A survey in South Africa for potential biological control agents against capeweed, *Arctotheca calendula* (L.) Levyns (Asteraceae)

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Summary

A survey for biological control agents against capeweed, *Arctotheca calendula*, was conducted in the western Cape Province of South Africa. Thirty phytophagous species were found associated with the plant, of which five may have potential to control the weed. The stem boring weevil, *Stenotypus indignus*, is possibly the most suitable agent as it is only known from capeweed and is damaging to the plant. Two leaf feeding chrysomelids, *Chrysolina fasciata*, and *Cassida sphaerula*, and a root feeding weevil, *Rhytirrhinus sordidus*, feed on a number of species from the tribe Arctoteae including capeweed, and may not be sufficiently host specific. The fifth potential agent is a gall causing nematode, *Subanguina mobilis*, which was originally collected on capeweed in South Australia. The nematode occurs in South Africa indicating that it was probably accidentally introduced into Australia. This survey shows that there are organisms available for assessment as biological control agents against capeweed. Even though capeweed is generally considered to be an important weed, it is also reputed to be a useful pasture species and a source of pollen for honey bees. Consequently biological control should not proceed before capeweed's status is clearly established.

Introduction

Capeweed, *Arctotheca calendula* (L.) Levyns, while having originated from southern Africa, is possibly the most abundant species of Asteraceae in southern Australia (Kloot and Burry 1982). For example, in south western Australia Arnold *et al.* (1985) found capeweed averaging half the pasture dry matter. Capeweed thus appears to be a plant much under-utilised in pasture. Sheep preferentially graze Wimmera ryegrass and clover and avoid capeweed (Broom and Arnold 1986). This results in a capeweed dominated pasture particularly when an area has been grazed continuously for a number of years. Despite this, capeweed has long been regarded as a useful plant in pasture, and has been shown in *in vitro* digestibility tests to be of a similar quality to sown species (McIvor and Smith 1973). Another positive attribute is the use of capeweed pollen by honey bees (Rayner and Langridge 1985).

In contrast capeweed is clearly a weed of crops, and is listed as a weed in rapeseed (Stephenson 1982) and cereals (Velthuis and Amor 1982). Powles (1987) states that capeweed is the first broad-leaved plant in Australia to have shown resistance to herbicides suggesting that it has been frequently sprayed and demonstrating its importance as a weed needing control. Capeweed is also a source of contact dermatitis in humans (Burry and Kloot 1982, Kloot and Burry 1982).

Capeweed has not been specifically identified as a target for biological control possibly because of its suspected importance in pasture. However its overall status as a weed prompted us to examine whether suitable biological control agents could be found in the weed's region of origin. At present the only study of the fauna associated with *A. calendula* is of Lepidopteran larvae feeding on the plant in Victoria (Cordingley and Danthanarayana 1976). In this paper we list the fauna associated with *A. calendula* in its native habitat, and discuss which species might have potential as biological control agents.

Methods

Capeweed was sampled in the western Cape Province of South Africa, a region with a Mediterranean type climate (Schulze 1984) which most closely resembles the climate of the area occupied by the plant in Australia. Sampling was carried out from August to November, 1986 with additional surveys done in 1987 and 1988. At each of 14 sites 30 whole plants and thirty capitula were collected and later dissected in the laboratory. Plants were searched and sweep net samples were taken at all sites to find externally feeding species. Adult insects were observed feeding and larvae reared to adults exclusively on *A. calendula* to confirm the association with this weed. A representative collection of specimens was lodged at the National Collection of Insects, Pretoria, South Africa.

The host specificity of each insect was determined from literature references and from field observations. Both monophagous (restricted to *Arctotheca* spp.) and oligophagous (restricted to the Arctoteae, a tribe of Asteraceae) species were considered as candidate biological control agents.

Results

The distribution of *A. calendula* and the study sites are shown in Figure 1. In the study area seedlings of capeweed appeared in May and the plants senesced from November to December. Flowers were present during most of the life span of the plant. The plants were collected from a range of habitats, mostly roadsides and pastures.

