Diet of kakapo in breeding and non-breeding years on Codfish Island (Whenua Hou) and Stewart Island

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Abstract Results from an analysis of plant remains found in faecal droppings of kakapo (*Strigops habroptilus*) collected from 1981 to 1998 on Codfish Island (Whenua Hou) and Stewart Island, were analysed statistically to identify patterns in the birds' diet related to breeding. Females were more likely to have eaten podocarp fruit or leaves of trees or shrubs; males to have eaten fern and *Lycopodium* rhizomes, monocots (in breeding years), and manuka fruit (in non-breeding years). Podocarp fruits were much more prevalent in kakapo diets in breeding than in non-breeding years. When podocarp fruits were available in breeding years, kakapo were less likely to have eaten several other foods. Conversely, *Blechnum* fern fronds appeared more frequently in the droppings of females in breeding than in non-breeding years. As podocarp fruits increased in prevalence in the diets of both males and females during the summers of breeding years, the incidence of many other foods declined. The incidence of Hall's totara leaf in the diet of females increased during summer in non-breeding years, but decreased in breeding years.

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Kakapo (*Strigops habroptilus*) usually breed only in years when certain plant species, particularly trees and shrubs in the podocarp family, produce large crops of protein-rich seeds and fruit (Powlesland *et al.* 1992; Elliott *et al.* 2001). Conservation managers have attempted to induce breeding in other years in order to increase the population growth rate of these critically endangered birds (Elliott *et al*. 2001). However, providing protein-rich supplementary food has not been sufficient to trigger breeding, and some unknown dietary or non-dietary factor may also be necessary (Elliott *et al.* 2001).

The goal of this study was to investigate possible dietary changes associated with breeding, to determine foods that might be important at different stages of breeding. Identifying such foods might, in turn, enable the improved design and success of future supplementary feeding programmes. We approached this goal by statistically analysing existing unpublished data of plant species and parts identified in kakapo droppings collected from Codfish (Whenua Hou) and Stewart Islands. We (1) compared the incidence of fruit and other common foods of male and female kakapo, (2) compared the incidence of these foods between breeding years and non-breeding years, and (3) identified changes in the diet just before and during breeding seasons.

METHODS

Source of data

Between 1977 and 1998, 648 kakapo droppings were collected on Codfish Island (Whenua Hou) and Stewart Island. Analysis of the kakapo's diet was based on the identification of up to 150 different microscopic fragments of plant material in each kakapo dropping. No mineral or animal remains had been found. Each fragment was classified as one of 84 plant species or, when precise identification was impossible, as a higher taxonomic group. Food provided by wildlife managers on Codfish Island, which included a variety of exotic nuts, fruits and tubers, and prepared pellet formulations, was coded as supplementary food. Each fragment was classified as one of 30 plant parts, including leaf cuticle, fruit, seed, flower, etc. These data were incorporated into a Department of Conservation database, supplemented by unpublished departmental reports (ADG, NP unpubl. data). A summary of the diet analyses is appended (Appendix 2)

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Table 1 Food types used in this analysis.

Food type	Species
Fruits	all species below combined
Podocarp fruit	rimu (*Dacrydium cupressinum*); Hall's totara (*Podocarpus hallii*); miro (*Prumnopitys ferruginea*); pink pine (*Halocarpus biformis*); yellow-silver pine (*Lepidothamnus intermedius*) combined
Podocarp leaf	above species
Dracophyllum leaf	*D. longifolium, D. pearsonii, D. politum*
Blechnum frond	*B. novae-zealandiae, B. procerum* and unidentified species
Blechnum rhizome	above species
Lycopodium rhizome	*L. ramulosum, L. varium* and unidentified species
Hall's totara leaf	*Podocarpus hallii*
Manuka leaf	*Leptospermum scoparium*
Manuka fruit	above species
Mingimingi fruit	*Cyathodes juniperina*
Leatherwood leaf	*Olearia colensoi*
Rata leaf	*Metrosideros umbellata*
Monocots (all grasses, sedges and rushes combined)	*Chionochloa* spp., *Lepidosperma australe* and unidentified grasses; sedges - *Carex appressa, C. dissita, Gahnia procera, G. setifolia, Uncinia* spp.; rush - *Empodisma minus*
Supplementary foods	

Food types

Fifteen food types (Table 1) that were either common in droppings or of particular interest (e.g., fruits) were chosen from all the combinations of plant species and plant parts identified and described. The presence and absence of these 15 foods in kakapo droppings was statistically analysed. Fruit was defined to include all items coded in the database as fruit, seed or nut.

