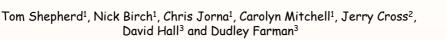
Profiling of raspberry cane wound volatiles using a combination of SPME and GC-TOF-MS



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Background

The raspberry cane midge, Resseliella theobaldi, is an important pest of red raspberry, Rubus idaeus, in the UK and northern and central Europe. Splits in young canes caused by In a raspberry cane miage, Ressellent medalar, is an important pest of real raspberry, Rubus ladeus, in the UK and normern and central Europe. Splits in young canes caused by damage or natural splitting are the sites of egg laying by adult females. Emerging larvae feed on the pith causing lesions which provide a means of entry of diseases such as cane blight fungus and midge blight. Methods for monitoring and biological control of midges involve development of mass trapping systems using natural chemical attractants as lures. For example, considerable effort has gone into development of traps using female sex pheromone for local monitoring of males. However, effective control requires identification of an attractant to lure the females as they emerge from the soil in early spring (first generation) and during the second generation which coincides with fruit harvest and the main period of fungal colonisation.

Behavioural analysis suggests that female midges are attracted to egg laying sites by volatile chemicals released from the split canes. We have developed a sampling technique which uses solid phase microextraction (SPME) fibres to entrain volatiles in the immediate vicinity of a split.



Methods

Sampling enclosures consisting of wire frames (a) supporting an inert plastic (PET) film (b) were positioned around the cane at sites of manually created splits (c). Sheathed SPME fibres were inserted into the enclosure and the fibres were exposed adjacent to the split for collection of volatiles (d).

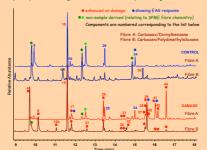
Entrainments were carried out in pairs, one being an unwounded control plant and the other having a 2-3 cm manually created wound. Fibres were either deployed singly (d) or in pairs (e).

Following transfer of fibre holder assemblies to the GC-MS autosampler, the volatiles were desorbed via a PTV injector and analysed using a GC-TOF-MS.

ration of volatiles was effected on a DB 1701 GC column (30m × 0.32mm × 1.0 up) using helium carrier gas at a flow rate of 1.2 ml/min. The *GC* -MS consisted of a ThermoFinnigan Tempus Time-of-flight (TOF) system operating at a data acquisition rate of 3 spectra/second. Data was acquired using the Xcalibur software package. Samples were desorbed for 2 minutes into a PTV injector assembly operating in a libiter software the two for the two flows of two flow splitless mode at temperatures varying from 200-280°C, depending on the type of SPMF fibre used

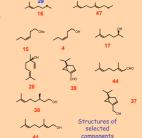
Results and Discussion

Volatile profiles obtained from both split and undamaged canes consist primarily of a mixture of monoterpenes, monoterpene alcohols, aliphatic alcohols, aldehydes and ketones rry cane (Malling Promise) volatiles analysed using SPME and GC-MS $\,$ $\,$ $\,$



22 02

21 g



Components showing major enhancement in production following

Profiles for the distribution of stem volatiles are shown for experiments conducted using the