Thirty phytophagous species are known to feed on *A. calendula* (Table 1). Ten of these were recorded in the literature, and twenty one were found in our survey. Most of the species fed externally on leaves or stems. Six species were recorded feeding on the capitula and two on the roots. There were three internal feeders; two gall formers and one leaf miner. Seed predation and internal feeding in the capitula were not observed. Few species were found per study site (mean ± SD, 3.4 ± 1.15; range 1 - 5, N = 14). On average half (49% ± 27%; range 0 - 93%, N = 14) of the plants at each site were free of damage by phytophagous species.

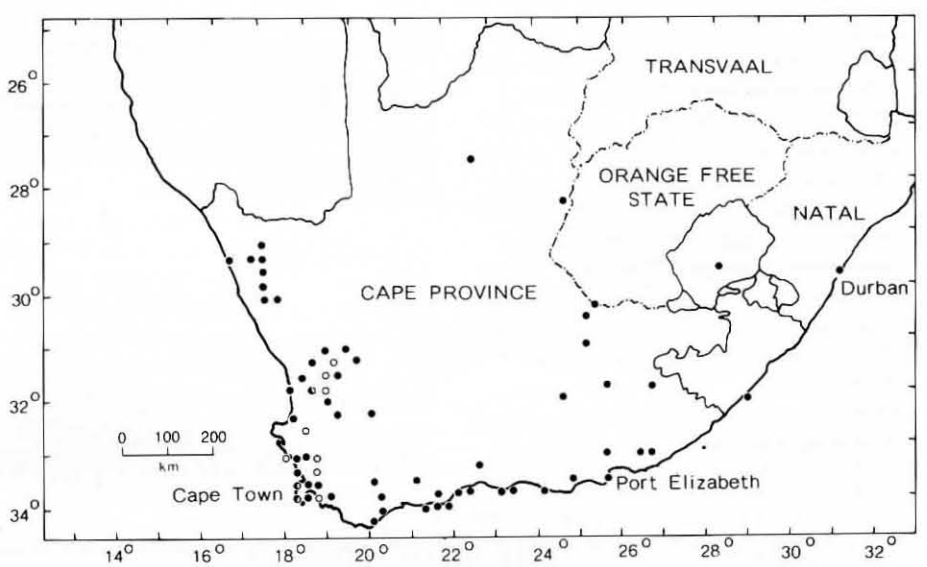

Figure 1. Distribution of *Arctotheca calendula* in South Africa. Closed circles indicate quarter degree squares with herbarium collections, open circles indicate quarter degree squares with study sites.

Table 1 Phytophagous fauna collected on *Arctotheca calendula* in South Africa.

Species	Life stage[1]	Site of attack[2]	Host specificity[3]	Literature record
LEPIDOPTERA				
Noctuidae				
Heliothis armigera armigera (Hübner)	L	L	P (1)	
Plusia limbirena Guenée.	-	-	P (6)	Taylor 1957
Trichoplusia angulum (Guenée)	L	L	P (5)	
Pyralidae				
Gen et spec. indet.	L	L	?	
Nymphalidae				
Vanessa (Cynthia) cardui (L.)	L	L	P (1)	
Tortricidae				
Epichorista ionephela (Meyr.)	L	-	P (3)	Myburgh & Basson 1961
Tortrix capensana (Wlk.)	L	-	P (1)	Myburgh & Basson 1961
COLEOPTERA				
Curculionidae				
Rhytirrhinus inaequalis (F.)	L	R	P (4)	
Rhytirrhinus sordidus Boheman	L	R	?O (7)	
Stenotypus indignus Boheman	L	S	?M (7)	
Chrysomelidae				
Chrysolina fasciata De Geer	L,A	L	?O (7)	
Cassida sphaerula Boheman	L,A	L	?O (7)	
Scarabaeidae				
Dichelus (Heterochelus) sp. (includes possibly 7 spp.)	A	C	P (7)	
Pachynema (Physocnema) calvinia Schein	A	C	?	
Nitidulidae				
Meligethes sp. (includes possibly 2 spp.)	L	C	?	
HEMIPTERA - HOMOPTERA				
Aphididae				
Aphis craccivora Koch	-	-	P (2)	Millar & Dürr 1985
Aphis fabae Scopoli	-	-	P (2)	Millar & Dürr 1985
Aphis gossypii Glover	-	-	P (2)	Millar & Dürr 1985
Myzus persicae (Sulzer)	-	-	P (2)	Millar & Dürr 1985
Aphis near *pseudocardui* Theobald	L,A	S	P (2)	
Uroleucon compositae (Theobald)	L,A	S	P (2)	
Uroleucon sonchi (L.)	-	-	P (2)	Millar & Dürr 1985
Pseudococcidae				
Pseudococcus capensis Brain	-	-	P (1)	Brain 1924
Aphrophoridae				
prob. *Poophilus* sp.	N	S	P (7)	
DIPTERA				
Agromyzidae				
Chromatomyia horticola (Goureau)	L	L	P (1)	
THYSANOPTERA				
Aeolothripidae				
Aeothrips brevicornis Bagnall	-	C	P (7)	
Phlaeothripidae				
Haplothrips clarisetis Priesner	-	C	P (7)	
Haplothrips nigricornis Bagnall	-	C	P (1)	
ACARINA				
Eupodidae				
Halotydeus destructor (Tucker)	-	L	P (1)	
NEMATODA				
Anguinidae				
Subanguina mobilis (Chit & Fisher)	-	L,S,P	?O (7)	Chit & Fisher 1975