Breeding and non-breeding years

In a breeding year, kakapo mate as early as late December, and the first eggs are laid in January (Powlesland *et al.* 1992, 2006; Eason *et al*. 2006). For the purpose of statistical analyses, a year was considered to span the period from August prior to the breeding season to the July following. For example, because, on Codfish Island in 1997, birds commenced laying eggs in January, droppings collected there between August 1996 and July 1997 were considered to come from that breeding year. Kakapo bred on Stewart Island in 1981 and 1985, and on Codfish Island in 1997; in all other years of this study kakapo did not attempt to breed.

Subset of data analysed

A subset of the complete dataset was selected for analysis, based on age of the birds and confidence in the data. Only droppings from adult kakapo, i.e. birds that could potentially breed, and only droppings that could accurately be assigned to a year and season were used. Data were analysed from droppings of 40 adult kakapo (15♀♀, 25♂♂). These droppings were collected on Stewart Island in 1981 (n = 11), 1982 (31), 1983 (29), 1984 (75), 1985 (171), 1986 (59), 1987 (21), and 1997 (4), and on Codfish Island in 1987 (n = 1), 1996 (1), 1997 (108) and 1998 (65). (Years were defined from August to July as explained above).

Data from throughout the breeding season (December–April) of all years were used in most statistical analyses. Most droppings had been collected during this period. However, for comparing diets between males and females, only December–March data were selected, because no droppings from females were collected in April in breeding years. In addition, data from females from May to July were analysed separately, to represent times when females would be raising offspring late in breeding years.

Finally, only Codfish Island data were used to answer questions about supplementary food in the diet, since managers fed kakapo on that island only. Few data were available for Codfish Island males. Therefore, the incidence of supplementary food was not compared between males and females, and data from males from all months were combined in comparisons between years.

Combining data to minimise pseudo-replication

Based on inspection of the data, droppings collected close together in time from the same bird contained the remains of many of the same foods. Therefore, to minimise pseudo-replication (Hurlbert 1984), data from droppings from the same bird within the same month were combined into a single observation. In this way, data from 576 droppings were combined into 272 monthly observations of diet. Sample sizes used in each statistical test are given in the relevant section of Results.

Most variation in these 272 data occurred between observations of the same bird, with little additional variation explained by other factors (island, month and bird, Appendix 1). That is, although diets of the same bird in different months were not strictly independent, they were not highly correlated. This result supports the approach taken to moderate the effects of pseudo-replication in the study design by combining data as described above.

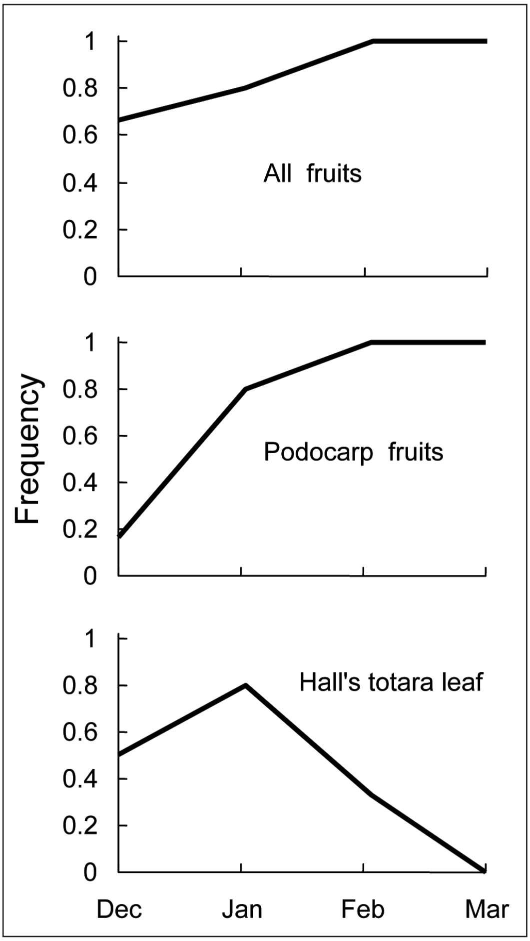

Figure 1 Frequencies of food types for which there was a significant linear trend ($P < 0.1$) during the breeding season (breeding years only) in the diet of female kakapo.

