HONEYDEW AND ITS IMPORTANCE TO BIRDS IN BEECH FORESTS OF SOUTH ISLAND, NEW ZEALAND

P. D. GAZE and M. N. CLOUT

Ecology Division, DSIR, Private Bag, Nelson, New Zealand

SUMMARY: Honeydew is produced by a scale insect *(Ultracoelostoma assimile,* Margarodidae) in some *Nothofagus* forests of South Island, New Zealand. The quantity of honeydew present and its sugar concentration varies through the year. Honeydew is a valuable resource for bellbirds *(Anthornis melanura),* tuis *(Prosthemadera novaeseal andiae)* and silvereyes *(Zosterops lateralis).* Bellbirds and tuis were commoner in forests with more honeydew. Bellbirds spent more time feeding on honeydew when its sugar concentration was low.

KEYWORDS: honeydew; beech forest; Nothofagus; Fagaceae; bellbird; Anthornis melanura; tui; Prosthemadera novaeseal andiae; honeyeaters; Meliphagidae; food; Mount Richmond State Forest; Golden Downs State Forest.

INTRODUCTION

Honeydew is the sugary exudation from sap-sucking insects such as aphids (Aphidae) and scale insects (Coccidae). The insect inserts its stylet into the phloem cell of a plant and passively receives the sap (Kennedy and Mittler, 1953). After extracting its requirements the insect exudes the remainder in the form of a clear droplet of honeydew.

The honeydew considered in this study is produced by the scale insect *(Ultracoelostoma assimile)* which infests the trunks and branches of beech *(Nothofagus)* trees. Within New Zealand this insect occurs mainly in South Island and is most common on black beech *(N. solandri solandri)* and mountain beech *(N.s. cliffortioides)* in Canterbury, parts of Westland, and Nelson. It also occurs on hard beech *(N. truncata)* where, by comparison, the infestation is mild.

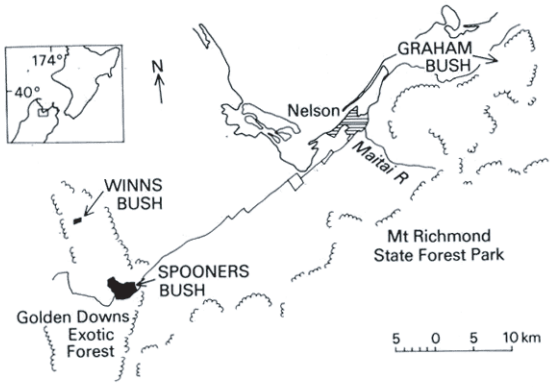

FIGURE 1. *Location of the study areas.*

The honeydew is produced by the female insect *(c.* 2 mm diam.) which is immobile and situated in a cavity in the bark protected by a waxy test (Miller, 1971). A silvery wax tube up to 10 cm long conducts the excess honeydew from the insect. As the cavity fills with eggs the adult female gradually atrophies and the eggs hatch into larvae which disperse.

Honeydew and related products are important in the diet of many honeyeaters (Meliphagidae) in Australia (Paton, 1980). In New Zealand, Kikkawa (1966) observed that the only *Nothofagus* forest he examined in which bellbirds *(Anthornis melanura)* were a dominant element of the avifauna was one where honeydew was abundant. This paper provides information on the seasonal production of honeydew in South Island beech forests and the extent to which birds consume it.

STUDY AREAS

There were three study areas, each in hard beech/ rimu *(Dacrydium cupressinum)* forest (Fig. 1). A one kilo metre transect with ten equidistant points was established in each area. The Graham Bush study area was on the eastern face of Whangamoa Valley in Mount Richmond State Forest Park. This section of forest had less beech and more kamahi *(Weinmannia racemosa)* than the other two areas. Spooner's Bush was c. 150 ha in area and Winn's Bush an isolated remnant of c. 23 ha. Both Spooner's Bush and Winn's Bush are surrounded by exotic forest *(Pinus radiata)* within Golden Downs State Forest. Honeydew was also examined in Maitai Valley, 5 km east of Nelson.

METHODS

Honeydew resource of each study area

An index of the abundance of honeydew was obtained by recording within 10 m x 10 m plots the number of beech trees of each species, the diameter at breast height if >10 cm, and whether honeydew was present. These plots were sited at each of the ten equidistant points along the transect. This survey was conducted in all areas in November 1978 during a week of fine weather.

