Larval establishment behaviour of the borer *Aenetus virescens* (Lepidoptera: Hepialidae) in live trees

J. R. GREHAN
Zoology Department, Victoria University of Wellington, Private Bag, Wellington

Abstract

Larval behaviour during establishment in living trees is described for *Aenetus virescens*. The form of the initial tunnel is compared with both preceding and subsequent larval tunnels. Establishment by *A. virescens* is compared with arboreal Cossidae.

Keywords: Lepidoptera; Hepialidae; *Aenetus virescens;* larva; biology; behaviour; borer.

INTRODUCTION

The early development of arboreal hepialids has been documented for only 3 species, *Endoclita sericeus* (Swinhoe), *E. gemelina* Tindale, and *Aenetus virescens* (Doubleday) (Kalshoven 1965; Dharanajan 1976; Grehan 1979, 1982). In these species the larvae tunnel in the wood of trees or shrubs only after an early development period amongst litter on the forest floor. Hatchling larvae feed on decaying wood and (in the case of *Aenetus virescens*) fungal fruiting bodies for several instars before ascending living trees and shrubs to tunnel into the wood. I have called these 2 life styles in larval development the 'litter phase' and 'tree phase' respectively. In *A. virescens* the instar involved in the change from litter phase to tree phase is characterised by certain conspicuous morphological specialisations. I refer to this instar as the 'transfer larva' and to this stage of development as 'transfer phase' (Grehan 1981a).

The habit and habitat change from litter to tree phase is probably a crucial stage in larval development since it is the one time in which the larva is not in close contact with a food source and possibly most exposed to potential mortality factors such as predation and desiccation. The main features of establishment are described here and contrasted with the Cossidae (Lepidoptera) which also has arboreal members but contrasts with the arboreal hepialids in the pattern of early larval development.

ESTABLISHMENT ON A HOST

Host selection is not a subject of this paper although it can be noted that transfer larvae have been found ascending non-host as well as host trees (A. Moeed & M. J. Meads pers. comm.). The following descriptions of establishment are taken from study of establishment on *Carpodetus serratus* and *Nothofagus truncata* but I believe the general pattern to be applicable to other hosts.

To enter a host the larva positions itself more or less axially, head uppermost, and places silk threads over itself which are fastened to the surrounding bark to form a roughly oval shaped web (cover) (Figs 1, 2).

The larva at this stage is visible through the cover which is raised above the substrate only so far as to accommodate the larva within. In some cases it has been observed that establishment occurs in a depression on the surface of the host and in these cases the surface of the cover appears flush with the bark.

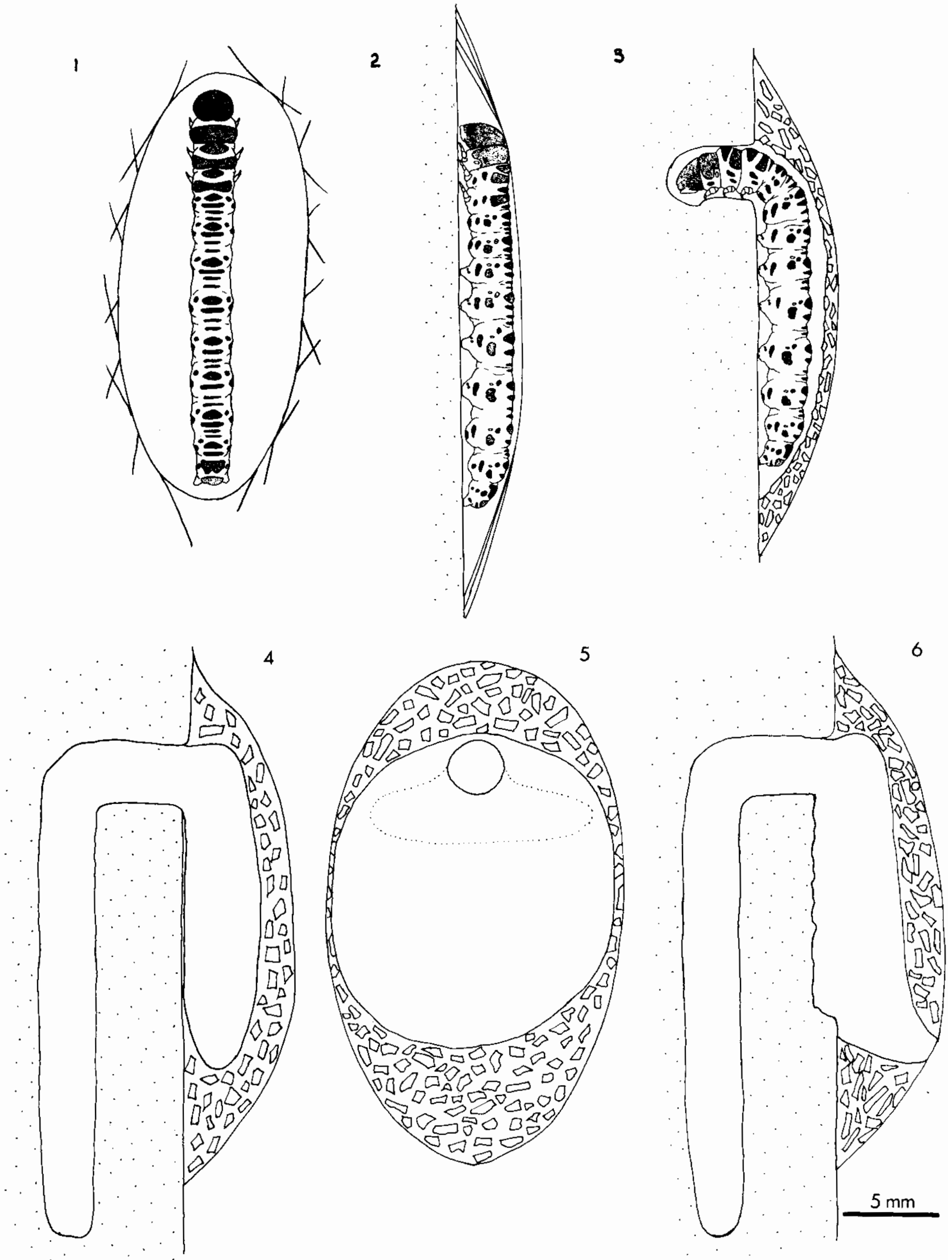
The larva then removes any surface growth such as moss or lichen and the particles are placed within the web. The larval tunnel is then begun by excavating bark and wood tissue from the host under the top part of the web. The tissue is removed in fragments referred to here as 'wood chips' which are not ingested but placed within the cover (Fig. 2). As wood chips accumulate under the cover the larva is no longer visible from outside. The wood chips are square to rectangular in general shape but may have oblique ends.