Statistical methods

The frequencies of remains of each food type in droppings (combined for each bird within each month as described above) were compared between (1) males and females, and (2) breeding and non-breeding years, with 2×2 contingency tables. Because significant differences were found between male and female droppings, the between-year comparisons were done separately for males and females. This simple statistical method was chosen because the data were too sparse for more complex analyses like logistic regression. The Fisher exact test (Zar 1996: 547–549) was used to calculate probabilities because small sample sizes made chi-square tests unreliable. Computations were done with S-PLUS (Insightful Corporation 2001).

Increasing or decreasing trends in the incidence of foods during the breeding season (December–March for females and December–April for males) were examined with the chi-square test for linear trend (Zar 1996: 562–565), the computations being programmed in Microsoft ® Excel. Few data were available from Stewart Island prior to December in most years. However, for the breeding year 1997 on Codfish Island, droppings of females were collected from August 1996 to March 1997. Therefore, in order to look for dietary changes prior to breeding, trends during this period on Codfish Island were also examined.

Significance level and multiple comparisons

The objective of the statistical analyses was to search for patterns in the diet, rather than to test a limited number of *a priori* hypotheses. A significance level of 0.1 was therefore chosen, to minimise the chance of missing important results due to Type II errors (failing to reject a false null hypothesis). However, Type I errors (rejecting a true null hypothesis) were likely, owing both to the many statistical comparisons done and to the high significance level. Statistically significant results should therefore be interpreted with caution and with reference to patterns in the other sex, other food types, and other times of year, and may need to be verified in future field studies.

RESULTS

Statistically significant results ($P < 0.1$) follow. The results of tests for plant species other than those listed, and for supplementary food, were not significant ($P > 0.1$).

Differences between diets of males and females

In December to March of breeding years (n = 21♀♀, 27♂♂), female kakapo were more likely than males to have eaten podocarp fruit ($P = 0.034$), *Dracophyllum* leaf ($P = 0.045$), Hall's totara leaf ($P = 0.095$), and rata leaf ($P = 0.073$). Males were more likely to have eaten *Lycopodium* rhizomes ($P = 0.005$) and monocots ($P = 0.058$).

During the same period in non-breeding years (n=29♀♀, 43♂♂), females were more likely than males to have eaten podocarp leaf ($P = 0.013$) and podocarp fruit ($P = 0.014$).Males were more likely to have eaten manuka fruit ($P = 0.047$) and rhizomes of *Blechnum* ferns ($P = 0.041$) and *Lycopodium* ($P = 0.0001$).

Differences between diets in breeding and non-breeding years

Female kakapo (n = 21 in breeding years, 40 in non-breeding years) were more likely to have eaten podocarp fruit ($P = 0.006$) and *Blechnum* frond ($P = 0.009$), and less likely to have eaten *Dracophyllum* leaf ($P = 0.079$) and leatherwood leaf ($P = 0.037$), in December to March of breeding years compared with non-breeding years. Females were more likely to have eaten all fruits combined in May to July of breeding years compared with non-breeding years (n = 19 in breeding years, 8 in non-breeding years; $P = 0.044$).

Table 2 Statistically significant ($P < 0.1$) linear trends during the breeding season in the frequency of foods identified in diets of kakapo on Codfish Island and Stewart Island. Table entries show χ^2_1 and P values from chi-square tests for trend; blank entries indicate non-significant test results. Sample sizes (n) per month are also shown.

	Breeding years		Non-breeding years		
Food type	Females Dec–Mar n = 6,5,3,7	Males Dec–Apr n = 7,8,6,6,5	Females Dec–Mar n = 8,10,9,2	Males Dec–Apr n = 18,5,10,10,7	Direction of trend
All fruits	3.3, 0.068				Up
Podocarp fruit	10.4, 0.001	5.1, 0.025			Up
Dracophyllum leaf		4.0, 0.045		5.2, 0.023	Breeding years: Up Non-breeding years: Down
Blechnum rhizome		7.5, 0.006			Down
Lycopodium rhizome		3.6, 0.057		3.6, 0.057	Down
Manuka leaf		6.8, 0.009			Down
Manuka fruit		11.5, 0.001			Down
Hall's totara leaf	5.2, 0.023		5.6, 0.018		Breeding years: Down Non-breeding years: Up
Leatherwood leaf		5.7, 0.017	3.2, 0.072	20.8, <0.0001	Down
Rata leaf		5.0, 0.026			Up

Male birds (n = 32 in breeding years, 50 in non-breeding years) were more likely to have eaten podocarp fruit (P < 0.0001) and less likely to have eaten *Dracophyllum* leaf (P = 0.019) and *Lycopodium* rhizome (P = 0.067) in December to April of breeding years compared with non-breeding years.

