Review

The biology of Australian weeds
57. *Sclerolaena birchii* (F.Muell.) Domin

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Name

Sclerolaena (Family: Chenopodiaceae) derives from two Greek words, *skleros*, hard and *hlaena*, overcoat, referring to the woody fruiting perianth wall in the genus; *birchii* acknowledges Mr C.W. de Burgh Birch who was first to collect the species (at Bowen Downs Station near Muttaburra, Queensland) (von Mueller 1874). The species name has two synonyms: *Anisacantha birchii* F.Muell. and *Bassia birchii* (F.Muell.) F.Muell.

The plant is widely known by the common name galvanised burr. However, it is also referred to as blue burr, Woolerino burr, Bassia burr, Hermidale lucerne and galvanised roly-poly.

Description

Sclerolaena birchii is a densely branched, native, perennial shrub up to 1 m high with stems clothed in a white tomentum (Figure 1). Leaves are alternate, obovate to oblanceolate, shortly petiolate, woolly on both surfaces; generally 4–7 mm wide and 12–18 mm long. Flowers are solitary, axillary, sessile and hermaphrodite. The perianth ('burr') is hypogynous, turbinate and shortly convex on its woolly summit, the narrow opening of the throat bordered by four irregular lobes, densely tomentose, hard when in fruit, obliquely attached to the stem at the base, with five acicular spines (± reflexed barbs), alternate with the perianth lobes. Two spines of similar length (1–3 mm) are proximal at the summit of the perianth and adjacent to, and generally obliquely parallel to, the stem. Three longer spines, usually of similar length (8–15 mm; sometimes one reduced to 2–3 mm), radiate divergently from an equatorial position, obliquely perpendicular to the stem.

There are four stamens, with flattened, translucent filaments and the yellow anthers are versatile. The style is short, persistent, with usually, three, white, setaceous stigmatic branches. The ovary is superior, monocarpellary and unilocular and the ovule is campylotropous. The fruit is enclosed in the perianth, compressed, ovoid, brown, vertical to obliquely vertical (Auld and Martin 1976, c.f. Harden 2000) (Figure 2). The pericarp and testa are membranous and the embryo is annular, green, with radicle and cotyledons erect; the perisperm is white, containing starch.

The species is sometimes confused with two other *Sclerolaena* species. It can be distinguished as follows: it differs from *S. convexula* (R.H.Anderson) A.J.Scott in leaf shape, and size and orientation of spines, while it differs from *S. muricata* var. *semiglabra* (Ising) A.J.Scott in leaf shape and the hairiness of adaxial surface.

Some apparent morphological differences between specimens of this species can be attributed to insect and mite attack. Symptoms similar to the well-known 'witches broom' condition in lucerne (*Medicago sativa* L.) caused by an eriophyid mite are also found in *S. birchii* over most of its range. They appear to be the result of attack by another eriophyid bud mite, *Aculops bassiae* Keifer (Auld and Martin 1976). On affected plants internode lengths are short, leaves are small and linear and flowers remain immature or absent.

Shoot tips are commonly attacked by an undescribed tunnelling lepidopterous larva (*Paratheta* (syn. *Mixodetis*) sp. Cosmopterigidae). The shoot tips become structurally weakened and eventually fall off. The effect of this pruning is quite dramatic: the removal of apical dominance produces a more complex branched plant than unattacked plants (Auld and Martin

Figure 1. Mature *Sclerolaena birchii* plant and close-up of flowering shoot.

1976). The insect was not found on plants on the southern extreme of the range of *S. birchii* in New South Wales (NSW) and this may account for the somewhat less compact shape of the species in this region.

A rare, spineless form of *S. birchii* was first collected near Ivanhoe on the south-western plains of NSW (32°54'S, 144°18'E) by Mr. Max Watson in 1970 (NSW 120365). It differs from normal *S. birchii* only in reduced development of the perianth. This form occupied an area of about 4 ha in 1973. Seeds from spineless plants produced fertile spineless plants (Auld and Martin 1976). A recent inspection (January 2010) of the area where the spineless plants were first discovered found no plants in the vicinity of the original spineless plants (M. Watson personal communication 2010).

History and distribution

The first collection of S. *birchii* from Bowen Downs station, at the northern extreme of the species range, was sent to Baron Ferdinand von Mueller in Melbourne in 1874. There are seven other records of the species in Queensland before it was first collected in NSW near Wee Waa in 1916, although it was often confused with some varieties of *S. muricata* (Moq.) Domin (syn. *Bassia quinquecuspis* (F.Muell.) F.Muell. (Anderson 1923, Auld 1974).