1. L = larvae, A = adult, N = nymph.
2. C = capitula, L = leaf, R = root, S = stem, P = petiole.
3. P = polyphagous, ?O = possibly oligophagous on Arctoteae, ?M = possibly monophagous on *Arctotheca* spp., ? = unknown. The source for the host range is given in parenthesis: 1 = Annecke and Moran (1982), 2 = Millar and Dürr (1985), 3 = Myburgh and Basson (1961), 4 = Scott and Way (1989), 5 = Taylor (1949), 6 = Taylor (1957), 7 = observed during this study.

Specificity

Most of the species are polyphagous (23 spp.), including five pests of agriculture (Annecke and Moran 1982), and thus not suitable as biological control agents. A further three species groups have unknown specificity (the pyralid, the scarabaeids, and nitidulids), but at least the latter two are highly likely to be polyphagous given the general biology of these groups. The five remaining species have sufficiently restricted host ranges to be considered as potential biological control agents.

Potential biological control agents

1. *Stenotypus indignus* Boheman (Coleoptera: Curculionidae)

The larvae of this weevil tunnel inside the lower stems of capeweed causing considerable damage, and a slight galling of the surrounding tissue. The larvae pupate inside the stem, and adults were often found on the ground under the host plant. The larvae are parasitised by the wasps, *Pteromalus* sp. (Pteromalidae) and *Eurytoma* sp. (Eurytomidae). This weevil was the insect most frequently encountered on *A. calendula*, infesting 37% of plants examined (N = 420), and being present at all except one of the study sites. The biology and host plants for the other four species of this southern African genus (Marshall 1956) are unknown.

2. *Chrysolina fasciata* De Geer (Coleoptera: Chrysomelidae)

Both larvae and adults of this leaf beetle were observed feeding on the leaves of *A. calendula* at one sample site. Gess and Gess (1988) report that it feeds on *Arctotheca populifolia* (Bergius) Norlindh. We observed it feeding on this plant as well as causing extensive feeding damage to the following species: *Arctotheca prostrata* (Salisb.) Britten in the eastern Cape Province; *Arctotus acaulus* L., *Arctotus auriculata* Jacq., *Arctotus hirsuta* (Harvey) Beauv. and *Gazania linearis* (Thunb.) Druce, in the Kirstenbosch Botanical Gardens in Cape Town.

3. *Cassida sphaerula* Boheman (Coleoptera: Chrysomelidae)

Both larvae and adults of *Cassida sphaerula* were observed feeding on the leaves of *A. calendula* at four sites on the Cape Peninsula. We also collected *C. sphaerula* on *A. prostrata* in the eastern Cape Province, and on *A. acaulus*, *A. aspera* L. and *A. auriculata* in the Kirstenbosch Botanical Gardens.