Trends in diet during the breeding season

In breeding years, the frequency of all fruits combined and of podocarp fruits in the droppings of female birds increased linearly from December to March, whereas the frequency of Hall's totara leaf declined (Fig. 1, Table 2). In the diets of male birds, frequencies of podocarp fruits, *Dracophyllum* leaf and rata leaf increased, but frequencies of *Blechnum* rhizome, *Lycopodium* rhizome, manuka leaf, manuka fruit and leatherwood leaf declined from December to April in breeding years (Fig. 2, Table 2).

In non-breeding years, the frequency of Hall's totara leaf in the diets of female birds increased linearly from December to March, and the frequency of leatherwood declined (Table 2). The frequency of *Dracophyllum* leaf, *Blechnum* rhizome and leatherwood leaf decreased in the diets of male birds from December to April in non-breeding years (Table 2).

Trends in diet of Codfish Island females from August to March 1997

In the 1997 breeding year on Codfish Island, the frequency of podocarp fruits (χ^2_1 = 15.6, P = 0.0001), Hall's totara leaf (χ^2_1 = 3.0, P = 0.082) and monocots (χ^2_1 = 3.8, P = 0.051) in the droppings of female birds increased linearly from August–September 1996 to February–March 1997 (Fig. 3; n = 7, 12, 8, 5 in each sequential pair of months, respectively). The frequencies of podocarp leaf and mingimingi fruit remains followed no significant linear trends, but first increased from August–September to October–November and then declined, and the frequency of *Blechnum* rhizome showed the reverse pattern (Fig. 3).

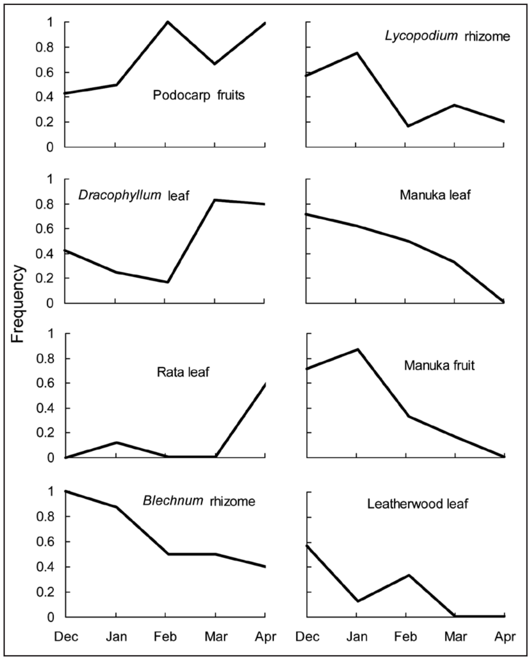

Figure 2 Frequencies of food types for which there was a significant linear trend (P < 0.1) during the breeding season (breeding years only) in the diet of male kakapo.

DISCUSSION

Differences between diets of males and females

Diets differed between female and male kakapo in both breeding and non-breeding years. Females were more likely to have eaten podocarp fruit and leaves of trees and of *Dracophyllum*. Males were more likely to have eaten fern and *Lycopodium* rhizomes, monocots (in breeding years), and manuka fruit (in non-breeding years). These results may reflect differences in foraging behaviour by the birds,

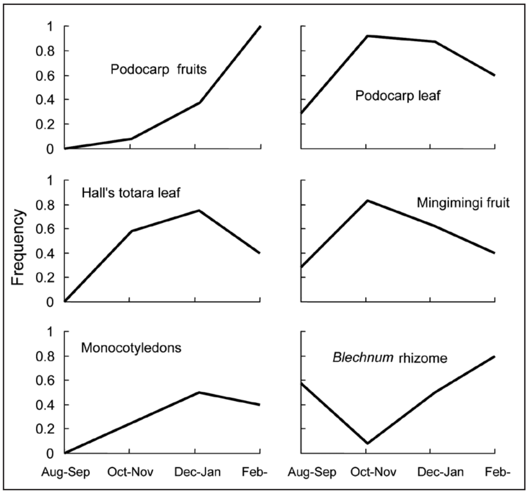

Figure 3 Frequencies of food types in the diet of females on Codfish Island from August–September 1996 to February–March 1997 (a breeding year). The linear trends over this period were statistically significant ($P < 0.1$) for podocarp fruits, Hall's totara leaf and monocotyledons but not for the other species shown.

particularly in breeding years, when females gather food for their chicks while males are active on the ground in lek breeding areas (Powlesland *et al.* 1992).

