A COMPARISON BETWEEN EUROPEAN AND AUSTRALIAN POPULATIONS OF HOREHOUND, *(MARRUBIUM VULGARE* L.*)*

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Abstract Horehound (*Marrubium vulgare* L.: Lamiaceae), a noxious weed throughout southern Australia, was imported from its native southern Europe during the 1800s. Horehound in its native habitats shows weed potential, but plant populations are scattered and their density is lower than Australian infestations where the plants are larger and more vigorous. Climate modelling based on overseas populations indicate that horehound in Australia maybe close to achieving its maximum potential distribution. The seed production and seed bank studies indicate that there is at least a one hundred fold difference between the populations on the two continents. At Victorian infestations, either competition or water appear to be the limiting factors affecting survival and recruitment while sustained herbivory pressure restricts Horehound in its native range.

The insect fauna of horehound in Europe has been examined and four insects have been identified as suitable agents for biological control. Two of these have been approved for release into Australia.

INTRODUCTION

Horehound is a perennial weed native to temperate Eurasia, Europe, the Middle East and the Mediterranean region including North Africa (Figure 1). It is also a weed in southern states of north America, including California and Texas, in South America (Argentina, Chile, Peru, Uruguay etc) and in New Zealand (Weiss, 1999). It is now naturalised over most of the pastoral areas in Australia with rainfall over 200mm. It occurs in all Australian states but is of most importance in Victoria and South Australia where an estimated 26 million hectares (Lane *et al*., 1980, Carter, 1990) are infested (Figure 2).

Horehound leaves contain marrubin, a bitter alkaloid, which makes it unpalatable for grazing animals. Horehound burrs are not only of nuisance to people, as they catch in clothing and socks, but they also contaminate wool, reducing the value of fleece.

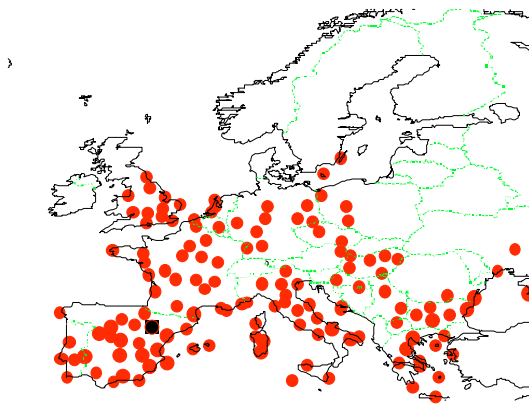

Figure 1. Distribution of horehound in Europe (adapted from Anerberg *et al.*, 1996)

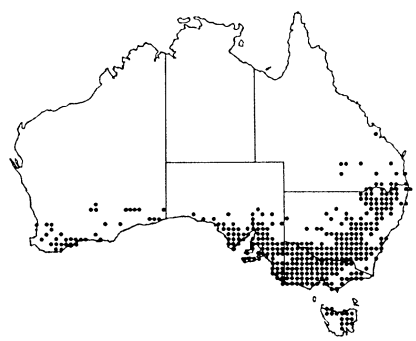

Figure 2. Present distribution of horehound in Australia (from Parson and Cuthbertson, 1992)

Horehound was possibly first introduced into Australia from Europe via a shipment of botanical specimens sent by Sir Joseph Banks. A record from Sir Joseph Bank's diary states that *M. vulgare* was sent to NSW on board the ship Porpoise on 11 October 1798 (Frost, 1993). The plant appears to have been introduced for use as a garden herb, medicinal use and for beer

brewing purposes. It was first recorded as naturalised by 1840s.

MATERIALS AND METHODS

Potential distribution of horehound in Australia was determined using CLIMEX for Windows version 1.1 (Sutherst, 1999). The distribution was based on the provided "Mediterranean template" and the parameters for temperature, moisture and stress were expanding upon utilising Australian and overseas information about stress limits and the distribution of horehound.

Comparative phenological studies of horehound were carried out at two sites in Europe (Cournonterral and La Crau in southern France) and two in Australia (Wyperfeld N.P. and Swifts Creek, in Victoria) during the period 1991-1997. Growth, reproductive capacity, size, and soil seed banks were measured seasonally or biennially. Individually marked plants were identified on each visit and details recorded. Soil cores were collected to measure the soil seed bank. Samples were washed free of soil and horehound seeds checked for viability.

Surveys of the insect fauna of Europe (Portugal, Spain, France, Italy and Yugoslavia) and Morocco were carried out during 1990-1997. Collected insects were identified by the IIE (British National History Museum, London), CNRS (Toulouse) and MNHM (Paris).

