

Observations on the ecology and conservation status of the rare herb *Gentiana wingecarribiensis*

P.G. Kodela, T.A. James and P.D. Hind

*P.G. Kodela, T.A. James & P.D. Hind (Royal Botanic Gardens, Sydney NSW Australia 2000) 1994. Observations on the ecology and conservation status of the rare herb Gentiana wingecarribiensis. Cunninghamia 3(3): 535–541. Gentiana wingecarribiensis L. Adams (Gentianaceae) is a rare, short-lived herb endemic to Wingecarribee Swamp in the NSW Central Tablelands (34° 34' S, 150° 31' E). Population estimates were made over two seasons and observations on distribution, growth and habitat recorded. Population numbers are low, with the Gentian restricted to a narrow ecotone area on the swamp margin. Specific regeneration requirements, poor seed dispersal and lack of competitiveness may help to explain its rarity. The survival of *G. wingecarribiensis* depends largely on protection of the ecotone area between the swamp and surrounding grassland, particularly from extreme and/or sudden changes in water level. Management strategies and recommendations are provided.*

Introduction and methods

Gentiana wingecarribiensis L. Adams (Gentianaceae) is a small, short-lived annual or ephemeral herb recorded only from Wingecarribee Swamp (34° 34' S, 150° 31' E), about 5 km WNW of Robertson on the Central Tablelands of New South Wales. It was first reported in the early 1960s by A.R.H. Martin, with herbarium specimens collected during November 1967 by P. Bates, and L.A.S. Johnson and B.G. Briggs. Further collections were made in 1971 and 1973, and it was described by L.G. Adams in Adams & Williams (1988). It was not, however, until 1992 that new interest emerged and it was found again by P.D. Hind and colleagues of the National Herbarium of NSW and the NSW National Parks & Wildlife Service.

Gentiana wingecarribiensis is assigned a conservation status code of 2E in the Australian rare or threatened plant list (Briggs & Leigh 1988). The 2 implies the species has a geographic range less than 100 km; E implies it is considered to be endangered with a serious risk of becoming extinct over the next few decades. In view of the threatened status of *G. wingecarribiensis*, a brief study was undertaken to compile further information on its distribution and ecology. Using site information from herbarium collections and communications with several past collectors, suitable areas were searched at Wingecarribee Swamp. Population estimates and observations relating to distribution, stage of growth, associated species and habitat characteristics were made for each site. Potential sites in other wetland habitats in the district were also briefly searched.

Plant description

Gentiana wingecarribiensis is an erect, glabrous herb to 11 cm high in flower, with opposite, ovate, sessile leaves 2–9 mm long. The 1–9 flowers are solitary, terminal and usually open in succession over a period of 2–3 months from October. Opening of the corolla (anthesis) occurs in bright sunlight (photonastic) and/or possibly as a response to change in temperature (thermonastic). The corolla is narrow-campanulate,

10–17 mm long, greenish-ribbed outside and purple-blue inside (Fig. 1). The distinctive capsule has a flared, 2-lipped apex (Fig. 2); seeds are numerous, 0.25–0.35 mm long. More complete descriptions are provided by Adams & Williams (1988) and Harden (1992).

Gentiana wingecarribiensis is one of four species of *Gentiana* recorded in Australia, all belonging in *Gentiana* section *Chondrophyllae* Bunge. This is a typically montane and predominantly Northern Hemisphere group, the southern limit of which is significantly extended by the Australian species (Pringle 1979, Adams & Williams 1988). All four species occur on the New South Wales tablelands and are considered endangered or vulnerable (Adams & Williams 1988).

Distribution and site characteristics

Wingecarribee Swamp is a large, montane peatland or fen at 680 m alt., supporting a complex of vegetation types and diverse flora (Hope & Southern 1983, Kodela & Hope 1992). The catchment is predominantly of Triassic Wianamatta Shale overlying Hawkesbury Sandstone with Tertiary basalt-capped hills mainly in the east.

