# DIETS OF PIPITS AND SKYLARKS HUIARUA STATION, TOKOMARU BAY, NORTH ISLAND, NEW ZEALAND

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SUMMARY: The gizzard contents of 57 pipits and 64 skylarks collected from December 1973 to April 1976 at Huiarua Station, Tokomaru Bay are described.

Pipits fed mostly on invertebrates; in only nine percent of the gizzards did the volume of seeds exceed that of invertebrates. Adult Coleoptera, Hymenoptera and Diptera occurred in 77%, 67% and 63% of the gizzards respectively while adult insects of three other orders, insect larvae, insect pupae, Arachnida and seeds of four plant families were each recorded less frequently but in 10% or more of the gizzards. Only Diptera displayed significant seasonal variation in frequency of occurrence.

Skylarks ate mostly seeds; only 25 % of the gizzards contained a volume of invertebrates equal to or exceeding that of seeds. Seeds of Gramineae occurred more frequently than those of any other plant family (in 73% of the skylark gizzards) and adult Coleoptera were the most frequent invertebrates (66%). Seeds of eight other plant families, adult insects of two other orders, insect larvae, insect pupae and Arachnida were each recorded in 10% or more of the gizzards. Seasonally, only Coleoptera were taken with significantly variable frequency.

In addition to the difference in the relative importance volumetrically of invertebrates and seeds in each diet, significant differences were determined between pipits and skylarks in the occurrence of all the food groups most frequently consumed by each and it is concluded that the level of interspecific competition for food can not be regarded as high.

## INTRODUCTION

The New Zealand pipit *(Anthus novaeseelandiae* Gmelin, 1789) and the skylark *(Alauda arvensis* Linnaeus, 1758) are found throughout mainland New Zealand and on many of the outlying islands (Bull, Gaze and Robertson, 1978; Falla, Sibs on and Turbott, 1979). Before European colonisation, the pipit was probably confined to alpine and lowland tussock areas, riverbeds and coastal zones, but the extensive conversion of forests to pasture by European man undoubtedly benefited it, initially at least, by providing more of the open habitat to which it appears best adapted. The introduced skylark, released widely during the period 1864-1879 (Thomson, 1922), apparently took rapid advantage of this new pastoral habitat as Bathgate (1897) noted that "it has spread all over the country".

Both species now occupy many habitats, including alpine and lowland tussocklands, low scrublands, riverbeds, coastal. zones, and farmland, and are frequently found together. However, the pipit generally avoids pure pastureland where the skylark is often observed (Falla *et al*.. 1979), and Hamel (1972) found in Otago that during the breeding season pipits were absent from areas with a mean annual rainfall of less than 767 mm.

The pipit extended its range and increased in abundance in some localities until relatively recently (based on analysis of the Classified Summarised Notes in *Nororn is***, 1939-80) but in other areas ccnsiderable diminution of pipit populations has occurred (Classified Summarised Notes, *loco dr.;* Stidolph, 1974). Disease (Dore, 1920; Westerkov, 1953; Quinn, 1971) and predation (Guthrie-Smith, 1927; Fitzgerald, 1964; Fox, 1977) have both been noted in pipits and cannot be discounted as factors that may have contributed to these declines. Stidolph *(loc. dr.)* suggested that in the Wairarapa the sealing of main roads, increased traffc, the spraying and destruction of roadside vegetation, more efficient farming methods, and the increase of the magpie *(Gymnorhina* sp.) have probably all contributed to a drastic decline in pipits there since 1950.

Moeed (1975) suggested that pipits and skylarks may compete for food. If this is so this might also be a factor contributing to the decline of pipits in some areas. However, as little is known of the food

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habits of either species, there is little evidence to support such a contention.

This paper describes the diets of pipits and skylarks from hill country farmland near Tokomaru Bay, Gisborne, and is based on gizzard contents analysis.

## STUDY AREA

All birds were collected from Huiarua Station (38°07'S, 177° 55'E), a farm comprising 13,200 hectares of broken hill country near the headwaters of the Mata River, about 30 km west of Tokomaru Bay. The farmland was cleared of most of its former heavy mixed beech/podocarp cover by the mid-1930s (Newton, 1969) and today consists of open grassland, oversown with rye grass and red, white and subterranean clovers (N. Millar, pers. comm.).

Pipits were more numerous than skylarks in some parts of the study area, and vice versa, but no obvious habitat differences were apparent between these areas.