raspber	aspberry varieties Glen Ample, Glen Clova, Glen Prosen, Latham, Malling Delight and Malling Promise.													an-3-cme	damage are numbered in red and are indicated:																			
Abundance values are reported as a percentage relative to the total combined measured amount of the $C_7 - C_{11}$ n - aldehydes present in each sample.						ampling Type lexanal L	apene (ocimene? a-pinene?) N	4 0-1-uaxau-t-s	amphene C	-heptanal L	-heptanol &	nalyl acetate 1	-containing of the second seco	monene 1. - or 4-hexene-1-ol acetate	4 15 shenen-ol-acetate	-methyl-5-hepten-2-one 9	18 Isuspo-	enzaldehyde 1		-hydroxybutanoate or dihdro-2(3H -nonen-1-ol 25	24 exide	25 26 26 26 26 26 26 26 26 26 26 26 26 26	nalool oxide (2) or isomer? 52 nalool 88	29 30 Itronellal	pinocarveol or t-verbenol C ka 5-ethvl-2/5H1-furanone etc. C	33 3	4 35 poeujdua;	rethylsañcyfate 90 tyttenol 20	citronellol 8	9 4 40	eral (2-citral)	eranial (E-citral) 75	5 46 eteretor investe	49 (30) esquitetiene (180) esqui
Raspberry Varieties			100	0 I	20 1	4 75 7 10.9	0 6	e 11	CN CN		4 28 7 04	67 0.1	2.0	9 9		-0 (S	4 13	+2 Ci	13	÷ 2	11 182	e 13	2 E	7.1 2	C 00	E E	ة <u>م</u>	5 10 S		c 6n 7		0.0 1.0		
GA:	Glen Ample	D4/12/07 11/12/07 11/12/07	MD DAMG	1 CWD/8 2 CWD/8 2 CWD/8	180	A1 40		3 120	45 03		0.2 0.0 0.2 0.1	10	- 05 - 04	52 01	12.9	40 66		6.0 27.	1 28	204 11	12	17 03	15 640	510 50	17 14	12.0 2	23 69	410 15	450 2	2 20 3 5 <u>31 3</u>	17 10.0	ki <u>504</u> 4		0.7 5.7
GC:	Glen Clova	11/12/07	MD DAMG	2 CWDVB CWDVB	180	A1 25.4	00 1	a 132	23 13	2.4	10 04	8.0 T	8 88 7 88	0.3 0.0	3.4	15 55	i ii	27.2 11	7 88	182.0 18.3	35.5	22 0.0	10 00	41.8 57	17.6 1.5	41 T	10 177	47.1 71.7	100.0	10 12 1 1	A 77.1 3	40 3652 7	0.0 11	00 00
GP:	Glen Prosen		BLANK-D	CARIPDMS		23.5	0.0 8	a 00	10 00	95.9	12.0 7.1	1.0 25	19 01	0.0 0.0	0.00	48 00	2.3.9	194.9 45	7 0.0	471.1 0.0	0.0	10 00	10 00	49.5 0.0	0.0 1.0	11.4 2	9.5 2.5	00 88	0.0 0	s ao c	0 80	25 08 0	00 80	3.6 0.0
	Latham	27/02/08 27/02/08 27/02/08	BLANK-D BLANK-D BLANK-D	CARIPDMS CARIPDMS CARIPDMS		23.5 1954 17.2	0.0 8	a 0.0 .1 0.1	10 0.0 11 0.1	7.8 20.5	6.6 0.8 9.3 4.5	8.0 T 8.1 57	7 0.8 10 0.1	0.0 0.0 0.1 0.1	0.0	8.2 0.0 10.8 0.1	2 37 54	88.1 87. 196.7 40.	7 0.0 1 0.1	136.8 0.0 582.4 0.1	0.0 0.1	10 0.0	8.0 0.0 8.1 41.8	39.8 0.0 30.5 0.1	0.0 8.0	01 2	6.8 5.2 0.9 4.0	0.0 8.0	0.0 D 0.1 D	8 0.0 0 1 0.1 0	10 8.0 1	19 0.0 0 67 0.1 0	0.0 8.0	4.6 8.1 0.1 0.1