In November 1992 three discrete, localised populations of *G. wingecarribiensis* were recorded on the southern side of the swamp. They were located in an ecotone area within 5–10 m of the swamp margin where the sedgeland, with some low shrubs, intergrades with the surrounding grassland/pasture. This micro-habitat on damp peat or peaty loam to clay loam supports a low, open vegetation cover 5–60 cm high, of predominantly sedges, grasses and other herbs, as well as woody subshrubs (Fig. 3). The soil was damp or occasionally saturated, but standing water was not evident. Earlier herbarium collections refer to a micro-habitat of low *Sphagnum* hummocks and at one of the three sites this was evident, the remaining sites being level ground. At one site there was marked disturbance from cattle trampling on the swamp periphery. Associated species included *Asperula* cf. *gunnii*, *Baumea rubiginosa*, *Carex* species, *Centella cordifolia*, *Comesperma retusum*, *Dichelachne inaequiglumis*, *Dichondra repens*, *Drosera peltata*, *Eriocaulon scariosum*, *Hydrocotyle peduncularis*, *Hypericum japonicum*, *Juncus planifolius*, *Leptospermum obovatum*, *Myriophyllum simulans*, *Prasophyllum uroglossum*, *Pratia surrepens*, *Pultenaea divaricata*, *Schoenus apogon*, *Thelymitra pauciflora*, *Themeda australis*, *Viola caleyana*, *Viola* species A (*V. hederacea* subspecies *fuscoviolacea*), *Wahlenbergia ceracea*, and the introduced species *Anthoxanthum odoratum*, *Holcus lanatus*, *Hypochaeris radicata*, *Lotus uliginosus*, *Sisyrinchium* species A and *Trifolium* species.

Much of the swamp is apparently unsuitable for *G. wingecarribiensis* due to a dense sedgeland or reedland cover and/or too high water levels. It has not been found at other potential sites in wetland habitats in the district, including Wildes Meadow, 4.5 km south of Wingecarribee Swamp, which has the most comparable environmental conditions.

Population size and biology

The location of individuals and estimation of population sizes is made difficult by the small inconspicuous appearance of the plants, the short life span of individuals and the flowers only opening in bright sunlight. During November–December 1992 the three identified sites had estimated populations of 36, 6 and 50 plants (estimates made by the NPWS were slightly higher, Cohn undated). The observed populations were highly localised, in areas of approximately 3 m x 3 m in sites 1 and 2 and c. 15 m x 3 m in site 3. Sites 1 and 2 were approx. 30 m apart, while site 3 occurs



Figure 1. *Gentiana wingecarribiensis* flowers over a period of 2-3 months from October. The corolla is only known to open in bright sunlight. All photos this page by D.W. Hardin.



Figure 2. The distinctive capsule of *Gentiana wingecarribiensis*.



Figure 3. *Gentiana wingecarribiensis* is now restricted to a narrow ecotone area on the margin of Wingecarribie Swamp where the vegetation is low in stature and relatively open.

c. 1.75 km due WNW of these sites. The individual plants had a scattered distribution within these sites. The Gentian was absent from adjacent areas with apparently similar habitat conditions.

In early November 1993 the estimated population at site 1 was approx. 30 plants. Individual plants were close to the previous year's population, indicating seeds are very locally dispersed. No plants were evident at the other known sites at this time or later in the season.

Gentiana wingecarribiensis flowers chiefly from October to December, but it was seen flowering in January 1988 (R. Bates pers. comm.). From our observations, flowering occurs in plants from 2.5 cm high, considerably shorter than the surrounding vegetation. Individual plants may have buds, flowers and capsules present at the same time. The capsules and seed appear to mature rapidly within about 1 month of flowering and the plants wither and die completely within about 2 months.