Differences between diets in breeding and non-breeding years

Podocarp fruits were much more prevalent in the diets of kakapo of both sexes in breeding years than in non-breeding years. When podocarp fruits were available in breeding years, kakapo were less likely to have eaten several other, perhaps less preferred, foods: *Dracophyllum* leaf (both sexes), leatherwood leaf (females), and *Lycopodium* rhizome (males). Conversely, *Blechnum* fronds appeared more frequently in the droppings of females in breeding than in non-breeding years.

Trends in diet during the breeding season

As podocarp fruits became increasingly prevalent in the diets of both males and females during the summer of breeding years, the incidence of many other foods declined. These declines were more apparent in the case of males, possibly as a result of larger sample sizes.

Two foods, *Blechnum* rhizome and leatherwood leaf, declined during summer in the diets of males in both breeding and non-breeding years. Leatherwood also declined in the diets of females in non-breeding years. Perhaps, in all years, enough seeds and fruits became available as summer progressed to lessen the need for these two foods. However, *Blechnum* rhizome did not decline in the diet of females on Codfish Island in the 1997 breeding season. This contrasting trend may indicate different requirements or behaviour of males and females, but it is also possible that some of these patterns may have occurred by chance.

The incidence of Hall's totara leaf in the diet of females increased during summer in non-breeding years, but decreased in breeding years. On Codfish Island in the 1997 breeding year, Hall's totara also increased in frequency in the diet of females from August–September (ahead of laying) to December–January (during laying). The reason for these patterns may be that the birds spent more time in totara trees searching for fruit in seasons and years when other fruits were scarce, eating the leaves of the trees at the same time

Recommendations for kakapo management

Several interesting dietary patterns have emerged from this study. Some of these patterns warrant further exploration in order to clarify their seasonal timing and whether they are unique to one sex. For example, the incidence of *Blechnum* rhizomes declined during the breeding season in the diets of males, but appeared to first decline and then increase in the diets of females on Codfish Island in the 1997 breeding year. Do these rhizomes provide starch or some other nutrient needed by breeding females? Similarly, the decline in frequency of Hall's totara leaf from January to March in the diet of breeding females, coupled with the increase in Hall's totara leaf in the diet of females on Codfish Island from August - September 1996 to December - January 1997, suggests the leaves or fruits of this tree may be important outside the breeding season.

Future studies will be able to draw stronger conclusions from statistical analyses by formulating a limited number of *a priori* hypotheses.

For example,

Hypothesis 1: Breeding female kakapo rely on fern rhizomes for dietary starch.

Prediction: The frequency of fern rhizomes in the diets of breeding female kakapo increases in December and decreases in April.

Hypothesis 2: Female kakapo rely on the leaves or fruits of Hall's totara for nutrition outside the breeding season.

Prediction: The frequencies of totara leaf or totara fruit in the diet of females decreases in December and increases in April.

The statistical analyses in this study were weakened by small sample sizes, particularly for females in breeding years. The difference in sample size between the sexes may, in part, explain why more statistically significant patterns were found in the diet of male than female birds. One reason the sample sizes used for statistical analyses were small was that data from multiple droppings were combined in order to avoid pseudo-replication. A sampling procedure that aims to collect droppings from different birds would alleviate this problem.

We suggest that questions about diet may be answered in future by deliberate and long-term collection of kakapo droppings from birds of known sex. Based on the statistical analyses reported here, collecting one dropping from at least 10 different females and 10 different males monthly in each region (island or group of islands) should yield strong statistical results. In breeding years, collecting droppings monthly from 10 birds of each sex that breed and 10 that do not, if possible, would allow comparison of diets between successful and unsuccessful breeders. Such comparisons were not possible in the present analysis because of small sample sizes. Sampling from November to May in both breeding and non-breeding years would permit dietary changes before, during and after breeding to be examined.

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APPENDICES

Appendix 1 Analysis of variance components

A variance components analysis was used to test whether variation between observations of the same bird in different months was small compared with variation between different birds. The analysis was repeated for three food types: podocarp fruit, *Blechnum* rhizome and totara leaf. The number of droppings from each bird in each month that contained a particular food type (X), relative to the total number of droppings from that bird in that month (n), were transformed as follows (Zar 1996, p. 183):

$$p = 0.5\left[\arcsin\sqrt{\frac{X}{n+1}} + \arcsin\sqrt{\frac{X+1}{n+1}}\right].$$

This equation is a variation of the arcsine transformation commonly used to normalise proportional data. The resulting 272 transformed monthly proportions (p) of droppings containing a food type corresponded to the 272 data of presence or absence of a food type that were used for the other statistical analyses in this report (section 4.3).