	Malling Delight		GP CONT GP CONT	1 CARIPONS 2 CARPONS	90 90	A1 187 A1 17.9	18.8 4	8 528.7 .3 568.8	1.5 2.3 4.1 2.5	7.3 6.0	3.4 0.1 3.5 0.4	8.1 20 16.3 18		41.8 80. 22.0 64.	2 2370.4 2 2117.0	64.1 8.4 73.4 12/	1 13 13	18.9 06. 14.3 27.	2 28	18.8 1.4 7.4 1.0	5.0	7.0 0.1	3.4 14.6 3.5 18.1	70.8 1.0 72.6 1.1	0.6 1.8 3.8 1.0	38 T 0.1 T	21 30	0.8 20.8 1.7 22.7	1.4 10 1.1 N	17 0.0 0 12 0.0 0	0 88 1 7 88 1	12 03 0 10 05 0	0.00 0.0	0.0 1.4 0.0 0.0
	Malling Promise	27/23/08 03/23/08 04/03/08 04/03/08	GP DAVIG GP DAVIG GP DAVIG GP DAVIG	1 CARIPOMS 2 CARIPOMS 3a CARIPOMS 3b CARIPOMS	90 90 30	A1 37.4 A1 22.4 A1 44.1	8.4 13 13.6 13 8.2 28	14 (994.7 17 (294.5 13 (338.9	12 1.1 20 1.1 26 1.2	8.8 4.5 11.0	17 02 52 05 10 2.1	12.2 19 23.7 19 11.9 21	12 4.8 13 6.3 10 7.2	28.8 40. 21.6 30.1 14.5 78.0	3 1999.0 8 1997.0 0 2495.4	T18 24 53.8 22 80.7 12	6 63 6 61	28.7 46. 28.5 65. 34.5 50.	6 33.2 0 23.0 2 54.2	88.8 1.4 21.7 0.9 44.7 1.6	43 47 94	13 1.0 5.1 1.6 7.1 0.3	2.8 142.7 3.6 176.2 7.0 58.2	99.1 3.5 70.7 4.9 62.5 3.3	19.0 12.1 22.7 11.1 22.9 35.1	62 3 65 5 38 7	4.6 8.7 4.7 11.8 5.5 10.8	3.2 80.0 3.1 169.3 22.6 25.9	14.0 27 18.5 27 1.5 16	16 26 3 21 29 5 11 20 1	4 18 1 9 23 1 3 86 -	21 7.3 0 21 8.1 1 40 2.5 0	0.0 8.0	0.0 0.2 0.0 0.3 0.0 0.4
				1 CARIPONS	90	A1 26.6	11.8	2 2119	18 03	8.4	18 08	16.8 19		18.3 28	1 100	10.3		18.7 44.		20.0 0.8		18 07	16.1	72.0 20	230 23	14.7 1	2.0 10		37 N	0 18 1		27 27 0	0.00 10	0.0 02
Plant Sta		31/23/09 27/05/09 31/23/09 27/05/09	GP CONT GP CONT GP DAMG GP DAMG	2 CARPONS 1 CARPONS 2 CARPONS	75 1	820 20.0 820 82.6	26.7 2	1 0.9	20.8 1.3	11.4	52 0.1 62 0.8	2.0 12	10 4.8 17 19.2	16.2 0.0	5 1.7 5 352.4	17.3 1.1	5.9	15.9 20.	5 03 0 85.6	267 15	13 -	42 0.0	17 5.1	453 49	00 E3	0.5 1	20 11	02 44	0.0 3	3 0.1 0 AT 178 0	4 E1	10 03 0	00 1	0.0 0.1
CONT: DAMG:	Control (undamaged) Damaged			2 CARPONS 1 CWDVB 15 CWDVB	75 1	B2D 94.0 B2D 8.2	18.5 1	a <u>61.9</u> .0 1.6	11.4 1.3 60.4 2.0	2.0	82 2.0 0.6 0.0	21.8 0.	7 57	20 8.80 1.0 0.0	0 <u>29</u> 0 182	27.3 60	0 11 0 43	516 25. 5.0 64.	00 0 00 0	452 1.2	5.0	10 <u>10</u> 10 03	10.2 414.1 8.0 83.3	72.6 15	0.0 1.9	25 \$	2 22.1 0.0 0.0	2.0 35.9	دو ديو پ ه مه	ao 158 3 8 ao 6	6 83 0	1.7 <u>22</u> 0	00 80 00 80	0.0 0.1
	-	31/03/09 02/04/09 27/05/09	GP CONT GP CONT GP CONT	2 CW0V8	78	A1 3.9 B20 3.5	00	2 21 6 03	11.0 03	2.5	0.2 0.0	8.0	a 13 9 65	21 02	0.5	41 0.1	41	15 61	0.0	22 07	0.8	29 00	10 11.4 10 1.5	73.0 0.2	0.6 1.9	0.0	72 11 69 0.5	13 14 0.1 14	0.4 1	5 0.9 0	.1 80 (9 82	1.9 02 0	0.0 10	0.0 0.3
