LEPIDOPTEROUS DEFOLIATORS IN A DEVELOPING PINUS RADIATA STAND

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ABSTRACT

A 4-year sampling programme of lepidopterous defoliators in a young developing stand of **Pinus radiata** D. Don showed that canopy density influenced the relative abundance of the two major defoliator groups, **Pseudocoremia** spp (Geometridae) and Tortricidae. Suction trap sampling showed that tortricid populations decreased as canopy closure led to reduced herbaceous growth, while **Pseudocoremia** spp. responded positively to increasing foliage density. Efforts to estimate the consumption of **P. radiata** foliage by measuring larval frassfall were frustrated by the high variability in rainfall leaching from frass traps.

Keywords: lepidopterous defoliators; suction traps; **Pinus radiata**.

INTRODUCTION

The development and impact of lepidopterous populations during the establishment and early growth phase of a *Pinus radiata* plantation were studied as part of an inter-disciplinary project to develop a biological growth model for *P. radiata* (Jackson & Chittenden 1981). The background to the project, nature of the study site, and stand management are dealt with elsewhere in this issue and will be discussed only where they relate directly to the entomological study.

A variety of sampling techniques have been used in the past to estimate population density of lepidopterous defoliators (Baltensweiler *et al.* 1977; Embree 1965; Morris 1963; Stinner *et al.* 1983). Direct larval counts (White 1975), counts of insects on foliage samples (Klomp 1966), light traps (Taylor & French 1974), pheromone traps (Houseweart *et al.* 1981; Struble 1983), and frass traps (Morris 1949) are but a few of these techniques. However, two important constraints were imposed upon the present study – namely, non-destructive sampling and the need for long-term quantitative data.

The primary input required for the growth model from the defoliator study was an estimate of total dry weight of foliage removed from the canopy annually by insects for a given area. The development and validation of sampling methods applicable to very low population levels are fundamental to providing these data. The general sampling philosophy was to estimate foliage consumption from frass production (Mathavan & Pandian 1974), establish a relationship between frass production and the subsequent adult population, and ultimately use adult numbers sampled by suction traps as an estimate of foliage removed from the canopy.

MATERIALS AND METHODS

Initially, larval counts were made on selected branches of selected trees along set transects. This was discontinued, however, when it became obvious that the populations were too low to be sampled effectively by this method. Sampling adults by use of suction traps promised the simplest solution, provided adult populations could be related to the frassfall of the contributing larval populations. The sampling programme therefore had two separate components – frassfall measurements to estimate larval populations, and suction trapping of the resulting adult populations.

Frassfall was measured using inverted cone-shaped plastic traps (Fig. 1) with a catching area of 0.283 m^2. All water passing through the traps was collected and measured and the following correction factor for leaching (M. Kay, pers. comm.) was applied.

$$\frac{\text{Frassfall (g)}}{1 - \cfrac{\text{Rainfall (mm)} + 61.59}{449.54}}$$

Frass collections were oven-dried and weighed.

The practical aspects of suction trap operation have been dealt with in some detail by Johnson & Taylor (1955) and the theoretical implications by Taylor (1962). The traps used (Fig. 1) incorporated a 240-volt single-phase fan operating at 1300 rpm with an air delivery of 0.5 m^3/s through a bellmouth diameter of 310 mm. The fan, mounted 1 m above the ground, drew insects into a synthetic gauze cone terminating in a collection jar containing isopropyl alcohol.

FIG. 1—Plastic cone frass trap with collecting tube in background. Suction trap, complete with isopropyl alcohol reservoir, being serviced in foreground.