4. *Rhytirrhinus sordidus* Boheman (Coleoptera: Curculionidae)

The larvae of this weevil feed externally on roots of capeweed before pupating in the soil. There was no obvious effect on the plants. Larvae were found at one site, Botterkloof Pass (31° 55'S; 19° 15'E) on an *Arctotus* sp. as well as on 20 of 30 *A. calendula* plants that were examined. The biology of this weevil appears similar to that of *Rhytirrhinus inaequalis* (F.) (Scott and Way 1989).

5. *Subanguina mobilis* (Chit and Fisher) (Nematoda: Anguinidae)

The nematode, *S. mobilis* (= *Anguina mobilis* Chit and Fisher), was originally described from galls on *A. calendula* found in the arboretum of the Waite Institute in South Australia (Chit and Fisher 1975). It has not previously been recorded from South Africa (Keetch and Buckley 1984). We found the nematode on *A. calendula* at two of the study sites, and also collected samples from *A. prostrata* at Brenton-on-Sea (34° 04'S; 18° 30'E). The galls caused the leaves, stems and petioles to become distorted and stunted. Seedlings are infected and many generations can be completed during the life of the plant (Chit and Fisher 1975), although the effect on the plant is not known. The nematode oversummers as a third-stage larva in the dry galls (Chit and Fisher 1975).

Discussion

If biological control of *A. calendula* was deemed desirable then there exist within the original distribution of the weed a number of potential biological control agents. The most promising and the first priority for future research should be the stem boring weevil, *Stenotypus indignus*. This weevil is only known from capeweed and is damaging to the stems. The impact this has on seed production, an important aspect in the biology of this annual weed, is not known and would need to be considered. Other potential candidates, *Chrysolina fasciata*, *Cassida sphaerula*, and *Rhytirrhinus sordidus*, feed on capeweed, a number of *Arctotus* spp. and *Gazania linearis*. These plants belong to the Arctoteae, a tribe of the Asteraceae (Norlindh 1977). Thus it seems likely that *C. fasciata*, *C. sphaerula*, and *R. sordidus* will feed on other species of Arctoteae. This tribe comprises 16 genera and some 200 species mostly found in southern Africa (Norlindh 1977). The only indigenous representatives in Australia are two species of *Cymbonotus*, and these species would need to be tested in any subsequent biological control program. Horticultural species of *Arctotus* and *Gazania* have been introduced into Australia and would be at risk if the leaf beetles and *R. sordidus* were released as biological control agents. However, some of these plants e.g. *Arctotus stoechadifolia* Berg., are now weeds in Australia, and could be included in the control program.

The nematode, *S. mobilis*, was probably accidentally introduced from South Africa to Australia, perhaps at the same time as the weed. Nematodes have been used as biological control agents against weeds e.g. creeping knapweed, *Acroptilon repens* (L.) DC. (Watson 1978). The host specificity of *S. mobilis* is not known nor is its present distribution in Australia and these aspects would need to be considered in any future research.

The absence of specialist seed feeding insects excludes the possibility of attempting control of capeweed by reducing seed production. In this respect capeweed is very similar to another annual weed from South Africa, *Emex australis* Steinh. (Polygonaceae). Both weeds have one species of stem feeding weevil, and very few specialist phytophagous species from which biological control agents can be chosen.

Arctotheca calendula in South Africa is very variable (Norlindh 1977), and its distribution (Figure 1) covers an area much larger than that examined during this study. Additional biological control agents may be found if the search is extended to cover the entire range of the plant.

In conclusion, there are potential biological control agents against capeweed available for further study. However we would not recommend that agents be introduced into Australia unless it is clearly established that they are sufficiently host specific, and that biological and thus non reversible control of *A. calendula* is desired.

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References

Annecke, D.P., and Moran, V.C. (1982). 'Insects and mites of cultivated plants in South Africa.' p.383. (Butterworths: Durban.)

Arnold, G.W., Ozanne, P.G., Galbraith, K.A. and Dandridge, F. (1985). The capeweed content of pastures in south-west Western Australia. *Australian Journal of Experimental Agriculture* 25, 117-23.

Broom, D.M., and Arnold, G.W. (1986). Selection by grazing sheep of pasture plants at low herbage availability and responses of the plants to grazing. *Australian Journal of Agricultural Research* 37, 527-38.