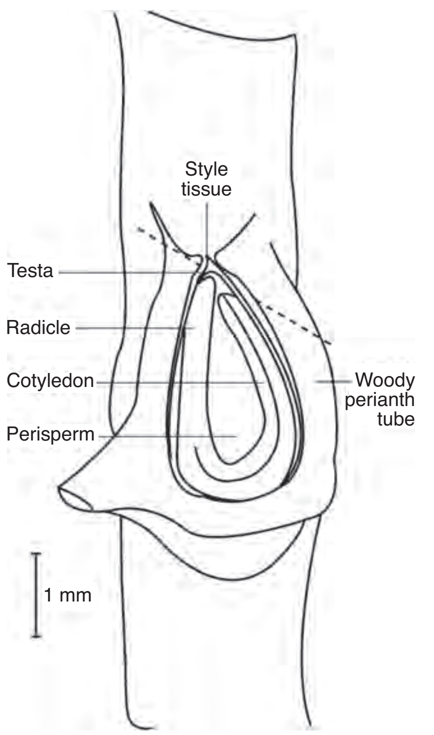

Figure 2. Position of seed in fruiting perianth of *Sclerolaena birchii*; tangential longitudinal section. Broken line indicates position of scalpel cut made to allow germination for experiments (after Auld 1976a, Figure 1).

The species had become troublesome by the mid-1920s. White (1925) stated that 'of recent years it has spread very much in western Queensland and New South Wales particularly along stock routes'. There is evidence that it was a problem in Queensland before NSW. A specimen of *S. birchii* from Wingen, NSW (NSW 79069) sent to the Government Botanist in Sydney in 1921, contains the following note on the herbarium sheet: 'Inspector Higgins (Inspector of Noxious Plants) says that the plant was known 20 years ago as "galvanised roly-poly" and is a bad one on the Goodooga, St. George and Castlereagh country and takes possession of any rich lands if allowed to grow'. Furthermore, *S. birchii* was included in Bailey's 'Weeds and Suspected Poisonous Plants of Queensland' in 1906.

The rise to prominence of the species in western NSW can be linked to overgrazing by sheep and drought (Auld 1983). The period from 1875 to 1891 saw vast expansion in sheep-raising in NSW when the sheep population more than doubled. The general effect of sheep grazing on vegetation was to reduce the diversity among plant formations. In woodlands, trees were removed or reduced in density over large areas and herbaceous vegetation was subjected to repeated trampling and grazing by relatively large numbers of animals (Moore 1962). After years of low rainfall from 1891, a drought persisted in western NSW from 1895 to 1903; sheep numbers fell by more than 50% from 1895 to 1900 in some counties in western areas (NSW Statistical Register 1901). F. Turner ('Botanist and Journalist') noted that an increase in wire grass and 'burr weeds' had taken place (Anon. 1901) and with further droughts from 1911–1916 and 1918–20 (Foley 1957), the prominence of *S. birchii* increased into the 1920s (Anderson 1926, Synott 1929) and 1930s (Anon. 1934, Blake 1935, 1937).

Dodd (1934) made the first study of the plant as a weed and conducted a mail questionnaire survey of Stock Inspectors in NSW and Land Rangers in Queensland to establish the range of the plant. A further mail questionnaire was conducted by the NSW Department of Agriculture and the Council for Scientific and Industrial Research (C.S.I.R.) in 1948 (Auld 1974). Beadle (1943) produced distribution maps of some species in his work over several years in western NSW. His map of *S. birchii* defined more constricted western and southern limits of the species' range, disagreeing with results from both mail questionnaire surveys, although he noted that *S. birchii* was very common in the north east of its range 'where it has become a noxious weed'. From 1970 to 1973, a more detailed ground survey was made in NSW by Auld (1974) (and was also reported in Auld and Martin 1976). The species appears to have extended the southern limit of its range in the last 50 years, but otherwise its distribution remains relatively stable. Generally, extensive populations of the species are limited to semi-arid areas of NSW and Queensland, with fewer specimens in eastern NSW, central Australia and south east South Australia (Figure 3), even though there are herbarium records

Figure 3. Distribution of *Sclerolaena birchii* (Australia's Virtual Herbarium 2010).

of the species from every mainland state (Australia's Virtual Herbarium 2010).