The variation in p within individual birds (the residual variation), between different birds within months, between months within islands, and between islands was calculated. 'Island', 'month' and 'bird' were considered to be random nested effects. Whether or not the data came from a breeding year ('breed') and the sex of the bird were considered to be fixed effects. The 'varcomp' procedure with restricted maximum likelihood estimation (reml) in S-PLUS was used for these calculations (Insightful Corporation 2001, p. 590; Crawley 2002, pp. 372–375), as follows:

varcomp(p ~ breed * sex + island/month/bird, method="reml").

The following percentage variance components were estimated with 'varcomp' for the three food types tested:

Source of variation	Podocarp fruit	Blechnum rhizome	Totara leaf
Island	1	3	< 1
Month within island	34	3	7
Bird within month	< 1	1	4
Residual (within bird)	66	93	89

In all three food types, most variation occurred within birds (i.e. between observations of the same bird in different months), with little additional variance explained by the variables 'island', 'month' or 'bird'. Therefore diets of the same bird in different months were not highly correlated. In the case of podocarp fruit remains, the residual variance component was about twice that due to months, in spite of the seasonal availability of fruit. This analysis suggests that the approach taken to moderate the effects of pseudoreplication in the study design, by combining data from droppings from the same bird within the same month into a single observation, was satisfactory.

Appendix 2 Frequency of occurrence (%) of plants in kakapo droppings collected on Codfish (n = 191) and Stewart (n = 457) Islands.

Plant	Plant part	Codfish Island	Stewart Island
Asplenium sp.	Leaf cuticle	1.6	0.2
Astelia fragrans	Leaf cuticle	3.7	0.0
Astelia solandri	Leaf cuticle	3.7	0.0
Baumea tenax	Leaf cuticle	0.0	2.4
Blechnum novae-zelandiae	Leaf cuticle	0.0	14.0
Blechnum novae-zelandiae	Reprod. frond	0.0	0.4
Blechnum novae-zelandiae	Rhizome	0.0	0.4
Blechnum novae-zelandiae	Scale	0.0	1.5
Blechnum novae-zelandiae	Spore	0.0	0.2
Blechnum procerum	Leaf cuticle	0.0	25.4
Blechnum procerum	Reprod. frond	0.0	1.5
Blechnum procerum	Scale	0.0	5.0
Blechnum sp.	Leaf cuticle	64.9	7.7
Blechnum sp.	Reprod. frond	0.0	6.1
Blechnum sp.	Rhizome	34.6	51.6
Blechnum sp.	Scale	18.8	8.3
Blechnum sp.	Spore	0.0	0.9
Brachyglottis rotundifolia reynoldii	Leaf cuticle	10.5	0.4
Brachyglottis rotundifolia reynoldii	Trichomes	0.0	0.2
Carex appressa	Leaf cuticle	0.0	0.2
Carex dissita	Leaf cuticle	0.0	0.2
Carex sp.	Leaf cuticle	0.0	0.4
Celmisia sp.	Leaf cuticle	0.0	0.2
Chionochloa sp.	Leaf cuticle	0.0	0.7
Coprosma colensoi	Fruit cuticle	0.0	2.0
Coprosma colensoi	Leaf cuticle	0.0	1.5
Coprosma colensoi	Seed	0.0	0.7
Coprosma foetedisima	Fruit cuticle	0.0	0.7
Coprosma foetedisima	Seed	0.0	0.4
Coprosma lucida	Fruit cuticle	0.0	0.2
Coprosma lucida	Leaf cuticle	0.0	0.7
Coprosma sp.	Fruit cuticle	0.0	1.1
Coprosma sp.	Leaf cuticle	21.5	3.5
Cyathodes empetrifolia	Fruit cuticle	0.0	0.7
Cyathodes empetrifolia	Leaf cuticle	0.0	0.7
Cyathodes juniperina	Fruit cuticle	42.9	44.0
Cyathodes juniperina	Leaf cuticle	11.0	0.4
Cyathodes juniperina	Seed	8.9	24.5
Cyathodes sp.	Rhizome	0.0	0.2
Dacrydium cupressinum	Fruit cuticle	22.0	2.2
Dacrydium cupressinum	Leaf cuticle	22.0	8.3
Dacrydium cupressinum	Pollen	0.0	2.2
Dacrydium cupressinum	Pollen cone	0.0	0.7
Dacrydium cupressinum	Seed	0.0	0.2
Dicksonia sp.	Leaf cuticle	1.6	0.0
Dicranoloma sp.	Leaf cuticle	0.0	0.2
Dicranoloma sp.	Whole plant	0.0	0.4
Dracophyllum longifolium	Flower cuticle	0.0	2.2
Dracophyllum longifolium	Fruit cuticle	0.0	0.2
Dracophyllum longifolium	Leaf cuticle	85.3	50.8
Dracophyllum longifolium	Pollen	0.0	4.8
Dracophyllum longifolium	Trichomes	4.7	0.0
Dracophyllum pearsonii	Leaf cuticle	0.0	1.5
Dracophyllum politum	Leaf cuticle	0.0	0.4
Earina autumnalis	Flower cuticle	0.5	0.0
Earina autumnalis	Leaf cuticle	6.3	1.5