Land-use history

All the recorded sites for *G. wingecarribiensis* appear to be either on freehold land or on the border of freehold land and the swamp, which was acquired by the Water Board in June 1993. Although the sites are within an area zoned for Environmental Protection (Cohn undated) there is no control over agricultural use. The western part of the swamp was flooded in the mid-1970s for a reservoir, which is managed by the Water Board to supply water to local towns and occasionally Sydney. Drainage channels on the swamp are associated with mining and agricultural activities. Peat mining operations have been active in the western part of the remaining mire over the last 20 years. Surrounding slopes in the catchment are used for grazing of beef and dairy cattle. As a result of human disturbance and pasture improvement, there are many exotic plant species that occur mainly on the swamp margins and surrounding land. Much of the swamp vegetation appears to be subject to annual burns, usually in late spring, though several fires may occur in a year. The fires are often patchy, and observations suggest that the Gentian sites are mostly not affected.

Discussion

Despite the difficulties encountered in estimating the frequency and distribution of *G. wingecarribiensis* and the short period of observation, recent field assessments appear to confirm that the species is restricted to Wingecarribee Swamp and that population numbers are low. More specifically, the plant is restricted to a relatively narrow ecotone area on the swamp margin where the vegetation is low in stature and relatively open.

Despite the production of large quantities of seed in 1992 (hundreds of seeds are produced per capsule), low population numbers at site 1 in 1993 indicate either a low percentage germination or low seedling survival rate. These observations and the absence of germination at the other sites in 1993, suggest that seed may be stored in a persistent soil seed bank. Seeds of the European species *Gentiana verna* remain viable until the second season when germination is often better than the first (Elkington 1963). Overseas studies on *Gentiana* also indicate that a cold phase (e.g. freezing) is required for germination (Simmonds 1946, Elkington 1963). The germination requirements of *G. wingecarribiensis*, however, need further investigation.

The rarity of *G. wingecarribiensis* may be explained by a combination of factors. The highly localised populations and fluctuations in population numbers suggest that regeneration requirements for the species may be very specific. If local environmental conditions are unsuitable the seed may experience some degree of enforced dormancy. The ability to remain dormant in the soil for long periods is a recognised feature of plants inhabiting unstable environments (Fenner 1985), including swamps which experience fluctuations in water level. Under Raunkiaer's life-form classification *G. wingecarribiensis* is a therophyte, i.e. 'a plant that completes its life cycle rapidly during periods when conditions are favourable and survives unfavourable conditions (e.g. cold, heat, or competition) as seed' (Allaby 1992). The viability of populations will be further affected if plants are unable to successfully exploit potential sites. The appearance of individuals at site 1 in 1993, in the close vicinity of the previous year's population, suggests a clumping effect consistent with limited seed dispersal, though the minute and lightweight seed of *G. wingecarribiensis* might be conducive to wind dispersal. Pringle (1979) suggests that seeds of certain species of *Gentiana* could be dispersed as the wind shakes the open capsules. The low height of *G. wingecarribiensis*, however, may limit the effectiveness of this dispersal method in the absence of air turbulence. When the capsules are open in wet weather, seed dispersal could be assisted by rain-splash. Once seeds have left the capsules, there may be a possibility for lateral water dispersal if the watertable is above the ground near the plants at the time of fruiting or if they occur near local ponds or channels on the swamp. There are several records of *G. wingecarribiensis* occurring near the edges of channels.

Rapid plant growth and seed production is apparent, *G. wingecarribiensis* completing its life cycle in approx. 3 months. It is feasible that strong selection pressures could operate in favour of such rapid development considering the small size of the plants and their dependency on bright sunshine for anthesis. The early flowering period may have evolved to ensure optimal conditions before the later growth flush of taller sedges and grasses. In early December 1992 one population was located in relatively dense stands of *Themeda australis* and other herbs to 60 cm high, but only one month later no Gentian plants could be found.