One reason for apparent conflicts between surveys is that although *S. birchii* is a perennial, it is generally short-lived (see below) and its populations have been observed to fluctuate widely (Everist and Moule 1952).

Habitat

Climatic and substratum requirements

Most infestations of the species occur between the 350 mm and 650 mm isohyets. The need for a fairly even seasonal spread of rainfall appears to limit its spread to the south and north. Low winter temperatures have restricted its easterly spread (Auld 1974).

The plant occurs on soils with gradational texture profiles (e.g. Gn 2.12, Gn 2.13 (Northcote 1960)) and duplex texture profiles (e.g. Dr 2.33) (Auld 1974). A characteristic common to nearly all infested soils is light surface texture (Auld 1974, Everist *et al.* 1976). The species is usually absent from grey and brown soils of heavy texture with uniform profiles; on these soils, the related *S. muricata* and *S. bicornis* Lindley are common (Auld 1974).

Plant associations

There is a broad correlation between the poplar box (*Eucalyptus populnea* F.Muell. ssp. *bimbil* L.A.S.Johnson & K.D.Hill) woodlands of Queensland and NSW and the distribution of *S. birchii* (Everist *et al.* 1976); these are the 'Western Peneplain Woodlands' in Keith (2004). The range of *S. birchii* also roughly corresponds to the semi-arid shrub woodlands of Moore and Perry (1970). Beadle (1948) noted that *S. birchii* was commonly found after overgrazing the *E. populnea – Callitris glaucophylla* Joy Thomps. & L.A.S.Johnson woodland association. Moreover, in the *E. populnea – Geijera – Eremophila* 'associes', *S. birchii* was 'common or even dominant' (Beadle 1948). Auld (1974) also found small areas of *S. birchii* in association with *Eucalyptus leptophylla* F.Muell. and *Acacia aneura* F.Muell. ex Benth. To the east of its range *S. birchii* often occurs on cleared land that had formerly carried stands of *Casuarina cristata* Miq., *Allocasuarina luehmannii* (R.T.Baker) L.A.S.Johnson and *Alectryon oleifolius* (Desf.) S.T.Reynolds. In the Hay area in NSW the species has invaded *Atriplex vesicaria* Heward ex Benth. shrub steppe (Leigh and Noble 1972).

Growth and development

Germination

Single seeds are tightly enclosed in a woody fruiting perianth which, in the field, weathers over time to expose the seeds to air and moisture. In the laboratory the woody fruit coat must be artificially pared away to conduct germination experiments (Auld 1974) (Figure 2). Seeds germinated over a range of temperatures tested from 10°C (16 h)/25°C (8 h) to 25°C (16 h)/35°C (8 h). There was no dormancy once the fruit coat was partially removed and seeds did not require light to germinate (Auld 1974, 1976a). In seedling emergence tests, seeds buried to 4 cm or deeper did not emerge; even if they germinated, the hypocotyl would not be long enough to reach the soil surface (Auld 1974). Germination and establishment can occur throughout the year in the field.

Growth and flowering

Following emergence, epigeal cotyledons reach their maximum development about a week after germination. At six weeks, plants are 2.0–4.5 cm high with 10–14 leaves. Flowers first develop at this time, regardless of day-length, but they do not grow to maturity (Auld 1976a). Axillary basal buds also first appear at six weeks. Subsequently, normal protogynous development of flowers occurs and self-pollination takes place. Shoot buds or flowers arise in groups of two or three in consecutive leaf axils. After 12 weeks the plant produces seeds within the spiny fruiting perianths from the first fertile flowers that appeared at eight weeks. Seed set continues throughout the year.

The plant develops a root system characterized by limited branching of some 6–8 radial roots that extend for about a metre to a depth of up to 60 cm. A single taproot exploits the higher moisture holding capacity of the clay subsoils (Auld 1976a) of the gradational and duplex texture profile soils that the species commonly occurs on (Figure 4).

Woody stems and roots develop asymmetrical radial growth and anomalous secondary thickening, with alternating bands of xylem and phloem (Auld 1974) common in the Chenopodiaceae. The phloem strands and vessels of this secondary tissue may anastomose both tangentially and radially. In stems, the inner phloem strands may remain active, protected by woody xylem, while outer tissues become dry during severe droughts. Thus nutrients may be supplied quickly to buds at the start of a growth period after a drought.

