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A Comparison Between the Flower-Head Insect Communities of South African *Berkheya* and European Cynareae

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Abstract

Plant morphological complexity is known to correlate, positively, with the number of insect herbivore species on individual plant species. Morphologically-similar plant species are therefore expected to support similar numbers of herbivore species. To test this hypothesis, the insect herbivore communities feeding on the flower-heads of six *Berkheya* species, indigenous to South Africa, were compared to communities previously sampled on Cynareae species in Europe. The composite genus *Berkheya*, in the tribe Arctoteae, is the same family. Also, both *Berkheya* and Cynareae have species that are weeds. The survey showed that *Berkheya* flower-heads were colonised by more herbivore species than flower-heads of Cynareae with a similar geographical range. Numbers of generalist species correlated positively with the geographical range of the host plant species, but the number of specialist species colonising flower-heads followed no pattern and could therefore not be predicted. The taxonomic composition of the herbivore species on *Berkheya* and Cynareae differed significantly, but two insect genera, *Larinus* and *Urophora*, colonised both groups. *Larinus* appears to have diversified in association with *Berkheya* in southern Africa as it has on Cynareae in Europe. *Larinus* species are recommended for the biological control of *Berkheya* weeds because of their specificity. Significant differences in guild structure between the two groups was also observed. These differences in the herbivore communities appear to be due to their exposure to different herbivore species pools, as a result of their geographical separation.

Introduction

Flower-heads of thistles in the tribe Cynareae (Compositae) have a characteristic morphology and are easily recognised. In southern Africa, the genus *Berkheya* Ehrh. (Compositae) has a remarkably similar morphology to the Cynareae, and its species are also commonly known as "thistles". *Berkheya* is part of a separate composite tribe, the Arctoteae, which is almost entirely endemic to Africa (Norlindh 1977). A few Cynareae species are native while some other species are introduced in sub-saharan Africa, but most species are restricted to the Palaearctic region (Zwölfer 1988).

The morphological similarity of these two "thistle" groups, which are separated geographically, provides an opportunity to test current ecological theory about the influence of plant architecture on insect herbivore diversity. Lawton & Schröder (1978) proposed that as plants increase in size and structural complexity, so they support increasingly more diverse insect herbivore communities. Several examples demonstrate this relationship (Lawton 1983). A corollary of this hypothesis is that morphologically similar plants should support similar numbers of insect herbivore species. The flower-heads of *Berkheya* thistles from southern Africa and of Cynareae thistles from Europe, which have similar geographical ranges, are therefore expected to support similar numbers of insect herbivore species.

Cynareae and *Berkheya* flower-heads, when closely examined, have some slight differences which may be used to differentiate between very similar species. However, on a larger scale they appear similar, with many structures characteristic of composite flower-heads in common (Fig. 1).

The herbivore communities of *Berkheya* and Cynareae were compared initially by determining the total number of herbivore species on each plant species so that the main similarities and differences between the communities could be identified. Then, to examine

the herbivore communities in more detail, their taxonomic composition and guild structure was compared.

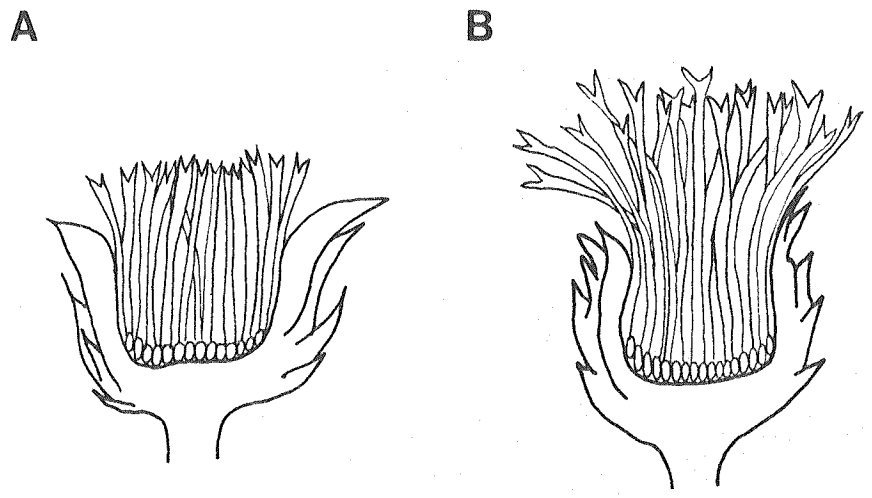

Figure 1. A generalised cross-section through the flower head of a *Berkheya* (A) and a *Cirsium* (B).