	ore Adsorbent Phases		GP DAMG GP DAMG	1 CWDVB 2 CWDVB	- 8	820 12		0 15	11 0.1	8	a		4 02	0.7 0.0		37 65	1	1.4 4.3	0.0	19 05		27 0.0	10 110	74.6 0.2	<u> </u>	a1 1	7.4 4.5	00 1004	12 8	0 22 2	0 11		0.0 1.1	0.0 0.0
PDMS: PEG:	Polydimethylsiloxane Polyethyleneglycol		GP CONT GP CONT GP DAMG GP DAMG	1 POMS 2 POMS 1 POMS 2 POMS	75	820 67 820 23	02 1	3 02	11 0.1 12 02	0.5	0.2 0.0	11 1	5 02	0.0 0.0	0.5	2.5 0.2	11	05 16. 25 25	6 00 6 00	28.5 0.5	0.8	25 0.0	E1 9.1	47.9 0.2	10 13	27 4	54 54 12 178	02 29	0.5 0	s 0.4 1	5 E4	46 0.1 0	0.01 1.0	0.5 0.2
CAR:	Carboxen		GP DAMG		75 1	820 0.6 820 6.7	0.5 1	.1 0.4 .1 0.8	8.1 0.1 6.1 0.5	0.8	0.2 0.0 0.5 0.0	10 1. 12 13	7 0.4	00 00 09 00	0.0	19 43 47 04	1.4	0.0 8.3	1 0.0 1 0.0	ES 0.4 02.8 4.1	0.0 10.0	28 0.0 <mark>.</mark> 58 0.0	12 744 88 0.0	41.5 0.5	0.6 1.0	7.4 4 2.0 3	9.5 7.5 9.7 2.1	24 21	22.2 4	10 72 4 8 4.0 9	15 81 1 10 84 1	_	0 00 80	0.0 0.2
CW: DVB:	Carbowax Divinylbenzene		GP CONT GP DAMG GP DAMG		75 1	820 6.1 820 11.2	0.5 1	a 1.1 a 182	25 05	7.3	0.5 0.1 0.9 0.0	13 54	19 1.8 13 2.1	0.3 0.0 5.4 0.0	26	44 92	53 2 34	0.1 10. 4.0 25.	0.00	62.7 1.1 111.0 0.9	2.2	11 0.0 88 0.1	8.0 15.7 8.0 127.8	53.5 1.2 51.6 2.0	17 88	47 2 142 2	0.0 5.0 27 147	0.5 1.5	1.0 0	8 0.4 0 9 283 8		48 0.5 0	00 80	0.0 0.5
		27/05/09	OP DAMO	2 PEG	75 1	820 0.8	02 1	a 15	25 03	- 14	0.5 0.0	11 0.	* 0.4	0.5 0.0	67	15 53	2.6	1.6 43	0.0	17.8 0.6	2.8	28 0.0	10 410	02.4 0.5	- C D	6.5 Z	3.5 3.8	2.5 85.8	11.1 15	6 <u>87</u> 5	17 11	3.1 3.5 0	01 1	0.0 62
Fibres used had the following adsorbents		28/23/08 05/23/08	MP CONT MP CONT	1 CARIPONS 2 CARIPONS 25 CARIPONS	90 90 /	A1 35.0 A2D 17.6	319 3 0.0 4 787 2	5 99.5 6 52.9 5 267	21.7 T.3 10.8 23 20.5 11	8.4 4.5	28.8 0.2	6.1 17 5.9 10	14 47 13 44 14 71	133.8 27/ 24.8 743 74.4 0.0	0 506.5 9 1080.0	08.7 4.8 05.8 5.5 09.8 5.5		17.3 83. 35.7 89. 29.9 91	7 7.3 5 1.7 1 0.7	10.3 0.7 27.6 2.0 33.5 2.3	8.0 8.0	14 0.1 84 0.8	2.5 0.0 12 0.0 2.8 12.9	43.5 0.5 43.6 0.0	2.1 16 0.0 14	45 T 50 T	3.5 1.4 3.8 0.0	78 83 15 84 417 108	0.0 21	7 9.5 0 8 9.0 1 15 9.9 0	2 83 1	10 0.0 0 2.4 0.5 0	0 82 81 72 80	0.1 2.4 210 4.6 349 330
singly or	in combination	26/03/06	MP CONT	20 CARIPOMS 1 CARIPOMS	90 /	A20 30.8 A1 29.2	28.0 4	6 723 5 9125	11.8 17/ 7.0 19:	7.4	48.4 0.3	15.9 21	13 7.8 7 2.6	28.7 257	6 879.5 9 717.4	27.3 55	14	18.4 64.	4 2.3	10.8 1.8	42	18 08 88 08	2.1 17.8	64.0 1.9	3.2 1.0	30 T	1.9 57	114.3 26.0	1.0 41	4 0.8 0		2.6 0.0 0	0 13.7 80	23.8 87
