

CURRENT INVESTIGATIONS ON PHYTOPHAGOUS INSECTS ASSOCIATED
WITH THISTLES AND KNAPWEEDS

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Thistles and knapweeds belong to the tribe Cynareae (Cardueae) of the plant family Compositae. The geographic centre of this tribe is the Mediterranean area and western Asia and its distribution pattern is predominately a Palearctic one. Many members of the Cynareae are protected against grazing animals by spines on the leaves or flower-heads. Other Cynareae are well adapted to survive under conditions of primitive agriculture. Thus, the tribe provides a number of important weeds of pastureland and cultivated fields. These noxious weeds are mainly found within the genera *Cirsium*, *Carduus* and *Centaurea*, whilst weeds of less importance occur within the genera *Silybum*, *Onopordum*, *Cynara*, *Arctium* and *Carthamus*. During the course of the last two centuries many noxious Cynareae species colonized agricultural land in North America, South Africa, Australia, New Zealand and other areas where the native vegetation had been modified or destroyed by the introduction of European crop-plants and animals. Whilst in their Palearctic countries of origin a very rich and diversified complex of phytophagous organisms is associated with thistles and knapweeds, these plants sustain only relatively small numbers of insect species in the areas where they have been accidentally introduced. This situation prompted the Research Institute, Belleville, Ontario, Canada, to request the Commonwealth Institute of Biological Control for a survey of phytophagous insects attacking thistles and knapweeds in Europe.

As it was felt that a comprehensive inventory of insects associated with European Cynareae would form the best basis for any detailed study an extensive survey was sponsored by the Belleville Research Institute. This survey was started in 1961 and included all accessible Cynareae species. Preliminary results were published in 1965 (Zwölfer, 1965). The inventory of Cynareae insects and concomitant comparative studies on certain insect taxa closely associated with this tribe gave information as to principles governing the insect - host association in the tribe Cynareae: A considerable number of insect taxa co-evolved with their Cynareae hosts, i.e. they developed monophyletic groups which are entirely or largely restricted to this tribe. The "*Cassida vibex* group", *Sphaero-*

derma (both Chrysomelidae), *Larinus*, *Rhinocyllus*, *Bangasternus*, the subgenus *Lixochelus*, certain members of the Cleonini, the subgenus *Ceratapion*, species groups within the genera *Ceutorhynchus* and *Ceutorhynchidius* (all Curculionidae), *Urophora*, the tribe Terelliini (both Trypetidae), and *Metzneria* (Gelechiidae) may be cited as examples. A general trend in the evolution of Cynareae insects was the diversification of food niches. Whilst there is still a certain "niche overlap" to be found within insect genera feeding on the leaves of thistles and knapweeds (e.g. *Cassida* spp. (Zwölfer & Eichhorn, 1966), the separation of the "food niches" is complete in the insect genera living within the heads of Cynareae. There are many cases of i n t e r g e n e r i c competition among insect species attacking the heads of the same host species, but we could not observe i n t r a g e n e r i c competition among such insect species, since within the genera there exists a perfect ecological differentiation. Within the genus *Larinus* there are even cases where an ecological displacement leads to the formation of biotypes differing in their host selection (Zwölfer, in preparation). The means by which Cynareae insects avoid intrageneric competition are: a) geographic separation (allopatry) of the species or biotypes, b) association with different host species (allotrophy), c) seasonal differentiation of the feeding periods (allochryony), and d) attack of different parts of the host plant.

Comparative investigations on the host ranges of thistle and knapweed insects (Zwölfer, 1969) showed the existence of a number of definite "feeding patterns" which usually reflect the botanical relationship of the plant genera tested. Such feeding patterns (e.g. the "*Carduus-Cirsium-Silybum* pattern", the "*Centaurea-Cnicus-Carthusmus*" pattern, the "*Carduineae* pattern", the "*Carduineae-Centaureinae* pattern") were established during experimental feeding tests and were found to occur under field conditions in the natural host ranges of closely related insects. The establishment of feeding patterns facilitates screening tests with candidate insects for the biocontrol of noxious Cynareae and it may eventually also lead to the detection of feeding stimulants and deterrents.

