The threat of black knapweed (*Centaurea* x *moncktonii*) on the Northern Tablelands of NSW

Graham W. Charles[1], Kerinne Harvey[2] and Claire Lock[3]
[1]Weed Biosecurity Research, NSW Department of Primary Industries, Locked Bag 1000, Narrabri 2390, New South Wales, Australia
[2]Weed Biosecurity Research, NSW Department of Primary Industries, PMB 2, Grafton 2462, New South Wales, Australia
[3]Weed Biosecurity, NSW Department of Primary Industries, Wollongbar 2477, New South Wales, Australia
(graham.charles@dpi.nsw.gov.au)

Summary Black knapweed (*Centaurea* x *moncktonii*) is Prohibited Matter under the NSW *Biosecurity Act 2015*. It is a member of the Asteraceae family, in the genus *Centaurea*, and is closely related to some common weeds of Northern NSW, including Maltese cockspur (*Centaurea melitensis*) and St. Barnaby's thistle (*Centaurea solstitialis*). Plants in this family are known to be difficult to control with herbicides when treated as flowering plants. However, plants are hard to detect prior to flowering, making targeted control at this earlier growth stage very challenging to achieve. No infestations of black knapweed, also known as meadow knapweed, were known to exist in NSW, until a 150ha infestation was discovered on the Northern Tablelands of NSW in early 2019. The discovery followed several years of drought and at the time this weed was one of the few green plants in the infested paddocks and was being heavily grazed by cattle. Very high plant numbers were present in a 2 ha section of the infested area, with densities exceeding ten small plants m^{-2}, and most plants were present in just one paddock of approximately 74 ha. Interestingly, there is evidence that black knapweed had been deliberately introduced to the infected property over 100 years earlier. While there is no direct evidence that this introduction is related to the present infestation, investigations have not revealed any other likely source. Since the find in 2019, the most heavily infested paddock received a boom application of Grazon® Extra Herbicide and escapes have been managed with spot-spraying. Survey transects established prior to treatment in 2019 show there has been a large reduction in the black knapweed population over time, following treatment and heavy competition from other pasture species. This weed remains an eradication target and evaluation continues.

Keywords eradication, infestation, prohibited matter.

INTRODUCTION

Black knapweed (*Centaurea* x *moncktonii* C.E.Britton) is Prohibited Matter under the New South Wales *Biosecurity Act 2015*. It is a member of the Asteraceae family, in the genus *Centaurea*, and closely related to some common weeds of Northern NSW, including Maltese cockspur (*Centaurea melitensis*) and St. Barnaby's thistle (*Centaurea solstitialis*). Black knapweed, also known as meadow knapweed, is an invasive weed that can be problematic in pastures and sensitive ecosystems. It is a thornless, rhizomatous, perennial thistle and is considered a serious weed in many states of the United States of America.

Black knapweed is a fertile hybrid between two European knapweeds, *Centaurea nigra* and *Centaurea jacea* (brown knapweed), and can cross back with either parent species. The lineage of the black knapweed found at Tenterfield is unknown.

Black knapweed identification has in the past been confused with *C. nigra* in Australia. *C. nigra* doesn't occur in NSW, but populations have established in Victoria and South Australia. Some plants of brown knapweed have also been found in Victoria where it may have been introduced as an ornamental. Black knapweed can also itself hybridise with *C. solstitialis* (St. Barnaby's thistle), a thorned thistle and a common weed throughout much of eastern Australia (Roche and Susanna 2010).

A black knapweed plant at Tenterfield, 2019. Photo: Josh Biddle.

Black knapweed is not established in NSW, but plants have been found in Queensland, South

Australia, Victoria, and Tasmania (Anon 2022). Black knapweed is a widespread weed in Europe, New Zealand, and the US, so many potential pathways for infestation exist. Old reports indicate that black knapweed was introduced as a potential pasture species in the Tenterfield area of NSW in the late 1800s, and a herbarium specimen was collected from the area in 1903. Black knapweed had not been detected in NSW since that time.