Materials and Methods

Mature flower-heads were collected from six *Berkheya* species found in the western and eastern Cape Province of South Africa: *B. bipinnatifida* (Harv.), *B. decurrens* (Thunb.), *B. heterophylla* (Thunb.), *B. onobromoides* (DC.), *Berkheya* sp and *B. rigida* (Thunb.). Flower-heads collected at each site were divided into two groups. One group was placed into an emergence box, the other group was frozen and dissected later. In the emergence boxes, adult insects, which had emerged from flower-heads, were attracted by light to a tube at one end of the box where they could be collected. The flower head dissections provided more specific information about feeding preferences.

Zwölfer (1965) collected accurate data on the herbivores of 59 Cynareae species during a comprehensive survey of Europe for potential biological control agents. Information about the flower head herbivores was extracted from this survey and used in the comparison with *Berkheya* insect communities.

Results and Discussion

Total Herbivore Species Numbers

Flower-heads of *Berkheya* have more herbivore species than Cynareae flower-heads which have been sampled a similar number of times (Fig. 2). Sampling frequency was used because no accurate information is available on the geographical range of the European Cynareae. According to Lawton & Schröder (1978), in their analysis of Zwölfer's (1965) data, in this example sampling frequency of the Cynareae does correlate with geographical range. Estimates of the area sampled for each Cynareae species, obtained from Zwölfer (1965), showed that those Cynareae sampled a similar number of times to the *Berkheya* species, had similar geographical ranges. The comparison of herbivore numbers could therefore be made using sampling frequency and not geographical range.

The larger number of herbivore species on *Berkheya* flower-heads is because there are more generalist species on these plants than on the Cynareae (Fig. 3). The number of generalist

