**THE POTENTIAL GEOGRAPHICAL DISTRIBUTION OF
ALLIGATOR WEED (*ALTERNANTHERA PHILOXEROIDES*)
AND A BIOLOGICAL CONTROL AGENT,
AGASICLES HYGROPHILA, IN NEW ZEALAND**

C. A. STEWART¹, M. H. JULIEN² and S. P. WORNER¹

¹*Department of Entomology and Animal Ecology,
PO Box 84, Lincoln University, Canterbury, New Zealand*

²*CSIRO Division of Entomology, P.M.B. No. 3,
Indooroopilly 4068, Australia*

ABSTRACT

Alligator weed is well established in the northern North Island but is considered to have potential to spread further south. To assist management of the weed, areas in New Zealand suitable for its establishment and growth were identified using a climate matching program (CLIMEX). Using parameters based on the known distribution of the weed in South and North America, CLIMEX indicated that alligator weed has the potential to spread south to the coastal North Island and some northern coastal areas in the South Island as far south as Christchurch. In addition, previously derived CLIMEX parameter values for *Agasicles hygrophila*, a biological control agent for alligator weed, were used to indicate regions where the insect would be most active in controlling the weed. Predictions of the potential for this insect to control the weed support current field information that the flea beetle cannot be relied on as a control for alligator weed in New Zealand.

Keywords: *Alternanthera philoxeroides*, *Agasicles hygrophila*, CLIMEX, alligator weed

INTRODUCTION

Alligator weed (*Alternanthera philoxeroides* (Mart.) Griseb. (Amaranthaceae)), a weed of waterways and pastures, is a perennial stoloniferous herb that grows primarily as an emergent aquatic plant, rooted in soil or substrate beneath shallow water. Floating mats of interwoven hollow stems develop and extend over the surface of the water. The weed rarely sets seeds and reproduction is through vegetative growth. Morphological and physiological attributes allow this weed to persist and spread in a range of ecosystems from almost arid conditions to swampy areas and open water (Julien and Broadbent 1980; Roberts and Sutherland 1989).

Alligator weed originated from South America, east of the Andes (Vogt *et al.* 1979) and has spread to other countries including the southern USA, Puerto Rico, Burma, Thailand, Indonesia, Australia, Asia, India and China (Julien 1980; Julien *et al.* 1992). It was first recorded in New Zealand from a ballast dump at Aratapu by the Northern Wairoa River (Cheeseman 1906) and is now distributed from the Waikato northwards to the Far North District (C. Stewart unpublished survey).

Alligator weed is spreading in New Zealand although quite slowly. It threatens to further invade native wetlands, waterways and farmlands with detrimental ecological and economic impacts. The weeds negative effects and the difficulty controlling it are well documented for other countries (Julien and Bourne 1988; Coulson 1977) suggesting that it is important to minimise spread and thus potential problems in New Zealand.

A South American flea beetle, *Agasicles hygrophila* Selman and Vogt (Coleoptera: Chrysomelidae), has been a useful biological control agent against alligator weed in other countries (Julien 1992). This agent was first released in Northland in 1982 by Entomology Division, DSIR (Roberts and Sutherland 1989) and although established, there is limited quantitative information on current and potential geographical range and effectiveness. However, post-release evaluations have shown that the flea beetle has a smaller geographical range than the weed in USA (Coulson 1977). A similar disparity of ranges has been predicted for Australia (Julien *et al.* 1995).

Information about the potential for spread of this weed in New Zealand would assist the allocation of resources to areas at risk of invasion. Further, knowledge about areas where the weed does or could exist, but where the flea beetle is unable to provide control, will allow implementation of other control strategies as required. Julien *et al.* (1995) predicted distributions of both weed and flea beetle for Australia and the continents of Asia, Europe and Africa, using the computer program CLIMEX. This paper describes CLIMEX predictions for locations where alligator weed will grow in New Zealand and areas where the flea beetle will survive and control the weed.

MATERIALS AND METHODS

CLIMEX is a computer based system that uses the climatic responses of an organism and meteorological data to assist the prediction of potential relative abundance and distribution of a poikilothermic organism (Sutherst and Maywald 1985). It uses long term averages (maximum and minimum temperature, rainfall and relative humidity) from meteorological sites to derive weekly and annual population growth indices (GI) that describe the potential of particular locations to support population growth of a nominated species during favourable seasons. Four stress indices (cold, hot, dry and wet) describe the probability of a species population surviving through unfavourable seasons. The GI and stress indices are subsequently combined into an "ecoclimatic index" (EI) to give a measure of the overall favourableness of the location for permanent occupation by the nominated species (Maywald and Sutherst 1991).

The climatic response parameters for both alligator weed and the flea beetle used in this study were first estimated by Julien *et al.* (1995) in a study of the potential distribution of *A. philoxeroides* and *A. hygrophila* in Australia, eastern Asia, Africa and Europe using CLIMEX. In their study, Julien *et al.* (1995) determined initial climatic response parameters by using the known distributions of both species cited in the literature. These initial parameters were adjusted when growth and ecoclimatic indices generated by CLIMEX were compared with the known seasonality and relative abundance of both alligator weed and the flea beetle in North and South America. When approximate final correspondence was achieved, the final parameters were used to predict the potential distribution of both species in Australia, eastern Asia, Africa and Europe.

