Distribution and dispersal of *Urophora cardui* (Diptera, Tephritidae) in Finland in 1985–1991

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Urophora cardui (Linnaeus) was reported for the first time from Finland in 1981, from the city of Helsinki. During the years 1985–1991 the distribution and dispersal of the species was monitored by searching for galls which the fly larvae cause on stems of the thistle *Cirsium arvense*. In 1986 galls were observed at a distance of 18–36 km from the center of Helsinki, and by 1991 the distance had increased to 37–55 km along the main roads. Annual dispersal of the fly was found to correlate strongly with the warmth of summers: after a cold summer the area occupied by the fly actually decreased, but in a warm summer new galls were found up to 16 km further from city center than the year before.

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1. Introduction

Urophora cardui (Linnaeus) is a univoltine fly which is a highly specialized gall-maker in stems of the creeping thistle, *Cirsium arvense* (Linnaeus) Scopoli. Under laboratory conditions the life cycle of the fly is as follows (Lalonde & Shorthouse 1984): The female lays up to 11 eggs per oviposition among the immature leaves of the thistle; the eggs hatch in 7–10 days, and the larvae tunnel down into the stem; externally observable gall growth can be seen 12–20 days after oviposition, and the gall grows for about 30 days, finally becoming hard and woody. Each larva has its own chamber in the gall, and the larvae spend the remainder of the summer, as well as the following fall and winter, inside the gall in a dormant state at third instar. The dormancy is broken, and the larvae pupate in the spring when the callus tissue of the gall disintegrates, and air enters the chamber; the pupal stage lasts about 25 days. Under natural conditions developmental time is obviously somewhat different depending on prevailing temperatures.

In Central Europe maturation of the galls takes some 60–70 days, and because the flies emerge in early to mid June (Zwölfer 1979, Schlumprecht 1989), the galls are mature from mid August on. In Finland, *U. cardui* adults fly in July, and considering that here the development of the larvae is somewhat slower than in Central Europe, the first mature galls would be ready by the end of September.

The galls affect *Cirsium* by reducing its flowering. For this reason, *U. cardui* has been imported to Canada as a potential biocontrol agent (Peschken & Harris 1975, Peschken & al. 1982). On the other hand, at least in Finland *C. arvense* already has begun to flower in July, and the

effect of *U. cardui* is not visible until August; therefore the fly does not seem to be very effective as a biocontrol agent here (cf. also Laing 1982, Peschken 1990).

During the past 30 years *U. cardui* has dispersed northward in Europe: the first record from Estonia was as recent as 1960 (Elberg 1962, six localities), and in 1982 a Finnish expedition collected the species and observed it to be abundant in the Lahemaa Rahvuspark conservation area on the north coast of Estonia (Albrecht, pers. comm.). The first record from Finland was in 1981 from Helsinki (Jansson & Lindeberg 1982), and as the fly has been found to range within only a fairly small distance from Helsinki, the origin of this dispersal must have been in Estonia. In the first report from Finland the host plant was erroneously given as *Artemisia vulgaris* Linnaeus. Older literature gives both *Artemisia* and *Cirsium* as host plants of *U. cardui* (cf. Peschken & Harris 1975), but all the galls found during the present study were on *C. arvense*, and the only other certified host plant is *C. creticum* (Lamarck) D'Urville in Greece (Zwölfer 1988).

As the number of occasional observations of galls on *Cirsium* increased rapidly in the early 1980's, an announcement of a search for these galls was published (Jansson 1985), and a preliminary field mapping was carried out. The results of this first attempt indicated that the fly occurred in a rather limited area around Helsinki, and its dispersal would be easy to follow.

2. Material and methods

As the galls caused by the fly are very conspicuous (Fig. 1), their presence is rather easy to observe in the fall. The galls are located either on the main shoot of the thistle or, perhaps more often, on axillary shoots of the plant. Annual mappings were carried out in October, when about half of the galls are still green and clearly visible (hardened dark galls are more difficult to detect). A rather detailed search for the galls was carried out in 1986–1989. By 1990 the area occupied by the fly had increased so much that its further dispersal was followed only along the main highways.