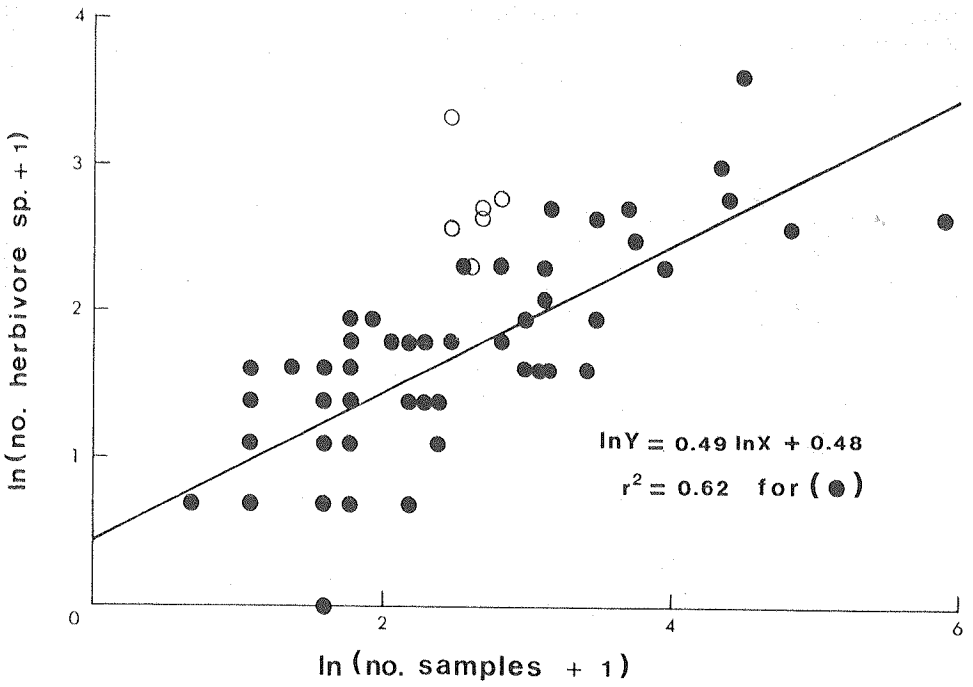

Figure 2. Relationship between number of sites sampled and number of insect herbivores recorded on various species of *Berkheya* (open circles) and Cynareae (closed circles).

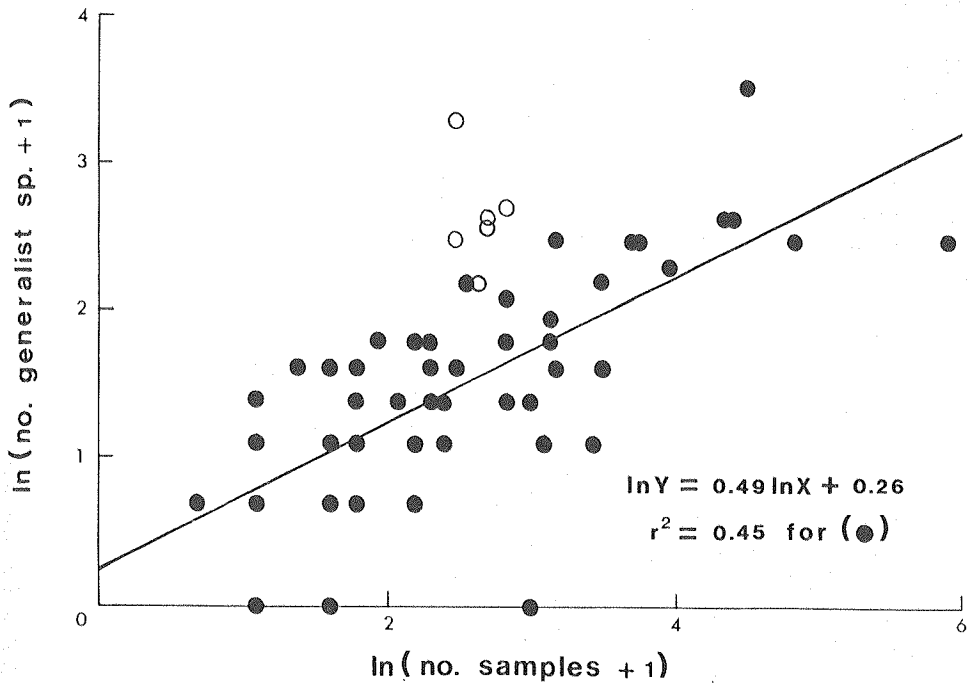

Figure 3. Relationship between the number of sites sampled and the number of generalist herbivore species recorded on various species of *Berkheya* (open circles) and Cynareae (closed circles).

species increased positively with the number of samples collected. Few specialist species attacked the flower-heads of either group and the number of species did not correlate with sampling frequency (Fig. 4). Each *Berkheya* species sampled had only one specialist herbivore species and numbers of specialist species on the Cynareae varied from nil to six.

Taxonomic Composition

There are major differences in the herbivore taxa found on *Berkheya* and on Cynareae (Table 1). No Hemiptera were recorded on Cynareae flower-heads, although they were found on the stems and leaves (Zwölfer 1965). No phytophagous Hymenoptera were found on *Berkheya* flower heads, but three species were recorded from six Cynareae species. In addition, the proportions of the taxa differed between plant genera within the Cynareae.

Table 1. Taxonomic composition of phytophagous insects that attack the flower-heads of *Berkheya* and selected genera of the Cynareae. Proportions are given in parentheses below the number of species.