(1) PC		06/03/08	MP DAMG	2 CARIPONS 1(2) CWDVB	90 /	A20 82.4 A20 2.5	0.0 1	.1 3.4	14.7 18. 60.3 0.5	21	19 0.0	12 2	17 7.3 3 03	28.7 30	0 1485.8 5 211.5	15.5 1.5	2.1	23.6 66. 2.4 11.	6 05	16.2 1.8 7.8 0.5	0.4	43 21 54 02	2.0 301.0 8.1 11.0	61.8 40 64.6 0.1	23.5 28.1 1.4 E.5	28.7 9 6.9 2	5.5 <u>19.8</u> 5.5 <u>5</u> .9	0.5 4.5	22.0 43	18 25 T	9 82 1	10 204 3	13.0 13 3.2 14	3.3 4.2 2.4 78.5
(2) PE	EG W/DVB	06/03/08	MP DAMG	1(2) CWOVB		A2D 3.9	00 B	1 93.0	20.8 0.6	-0	0.0	86 2	4 03	5.2 0.4	302.1	10.0	17	47 50	2 21	53 O.O	0.8	LA 02	8.5 50.0	59.6 21	40 14	23.5 2	98 <mark>78</mark>	24 223	54.2 96	6 164 2	2 44	1957 6	at 🔜	0.0 20.0
(4) C	AR/PDMS	03/10/08 17/10/08	GC CONT	1 CARIPDMS/DV 2 CARIPDMS/DV	8 90 8 50	A1 48.9 B1 53.0	33.3 8 71.2 8	0 6.6 0 1.8	213 53 6.1 5.4	1927 11.5	48 10 29 05	8.8 24 8.6 24	11 11.5 12 19.2	2.4 0.0 34.2 0.0	72	415 0.5 04.5 0.5	52.5 7.8	78.9 1021 64.2 155	12 0.0 7 0.0	92.5 1.7	10.2 5.5	19 0.0 28 0.0	66 57 88 0.0	54.5 57 56.7 5.1	64 18 50 12	20 S 34 D	23 9.1 0.8 11.4	0.0 8.6 0.0 1.2	0.0 B 0.0 1	7 0.0 1 8 0.0 0	0 80 8 10	6.1 0.8 0 3.1 0.8 0	0 0.0 BA	0.0 1.4 0.0 0.0
(5) C	AR/PDMS/DVB	00/90/08 17/90/08 17/90/08	GC DAMG GC DAMG GC DAMG	1 CARPONSOV 1(b) CARPONSOV 2 CARPONSOV	8 90 1 8 90 1 8 70 1	A1 828 1217 828 1411	139.2 8 113.8 8	0 11.6 0 88.4	12.8 6.5	15.8 17.4	0.4 0.5 3.0 1.0	8.7 30 1.9 32	0 362 7 328	0.0 0.0 0.0 0.0	25	637 33 T01 12	11	62.4 285 104.8 334	8 0.0 2 18	79.0 1.2 91.2 2.1	6.4 6.9	10 0.1 40 02	10 0.0 13 0.0	55.1 1.0 51.7 1.8	53 23 81 49	60 9 64 9	0.1 22.5 8.6 23.7	0.3 16.0	2.0 %	6 0.7 0 8 1.2 3	0 89	1.9 0.8 0 24 22 0	0.00 83	0.0 0.5
Using si	x different	29/05/09	GC CONT	1 PDWS 2 PDWS	72	B1 0.3 B1 0.4	0.5 E 0.4 E	3 0.1 3 02	10 0.1 10 03	0.4	0.1 0.0 0.2 0.0	8.0 0. 8.1 1.	9 02 4 0.4	0.2 0.0 0.2 0.0	1.5	2.5 0.1	11	0.4 4.7 0.5 8.7	0.0 0.0	82 0.5 83 0.5	03	15 0.0 16 0.0	E3 1.4 82 6.4	20.7 0.1 36.0 0.2	08 E3	1.7 8	5.4 0.7 7.5 0.9	0.1 84	0.1 D 0.7 3	5 0.1 1 2 0.4 1	1 13 1 8 14 1	LT 0.1 0	0.1 83	0.0 0.2
	ry varieties	29/05/09 29/05/09	GC DAMO	1 PDMS 2 PDMS	25 75	B1 0.1 B1 0.4	01 8	0 12 1 30	80 00 80 0.1	0.2	ai op ai oi	12	2 02	0.4 0.0	15.0 36.0	4.5 3.1	17 14	0.5 1. ¹ 0.8 2.4	0.0	84 03 81 04	0.5 1.0	12 0.0	LS 018 11 138.8	24.6 4.2	45 11	20 1	6.5 <u>3.9</u> 4.9 7.0	0.5 83.5	8.6 13 21.6 32	10 5.3 2 17 9.4 2	40 13 1 77 10.8	7.T 24.0 5		0.0 0.1 0.0 0.3
sampled using a range of		26/15/08	GA CONT	1 CARIPONS	90 /	A20 M-3	34.3 1	7 30	10.0 2.1	18.0	20 02	1.5 21	0 04	312 0.0	36	44.3 0.0	11.8	7.8 70.	0.00	84 35 1933 - 27	73	18 00	10 11	47.7 11	35 14	12 2	0.6 8.8	02 88	00 0	7 9.6 0		2 00 0	0.0	0.0 0.1