During the search, at least two persons were inspecting the thistles. A location was considered negative when no galls were found on at least 200 thistle stems inspected by each observer (in most cases many more). Negative observations were in most cases confirmed by surveying one or two locations a few kilometers further on. In consecutive years, the outermost locations of the previous year were always checked (and almost always found positive) before extension of the search.

Fig. 1. Average size of the *Urophora cardui* galls on the thistle *Cirsium arvense,* 1:1. — Photo R. Tyynelä.

3. Results

Fig. 2 shows the results of the annual mappings (excluding the year 1991).

1985: The preliminary survey revealed that galls occurred inside the Ring III road surrounding the city at a distance of 15–20 km from city center; one location about 25 km north of city center was also found along road number 130. Negative observations were made in various directions at distances of 20 km and more, but the mapping was not very detailed during this first year. The fly was, however, found in seven of the 10×10 km squares, in altogether 14 locations.

1986: A detailed mapping gave positive finds at distances varying from 20 to 35 km from city center. In the east (along road number 7) and in the west (road 51) galls were found in areas which were negative in 1985. The number of squares in which the galls were observed increased to 14, with 23 new locations.

1987: Dispersal had advanced a further 0 to 10 km. The strongest advance occurred in the east (road 7) and in the north (between roads 3 and 4), while elsewhere the dispersal had stopped or advanced only slightly. The number of squares increased by only four, with 18 new locations. In the direction of road number 120 the fly had reached the province *Ab*.

1988: Dispersal had nearly stopped. Only five new locations were detected, and from three of the previous year's locations the fly had actually disappeared. The number of squares decreased by one to 17.

1989: A real boost in dispersal occurred in the southwestern and western areas: 12–14 km. Elsewhere dispersal advanced 4–10 km. The number of squares increased to 28, with 40 new locations.

1990: Dispersal was monitored only along the main roads, where it had advanced 5–10 km (19 new locations), except on road number 1, where a gall was found at the same site as the year before but not any further. The number of squares increased to 33, but had the mapping been done in more detail, the galls would probably have been found in close to 40 squares.

1991: The monitoring was repeated only along the main roads, and the dispersal had advanced 2–16 km (28 new locations), except on road number 7, where a gall was found at the same site as the previous year, but not any further. In the direction of road number 132 the fly had reached the province *Ta*.

Table 1 gives the observed distances along the main roads of the area measured from the center of Helsinki to the most remote records in 1986, and the changes observed in 1987–1991. Annual extension of distributional area varied from zero to 16 km (mean of positive changes 6.9 ± 4.2 km; $n = 26$).

4. Discussion

In Finland, where *U. cardui* reaches the margin of its distribution, differences in its dispersal between years correlate very well with warmth of the summers (Fig. 3), but with a one-year delay: 1987 was a very cold summer, but yet dispersal reached up to 10 km from the previous year records. However, the larvae evidently did not reach a mature stage for overwintering in the most peripheral areas where the eggs by necessity had been laid later (i.e. after the adult flies had reached that far) than in areas occupied already in the previous year. Therefore, even though 1988 was a warm summer, the distributional area of the fly actually decreased. On the other hand, during the warm 1988 summer the population recovered very well, and as 1989 was another warm summer, a real boost occurred then. Early summer low temperatures do not seem to have much effect: 1991 was cold until the end of June, but as the fly is in the adult stage in July, relatively warm July–September weathers seem to balance the situation.

Table 1. Distances (km) of most remote records of *Urophora cardui* from central Helsinki in 1986 along main roads (Fig. 2), with changes 1987–1991.

