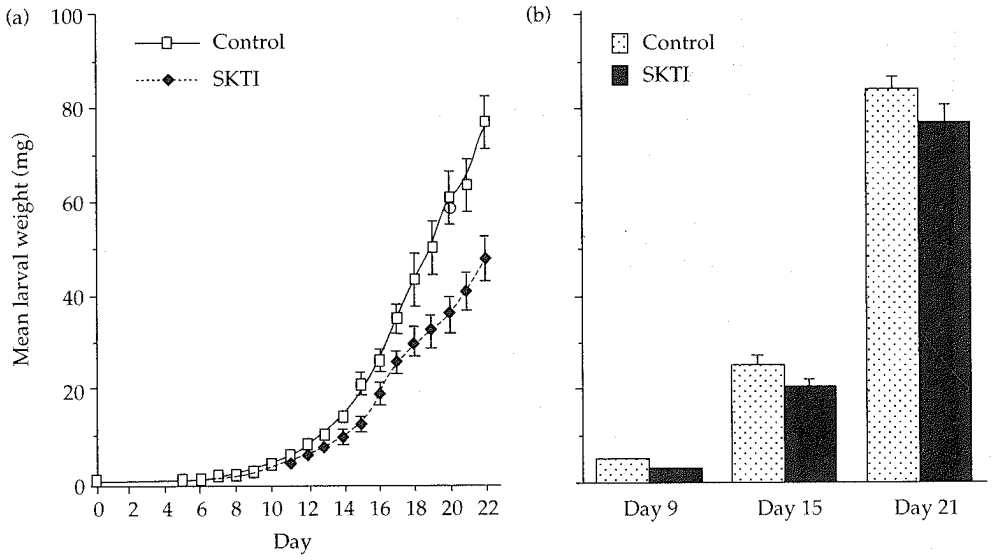

Figure 2.13 Effect of a soybean trypsin inhibitor (SKTI) on the mean mass (±SE) of surviving tomato moth larvae (*Lacanobia oleracea*) feeding on (a) artificial diet and (b) transgenic potato plants.

Note: The inhibitor was expressed at 2% of total protein in potato leaf-based diet and at 0.5% of total protein in potato plants. Reduction of growth was much more apparent for larvae feeding on artificial diet than for those on SKTI-expressing plants.
Source: Reprinted from *Journal of Insect Physiology*, **45**, Gatehouse *et al.*, 545–558. © 1999, with permission from Elsevier.

and rapid adaptation on the part of the insect pest. Insects can compensate for the loss of activity by hyperproduction of endogenous proteinases or by upregulation of new, inhibitor-insensitive proteinases, but both strategies are expensive in terms of amino acid utilization (Broadway and Duffey 1986; Jongsma and Bolter 1997). We might expect better adaptation in specialist herbivores, but the Colorado potato beetle, *Leptinotarsa decemlineata*, is only partially able to compensate for the effects of induced proteinase inhibitors in potato leaves (Bolter and Jongsma 1995).

Most proteinase inhibitors have little effect against phloem-feeding insects, whose diet is rich in free amino acids. However, the activity of lectins against homopteran pests is receiving considerable attention. Lectins are a diverse group of anti-nutrient proteins, often accumulated in plant storage tissues, which bind to carbohydrates (Peumans and Van Damme 1995). They have multiple binding sites and may bind directly to glycoproteins in the midgut epithelium, or may bind to and clog the peritrophic matrix. Snowdrop lectin, when expressed in transgenic potato crops, confers partial resistance to aphids (Down *et al.* 1996). Because lectins bind to the gut epithelium and enter the haemolymph, they have the potential to act as carrier proteins for delivery of insect neuropeptides as insecticides, when oral administration of the peptides alone is ineffective (Fitches *et al.* 2002).

Coping with plant allelochemicals

Apart from behavioural avoidance, insects can deal with allelochemicals by detoxifying and excreting them. Polysubstrate monooxygenases (mixed-function oxidases) are non-specific detoxification enzymes, rapidly induced by the presence of toxins. The terminal component is cytochrome P-450, which catalyses the oxidation of toxins to produce more polar compounds that are excreted or further metabolized. Multiple cytochrome P-450 genes are typically expressed simultaneously, hence the wide range of chemically dissimilar toxins (including pesticides) on which they act. To take a familiar insect as example, the specialist tobacco feeder *M. sexta* absorbs ingested nicotine into the midgut cells and metabolizes it to cotinine-N-oxide, which is cleared from the haemolymph by the Malpighian