Plant genus	Number of species in each taxon				
	Coleoptera	Lepidoptera	Diptera	Hemiptera	Hymenoptera
Berkheya	10	18	7	14	0
(6 species)	(0.20)	(0.37)	(0.14)	(0.29)	(0)
Arctium	1	3	3	0	0
(3 species)	(0.14)	(0.43)	(0.43)	(0)	(0)
Carduus	7	7	10	0	0
(8 species)	(0.29)	(0.29)	(0.42)	(0)	(0)
Cirsium	7	7	12	0	0
(15 species)	(0.27)	(0.27)	(0.46)	(0)	(0)
Onopordum	5	2	2	0	0
(2 species)	(0.56)	(0.22)	(0.22)	(0)	(0)
Centaurea	7	13	12	0	2
(16 species)	(0.21)	(0.38)	(0.35)	(0)	(0.06)
Carlina	2	4	1	0	0
(3 species)	(0.29)	(0.57)	(0.14)	(0)	(0)
Echinops	1	0	0	0	0
(2 species)	(1)	(0)	(0)	(0)	(0)

Two genera, *Larinus* (Coleoptera: Curculionidae) and *Urophora* (Diptera: Tephritidae), occurred in both *Berkheya* and Cynareae flower-heads. The taxonomy of *Larinus* in southern Africa requires revision, but initial observations suggest that each of the six *Berkheya* species sampled is attacked by a different *Larinus* species. The close evolutionary association of *Larinus* with the Cynareae in Europe is already well documented (Zwölfer *et al.* 1971, Zwölfer 1988). It is therefore remarkable that, in addition to its association with the Cynareae, *Larinus* appears to have diversified in a similar association with *Berkheya* in southern Africa. A survey of other *Berkheya* species will show the extent of this association. *Urophora agromyzella* Bezzi is the only *Urophora* species found on the *Berkheya* species sampled. Records kept at the National Collection of Insects, Pretoria, indicate that *U. agromyzella* is a generalist and has been recorded from other distantly-related composite

species. These records also show that other *Urophora* species have been recorded from the Compositae, therefore this genus is not confined to *Berkheya*.

Guilds

Feeding preferences of insect herbivore species on *Berkheya* and on Cynareae flower-heads differed significantly (Fig. 5). Because no Hemiptera attack Cynareae flower heads they have no sap-sucking insects, a guild that comprises 18.2% of the herbivore species on *Berkheya*. The specialist gall-forming species did not occur on *Berkheya* and this may reflect the low number of specialist feeders on this genus.

Each *Berkheya* species has only one species of internal chewer (*Larinus*) and external chewers and suckers form a large proportion of the herbivore species on these plants (Fig. 5). Strong *et al.* (1984) suggested that endophagous miners and gall-formers colonise at a slower rate than external chewing and sucking species. If Strong *et al.* (1984) are correct, then the herbivore community on *Berkheya* may be younger, in evolutionary terms, than on Cynareae. The Arctoteae are closely related to the Cynareae and were previously included in this tribe (Norlindh 1977).

The Arctoteae are not as diversified as the Cynareae with about 194 species (Norlindh 1977) compared to about 2,175 species (Tutin *et al.* 1976) respectively, which may mean that the Arctoteae is a younger group. However, it may also mean that there are fewer specialist species on *Berkheya* because the pool of potential colonisers is smaller in the Arctoteae than in the Cynareae.

Conclusions

Herbivore communities of *Berkheya* and Cynareae flower heads differed significantly, in spite of the morphological similarity of the flower heads. However, the hypothesis that morphologically-similar flower-heads have similar insect herbivore communities does hold for herbivore communities within each group (*Berkheya* and Cynareae) which showed closer affinities. The main differences between these groups may be due to their geographical separation. The effect of the different numbers of plant species and the different habitats found in each area would have a major effect on the herbivore species pool available for colonisation.

Because the number of specialist species colonising flower-heads followed no pattern, it is not possible for biological control workers to predict specialist species numbers in advance to help with their planning. *Larinus* species appear to be the only good candidates for the biological control of *Berkheya* species that are weeds because of their close association with this plant genus.