Quantity of honeydew

In each study area, seasonal changes in the quantity of honeydew were measured on 20 beech trees. Trees producing good quantities of honeydew were. chosen and two vertical quadrats, 30 cm x 20 cm, were marked out, one above the other, on the northern aspect of the trunk at breast height. Honeydew is most abundant on the northern aspect (Crozier, 1981).

The study areas were visited on one morning once a month from August 1979 to July 1980 and all droplets in each quadrat were counted. Droplets were most readily observed with the light behind them. Droplet size (0.2 - 2.0 mm) was not measured. Heavy rain washes honeydew off the trunk and breaks the delicate wax tube through which it flows, so whenever possible droplets were not counted for three days after rain.

Sugar concentration of honeydew

The concentration of sugars in honeydew was measured as grams of solute per 100 grams of solution (Bolton *et al*.. 1979), using a hand-held 'Atago' refractometer. To obtain a measurement, 10-20 droplets were placed on the refractometer slide and thoroughly mixed.

Each month the concentration of honeydew was measured from every marked tree carrying sufficient droplets. These measurements were always made between 0900 and 1100 hrs. The number of trees able to be sampled varied between months and in some months no reading was possible because of rain.

To measure changes in the concentration of honeydew during daytime, repetitive readings were taken from ten black beech in Maitai Valley at two-hourly intervals on the clear fine day of 12 May, 1980. The ten trees selected were all heavy producers of honeydew, and this ensured that successive samples could all be taken from the northern aspect without sampling any insect more than once.

Honeyeater numbers

For two .years, from November 1977 to October 1979, birds were counted each month in all three study areas by two observers (Clout, 1980) using the method of Dawson and Bull (1975). The study was designed to reduce any bias between areas that may be caused by time of day, weather, or the observer's ability. The method provided only an index of abundance, and although counts of a particular species may be compared between areas and between months they are not counts of the actual numbers of birds present.

Honeydew consumption by honeyeaters

During monthly visits to each area from August 1979 to July 1980 the activities of bellbirds, tuis *(Prosthemadera novaesealandiae)* and silvereyes *(Zosterops lateralis)* were recorded. Individual birds were followed for up to ten minutes (although observation periods were often shorter than this). The birds' activities were classed as follows: feeding on honeydew, feeding on insects, feeding on fruit. general foraging, loafing, and singing and preening. The plant species, forest stratum and duration of the activity were also recorded. The time spent on each activity was recorded using an electronic timer which clicked every five seconds.

Observations on the birds' feeding were biased towards the more conspicuous species and individuals. Silent birds in the canopy were less likely to be recorded than those which were vocal or active lower down. Bellbirds were the most conspicuous species and there were more observations on this species than the other two. In some months, particularly in late autumn and winter, fewer observations were made because the birds were less conspicuous and the weather was bad.

RESULTS

Honeydew resource of each study area

The forest at Graham Bush had less beech than the other study areas and only a small proportion of the beech present had honeydew (Table 1). Honeydew was found on the highest proportion of beech at Spooner's where the trees were densest.

Hard beech of 10-29 cm diameter were infested more often than those 30 cm or more in diameter (Fig. 2), ($G = 4.13$, $p < 0.05$; Sokal and Rohlf, 1969).

TABLE 1. *The number of trees recorded from all ten quadrats (combined area = 1000 m^2) in each area, the number of beech trees and the percentage of these with honeydew.*

	Graham Bush	Winn's Bush	Spooner's Bush
No. of trees	105	57	100
No. of beech trees	8	50	65
% of beech trees with honeydew	12	24	43

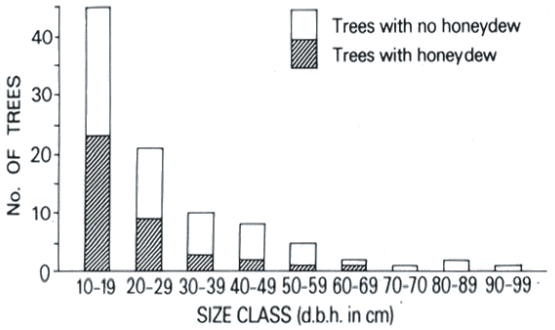

FIGURE 2. *The total number of hard beech trees of each size class showing the number with honeydew present. (Data for all plots in all study areas combined).*

