The effects of condensed tannins on behaviour and performance of a specialist aphid on Aspen

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Abstract

The plant defence syndromes (PDSs) concept predicts host plants should develop diverse resistance profiles against their herbivores. We used Electrical Penetration Graphs (EPG) to investigate complex and genotype-specific penetration-barriers to Chaitophorous tremulae aphid feeding on Aspen (Populus tremula). Leaf condensed tannins were associated with enhanced probing activity and increased ingestion of xylem sap. Aphids probed less on Aspen genotypes low in tannins, suggesting other defence traits might be elicited. Our results support the idea of multi-layered PDS defence traits, and provide evidence of high plasticity in tannin profiles across temporal and spatial scales. We conclude that tannin plasticity may form a dynamically unpredictable aspect of the PDS defence arsenal that protects Aspen against piercing-sucking aphids.

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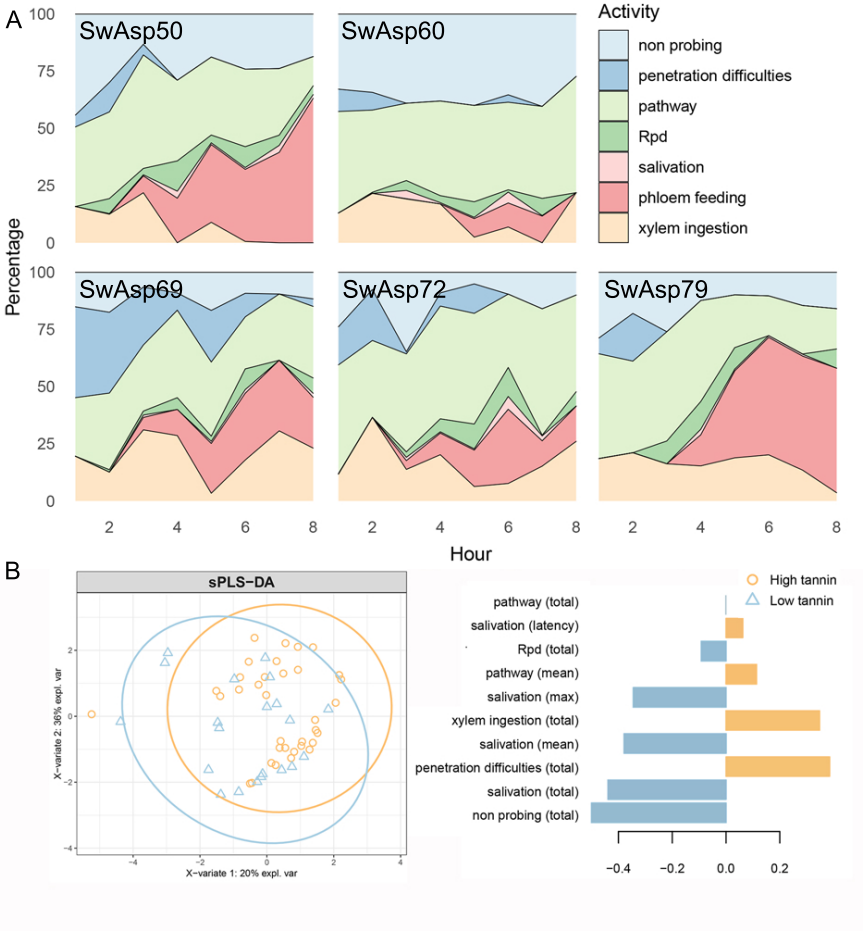