RESULTS

Potential distribution

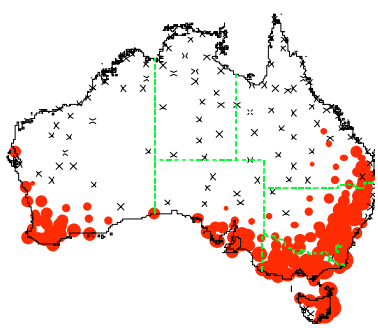

Figure 3. Potential distribution of horehound in Australia (as predicted using CLIMEX Version 1.1)

Plant Phenology Table 1 presents a summary of the phenology and demography of two populations of horehound in France and two in Victoria. The horehound plants in southern France are much smaller with only about one third the number of stems, and produce about half the seeds that the Victorian populations do. Most importantly though, the density of plants in Victoria is about 20 to 50 times more, 200 to 1000 times as many seedlings occur and 70 to 250 times as much seeds are in the soil seed bank than southern France.

Table 1. Demography and seed banks of horehound in Europe and Australia.

	France		Victoria, Australia	
Demography	Cournt.	La Crau	Swifts C.	Wyper.
Density of plants/ m^2	0.4	0.2	6.9	9.9
Mean height plant (cm)	14.6	9.6	36.1	27.1
Mean no. of stems	6.3	6.8	35.2	18.9
Mean no. seed prod. / plant	878	174	1,746	498
Mean no of seed prod./per stem	139.4	25.6	49.6	26.4
Mean no. seedlings/ m^2	0.11	0.32	69.5	196.3
Mean soil seed bank (seeds/m^2)	116.9	61.2	15,290	7,880

Insect Fauna in Europe Twenty seven species of insects were found on *M. vulgare* in Europe and Morocco. Figures 1 and 2 show the relevant orders and feeding behaviour of the horehound insect fauna. One other insect, a rare weevil, and a leaf-spotting fungus have been reported in the literature (Sagliocco and Weiss, 1996) but were not found during the surveys.

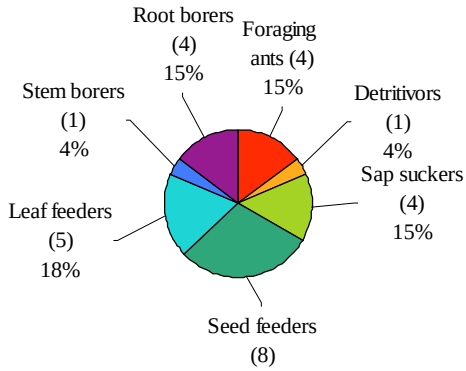

Figure 4. The different groups of insects recorded feeding on *M. vulgare* in Europe

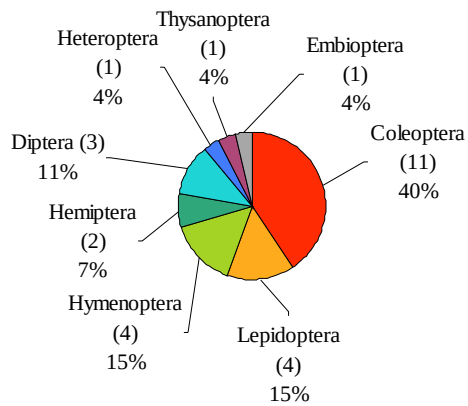

Figure 5. The insect Orders recorded to feed on *M. vulgare* in Europe

DISCUSSION

Distribution in Australia and Europe The present and potential distribution maps of horehound in Australia (Figures 2 and 3) are very similar indicating that horehound maybe close to reaching its maximum potential distribution. Horehound has the potential of increasing in Western Australia and parts of NSW, but in South Australia, Victoria and most of NSW, it will more likely increase the density of present infestations rather than move into new localities.

In Europe, horehound generally grows on waste lands, on well drained calcareous soils. The persistence of permanent plant populations depends on low interspecific plant competition, which is favoured by sheep grazing, and a sufficient seed dispersal by animals. In western Europe, large horehound populations are very rare, but are found where sheep or horse grazing occurs.

Horehound Phenology Although Australian plants are significantly larger and have more stems, the amount of seeds produced per plant is not dramatically greater than that in Europe. The number of seeds produced per stem is roughly equivalent in both populations. However as the density of plants is 20 to 50 times more this greatly increases the seed bank, and recruitment potential of seedlings. The extreme low levels of seeds in the soil in Europe is most likely due to predation and destruction by the foraging ants species.

Horehound in both Europe and at Swifts Creek, Victoria, have consistent populations with very little seasonal or yearly fluctuations. In comparison, horehound in the drier more drought prone Mallee at Wyperfeld, undergoes dramatic "boom – bust" cycles. Mature plants die off during severe droughts and the infestations rely on the very large seed bank to recolonise when sufficient rainfall occurs. This most likely indicates that horehound in these drier areas are surviving in less than optimum conditions and without the large seed bank reservoirs, the infestations would disappear in time. Control strategies in these dry areas should concentrate on removing the seed bank, by fire for example (Weiss, 1996), or by reducing the seed production of the plants using biological control agents.

Seed germination Lippai *et al.* (1996) reported on the effects of temperature and water potential on the germination of Victorian horehound seeds. They indicated that Australian horehound is not a drought tolerant germinator but more opportunist, germinating whenever sufficient rains occur. In contrast horehound seeds from America require much more specific environmental factors prior to germination including fluctuating temperatures of at least 15°C of stratification.

