Distribution and seasonal activity of adult carrot rust flies (Diptera: Psilidae)

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The carrot rust fly, *Psila rosae* F., is a major pest of carrots, *Daucus carota* L. (Apiaceae), in the principal production areas of Newfoundland, Quebec, Ontario, and British Columbia (Boivin 1994), as well as in temperate Europe and New Zealand (Ellis and Hardman 1992). Larvae cause damage by tunneling into the roots (Boivin 1994), reducing both yield and marketability. The insect was first recorded in Canada in 1885 but was not reported in Newfoundland until the 1930s (McClanahan and Niemczyk 1963). By the 1950s, *P. rosae* had spread from an initial infestation around St. John's to commercial farms and home gardens throughout the carrot-growing areas of Bonavista and Conception bays in eastern Newfoundland (Boivin 1994).

The number of generations and the timing of adult emergence vary according to climate; for example, *P. rosae* has three generations per year in British Columbia (Judd and Vernon 1985) and two in Ontario and Quebec (Stevenson 1981; Boivin 1987). Degree-day (°d) summations have been used to predict spring emergence of adult *P. rosae* in British Columbia (Judd and Vernon 1985), Ontario (Stevenson 1981), and Quebec (Boivin 1987). In Newfoundland, the distribution of *P. rosae* has not been assessed since the 1950s and little is known about its seasonal activity. Information on degree-day requirements from other provinces may not be applicable to Newfoundland due to differences in climate and soil type, which could affect *P. rosae* development. The objectives of this study were (*i*) to determine the seasonal activity of *P. rosae* and relate adult emergence to degree-day accumulations and (*ii*) to assess the distribution of the pest in Newfoundland.

Fieldwork was carried out in 1995 and 1996. To assess degree-day requirements, adult *P. rosae* were monitored in 11 commercial carrot fields and home gardens in the St. John's area (47°37′N, 52°45′W). Study sites, which varied in cultural practice and size, were selected according to the likely presence of *P. rosae* populations based on past infestations, occurrence of sheltered areas, and records of previous carrot production. For *P. rosae* monitoring, four-sided marigold–yellow cardboard traps, which measured 12 × 6 cm per side and had been coated with Tanglefoot™, were positioned 30 cm above the soil level. A variable number of traps was placed at each of the 11 sites in early June and monitoring continued throughout the season until carrot harvest. A total of 24 traps was used each week; however, trap density, typically at 120 traps/ha, varied according to the size of the area in production. Traps were placed only along the edges of small garden plots or 2 m inside the perimeter of larger fields, close to

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probable shelter sites (Boivin 1987). Each week the traps were monitored, *P. rosae* on the traps were identified (Steyskal 1987), the number captured was recorded, and traps were replaced. For each site the total adult catch per trap was calculated. The mean ± SE weekly catch (mean number of adults captured per trap on a weekly basis) was calculated using data from all sites.

Daily maximum and minimum air temperatures were recorded by Environment Canada at the St. John's Airport and at the Atlantic Cool Climate Crop Research Centre of Agriculture and Agri-Food Canada in St. John's. All monitoring sites were within a 15-km radius of one of the two weather stations. Temperatures from the stations were averaged and then used to calculate the degree-day accumulations using Arnold's standard formula (Arnold 1960):

$$\frac{(\text{max.}\,T - \text{min.}\,T)}{2 - \text{base}\,T} \qquad [1]$$

We used a threshold temperature of 3°C (°d_3) because other studies indicated that it gave an accurate result for the first trap catch of the first generation (Stevenson 1983). A threshold of 5°C (°d_5) was also used to allow for a comparison between seasonal events of *P. rosae* in Newfoundland and in Ontario (Stevenson 1983). To determine the starting date that would provide the most appropriate estimate, we calculated degree-day accumulations from 1 March to compare the results with Ontario and British Columbia and from 1 April to compare the results with Quebec. Little accumulation above 3°C was expected to occur in Newfoundland before 1 May, so accumulations starting 1 May were also used.