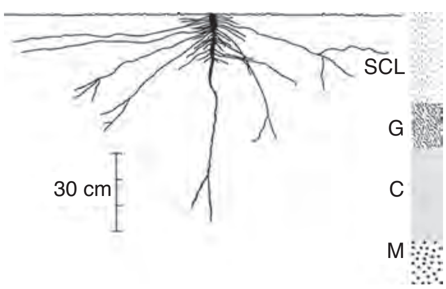

Figure 4. Root system of *Sclerolaena birchii* on a sandy clay loam (Gn 2.12; Northcote 1960) (after Auld 1976a, Figure 4). SCL = sandy clay loam, G = gravel, C = clay and M = mudstone.

Population dynamics

The species is often characterized by sudden increases in its population in various areas, often referred to as 'burr years'. An explanation for this can be found in the biology of its reproduction.

The woody fruiting perianths (hereafter 'burrs') do not detach from the woody stems on which they are borne. Thus pieces of broken stem with burrs attached are the plant's propagules. Stem fragments are commonly broken off by grazing sheep, attaching to wool and may be subsequently trampled into the soil. Prior to the introduction of sheep, the soft-footed, short-furred native marsupials would not have played such an important role in the species' demography.

Apart from detached stem pieces, the main driver in population growth of the species is the death of mature plants, each providing hundreds of seeds developed over a few years for dispersal at one time (Auld 1981). Again, sheep may play a role in breaking dead woody bushes by trampling and carrying fragments in their wool. Factors associated with plant death are discussed below.

Having been dispersed by wind, water and animals, burrs may remain on the soil surface or become buried. In field experiments, burrs on the soil surface weathered after a year, exposing the seed and allowing germination. Buried (2 cm) burrs began to break down after two years and maximum germination occurred after about four years (Auld 1981). These two treatments represent two phases that would occur *in vivo* for most burrs, that is, they are weathered to some extent on the soil surface after bushes break up before becoming buried in organic debris and topsoil. (Burrs that have been directly trampled upon may break down immediately.) In the topsoil, burrs undergo attack by fungal saprophytes (Auld 1974), a process that would not cease even if the soil was at permanent wilting point (Griffin 1963).

Adult plants are usually short-lived, with few surviving for more than four years (Auld 1981). In the field, the simultaneous death of populations of *S. birchii* was often observed. These deaths were usually associated with damage to the tap root of the plants caused by termites, insect larvae and/or fungi (Auld 1974). The alternate bands of xylem and phloem in the anomalous secondary thickening in the species provide food and shelter for insect larvae. This damage may occur over a long period without any clinical symptoms above ground, plants surviving provided sufficient moisture was available in the top soil for the shallower radial roots. However, once the topsoil becomes dry, large populations of plants die simultaneously. This provides a massive input of propagules at one time. As most of these burrs will break down at about the same rate, a massive population of seeds, without any dormancy mechanism, awaits in a labile state (Figure 5) for suitable rainfall to germinate and establish.

Given that most adult plants live less than four years, we could expect that 'burr years' may occur at 5–7 year intervals provided conditions for germination and establishment were favourable (Auld 1981). If seedling establishment fails we may expect several years to pass before large populations of the species build up again in that area (Figure 5).

Ironically some attempts to control *S. birchii* simply provide massive inputs of seeds into the soil by killing adult plants but leaving viable seed in the debris (see below).

