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Flight behaviour of the aphid *Myzus persicae* during its maiden flight

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Abstract

The assumption that the first flight of aphids from their secondary host is several kilometers long, followed by short hops, is mainly based on research done with *Aphis fabae*. The validity of these observations has not been proved satisfactorily in the case of the peach aphid *Myzus persicae*. By using radiolabelled aphids their behaviour during the maiden flight was studied. The results indicate that the first flight can be as short as 1 to 100 m, which might have consequences for our views on the spread of viruses in the crop.

Additional keywords: autoradiography, ^{32}P, radiolabelling, seed potatoes, PVY^N, aphid traps.

Introduction

A number of virus diseases in seed potatoes are transmitted by several aphid species. Transmission of non-persistent viruses like potato virus Y^N can occur by both 'residents' and 'non-residents'. From the first group *Myzus persicae* is considered to be the most important vector. After completion of their teneral development alate aphids take off from a primary or secondary host under favourable weather conditions (Johnson *et al.,* 1957) for a long-distance maiden flight, followed by a brief erratic phase in which the aphids try to find a suitable host plant (Fig. 1a). It is assumed that at least during the first part of a maiden flight alate *M. persicae* are attracted by U.V. light, activating them to ascend quickly. After a long flight they are inclined to alight and as they have a preference for green and yellow parts of the light-spectrum they tend to select surfaces in these colours in their final landing phase (Hille Ris Lambers, 1972). Viruses can be picked up from a diseased secondary host either shortly before the beginning of the main flight, which can last for hours (Kennedy and Booth, 1963) or during probing between attack flight and settlement.

The second group comprises about a dozen aphid species other than *M. persicae.* Although these aphids are in general less efficient virus vectors they may seriously contribute to the spread of non-persistent viruses in years of early flight (Van Hoof, 1980). One can only speculate about the distance over which a non-persistent virus is spread by this group of aphids.

Van Hoof (1979) found spread of PVY^N in early flights to occur over relatively short distances from a virus source. Alate aphids of various non-resident species may have picked up virus which is then transmitted to the crop. A different situation

Fig. 1a. Flight behaviour of aphids as generally accepted.
Fig. 1b. Possible flight behaviour of *Myzus persicae* under less favourable weather conditions.

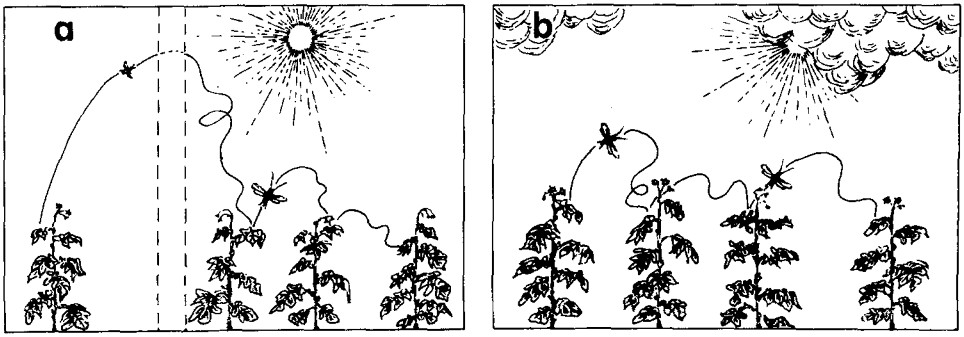


Fig. 1a. Vlieggedrag van bladluizen zoals algemeen aangenomen.
Fig. 1b. Mogelijk vluchtgedrag van Myzus persicae onder minder gunstige weersomstandigheden.

is expected concerning transmission of PVY^N by colonizing aphids such as *M. persicae,* known to cover long distances (Johnson, 1953). Van Hoof, however, found spread of PVY^N over short distances to be predominant in July 1978, when *M. persicae* was mainly present as a vector. These facts would suggest that even after first take-off following the last moulting short hovering flights are no exception (Fig. 1b).

Taimr and Křitž (1978) using radiolabelled aphids found part of a population of migratory *Phorodon humuli* to fly over short distances low above the ground. Kennedy *et al.* (1959) in their study on *Aphis fabae* stated that repeated alighting, brief probing and re-take-off from hosts and non-hosts is common practice among migrating aphids. The aim of our research was to find out whether *M. persicae* can perform short flights immediately after take-off and if so, what proportion of aphids makes hovering flights after take-off. A positive answer to the first question would have serious implications with regard to the technique of seed potato growing.

