The impact of insects on forests

Are our eucalypts providing fodder for large numbers of insects?

Past studies have concluded that insects on eucalypts in Australia destroy 20–50% of total tree foliage each year, much more than the 3–10% recorded in tree communities in temperate regions elsewhere. Using such published work as a basis, one ecologist extended the argument to propose that insects are among the main regulators of the productivity of eucalypt forests and play an important role in nutrient cycling.

Scientists from the CSIRO Division of Forest Research have conducted a 2-year study of eucalypt forest in the Brindabella mountains near Canberra and have come up with very different findings: leaf-eating insects have little continuing effect on forest productivity and short-term cycling there.

Funnels set up to measure insect frass-fall from eucalypts.

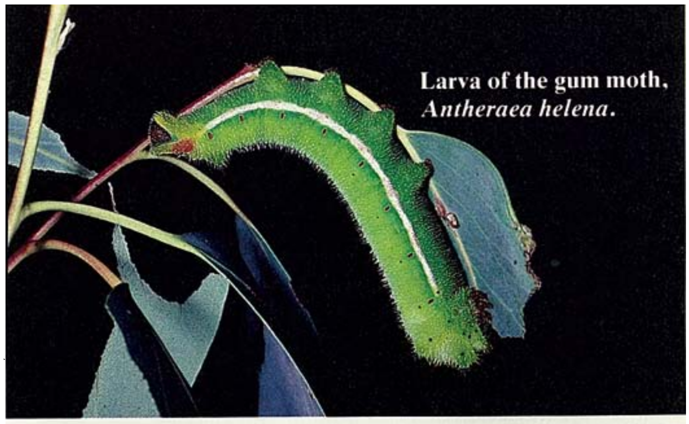
Dr Cliff Ohmart, Mr Leroy Stewart, and Ms Jeanette Thomas established study sites in each of three major forest types in the study area — alpine ash (*Eucalyptus delegatensis*), broad-leaf peppermint (*E. dives*), and snow gum (*E. pauciflora*). They estimated defoliation directly, taking leaf samples from a number of trees and photocopying the leaves to measure the area lost from the natural leaf silhouette.

To calculate the mass of leaves consumed, they measured the amount of insect faecal material (frass) falling from the trees into the gauze-lined necks of plastic funnels set up on stakes 1 metre above the ground. These measurements also enabled the researchers to estimate the amount of nitrogen, phosphorus, and potassium entering leaf litter as a result of insect consumption.

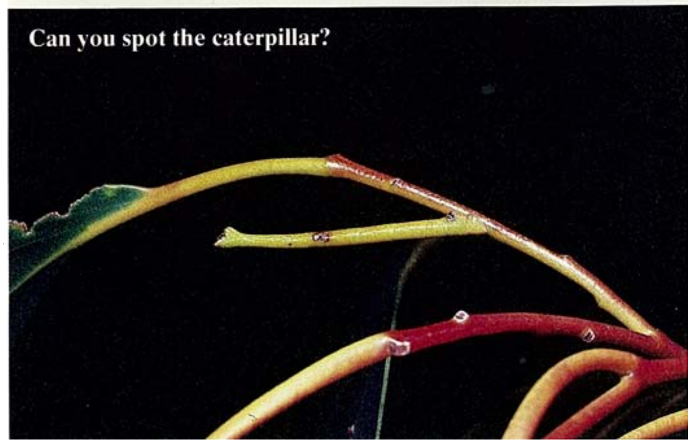
Obtaining frass-fall measurements proved to be more difficult than expected. The funnels set up under trees collected only tiny amounts of material and their white colour sometimes proved fatally attractive to scarab beetles, which remained imprisoned by the smooth sides, unable to manoeuvre themselves into a 'take-off' position.

Allowing for this bias from the beetle-ridden samples, Dr Ohmart calculated that the nitrogen, phosphorus, and potassium from grazing insects contributed only 2–4% of the total amounts falling in the forest litter. The data further showed that more nitrogen and potassium accrued on the forest floor annually in defoliator insect bodies than in their frass.

The total leaf area lost through insect grazing generally remained below 10% per year in the three forest types. Dr Ohmart discovered, however, that this measurement could be misleading. Eucalypt leaves



Larva of the gum moth, *Antheraea helena*.



Can you spot the caterpillar?

can remain on a tree for 2–3 years and so, at any given time, measurement of leaf area loss due to insect feeding may include the effects of previous years' attacks.

In their study of the leaf-eating insects found in the three forest types, the researchers found that numbers of individuals were low — 20 per kg of leaves, or four individuals per sq. m — and similar to those for northern temperate forests. Lower branches appeared to carry higher densities of insects and suffered more extensive defoliation than the upper tree crown. Broad-leaf peppermint forests appeared to be more insect-prone than the others.

