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Researching biological options for managing Bathurst burr on the Nullarbor
Bathurst burr (*Xanthium spinosum*)

Introduction

Bathurst burr (Asteraceae: *Xanthium spinosum* L.) is a significant weed on the Nullarbor and Eastern Goldfields rangelands of Western Australia. Significant funds have been expended to control Bathurst burr in this region in the past with no long-lasting impact. Bathurst burr first established itself this region in the early 20th century. It has since spread to low-lying, seasonally wet depressions (locally referred to as "dongas") and around stock yards. It is estimated that it currently effects 5,000 km^2 land in this area. Bathurst burr produces seed encased in burrs that readily attach to sheep's wool and other vectors. Wool infested with burrs must be separately treated to maintain fleece value.

The Goldfields Nullarbor Rangelands Biosecurity Association (GNRBA) and its earlier formats have been involved with biological control methods on weeds and vermin over many years. Recently, it has had success with biological control of various problem cacti in the Goldfields with results far exceeding initial expectations. These results have stimulated desire to research, and where possible implement, more biological control options for weeds (in this case Bathurst burr) and vermin that cause significant production losses and/or environmental damage.

Direct spraying or cultivation of weeds at a significant scale over vast areas of Nullarbor and Goldfields' rangelands is an uneconomical process and not a process likely to be widely effective or efficient for pastoralists. However biological control agents such as viruses, insects and fungi that are self-spreading or distributed by natural vectors such as animals, insects or wind have significant weed control potential provided no other species are impacted.

The history, incidence and recommended control strategies for Bathurst burr are well documented in all states of Australia from Queensland to Tasmania. All have fact sheets and similar information representing this weed's national significance.

What is Bathurst burr?

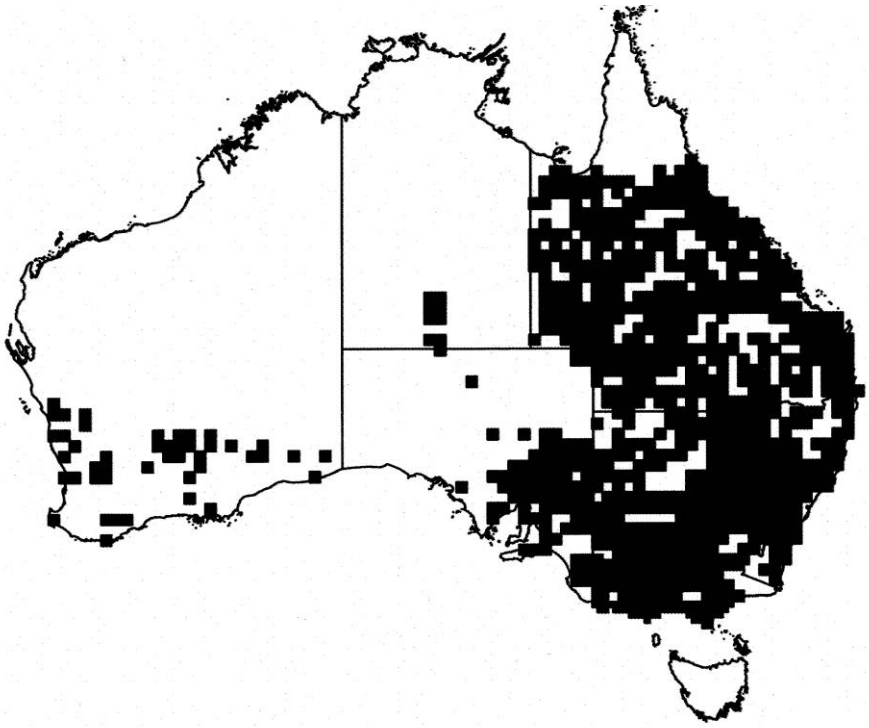
Bathurst burr (*Xanthium spinosum*) is an annual herb native to South America, arriving in Australia possibly in horse tails imported from Chile in the 1800's (DPIRD Farmnote 161). It became established near Bathurst in NSW in the early 1800's before spreading across the continent, including across seas to Tasmania.