To determine species distribution, adult *P. rosae* were monitored in carrot-growing areas at 18 sites across the province. Sites were monitored using four-sided marigold–yellow traps as described above. Traps were supplied to commercial growers and home gardeners who were trained to install them in the field at the time of crop emergence. Traps were changed weekly and the used traps wrapped in waxed paper, dated, and mailed to the authors for examination. *Psila rosae* on the traps were identified (Steyskal 1987) and the number present was recorded.

Trapping results for both years indicated one peak in mid-July and a second smaller peak in September (Fig. 1). There was a large variance in the total flies captured at each site, which may be attributed to the small sample size or to site variation. In 1996, peaks probably reflect the first and second generations, respectively; however, in 1995 there was only one *P. rosae* trapped after 30 August and degree-day accumulations indicate that this was likely a fly from the first generation. It appears that, in Newfoundland's climate, there are usually two generations of *P. rosae* each year, which is comparable with other carrot-growing provinces that consistently sustain two (Stevenson 1983; Boivin 1987) or three generations annually (Judd and Vernon 1985); however, in 1995 the climate was too cool for the second generation.

Comparison of the calendar dates to the °d_3 accumulated from 1 April indicated that the first adults were trapped in mid-June at 307.9 ± 60.1°d_3 and the peak adult catch for the first generation in mid-July corresponded to 589.5 ± 50.2°d_3. The smaller peak of the possible second generation in late September 1996 corresponded to 1259.8°d_3. These results are similar to those reported for the earliest capture of first generation flies by Boivin (1987) in Quebec (361.8 ± 33.1°d_3) and Judd and Vernon (1985) in British Columbia (381 ± 26°d_3). Accumulations at °d_5 beginning 1 April were calculated to allow for a comparison between seasonal events of *P. rosae* in Newfoundland and in Ontario. The first adults were trapped in mid-June at 199.9 ± 55.7°d_5, similar to the degree-days reported by Stevenson (1983) for the earliest capture in Ontario (258 ± 1.5°d_5). Although the flies have similar degree-day requirements for emergence

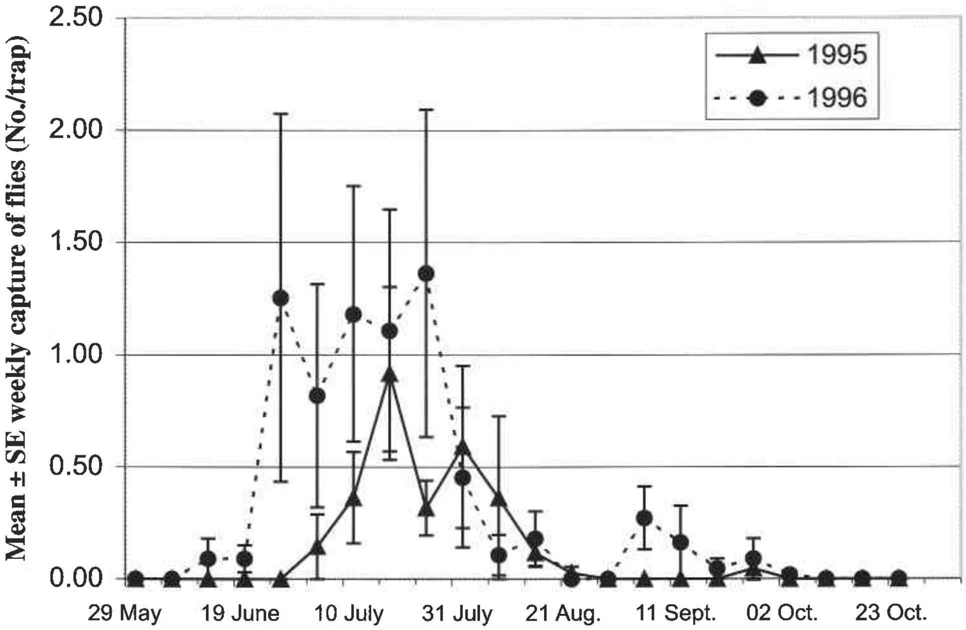

FIGURE 1. Mean ± SE weekly catch of adult *Psila rosae* on yellow sticky traps in 1995 and 1996, St. John's, Newfoundland.

in Newfoundland and other provinces, actual calendar dates for emergence are earlier in Quebec and Ontario (16 May to 1 June), owing to their warmer springs.

