain toxic levels of nitrate ("Section 6 Profiles of common weeds of cropping," 2014), and may be a valuable forage plant. In wet areas it is regarded as a weed because it competes with other, potentially more useful, pasture species ("Section 6 Profiles of common weeds of cropping," 2014). However, capeweed is palatable to livestock (Pethick & Chapman, 1991), and is as nutritious for sheep as subterranean clover (Arnold et al., 1985) or clover and grass pasture (Pethick & Chapman, 1991). Capeweed hay may be used in place of grass hays to provide roughage for grain-finished lambs with no detrimental effects (Ponnampalam et al., 2010). As capeweed is more drought resistant than many pasture species and in drier areas it can grow well during the summer and autumn periods when many pasture species are not active (Ward et al., 2013). Improving fodder supply from pasture during the summer and autumn period can have significant economic benefits to farmers. An increase of 20 kg dry matter per hectare can enable increases to the stocking rate worth about $200 per hectare in additional income for the farm (Ward et al., 2013). Broadly, capeweed may have positive and negative effects on pasture quality and stock production, depending on the context, circumstances, and management.

In overgrazed or poor pastures, capeweed is persistent and may become the dominant species ("Section 6 Profiles of common weeds of cropping," 2014). In part, this is due to the herbicide resistance which some capeweed populations have evolved. In Victoria, capeweed has become resistant to diquat and paraquat herbicides (Soar, Preston, Karotam, & Powles, 2004). Where capeweed has become the dominant species in a grassland, rangeland or pasture area, during part of the year there may be little or no ground cover vegetation due to capeweed's annual habit. This increases soil erosion and gullying in these areas, damaging the long term ecological health of the area. This damage to the agroecosystem is more significant to the long term resiliency and sustainability of the region than the short term economic damages imposed by capeweed's competitive tendencies.

Cropping regions and pastures are not the only ecosystems affected. In a similar manner, capeweed is of increasing concern in bushland and rangeland areas, as it competes effectively against native annual and ephemeral species. In arid rangeland areas of Australia, the plant communities are normally made up primarily of short-lived annual (ephemeral) native species which respond quickly to rainfall events (Waudby & Petit, 2015). In Western Australia, capeweed populations in these arid areas are increasing, displacing native species ("Factsheet - Arctotheca calendula," 2015). Due to its highly competitive nature and adaptation to Australian conditions, capeweed presents a not insignificant threat to the survival of threatened species such as Irwin's conostylis (*Conostylis dielsii* subsp. *teres*) and mountain villarsia (*Villarsia calthifolia*) in these arid areas ("Factsheet - Arctotheca calendula," 2015). In some ways, capeweed is a more serious ecological than agricultural weed.

## Management

Capeweed is a classic example of the negative effects of pest management strategies which rely solely on a limited range of herbicides, or misuse herbicides. Soar, Preston, Karotam and Powles (2004) noted that 23 consecutive years of annual or more frequent applications of paraquat and diquat herbicides had led to the development of paraquat resistance in capeweed. This is partly because of the cellular pathways that are activated in capeweed plants in response to paraquat-induced oxidative damage (Soar et al., 2004), and partly because of the growth habit of capeweed plants. At rosette stage, a capeweed plant may be as much as 600 mm in diameter, and plants of this size are difficult to control with herbicides ("Section 6 Profiles of common weeds of cropping," 2014). As with any organism exposed to a toxin at sub-lethal levels, exposing capeweed plants to herbicides which do not effectively control them can lead to resistance in the capeweed population. The long term use of a few classes of herbicide, and the use of inappropriate or marginally effective application levels, has given rise to widespread resistance in capeweed to some previously effective herbicides.

This is exacerbated by an extensive seed bank, and capeweed’s dormancy characteristics. A mature capeweed plant may produce several thousand seeds in a season, and these seeds are easily spread by environmental means, animal movement, and human activity ("Section 6 Profiles of common weeds of cropping," 2014). In addition, capeweed exhibits high levels of both primary and secondary dormancy, making it difficult to control with herbicide application. Seeds are usually dormant at maturity, with a dormant ripening period of around three months ("Section 6 Profiles of common weeds of cropping," 2014). Secondary dormancy is a combination of embryo and seed-coat based effects, and is overcome by high summer temperatures, leading to widespread autumn germination ("Section 6 Profiles of common weeds of cropping," 2014). Capeweed germination is favoured by ‘false breaks’, with early rains followed by a dry period, due to the structure of the seeds ("Section 6 Profiles of common weeds of cropping," 2014). There is also evidence of regional adaptation in capeweed populations towards long term dormancy, with 75% of seeds from the northern agricultural area of Western Australia germinating in the second season rather than the first ("Section 6 Profiles of common weeds of cropping," 2014). The high secondary dormancy behaviour of the seeds combined with the large number of seeds in the soil seed bank serve to reintroduce capeweed even if it is eradicated from an area during one season.

