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RESOURCE DIVISION BETWEEN BIRDS IN A SANDPLAIN HEATH.

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CONTENTS

INTRODUCTION

Competition has been defined by Birch (1957) as the process occurring "when a number of organisms (of the same or different species) utilise common resources that are in short supply; or, if the resources are not in short supply, competition occurs when the organisms seeking that resource nevertheless harm one or other in the process".

Interspecific competition in birds has been studied by many authors including MacArthur (1958), Cody (1968)and Williams (1975). Australian studies include those by Recher (1971) and Recher & Abbott (1970).

One method of studying competition between two (or more) species is to measure the niche of each species and calculate the amount that the niches overlap. Hutchinson (1958) defined the species niche as a n-dimensional hypervolume where each resource used by the species constitutes a dimension. Resources include food, roosting sites, nesting sites and oxygen. Particular bird species use only a part of the range of each resource. For example, many types of food are available but a species is limited by morphology and behaviour to certain food types. The niche of a species is determined by the parts of the ranges utilised for all n resources used by the species. The presence of another, competing species will cause a species to use smaller parts of the ranges of one or more resources than it would when alone. For this reason two types of niche are recognised (MacArthur, 1968):

(1) fundamental niche which is the niche occupied by a species when alone.

(2) realised niche which is the niche occupied in the presence of competing species.

In practice one cannot measure the usage by a species of all its resources and most studies of competition have assumed that the level of competition between species can be estimated by measuring the amount of overlap in the usage by the species of the limiting resource. A resource is limiting if an increase in the resource causes an increase in the number of individuals of the species that the habitat supports (Slobodkin, 1954).

The resource most commonly assumed to be limiting is food although it frequently is not (Hutchinson, 1958). Seed, fruit, nectar and insect eating birds usually are food limited (Murdoch, 1966; Slobodkin, Smith & Hairston, 1967). When food is a limiting resource, one would expect the bird species in a community to be distributed over the food item range so as to exert equal feeding pressure on all food items (Cody, 1968). More species would feed in parts of the range where food items are abundant than parts where food items are rare.

The fact that the species of a community are distributed over the food item range does not ensure the persistence of all the species. If two species are feeding on the same food items the more efficient feeder will displace the other species from the community. To persist in the community a species may adopt one of two feeding strategies (MacArthur, 1958):

(1) the individuals of the species may concentrate their feeding in a very small part of the food item range where they feed most efficiently (and for which they possess specialisations) and they will displace other species which feed less efficiently on the same range of food items.

(2) the individuals may feed in such a manner as to feed mainly on food items that are not available to other species in the community. This may be achieved in four

ways (MacArthur, 1958):

(a) using different parts of the habitat from other species,

(b) feeding at different heights above ground,

(c) using different food searching behaviour so as to come across different food items,

(d) temporal separation from other species with the same food item preferences in cases where the food supply is renewable.

The vegetation, climate and soil of an area determine, either directly or indirectly, the range of food items available to birds. The vegetation determines:

(a) the habitat heterogeneity,

(b) has a strong influence on the range of vertical heights available for feeding,

(c) affects the type of food searching behaviours that are profitable.

Because the vegetation of an area exerts such a strong influence on the ways that bird species may divide up the food resource to lessen interspecific competition, one would expect areas of similar vegetation (with similar climates and soils) to possess bird communities which had divided up the food resource similarly. The two communities would contain pairs of species with similar niches (assuming that the limiting food resource is the primary determinant of a species' niche). These pairs would constitute ecological equivalents, unrelated (usually at family level) bird species from different geographic areas that have similar diets and feeding behaviour.

Cody (1974) examined the bird communities of two sites with similar climates, vegetation and soils, one in California and the other in Chile. The two communities contained a similar number of species and in almost all cases there were pairs of species that formed ecological equivalents. The similarity in structure of the two communities was impressive and Cody suggested that a comparison of the Californian and Chilean bird communities with those of other areas in the world that have a Mediterranean climate and chaparral-like vegetation would be interesting.

The suggestion by Cody formed the basis of the present study, which had two purposes:

(1) To compare the bird communities of the Californian chaparral site and its south-west Australian equivalent.

(2) To examine how a group of related bird species (all members of the Meliphagidae) divide up their food resource.

The species were *Gliciphilia melanops* (Tawny-crowned honeyeater), *Phylidonyris niger* (White-cheeked honeyeater), *Acanthorhynchus superciliosus* (Western Spinebill), *Lichmera indistincta* (Brown honeyeater), *Melithreptus brevirostris* (Brown-headed honeyeater) and *Myzomela nigra* (Black honeyeater).

Specht (1969) described the chaparral as a fire-tolerant, broad or needle leafed, sclerophyllous vegetation occurring in areas of 375-750mm annual rainfall and infertile soil. Specht considered that sandplain heath and mallee are the southern Australian equivalents of chaparral. The site chosen for this study was an area of sandplain heath near Aldersyde.