different fibre			GA CONT GA DAMG	1 CM040		A20 11.0 A20 51	00	2 05	24.4 0.7	11.4	ar 0.0	42 7	1 11	43 00	12	12.7 00	2	3.6 27	0.00	18.8 1.0	23	18 0.0	10 04	50.0 0.3	12 13	12 2	0.1 2.1	03 81	00 0	1 90 0	0 01	0.000		0.0 0.1
chemistries, we have identified a suite of			GA CONT GA DAMG GA DAMG		B 90 B 90	A1 25.5	38.7 2	0 13	89 20		1.4 0.4	8.0 22	14 81	11.8 0.0	13.9	64.8 0.0	2.4	62.8 191	8 1.0	71.1 2.2	38.4	10 0.0	18 28	47.6 1.3	62 89	2.8 9	0.0 10.9	0.0 2.7	0.0 Z	2 0.0 1	2 10	18 18 0	0.0 0.0	0.0 0.8
volatiles which show a			GA DAMG		8 90 75	A1 57.9 D1 1.5	21 8	4 507.5 2 0.6	24.3 1.5	90.6 1.1	2.3 0.0 5.1 0.1	10 25 12 2	0 11.5 <mark>.</mark> 9 1.7	42.5 0.0	57.4 11.9	94.5 0.5	14	58.1 98. 2.2 27.	5 0.1	23.1 1.7 22.9 0.9	14	22 0.6 5.5 0.2	11 27.6 12 1.5	53.6 5.7 59.1 0.4	5.8 44	12 2	6.9 12.1 2.1 2.0	1.4 512 0.3 8.9	110 51 0.0 0	16 9.4 6 8 9.4 1	1 17 1 1 11 1 3 11 1	20 89 0 5.1 05 0	0 0.0 E.	0.0 0.3
consistent pattern of			LA CONT LA DAMG LA DAMG		97 75	B1 2.0	1.6 8	2 0.6	8.2 0.1 8.4 1.4 8.2 0.4	12	6.9 0.1 65.2 0.5	12 2	8 12 2 18 <mark>8</mark>	18 00	0.9	7.1 0.1 8.9 24 5.9 07	12	2.1 23. 2.5 26	0 00 0 00	28 0.5 207 0.6	12	29 0.0	16 0.0	51.5 0.4 53.0 53	10 88	20 3 28 3 17 4	07 25	0.3 8.8	0.5 0 27.8 B	4 0.0 1 12 184 3			0 5.6 83 0 1941 13	0.0 82 22 %7 0.0 52
	ment following	25/05/00	DA DAMO	2 POWS	~	81 0.9				0.8	10 02		5 68	14 0.0	40	59 01	14	1.5 15.	2 0.0	10 0.4	12	25 0.1	25 1.1	50.9 0.3	1.1 1.6	17 4	05 00	0.5 38.7	111 24	0 70 1		15 55 0	5 55 11	0.0 52
damage to the cane. These compounds						ngoi	ing	Wc	orK																							$\sqrt{1}$		

consist mainly of a family of structurally related terpenes, many of which are known to have behavioural effects on insects and plants (e.g. attract natural enemies) and/or are produced in response to insect herbivory.

The physiological activity of the entrained volatiles is being investigated by means of a GCelecroantennography (EAG) system which identifies the metabolites which elicit a response from the antenna of female midges. Compounds showing enhanced production on damage to canes and those shown to elicit a response from the midge are being used to test and develop lures for biological control and monitoring. Some compounds identified from preliminary experiments are indicated in the chromatographic trace above

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