APHIDS IN A NEW MILLENNIUM

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Alate aphid diversity and habitat selection, in east central Illinois, USA

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Abstract

Suction traps were used to catch alate aphids and measure their relative diversity in adjacent but different habitats during five Augusts, 1996-2000, in east central Illinois, USA. One pair of traps was placed in a crop field and an adjacent restored prairie, and the second pair, 22 km away from the first, was placed in a crop field and an adjacent wooded plot. Alate aphid diversity was compared between all four traps using numbers of species, Shannon's index of alpha-diversity, and Sørensen's index of beta-diversity. Overall, the traps collected a greater and more stable year-to-year diversity of alate aphids in the natural habitats than in the crop habitats. In pair-wise comparisons of the species complement of each habitat, three patterns were observed: in 1996, adjacent prairie and crop were most similar, and the distant crop was more similar to the prairie and the other crop than it was to its own adjacent woods; in 1997, adjacent habitats were most similar to each other; in 1998, distant crop habitats were most similar to each other, and the prairie was more similar to the crop habitats than it was to the woods.

Introduction

Few aphid diversity studies have been made at a regional or habitat level, and those are usually only done with morphospecies. In fact, Murdoch *et al.* (1972) looked at homopteran diversity but specifically excluded aphids. Andow and Risch (1985), working with aphids, found that species richness was higher in polyculture than in monoculture, but in the case of aphids on the wing, it is not immediately apparent whether one habitat produces and harbours a greater diversity than another, or whether one habitat actually attracts a greater diversity of migrating aphids.

Various migrating aphid species discriminate between adjacent habitats even when neither habitat contains suitable hosts, and more of these species are attracted to a crop

monoculture than to a natural polyculture (Favret & Voegtlin, 2001). We wished to see if this general preference was sufficient enough that there would be a greater alate aphid diversity in a monoculture than in a polyculture. Although polycultures are known to harbour a greater diversity of herbivores than polyculture, we thought it possible that in the case of alate aphids, the reverse might be true.

Materials and methods

We placed identical, 2m tall, paired suction traps in adjacent agricultural (corn or soybean) and natural (prairie or woods) habitats. One pair was placed at the University of Illinois's Phillips Tract in Champaign County, Illinois (40°08.01'N x 88°08.98'W), with one trap 15m into a crop field and the other 15m into a restored tall-grass prairie; the traps were 30m apart. The other pair of traps was placed at the University of Illinois's Rutan Tract in Vermilion County, Illinois (40°04.26'N x 87°54.27'W), with one trap 3m into a crop field and the other 3m into a wooded habitat; traps were separated by an additional 15m of grass. Phillips and Rutan Tracts are 22km apart. Details regarding collecting, sorting, and identifying of aphids can be found in Favret and Voegtlin (2001).

August was the only month for which all four traps had complete, uninterrupted samples for 1996-2000, so diversity measures were calculated for this month only. There has been much debate as to the validity of various measures of diversity, but Hurlbert (1971) rightly argues that any index of diversity has weaknesses. We chose two that are prevalent in the literature: species richness (S) and Shannon's index of alpha-diversity (H'; Shannon & Weave, 1963). In order to make pair-wise comparisons across all four trap localities, beta-diversity was calculated using Sørensen's Quotient of Similarity (QS; Sørensen, 1948; as cited in Risch, 1979). QS was then used to construct UPGMA dendrograms of alate aphid species diversity (Hövemeyer, 1999).

Corn and soybean were rotated annually at both Phillips and Rutan Tracts and their rotations were asynchronous relative each other (corn was planted at Phillips Tract in 1997 and 1999, and at Rutan Tract in 1996, 1998, and 2000, with soybean being planted all other years); thus proper comparisons of diversity between corn and soybean habitats were not possible. At the time of this project soybean was a generally aphid-free crop (Turnipseed & Kogan, 1976) and only one species, *Rhopalosiphum maidis* (Fitch) was noted to colonize corn to any significant degree. We therefore thought it valid, in a diversity experiment, to treat both monocultures similarly and refer to them simply as "crop".