METHODS

The study site was a 4 hectare area of sandplain heath surrounded by wandoo (Eucalyptus wandoo) and mixed wandoo-sheoak (Casurina glauca) woodland. It was located in the East Pingelly Wildlife Reserve.

Within the study area ten 30m diameter sampling sites were chosen to represent a range of different habitats within the study area and marked out. All bird observations were made in these sampling sites. Information about the vegetation structure and species composition of each sampling site was obtained from two 30m line transects, one running North-South and the other running East-West. The height of each layer of vegetation was measured every metre. For example, if a bush were growing under a tree at a metre intercept, and they formed two distinct vegetation layers, both the height of the bush and the tree were recorded. These data were converted to percentage ground cover. The sampling method used was a variation on the method of Gates (1949), who used continuous sampling along the transect instead of regular point quadrats (metre intercepts). Continuous sampling is slower and less suitable for conversion of sampling data to diversity indices. The plant species present at each metre intercept were recorded and the data were converted to plant species frequency.

Each bird observation period in a sampling site was one hour long and the observation periods were spread throughout the day so that each site was sampled during four periods, early morning (7.00 - 9.00 a.m.), mid-morning (9.00 - 11.30 a.m.), afternoon (1.30 - 4.00 p.m.) and late afternoon (4.00 - 5.00 p.m.). There was a total of 47 hours of observation in the sampling sites.

During the observation periods three types of quantitative data were collected:

(1) the bird species that entered the sampling site.

(2) the number of individuals of each species whose feeding behaviour was recorded.

(3) the length of time that each individual carried out feeding behaviour (50 second limit on an individual bird).

Feeding time was divided into:

(a) time spent nectar feeding.

(b) time spent insect feeding.

(c) time spent feeding in each vegetation height class.

Some observations were made of the parts of the trees and bushes that different species used while feeding.

At the conclusion of the study period a day and a morning were spent walking in the different habitats around the study area to see whether the bird species found in the study area also occurred in other habitats. These observations were combined with observations made while searching for a suitable study area.

A bird species list for the study area was prepared. Information about species' size was obtained from Serventy & Whittell (1967) and about species' feeding preferences from my own and I.J. Abbott's observations. An estimate of the relative abundance of the species was calculated from the number of feeding observations for each species in the sampling sites.

The bird species data was compared with that of Cody (1974) for the Santa Monica (California) chaparral bird community. The feeding preference data for the Santa Monica bird species was taken from Reilly (1968).

In addition to data about feeding behaviour collected in the field the bill lengths of the six honeyeater species commonly encountered in the study area were measured.

Gape length was used as a meaningful measure of bill length, and five male and five female birds of each species were measured except in the case of _P. niger_ where six males and two females were measured.

RESULTS

3.1 Vegetation

Over half the area of the sampling sites was either bare ground or covered by vegetation less than 0.5m high (Fig.1). Only two (*Dryandra sessilis*, *Banksia attenuata*) of the twenty seven species present in the sampling sites grew above 2m high.

Taken as a whole the sampling sites were dominated by *D. sessilis*, with *Casurina humilis* and *Melaleuca sp* prominent in the understorey vegetation (Table 1). There was considerable variation in the plant species composition of the different sampling sites however and *D. sessilis* was replaced by *B. attenuata* in some sites.

During the study period *D. sessilis* was in flower and was being used for nectar feeding by honeyeater species. In the latter part of the study *Adenanthos sp* began flowering and was also used for nectar feeding. Other plant species were flowering but did not appear to be used by the honeyeater species for nectar feeding. The plant species were *Acacia lasiocalyx*, *A. lasiocarpa*, *Anigozanthos humilis*, *Baeckea preissiana*, *Boronia capitata*, *Calytrix brachyphylla*, *Casurina humilis*, *Dryandra nobilis*, *Hibbertia enervia*, *Hibbertia sp*, *Isopogon formosus* and *Stirlingia latifolia*.

3.2 Bird Species

Although other species were recorded (Appendix 1) only the way that honeyeaters divide up the food resource was examined. Division of the food resource was achieved in several ways:

(a) Food Preferences

The honeyeater guild (Root, 1967) could be divided into two groups consisting of those species that were entirely nectivorous or almost so (*L. indistincta*, *M. brevirostris*, *M. nigra*) and those species that spent approximately equal time insect and nectar feeding (G. melanops, P. niger, A. superciliosus) (Table 2)

(b) Feeding height and behaviour.

Because all species distributed their nectar feeding time equally in D. sessilis and in Adenanthos sp there was no difference in the vertical nectar feeding height distribution of the six honeyeater species. Small differences existed in the feeding behaviour of some of the species. Most notably, M. brevirostris was able to feed on the outermost D. sessilis flowers by hanging from the stamens of the flower on which it was feeding upside down. G. melanops and P. niger were restricted to the central and upper parts of D. sessilis trees because they almost always fed from small branches. L. indistincta and A. superciliosus were intermediate in this respect and often fed while perched on leaves, although they sometimes fed on the outermost D. sessilis by hovering for short periods.