As the cover becomes filled with wood chips the larva constructs an inner silk lining around itself forming a bag-like cavity extending from the tunnel entrance (Fig. 4). As a result a wall of wood chips is formed between the cavity and the outside. The silk lining of the cavity may also extend over the bark surface and into the tunnel. During tunnel construction the larva may ingest some of the wood and faecal pellets are placed within the lower (about one-third) of the cover.

When the tunnel is at least large enough to contain the larva, bark is removed from around the tunnel entrance to form a feeding surface. Removal of bark results in formation of callus tissue by the host as a wound reaction (Hewitt 1977). The feeding surface is initiated just below and/or to either side of the tunnel entrance (Fig. 5) and is then extended over the remaining area under the cover. In the host *Carpodetus serratus* the inital depth of the feeding surface depression around the tunnel entrance is about 3 mm.

About the time the excavation of the feeding surface is begun a 'valve' is constructed approximately at the bottom of the silk lined cavity (Fig. 6). This valve is for the removal of faecal pellets and other material (Grehan & Winstanley 1980). When not in use the valve is closed by threads of silk. The accumulation of faecal pellets and wood chips in the bottom third of the cover will be immediately or subsequently removed. Once the feeding surface is extended to the cover boundary the cover becomes enlarged mainly along the lateral margins to accommodate the increase in area. This area increase of the cover depends on the host species. In some such as *Nothofagus* much of feeding surface may be overlain by bark (Grehan & Winstanley 1980).

The size of the initial cover ranges from 12 to 55 mm in vertical length and from upwards of 10 mm in width (n = 40). The upper range in cover width is less certain since it is altered by extension of the feeding surface. The size of the transfer larva is variable (Grehan 1981a) and this also applies to the dimensions of the larval tunnels. The tunnel, which ranges from 2.0-5.8 mm in diameter (n = 167), penetrates 12-20 mm into the tree and then extends downwards for another 13-45 mm (n = 37).



Figs 1-6. *Aenetus virescens.* **1.** Surface view of transfer larva prior to entering a live tree host. The larva has constructed a silk covering over itself. **2.** Lateral view of transfer larva prior to entering a live tree host. **3.** Transfer larva entering a live tree host. The larva is excavating a tunnel and wood chips are placed within the cover. Lateral view. **4.** Establishment tunnel at the stage where it is large enough to contain the entire larva. A silk baglike inner lining has been constructed from the tunnel entrance. Lateral view. **5.** Establishment tunnel where a feeding surface has been excavated within the confines of the original cover. Lateral view. **6.** Surface view of establishment tunnel. Dotted outline = area where feeding surface is initiated. Solid outline = full extent of feeding surface within confine of original cover.

Larvae have been found entering hosts in all months of the year. The transfer larva probably searches for hosts and initiates establishment at night. Litter phase and tree phase larvae are active at night. Three transfer larvae have been found in the open. Two were observed at night (author and Mrs D. E. Willis) and one during daytime (R. A. Page). Three transfer larvae have been observed excavating a tunnel during the afternoon. In these instances the establishment tunnels were still too small to contain the larvae. In one case the tunnel had penetrated only 5 mm. This suggests that establishment may not be completed in one night and may take up to 12-24 hours. The upper time limit for establishment is difficult to determine since it is a continual process. Establishment is not always successful and the fungus *Beauveria bassiana* has been identified as one cause of mortality (Grehan 1981b).