The plant grows readily in disturbed ground of well drained soils of various fertility, especially along water courses and dams in all States and Territories of Australia (Cullen *et al.* 2012).

It belongs to Family Asteraceae (Queensland, New South Wales, the ACT, Victoria, Tasmania, Western Australia and the Northern Territory) or Compositae (South Australia). Common names include Bathurst burr, burrweed, burweed, cat's eggs, clotbur, cocklebur, common cockleburr, dagger, dagger cocklebur, dagger weed, daggerweed, prickly burrweed, Spanish thistle, spiny burweed, spiny clotbur, spiny cocklebur, spiny cockleburr, spring clotbur, thorny burweed (Cullen *et al.* 2012)

Each seed pod (burr) is covered in numerous straw-coloured hooked spines with two seeds inside. Generally, only one seed will germinate at a time while the other one will remain dormant for several years. In this way, the plant increases its chances of reproduction and negates one-off control applications such as spraying or cultivation.

Distribution and Habitat



Map 1. Distribution of Bathurst burr (Xanthium spinosum) in Australia. Map reproduced in *"Cullen et al 2012".* Map originally drawn by the Bureau of Rural Sciences using data presented in Thorp and Lynch (2000).

This species has spread widely in Australia, particularly in the eastern half occurring mostly in New South Wales, the ACT, Queensland, Victoria and south-eastern South Australia. However, it can also be found in the southern parts of the Northern Territory, other parts of South Australia and in southern Western Australia. Bathurst burr also grows in other parts of the world, including Europe, Africa, Temperate Asia, Papua New Guinea, New Zealand, North America and South America. Bathurst burr is a weed of pastures, crops, waterways, grasslands, open woodlands, floodplains, waste areas, roadsides, stock handling areas and disturbed sites in arid, temperate to tropical environments.

It is an annual, erect, multi branched, herbaceous plant usually growing to 30 to 120 cm tall. Stems are fiercely armed with yellowish three-pronged spines 15 to 50 mm long. Leaves are usually dark green with shiny upper surfaces and pale green lower surfaces covered in downy hairs. Male flowers occur as dense clusters near the tips of the stems, while separate female flowers occur in the leaf forks. Stalkless 'burrs' 8-15 mm long covered in numerous small hooked spines 2-3 mm long are produced annually.

The fruit 8-15 mm long and 4-6 mm wide are greenish when young, later becoming more straw-coloured, then brownish as they mature as oval-shaped 'burr' with two seeds. These 'burrs' are covered in numerous small hooked spines 2-3 mm long mostly formed during late summer and autumn. The brown or black seeds about 10 mm long are flattened. One of each pair is slightly larger than the other. Bathurst burr is very well adapted for dispersal by furry or woolly animals. They may also be spread by water and in contaminated agricultural produce.