The three insect/nectar feeding species showed differences in their height distributions while insect feeding (Table 3). All three species did some insect gleaning but whereas A. superciliosus was primarily a gleaner in shrubs and the lower parts of trees, P. niger and G. Melanops spent most of their insect feeding time hawking for insects (Table 4). P. niger caught insects on short flights around tree top level (5 - 8m) whereas G. melanops caught insects high above the heath (15 - 30m) Both species spent long periods perched in trees waiting for insects to fly past. B. attenuata was used more commonly than D. sessilis, particularly G. melanops was seen frequently sitting on top of B. attenuata cones in top of the tree (Table 5).

(c) Horizontal distribution

The sampling sites were not used equally by the species (Table 6), suggesting that habitat selection was occurring. Further evidence of habitat selection was provided by the species -

sampling site data (Table 7) which may also be interpreted as evidence of competition, although it is more likely that they only reflect habitat selection. With two exceptions (P. niger, L. indistincta) there was a significant inverse relationship between the number of individuals of a given species observed in a sampling site and the proportion of all individuals observed in the site that belonged to other species. If all six species preferred the same habitat, one would expect the abundance of all six species to be high in some sampling sites and low in others. As the number of observations of a given species in a sampling site increased, the proportion of all individuals observed that belonged to other species would remain constant. An inverse relationship between the number of observations of a given species and the proportion of all observations that were of other species indicates that the given species prefers a different habitat to those preferred by the other species.

P. niger did not appear to be excercising habitat selection within the study area but L. indistincta was restricted to areas where D. sessilis was dominant (which covered a wide range of habitats).

(d) Dryandra as a factor in habitat selection

D. sessilis was an important factor in determining the spatial distribution of the honeyeaters in the study area during the study period. The amount of time spent nectar feeding was correlated with the amount of D. sessilis in each sampling site (Spearman's Rank Correlation Co-efficient for tied values, $r_s = 0.705$ $n = 10$, $P < 0.05$). Although additional factors had a role in habitat selection, D. sessilis abundance was the primary factor used by the honeyeater species in choosing a habitat for nectar feeding.

Sites with abundant D. sessilis supported as much insect feeding activity and a greater amount of nectar feeding than other sites. These sites had a greater bird species diversity (MacArthur & MacArthur, 1961) than sites with less D. sessilis (Fig. 2; $r_s = 0.906$, $n = 10$, $P < .01$).

(e) Habitat Overlap

Although data was collected that suggested the honeyeater species had different preferred habitats (Tables 6 & 7) the differences in the habitats could not be quantified. Differences in the preferred habitats of two groups of honeyeaters, nectar feeders and insect feeders, can be shown. Nectar feeders were found only where D. sessilis was present and were most abundant where D. sessilis was abundant. Insect/nectar feeders were more independent of the distribution of D. sessilis and therefore the horizontal, habitat overlap (index I; Whittaker, 1960) between nectar and insect/nectar feeders was least in sites with a low D. sessilis abundance and greatest in sites with a high D. sessilis abundance (Table 8). The nectar feeding species had a more restricted range in the study area than insect/nectar feeding species.

(f) Bill size

The bill length of the honeyeater species was variable (Table 10). Although the bill length ratio between species is often used as an indicator of feeding overlap, there was no correlation between bill length ratio and feeding overlap (either insect or nectar) of pairs of species in the honeyeaters studied. It was impossible to measure tongue length, which is probably a more appropriate indicator of feeding overlap between honeyeaters, because the tongues of the bird skins had been removed or were inaccessible.

DISCUSSION

The vegetation of the Santa Monica (California) site (Cody, 1974) and the East Pingelly site were different (Fig. 1). The East Pingelly site had a more open vegetation with a lower mean height although the maximum height of the vegetation on the two sites was the same. The small areas of mallee that grow on some ridges comprised a vegetation probably more like the Californian chaparral although somewhat lower. The soil in these areas (shallow soils over laterite) is more like most of the chaparral soils than the deep sand on which sandplain heath grows. Unfortunately no area of mallee exceeding 0.2 hectare, which was considered to be too small an area to study, was found.

A similarity between the Santa Monica and East Pingelly bird communities, such as Cody (1974) found between the Santa Monica and Chile bird communities, would not be expected because of the different vegetation structure and soil in the two sites. It is interesting nevertheless to compare the bird communities of the two sites because they represent equivalent vegetations in a Mediterranean climate (Specht, 1969).

The two sites both supported seventeen bird species but there were notable differences in the structure of the two bird communities.