Sampling was carried out in the Toru (Area 1) and Rua (Area 2) subcatchments of the Puruki catchment (Fig. 2). Both areas had been planted at 2200 stems/ha in 1973; Area 1 was pruned in April 1981 and thinned in November of the same year, and Area 2 was pruned and thinned in April 1980. Each sample area consisted of two suction traps 20 m apart, with 10 frass traps randomly distributed within 10 m of a line between the two traps. The random distribution of the frass traps initially placed 50% of those in Area 1 and 90% of those in Area 2 under at least 50% canopy cover. The number of trees overhanging the traps varied from one to three, with 60% of traps in both areas being overhung by two trees. After Area 2 was pruned to 2.4 m two extra suction traps were raised to just below the green crown to monitor any changes in insect flight behaviour.

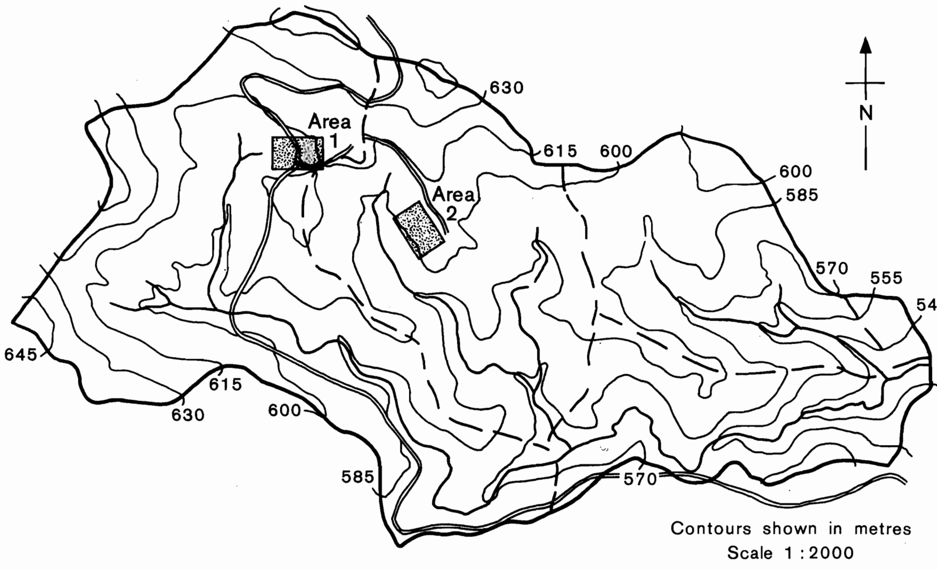

FIG. 2—Puruki catchment, showing location of the two sample areas.

Frass traps were serviced weekly over the peak frassfall periods of October to December, and February to April during 1981 and 1982. Adult sampling with suction traps was continuous from early 1978 until early 1983. Suction traps were serviced weekly during summer and fortnightly or monthly during winter.

Complete sorting to species of a 10-week sample from Area 1 (May to August 1978) showed 90% of the *Pseudocoremia* spp. to be *P. suavis* Butler and 80% of the Tortricidae to be *Ctenopseustis obliquana* (Walker), *Planotortrix notophaea* (Walker), or *Epiphyas postvittana* (Turner). Because of the poor condition of the specimens, complete sorting was extremely time-consuming and so the defoliators were subsequently sorted into the two broad categories of tortricids and *Pseudocoremia* spp. These categories included virtually all *P. radiata* defoliators apart from *Declana floccosa* (Walker) which did not reach any appreciable level at any time over the study period. The presence of *E. postvittana,* which is a herb feeder, in the tortricid sample was not large and was expected to decrease with time as the trees grew.

Both suction and frass trap data were subjected to analysis of variance.

RESULTS

The study provided considerable information on defoliator populations, especially as related to stand development; however, difficulties were experienced in relating adult populations to frassfall data.

Defoliator Populations

Both *Pseudocoremia* spp. and tortricid populations showed strong seasonality, with adult peaks appearing in spring, summer, and autumn (Fig. 3 and 4).

Analysis of variance by year, trap, and defoliator group showed a general increase in conformity between trap catches over time (Table 1). There was a significant difference between the two sampling areas in 1978 with Area 2 supporting a higher *Pseudocoremia* spp. population while Area 1 was numerically dominated by tortricids until mid-1979. By the end of the sampling period there was no significant difference between subcatchments or traps.