Black knapweed at Tenterfield An infestation of black knapweed was discovered on a roadside near Tenterfield on the northern NSW Tablelands in March, 2019. Given that neither *C. nigra* nor *C. jacea* (the two parent species) occur in NSW, it is unlikely that the infestation resulted from hybridisation between the parent species, but is more likely from a direct introduction of *C.* x *moncktonii*.

Mature black knapweed plant at Tenterfield, 2019. Photo: Josh Biddle.

Surveys of the surrounding area detected a heavy infestation of black knapweed in an adjoining paddock, with additional plants detected along the road and in a few surrounding paddocks. The total infestation covered an area of around 150 ha. The core area of infestation was approximately 74 ha, with a very heavy population of knapweed along 2 ha of creek line, exceeding ten small plants m^{-2} in this area. Tenterfield was experiencing severe drought conditions at the time and the plants were easily seen as they were almost the only green in the paddock. They were being heavily grazed by cattle and few reproductive plants were obvious in the grazed area. Plants along the roadside were generally larger and more mature.

Characteristics of black knapweed from Tenterfield Seed heads were collected from the black knapweed plants at Tenterfield to test the seed viability, time to emergence etc. Viability testing under glasshouse conditions showed that most of the seed was not viable. Most of the seeds collected were small, white, and immature. Heads contained a small number of darker, apparently mature seeds. The first collection of seed heads contained 0.9 mature seeds per head. Just 16% of seeds germinated after planting, with emergence in 10 to 34 days. This test was repeated, with similar results from a second batch of seed heads. Viability was higher at 64% on an additional batch of seed heads, but the heads contained only 0.4 mature seeds per head. A further three plants (2%) emerged from these pots in the following year. Hence, it seems that the black knapweed from Tenterfield produces few viable seeds per head, which may have limited the spread of this weed. The seed number and viability were too poor to allow us to accurately assess the seedbank longevity of this weed.

There was concern that the cattle grazing in the infested paddock may have been ingesting knapweed seed heads and spreading the seed via their manure, particularly as knapweed was almost the only "pasture" plant alive in autumn 2019 in the infested paddock. Fresh manure from a series of cowpats was collected in autumn 2019 to test this possibility. Dry cow manure was added to the surface of 30 pots in a glasshouse, with 40 g of manure applied per pot. No knapweed seedlings emerged from the manure over a 59-day period, although 4.4 grass seedlings/pot and some other broadleaf seedlings did establish from the manure. This result is in line with the low viability of seed observed earlier and suggests that ongoing grazing of the infected paddock is not a major issue for the control of knapweed.

The main area of infestation was a heavily grazed paddock at Tenterfield, detected in the 2019 drought.

Controlling black knapweed Seed heads were removed from black knapweed plants on the roadside and from mature plants found in the paddock. Cattle were grazing the infested paddock at the time of the

initial discovery and this practice has been allowed to continue.

Information from the US indicates that black knapweed can be controlled using a range of herbicides, including: 2,4-D, clopyralid, dicamba, picloram, and glyphosate (Duncan *et al.* 2022). None of these herbicides is registered for controlling black knapweed in NSW, but we were able to use Grazon® Extra herbicide (300 g/L triclopyr + 100 g/L picloram + 8 g/L aminopyralid) under permit. Grazon Extra was applied by boom spray to the most heavily infested areas in April and May 2019, and escapes have been spot sprayed in the paddock and on the roadside.

To determine the effectiveness of treatment, we established ten permanent transects in the main paddock prior to treatment (Transects 1-10). The transects were each 10 m in length, and the groundcover of knapweed (cm presence) was recorded in each transect. A 30 m transect was also established at a tangent to the creek line (Transect 11). Groundcover was recorded rather than plant number, as this is a rhizomatous, perennial plant, where the presence of above-ground plant parts does not necessarily indicate individual plants, as multiple plant parts could arise from a single rhizome. An additional twelve transects were established on the fence line and roadside in October 2019 (Transects 12 – 23). Results are shown in Table 1.