(1) The East Pingelly community contained seven predominantly nectar feeding species and two other species which take some nectar compared to one nectar feeding species in the Santa Monica community. This major difference in the communities must surely be attributable to the differences between the plant species present at the two sites and thus questions the generality of the statement by MacArthur & MacArthur (1961) that "plant species diversity, except by influencing (the foliage) profile, has nothing to do with bird species diversity" which can be restated as "habitats of the same

profile have the same bird species diversity whether composed of few or many plant species".

In the different sampling sites in the study area habitat usage (bird species diversity) was not dependent on vegetation height diversity but was dependent on the abundance of a particular plant species, D. sessilis. When D. sessilis ceased flowering habitat usage would be dependent on another plant species and would probably change. While MacArthur & MacArthur's (1961) statement about plant species diversity is probably true for all North American and most Australian situations, it ignores the importance of individual plant species in determining how many nectar feeding species can co-exist in a habitat. If all the D. sessilis in the sampling sites had been removed and replaced with B. attenuata, thus lowering the plant species diversity but maintaining the same vegetation profile, the bird species diversity of the sites would have decreased.

A major difference between Australian and North American situations is stability. Whereas North America has a very predictable climate, Australia has an erratic climate which leads to different parts of the food resource being limiting in different years (S.J.J.F. Davies, pers. comm.). For example, karri trees (Eucalyptus diversicolor) produce flowers at intervals of up to 15 years. Competition for food will occur between different bird species in different years. In years when karri trees flower in the south-west forests nectar feeding birds may not compete with each other, but a migration of nectar feeding birds into the forests may result in insect/nectar feeding species competing for insects with insect feeding birds.

(2) The Santa Monica site supported five ground feeders while the East Pingelly site supported only one ground feeding species (Phaps chalcoptera). Cody (1974) considered Australia to be depauperate in ground feeding birds. Presumably this is

due to few Australian plants producing seeds and berries in such a way as to be accessible to ground feeders. The floras of arid areas where finches (Ploceidae) are common are exceptions.

(3) Eleven of the Santa Monica species eat berries and fruit whereas only one of the East Pingelly species (*Zosterops gouldi*) does. This reflects the absence of berries and soft fruit in the sandplain heath vegetation while they form a conspicuous part of the Santa Monica flora. Parrots (Casatuidae) comprise the primary group of fruit eaters in Australia, eating the seeds and inner parts of woody *Eucalyptus* fruits. One parrot species (*Barnardius zonarus*) was present in the East Pingelly site.

In this study the ways in which a group of six honeyeater species divided up their food resource were also examined. It was assumed that all *D. sessilis* flowers were of equal value to the honeyeaters since all parts of the *D. sessilis* trees appeared to be used equally (although not always by the same species). This was also true of *Adenanthos sp*. Because the *D. sessilis* flowers produced the same nectar (assumed), the feeding behaviour differences observed only caused feeding pressure to be more even on all flowers which probably allowed more honeyeater species (and individual to co-exist than would have been the case if they all foraged for nectar in a similar fashion.

The composition of nectar feeding species in a habitat must vary throughout the year as different plant species become the primary nectar source. This was illustrated when several *M. nigra* individuals appeared during the later stages of the study. Presumably they had been feeding on a nectar flow elsewhere that had finished and none of the other plant species flowering in that habitat were suitable for nectar feeding by *M. nigra*.

The three honeyeater species in the study area that were recorded as spending considerable time insect feeding are usually considered to be primarily nectar feeders (I.J. Abbot pers. comm.).

The species may have been insect feeding because they were nesting and required more protein than nectar provided (Ford & Paton, 1975). In the study area, at least two pairs of G. melanops were nesting during the study period and two pairs of P. niger were seen feeding fledgelings that were perched in the centre of low bushes. A large number of pairs of P. niger had nested in mallee, north of the study area, and fledgelings and juveniles were common in this area at the conclusion of the study.

A. superciliosus, the third insect/nectar feeding species, was not observed nesting and no juveniles were identified. It remains possible however, that insect feeding in this species was due to nesting behaviour that was overlooked.