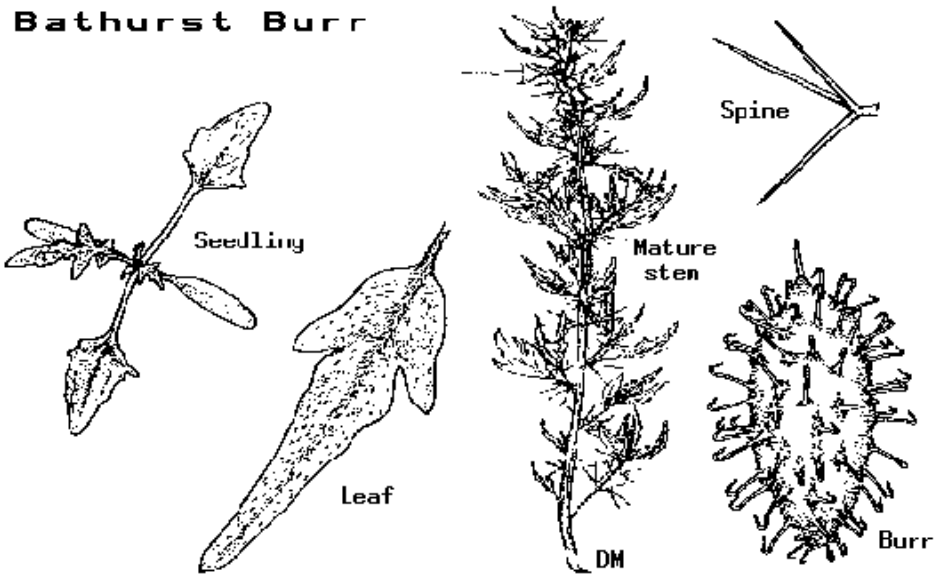


Figure 1 Diagrams of *Xanthium spinosum* L.
Acknowledgement HerbiGuide. 08 98444064 or www.herbiguide.com.au

Photography by R Knox. Image used with the permission of the Western Australian Herbarium, Department of Biodiversity, Conservation and Attractions (https://florabase.dpaw.wa.gov.au/help/copyright). Accessed on Wednesday, 5 February 2020.

The Problem

Bathurst burr is a declared weed in the ACT, NSW, NT, SA, Tas and Vic. In Western Australia it is a declared pest **s22(2)** under control categories C2 and C3. **C2** dictating that it is to be eradicated throughout the whole of the state, except for the Coolgardie and Kalgoorlie/Boulder local authority areas where it is declared as **C3** accepting that eradication in the short term is a challenge but must it be kept under 'control'. Bathurst burr is listed as an environmental weed in Queensland, NT, NSW, Victoria and SA.

The Nullarbor Bathurst burr (BB) problem most likely began in 1927 when the railroad was put through from the east coast of Australia to the west (Ross Wood pers comm). It probably came west in horse and cattle feed, possibly establishing itself first at Peppers Construction Camp at Rawlinna alongside the Trans line. It is unlikely that the weed spread far from there at that time, as there were no significant vectors present.

When Rawlinna station commenced pastoral operations in the 1960's, sheep became a vector to move BB seed around. It established particularly in low lying hollows prevalent in the Rawlinna landscape, known locally as dongas. Dongas collect runoff when it occurs, which can form pools approximately 1 metre deep. These dongas provided an ecosystem that suited BB growth and spread. The water also attracted sheep and rabbits that BB burrs could attach to for further spreading. Map 2 shows numerous "dongas" on the stations east of Kalgoorlie.

Spraying BB in dongas with non-selective herbicides wasn't particularly successful as BB was able to come back faster than the native vegetation. It was very competitive with other vegetation in the dongas.

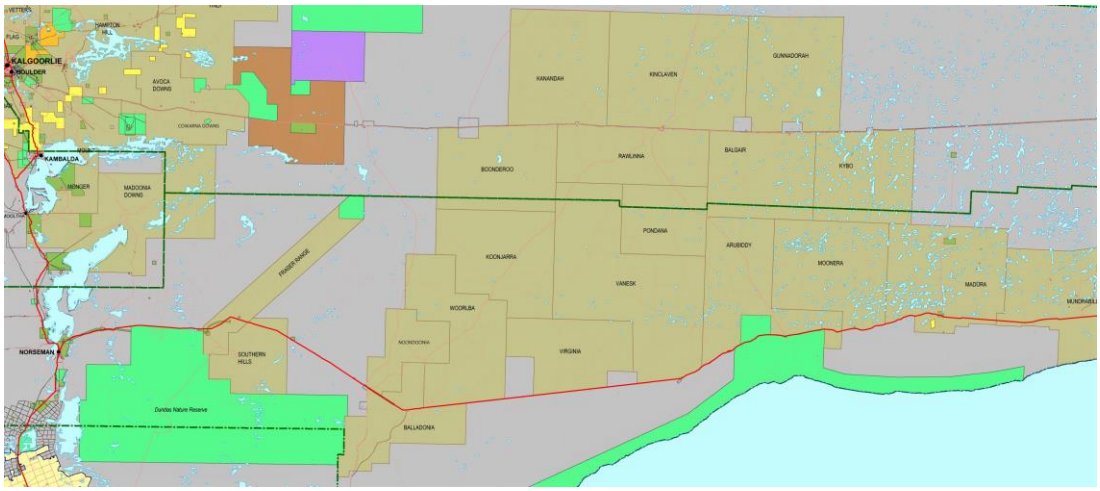
Sheep in yards dropped seed and therefore BB also established around yards although general control with sprays or mechanical means was more effective at these sites.