Using herbicides for control of capeweed is further complicated by the fact that capeweed is easily mistaken for other broadleaf weeds. Especially during the vegetative growth stage, capeweed may be confused with true dandelions (*Taraxacum officinale*) as well as other broadleaf weeds such as fleabane (*Conyza spp.*), prickly lettuce (*Lactuca serriola*) or sowthistle (*Sonchus oleraceus*) ("Section 6 Profiles of common weeds of cropping," 2014). Management strategies, and especially herbicides, which are effective for other broadleaf weed species may not be effective in controlling capeweed, or may have unintended side effects. For example, applications of herbicides or plant hormones may elevate nitrate levels in capeweed plants, which in a pasture situation can lead to nitrate poisoning of ruminant livestock ("Section 6 Profiles of common weeds of cropping," 2014).

In spite of issues with the use of some herbicides for capeweed control, the Grains Research and Development Corporation (GRDC) suggests several herbicides in its list of strategies for capeweed control along with non-chemical control methods. The GRDC lists the following strategies for consideration when developing an integrated management plan for capeweed: selected herbicides where crops are resistant (e.g. triazine, imidazolinone, glyphosate); inversion ploughing or fallow and pre-sowing cultivation to bury seeds; manuring, mulching and hay freezing; and active management through grazing, including rotational grazing ("Section 6 Profiles of common weeds of cropping," 2014). The GRDC also recommend a number of non-selective or knockdown and double knockdown herbicides for control of actively growing plants, and both pre-emergence and post-emergence herbicides for control of germinating or recently sprouted capeweed ("Section 6 Profiles of common weeds of cropping," 2014). Although a number of options for biological control have been identified, it is unlikely that they will be introduced due to capeweed's importance as a pasture species in some areas ("Section 6 Profiles of common weeds of cropping," 2014). The current recommendations for capeweed control focus on herbicides, with some additional options for cultivation and grazing.

The non-chemical control mechanisms noted above, and some others which are in use in the field, appear to be generally more useful than herbicide control for capeweed. Borger et al. (2012) commented that capeweed was primarily controlled in crop farming situations by pre-seeding and in-crop control tactics. Grazing has also been shown to be an effective control, although it is inadequate as a sole control mechanism during the summer fallow, and may increase soil erosion and compaction (Michael et al., 2010). The Tasmanian Department of Primary Industries, Parks, Water and Environment recommends heavy grazing in late winter and early spring to control capeweed, but recommends against heavy grazing in the summer and early autumn as the resulting bare earth can be easily colonised by capeweed ("Capeweed Control Guide," 2014). Pasture management is essential, especially in years where a dry period following early rains may favour early establishment of large capeweed populations.

Grazing as a management tool may not appear to be of significant use to crop farmers, but this is not the case. Many Australian farms are practising or have expressed an interest in integrated crop and livestock production as a risk mitigation exercise (Bell, Moore, & Kirkegaard, 2013), as well as increasing the overall resiliency of the farm system. As the awareness of the negative impacts of intensification and specialisation in agricultural systems has increased, there is a greater drive for farmers to modify their management practices to avoid issues such as increasing soil salinity, soil erosion, greenhouse gas emissions, and loss of biodiversity (Lemaire, Franzluebbers, Carvalho, & Dedieu, 2013). Practices such as crop rotation through an annual pasture phase with livestock, sacrificially grazing crops when grain yield or prices are low, or dual use of grain and canola (Brassica napus) for forage during the vegetative growth stage in addition to later harvesting for grain, and intercropping with lucerne or other leguminous or broadleaf pasture plants are increasingly common (Bell et al., 2013). Grazing may allow crop farmers to improve the overall resiliency of their farm ecosystems while mitigating the risks they face from unpredictable grain prices and a changing climate. It is also useful in the long term, as it is more difficult for plants to evolve resistance to being grazed as part of an integrated management system than it is to evolve herbicide resistance.

Intercropping, specifically, could provide a means of effectively controlling capeweed when combined with other control mechanisms. Herbicides could be held back for use only in necessity, and cultivation could be used where it would not increase the risk of soil erosion. Maintaining a summer pasture would decrease the opportunities for capeweed to colonise areas of bare earth, and capeweed could be managed as a productive part of that pasture. The use of deep-rooted perennial pasture species such as lucerne contributes to groundwater recharge (Li et al., 2008), decreasing the risk of soil salinity. Capeweed has been shown to prefer locations with a deeper water table (Bennett & Barrett-Lennard, 2013), like lucerne, which makes it potentially of similar benefit in an intercropped situation. Intercropping does reduce the both the grain yield and pasture yield as compared with monocultural production, but overall farm productivity is increased by up to 30%, equating to a median increase to whole farm economic return of 12% (Bell et al., 2013).

## CONCLUSION

There are several options for control of capeweed, including both chemical and non-chemical means. Current control mechanisms appear to be satisfactory to farmers, but as capeweed has a demonstrated propensity for evolving herbicide resistance it is important to consider non-chemical control mechanisms which may be effective. Both cultivation and grazing are recommended as part of a management strategy, especially since capeweed is of some value as a forage plant in pastures. As farmers move towards a more sustainable model for food production, it is plausible that an increase in crop and livestock integration will be seed in Western Australia; such a trend already exists in some areas. As such, grazing could play a much more significant role in capeweed management in the future, as part of an integrated management strategy, perhaps in the context of intercropping or rotational cropping and pasture. Such a move would be of benefit to the agroecological systems, and has potential to bring some economic benefits in addition to weed control.

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