This contrast is possibly due to environmental differences the seeds are subjected to in North America and Australia, which is substantiated by increased germination following moist chilling of North American seeds, but not of Australian seeds. It would be interesting to see what factors influence the germination of European horehound. Anecdotal evidence indicates that horehound seeds survive in the soil seed bank for between 7 to 10 years (Weiss, 1999).

Potential Biological Control agents In Australia prior to 1994 only a couple of arthropods (mites, mealy bugs and one bug) fed on horehound. The native brightly coloured orange and black horehound bug, *Agonoscelis rutila*, is often seen on the weed in great numbers, but does not have any significant impact.

In comparison twenty seven species have been found to feed on *M. vulgare* in Europe and Morocco. As areas such as Greece, the Middle East and other countries of northern Africa also rich in *Marrubium* genera have yet to be investigated, the total number of insects feeding on M. vulgare is expected to be much higher.

So far, through the surveys and the field observations, five insect species have been identified as having a potential for the biocontrol of horehound in Australia. These species are:

Wheeleria spilodactylus Curtis (Lep: Pterophoridae)

Chamaesphecia mysiniformis Rambur (Lep:Sesiidae)

Meligethes rotroui Easton (Coleoptera: Nitidulidae)

Phytoecia melanocephala Fabricius (Coleoptera: Cerambycidae)

Carcharodes boeticus Rambur (Lep: Hesperiidae)

Two of these agents have been host specificity tested and approved for release in Australia.

The horehound plume moth, *W. spilodactylus*, was first released in 1994 and is now established at over 100 localities throughout south eastern Australia (SA, VIC, Tas and NSW). The caterpillar feeds on the growing tips of the plants and then works its way down the shoot, progressively defoliating the stem. This weakens the plant and reduces the number of seeds and flowers produced.

The horehound clearwing moth, *C. mysiniformis*, was released in March 1997. Larvae feed within the growing tissue of the root and lower stems. Larval infection affects the flow of water and nutrients through the plant, weakens it, reduces growth and increases the likelihood of the plant dying (especially when water stressed). Success with this agent may be restricted to sites where maximum summer temperatures often exceed 30°C.

CONCLUSION

The reasons for the dense horehound infestations in southern Australia are most likely a combination of factors. Horehound in Europe has few vectors to transport the seed calyxes apart from the occasional sheep, while in Australia, kangaroos, sheep, rabbits, farm machinery and water courses all aid in the transport of the seeds to new areas. Because of different land management techniques, competition from other plant species maybe higher in Europe than in Australia. Horehound seeds have a limited ability to germinate in conditions where moisture availability, or where temperatures are low. However, mature plants can survive dry and drought conditions effectively as animals preferentially graze more palatable pasture species, reducing competition for available water. In Australia, the prolific seeding, high germination rates, and the large seed bank enable horehound to colonise newly disturbed areas and to recruit new seedlings into the weed infestation when conditions are favourable. In comparison, horehound in Europe is restricted by the high specific herbivory pressure which reduces the ability of mature plants to produce a large quantities of seeds hence the seed bank reduction. The low level of specific herbivory in Australia by insects and disease by pathogens (no pathogen observed in Europe except unidentified soil pathogen) is probably the major reason for the high level of infestation in Australia.

ACKNOWLEDGMENTS

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REFERENCES

Anderberg, A., Anderberg, A-L. and Salter, M.E.S. (1996). "Virtual Flora of Swedish Vascular Plant", Swedish Museum of Natural History, Stockholm. http://linnaeus.nrm.se/flora/

Carter, R.J. (1990). Biology and Control of Horehound, *Marrubium vulgare*. Proceeding 9th Australian Weeds Conf. 382-386. Crop Science Soc. S.A. Inc.

Frost, A. (1993). 'Sir Joseph Banks and the transfer of Plants to and from the south Pacific 1786-1798'. Melbourne Colony Press

Lane, D.W.A., Riches, K. and Combellack, J.H. (1980). A survey of the Distribution of Noxious weeds in Australia. Dept. Crown Lands and Survey, Frankston.

Lippai, A., Smith, P.A., Price, T.V., Weiss, J. and Lloyd, C.J. (1996). Effects of temperature and water potential on germination of horehound (*Marrubium vulgare*) seeds from two Australian localities, Weed Science, 44, 91-99.

Parsons, W.T. and Cuthbertson, E.G. (1992). Noxious weeds of Australia. pp. 496-499. Inkata Press, Melbourne.

Sagliocco, J-L. and Weiss, J. (1996). Biocontrol of Horehound (*Marrubium vulgare* L.). Work in Europe 1990-1996. Project DCV 14. Final Report to International Wool Secretariat.

Sutherst, R.W. (1996). CLIMEX: Predicting the effects of climate on plants and animals. Version 1.1, CSIRO.

Weiss, J. (1996). Control of Horehound, *Marrubium vulgare* L., in Wyperfeld National Park, Victoria. Eleventh Australian Weeds Conference Proceedings. 471-419.

Weiss, J. (1999, in press). Best Practice Management Guide: Horehound (*Marrubium vulgare*). CRC for Weeds Management Systems.