Accumulations at °d_3 beginning 1 April were calculated for 1986–2000 (1998 not available) using weather data from the Atlantic Cool Climate Crop Research Centre of Agriculture and Agri-Food Canada in St. John's. These degree-day accumulations were compared with the results from the St. John's area in 1996 and 1997. Calendar dates were matched to degree-day accumulations for first capture, peak adult catch for the first generation, and peak adult catch for the second generation. In addition, this information was converted to Julian days and the average Julian days and standard deviation calculated for the various events. The first capture in the spring was expected around 310°d, which over 14 years occurred on 18 June (±6.95 d), although actual calendar dates ranged from 5 June (1999) to June 25 (1995, 1997). Peak adult catch is expected around 590°d, which over the same period occurred on 14 July (±7.26 d), although actual calendar dates ranged from 1 July (1999) to 27 July (1991). The second-generation peak of *P. rosae* is more variable over the same period. An accumulation of 1260°d occurs on average on 4 September (±13.68 d) and the calendar dates ranged from 13 August (2000) to 27 September (1993). Given the variability in degree-day accumulation over the 14-year period and the accumulation of sufficient degree-days in 12 of 14 years, we would speculate that a second generation would occur 80% of the time. The first instar of *P. rosae* feeds on the carrot radicles and it is only the second instar that enters the main root. Until this happens, no damage is done. After the second instar is in the root, the damage is done even after the carrot is harvested. The potential damage to the crop from the larvae of the second generation is less variable because the later in the season the adults peak the later the larvae begin to damage the crop. As the larval stage lasts for a minimum of 6 weeks (McKinlay 1992) and harvest usually occurs in mid-September, we speculate that the second generation would have the potential to damage the crop only about 50% of the time because sufficient degree-day accumulation for a second generation does not occur until after 1 October in 7 of the 14 years studied.

In the distribution part of the study, adult *P. rosae* were trapped in St. John's, Marystown, Lethbridge, Bishop's Falls, Springdale, and Cormack. Adult *P. rosae* were not trapped in carrot-growing areas on the west coast around Codroy or in Labrador. Therefore, in the 40 years since the last distribution data, *P. rosae* has spread throughout most of the carrot-growing areas of Newfoundland.

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Arnold CY. 1960. Maximum–minimum temperatures as a basis for computing heat units. *Journal of the American Society for Horticultural Science* **76**: 682–92

Boivin G. 1987. Seasonal occurrence and geographical distribution of the carrot rust fly (Diptera: Psilidae) in Québec. *Environmental Entomology* **16**: 503–6

——— 1994. Carrot rust fly. pp 77–8 *in* RJ Howard, JA Garland, WL Seaman (Eds), *Diseases and pests of vegetable crops in Canada: an illustrated compendium.* Ottawa, Ontario: The Canadian Phytopathological Society and The Entomological Society of Canada

Ellis PR, Hardman JA. 1992. Pests of umbelliferous crops. pp 327–78 *in* RG McKinlay (Ed), *Vegetable crop pests.* Boca Raton, Florida: CRC Press Inc

Judd GJR, Vernon RS. 1985. Seasonal activity of the adult carrot rust fly, *Psila rosae* (Fab.) (Diptera: Psilidae) in the lower Fraser Valley, British Columbia. *The Canadian Entomologist* **117**: 375–82

McClanahan RJ, Niemczyk HD. 1963. Continuous rearing of the carrot rust fly, *Psila rosae* (Fab.). *The Canadian Entomologist* **95**: 827–30

McKinlay RG. 1992. Vegetable crop pests. Boston, Massachusetts: MacMillan Press Ltd

Stevenson AB. 1981. Carrot rust fly: monitoring adults to determine whether to apply insecticides. *Journal of Economic Entomology* **74**: 54–7

——— 1983. Seasonal occurrence of the carrot rust fly (Diptera: Psilidae) adults in Ontario and its relation to cumulative degree days. *Environmental Entomology* **12**: 1020–5

Steyskal GC. 1987. Psilidae. pp 781–4 *in* JF McAlpine (Ed), *Manual of Nearctic Diptera.* Volume 2. Research Branch, Agriculture Canada, Monograph No. **28**

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