Another result of this comparative study of thistle insects were observations on the territory and rendezvous behaviour of Trypetids associated with Cynareae hosts. The Trypetids studied show a high degree of intra- and inter-specific aggressiveness which affects the distribution patterns of the species. It could be shown that territory behaviour in male Trypetids is elicited by token stimuli of the host plant. The host plant serves as a

specific "rendez-vous place" for males and females. It thus operates as an isolation factor. Under laboratory conditions this sexual isolation can be overcome by bringing together males and females of different congeneric Trypetid species without their host plants. It is then easy to induce interspecific mating.

The Cynareae species of which the insect fauna has been studied in detail at the European Station are: *Cirsium arvense* (L.) Scop., *C. vulgare* (Savi) Ten., *Carduus nutans* L., *Centaurea maculosa* Lam., *C. diffusa* Lam. and *C. solstitialis* L. *C. arvense* has a very resistant system of creeping roots which have made it a cosmopolitan pest of agriculture. The present biological operations aim at the control of *C. arvense* in areas where it is already under environmental pressure (e.g. grassland on poor soil). The flea-beetle *Altica carduorum* Guer. (Karny, 1963; Harris, 1964; Zwölfer, 1965) and the weevil *Ceutorhynchus litura* F. (Zwölfer & Harris, 1966) have been studied in detail and were released in North America. The flea-beetle *Lema cyanella* L. (= *puncticollis* Curt.) is another highly specialized thistle insect which with *Sphaeroderma testaceum* F. may be considered as a candidate species for the biological control of *C. arvense* in Canada. Also highly host specific is the Trypetid *Urophora cardui* L., the biology of which is being studied in Canada (Peschken, in preparation).

C. vulgare is a biennial thistle which for its survival is entirely dependent on seed production. In Europe the widely distributed Trypetid *U. stylata* F. is an important enemy of this plant since it is capable of destroying a considerable proportion of the achenes. *U. stylata* is highly specific (Zwölfer, in preparation). It is likely to be released in Canada.

Carduus nutans is an important weed in some parts of North America, whilst in Europe it is of no or only minor economic importance. *C. carduus* is attacked by many phytophagous insect species. The weevil *Rhinocyllus conicus* Froel. feeds in the flower-heads, it is highly host-specific (Zwölfer, in preparation) and has been recently released in Canada and in the USA.

Centaurea maculosa is another biennial which is noxious in North America but harmless in Europe. Many specialized insects attack *C. maculosa* in Europe. Some of these can survive on safflower under laboratory conditions, hence they cannot be considered for transfer to North America. The flower-inhabiting Trypetid *Urophora affinis* Frfld. was

found to be specific enough (Zwölfer, in preparation) to warrant transfer to Canada. A seed-feeding Gelechiid of the genus *Metzneria* is at present being studied in detail (Englert, in preparation), and results available to date suggest that it may be a promising insect for control of *C. maculosa*.

C. diffusa is a weed of east European and west Asiatic origin. It is closely related to *C. maculosa* and has many phytophagous insects in common with this species. So far the most promising insect attacking *C. diffusa* is the Buprestid *Sphenoptera jugoslavica* Obenb. which is at present being studied at the European Station. Other possible insects for the biological control of *C. diffusa* are the fly *Pegohylemyia centaureae* Hennig and a gall-mite belonging to the genus *Aceria*.

C. solstitialis is a biennial weed of Mediterranean origin which has now a world-wide distribution. The European Station, CIBC, is studying the insect fauna of this weed on behalf of the University of California. The highly specialized, gall-forming Trypetid *Urophora siruna-seva* Hg. was studied intensively and transferred to California (Zwölfer, 1969), where it has now been released. At present studies are under way on a Trypetid belonging to the genus *Chaetorellia*.

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