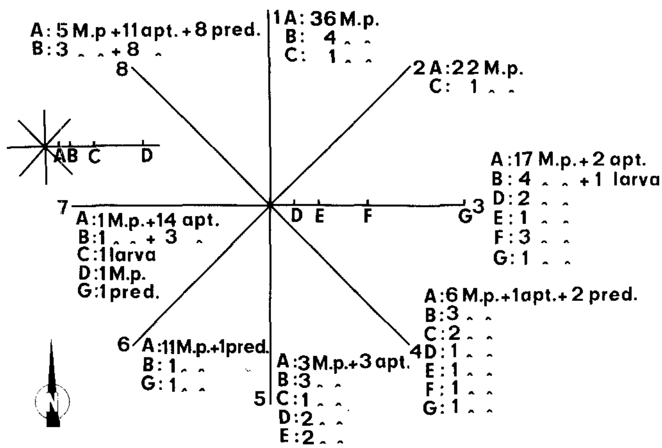
Material and methods

Aphids. A dense population of *M. persicae* was reared on potato plants 'Bintje' in the flowering stage in a glasshouse. Under these circumstances a high proportion of the winged morph developed.

Radiolabelling and aphid traps. To label the aphids 10 potato stems with colonies of *M. persicae* were put in 30 ml of water to which 92.5 MBq (2.5. mCi) of ^{32}P was added. After 3 h the solution was taken up by the stems that were then transferred to a jar with tap water for 7 days. Random samples were taken from the aphids to verify their radioactivity.

On July 2, 1979 the stems, now covered with about 30 000 prae-alatae were placed in a maize field, in the centre of a circle with a diameter of 128 m (Fig. 2). This circle

Fig. 2. Spread of *Myzus persicae* in the experimental field. A – G indicate the location of the yellow traps along the whole radius.



M.p. = alatae/*gevleugelde bladluizen*
apt. = apterae/*ongevleugelde bladluizen*
pred. = predators/*predatoren*

Fig. 2. Verspreiding van Myzus persicae in het proefveld. De punten A t/m G geven de plaatsen van de gele vangplaten op de gehele straal aan.

was divided into 8 sectors in which yellow sticky traps were placed at distances of 1, 2, 4, 8, 16, 32 and 64 m from the centre, forming 7 rings of traps. Up to 16 m one trap was used per site, at 32 m three traps and at 64 m four traps. In the last two cases the traps were put one metre apart. The traps consisted of horizontally placed hardboard plates of 24 × 30 cm, fixed at a height of 45 cm and covered with a sheet of yellow plastic. At the time of the trial the maize crop had approximately the same height and had a closed formation. A natural daylight reflection curve of the sheets showed a very low reflection below 500 nm and a high reflection above 520 nm. Fluorescence of the sheets at excitation with light of 365 nm was very weak, so the brightness of the sheets in daylight was entirely caused by reflection. The sheets were covered with waterproof sticky material, specially prepared for us at the Division for Technology in Society, TNO, Delft.

Assessment of radioactivity by way of autoradiography. The experiment was terminated on July 6. The cardboards were collected and the larger insects removed. Then the sticky sheets were coated with a layer of Mylar (3.5 nm thick) and covered with a sheet of Kodak Definix medical röntgen film. The films had the same dimensions as the yellow sheets and remained in their light-tight envelope. Preliminary trials had shown that an exposure time of 3 weeks gave satisfactory results. A total of 96 films was used. After development the films were put on top of the sheets and the origin of the black dots was determined. A slight contamination was caused by the way the sheets were stacked during exposure.

Physical constants. Weather conditions were registered by the Department of Physics and Meteorology, Agricultural University, Wageningen. During the experiment the weather was quiet and rather cloudy. Max. temp. was 17-21 °C, min. temp. 8-12 °C. There was no rainfall and r.h. was 70-75%. Total hours sunshine were 2-5 for each day, with an almost constant radiation of 1500 J/cm. Wind direction was mainly from N to NNW, wind velocity 2-3 m/sec.

Results and discussion

Although the weather was rather cloudy, circumstances for aphid flight appeared to be favourable, as large numbers of aphids including *M. persicae* were trapped on the yellow sheets. Among these were many non-labelled aphids, which may have travelled several kilometers, but a total of 142 radioactive alate *M. persicae* were found on the sheets (Fig. 2). This means that short flights as depicted in Fig. 1b are not exceptional for this aphid and may under similar climatological conditions be even more important than long-distance flights as in Fig. 1a. A simple calculation will support this statement. The yellow sheets had a total surface of 6.9 m^2, which amounts to 0.054% of that of a circle with a diameter of 128 m. If all alatae had made a long-distance flight directly after take-off from the source no aphid would have been caught. If all alatae had made one landing within 64 m from the source, 0.054% or 16 aphids would have been caught. As 142 or 0.47% landed on the traps we must conclude that at least this proportion of the alatae did not intend to make a long flight and, instead, made several short flights until being caught on the traps. In part, the relatively high number of aphids on the traps may result from attractiveness of the yellow colour of the traps. As, however, this attraction is only exerted within a few meters only low flying alatae making short flights may have been attracted.