Brain, C.K. (1924). Host plant index of South African scale insects (Coccidae) with a list of species found on each plant recorded. *Annale Universiteit van Stellenbosch Serie A* 2, 1-44.

Burry, J.N., and Kloot, P.M. (1982). The spread of Composite (Compositae) weeds in Australia. *Contact Dermatitis* 8, 410-13.

Chit, W., and Fisher, J.M. (1975). *Anguina mobilis* n. sp., a parasite of capeweed (*Arctotheca calendula*). *Nematologica* 21, 53-61.

Cordingley, C.L., and Danthanarayana, W. (1976). The lepidopterous fauna of capeweed (*Arctotheca calendula*) in Victoria with keys for larval identification. *Journal of the Australian Entomological Society* 15, 19-34.

Gess, F.W., and Gess, S.K. (1988). Terrestrial invertebrates: Insects. *In* 'A field guide to the eastern Cape coast', eds R. Lubke, F. Gess, and M. Bruton, p.520. (Wildlife Society of southern Africa: Grahamstown).

Keetch, D.P., and Buckley, N.H. (1984). A check-list of the plant-parasitic nematodes of southern Africa. *Technical Communication Department of Agriculture Republic of South Africa* 195, 1- 213.

Kloot, P.M., and Burry, J.N. (1982). Some botanical aspects of Compositae dermatitis in South Australia. *Australian Weeds* 2, 61-70.

Marshall, A.K. (1956). New African Curculionidae (Col.). *Annals and Magazine of Natural History Series* 12, 9, 833-52.

McIvor, J.G., and Smith, D.F. (1973). Plant factors influencing the nutritive value of some temperate annual pasture species. *Australian Journal of Experimental Agriculture and Animal Husbandry* 13, 404-10.

Millar, I.M., and Dürr, H.J.R. (1985). A list and host plant index of the aphids (Homoptera: Aphidoidea) of South Africa. *Entomology Memoir Department of Agriculture and Water Supply Republic of South Africa* 62, 1-38.

Myburgh, A.C., and Basson, S.G. (1961). *Tortrix capensana* (Wlk.) and *Epichorista ionephela* (Meyr.) as pests new to apples and pears (Lepidopt.: Tortricidae). *Journal of the entomological Society of southern Africa* 24, 348-9.

Norlindh, T. (1977). Arctoteae - systematic review. *In* 'The biology and Chemistry of the Compositae', eds V.H. Heywood, J.B. Harborne, and B.L. Turner, p. 831. (Academic Press: London.)

Powles, S.B. (1987). A review of weeds in Australia resistant to herbicides. Proceedings of the Eighth Australian Weeds Conference, Sydney, pp. 109-13.

Rayner, C.J., and Langridge, D.F. (1985). Amino acids in bee-collected pollens from Australian indigenous and exotic plants. *Australian Journal of Experimental Agriculture* 25, 722-6.

Schulze, B.R. (1984). 'Climate of South Africa Part 8 General Survey', Fifth Edition, p. 330. (Weather Bureau: Pretoria.)

Scott, J.K., and Way, M.J. (1989). Biology of *Rhytirrhinus inaequalis* (F.), a weevil associated with *Emex australis* Steinh. (Polygonaceae) in southern Africa. *Journal of the entomological Society of southern Africa* 52, 1-9.

Stephenson, D.W. (1982). Weed control in rapeseed crops in Australia. *Australian Weeds* 1, 12-6.

Taylor, J.S. (1949). Notes on Lepidoptera in the Eastern Cape Province (Part 1). *Journal of the entomological Society of southern Africa* 12, 78-95.

Taylor, J.S. (1957). Notes on Lepidoptera in the Eastern Cape Province (Part IV). *Journal of the entomological Society of southern Africa* 20, 313-32.

Velthuis, R.G., and Amor, R.L. (1982). Weed survey of cereal crops in south west Victoria. *Australian Weeds* 2, 50-2.

Watson, A.K. (1978). The biological control of Russian knapweed with a nematode. Proceedings of the IV International Symposium on Biological Control of Weeds, 30 August to 2 September 1976 Gainesville, Florida. Freeman T.E.(ed) Centre for Environmental Progress, Institute of Food and Agricultural Sciences, University of Florida, Gainsville pp. 221-3.