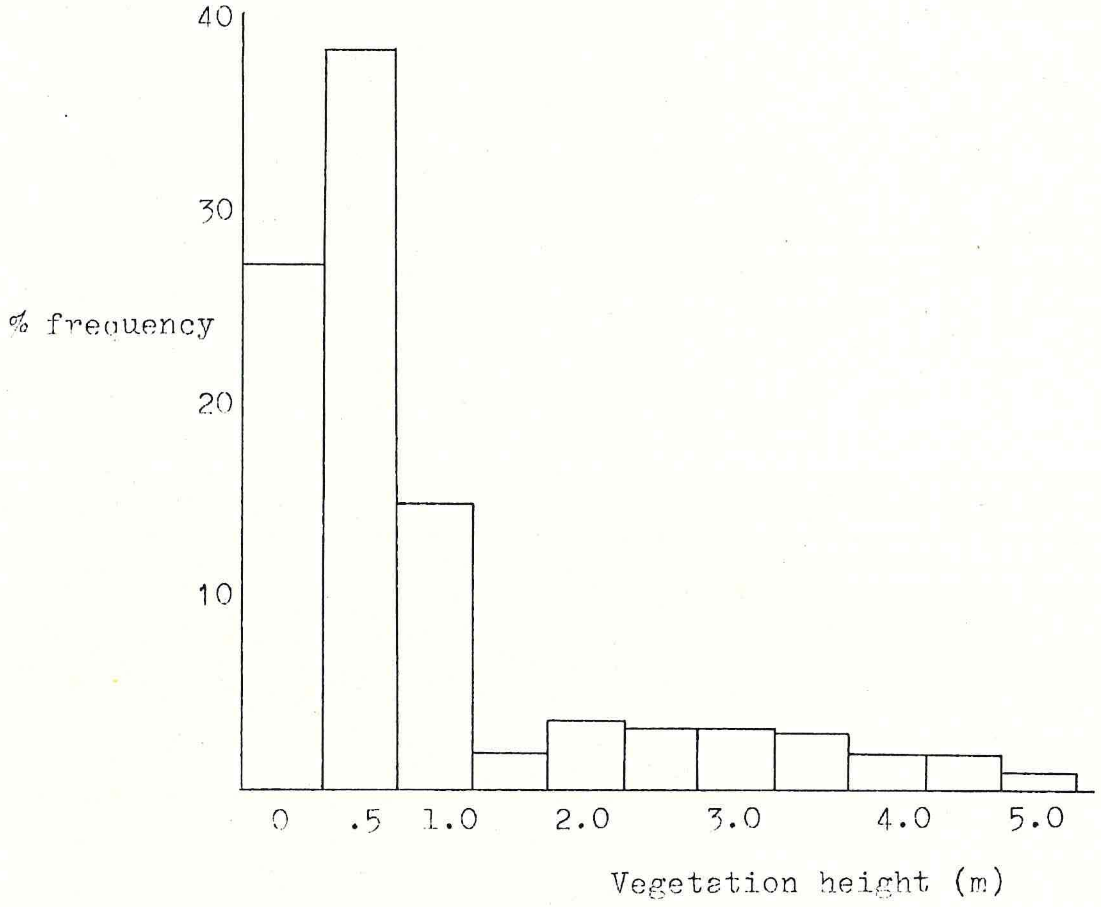
Almost no insect feeding by M. brevirostris was observed during the study although Keast (1968) reported that the species is primarily insectivorous in other parts of Australia. It is unlikely that the behaviour of the south-western M. brevirostris population differs from those in other parts of Australia to the extent that the south-western population is nectivorous while the others are insectivorous but there is no doubt that the south-western M. brevirostris population may spend a large portion of its time nectar feeding when in an area with a suitable nectar flow. In this study M. brevirostris was found to be abundant in the nearby wandoo woodland where groups of individuals may have been foraging for insects in the ways described by Keast (1968) and occasionally moving into the sampling sites to feed on D. sessilis flowers.

D. sessilis abundance predicted the amount of nectar feeding in a site better than D. sessilis and Adenanthos sp abundance combined because Adenanthos sp, which was found infrequently throughout the sampling sites, was only fed upon in sites where D. sessilis was present.

D. sessilis abundance was not the only factor used in habitat selection, therefore species may occupy similar habitats when D. sessilis is not flowering if another plant species is providing a suitable nectar source. This type of habitat selection has been reported for G. melanops by Gannon (1966) who claimed that it was always found in open, heath-type habitats.

Honeyeater species may move from area to area as different plant species flower in the different areas, but they must remain in one area at some time during the year long enough to breed. G. melanops, P. niger and perhaps A. superciliosus, were doing that during the study period. They were using a strong, long-lasting nectar flow to provide the energy for nesting, which included energy required to enable them to forage for insects as a source of protein.

Fig. 1. The vegetation height distribution at the East Pingelly study site and the Santa Monica site (Cody, 1974). The East Pingelly vegetation heights are expressed in metres, the Santa Monica heights are in feet.


