

Taxonomy and nomenclature of invasive plants in a review of state-level weed policies and weed declarations

David A. Cooke, Tim Reynolds, Michaela Heinson and Julie Dean
Biosecurity SA, GPO Box 1671, Adelaide, SA 5001, Australia
(david.cooke@sa.gov.au)

Summary Accurate and usable nomenclature of invasive alien plants is necessary in natural resource management as weeds must be identified, delimited and risk assessed before management actions can be planned. Taxonomic studies of introduced plants depend firstly on knowledge of these plants in their native range, plus the additional complexities due to rapid changes since their entry to South Australia.

Questions that have arisen in our review of policies on plants declared under the South Australian *Natural Resources Management Act 2004* (NRM Act), and case studies on *Olea* Moench, *Eragrostis* Wolf, *Watsonia* Mill. and *Gazania* Gaertn., illustrate these points.

Keywords Nomenclature, legislation, species.

INTRODUCTION

When a weed is to be declared under legislation, a decision must be made on the scientific nomenclature to circumscribe the weedy taxon precisely. For example, the weed may be a subset of a species that also includes a valuable crop plant, as in the case of feral olives (*Olea europaea* L.) and wild artichokes (*Cynara cardunculus* L.). Even the despised Lincoln weed (*Diplotaxis tenuifolia* (L.) DC.) is conspecific with a trendy salad vegetable, wild rocket.

Plants are not discrete individuals, since each has organic continuity with its ancestors and siblings. Nor do species, genera and other taxa exist objectively as irreducible entities. They are more like working hypotheses, useful divisions of the diversity that exists within biota. It is not surprising that taxonomists continue to have differing opinions on the division of genera into species, or division at other levels.

The boundaries drawn between taxa may depend on the purpose of the classification. If this purpose is defining the legal status of particular weeds, the boundaries must be unambiguous, readily understood by stakeholders, and defensible in the event of challenge.

A species is the lowest level taxon that can be called stable in that it is not liable to vanish within a few generations through gene flow. It is a solution to the problems posed by its niche and environment, so natural selection has given it some degree of reproductive isolation.

There is no guarantee that a morphological species, based only on herbarium specimens with a distinctive appearance in common, has such stability. Nor is there any more guarantee of the stability of a species based solely on genetic studies of population samples, if genetic evidence is not correlated with ecology or morphology.

For practical purposes a taxonomic species is often taken as equivalent to a biological species: a reproductively isolated population or group of populations. The biological species concept was adopted by zoologists who considered only sexually reproducing organisms and ignored such things as clones and apomicts.

This concept may be of limited use for plants in which self-fertilisation and vegetative reproduction are common, and especially for weeds, which are often hybrids or special biotypes developed within a species introduced generations ago from its native habitat. In particular, sterile or apomictic clones are morphologically distinct and function as species in ecology even though they do not fulfil the biological definition of a population as a unit within which genes are exchanged.

A population moved to a new habitat immediately behaves as a new biological species because it is reproductively isolated from the original populations and subjected to different selection pressures. Morphological changes may occur later, but it has already started on a new evolutionary trajectory. Naturalised plants may not be assignable to any species from the habitat where they evolved since the weed flora has a higher proportion of hybrids, apomicts and new variants than the flora as a whole.

Biodiversity cannot always be divided into discrete species. Speciation is not tightly coupled to diversification: it can form clearly articulated branching clades when evolution is driven by the gradual and piecemeal emergence of new niches. But rapid landscape-scale changes following the introduction of alien plants may yield, in the short term, arrays of weedy biotypes that have not been sorted by natural selection into stable entities.

CASE STUDIES

Feral olives Olives are a crop plant and also a weed of native vegetation. Even in their native range around

the Mediterranean, gene flow has continued between cultivated and wild olives. Although named cultivars are at most a few generations removed from land races, indigenous wild *O. europaea* genotypes are now rare.

In South Australia the fruit crop and the weed are the same subspecies, *Olea europaea* subsp. *europaea*. But feral olive populations in the eastern States are subsp. *cuspidata* (Wall. ex. G.Don) Cif., which was imported as wild-type plants from southern Africa as an amenity tree.

