Garry oak ecosystems recovery team

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Bibliographic summary of the Ecology and Management of Invasive Species:

Cyclamen spp.

(C. hederifolium, C. coum, C. parviflorum)

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February 2012

Funds for this project were provided by

the Habitat Stewardship Program for Species at Risk

of the Government of Canada

Environment Canada Environnement Canada

Peer-reviewed journal articles

Affre, L., and J.D. Thomspon. 1999. Variation in self-fertility, inbreeding depression and levels of inbreeding in four *Cyclamen* species. J of Evol Bio, Vol. 12, Issue 1, pp. 113-122.

> Authors' abstract: The ability to self in the absence of pollinators, i.e. reproductive assurance, and the detrimental consequences of inbreeding, i.e. inbreeding depression, are central factors influencing plant mating system evolution. The purpose of this study was to quantify whether self-fertility and inbreeding depression are related to levels of inbreeding in four Cyclamen species, namely C. balearicum (mean Fis = 0.930), C. creticum (mean Fis = 0.748), C. repandum (mean Fis = 0.658) and C. hederifolium (mean Fis = 0.329). C. balearicum showed a markedly greater capacity to autonomously self-fertilize than the three other species, which may have favoured inbreeding in this species. Levels of inbreeding depression were highest in C. creticum and C. hederifolium at the fruit maturation (δ = 0.18 and 0.20, respectively) and seed number (δ = 0.32 and 0.30, respectively) stages, and for C. repandum at the seed weight stage (δ = 0.23). Although C. balearicum showed inbreeding depression on seed germination (δ = 0.45), this may be an artefact of the generally low levels of seed germination in the experiment. Overall, we observed only limited evidence for the predicted negative relation between inbreeding coefficients and levels of inbreeding since C. creticum had high levels of inbreeding and inbreeding depression. Other factors may thus influence the relationship between inbreeding and inbreeding depression in these species.

Affre, L., and J.D. Thomspon. 1998. Floral trait variation in four *Cyclamen* (*Primulaceae*) species. Plant Systematics and Evolution, Vol. 121, Nos. 3-4, pp. 279-293.

> Authors' abstract: The purpose of this study is to examine floral trait variation between four *Cyclamen* species that show variation in their ability to reproduce in the absence of pollinators and in levels of inbreeding. Pollen and ovule production, pollen/ovule ratio, pollen volume, petal length and width, diameter of the corolla mouth, pistil and stamen length, and stigma-anther separation varied significantly between the four study species. Flower, pollen and ovule production, pollen volume and corolla size were generally highest in *C. hederifolium*, the species with the lowest level of inbreeding (mean Fis = 0.329), intermediate in both species with relatively high levels of pollinator-mediated inbreeding, *C. repandum* (mean Fis = 0.658) and *C. creticum* (mean Fis = 0.748), and lowest in the highly inbred *C. balearicum* (mean Fis = 0.930). The two species with the most different inbreeding coefficients, *C. hederifolium* and *C. balearicum*, had lower pollen-ovule ratios and shorter longevities of stigma receptivity and pollen viability than *C. creticum* and *C. repandum*. These patterns of variation in floral traits are discussed in relation to the relatedness, pollination ecology and levels of inbreeding of the four species.

Debussche, M., E. Garnier, and J.D. Thompson. 2004. Exploring the causes of variation in phenology and morphology in Mediterranean geophytes: a genus-wide study of *Cyclamen*. Bot J of the Linnean Society, Vol. 145, Issue 4, pp. 469-484.

