that acetaldehyde at low concentrations is utilized both as a resource and is a larval attractant.

Adults of the above populations and the Adh^{n2} mutant of *D. melanogaster* were exposed in a closed system containing a constant amount of gaseous acetaldehyde (water vapour in controls) in equilibrium with the liquid phase in the apparatus, as previously described for exposure to gaseous ethanol[3,5]. Adult tolerances were expressed as mean LT_{50}'s being the mean number of hours at which 50% of flies had died. Since control LT_{50}'s varied among species, LT_{50}/LT_{50} control values were used for comparative purposes[6]. The thresholds (fig. 1) were all close to 1% acetaldehyde except for *D. immigrans* where the threshold was somewhat lower. The increased longevity at low acetaldehyde concentrations indicates resource utilization.

Newly-hatched larvae are additionally good indicators of resource utilization, being the stage of maximum feeding[12].

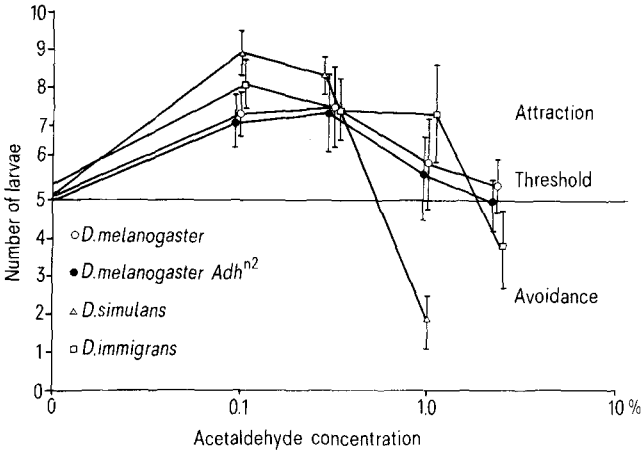

Fig. 2. Mean number of larvae out of 10 choosing agar containing acetaldehyde after 15 min based upon 8 replicates of each concentration tested for each species and genotype. The plots were very similar after 30 min. The intersection of the plots of each species with the straight line gives the threshold concentration between attraction and avoidance. The vertical bars indicate 95% confidence limits.

Larval behaviour was assessed by placing ten newly hatched larvae centrally on a Petri dish containing agar[12,13]. One semicircle of the agar contained one of the acetaldehyde concentrations, the other being pure agar. A range of concentrations was selected whereby the thresholds between attraction and avoidance could be identified. They were all in the region of 1% acetaldehyde (fig. 2).

Hence acetaldehyde at low concentrations is utilized as an energy source, and is a larval attractant for the 3 species and the Adh^{n2} mutant. However, at concentrations where ethanol and acetic acid are often resources and attractants[5,6], acetaldehyde is both toxic and a larval repellant. In addition, while there is a good correspondence between biochemical and behavioural phenotypes for the 3 species and the Adh^{n2} mutant for ethanol and acetic acid[10], this relationship is not apparent for acetaldehyde. Inter-and intraspecific differences would in any case be extremely difficult to detect given the toxicity of acetaldehyde at all except the low concentrations here examined. Investigations of acetaldehyde levels in *Drosophila* habitats in nature appear necessary.

1 We thank Jan Clarke for assistance, and the Australian Research Grants Committee for partial financial support.
2 J. van Herrewege and J.R. David, C. r. Acad. Sci. Paris *279*, 335 (1974).
3 W.T. Starmer, W.B. Heed and E.S. Rockwood-Sluss, Proc. natl Acad. Sci. USA *74*, 374 (1977).
4 J. van Herrewege and J.R. David, Experientia *34*, 163 (1978).
5 P.A. Parsons, S.M. Stanley and G.E. Spence, Aust. J. Zool. *27*, 747 (1979).
6 P.A. Parsons, Experientia *36*, 1363 (1980).
7 M.C. Deltombe-Lietaert, J. Delcour, N. Lenelle-Montfort and A. Elens, Experientia *35*, 579 (1979).
8 J.A. McKenzie and S.W. McKechnie, Oecologia, Berl. *40*, 299 (1979).
9 E.H. Grell, K.B. Jacobsen and J.B. Murphy, Ann. N.Y. Acad. Sci. *151*, 441 (1968).
10 P.A. Parsons and G.E.Spence, Aust. J. Zool., in press (1981).
11 J.R. David, C. Bocquet, M.F. Arens and P. Fouillet, Biochem. Genet. *14*, 989 (1976).
12 P.A. Parsons, Oecologia, Berl. *30*, 141 (1977).
13 P.A. Parsons and S.B. King, Experientia *33*, 898 (1977).