(a) East Pingelly

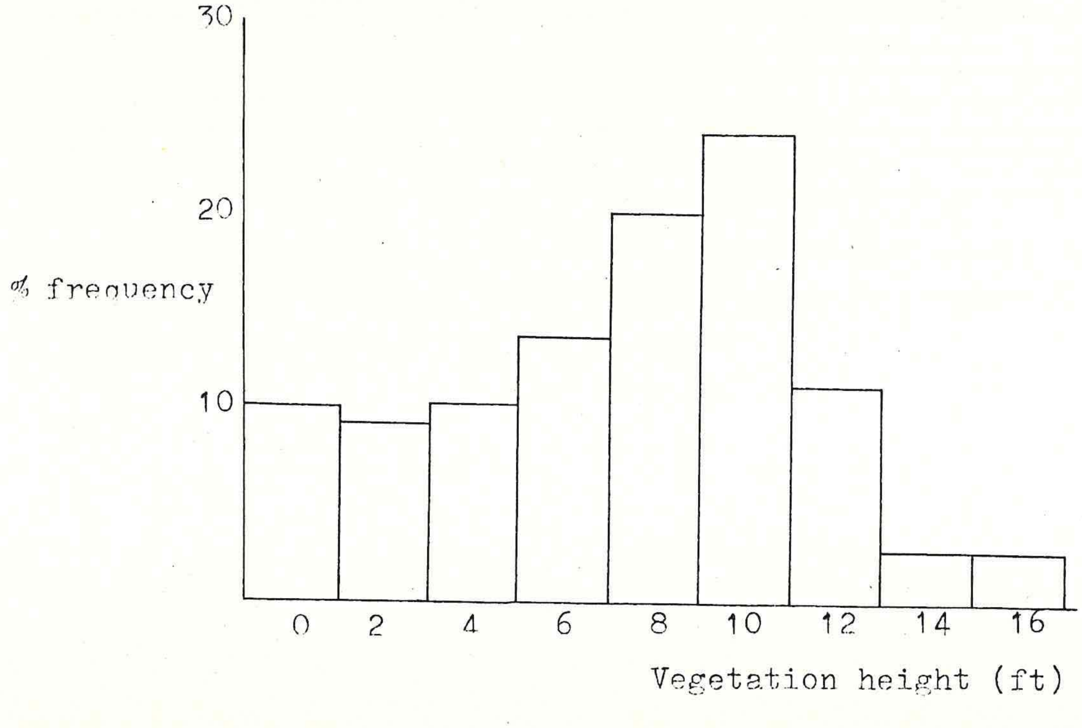
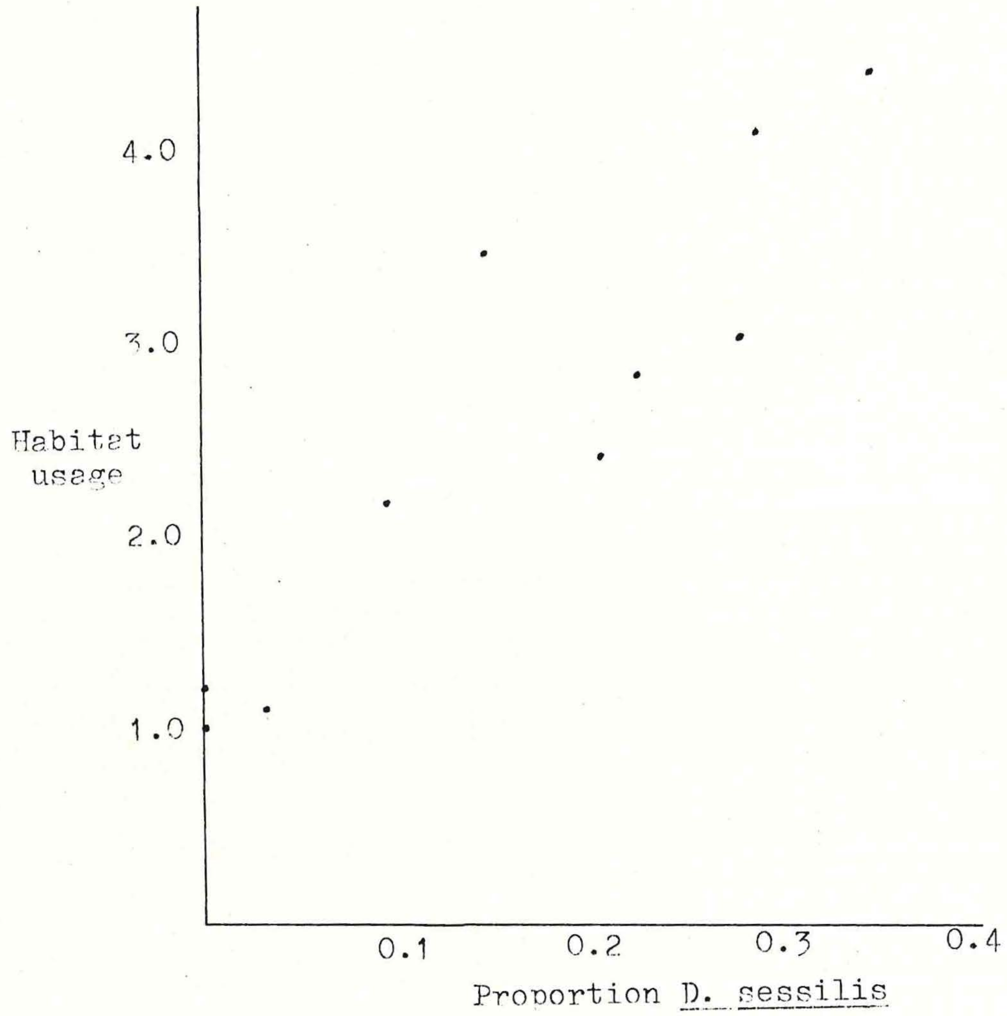

(b) Santa Monica

Fig. 2. Comparison of the habitat usage with the amount of *D. sessilis* in each of the sampling sites. Habitat usage for a sampling site was calculated by $\frac{1}{\Sigma p_i^2}$ where p is the proportion of time spent feeding in the site by the species. Habitat usage is an equivalent indice to Bird Species Diversity ($- \Sigma p_i \log_e p_i$ MacArthur & MacArthur, 1961).