> Authors' abstract: The phenology and morphology of Mediterranean plants are constrained by drought in summer and cold temperatures in winter. In this study we examine how climatic factors and phylogenetic constraints have shaped variation in the phenology and morphology of 17 species of the genus *Cyclamen* cultivated in uniform garden conditions. We quantify the extent to which traits differ among subgenera and thus represent conserved traits within evolutionary lineages. We also explore whether leaf, flowering and seed-release phenology are correlated among species, and thus whether variation in flowering phenology

results from selection on dispersal phenology. Our results show a significant influence of subgenus membership on leaf and flowering phenology but not on morphological traits or the timing of seed release. Among-species variation in foliage height, leaf size and seed mass (but not in floral traits) is correlated with chromosome number. Leaf traits show that species with a shorter vegetative period have a higher capacity for resource acquisition. Major phenological shifts, i.e. spring vs. autumn flowering and a decoupling of leaf and flower phenology in autumnal flowering species, thus occurred prior to the diversification of species in each subgenus and not as a response to selection on dispersal timing. Leaf and flowering phenology illustrate a gradient of strategies from autumn flowering in the absence of leaves (hysteranthous species) to spring flowering with fully developed foliage (synanthous species). In the former, flowering is uncoupled from resource acquisition by simultaneous photosynthesis, indicative that hysteranthy is a response to temporal unpredictability in the onset of rain after the summer drought. Our results support the idea that whereas leaf development is controlled primarily by moisture availability and secondarily by temperature, flowering is temperature dependent, above a minimum moisture threshold.

Lobstein, M.B., and L. L. Rockwood. 1993. Influence of Elaiosome Removal on Germination in Five Ant-Dispersed Plant Species. Viriginia J of Sci. Vol 44, No. 1, pp. 59-72.

Authors' abstract: Seed dispersal by ants is a common phenomenon in Eastern deciduous forests of the United States. Among the proposed benefits to the plant of seed manipulation by ants is enhancement of the germination rate. Since 1984 we have investigated the hypothesis that elaiosome removal enhances germination rate on eight different ant-dispersed species. Preliminary results have shown a significant increase in germination rate with elaiosome removal in only one species, *Sanguinaria canadensis*. We report here the results of two years of laboratory experiments. Intact (control) seeds, and seeds whose elaiosomes have been removed were incubated on moistened foam pads in petri dishes. Seeds were exposed to three months each of temperature regimes meant to simulate summer, fall, and winter (5^{o}C) conditions. High germination rates were obtained for *S. canadensis*, *Asarum canadense*, *Jeffersonia diphylla*, and *Viola striata*. Only in *S. canadensis* did elaiosome removal significantly enhance germination ($p<0.001$). Germination rates were poor in *Dicentra cucullaria* and the effects of elaiosome removal were inconclusive. The results strongly suggest that elaiosome removal does enhance germination in *S. Canadensis*.

Nderberg, A.A. 1994. Phylogeny and subjeneric classification of *Cyclamen* L. (Primulaceae). Kew Bulletin, Vol. 49, No. 3, pp. 455-467.

Summary: The genus *Cyclamen* L. (Primulaceae) has been subject to a cladistics parsimony analysis based on morphological and cytological data, using *Soldanella* L. and *Dodecatheon* L. as outgroups. The analysis yielded two equally parsimonious cladograms from which a hypothesis of phylogenetic interrelationships has been formulated. Subgenus *Psilanthum* Schwartz was found to be the sister-group of the two subgenera *Cyclamen* and *Gyrophoebe* Schwarz, whereas the former sub-genus Eucosme Schwarz was found to be a derived group within subgenus *Cyclamen*. Based on the cladistics analysis character evolution in *Cyclamen* is discussed, a sub-generic reclassification of the genus is proposed and *Cyclamen graecum* Link is hypothesized to be a taxon of hybrid origin.

Schmutz, K.D., J. Tuza, C. Perrings, and M.Williamson. 2006. The Horticultural Trade and Ornamental Plant Invasions in Britain. Cons Biol, Vol 21, Issue 1, pp. 224-231.