In the 1980's it was realised that BB had spread further than thought. From a perceived 50 sites it was estimated that more than 400 sites existed. It had become too expensive to control, although Rawlinna and Madura stations were spending up to $70,000 per year on BB control. These stations now only spray holding yards.

To prevent BB spreading from the Nullarbor, sheep were required to be shorn before departing. Although the problem is not now an issue for feedlots where spraying can control weeds or in woollen mills due to modern spinning processes that remove unwanted vegetable matter from wool. It was and still may be a problem for sheep that move to other stations.

BB is both an agricultural and environmental weed. It is at a minimum endemic on Rawlinna, Seemore Downs, Madura, Gunnadorah and Kanandah stations. It is particularly well established on Rawlinna. There is a perception that it may currently be at an equilibrium (Ross Wood pers comm).

Photo 2 A patch of Bathurst burr WA *anon WA Gov*



Map 2 Pastoral properties Eastern Goldfields Nullarbor Extract from "Department of Primary Industries and Regional Development" website

Recent success with Biological Control Options

The GNRBA, with the Department of Primary Industries and Regional Development (DPIRD), is continuing to trial the biological control of Coral cactus at Tarmoola Station with the Cochineal bug insect, with promising results. It is possible that a future cacti management model could be biological control of a central hub of a species of cactus, in conjunction with drone mapping to identify outlier infestations for direct chemical or mechanical control.

Additional biological control for other cactus species are underway in the rangelands, but at an earlier stage of development.

Summary of research on Biological Control Options for Bathurst burr

In 2012, CSIRO published a highly significant book directly applicable to this project titled "Biological Control of Weeds in Australia" (Cullen *et al.* 2012). [Two researchers Louise Morin of CSIRO Ecosystem Sciences and Professor Bruce of Charles Sturt University and DPI Orange contributed the chapter on Bathurst burr]. According to the above publication, prospects for the classical biocontrol of Bathurst burr were first examined in the 1930s. In the 1990's, surveys for potential control agents were conducted in the USA and South America. Australia appears to be the only country that has led such studies for Bathurst burr.

Insect Possibilities

In overseas surveys from 1936 to 1995, over 30 insect species were discovered with potential to attack Bathurst burr (Cullen *et al.* 2012). Only a tetranychid webbing mite was investigated further but found not to be sufficiently specific for biocontrol.

Of the other 30 or so species investigated, some such as Seed fly (*Euaresta bullans*) were reported to destroy large numbers of seeds however apparently had no impact on the abundance of plants. Three native stem borers were observed to attack and kill Bathurst burr with *Corrhenes paulla* observed to kill the most Bathurst burr in some situations.

Early researchers apparently concluded that none of the insect species were suitable as biocontrol agents. Of interest for this study is that the researchers Morin & Auld (Cullen *et al.* 2012) commented that stem-borer and stem-miner warrant further investigation. The potential to also attack non target species appears to have been, and may still be, the main reason that these insects will not be good biological control.

According to Andrew Reeves, DPIRD Priority Weed Response Manager, Bathurst burr occurs as groups of plants. This makes it not well suited to a seed weevil that requires large masses of seed (similar to grain storage masses) for them to have a real impact on plant populations. They rely on mass weevils working together which requires the large seed mass. He confirmed that the Bathurst burrs do contain a large seed with early germination and a smaller seed with a tough outer coating that provides dormancy. Bathurst burr is ideally suited to survival in the rangelands.

Fungi Possibilities

Three fungal pathogens including an anthracnose fungus, a leaf spot fungus *Cercospora xanthicola* and a powdery mildew *Golovinomyces cichoracearum*, were studied (Cullen *et al.* 2012).

Bathurst burr and three of eight sunflower cultivars tested with Argentinian isolates of the powdery mildew were heavily infected. The leaf spot fungus caused severe necrosis on Bathurst burr leaves but did not infect stems. Both caused lesions on lucerne and five sunflower cultivars. Hence these fungi were not investigated further as possible biocontrol agents due to lack of specificity.