The effect of potato virus X on the nitrogenous constituents of potatoes

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Summary. Infection with potato virus X (PVX) increased the total nitrogen and non-protein nitrogen contents of Katahdin tubers. Protein nitrogen remained unchanged, but a 22% increase in free amino acid content accompanied infection. No differences were observed in the number or composition of protein fractions in infected tubers.

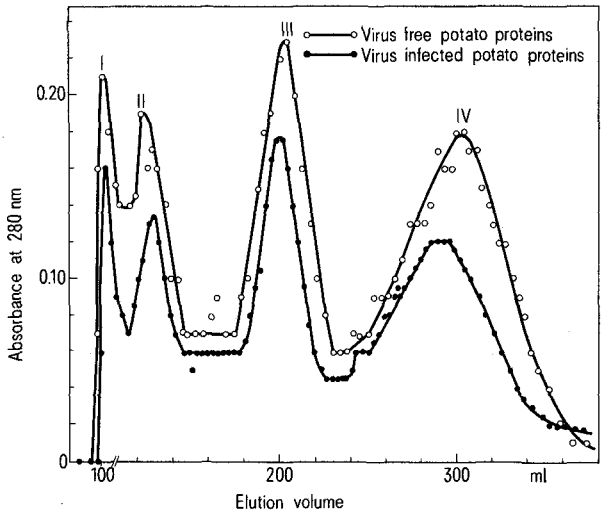
The potato is an important vegetable with regard to nutritive value and extent of cultivation. However, many varieties are susceptible to infection with potato virus X (PVX), and several researchers have reported that PVX caused appreciable reduction in tuber yield[1-3]. Potato tubers from PVX-infected Katahdin plants were significantly higher in specific gravity than tubers from healthy plants, however, Kennebec variety did not show any significant changes with infection[4]. Previous work from our laboratory revealed that potato tubers from PVX-infected plants were more susceptible to enzymatic discoloration, higher in phenolic and lower in lipid content than the controls[5]. Potato plants infected with PVX have been reported to have 70-150% more free amino acids in the leaves, but no studies have been reported showing the effect of PVX on the tuber, the part of the plant used for human consumption. The present investigation was undertaken to study the changes in the nitrogenous constitutents of potato tubers following infection with potato virus X.

Katahdin potatoes used in this study were grown during 2 seasons at the Uihlein Vegetable Research Farm of Cornell University at Lake Placid, N.Y. PVX-free and PVX-infected tuber-lines originating from the same Katahdin clone were planted in a field plot using a randomized block design. Following a 104-day growth period the vines were removed by cutting with a corn knife leaving 10-12 cm

Table 1. Total nitrogen, non-protein nitrogen (NPN) and protein nitrogen (PN) contents of PVX-free and PVX-infected potatoes expressed as mg/g dry weight

Treatment	Year 1 Total N	NPN	PN	Year 2 Total N	NPN	PN
Katahdin PVX-free	15.93±0.040	3.23±0.088	12.7 ±0.100	15.50±0.058	3.07±0.033	12.43±0.088
Katahdin PVX-infected	18.67±0.037	5.60±0.058	13.07±0.067	17.67±0.033	5.12±0.033	12.53±0.067
Significance	$p<0.01$	$p<0.01$	N.S.	$p<0.01$	$p<0.01$	N.S.

Data represents average ± SE. N.S. represents not significant.



Sephadex G-100 gel filtration pattern of PVX-free and PVX-infected potato protein.

Table 2. Free amino acid composition of PVX-free and PVX-infected potatoes expressed as mg/g dry weight