Road:	51	1	120&2	132	3	4	7	Mean
1986	23	22	20	29	36[a]	28	18	25.14
1987	0	+3	+10	+5	0	+3	+9	+4.28
1988	0	0	-5	+2	0	0	0	-0.43
1989	+12	+14	+8	+4	+9[a]	+4	+4	+7.86
1990	+7	0	+2[b]	+2	+7	+4	+6	+4.00
1991	+2	+16	+14	+10	+3	+11	0	+8.00

[a] Record between roads 132 and 3.
[b] +9 if measured by the records along road 2 from road 1.

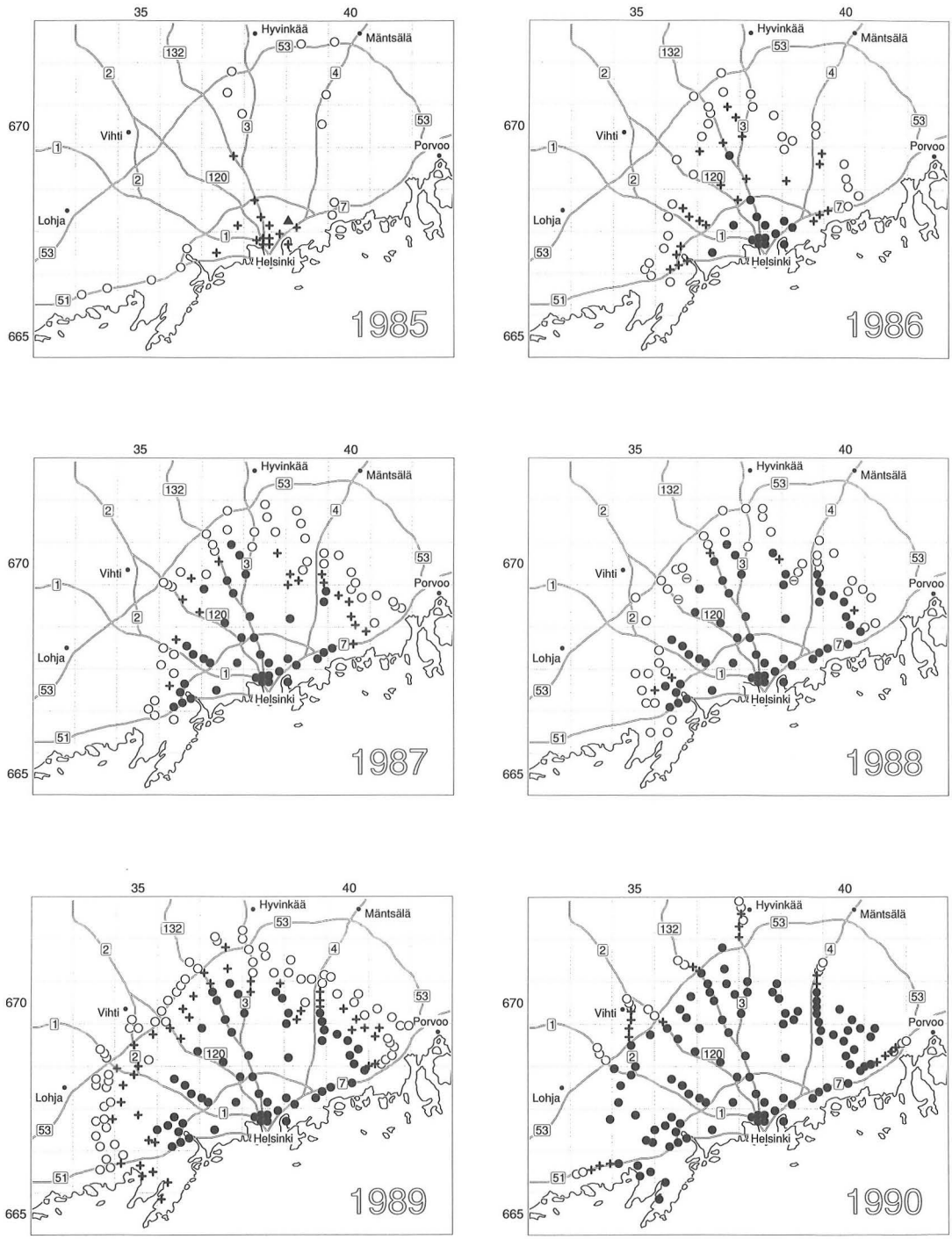

Fig. 2. Dispersal of *Urophora cardui* in Finland 1985–1990. Symbols: ▲ = the site where the fly was recorded for the first time in Finland; + = annual new records; ● = records from previous years; ⊖ = sites where the fly had been observed in 1987, but not in 1988; O = sites where no galls were observed. The map shows the main roads of the area (with their official numbers) and the 10×10 km squares based on grid 27°E.

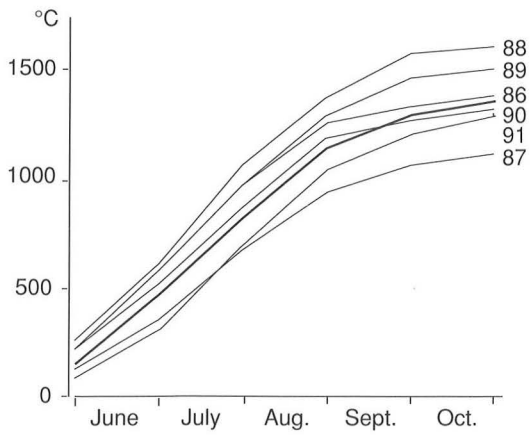

Fig. 3. Sum of effective temperature at Vantaa airport, square 669:38. Long-term average (thick line) and the years 1986–1991.

Dispersal of *U. cardui* has been monitored elsewhere also by observing the presence of galls on *C. arvense*. In Central Europe the distribution of *U. cardui* is patchy, although *C. arvense* is common throughout the area (cf. Seitz & Komma 1984, Hultén & Fries 1986). Artificial releases have shown that the fly can colonize new areas successfully, but the dispersal ability of such populations has been found to be rather poor: only a mean of 100 m/year in one case (Zwölfer 1982) or a mean of 2.6 km/year with a maximum of 4.0 km in another (Schlumprecht 1989). When introduced to Canada, the fly's fastest dispersal was found to be 4 km in five years (Peschken & al. 1982). Thus, in favourable years the dispersal seems