$r_s = 0.705$ $r_{s\ 0.05} = 0.564$

TABLE 1. The plant species composition of the ten sampling sites, based on two 30m transects in each sampling site. For each species the number of metre intercepts at which it was present and the number of times that the species occurred compared to the total number recordings, expressed as a percentage, are shown.

SPECIES	INTERCEPTS	% ABUNDANCE
Dryandra sessilis	84	15.5
Melaleuca sp	68	12.5
Casurina humilis	58	10.7
Leptospermum sp	47	8.7
Calytrix brachyphylla	40	7.4
*Unknown A	39	7.2
Coustis dioica	32	5.9
Hakea ruscifolia	28	5.2
Banksia attentuata	27	5.0
Stirlingia latifolia	26	4.8
Ereamea sp	19	3.5
Petrophile sp	16	3.0
Lepidospermum	13	2.4
**Unknown B	11	2.0
Acacia lasiocarpa	6	1.1
Leucopogan sp	5	0.9
Adenanthos sp	2	0.4
Xanthorrea preissii	3	0.6
Dryandra nobilis	2	0.4
Davesia brevifolia	2	0.4
Gastrolobium spinosum	2	0.4
Anigozanthos humilis	2	0.4
Baeckea preissians	2	0.4
Hibbertia sp	2	0.4
Calothamnus sp	2	0.4
Acacia lasiocalyx	1	0.2
Boronia capitata	1	0.2

*Unknown A - Liliaceae, similar to Acanthocarpus in growth form.
**Unknown B - small heath-type bush.

TABLE 2. The proportions of insect and nectar feeding carried out by each species. The number of observations and the total feeding time of each species is shown.

SPECIES	PROPORTION NECTAR	PROPORTION INSECT	# OBS.	FEEDING TIME (Sec)
G. melanops	0.45	0.55	125	3283
P. niger	0.72	0.28	66	1897
A. superciliosus	0.54	0.46	31	740
L. indistincta	0.99	0.01	59	1586
M. brevirostris	0.97	0.03	25	660
M. nigra	0.93	0.07	8	172

TABLE 3. Comparison of the time spent insect feeding by the three insect/nectar feeding species in the different vertical height classes.

SPECIES	VERTICAL HEIGHTS (m)				
	0	0 - .25	.25 - .75	.75 - 1.75	1.75
G. melanops	110	204	220	156	1103
P. niger	6	0	30	134	347
A. superciliosus	20	42	116	22	136

$X^2 = 244.62 \qquad X^2_{0.001,8} = 26.12$

Where X^2 tests whether there is a significant interaction between species and vertical height classes.

TABLE 4. Number of observations of hawking and gleaning for insects by three species, G. melanops, P. niger and A. superciliosus.

SPECIES	HAWKING	GLEANING	# OBS.	% HAWKING
G. melanops	23	16	39	59.0
P. niger	9	5	14	64.3
A. superciliosus	0	8	8	0

TABLE 5. Comparison of the use of B. attenuata and D. sessilis as a perch by G. melanops and P. niger during insect hawking with the relative abundance of B. attenuata and D. sessilis in the same area.

SPECIES	OBS. in BANKSIA	OBS. in DRYANDRA	$\frac{\text{OBS. BANKSIA}}{\text{OBS. DRYANDRA}}$	$\frac{\text{BANKSIA ABUNDANCE}}{\text{DRYANDRA ABUNDANCE}}$
G. melanops	15	2	7.5	0.26
P. niger	6	2	3.0	0.23

$X^2 = 7.88 \qquad X^2_{0.01,1} = 6.64$

TABLE 6. The number of observations of each honeyeater species observed in the ten sampling sites.

SPECIES	SAMPLING SITES									
	1	2	3	4	5	6	7	8	9	10
G. melanops	12	50	4	2	4	18	6	9	13	5
P. niger	0	3	5	0	15	2	8	10	0	12
A. superciliosus	2	0	0	0	2	0	2	0	6	7
L. indistincta	0	0	2	0	0	16	10	4	1	16
M. brevirostris	0	0	0	0	5	4	4	9	0	1
M. nigra	0	0	0	0	0	0	5	0	0	2

$$X^2 = 220.44 \qquad X^2_{0.005,45} = 73.5$$

Where X^2 tests whether there is a significant interaction between species and sampling sites.