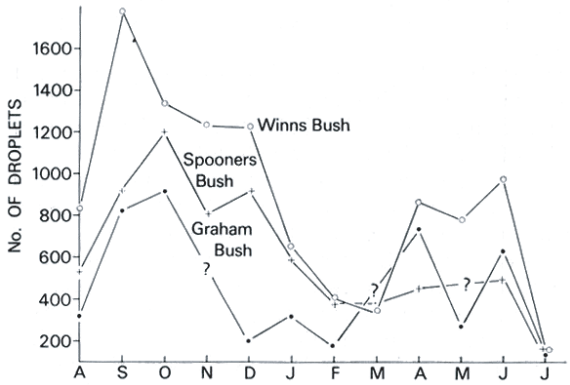

FIGURE 3. *The total number of honeydew droplets counted in two 30 cm x 20 cm quadrats on 20 beech trees in each study area each month.*

Quantity of honeydew

Monthly counts of the droplets showed a similar seasonal trend in each of the study areas (Fig. 3). The number of droplets peaked in September or October and then gradually decreased until February or March. A minor peak occurred in autumn before falling to a minimum in July.

Sugar concentration of honeydew

Individual droplets on a single tree varied in viscosity, but the sugar content of consecutive samples from the same tree seldom varied by more than 2 g per 100 g of solution (%). Monthly data on sugar concentrations were combined for all areas for each of the months from September 1979 to June 1980 (Fig. 4). The highest reading was in September with a mean of 76% (range 72-81 %). The mean dropped to 50% in October and fluctuated between 21 % and 43 % in the next eight months.

Honeydew also became more concentrated as the day progressed, from an initial concentration of 16% at 0900 hrs to 40% seven hours later (Fig. 5).

When sugar concentration is below 30% honeydew flows freely, but at concentrations greater than 70% the droplets become tacky and hang to the wax thread of the insect and may inhibit further flow. Such a droplet may hang for hours without becoming larger, yet another begins to form as soon as it is removed.

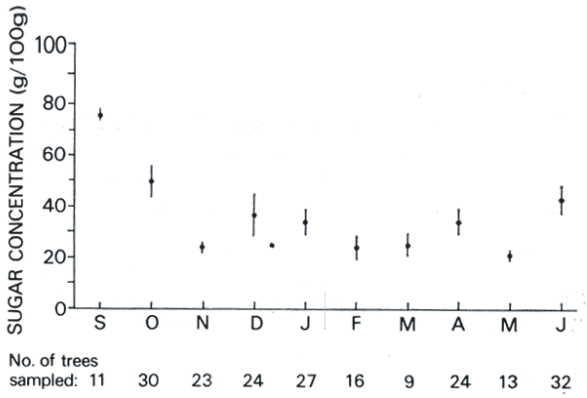

FIGURE 4. *The mean (± 95 % confidence limits) monthly concentration of sugar in honeydew.*

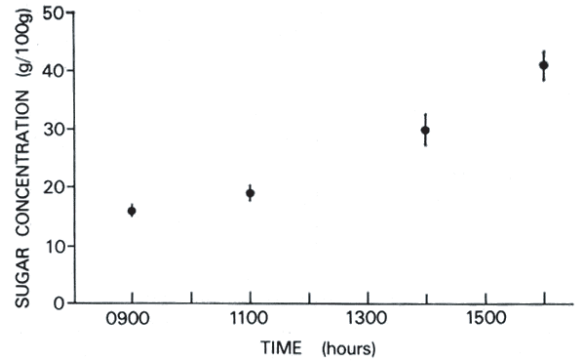

FIGURE 5. *The mean (± 95% confidence limits) concentration of honeydew collected from 10 black beech trees between 0900 hrs and 1600 hrs, 12 May 1980.*

TABLE 2. *The mean numbers of bellbirds, tuis and silvereyes recorded during 5-minute bird counts (N = 480/area) from November* 1977 *to October* 1979

Species	Graham Bush	Winn's Bush	Spooner's Bush
Bellbird	1.42	5.96	3.50
Silvereye	2.48	1.19	2.41
Tui	0.13	0.60	0.75

TABLE 3. *The percentage of time spent by bellbirds, tuis and silvereyes on each of five activities for all areas and all months.*

Species	Total time observed (5 second periods)	Feeding On			Foraging generally	Loafing	Singing & preening
		Honeydew	Insects	Fruit			
Bellbird	6237	21	17	0.3	12	31	19
Silvereye	441	32	25	0	20	18	5
Tui	1029	36	7	0	8	28	21

Honeyeater numbers

Tuis and bellbirds were most abundant in the areas with most honeydew (Table 2). There were fewer silvereyes in Winn's Bush than in the other two areas despite the high incidence of honeydew.