Table 1. Percentage ground cover of knapweed over five observations. Values are averages and standard errors from sets of transects.

Date	T 1-10	T 11	T 12-23
17 April 2019	18.2%	23%	
s.e.	± 3.9%		
31 Oct 2019	0.8%	2.2%	1.7%
s.e.	± 0.5%		± 0.7%
25 Feb 2020	0.5%	0.2%	0.6%
s.e.	± 0.3%		± 0.7%
9 Jun 2020	0%	0%	0%
3 Dec 2020	0%	0%	0%

Results from the fixed transects indicate a rapid decline in knapweed density along fixed transects in response to boom applications and spot spraying of Grazon Extra Herbicide. Initial levels of knapweed presence occupied around 20% of the ground cover in April 2019, to no knapweed occurrence by December 2020 (Table 1). Heavy competition from perennially grasses was observed after the drought broke in early 2020 which likely contributed to the decline in knapweed presence.

No knapweed plants have been observed in the transects since June 2020, although occasional plants remain in the paddock. These plants continue to be treated by spot-spraying but are difficult to find in the tall and heavy grass sward, primarily African lovegrass (*Eragrostis curvula*), that established in the paddock following rain.

The main area of knapweed infestation covered by competitive perennial grass following rain (photo 26th February 2020).

Two knapweed flowerheads (center of photo) among tall perennial grasses demonstrate the difficulty in observing knapweed presence.

Future management for black knapweed at Tenterfield The aim of the current work at Tenterfield is to contain the infestation and over time to eradicate this weed. The initial program has proven to be successful, with few plants now apparent even in what were previously the most heavily infested areas.

An issue for the eradication program has been that small black knapweed plants are difficult to distinguish from many of the other broadleaf plants growing in the infected paddock. Plants can be distinguished by close examination, but this level of scrutiny is difficult to achieve in the very dense grass sward that has established post-drought and impractical to undertake on an area of over 100 ha.

Plants are readily identified by their flower heads once these become obvious through the grass sward, but mature seed may have already developed on these plants by the time they are detected, such that the weed seed bank is replenished, and the weed problem is perpetuated.

To ensure the success of the eradication program, the level of scrutiny and targeted treatment may need to be increased to ensure plants do not produce viable seed. This increased level of scrutiny may need to be maintained over the proof-of-freedom period, which will be a number of years after the last plant is found and destroyed.

A more technically challenging, but in the long-term, potentially cheaper, and more effective alternative for detecting and eradicating black knapweed might be the use of drones and robot sprayers that are able to identify black knapweed flowers (by drone) and target these plants for control (by robot). This option is becoming increasingly feasible with the development of robot and artificial intelligence (AI) technologies. A single person should be able to manage such a system, surveying the infected area several times a week and managing the robot/s with a minimal manpower requirement. The main cost of the approach would be the technology used, but this cost will decline with time and the approach should have great value for future weed eradication programs, should these occur. At Tenterfield, this approach may have to be augmented by some hand-spraying of areas such as the creek line where it may not be feasible for a robot to access.

This approach of using drones to locate knapweed plants would be particularly attractive during the years of the proof of freedom phase, when no active spraying would be required.

The black knapweed flower head appears to the human eye to be distinctively different to anything else in the infected areas and we anticipate that it would be easily distinguished by AI. The head is relatively large, around 2 cm in diameter and pinkish-purple in color. Flowering heads are present from spring through to autumn.

The flowers could be confused with other thistles, such as spear thistle (*Cirisium vulgare*) or variegated thistle (*Silybum marianum*). However, examples of these thistle have not been commonly observed in the infected areas, and their inadvertent inclusion in the initial eradication effect (should this happen), would be of minimal negative consequence.

Conclusion We consider that the current program to eradicate black knapweed from NSW is viable but will require a continuing investment in time and resources. Augmenting the eradication program with AI may be a better option for this weed and would be a biosecurity investment that could be invaluable for dealing with future prohibited matter events.

Black knapweed flower head.

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