Authors' abstract: Ornamental horticulture has been recognized as the main pathway for plant invasions worldwide. We examined the link between propagule pressure created by the presence of ornamental plants in the market and their ability to escape from cultivation and

establish in the wild. A random sample of 534 non-native ornamental species on sale in nineteenth century Britain showed that 27% of these species were recorded growing outside cultivation and 30% of those were established. Species that had escaped from cultivation were more frequently on sale both in the nineteenth century and today than non-escaping species. We used logit regression models to identify biological and socioeconomic variables that affect species' abilities to escape cultivation and become established. Frequencies in the market in the nineteenth century and today were good explanatory variables that distinguished escaping from non-escaping species, whereas for the transition from casual to established status these two socioeconomic variables were either absent or only of weak significance. Biological characteristics that increased the probability that a species would escape from cultivation were species height, a European native range, and being an annual. Climbing plants and species intolerant of low temperatures were less likely to escape. In contrast, the establishment probability was greater if the species belonged to a genus native to Britain and increased as the number of continents in a plant's native range increased. Annual plants had a reduced probability of establishment. Market presence, prices, and the date of introduction are among the socioeconomic factors that have had important effects on the observed course of invasions.

Schwartz-Tzachor, R., D. Eisikowitch, and A. Dafni. 2008. Flower characteristics and breeding system of two phenological ecotypes of *Cyclamen persicum* Mill. (Myrsinaceae) in Israel.

Authors' abstract: *Cyclamen persicum* Mill. in Israel consists of two discrete population types that differ in their flowering (fall versus winter) as well as leafing (hysteranthous versus synanthous) phenology. The two populations have similar pollen:ovule ratios, index of self incompatibility, stigma receptivity duration, pollen longevity, flower longevity, floral morphology and seed production rate. These data indicate no apparent selective pressure on floral characteristics or on the breeding system, which may be exerted by the pollinators. The two populations retained their autonomous blooming rhythm even after transplantation, which indicated that this character was genetically determined. There are no genetic barriers and the populations may share some pollinators (Schwartz-Tzachor et al. 2006). Thus the main potential restriction on gene flow is the incomplete phenological barrier. These findings may indirectly support our hypothesis that the phenological shift is due to environmental cues. Thus it was concluded that these two types are 'phenological ecotypes' in the sense of Turesson (1922) due to the unequivocal delineation of both types, as revealed by the timing of leaf appearance (synanthous versus hysteranthous) without any evidence of any intermediates.

Yesson, C., and A Cultham. 2006. A phyloclimatic study of Cyclamen. Evolutionary Biology. Vol. 6, Issue 1. 72 pp.

Authors' abstract: Background: The impact of global climate change on plant distribution, speciation and extinction is of current concern. Examining species climatic preferences via bioclimatic niche modelling is a key tool to study this impact. There is an established link between bioclimatic niche models and phylogenetic diversification. A next step is to examine future distribution predictions from a phylogenetic perspective. We present such a study using *Cyclamen* (Myrsinaceae), a group which demonstrates morphological and phenological adaptations to its seasonal Mediterranean-type climate. How will the predicted climate change affect future distribution of this popular genus of garden plants? Results: We demonstrate phylogenetic structure for some climatic characteristics, and show that most *Cyclamen* have distinct climatic niches, with the exception of several wide-ranging, geographically expansive, species. We reconstruct climate preferences for hypothetical ancestral *Cyclamen*. The ancestral *Cyclamen* lineage has a preference for the seasonal Mediterranean climate characteristic of dry summers and wet winters. Future bioclimatic

niches, based on BIOCLIM and Maxent models, are examined with reference to a future climate scenario for the 2050s. Over the next 50 years we predict a northward shift in the area of climatic suitability, with many areas of current distribution becoming climatically unsuitable. The area of climatic suitability for every *Cyclamen* species is predicted to decrease. For many species, there may be no areas with a suitable climate regardless of dispersal ability, these species are considered to be at high risk of extinction. This risk is examined from a phylogenetic perspective. Conclusion: Examining bioclimatic niches from a phylogenetic perspective permits novel interpretations of these models. In particular, reconstruction of ancestral niches can provide testable hypothesis about the historical development of lineages. In the future we can expect a northwards shift in climatic suitability for the genus *Cyclamen*. If this proves to be the case then dispersal is the best chance of survival, which seems highly unlikely for ant-dispersed *Cyclamen*. Human-assisted establishment of *Cyclamen* species well outside their native ranges offers hope and could provide the only means of dispersal to potentially suitable future environments. Even without human intervention the phylogenetic perspective demonstrates that major lineages could survive climate change even if many species are lost.