Canopy density, measured as leaf area index (LAI), appeared to limit *Pseudocoremia* spp. populations during early stand development and after heavy thinning (Fig. 4). When LAI was high the main influence on the *Pseudocoremia* spp. population was rainfall over the formative period (adult peak minus 7 weeks). The second generation,

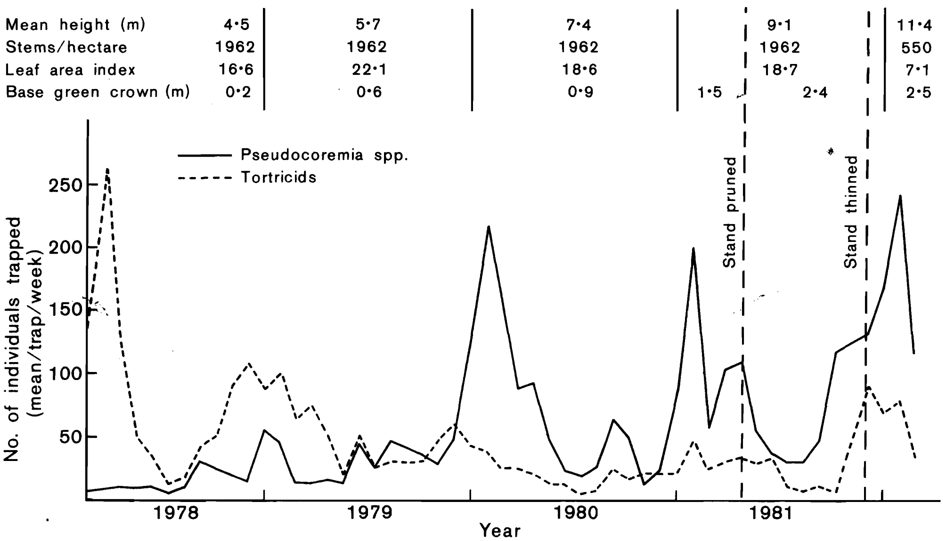

FIG. 3—Suction trap catches of **Pseudocoremia** spp. and tortricids in Sample Area 1 (Toru subcatchment) with associated stand parameters.

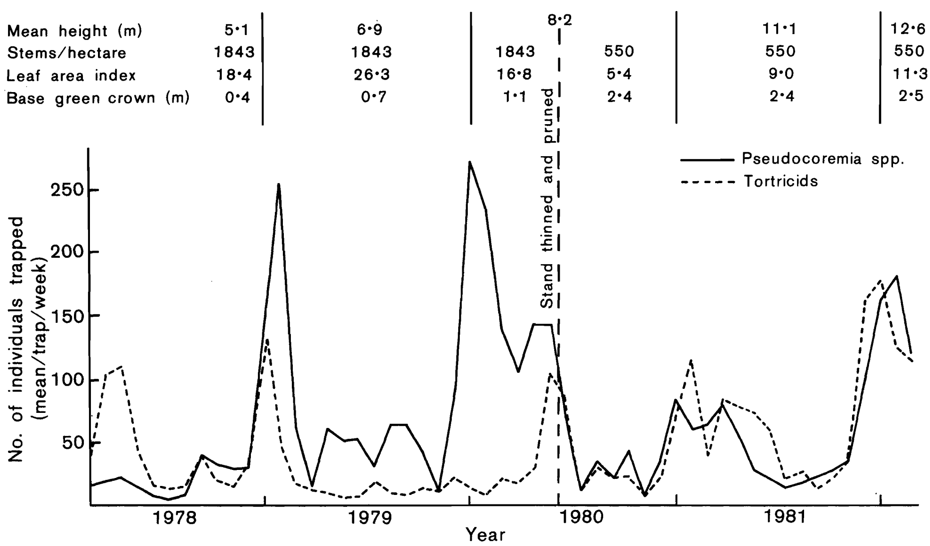

FIG. 4—Suction trap catches of **Pseudocoremia** spp. and tortricids in Sample Area 2 (Rua subcatchment) with associated stand parameters.