In the 1980s–90s, isolates of the anthracnose fungus *Colletotrichum orbiculare* collected in semi-arid and arid areas of Argentina were found not to be superior, in terms of dew requirement for infection, to an Australian isolate of the same fungus. Anthracnose fungus naturally occurs on Bathurst burr in Australia.

Subsequently, a bioherbicide based on *Colletotrichum orbiculare* was developed. Despite initial optimism, commercial development of the potential bioherbicide did not go ahead (at that time) as the commercial interests calculated that production costs were prohibitive. The extent of spreading of the bioherbicide to plants not treated with the bioherbicide was not reported. A hope would be that each donga on the Nullarbor might only need a small infection at the right time for all Bathurst burr plants surrounding the donga /at the water's edge to be impacted. Such methods including bulking up the fungus in straw for distribution may be worth investigating.

Since 2012, there has been more work on *Colletotrichum orbiculare.* It was found that the active ingredient *Colletotrichum orbiculare* was an aggregate species that later work has shown contains the distinct species *Colletotrichum spinosum.*

According to Dr Stephen Johnson, Project Leader Commercialisation, Department of Primary Industries NSW (DPI NSW) of a bioherbicide based on *C. spinosum* is now well advanced (Dr Stephen Johnson pers comm). It is hoped that agreements with a likely commercial partner can be reached within early 2020.

That the bioherbicide works best when plants are wet was established by earlier work. Lack of moisture was retarding the efficacy of earlier bioherbicides, however work on various agents has reduced the impact of this major limitation (Dr Stephen Johnson pers comm). A tender to further the commercialisation process was imminent in February 2020. Dr Johnson is interested in trialling the new bioherbicide in WA, possibly as early as the 2020 / 2021 summer.

C. spinosum fungus, once applied to target Bathurst burr plants, will potentially spread to other Bathurst burr plant populations provided there is sufficient moisture. The fungus may persist in soil. Wind could spread fungus on/from infected dead plant parts to live Bathurst burr. The current situation appears to be an exciting opportunity for GNRBA.

Colletotrichum spinosum has been tested for impact on other species, mostly proving it is specific to Bathurst burr. Some eucalypts, wattles and safflower may be impacted but not killed. It is not known to impact any crop or pasture species, including lupins (*Lupinus angustifolius* cv. Uniharvest was tested in the late 1980's) (Dr Stephen Johnson pers comm). However, it may damage one old cultivar of safflower *Carthamus tinctorius* L.) cultivar 'Gila'. Further testing on *Acacia* and *Eucalyptus* spp., may be warranted as testing has showed some limited leaf damage in some of the few species tested (but not plant death). Work in the USA has shown that *Colletotrichum* spp. are quite specific to the plants they attack.

Specific permits/clearances are likely to be needed before a commercial bioherbicide could be released in WA.

Dr Johnson advised (some minor editing of original comments has been applied) that "*Colletotrichum and other pathogens require dew to cause disease and plant death (a common global constraint with respect to fungal bioherbicides). His team has identified, included in and now proven that an additive (made of common food grade materials) can overcome this constraint (this may well also apply to many other bioherbicides globally too which also makes it exciting). The additive is made by a research partner (who has placed the IP in the public domain) but whom we wish to continue to work with".*

The bioherbicide tends to be 100% effective (causes plant death) after 10-14 days on seedlings and small plants. Previous work suggests that mass (but not total) seed sterility is caused in larger plants. The pathogen used is a selected population of a naturally occurring organism (pathogen) found in NS. It is known to spread from where it was sprayed to some degree, and that is best under stormy and/or high humidity conditions (probably in Nullarbor region as a result of south spreading cyclonic fronts). This may apply to successive cohorts within a season dependent on later humidity once it has been applied, as the additive would probably only work initially; with the additive, can be sprayed under non-stormy or humid conditions and still work; will probably have to be applied more like a contact herbicide each season but can be applied through standard sprays/equipment.