Other published sources

Altay, H., and N.M. Muftuoglu. 2004. The effects of varying applications of nitrojen, phosphorus, and potassium on the size of *Cyclamen hederifolium* corms grown in peat medium, in *Proceedings of the International Soil Congress* on “Natural Resource Management for Sustainable Development” June 2004, Erzurum-Turkey. 6 pp.

Authors’ abstract: The purpose of this study was to show that the *Cyclamen hederifolium* plant could be cultivated by producers in Turkey so that its depletion in the wild could be prevented and to determine how to produce export-sized corms of at least 10 cm circumference in the shortest possible time. The growing medium was peat and various doses of ammonium sulphate, triple super phosphate and potassium sulphate fertilisers were applied. During the study, 80 different applications were carried out, the seeds were sown on 14th October 2001 and the corms were gathered on 17th May 2003. Taking into account all the corms in the study, in 12 of the 80 applications the corms reached an average circumference size of 10 cm or more. With ammonium sulphate applications of 150 kg/da and 200 kg/da none of the corms had a circumference of more than 10 cm. It was determined that all three fertilisers together had an effect on the size, with the N2P3K2 application producing the longest circumference and the N0P2K0 application producing the largest number of corms. On the other hand, 74 of the 80 applications having a circumference size of 10 cm or more, met the corms export criterium [sic], that corm size should be at least 10 cm. The application of N1P3K1 produced the longest circumference while the largest number of exportable corms was produced by the application of N1P3K3. Taking into consideration all the corms obtained from the experiment, the heaviest corm was produced with an application of N1P3K1. When the dosage of ammonium sulphate fertiliser was either more or less than 100 kg/da, the weight of the corms decreased. In the case of triple super phosphate, it was determined that larger dosages led to an increase in the weight of corms. The average height of two-year corms varied between 0.88 - 2.03 cm, with the height approximately equal to half the diameter. An application of N2P3K2 was found to have the most effect on the height. In conclusion, when fertilised for two years after sowing with the same type and dosage of fertiliser, it was observed that the *Cyclamen hederifolium* plant was negatively affected by excessive nitrogen, that, statistically, potassium alone produced little effect, but that phosphorus had a positive effect.

Corbineau, F., N. Neveur, and D. Côme. 1988. Seed Germination and Seedling Development in *Cyclamen persicum*. Communication presented at Advances in Seed Biology at the Royal Botanic Gardens, Kew (14–15 April 1988), in Annals of Botany, Vol. 63, No 1, pp. 87-96.

Gorb, E., and S. Gorb. 2003. Seed Dispersal by Ants in a Deciduous Forest Ecosystem: Mechanisms, Strategies, Adaptations. Kluwer Academic Publishers, Netherlands. 227 pp.

Leeds, R. 2010. Autumnal Assembly. *Garden*, magazine of the Royal Horticultural Society, Vol, 135, Part 8, pp. 546-549.

Annotation: This article states that Hardy Cyclamen "…is a superb plant to naturalise in dry, dappled shade. Seeds set abundantly and are naturally distributed by ants."

Takamura, T. 2007. Cyclamen, *Cyclamen persicum* Mill. In Anderson, N.O. (ed.) Flower Breeding and Genetics, Chapter 16, pp 459-478.

Fact sheets, websites, and databases

Convention on International Trade in Endangered Species of Wild Fauna and Flora. http://www.cites.org/eng/app/appendices.php

Annotation: The entire genus of Cyclamen falls under Appendix II of the Convention. Appendix II lists species that are not necessarily now threatened with extinction but that may become so unless trade is closely controlled. The intent is to block trade in Cyclamen plants that have been dug up from their native habitat for export. Artificially propagated specimens of cultivars of Cyclamen persicum are not subject to the provisions of the Convention; however, this exemption does not apply to such specimens traded as dormant tubers.