Morphology of collections supports the view that the African olive (subsp. *cuspidata*) has not contributed to South Australian feral populations even though it was introduced at the Adelaide Botanic Garden by 1870. Chloroplast DNA and nuclear microsatellite data (Besnard *et al.* 2014) confirmed that South Australian populations are derived from a range of western and central Mediterranean cultivars, and have similar genetic diversity to native Mediterranean populations. In contrast, the wild olives of subsp. *cuspidata* from New South Wales have lower genetic diversity and almost entirely African haplotypes. No hypothesis is here advanced to explain the difference in behaviour of the two subspecies in different parts of Australia.

For the sake of simplicity and inclusiveness, the legal declaration of feral olives covers the whole species *Olea europaea*, but we are seeing only one subspecies in the wild in South Australia.

Eragrostis Several introduced perennial species of the grass genus *Eragrostis* (Poaceae) are weeds in Australia, growing alongside native species that they closely resemble. The African *Eragrostis trichophora* Coss. & Durieu is naturalised in New South Wales and was first reported in South Australia from Eyre Peninsula in 2012. Subsequent surveys showed it to be much more widespread in that State, growing mainly along roadsides. Specimens collected north of Adelaide have been confirmed as *E. trichophora* but there is uncertainty about plants collected south of Adelaide from Willunga to the South East. *E. trichophora* has evidently been in South Australia for some time before 2012, and had been confused with the widespread weed *Eragrostis curvula* (Schrad.) Nees. The name *E. trichophora* may also be a synonym of *E. cylindriflora* Hochst., which would take priority.

Eragrostis curvula is a declared weed under the NRM Act, and questions of delimiting this species from the others have arisen in the context of roadside control programs. Herbarium studies, including comparison with reliably identified material from overseas, to clarify the species of native and introduced *Eragrostis* present in Australia will be needed before any decisions on management of other weedy *Eragrostis*

species, with or without legal declaration, can be considered. In particular, it is necessary to clarify whether any given population is a native or an introduction.

Bulbil watsonia The South African biodiversity hotspot has given the world many genera of ornamental plants that have diversified rapidly in the last few million years. Some of them are gifts to the plant breeder because in cultivation they function as coenospecies with all their genetic diversity ready to use in hybridisation.

Watsonia (Iridaceae) contains 52 morphological species that rarely hybridise in the wild. But all are diploids with the same chromosome number that be interbred in cultivation, often with hybrid vigour and high fertility in the F1 generation. *Watsonia* appears to be a genus with little evolutionary depth. Traits are readily transferred between lines derived from different species and each cross shows only a limited range of recombination in the F2. The wild species, although they differ conspicuously in size, ecological tolerances and adaptations to insect or bird pollination, may all have a similar genetic architecture and closely homologous genes.

Watsonia meriana (L.) Mill. is a widespread, variable species in western Cape Province. It has several parapatric satellite species, each with a specific habitat, such as the tall *W. vanderspuyae* L. Bolus on sandstone in the mountains, and the dwarf autumn-flowering *W. hysteraantha* J.W. Mathews & L. Bolus on near-coastal granite outcrops. The weed bulbil watsonia is a vegetatively reproducing biotype of *W. meriana* that was reproductively isolated by becoming triploid. It found a niche in periurban lowlands disturbed by human activity, first in its native South Africa from the 17th century and more recently as an introduction in Australia, New Zealand and California.

Should we call bulbil watsonia a species even though it originated less than 400 years ago in response to human influence? After all, it has a distinctive appearance, different ecological properties to its diploid parent, and is reproductively isolated. But the current revision of the genus (Goldblatt 1989) did not recognise it as a real taxon due to its sterility and anthropogenic origin. For purposes of declaration, we have chosen the middle way of calling it a variety, distinct from the horticulturally valuable diploid *W. meriana* (Cooke 1998).