Amino acid	PVX-free	PVX-infected	Significance
Aspartic acid	2.32±0.069	2.52±0.058	N.S.
Threonine	0.54±0.012	0.73±0.017	$p<0.01$
Serine	4.28±0.012	5.80±0.019	$p<0.01$
Glutamic acid	1.09±0.003	2.28±0.069	$p<0.01$
Proline	0.65±0.017	0.19±0.006	$p<0.01$
Glycine	0.04±0.003	0.07±0.004	$p<0.01$
Alanine	0.14±0.004	0.21±0.005	$p<0.01$
Valine	0.74±0.020	1.10±0.058	$p<0.01$
Methionine	0.24±0.001	0.19±0.001	$p<0.01$
Isoleucine	0.32±0.015	0.41±0.009	$p<0.05$
Leucine	0.23±0.004	0.19±0.003	$p<0.01$
Tyrosine	0.23±0.017	0.46±0.005	$p<0.01$
Phenylalanine	0.36±0.006	0.29±0.003	$p<0.01$
Histidine	0.24±0.001	0.38±0.010	$p<0.01$
Lysine	0.20±0.018	0.28±0.003	$p<0.05$
Arginine	0.62±0.031	0.70±0.012	N.S.
Tryptophan	0.07±0.005	0.12±0.003	$p<0.01$

Data represents average ± SE. N.S. represents not significant.

stubble. 5 or 6 days following the cutting the remaining stubble was sprayed with Dow General to inhibit further possible growth and prevent contamination with the virus. PVX-free seed potatoes were screened on *Gomphrena globosa* each year prior to planting and, in addition, a random check of plants were made during the growing season to assure freedom from PVX. The potatoes were separated into cortex and pith sections and were cut longitudinally from bud to stem end in order to obtain equal sampling of both ends. Cortex tissue including the periderm was used in the study since this is the area of highest metabolic activity. Total nitrogen was determined using freeze-dried potato powder by the microkjeldahl technique[7], and non-protein nitrogen by trichloracetic acid method[8]. Free amino acids were extracted from the freeze-dried potato powder using 70% ethanol[9]. Ion exchange column chromatography technique was used for quantification of amino acids using a Beckman Model 119-CL amino acid analyzer. Norleucine was used as an internal standard and analyses were made in triplicate.

Gel filtration experiments were carried out on Sephadex G-100 (40×120 µm), column (4×52 cm) equilibrated with phosphate buffer of pH 7.8 (10 mM) containing 0.5 M NaCl and 0.02% sodium azide. After adsorption of the protein the column was eluted with the phosphate buffer. Gel filtration experiments were carried out at 20 °C with a flow rate of 20 ml/h. Fractions (3 ml) were collected and the absorbance was measured at 280 nm in a Bausch and Lomb Model 700 Spectrophotometer.

In both years of study, potato tubers from the PVX-infected plants were significantly ($p < 0.01$) higher in total nitrogen and non-protein nitrogen (table 1). No significant changes were observed in protein nitrogen. These observations are in agreement with those reported for tomato fruit[10].

Significant differences in amino acid composition were observed in the PVX-free and PVX-infected tubers (table 2). Threonine, serine, glutamic acid, glycine, alanine, valine, isoleucine, tyrosine, histidine, lysine and tryptophan were significantly lower accompanying the PVX-infection. An increase of 22% of total free amino acids was found in PVX-infected tubers in contrast to the 70–150% increase reported in potato leaves[6]. Gel filtration pattern of protein from PVX-free and PVX-indfected tubers is shown in the figure. In each the PVX-free and PVX-infected tissue the total protein on Sephadex G-100 gel chromatography yielded 4 fractions. Fraction I contained 11%, fraction II 16%, fraction III 28% and fraction IV 45% of the total protein in both PVX-free and PVX-infected tubers. No significant differences were found in the composition or in the concentration of the fractions.

1 L.J. Dowley, Potato Res. *16*, 3 (1967).
2 B. Emilsson and N. Gustafsson, Acta Agric. scand. *6*, 369 (1956).
3 N.S. Wright, Am. Potato J. *47*, 475 (1970).
4 H.J. Murphy, M.J. Goven and D.C. Merriam, Am. Potato J. *43*, 393 (1966).
5 N.I. Mondy and R.L. Koch, J. Food Sci. *43*, 703 (1978).
6 L.K. Zherebchuck and Z.M. Olevinskaja, Biol. Nauki. *3*, 98 (1972).
7 A.O.A.C., Assoc. of Official Analytical Chemists, Washington, D.C. 1975.
8 L.B. Klein, S. Chandra and N.I. Mondy, Am. Potato J. *57*, 259 (1980).
9 M.L. Weaver, H. Timm, M. Nonaka, R.N. Sayre, K.C. Ng and L.C. Whitehand, Am. Potato J. *55*, 319 (1978).
10 R. Singh and T.P. Mall, Curr. Sci. *43*, 764 (1973).
11 D.H. Spackman, W.H. Stein and S. Moore, Analyt. Chem. *30*, 1190 (1958).