Cyclamen Society, The. http://www.cyclamen.org/indexCS.html

Annotation: This website, inactive since 2003, provides information regarding known Cyclamen species and cultivars, and methods for propagation. The Cyclamen Society exists to encourage cultivation and conservation, and to disseminate and extend knowledge of the genus Cyclamen and its species, forms and cultivars. It combines scientific study with all the activities of a society for enthusiasts who cultivate the plants. The Society was formed in England in January 1977 and had over 1600 members as of 2003.

United States Department of Agriculture, Agricultural Research Service, Beltsville Area, Germplasm Resources Information Network (GRIN). Taxon: *Cyclamen hederifolium* Aiton.

Annotation: Species of conservation concern because rare or endangered.

Klinkenberg, Brian (Editor). 2010. E-Flora BC: Electronic Atlas of the Plants of British Columbia [eflora.bc.ca]. Lab for Advanced Spatial Analysis, Department of Geography, University of British Columbia, Vancouver.

Personal communications

Barbarasch, Bruce. Superintendent of Natural Resources & Trails Management, Tualatin Hills Park & Recreation District, 6220 SW 112th Ave., Beaverton, Oregon. 20 Jan 2012.

"We aren't seeing this Cyclamen in Beaverton, Oregon, except as very occasional escapees from yards. Even then they are small (less than 1 foot diameter) patches."

Costanzo, **Brenda**. Senior Vegetation Specialist, Terrestrial Conservation Science Section, BC Ministry of Environment. 18 Jan 2012.

Ferguson, Aryana. Madrona Consulting, Eugene, Oregon, 20 Jan 2012

> "We used Glyphosate [to control *Cyclamen*] but…it is difficult to tell if the plants are coming up from the remaining tuber that wasn't killed or whether there is some level of seed bank there as there was a significant time lapse between dieback from the spray and the occurrence of new plants -- perhaps over a year or more. The seed bank could be established as sometimes I have caught plants only after they went into that curly stem phase which is supposedly when they produce seeds (although I have to say I don't believe I have ever actually seen a seed capsule on any of our plants. Do you have any idea how long the seeds remain viable in the soil? We have been trying to stay more on top of it in the last 4 or so years than in years past as we realized what was happening in our local park. And I will have to be more attentive as to when it blooms as I usually try to deal with it when it first appears vegetatively and not yet in flower...flaming will never be strong enough to actually kill the tubers. It will only be through repeated flaming over time to reduce the energy stored in the tuber…"

Forney, Thomas W. Projects Coordinator, ODA Noxious Weed Control Program, 20 Jan 2012.

> "I have seen it in a few oak woodlands in the Willamette Valley. Mostly in areas with homes nearby, likely escapes from gardens similar to BC. Slow mover from what I have observed. I had some at my previous home where it is spread over the hillside (oak woodland) in many small patches. That location is just outside of Jefferson. If you dig them up there are tuber like bulbs from the size of a pea to a potato. I did not try to spray it out, so not sure about difficulty to control with herbicide. I would think with the tubers it may be hard to kill. Small patches dig out easily and the few I had were controlled after a couple of years. I have not seen the effect of large mats. Only small patches and dispersed plants. It emerges in late summer and fall, puts up foliage and flowers for a few months and dies back for the year. Some spring flowering, but not the flush of foliage and flowers that occurs later in the season."

GOERT Invasive Species Steering Committee. Minutes 17 Feb 2010, New Business, Item 5:

> "Cyclamen as invasive plant status Jeff Hallworth [Ministry of Forests, Lands & Natural Resource Operations] has reported *Cyclamen hederifolium* is on his watch list. The Global Compendium includes: *C. coum* (moist plant along water); *C. graecum* (hard to grow here); *C. persicum* (could also show up) and *C. repandum* (moist woods species). June P[retzer] mentioned that she has a problem with *C. h[ederifolium*] on Christmas Hill. Fred [Hook] mentioned that the seeds are only carried by ants. Moralea [Milne] suggested that it is found in Devonian Park well away from ants. Seems to grow in shallow rocky sites as well as partial shade. June reported that it forms dense mats with corms and little bulbils that make removal difficult. Fred reported that the seeds are formed cleistogamously. *Cyclamen* should be added to the HotSpots crew list … It should be added to IAPP..."