TABLE 7. Comparison of the numbers of a given bird species (x) with the proportion of the birds present that belong to other species (y) for the ten sampling sites. The correlation co-efficient (r) was used as a measure of the relationship between x and y. r^2 shows the amount of variation in the y values due to changes in the value of x.

SPECIES	r	r^2	P, r = o
G. melanops	0.72	0.52	0.02
P. niger	0.36	0.13	<0.10
A. superciliosus	0.88	0.77	0.001
L. indistincta	0.58	0.34	0.10
M. brevirostris	0.67	0.45	0.05
M. nigra	0.99	0.98	0.001

TABLE 8. Comparison of the horizontal overlap between nectar and insect/nectar feeding species with the percentage *D. sessilis* ground cover in the ten sampling sites. The proportion of all individuals observed in each sampling site is shown for each guild.

	SAMPLING SITES										# individuals
	1	2	3	4	5	6	7	8	9	10	
Nectar feeders	0	0	0.022	0	0.087	0.283	0.206	0.185	0.011	0.206	92
Insect feeders	0.063	0.238	.040	.018	0.094	0.126	0.072	0.143	0.099	0.108	223
Overlap	0	0	0.022	0	0.087	0.126	0.072	0.143	0.011	0.108	
% Dryandra	0	3.3	9.3	0	27.5	20.4	34.0	28.1	22.6	14.8	

Spearman's Rank Correlation Coefficient for tied values,

$r_s = 0.708, \quad r_{s\ 0.05} = 0.564$

TABLE 9. Bill length of the six honeyeater species (using gape length as a measure of bill length).

SPECIES	bill length (mm)		S.E.
G. melanops	10	17.8	0.30
P. niger	8	21.7	0.51
A. superciliosus	10	19.4	0.60
L. indistincta	10	15.3	0.40
M. brevirostris	10	10.2	0.16
M. nigra	10	14.8	0.23

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APPENDIX I

The bird species that occurred in the East Pingelly (near Aldersyde) and the Santa Monica (California) study areas. The size and main feeding preferences and relative abundance of the species (East Pingelly only) are shown. The Californian data was extracted from Cody (1974) and Reilly (1969).

(a) East Pingelly site.

SPECIES - scientific name - common name	SIZE (cm)	FOOD	REL. ABUNDANCE
Gliciphilia melanops Tawny-crowned honeyeater	15	Nectar	0.37
Phylidonyris niger White-cheeked honeyeater	17	Nectar	0.20
Lichmera indistincta Brown honeyeater	12	Nectar	0.18
Acanthorhynchus superciliosus W. Spinebill	15	Nectar	0.05
Myzomela nigra Black honeyeater	11	Nectar	0.02
Melithreptus brevirostris Brown-headed honeyeater	13	Insects	0.07
Meliphaga leucotis White-eared honeyeater	21	Insects	.01
Zosterops gouldi W. Silvereye	11	Nectar, Insects, Berries	.02
Petroica goodenovii Red-capped robin	11	Insects	.005
Acanthiza inornata W. Thornbill	10	Insects	.001
Acanthiza apicalis Broadtailed Thornbill	11	Insects	.04
Rhipidura fuliginosa Grey Fantail	15	Insects	.02
Colluricincla rufiventris W. Shrike Thrush	24	Insects	.01
Cacomantis pyrrhophanus Fantailed Cuckoo	26	Insects (caterpillars)	.01
Phaps chalcoptera Common Bronzewing	32	Seed	low
Anthochaera chrysoptera Little Wattlebird	29	Nectar	low
Barnardius zonarius Port Lincoln Parrot	37	Eucalyptus fruit	low

(b) Santa Monica site.

SPECIES - scientific name - common name	SIZE (cm)	FOOD
Calypte anna Anna's Hummingbird	10	Nectar
Vermivora calata Orange-crowned warbler	13	Insects
Vireo solitarius Solitary vireo	14	Insects
Psaltriparus minimus Bushtit	11	Insects, seed, fruit.
Myiarchus cinerascens Ash throated flycatcher	20	Insects
Dendrocarpus nuttallii Nuttall's Woodpecker	18	Insects, berries, fruit.
Thryomanes berwickii Berwicks wren	13	Insects
Colaptes cafer Red-shafted flicker	34	Insects, ants, fruit, berries.
Chamaea fasciata Wrentit	16	Insects, berries, fruit.
Parus inornatus Plain titmouse	13	Seeds, fruits, insects.
Aeronantes saxatalis White fronted swift	17	Insects
Pipilo erythrophthalmus Rufous-sided towhee	20	Seeds, fruit, insects.
Pheucticus melanocephalus Black headed grosbeak	18	Seeds, fruit, berries, insects.
Pipilo fuscus Brown towhee	23	Seeds, fruit, insects.
Toxostoma rediviuum Californian Thrasher	30	Berries, fruit, insects.
Aphelocoma coerulesceus Scrub jay	30	Berries, seeds, fruit, insects.
Lophortyx californicus Californian quail	27	Seeds, leaves, fruit.