DISCUSSION

The establishment tunnel and associated features of the transfer larva shows features in common with the tunnels constructed in both litter phase and tree phase. The habits of both litter and tree phase are concealed, the larva occupying a tunnel and feeding at the tunnel entrance under a cover. The tunnel structure can be described as having 2 components: radial (penetrating) and longitudinal (parallel to the substrate surface). The tunnel of the litter and transfer phase is very similar and simple in design. The tree phase is initiated at the first moult following establishment at which the transfer morph is 'lost'. During the tree phase the tunnel may become comparatively elaborate with more than one longitudinal tunnel, a shelf at the junction of the tunnel components and/or an extension of the longitudinal tunnel. Orientation of the litter phase longitudinal tunnel is flexible being directed horizontally, downwards, or (rarely) upwards. In the transfer phase (and subsequently the tree phase) it is directed downwards subject to the inclination of the branch or stem.

All larval stages feed on the surface of the substrate, the litter phase larvae remove fungal hyphae or fungal infested wood while the transfer and tree phase larvae feed on callus tissue. In the litter phase the feeding area is overlain by a cover of wood chips and faecal pellets bound with silk while in the transfer phase and tree phase, faecal pellets are rarely incorporated into the cover. The cover over the tunnel of the transfer and tree phase is a much firmer structure than that of litter phase where it loses shape if removed from the substrate.

The establishment of the transfer larva may be contrasted with the Cossidae which like the Hepialidae includes subterranean and arboreal species (Common 1970). Although both families share similar habits they are only distantly related. The Cossidae belongs to the suborder Ditrysia (Common 1970) while the Hepialidae belongs to the suborder Exoporia (Kristensen 1978). Unlike the arboreal hepialids referred to in this paper the Cossidae do not have a litter phase during larval development and establishment occurs in the first instar. In *Xyleutes strix* L. eggs are laid in a single mass in which the larvae live for several days before dispersing by suspending themselves on silk threads and drifting through the air on wind currents (Kalshoven 1965). This dispersal also occurs with *Zeuzera coffeae* (Beeson 1941) and is suggested for *X. boisduvali* Rothschild (McInnes & Carne 1978). In these cases larvae appear to have little control over selection of hosts while the larvae of *A. virescens* are able to travel extensive distances (as indicated by ascending tall trees). However *X. durvillei* (Boisd.) (Cossidae) is considered to lay eggs at or on host trees (McInnes & Carne 1978). Establishment by the larva of *X. ceramica* (Cossidae) occurs by the larva protecting itself with silk until it has bored its way completely into the host (Beeson 1941). Although a silk cover may be utilised by arboreal Cossidae during establishment it appears to have no subsequent use, while in the arboreal Hepialidae the cover remains after establishment and is incorporated as part or all of the covering over the subsequent feeding surface. In the Cossidae the feeding surface is entirely overlain by bark and underlying tissue.

ACKNOWLEDGMENTS

I thank Dr G. W. Gibbs (Zoology Department, Victoria University of Wellington) for criticism of the manuscript and Dr A. Moeed and Mr M. J. Meads (Ecology Division, DSIR) for information on *A. virescens* larvae.

REFERENCES

BEESON, C. F. C. 1941: "The ecology and control of forest insects of India and the neighbouring countries". Part 2. Dehra Dun, India.

COMMON, I. F. B. 1970: "Lepidoptera" pp. 765-866. In "The Insects of Australia, CSIRO". Melbourne, Melbourne University Press.

DHANARAJAN, G. 1976: Some observations on the teak collar ring borer *Endoclita gmelina* (Lepidoptera: Hepialidae) in North Western Malaysia. *The Malaysian forester 39*:214-223.

GREHAN, J. R. 1979: Larvae of *Aenetus virescens* (Lepidoptera: Hepialidae) in decaying wood. *New Zealand journal of zoology 6*:583-586.

——— 1981a: Morphological changes in the three-phase development of *Aenetus virescens* larvae (Lepidoptera: Hepialidae). *New Zealand journal of zoology 8*:505-514.

——— 1981b: Infection of *Aenetus virescens* (Lepidoptera: Hepialidae) larvae by the fungus *Beauveria bassiana*. *New Zealand entomologist 7*:327-329.

———; WINSTANLEY, W. J. 1980: The puriri moth. A large colourful insect. *Forest and bird 13*:28-32.

HEWITT, E. W. 1977: Some effects of infestation on plants: A physiological viewpoint. *New Zealand entomologist 6*:235-243.

KALSHOVEN, L. G. E. 1965: Notes on some injurious Lepidoptera from Java. *Tijdschrift voor entomologie 108*:73-93.

KRISTENSEN, N. P. 1978: A new family of Hepialoidea from South America, with remarks on the phylogeny of the suborder Exoporia (Lepidoptera). *Entomologica germanica 4 (3/4)*:272-294.

MCINNES, R. S.; CARNE, P. B. 1978: Predation of cossid moth larvae by yellow-tailed black cockatoos causing losses in plantations of *Eucalyptus grandis* in North Coastal New South Wales. *Australian wildlife research 5*:101-121.