TABLE 1—Mean weekly suction trap catches for *Pseudocoremia* spp. and tortricids for the 12-month periods June 1978 to May 1979, and June 1982 to May 1983 (means followed by the same letter show no significant difference at p = 0.5%)

	Area	Trap	1978–79 Mean	1978–79 SD	1982–83 Mean	1982–83 SD
Pseudocoremia spp.	1	1	25.7a	25.4	69.9a	37.5
	1	2	15.9a	16.2	53.8a	32.3
	2	3	44.3ab	72.1	58.7a	39.6
	2	4	85.2 b	131.5	65.2a	47.6
Tortricids	1	1	55.6a	38.5	33.2a	20.7
	1	2	66.1a	55.1	44.7a	28.1
	2	3	18.9a	16.3	33.2ab	28.1
	2	4	25.4a	19.7	53.9 b	32.3

expressed as a percentage of the first generation and regressed on rainfall during the formative period, gave an r^2 value of 0.73.

Adults of both *Pseudocoremia* spp. and tortricids showed no inclination to fly higher as the base of the green crown was lifted with pruning. The raised suction traps caught very few specimens of either group.

Biomass Consumption

Populations of defoliators were very low during the study period, with no damage apparent on the trees and larvae rarely encountered during visual inspections. The low population levels resulted in a light and spatially discontinuous frassfall. The uneven nature of the canopy affected the water distribution such that rainfall passing through different traps within individual 1-week periods varied from 5 *l* to 21 *l*. The variation in amount and timing of this throughfall over the weekly sample period severely compromised the estimation of foliage consumption based upon the frassfall data. The best r^2 value we could achieve between frassfall and subsequent adult populations was 0.44.

DISCUSSION

The patterns of change in populations of defcliators generally appeared to reflect vegetation changes within the stands, with initially high numbers of tortricids being replaced by high numbers of *Pseudocoremia* spp. as the canopy approached closure. This pattern was most evident in Area 1 (Fig. 3), where the initially open forest structure was still apparent when sampling began.

Increases in tortricid numbers also reflected increased herbaceous growth after thinning. However, tortricid numbers were confounded by the changing proportions of the three main species, one a herb feeder (*E. postvittana*), one a generalist (*C. obliquana*), and one a conifer feeder (*Planotortrix notophaea*). The complete sort to species level was done using samples from the winter months during 1978 when the trees were only 5 years old (4–5 m tall) and there was still abundant herbaceous growth present. We therefore assumed that the use of these figures under-estimated the proportions of the *P. radiata* defoliators present in later samples, especially at times when canopy density was at its maximum. It is likely that increasing dominance of the conifer-feeding species in Area 2 led to the tortricids numerically challenging *Pseudocoremia* spp. by the end of the study period.

The foliage consumption measurement and its relation to suction trap catches was unsuccessful owing to the very limited frass production and the inconsistent movement of rainfall through the young *P. radiata* canopy.

The problem was compounded by the smaller diameter frass of the Tortricidae and the early instar *Pseudocoremia* spp. passing through the mesh at the base of the frass traps. However, this loss could be considered acceptable as 90% of the consumption of the most important defoliator, *P. suavis*, occurs in the fifth and sixth instars (Kay 1978). It is clear that suction trap sampling can be used to obtain a relative population measure of lepidopterous defoliators on an annual basis. The problem of relating catches to previous biomass consumption, while not insuperable, might best be attempted during a period of higher-than-normal defoliator populations by sampling daily during fine weather only, and using finer mesh in the frass traps. The greater input of resources might be justified for a period sufficient to establish the relationship to suction trap catches.

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