Meteorological data for all New Zealand sites were compiled from standard meteorological data records (Anon. 1983) and added to the meagre New Zealand data base that existed within the worldwide CLIMEX data base, creating an expanded data base. Using the CLIMEX program, the parameters derived from the known North and South American distributions of the weed and beetle by Julien *et al.* (1995) and the expanded data base, the EIs were determined for alligator weed and the flea beetle in New Zealand.

Julien *et al.* (1995) determined locations where the EI values exceed 10 are considered favourable for establishment of alligator weed while locations with EIs 1 to 10 are considered marginal. For the flea beetle, locations with EIs over 25 are considered suitable to maintain beetle populations capable of controlling alligator weed. Such locations have mid and post winter temperatures that permit populations to survive and increase to levels that will destroy the weed during summer. Locations with EIs between 1 and 25 are suitable to support beetle populations but winter temperatures will limit those populations below levels required to control the weed.

RESULTS

The present distributions of alligator weed and the flea beetle are shown in Fig. 1 and the predicted distributions in Figs. 2 and 3. Areas that are most suited for alligator weed growth include the coastal North Island and most of the Auckland and Northland Regions between South Auckland and Cape Reinga. The highest EI, 33, occurred on Mokohinau Islands, situated north of Little Barrier Island. A few locations on the northern coastal sections of South Island, as far south as Christchurch, are marginal for alligator weed while the remainder is unsuitable due to cold stress in winter.

FIGURE 1: The current distribution of alligator weed and the flea beetle in New Zealand (distributed in the North Island only) (C. Stewart unpublished survey).

FIGURE 2: The predicted distribution of alligator weed in New Zealand.

Areas most suited to the flea beetle are coastal North Island, including the area from South Auckland to Cape Reinga where the most suitable location is Aupouri Forest, north of Hokianga Harbour with an EI of 49. Numerous North Island locations are predicted suitable to support populations of the flea beetle but not at levels sufficient to control the weed. With a few exceptions, the South Island is unsuitable.

FIGURE 3: The predicted distribution of the flea beetle (*Agasicles hygrophila*) in New Zealand.

DISCUSSION

Alligator weed occurs from South Auckland to the Far North District (C. Stewart unpublished survey) and isolated patches have been found at Orongo (near Thames), Te Aroha (C. Jeffery pers. comm. 1993) and in the Waikato river (C. Winks pers. comm. 1992) (Fig. 1). Two isolated infestations of alligator weed were found growing on the Canterbury plains but have been eradicated (G. Bourdot 1994 and P. Champion 1993 pers. comm.).

The EIs for the growth of alligator weed in New Zealand are low compared to the predictions by Julien *et al.* (1995) for Australia, Asia and Africa where some locations had EIs >70. However, alligator weed grows abundantly in areas in the Northland and Auckland Regions (Fig. 1). Furthermore, the CLIMEX predictions suggest alligator weed has not yet reached its full geographical distribution within New Zealand (Fig. 2).

The known geographical distribution of the flea beetle in New Zealand extends from the Rodney District northwards (Fig. 1). In addition, an isolated site at Port Waikato (Waikato District) has been identified (C. Stewart unpublished survey). However, information on the level of control of alligator weed in these areas by the flea beetle is currently lacking although it is known that consistent control occurs at a site in Northland (Whatatiri) (C. Stewart, unpublished observation). The closest meteorological sites to Whatatiri are Whangarei and Whangarei airport where EI values for the flea beetle were 34 and 39, respectively.

It is apparent that the flea beetle will not control alligator weed over its whole potential range when the predicted distributions for the weed (Fig. 2) and the flea beetle (Fig. 3) are considered together. These results are similar to those observed in USA and have been predicted for Australia and elsewhere. It is possible that such a situation already exists in New Zealand as there are many areas of alligator weed where the beetle seems unable to control this weed. For example, in the Auckland Region there are no known areas where alligator weed has been controlled by the flea beetle, although it has been established there for over 11 years, despite CLIMEX predictions to the contrary. The reasons for this lack of control in New Zealand have not been defined, although climatic factors are considered very important in USA (Coulson 1977; Vogt *et al.* 1992) and are currently under study for New Zealand.

The output from CLIMEX, and all predictive models, has limitations and must be interpreted with care. CLIMEX predictions are based on available meteorological site data. If sites are widely spaced and conditions differ between them, extrapolation of the predictions is inadvisable. Furthermore, CLIMEX ignores local climate variations and microclimates as occur on water bodies, and because the predictions are based on data away from the habitat of most organisms the level of reliability of predictions may decrease as marginal areas for the organism are approached. For example, alligator weed grew successfully on a large water body near Canberra, Australia, while CLIMEX predictions indicated that Canberra was too cold to support the weed (Julien *et al.* 1995) and also the Canterbury Plains, an area predicted marginal or unsuitable (Fig. 2).

Regardless of their shortcomings, predictions can provide useful information when their interpretation is based on knowledge of the ecological requirements of the organism in question. For example, populations of the flea beetle cannot increase to control alligator weed mats growing on rivers and drains prone to large fluctuations in water levels (Coulson 1977; Roberts *et al.* 1984) regardless of the EI value of the location. CLIMEX allows approximate definition of little-known climatic responses a species and can give valuable information in the absence of more detailed data (Worner *et al.* 1989). This in turn can assist in the allocation of resources to reduce spread and to decide appropriate control strategies.

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