CHAPTER 17

Chenopodiaceae

Economically important species are present in the genera *Beta* L., *Spinacia* L. and *Tetragonia* L.

Beta vulgaris **L.**

The species *B. vulgaris* includes several distinct cultivated types including sugar beet, garden beet, spinach beet and mangold. The small greenish flowers occur in clusters of two or three. Each has five narrow, incurved sepals, five stamens inserted at the base of the calyx lobes, an inferior ovary of three fused carpels containing a single ovule, and a short style with three stigmatic lobes (Fig. 17.1). The flowers open in the morning and, if the day is warm and sunny, the anthers dehisce before midday. Soon afterwards the pollen becomes dry and powdery and is dispersed by wind and insects. In most varieties the stigmatic lobes begin to open gradually in the afternoon and are not fully exposed until the following day or even 2 days later. The anthers may have shrivelled completely before the stigmatic lobes open. Hence there is usually pronounced protandry but, very rarely, anther dehiscence and opening of the stigmatic lobes occur simultaneously (Artschwager, 1927). The stigmas are reported to be receptive for 17 days at the beginning of the flowering season and 24 days at its end.

This figure is being redrawn.

Fig. 17.1 Flower of *Beta vulgaris,* beet (after Robbins, 1931, with permission of McGraw-Hill Book Company).

Not only does the behaviour of the flower usually favour cross-pollination, but self-incompatibility seems to be the general rule (Shaw, 1916). Following self-pollination the pollen grains germinate, even when the stigmas have not spread open, but the pollen tube growth rate is slow compared to that of foreign pollen and is soon greatly diminished or stops completely, usually failing to reach the ovules. Even when fertilization occurs the newly formed zygote soon degenerates. However, isolated plants sometimes set a limited amount of seed after self-fertilization and some highly fertile strains, which have pollen tubes that grow fast and the ability to undergo self-fertilization without degeneration of the embryo, have been selected (Archimowitsch, 1949; Savitsky, 1950).

Archimowitsch (1949) planted 300-600 genetically marked beet plants in the centre of a field occupied by plants of other crops and grew small groups of recessive beet plants at different distances and directions from the centre. The percentage of cross-pollination of plants in the small groups varied with their direction from the centre of the field and, in accordance with the direction and strength of the wind during flowering, but the average percentage of hybrids at various distances from the centre was: 0-80 m, 7.7%; 80-200 m, 1.2%; more than 200 m, 0.3%. Archimowitsch (1949) also tested the amount contamination was reduced by growing relatively tall plants (e.g. hemp and sorghum) between blocks of beet. When the plant screens were 6, 10 and 12-m wide the contamination between adjacent blocks was 17.1, 5.4 and 0.7%: hence a 12-m wide plant screen between blocks is equivalent to 200 m of open space. However, when the pollen source is more extensive and consists of a whole field of plants instead of a few hundred, contamination is likely to be much greater. Poole (1937) reported that cross-pollination can occur over a distance of several kilometres and, because all forms of *B. vulgaris* inter-breed freely, a system of zoning the different strains for seed production has been developed in the USA as the most practical solution.

The production of triploid hybrid varieties by crossing male-sterile diploids with male-fertile tetraploids (Hornsey, 1970) has emphasized the need for cross-pollination within the seed crop and the necessity of avoiding contamination from outside sources. It is sometimes considered to be more difficult to avoid contamination by insect-borne pollen than by air-borne pollen (Shaw, 1916). Scott and Longden (1970) pointed out that the slower diurnal release of pollen from the tetraploid than from the normal male fertile diploid flowers may allow contamination of the male-sterile flowers by pollen from diploids early in the day.

It seems to be generally supposed that wind pollination is important; sugar beet pollen has been collected 4500 m from a crop and at a height of 5000 m above it, although most airborne pollen occurs up to 750 m above ground level (Meier and Artschwager, 1938). In East Anglia, England, the average concentration of sugar beet pollen at about crop level during 24-h periods ranged from 170 to 12 400/m^3 (Scott, 1970).

Stewart (1946) grew isolated, recessive plants among a crop which consisted mostly of genetically marked plants, and enclosed part of each recessive plant in a cage whose walls allowed access to small but not to large insects. In each of two years the sets on the exposed and caged flowering branches of the recessive plants were similar. He concluded that his experiment indicated that wind alone is sufficient to effect the necessary transfer of pollen in a crop. Unfortunately, however, he did not record whether the exposed parts of the recessive plants were in fact visited by large insects and, as he pointed out, the role of thrips, and other small insects that could enter the cages, was not evaluated.