LoCascio, Tom. Site Manager, Mount Pisgah Arboretum, Eugene, Oregon, 20 Jan 2012.

> "Hand digging is the method we've used for removing Cyclamen populations. This method requires at least two years of monitoring to be sure you've removed all of the tubers."

Hook, Fred. Parks Environmental Technician, City of Victoria, 4 Feb 2012.

> Reported that "*Cyclamen coum* is very recognizable.The blossoms are small - around the size of a dime. The leaves are about the size of a Loony and nearly circular. *C. parviflorum* is similar but with (usually) darker flowers and more distinctly marked leaves. The ones we've been seeing here have flowers and leaves at least twice that size. My experience of them is that they do hybridize quite readily (although not between the spring and fall flowering species). There were a few growers locally (notably Dr. Ian McTaggart Cowan on Ten Mile

Point) who collected and grew all of the known species and got many crosses in his seedlings.

Johnson, Bart. Associate Professor, Dept., of Landscape Architecture, University of Oregon – Eugene, 20 Jan 2012.

Reported a number of years ago that "…we've seen a *Cyclamen* species making what appears to be a relatively rapid invasion in an Oak woodland at Tugman Park in Eugene. It hasn't seemed as dense as described below, but looks like it has the potential to become so. We're very concerned about its potential invasion in local oak woodlands but only know from this one site."

Milne, Moralea. Naturalist, Metchosin, BC, 20 Jan 2012.

"We have found just a few plants at Devonian Park, in the middle of wooded areas, not in the open rocky outcrops with the oaks. We find a few every couple of years. So far digging them out has done the job, perhaps because it wasn't a large established population and the seedbank hasn't developed. One problem is that everyone loves them and can't imagine why we would take them out. And they want to take them home to replant...which just defers the problem. I don't have much more to contribute because, fortunately, it is not much of an issue here yet."

O'Brien, Colleen. Volunteer site steward, Playfair Park, Saanich, BC. 20 Jan 2012.

"… in Playfair, it occurs in both deep and shallow soil areas. There's none in the GORP site because the two times I've seen it, I've dug it out. Both times it's been young plants, dug out before it's old enough to flower and set seed. And both were isolated from the main patches, likely far too distant for insect dispersal, so I'm assuming it came in on muddy boots or paws. I've dug out a couple of isolated patches elsewhere in the park in soil pockets in natural rocky areas. But, I've pulled the flowers off for a couple of years before I've attempted to dig them out, thinking that it would, overall, minimize soil disturbance."

Roemer, Hans. Biologist. Jan 2012.

Cyclamen hederifolium flowers in fall. *Cyclamen* seen blooming in spring are a different species, possibly *C. coum* or *C. parviflorum*.

Skinner, Caroline. Friends of Nob Hill Nature Park, 12 Feb 2012.

Nob Hill Nature Park, [is] a 6-acre Garry oak woodland in St Helens, OR. (It's about 30 miles north of Portland, overlooking the Columbia River.) We have been noticing healthy cyclamen patches growing there, and …decided to try and remove them by digging. The largest, a rosette of leaves about 2 feet in diameter, did have a root or bulb and the size of half a bowling ball. Man[y] of the others had a hard "nut" at the base of the stems, about the size and shape of a used bar of soap."

Stewart, Elaine. Senior Natural Resources Scientist, Metro - Natural Areas Program, Portland OR. 20 Jan 2012.

"There is only one *Cyclamen* entry, for *C purpurascens*, but the description is telling: spreading from flowerbeds into surrounding lawn, the furthest individual 15 feet from a flowerbed. I will keep an eye out for this genus and appreciate the heads-up. I work on an area with homes near the oak patches and will watch for it."