Plant	Plant part	Codfish Island	Stewart Island
Earina autumnalis	Stem	0.5	0.0
Empodisma minus	Leaf cuticle	0.0	5.0
Fern sp.	Leaf cuticle	0.0	1.1
Fern sp.	Rhizome	0.5	0.0
Fern sp.	Sporangia	2.1	0.4
Gahnia procera	Leaf cuticle	26.7	44.0
Gahnia procera	Seed	0.0	1.8
Gahnia setifolia	Leaf cuticle	26.7	0.4
Gahnia setifolia	Seed	0.0	0.4
Gaultheria antipoda	Fruit cuticle	0.5	0.2
Gaultheria antipoda	Leaf cuticle	6.8	2.4
Gaultheria antipoda	Stem	1.0	0.0
Gleichenia dicarpa	Leaf cuticle	0.0	1.5
Gleichenia dicarpa	Rhizome	0.0	0.2
Gleichenia dicarpa	Scale	0.0	0.4
Gleichenia dicarpa	Spore	0.0	0.2
Gleichenia microphylla	Leaf cuticle	0.0	0.2
Gleichenia microphylla	Spore	0.0	0.2
Gleichenia sp.	Leaf cuticle	2.6	0.0
Grammitis billardieri	Leaf cuticle	0.0	0.2
Grammitis sp.	Leaf cuticle	0.5	0.2
Griselinia littoralis	Fruit cuticle	0.0	0.7
Griselinia littoralis	Leaf cuticle	0.5	0.2
Griselinia littoralis	Seed	0.0	0.4
Halocarpus biformis	Fruit cuticle	0.0	16.0
Halocarpus biformis	Leaf cuticle	0.0	14.9
Halocarpus biformis	Pollen	0.0	11.2
Halocarpus biformis	Seed	0.0	0.4
Histiopteris sp.	Leaf cuticle	0.0	0.2
Hymenophyllum sp.	Leaf cuticle	3.7	0.2
Juncus antarcticus	Leaf cuticle	0.0	0.7
Juncus articulatus	Leaf cuticle	0.0	1.8
Juncus bufonius	Leaf cuticle	0.0	0.2
Juncus planifolius	Leaf cuticle	0.0	0.4
Juncus sp.	Leaf cuticle	13.6	2.2
Juncus sp.	Whole plant	0.0	0.2
Korthalsella salicornioides	Leaf cuticle	1.0	1.3
Korthalsella salicornioides	Whole plant	0.0	5.0
Lepidosperma australe	Leaf cuticle	3.7	0.4
Lepidosperma australe	Rhizome	0.0	0.4
Lepidosperma australe	Seed	0.0	0.7
Lepidothamnus intermedius	Fruit cuticle	0.0	7.4
Lepidothamnus intermedius	Leaf cuticle	0.0	4.6
Lepidothamnus intermedius	Pollen	0.0	0.9
Lepidothamnus intermedius	Seed	0.0	0.7
Leptopteris hymenophylliodes	Leaf cuticle	0.0	0.2
Leptospermum scoparium	Flower cuticle	0.0	2.0
Leptospermum scoparium	Fruit cuticle	4.7	19.9
Leptospermum scoparium	Leaf cuticle	31.9	58.9
Leptospermum scoparium	Nut	0.0	11.8
Leptospermum scoparium	Scale	0.0	0.2
Leptospermum scoparium	Seed	0.0	3.3
Liverwort sp.	Leaf cuticle	2.1	5.5
Liverwort sp.	Spore	0.0	0.4
Liverwort sp.	Whole plant	0.0	0.7
Luzuriaga parviflora	Fruit cuticle	0.5	0.9
Luzuriaga parviflora	Leaf cuticle	1.6	1.3
Lycopodium ramulosum	Leaf cuticle	0.0	8.3