The bioherbicide is almost certainly not toxic to people, animals and non-target species (we have found no evidence of that at least).

It is hoped that cost will be similar to other broadacre herbicides like 2,4-D or glyphosate ca. It can be manufactured in the laboratory and probably in giant fermenters (e.g. like they make vaccines and yeast and beer in) as this is essentially low cost and very common."

Discussion

This study has identified that there is at least 90 years of history of collecting and testing various insects and fungi to biologically control Bathurst burr. In 2012, the most significant summary of this history (Cullen *et al.* 2012) provided no specific biological control agent for Bathurst burr. However, in early 2020, an exciting development in NSW has come to light where current negotiations between researchers and commercial entities could result in a bioherbicide for Bathurst burr control becoming available. In the first instance, testing in the WA Rangelands in 2020 or 2021 is possible.

The significance of this development should not be underestimated, as there is a perception that agricultural research is littered with unfulfilled attempts to find biological control methods for pests. Although according to (McFadyen 2000) there are also numerous examples of success. Additionally, some have also spectacularly resulted in worse problems (e.g. cane toad) leading to cautions when dealing with possible biocontrol.

The comment by Morin & Auld (Cullen *et al.* 2012) that stem-borer and stem-miner warrant further investigation is worthy of further research.

Potential Actions

1. Actively pursue further involvement with Dr Johnson and DPI NSW bioherbicide project
2. Actively seek involvement in trials and application of the new bioherbicide
3. Identify and monitor Bathurst burr throughout the region
4. Further develop a GNRBA Bathurst burr management strategy
5. Communicate best practice Bathurst burr control for the rangelands
6. Encourage each pastoral station to further develop and apply best practice
7. Participate with DPIRD in any national Bathurst burr management strategies
8. Foster national Bathurst burr research

Conclusion

GNRBA should make every effort to work with Dr Stephen Johnson, NSW DPI and its commercial partner developing the bioherbicide based on *Colletotrichum spinosum*. By being involved in potential trials and discussions GNRBA will be well placed to take advantage of opportunities to biologically control Bathurst burr in the region.

Recommendations

1. Further assess the issue of Bathurst burr on the Goldfields Nullarbor Rangelands
2. Seek involvement in DPI NSW Bioherbicide project through Dr Johnson
3. Further develop management strategies locally and nationally

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List of Papers & Publications cited

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Cullen et al 2012 ebook "Biological Control of Weeds in Australia" CSIRO Publishing; March 2012
ISBN: 9780643104204 Author: Jim Cullen (ed.); Mic Julien (ed.); Rachel McFadyen (ed.)
https://ebooks.publish.csiro.au/content/biological-control-weeds-australia
Pages 601 – 608 *Xanthium spinosum* Louise Morin[1] and Bruce A. Auld[2]
1 CSIRO Ecosystem Sciences, GPO Box 1700, Canberra, ACT 2601, Australia
2 Charles Sturt University, Orange, NSW 2800 Australia

DPIRD Farmnote No 161 (Dept Primary Industry and Regional Development WA)
formerly Department of Agriculture & Fisheries)

List of researchers contacted/interviewed

Dr Stephen Johnson – DPI NSW

Mr Ross Wood – former manager Rawlinna Station

Professor Bruce Auld – DPI & Charles Sturt University, Orange

Dr Andrew Reeves - DPIRD Priority Weed Response Manager

Further information on the management of Bathurst burr:

Biosecurity Queensland Fact Sheet http://www.dpi.qld.gov.au

Northern Territory Department of Natural Resources, Environment and The Arts Agnote http://www.nt.gov.au/weeds

Western Australian Department of Agriculture and Food Farmnote on this species, http://www.agric.wa.gov.au

Tasmanian Department of Primary Industries and Water http://www.dpiw.tas.gov.au

Victorian Department of Primary Industries Landcare Note http://www.dpi.vic.gov.au

Flora Base Department of Parks and Wildlife WA https://florabase.dpaw.wa.gov.au

Common regional pests of Western Australia Department of Agriculture and Food, Western Australia. (2009) Bulletin 4771.