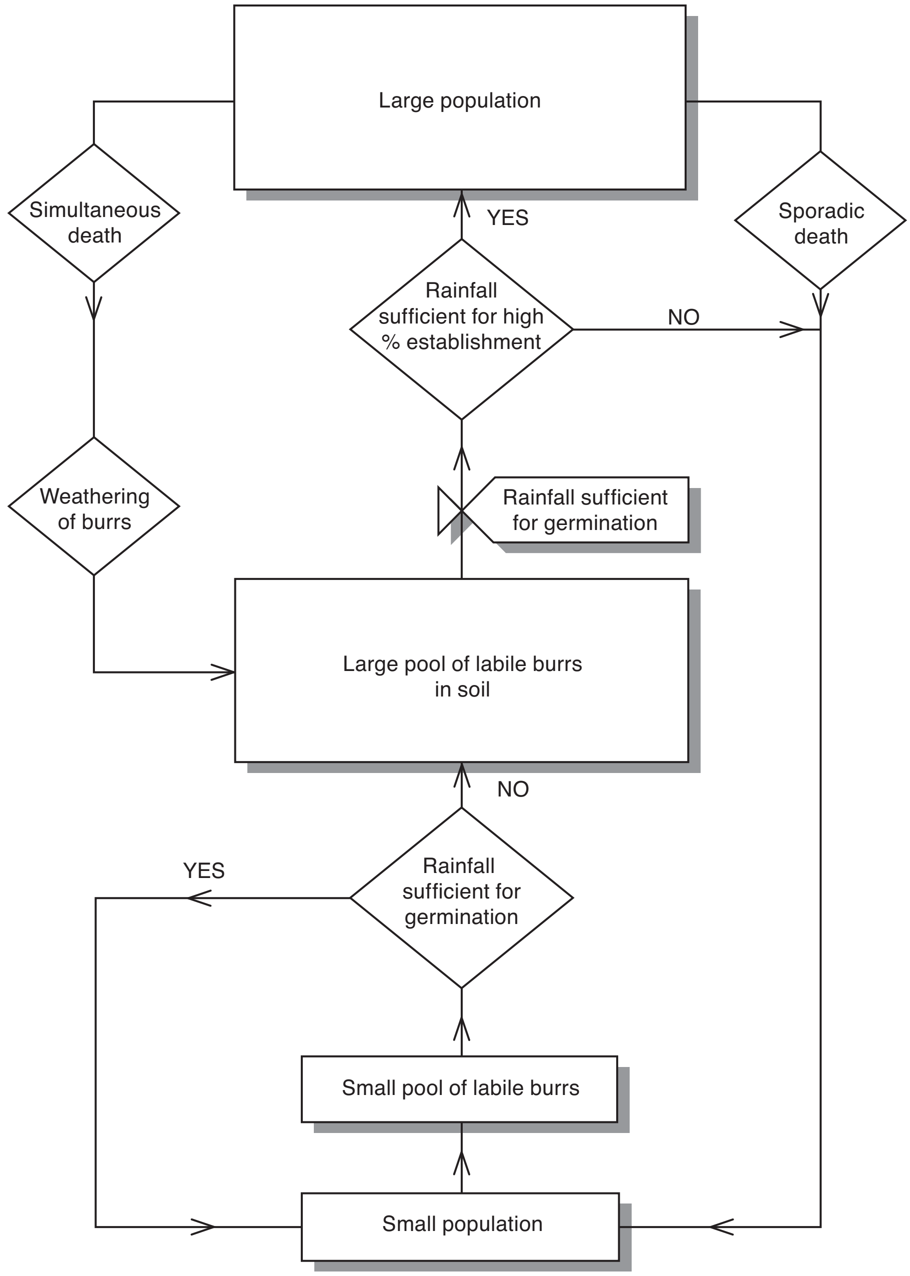

Figure 5. Model of population dynamics of *Sclerolaena birchii* (after Auld 1981, Figure 4).

Importance

Sclerolaena birchii is regarded as a weed because it is not usually eaten by stock and competes with useful herbage for resources. The spines on the burrs along its stems discourage grazing. Although the spines and burrs do not affect wool quality they are a considerable nuisance to shearers, stock and working dogs. Dense infestations also interfere with stock and machinery movement (Auld 1974).

It is difficult to estimate the economic cost of infestations because of the lack of data on the effect of *S. birchii* on production (Menz and Auld 1977). In many areas the species is symptomatic of overgrazing and degraded rangeland. In these instances *S. birchii* can perform a useful function by preventing complete denuding of ground cover and soil erosion. Shrubs collect wind-borne grass seeds and organic debris and serve as sites for recolonization, protecting seedlings from grazing (Figure 6).

Shoot tips that do not have spines and seedlings of *S. birchii* may also provide a food source in droughts. They contain 12–18% protein and have a comparatively high digestibility of about 46%, compared with 10% for the woody stems (Auld 1976b).

To the east of its range where sown pastures such as lucerne can be established, the net negative impacts of the species are more apparent and the case for control stronger.

Legislation

Sclerolaena birchii is a declared weed species only in parts of NSW and in South Australia.

New South Wales

Sclerolaena birchii is a class 4 weed in NSW under the *Noxious Weeds Act 1993* in 54 local government areas covering nearly all of the state west of the Great Dividing Range (Industry and Investment NSW 2010). A Class 4 weed poses a threat to primary production, the environment or human health, is widely distributed and is likely to spread. As a Class 4 species 'the plant must be controlled where it impacts on normal agricultural practices including cropping and pasture management'.