Results

Table 1. Number of Individuals Trapped

	Phillips		Rutan		
	Prairie	Crop	Woods	Crop	Total
1996	548	204	46	300	1098
1997	1954	907	117	1272	4250
1998	556	737	44	302	1639
1999	269	345	10	693	1317
2000	314	970	5	204	1493
Total	3641	3163	222	2771	9797

Table 2. Number of Species Trapped

	Phillips		Rutan		All
	Prairie	Crop	Woods	Crop	Sites
1996	27	24	17	24	43
1997	34	23	19	29	53
1998	23	22	17	23	44
1999	13	14	6	18	26
2000	19	30	4	20	37
All Years	48	48	36	54	82

Over the five year (August-only) sampling period, we identified 9,797 aphids and recorded 82 species. There are roughly 400 species known from Illinois, so this represents ~20% of the state fauna. August 1997 had the highest number of individuals trapped, overall and at all four sites (Table 1), as well as the largest number of species, overall and at three of four sites (Table 2). In 1999 and 2000, vegetation had grown thick around the Rutan woods trap, explaining the low capture rate, and for this reason, H' and QS were not calculated for those years. Excluding Rutan woods, then, 1999 had the fewest number of species trapped at all three sites (Table 2).

Diversity patterns, as measured by H', varied from year to year but were fairly constant across sampling sites: 1996 was the most diverse year for aphids, across all four sites, whereas 1999 was the least diverse across three sites (omitting Rutan woods; Table 3). Rutan woods had the three years with the highest H' (1996-1998) despite having a consistently lower S. The lowest four H' were all crop habitats (Phillips, 1997, 1999, 2000, and Rutan, 1999; Table 3). Rutan woods had a higher H' than its adjacent crop all three years, and Phillips prairie had a higher H' than its adjacent crop 4 of 5 years. Not only were alate aphids more diverse in the natural areas than in adjacent crops, but that diversity was more stable year to year, as measured by the standard deviation of H'.

Table 3. Alpha Diversity

	Phillips		Rutan			
	Prairie	Crop	Woods	Crop	Avg.	S.D.
1996	2.27	2.94	3.59	2.72	2.88	0.55
1997	1.97	1.67	2.96	1.80	2.10	0.59
1998	2.17	1.72	3.46	2.38	2.43	0.74
1999	1.71	1.02		1.65	1.46	0.38
2000	2.14	1.48		2.27	1.96	0.43
Avg.	2.05	1.76	3.34	2.17		
S.D.	0.22	0.71	0.34	0.44		

Figure 1.
UPGMA Dendrogram
Based on QS for1996

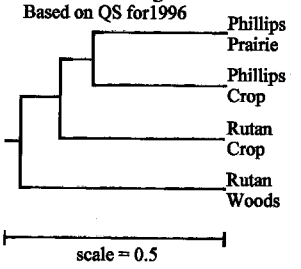


Figure 2.
UPGMA Dendrogram
Based on QS for1997

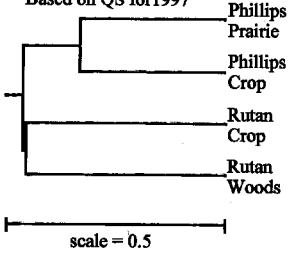
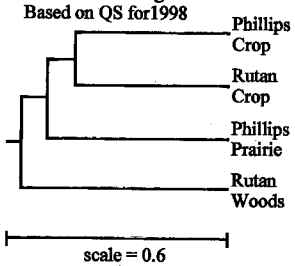


Figure 3.
UPGMA Dendrogram
Based on QS for1998



Although diversity measures for natural areas were relatively consistent over time, their relative quotients of similarity varied from year to year. In 1996, adjacent Phillips Tract habitats had more aphid species in common with each other than either did with either of the Rutan habitats, and Rutan crop was more similar to the Phillips Tract habitats than it was to its adjacent woods habitat (Fig. 1). In 1997 the aphid species complements of adjacent habitats were more similar to each other than to either of the more distant habitats (Fig. 2), but in 1998 Phillips crop had more aphid species in common with Rutan crop, 22km away, than it did with its adjacent prairie only 30m away (Fig. 3). In a 20 by 20 (4 sites and 5 years) pair-wise comparison with QS, the Rutan woods years clustered together to the exclusion of all other sites.