Conservation and management

The long-term survival of *G. wingecarribiensis* is likely to depend on the maintenance of the micro-habitat found in the ecotone area of the swamp. Adams & Williams (1988, p. 168) state that 'viable populations are probably dependent on a stable habitat of short, damp turf of forbs, sedges, grasses and bryophytes' and 'its long-term survival could depend on the watertable remaining relatively high and fluctuating only within limits of a few centimetres for lengthy, and possibly critical, seasonal periods'. Prior to European settlement, grazing by native herbivores may have played an important role in maintaining short, open conditions in this type of habitat (Adams & Williams 1988). Today, over-grazing and trampling by cattle, as well as ground disturbance caused by heavy machinery such as tractors would be detrimental to such sites, particularly during the plant's growing season. Potential Gentian habitats have already been lost on the edges of the swamp where intensive trampling has created muddy, rough surface conditions.

Disturbance by fire or physical means, in the absence of grazing by native herbivores, may be a necessary management tool to reduce competition with other species, including weeds, and to promote an open vegetation structure that provides sufficient light and shelter for the Gentian. Such management recommendations were made by Bishop (1992) as a result of a survey of the rare orchid *Prasophyllum uroglossum*

which also occurs in this ecotone area of the swamp. A report of *G. wingecarribiensis* flowering on recently burned peat mounds late in the season (R. Bates pers. comm.), when sites may normally be overgrown with other species, supports this view. A fire shortly before the Gentian's growing season or subsequent to completion of fruiting could be beneficial; however, if the fire coincides with the flowering and fruiting stages the plants are likely to be killed.

Current land-use practices, i.e. peat mining, agriculture and use of part of the swamp as a reservoir may threaten the survival of *G. wingecarribiensis*. Major alterations in the watertable or changes in the hydrological regime, as well as grazing pressure and competition from exotic plant species appear to be the most critical factors. The Gentian appears to be sensitive to changes in water level and may have occurred more widely in areas now flooded by the reservoir. Damming would have also increased watertable levels in the remaining swamp, which may have affected the distribution of *G. wingecarribiensis*. This is supported by observations made by Martin (pers. comm.) in the early 1960s, which indicate that the Gentian was growing in central parts of the swamp prior to construction of the reservoir. Peat mining, drainage and cattle grazing and trampling, directly or indirectly, threatens the remaining suitable habitat. Changes in water quality and soil nutrient status are likely to have resulted from agricultural practices and peat extraction. The impacts of these changes on the Gentian and other wetland species need investigation.

The ecotone between the swamp and the grassland/pasture is of considerable conservation value, not only for the survival of *G. wingecarribiensis* but also for the rare and endangered *Prasophyllum uroglossum*, which also appears to be restricted to Wingecarribee Swamp. Additionally, species diversity is high in the ecotone as it is an overlap zone between two communities and may provide a refuge for marginal swamp species. The conservation of *G. wingecarribiensis* will depend on protecting its habitat in the ecotone area, including the maintenance of a buffer zone.

Management strategies and recommendations

Further investigation of the ecology of *G. wingecarribiensis* is warranted, particularly by monitoring population numbers over several years and investigating the impacts of burning and other land-use practices. To assess the long-term viability of the species, the size and longevity of the soil seed bank requires investigation. Seed germination trials should continue at Mount Annan Botanic Gardens and self-perpetuating populations be established in accordance with the Royal Botanic Gardens Plant Conservation Policy (Royal Botanic Gardens 1993). Considering the small size of populations at Wingecarribee Swamp, further collections should be limited and the impacts of human trampling associated with field studies considered.

The recorded sites of *G. wingecarribiensis* should be fenced for protection from grazing and trampling. Additional areas with similar habitat conditions could also be managed as potential Gentian sites. While grass mowing and slashing may be useful in maintaining open sites, such practices should be avoided during the Gentian's growing season i.e. October–January. The control of exotic plant species in these areas is important. The Blackberry *Rubus discolor*, for example, occurs on swamp margins near the Gentian sites. Methods for the control of woody weeds are outlined in Cohn (undated).