South Australia

This species is declared in South Australia under the *Natural Resources Management Act 2004*. Under this declaration, the presence of the species must be notified to the regional Natural Resource Management (NRM) Board. Control is not legally required.

Declaration of native species

Native Australian species are unlikely candidates for declaration (Johnson *et al.* 2009, Borger and Scott 2009) except where they are troublesome beyond their native range (for example Mullet 2009, Department of Environment and Climate Change NSW 2007). Two notable exceptions to this generalization are *S. birchii* and *Cassinia arcuata* R.Br. (sifton bush, Campbell *et al.* 1998, Industry and Investment NSW 2010).

One of the key criteria for the declaration of plant species is the presence of an externality, that is a cost being borne by an individual outside the decision-making

Figure 6. *Sclerolaena birchii* on degraded rangeland.

domain of that individual (Menz and Auld 1977). Explained in its simplest sense, if farmers fail to control weeds on their farms, then the risk of infestation increases to surrounding farms. In the case of native species, it is difficult to argue that there is a liability for allowing its spread onto land where it naturally occurs, whether presently or historically.

Further, in an ecological sense, many apparently weedy plants like *S. birchii* are early successional species, often symptomatic of overgrazed and degraded pasture or rangeland where they may have a useful role in recolonizing degraded rangeland. Public resources spent in enforcing control of this declared species may be better spent on pastoral redevelopment (Menz and Auld 1977).

Management

Eradication of *S. birchii* is neither practical nor appropriate. An examination of the benefits and costs of control can provide guidance in setting appropriate levels of control. This will differ markedly between regions (Menz and Auld 1977). In some degraded areas, *S. birchii* may provide a net economic benefit by acting as a pioneer species and preventing soil erosion. In these areas there is no need for control, although the reasons for rangeland degradation should be addressed.

In cultivated areas *S. birchii* is rarely a persistent problem as it can be controlled by cultivation, deep burial, chemical control of young plants and strategic grazing or combinations of these methods (see below).

Herbicides

Towards the eastern limits of its range, where it competes with pasture species, *S. birchii* can be controlled with herbicide treatment followed by burning dead plants. Mature seeds within the woody fruiting perianths have no vascular connection with the parent plant and are not usually affected by the herbicide when the plant is sprayed (Auld 1973). By the time the woody perianths from dead plants have broken down (i.e. after a minimum of a year) the activity of most selective herbicides has been depleted; 2,4-D for instance has a half-life of about four weeks. Therefore it is necessary to burn dead bushes to prevent seed dispersal. Deep burial (>4 cm) is another possible way to dispose of seeds. Herbicides recommended for control of *S. birchii* include 2,4-D amine, dicamba and dichlorprop (Ensbey and Johnson 2007), while 2,4-D ester and metsulfuron-methyl are also registered (Australian Pesticides and Veterinary Medicines Authority 2010). As the young plants form their first seeds at about 12 weeks, chemical control of seedlings is possible without the need for burning or burial, before they reach this age.

Other treatments

Grazing Although sheep will usually only graze the tips of adult plants, avoiding spines, grazing can be used to control seedlings after adult plants have been removed. Severe defoliation of seedlings more than six weeks old is required, as basal buds are formed at this time allowing recovery from light defoliation (Auld 1976b). Once plants are 12 weeks of age they have several spines and become less attractive to sheep. Since *S. birchii* may germinate at any time of the year, a system of strategic or rotational grazing is required to ensure reinvasion from buried seeds does not occur. A lucerne based pasture subdivided into a number of paddocks provides one means of doing this (Robards and Peart 1967, Auld 1976b).

Goats graze mature *S. birchii* more severely than sheep and have been used in attempts to control this and other woody species in semi-arid areas. It was thought that they may be able to be used in conjunction with sheep. However, although goats do not usually graze the valuable annual *Medicago* spp., much of their diet is the same as sheep and they compete for the same pasture species (Campbell *et al*. 1979).

Natural enemies

Natural enemies of this native plant vary in abundance from season to season and from place to place (Auld 1974). They include an eriophyid mite, a scale insect, several weevil and other insect larvae, termites including *Amitermes* sp., rust fungi, *Puccinia bassiae* Samuel and *Camarosporium* sp., as well as saprophytic fungi, including *Fusarium oxysporum* Schleet. ex Fr. Rarely does any single natural enemy cause mortality of adult plants directly. When adult plants do die it is often apparently due to a combination of factors, including damage to the crown and tap root and moisture stress (Auld 1974).

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