Discussion

Aphidologists have long known that aphid diversity and abundance vary greatly from year to year; we found that to be true in our sampling as well but without there being any clear indication as to why. Many previous authors have found insect diversity to be higher in polyculture than in monoculture (Allan *et al.*, 1975; Altieri, 1984; Sanderson, 1992; Siemann *et al.*, 1998), and our findings with alate aphids in August follow this same trend. When choosing between two unsuitable habitats, migrating aphids show a preference for a crop monoculture (Favret & Voegtlin, 2001), but this preference did not cause overall alate aphid diversity to be greater in the crop. In this study we did not distinguish between those aphids arriving from outside our trapping plots (i.e. migrants) and those produced locally on local vegetation. We expect that a greater diversity of aphids would be produced in the poly- than the monocultures, and their abundance may have been great enough to mask any effect by arriving migrants. Additionally, migrants constitute a lower proportion of alate aphids in August than in spring or early summer, and they may not have been in high enough numbers to affect diversity in the crop.

Previous authors have also suggested that polycultures are more stable with regard to yearly fluctuations in diversity (Naeem, 1998, Tilman *et al.*, 1996; Yachi & Loreau, 1999), and we have shown here that the natural habitats had a more consistent and stable alate aphid diversity than the crops: the standard deviation of H' at Phillips prairie was lower than it was at Phillips crop (Table 3), and the Rutan woods samples were more similar to each other year to year than they were to any of the other 15 samples (in the 20 by 20 comparison).

Rutan crop was consistently more diverse and more stable than its crop counterpart at Phillips Tract. Despite the fact that Phillips and Rutan crops had very similar average

numbers of species (Table 2), Rutan crop had greater H' in four of five years and a lower standard of deviation (for both S and H'). That Rutan woods overcame large yearly fluctuations in aphid numbers and species (Tables 1 and 2) to group together to the exclusion of same-year adjacent samples suggests that there was something fundamentally different and unique about the woods relative the other habitats. As a consequence, the diversifying effect of the Rutan woods on its adjacent crop may have been more pronounced than that of Phillips prairie on its adjacent crop.

In 1996, adjacent habitats at Phillips Tract were more similar in their aphid species, but Rutan crop, 22km distant, was more similar to the Phillips Tract habitats than it was to its adjacent woods. Perhaps these three habitats clustered by virtue of the similar structure of their vegetation: the trees in the woods were obviously much higher than the crop or prairie plants and thus the woods had a very different exposure to the wind and hence wind-borne insects (Mayse & Price, 1978). Alternately, perhaps there are species-specific preferences for differences in vegetation canopy (Halbert & Irwin, 1981). Alate aphids were not affected by vegetation structure in 1997, however (Fig. 2), and in 1996 Rutan crop was more similar to Phillips crop (QS distance = 0.333) than it was to Phillips prairie (QS distance = 0.412), although by nature a UPGMA tree (Fig. 1) cannot show this. Finally, there is the case in 1998 when Phillips and Rutan crops (22km distant) were more similar to each other in alate aphid species than either were to their immediately adjacent habitats (Fig. 3). In other words, in 1998, a similar set of alate aphid species were found in distantly separated crops, whereas relatively dissimilar sets of alate aphid species were found in the adjacent natural areas. This appears to be the one year where aphid habitat choice may have played a role.

Finally, as can be seen in Table 2, the number of aphid species trapped in any one year at any one site was never more than about one-third the total species collected. Therefore, year to year fluctuations in the patterns of similarity (Figs. 1, 2, and 3) were likely caused by differences in the composition of aphid species trapped. In contrast, differences in H' may have been caused by variation in the number of individuals trapped. Overall, more individuals of *R. maidis* were trapped than all other species combined, so its effect on H' may have been significant when comparing years of relatively high and low *R. maidis* density.

The natural habitats generally did have a greater diversity of August alate aphids than the crops, contradicting our hypothesis that migrant aphids might cause the reverse to be true. However, perhaps our best and most thought-provoking conclusion is simply that the variability of results between years make it difficult to impossible to draw any firm conclusions concerning the influences on alate aphid diversity in crop and natural habitats.

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