Plant	Plant part	Codfish Island	Stewart Island
Lycopodium ramulosum	Rhizome	0.0	0.9
Lycopodium ramulosum	Spore	0.0	0.2
Lycopodium sp.	Leaf cuticle	5.8	3.7
Lycopodium sp.	Rhizome	0.0	38.3
Lycopodium sp.	Spore	0.0	0.4
Lycopodium varium	Leaf cuticle	0.0	0.7
Meterosideros umbellata	Flower cuticle	0.0	4.4
Meterosideros umbellata	Leaf cuticle	20.9	15.3
Meterosideros umbellata	Pollen	0.0	1.1
Meterosideros umbellata	Seed	0.5	0.0
Monocot sp.	Leaf cuticle	2.1	0.0
Moss sp.	Leaf cuticle	0.0	1.5
Moss sp.	Scale	4.2	0.2
Myrsine australis	Fruit cuticle	0.5	0.2
Myrsine australis	Leaf cuticle	3.1	2.0
Myrsine divaricata	Fruit cuticle	0.0	0.2
Myrsine divaricata	Leaf cuticle	0.0	0.2
Neomyrtus pedunculata	Fruit cuticle	0.0	0.2
Nertera depressa	Leaf cuticle	0.5	0.7
Olearia colensoi	Leaf base	0.0	0.4
Olearia colensoi	Leaf cuticle	12.0	24.7
Olearia colensoi	Trichomes	3.1	1.8
Oreobolus pectinatus	Leaf cuticle	2.6	0.9
Oreobolus strictus	Leaf cuticle	0.0	7.4
Oreobolus strictus	Whole plant	0.0	1.3
Pentachondra pumila	Fruit cuticle	0.0	1.5
Pentachondra pumila	Leaf cuticle	0.0	1.3
Pentochondra pumila	Leaf cuticle	4.2	0.0
Phormium cookianum	Fruit cuticle	0.0	2.0
Phormium cookianum	Leaf cuticle	2.1	0.2
Phormium cookianum	Pollen	0.0	0.4
Phormium cookianum	Seed	0.0	0.4
Podocarp sp.	Fruit cuticle	1.0	10.3
Podocarp sp.	Leaf cuticle	7.3	5.9
Podocarpus hallii	Leaf cuticle	22.5	11.8
Podocarpus hallii	Pollen	0.0	1.1
Podocarpus hallii	Pollen cone	0.0	0.4
Prumnopitys ferruginea	Leaf cuticle	7.3	0.2
Prumnopitys ferruginea	Seed	0.0	0.2
Pseudopanax colensoi	Fruit cuticle	0.5	0.2
Pseudopanax colensoi	Leaf cuticle	0.5	1.8
Pseudopanax simplex	Leaf cuticle	0.0	1.8
Pseudopanax sp.	Seed	0.0	0.4
Pseudowintera colorata	Fruit cuticle	0.5	1.1
Pseudowintera colorata	Leaf cuticle	0.0	0.2
Pseudowintera colorata	Seed	0.0	0.4
Psuedopanax crassifolius	Leaf cuticle	2.6	0.0
Psuedopanax simplex	Leaf cuticle	1.0	0.0
Ripogonum scandens	Leaf cuticle	1.6	0.0
Schizaea fistulosa	Spore	0.0	0.2
Schizaea fistulosa	Whole plant	0.0	0.7
Senecio lyallii	Leaf cuticle	0.0	0.2
Thelymitra hatchii	Leaf cuticle	0.5	0.0
Thelymitra hatchii	Rhizome	0.0	0.2
Thelymitra pulchella	Leaf cuticle	0.0	0.2
Thelymitra pulchella	Rhizome	0.0	0.2
Thelymitra venosa	Bulb	0.0	0.4
Thelymitra venosa	Flower cuticle	9.4	1.1

Plant	Plant part	Codfish Island	Stewart Island
Thelymitra venosa	Leaf cuticle	20.9	9.6
Thelymitra venosa	Rhizome	0.0	8.8
Tmesipteris tannensis	Leaf cuticle	0.5	0.0
Todea superba	Leaf cuticle	0.0	0.4
Uncinia sp.	Leaf cuticle	0.5	11.2
Uncinia sp.	Reprod. frond	0.0	0.2
Uncinia sp.	Rhizome	0.0	0.7
Weinmannia racemosa	Leaf cuticle	2.1	4.8
Weinmannia racemosa	Pollen	0.0	0.2