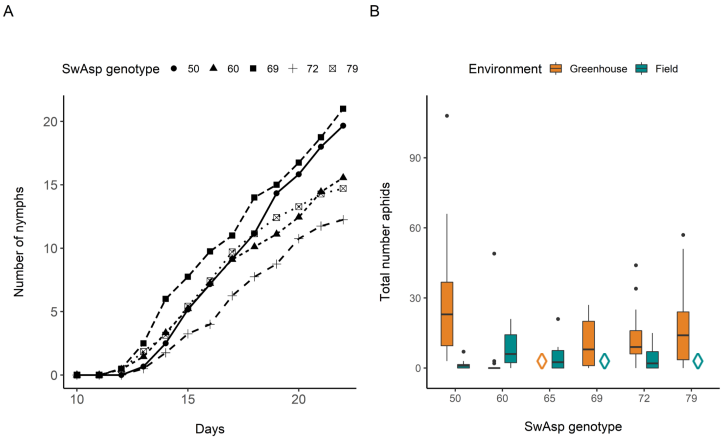

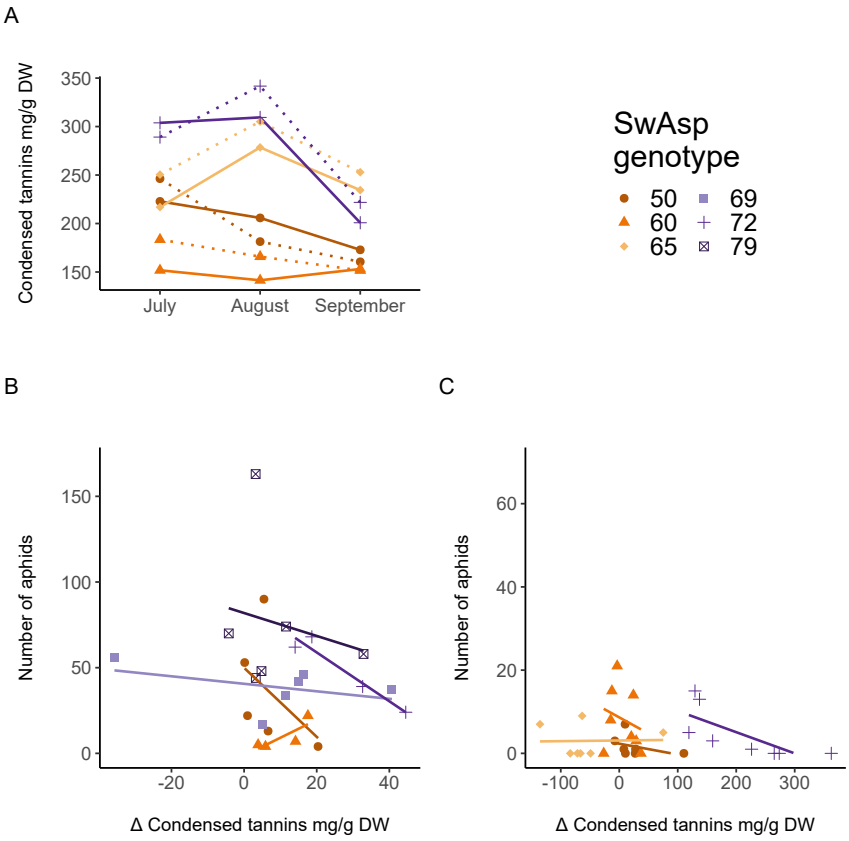

Behaviour details	SwAsp50	SwAsp60	SwAsp69	SwAsp72	SwAsp79
Total duration no probing	119.7 ± 28.3ab	172.5 ± 34.1b	54.1 ± 12.6a	65.4 ± 13.7a	86.5 ± 29.2ab
Pathway events (# C/aphid)	16.1 ± 1.8b	16.9 ± 1.7b	11.3 ± 1.3a	15.4 ± 2.5ab	15.2 ± 2.7ab
# C < 3 min	14.7 ± 1.8b	14.5 ± 1.6b	8.8 ± 1.2a	13.5 ± 2.3ab	12.2 ± 2.5ab
Mean duration C	9.8 ± 1.4	10.9 ± 1.2	11.8 ± 1.4	14.4 ± 1.9	10.1 ± 1.1
Total duration C	146.1 ± 19.4ab	168.7 ± 14.2b	125.9 ± 19.5a	181.8 ± 19.7ab	140.6 ± 21.2ab
Pd rate (# pd/min C)	0.6 ± 0.1	0.6 ± 0	0.6 ± 0.1	0.6 ± 0.1	0.5 ± 0
Repetitive potential drops (# RPD/aphid)	2.4 ± 0.6b	2.4 ± 1.1ab	2.1 ± 0.9ab	2.4 ± 1ab	0.9 ± 0.2a
Mean duration RPD	15.5 ± 5.6	7.3 ± 3.1	11.5 ± 5.2	17.5 ± 5.6	30.8 ± 9.2
Total duration RPD	29.2 ± 7.4b	14 ± 6.4ab	13.8 ± 6.2a	27.4 ± 10.4ab	28.6 ± 9.2ab
Salivation events (# E1/aphid)	1.2 ± 0.3	0.6 ± 0.4	0.5 ± 0.3	0.8 ± 0.3	0.6 ± 0.2
Mean duration E1	7.6 ± 2.6	6 ± 3.1	5.2 ± 0.5	8.4 ± 3.5	4.5 ± 0.9
Total duration E1	11.6 ± 6.7b	6 ± 5.1a	2.6 ± 1.2ab	4.7 ± 2.1ab	2.5 ± 0.9ab
Max duration E1	9.3 ± 4.1	8.8 ± 5.7	6.2 ± 0.7	9.7 ± 3.3	4.8 ± 0.9
Latency to first E1	295.4 ± 41.4	397.4 ± 40.5	401.1 ± 36.1	376.5 ± 35.3	362.5 ± 36.7
# of E1 not followed by E2	0.4 ± 0.2	0.1 ± 0.1	0.1 ± 0.1	0.2 ± 0.1	0 ± 0
% E1 in total phloem phase (E1+E2)	8.2 ± 4.5	17 ± 9.9	6.8 ± 2.9	3.9 ± 1.9	2.2 ± 0.4
Phloem ingestion events (# E2/aphid)	0.8 ± 0.2	0.4 ± 0.2	0.4 ± 0.2	0.5 ± 0.2	0.6 ± 0.2
% Aphids performing E2	70%	27%	36%	31%	50%