Indeed, other workers, and especially Shaw (1914), have stressed the importance of thrips in cross-pollinating sugar beet flowers. Shaw discovered that, although he 'emasculated and protected single flowers with paper bags, they still became fertilized, and he supposed that thrips were the only pollen-bearing insects that were small enough to gain entrance to the flower through gaps that occurred where the mouth of the paper bag was tied round the stem. When the cloth used to enclose beet plants was not closely woven, wind and thrips carried pollen between its meshes (Shaw, 1916). He collected thrips from flowers by exposing them to chloroform vapour and discovered that the most abundant species in Utah were *Heliothrips fasciatus, Frankliniella fusca, F. tritici* and *Thrips tabaci.* Thrips were also abundant in beet fields in Idaho, Indiana and Michigan. In some localities, in some seasons, they were especially numerous, and there were sometimes as many as five or six per flower. Both the larva and adult stages fed on the nectar and pollen and had averages of 40 and 140 pollen grains on their bodies. Pollen was transferred from one insect to another when they brushed against each other. Because thrips walked over all the parts of the flowers, including the stigmas, Shaw thought they probably contributed toward pollination and he made experiments to test this. When he freed flowers of thrips, emasculated and bagged them, none set seed, but when he introduced thrips from other flowers about 20% did so, which was similar to the percentage set of flowers not bagged. He obtained similar results in two other trials. However, in these experiments he actually transferred thrips from one flower to another, whereas the amount they cross-pollinate in natural conditions will depend on how often they move between flowers. He observed that this does in fact frequently happen and that the thrips carry pollen grains with them; it was very noticeable that thrips migrated away from blocks of beet that had ceased to flower onto other beet plants that were just beginning to do so.

Unfortunately, the value of thrips as pollinators is diminished by their tendency sometimes to injure the floral organs, particularly when they occur in such large numbers that the available nectar and pollen is insufficient to support them. Hence there is some doubt as to whether, on balance, they are beneficial, although it would certainly be interesting to discover whether there is any correlation between the abundance of thrips and seed production.

Treherne (1923) reported that in Canada, syrphids were the most abundant visitors to sugar beet and mangold flowers, but honeybees, solitary bees and various Hemiptera were also important and coccinellids were sometimes locally numerous. Archimowitsch (1949) classified insects that were possible pollinators of beet flowers in the Ukraine into the following groups: (a) those that suck sap, e.g. thrips and *Aphis fabae;* (b) those that are attracted to plants by the presence of *A. fabae,* e.g. ladybird beetles *{Coccinella septempunctata)* and their larvae, and ants; (c) those that eat pollen, e.g. beetles of the genera *Zonabris, Leptura* and *Cerocoma;* (d) those that collect nectar only, e.g. the wasp fly *Sphaerophoria scripta;* (e) those that collect both nectar and pollen, e.g. the honeybee, *Andrena* spp. and *Halictus* spp. Popov (1952) observed that solitary bees belonging to the Halictidae, Megachilidae, and Anthophoridae were the most abundant visitors to beet flowers.

In England, during three consecutive years, Free *et al.* (1975b) recorded 129 insect species visiting sugar beet flowers. The most abundant insects were the Cantharidae, Coccmellidae, Syrphidae, Larvaevoridae, and Muscidae. However no species was consistently abundant and there was great variation in the numbers and kinds of insect present on different fields and in different seasons, probably reflecting both the presence of alternative floral sources in the vicinity and the differential effect of changing weather conditions.

In suiptable weather, most insects were on a crop between 10.00 and 16.00 h, the peak number occurring between 12.00 and 15.00 h, ie. at a similar time to that of airborne pollen. On days when there was relatively little pollen in the air the number of insects present was no less than on days when abundant pollen was present.

Few of the insects examined carried no pollen grains, and on average individual insects of the families Cantharidae, Elateridae, Apidae, Empididae and Syrphidae each carried more than 5000 pollen grains, and so probably made a considerable contri-bution to pollination. The Syrphidae and Larvaevoridae were more numerous than other insects, carried more pollen on their bodies, readily flew from plant to plant and so were probably the most important cross-pollinators in seed production; however they also carried a large proportion of pollen that was not from sugar beet, probably reflecting their mobility and foraging range and so could be a source of any contamination between seed crops and by pollen of wild beet.

Tetraploid plants produce fewer and larger pollen grains than diploid and pollen is less readily released by the anthers (Scott and Longden, 1970). Insect pollination is therefore probably more important for hybrid than normal seed crops, especially on days when the relative humidity is high and little pollen is airborne while insect activity is unaffected.

Archimowitsch (1949) pointed out that, although honeybees are reluctant to visit beet, they will do so in large numbers when no other sources of nectar and pollen are available to them. Mikitenko (1959) also found this, and obtained data suggesting that bee visits may increase yield. In contrast Aleksyuk (1981) found that honeybees foraged infrequently on sugar beet, and estimated that honeybees are responsible for only about 4% of the total pollination. In England, very few honeybees were observed foraging on sugar beet crops, although those that did so carried much sugar beet pollen on their bodies (Free *et al.,* 1975). It seems unlikely that movement of honeybee colonies to crops of sugar beet would benefit pollination especially when more favoured sources of forage are available.

Spinacia oleracea **L.**

The flowers of *S. oleracea,* spinach, are unisexual; male and female flowers are usually on separate plants but occasional monoecious plants do occur. The female flower has a two- to four-lobed perianth, four to five short styles and an ovary with a single ovule. The male flower has four to five perianth segments and four to five stamens which -produce abundant pollen. Because the flowers of a single plant open over several days and a stamen does not shed all its pollen on one day, the pollen is available over a long -period. Cross-pollination, probably by wind, can occur over considerable distances and it is recommended that varieties being grown for seed should be separated by 1.6 km or more (see Hawthorn and Pollard, 1954). Any insects that contribute to cross-pollination presumably collect nectar as pollen-gatherers would probably tend to confine their visits to male plants.

Tetragonia expansa **Murr**

T. expansa, New Zealand spinach, has small greenish-yellow perfect flowers, with four perianth segments, numerous; stamens and an ovary with several ovules. No information about its pollination could be found.