In absolute figures many more aphids were found on the traps of the first ring than on traps of following rings. This can be attributed to the fact that the first ring of traps was so close to the release point that aphids in the 'mood' for direct landing were caught on the first ring.

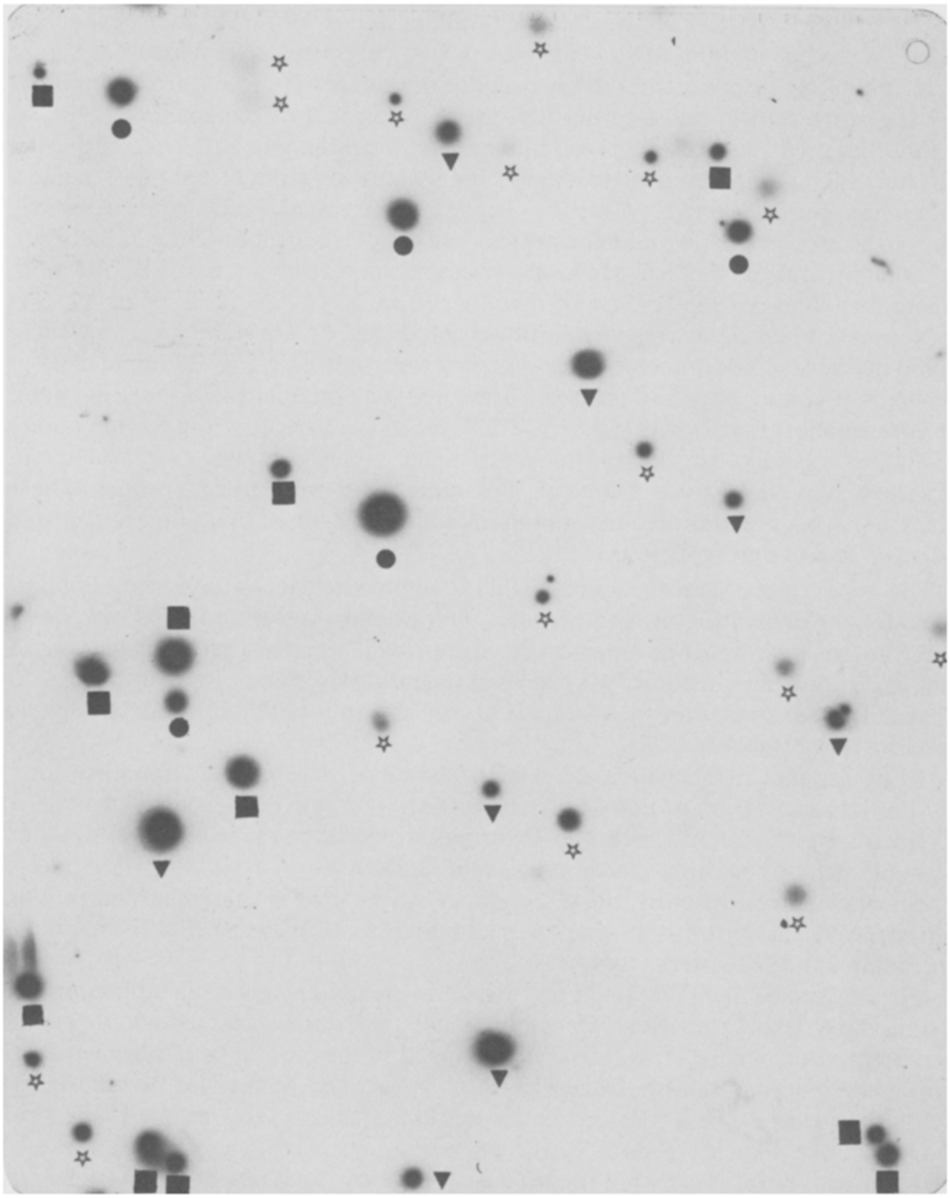
A multinomial distribution of the number of aphids terminating their short-distance flight at any of the rings has been fit. Goodness of fit of this distribution has been analysed by a Chi-square test, resulting in an adequate fit ($P < 0.05$) except for the first ring. This means that *M. persicae* did not discriminate between any one of the sheets of the six outer rings.

As these sheets had a surface of 6.3 m^2 (0.049% of the remaining experimental area) one would expect, following the above reasoning, at least 15 aphids to have been caught. Actually 41 aphids were caught in the six outer rings. This means that at least 0.13% of the alatae were attracted by the yellow sheets in these rings.