Mean duration E2	138.7 ± 47.1	64.7 ± 45	172.4 ± 65.7	130.2 ± 35	208.1 ± 24
Total duration E2	102 ± 38.2b	20.9 ± 14.7a	62.7 ± 34ab	50.4 ± 23.4ab	115 ± 35.9ab
Total duration of E2 events > 10 min	102 ± 38.2b	20.3 ± 14.7a	62.7 ± 34ab	50 ± 23.2ab	115 ± 35.9ab
Max duration E2	142 ± 46.2ab	76.3 ± 42.7a	172.4 ± 65.7ab	149.2 ± 28ab	218.8 ± 19b
Penetration difficulties (# F/aphid)	0.2 ± 0.1a	0.6 ± 0.3ab	1.3 ± 0.3b	0.8 ± 0.3ab	0.5 ± 0.2a
% Aphids performing F	20%a	45%ab	82%b	38%ab	33%ab
Total duration F	12.4 ± 10.1a	20.2 ± 9.4a	103.4 ± 30.4b	42.9 ± 25.4a	20.7 ± 11a
Xylem ingestion events (# G/aphid)	1.6 ± 0.4	1.7 ± 0.3	1.7 ± 0.3	2.1 ± 0.3	1.8 ± 0.3
% Aphids performing G	70%	100%	91%	100%	100%
Total duration G	50.6 ± 13.2	68.3 ± 12.4	109.5 ± 28.8	96.6 ± 18	78.7 ± 22.4

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	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
Model 1						
SwAsp	4	411	102.8	4.609	0.001	**
Aphid age	35	17420	497.7	22.318	< 0.001	***
SwAsp:Aphid age	114	1105	9.7	0.435	1.000	
Residuals	596	13292	22.3			
Model 2						
SwAsp	5	4305	861.0	2.961	0.01578	*
Environment	1	2454	2453.8	8.440	0.00457	**
SwAsp:Environment	2	3564	1782.0	6.129	0.00314	**
Residuals	95	27619	290.7			

	Experiment 1			Experiment 2	
GT	p	r_m	DT	r_m	DT
50	14.2 ± 1.2	0.18 ± 0.01	3.91 ± 0.28	0.13 ± 0.02	7.12 ± 1.36
60	12.9 ± 0.9	0.18 ± 0.01	3.96 ± 0.13	0.10 ± 0.07	30.91 ± 22.6
69	11.7 ± 0.3	0.17 ± 0.05	6.79 ± 9.61	0.14 ± 0.03	4.67 ± 0.48
72	14.0 ± 1.5	0.15 ± 0.03	5.26 ± 2.22	0.10 ± 0.02	11.10 ± 4.04
79	13.4 ± 0.8	0.16 ± 0.01	4.45 ± 9.38	0.16 ± 0.01	4.59 ± 0.45