Acknowledgements

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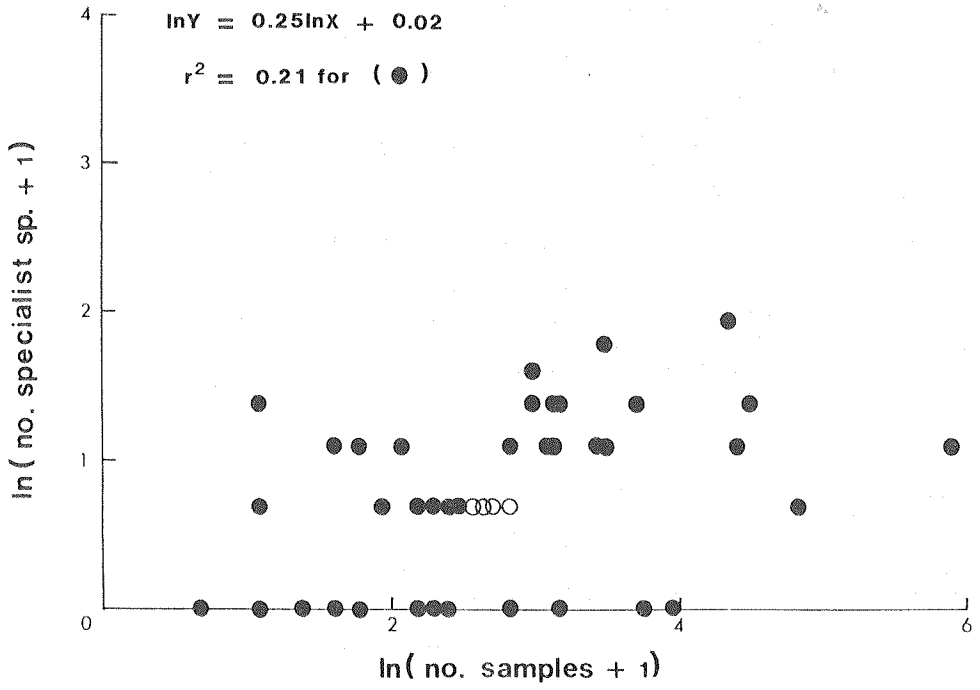

Figure 4. Relationship between the number of sites sampled and the number of specialist herbivore species recorded on various species of *Berkheya* (open circles) and Cynareae (closed circles).

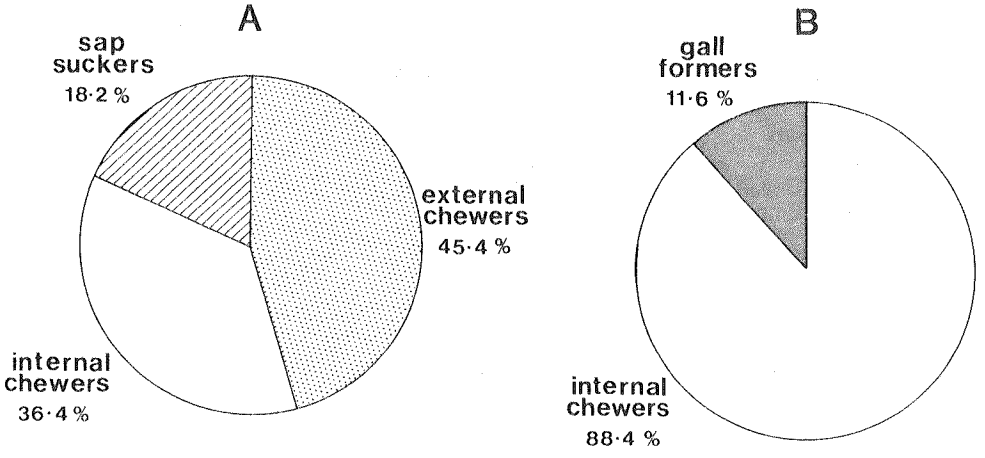

Figure 5. Pie diagrams showing the relative proportions of the major guilds of herbivorous insects that attack the flower-heads of (A) *Berkheya* and (B) Cynareae.