The number of 15 aphids was calculted by assuming that no alatae made a long-distance flight (Fig. 1a). Considering the physical conditions during the trial period this is most probably not the case. It follows that part of these aphids on their maiden flights landing close to their take-off point, do so by making a number of intermediate hops: a similar behaviour as found at the termination of a long-distance flight (Fig. 1b).

Up to 2 m from the release point some radioactive apterae were found on the

Fig. 3. Autoradiograph of sticky sheet Nr 8A after exposure of 3 weeks.



● = Alatae/*gevleugelde bladluizen*
■ = apterae/*ongevleugelde bladluizen*
▼ = predators/*predatoren*
★ = contamination/*verontreiniging*

Fig. 3. Autoradiogram van vangplaat 8A na een belichtingstijd van 3 weken.

sheets (Fig. 3). They left the crowded plants of origin and climbed any vertical object in the neighbourhood. One might therefore wonder whether a certain number of alatae may have reached the sheets by walking , thus obscuring statistical operations. Although mature aphids can walk a few cm on the sticky material before being definitely stopped, the average distance the alatae were found from the rim of the sheets was much, and significantly, greater than that of the apterae.

Another point is whether a predominant wind direction may influence dispersion on short flights. Fig. 2 shows that winds mainly blowing from N and NNW cause a dispersion cone of aphids towards S and SE, whereas a reverse current directly above the crop, which was demonstrated with air current tubes (Dräger, Lübeck), takes many of those that leave from the release point slowly in a northern direction, where they land on traps of one of the inner rings.

Not every black dot corresponds with an aphid (Fig. 3). On some sheets we found aphid predators like anthocorid bugs. As they were only occasionally found close to radioactive aphids, they had probably been predating on aphids at the release point before perishing on the sticky sheets. The layer of glue was too thin to catch other flying predators like ladybirds. Minor alterations of the traps, however, would render them suitable to study the activity of other air-borne natural enemies. Those black dots that are indicated as 'contamination' were caused by radioactivity from adjacent sheets during exposure.

The importance of short-distance flights as emphasized above has serious implications for the cultivation of seed potatoes. On the short hovering flights there is almost no inactivation of non-persistent viruses, which means that *M. persicae* can cause considerable spread of PVY^N virus in the neighbourhood of a virus source. As a result of this conclusion we now have to consider four possibilities for the spread of virus by *M. persicae:*

1. Long-distance flights with a direct transmission of virus from an unknown source. Partial inactivation of non-persistent viruses.
2. Successive flights on which non-persistent virus can be taken up from diseased plants in the crop or from plants in adjacent fields.
3. Short-distance flights by alatae developed in the crop on diseased plants. Van Hoof (1979) has shown that after the last moulting *M. persicae* is still capable of spreading a non-persistent virus.
4. Short-distance flights by alatae developed on diseased plants of an adjacent crop.

It is clear that insecticides are of little use to reduce transmission of a non-persistent virus in cases 1, 2 and 4 when applied in the crop only. Transmission of both persistent and non-persistent viruses in cases 3 and 4 may also be reduced by cultural measures such as the application of trace elements (Harrewijn, 1980).

Our results indicate that it might be advantageous to increase the distance between seed potato and ware potato fields. Starting from the numbers of aphids that landed at various distances from the release point, all 30 000 alatae would have terminated their flight at between 53 and 121 m. As the experiment covered four days with a type of weather which is not at all unusual for the Netherlands during this time of year, we expect the infection pressure to be strongly reduced at 100 m from the source.

Björling *et al.* (1951) already tried to study the spread of beet yellows virus in a sugar beet field releasing radioactive *M. persicae* from a diseased plant and pressing collected aphids against a röntgen film. As no sticky traps were used and virus was spread over a small area, it would seem that apterous aphids played an important role in the spread of virus over short distances. Our experiments indicate that winged aphids may just as well be responsible for the typical local spread of this virus.

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Samenvatting

Vluchtgedrag van de bladluis Myzus persicae tijdens zijn eerste vlucht

Op grond van onderzoek dat in hoofdzaak is verricht met de bladluis *Aphis fabae,* wordt algemeen aangenomen dat de eerste vlucht vanaf de secundaire waardplant over een grote afstand plaatsvindt, gevolgd door meerdere korte vluchten. De juistheid van deze veronderstelling is voor *Myzus persicae* niet afdoende bewezen. Door gebruik te maken van radioactief gemerkte perzikluizen is getracht hun gedrag tijdens de eerste vlucht te volgen. Uit dit onderzoek blijkt dat de eerste vlucht van deze bladluis wel degelijk kort kan zijn. Deze resultaten kunnen consequenties hebben voor onze inzichten omtrent de verspreiding van virussen in het gewas.

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