Gazania Another South African example is *Gazania* (Asteraceae), in which the process of speciation may not have proceeded even as far as it has in *Watsonia*.

The studies by Howis *et al.* (2009) are a reminder that biodiversity is not always divisible into discrete

species. Increase in the information content of a gene pool and its packaging into discrete taxa by natural selection are separate, and even contradictory, processes.

Gazania includes seven monophyletic species, each reproductively isolated with a distinct morphology, habitat and genetic identity, but the majority of its morphological, ecological and genetic variation are only partly correlated in a broad complex. This complex may be called a polymorphic species with chaotic infraspecific variation intractable to formal taxonomic treatment. Howis *et al.* (2009) gave it the informal name of the krebsiana-rigens (K-R) complex, as *G. krebsiana* Less. has been a widely used name in South Africa, while *G. rigens* (L.) Gaertn. is usually applied to the stoloniferous sand-binding forms that are distinct from the others morphologically and ecologically, but not genetically.

A complex that has diversified only since the Pleistocene is likely to consist of populations with similar functioning genes that determine the morphology and physiology of individual plants. This is quite apart from the fine variations in the four non-coding chloroplast sequences and two nuclear spacers used by Howis *et al.* (2009). Similar traits of morphology and physiology have appeared repeatedly in response to the appropriate environmental conditions. The stoloniferous 'rigens' forms of *Gazania* may have arisen polyphyletically in various coastal areas. They do not form a genetically coherent entity since natural selection has shaped them from the same gene pool as the rest of the complex.

The many forms of *Gazania* that have escaped from gardens are all within the K-R complex. For the practical purposes of legal declaration as weeds they need a scientific name. There are three possibilities:

1. Separate *G. rigens* out as the name of the stoloniferous forms that have been planted for sand stabilisation on our coasts. The earliest valid name for the rest of the K-R complex would then be *G. rigida* Burm.f.
2. Use the name *Gazania rigens*. for the whole K-R complex. This species epithet has priority under the International Code of Nomenclature (McNeill *et al.* 2012), having been published as *Gorteria rigens* L. in 1763.

3. In the proposed declaration under the NRM Act we have taken the third alternative of referring simply to the whole genus *Gazania*. As none of the seven distinct species are naturalised here, in practice this means the K-R complex.

This solution allows for future recombination in feral *Gazania* populations, which are still diverse garden escapes but may evolve into distinct biotypes adapted as weeds for Australian habitats.

There are already many named cultivars within *Gazania*, and some of these are now subject to Plant Breeders Rights (PBR) in Australia. There is potential to exempt from the declaration any PBR cultivars that are proven sterile, as PBR provides a legal guarantee of the accuracy of plant names in retail trade.

ACKNOWLEDGMENTS

The authors acknowledge the expertise and ongoing support of Mr Chris Brodie and the other botanists at the State Herbarium of South Australia.

REFERENCES

- Besnard, G., Dupuy, J., Larter, M., Cuneo, P., Cooke, D. and Chikhi, L. (2014). History of the invasive African olive tree in Australia and Hawaii: evidence for sequential bottlenecks and hybridization with the Mediterranean olive. *Evolutionary Applications* 7, 195-211.
- Cooke, D. (1998). Bulbil watsonia is a variety of *Watsonia meriana* (L.) Miller (Iridaceae). *Journal of the Adelaide Botanic Garden* 18, 5-7.
- Goldblatt, P. (1989). The genus *Watsonia*. *Annals of Kirstenbosch Botanic Gardens* 19, 1-148.
- Howis, S., Barker, N. and Mucina, L. (2009). Globally grown, but poorly known: species limits and biogeography of *Gazania* Gaertn. (Asteraceae) inferred from chloroplast and nuclear DNA sequence data. *Taxon* 58, 871-82.
- McNeill, J., Barrie, F.R. and Buck, W.R. (eds) (2012). 'International Code of Nomenclature for algae, fungi, and plants (Melbourne Code). Adopted by the Eighteenth International Botanical Congress Melbourne, Australia, July 2011'. (International Association for Plant Taxonomy, Bratislava).