to be really rapid in Finland (Table 1). Zwölfer (1982) reported that parasites cause a mortality of 90% in *U. cardui* in Central Europe, and a lower level of parasitism (only 10.1 % in a sample of 414 larvae and pupae exported to Canada in 1985; Peschken pers. comm.) may explain part of the dispersal advantage of the Finnish population. This same reason does not, however, apply in comparison to the Canadian populations which have no parasites (excluding the New Brunswick population which is parasitised, cf. Peschken 1990).

In the coming years it will be interesting to see how far north *U. cardui* is able to disperse in Finland: *C. arvense* is common up to about the level of Oulu, some 500 km north of Helsinki (Hultén 1971), but the limiting factor for *U. cardui* is probably the sum of effective temperature for the growing season, as was already indicated by the 1987-88 mapping results.

In Central Europe, *U. cardui* has four Hymenopteran parasitoids (Schlumprecht 1990): the monophagous endoparasitoid *Eurytoma serratulae* Fabricius, and the non-monophagous ectoparasitoids *E. robusta* Mayr, *Torymus chloromerus* Walker and *Habrocytys elevatus* Walker. Of these, *E. robusta* has not thus far been found in association with *Urophora cardui* galls in Finland, but all the others have been obtained from these galls (Veli Vikberg, pers. comm.). It is of particular interest that the monophagous *E. serratulae* has been recorded from Finland: the species must have crossed the Gulf of Finland soon after its host, and thus seems to have a dispersal ability equal to that of its host (cf. Schlumprecht 1989).

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