The survival of *G. wingecarribiensis* depends largely on protection of the swamp from extreme and/or sudden alterations of water levels resulting from land-use activities in the catchment. Watertable levels should be monitored and consideration given to the potential impacts of any manipulation of water levels and future works in Wingecarribee Reservoir. Any future expansion of the reservoir onto the swamp

could result in the loss of habitats crucial to the survival of *G. wingecarribiensis*. The designation of Wingecarribee Swamp as a nature reserve, including a buffer zone, is recommended to increase protection of this rare and endangered species and the associated wetland communities.

Acknowledgements

We are grateful to Mr L.G. Adams of the Australian National Herbarium, Canberra, Drs L.A.S. Johnson and B.G. Briggs of the National Herbarium of NSW, Sydney, Dr A.R.H. Martin and Prof. R.C. Carolin formerly of Sydney University, and Mr R. Bates, Adelaide, for providing information on the distribution and ecology of *G. wingecarribiensis*. We thank Messrs L. Adams and Doug Benson for commenting on the manuscript. We thank Mr Bob Coveny for his valuable field assistance and botanical knowledge during several visits to the swamp. Photographs taken by Mr David Hardin are gratefully acknowledged. The School of Geography, University of NSW, supported P.G.K. during earlier visits to the swamp. This rare species will greatly benefit from investigations by the NSW National Parks & Wildlife Service, including a Conservation Research Statement and Recovery Plan prepared by Ms J. Cohn. This plan is currently being implemented by Ms M. Matthes of NPWS. We would also like to acknowledge the assistance of the Water Board, Department of Conservation and Land Management and Department of Mineral Resources. We thank Amgrow and landowners for allowing us access to the investigation sites.

References

- Adams, L.G. & Williams, J.B. (1988) *Gentiana* sect. *Chondrophyllae* (Gentianaceae) in Australia. *Telopea* 3: 167–176.
- Allaby, M. (ed.) (1992) *The concise Oxford dictionary of botany*. (Oxford University Press: Oxford).
- Bishop, A.D. (1992) Conservation of *Prasophyllum uroglossum* at Wingecarribee Swamp: Report of survey 26/11/92 and recommendations for management. Unpubl. Report.
- Briggs, J.D. & Leigh J.H. (1988) *Rare or threatened Australian plants*. Special Publication No. 14. (Australian National Parks & Wildlife Service: Canberra).
- Cohn, J. (undated) *Recovery plan — research phase & conservation strategy: Gentiana wingecarribiensis* L. Adams. Australian National Parks & Wildlife Service Endangered Species Program Project No. 251. (NSW National Parks & Wildlife Service: Hurstville). Unpubl. Report.
- Elkington, T.T. (1963) *Gentiana verna* L. *Journal of Ecology* 51: 755–767.
- Fenner, M. (1985) *Seed Ecology*. (Chapman & Hall: London).
- Harden, G.J. (1992) Gentianaceae. Pp. 508–515 in G.J. Harden (ed.), *Flora of New South Wales* Volume 3. (New South Wales University Press: Kensington).
- Hope, G.S. & Southern, W. (1983) *Organic deposits of the Southern Tablelands region, New South Wales*. Unpublished report to the NSW National Parks & Wildlife Service, Sydney.
- Kodela, P.G. & Hope, G.S. (1992) *Wingecarribee Swamp: statement of significance*. (National Trust of Australia (NSW): Sydney).
- Pringle, J.S. (1979) Taxonomy and distribution of *Gentiana* (Gentianaceae) in Mexico and Central America. II. sect. *Chondrophyllae*. *Sida* 8: 14–33.
- Royal Botanic Gardens Sydney (1993) *Plant conservation policy*. (Royal Botanic Gardens: Sydney).
- Simmonds, N.W. (1946) Biological flora of the British Isles: *Gentiana pneumonanthe* L. *Journal of Ecology* 33: 295–307.

Manuscript received 10 December 1993

Manuscript accepted 14 March 1994