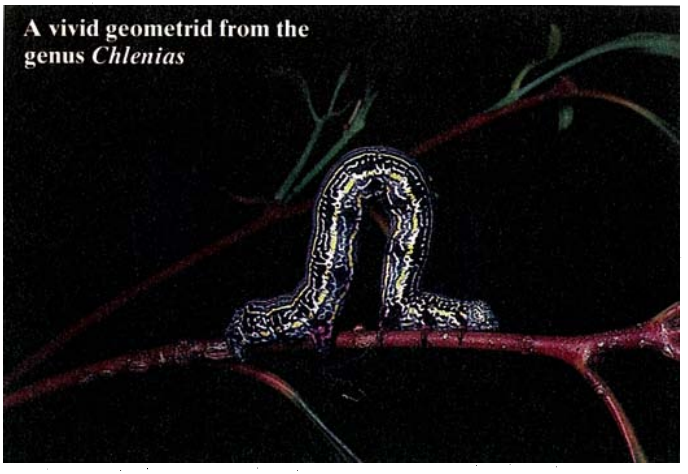
The most abundant leaf-chewing insects were small moth larvae; the rest comprised mainly inch worms, leaf beetles, and weevils. Other groups inhabiting the leaves — non-leaf-eaters, gall-making insects, and a substantial number of leaf-hoppers — were not classed as defoliators, since they are mainly 'sap-feeders' rather than 'leaf-chewers'.

The insect survey pointed to possible age- and species-related differences in vulnerability between trees. The broad-leaf peppermint forest contained many more leaf-eating insects per unit weight of foliage as well as more per hectare than the other two. Further, Dr Ohmart, Mr Stewart, and Ms Thomas concluded that insect consume more sap and leaves in young regenerating eucalyp stands than in mature forests.

Resistance and susceptibility to insects differ between individual plants. This is the basis of extensive plant-breeding programs that aim at developing more resistant populations of economically important species.

In a separate study of eucalypt forests, the CSIRO scientists attempted to identif differences in resistance to leaf-chewing insects between mountain ash trees from Tasmania and their Victorian counterparts. The Tasmaniar trees suffered more extensive defoliation than those from th mainland.

Why the difference in susceptibility within this species? One reason may be



A vivid geometrid from the genus *Chlenias*

that trees from mainland provenances have had the opportunity to evolve resistance to insect defoliators in their environment over a long period. The Tasmanian trees, which normally encounter few of these insects, would have little or no defence against them when grown on the mainland.

Another explanation for differences in resistance is that leaves from different geographical areas may have varying levels of tannins, phenols, essential oils, and nitrogen. Indeed, nitrogen may play a key role in defoliation by certain insect species, as shown in studies by Dr Tom White of the Riverina College of Advanced Education in Wagga Wagga, N.S.W., and Dr Mark McClure of the Connecticut Agricultural Experimental Station, U.S.A. Dr Ohmart thinks that mountain ash trees from Tasmania could have higher levels of nitrogen in their leaves than mainland trees.

Nitrogen is essential for insect growth: in laboratory insect populations, nitrogen deficiency causes stunted growth and reduced fecundity.

This may partly explain the large numbers of insects found on dieback-affected eucalypts in the New England area of New South Wales. Land clearing leaves isolated single trees that are more vulnerable to the outside world than forest trees. Fertilization can make the tree foliage more palatable to insects. And over-stocking may lead to soil compaction at tree roots, 'suffocating' the trees and causing foliage deterioration. This increases nitrogen in the leaves.

Trees weakened by these processes may attract leaf-chewing insects, such as the Christmas beetle, which accelerate dieback rather than cause it.

Dr Ohmart and his colleagues have begun studying the nitrogen metabolism of one species of leaf-eating beetle. Its response to fluctuating nitrogen concentrations should provide more clues to the significance of the element in defoliation.

The discrepancies between his results and those of previous studies that reported high levels of insect defoliation in Australian eucalypt forests led Dr Ohmart to carefully review the existing work on insect defoliation there.

He found that many of the earlier studies focused on young trees or smaller ones in semi-open woodland, along road-cuts, or in alpine areas, where insect defoliation seems to be much higher than in the mature, densely populated forests in which the CSIRO study was made.

Further, a lot of the previous work had been done in areas selected for study because of localized pest 'plagues'. Obviously, in these areas defoliation would be abnormally high.

Finally, the earlier studies appeared to have used annual leaf-area-loss measurements to estimate defoliation. As explained earlier, this does not account for losses incurred during the previous 1 or 2 years, and the CSIRO researchers calculated that such methods can overestimate annual leaf consumption by insects by 200–300%.

Despite the conclusions from the CSIRO study for mature eucalypt forests areas, there is one forest situation where insect defoliation can be significant. During the occasional defoliator 'plagues', beetles or other leaf-chewers can eat their way through more than 40% of the foliage. This leads to increased rates of nutrient uptake by each tree, increased litter turnover, and accelerated rates of recycling and turnover of elements in litter around the tree base, all of which can dramatically affect forest stand dynamics.

Mary Lou Considine

Phytophagous insect communities in the canopies of three *Eucalyptus* forest types in south-eastern Australia. C.P. Ohmart, L.G. Stewart, and J.R. Thomas. *Australian Journal of Ecology*, 1983, **8**, 395–403.

Differential defoliation by insects among provenances of *Eucalyptus delegatensis*. C.P. Ohmart, J.R. Thomas, and L.G. Stewart. *Journal of the Entomological Society*, 1984, **23** (in press).