Honeydew consumption by honeyeaters

Bellbirds fed on honeydew by hopping up the trunk, often spirally, with tail depressed and neck stretched forward, taking each droplet with a flash of their brush-like tongue. There was no noticeable interference between bees and birds feeding on the same. trunk, but bellbirds sometimes chased other bellbirds attempting to feed from the same trunk. Bellbirds foraged for honeydew for 21 % of the total time they were observed, silvereyes (with fewer observations) for 32 % of their time, and tuis 36 % (Table 3). Tuis spent the greatest proportion of their total' foraging time on honeydew whilst silvereyes, which spent more time foraging than the other two species, devoted the smallest proportion of this time to honeydew.

Bellbirds were the only species observed often enough to analyse their time-budget monthly (Fig. 6). Combining data for all months, bellbirds spent 50% of their time foraging (range 36-70%). They spent significantly longer feeding on honeydew when its sugar concentration was low ($r = -0.652$, $p < 0.05$), but their feeding was not affected by the number of droplets present ($r = -0.564$, $0.1 > p > 0.05$). Bellbirds spent most time feeding on honeydew during February and March when the droplets were furthest apart and least concentrated. The increased time spent foraging for honeydew during these months therefore may reflect the greater amount of time needed to obtain the same amount of energy from this food.

DISCUSSION

The amount of honeydew present in a beech forest depends on the habitat, the weather and the time of year. The age structure of the forest is important, as *U. assimile* is found abundantly on trees of 10-30 cm diameter. The proportion of trees with honeydew varies with the density of beech as well as with other features not investigated in this study, such as aspect and fertility (Belton, 1978), altitude (Crozier, 1981), and species composition of the forest (pers. obs.).

Honeydew abundance varied seasonally, with the main flush in spring and a lesser one in autumn. These changes may be indicative of the breeding cycle of *U. assimile,* of which little is known. In February and July, when honeydew production was low, many of the capsules observed on the trees were open and those opened with a knife contained well advanced larvae. In each case a peak in honeydew production occurred two months later, presumably from the activities of the new generation of insects.

The sugar concentration of honeydew varied seasonally, from 16% to 81 %. Activity of the insects is unlikely to be responsible for such major changes, particularly as Mittler (1953) showed that the sugar concentration of sap and honeydew seldom differ by more than 3 %. Atmospheric conditions, however, will affect the concentration. Hot, dry and windy conditions will concentrate sugars in the honeydew through evaporation, while under humid conditions moisture in the air will dilute the droplet. The major changes in concentration must be caused by variation in the concentration of sugars in the sap. It has

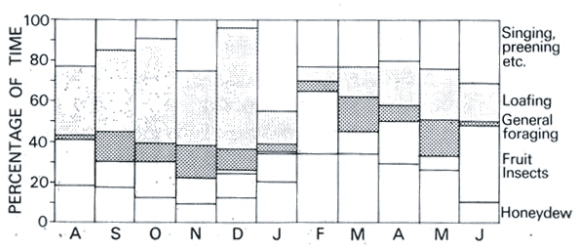

FIGURE 6. *Bellbird time budget showing the proportion of time spent feeding on honeydew in relation to the time spent feeding on insects, fruit. Generally foraging, loafing and singing and preening.*

been shown for many species of plant that there is a seasonal and diurnal periodicity in the movement of solutes (Meyer, Anderson and Mohning, 1960). Seasonal translocation of solutes is greatest in spring and this corresponds well with the peak concentration of honeydew recorded at this time in the present study. The seasonal changes in honeydew concentration are positively correlated with the seasonal trend in the number of droplets present. In late autumn and early spring more honeydew was produced and it had a higher sugar concentration.

Although bellbirds, tuis and silvereyes feed on insects, fruit and nectar (Gravatt, 1971; Craig, Stewart and Douglas, 1981) honeydew is also an important food for them in South Island beech forests. There were more bellbirds and tuis in those forests with more trees producing honeydew, which suggests that honeydew may be an important factor governing their abundance in beech forests.

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