## METHODS

The gizzards of 57 pipits and 64 skylarks shot (under permit) in all months except January and July during the period December 1973 to April 1976 inclusive, were removed, preserved in 70% alcohol and the contents examined.

All gizzards contained food, and most were full and contained grit. Invertebrates were in varying stages of breakdown. Insects were identified mainly from head capsules and mandibles, since these persisted longer than other parts, although the characteristic legs of tipulids (O. Diptera) often remained when all other traces had disappeared. Arachnids were recognised by the presence of thoracic and head regions, which best displayed taxonomic characters when dried. Seeds also showed varying degrees of resistance to digestion, and identification was often based on the recognition of the seed minus an outer layer or. layers (ovary wall or testa). Identification was best carried out when the seeds were wet, as they' frequently underwent significant colour and shape changes when dried.

Counting of food items and precise measures of volume were precluded because the food material was generally very fragmented and mixed and the gizzards had such a small capacity (maximum about 1.5 ml). Therefore the following analyses were employed :

(i) the occurrence of particular food items in each gizzard was recorded and the frequencies of occurrence of those items, with respect to the total number of gizzards, were determined.

(ii) the relative proportion of invertebrate and seed material in each gizzard (expressed as percent invertebrate) was estimated by placing the contents of each gizzard into a petri dish. The percent invertebrate content was then visually approximated to the nearest of one of the following categories: 0, 1 5, 10, 25, 50, 75, 90, 95, 99, or 100%. Estimates of the relative proportions of seeds and invertebrates present in a gizzard were easiest to make at the extremes of the range of variation, but became more difficult when similar quantities of the two component food types were present. For this reason, the middle categories of the percent invertebrate scale have wider intervals (25%) than those higher or lower (progressively 15 %, 5 % and 1 % intervals) reflecting the loss of sensitivity of the technique in the middle of the range. The 75 % category was used to analyse seasonal variation within and between pipits and skylarks as this category best emphasised the major aspects of each diet.

Data from all years were combined to provide larger monthly sample sizes. Three-monthly seasons grouped on the base January-February-March (= summer) were used to investigate seasonal variation. Although perhaps not as natural a grouping as seasons based on December-January-February, these provided the best distribution of sample sizes for comparison.

Chi-square tests were used to test for significant differences within and between pipits and skylarks in the frequencies of occurrence of invertebrate groups and seed groups, and in the volumetric content of gizzards. Differences were regarded as significant if $p \leq 0.05$.

## RESULTS

*Pipits*

1. Food items and frequency of occurrence

The orders Coleoptera (77% of gizzards), Hymenoptera (67%) and Diptera (63%) each occurred with significantly greater frequency in the pipit gizzards than any other group (see Table 1). Insect larvae (39%) were consumed with comparable frequency to Arachnida (25%) and insect pupae (21 %), but occurred significantly more frequently than Orthoptera (18%), Lepidoptera (14%) and Hemiptera (12%).

An aquatic snail, an isopod and a feather louse were each recorded in one gizzard only.

The most frequently consumed seeds belonged to the plant families Leguminosae (33 %), Gramineae (25 %), Compositae (23 %), and Plantaginaceae (23 %) (see Table 2). Seeds of each of the remaining

TABLE 1. *Invertebrates and the number of gizzards in which they were recorded.*

| | Pipits (n = 57) | Skylarks (n = 64) |
|---|---|---|
| Insecta | | |
| Adults | | |
| O. Coleoptera (total) | 44 | 42 |
| F. Coccinellidae (unid.) | 0 | I |
| *Coccinella undecimpunctata* | 12 | 0 |
| F. Carabidae | | |
| Sub F. Cicidelinae | 6 | 1 |
| F. Scarabaeidae (unid.) | 1 | 0 |
| Sub F. Aphodiinae | | |
| *Aphodius granarius* | 2 | 4 |
| Sub F. Melolonthinae (unid.) | 1 | 0 |
| *Pyronota* sp. | 2 | 3 |
| F. Curculionidae | 3 | 17 |
| F. Chrysomelidae (unid.) | 0 | 1 |
| *Eucolaspis* sp. | 2 | 0 |
| *Eucolaspis sculptus* | 1 | 0 |
| F. Elateridae | | |
| *Lacon variabilis* | 1 | 0 |
| O. Hymenoptera (total) | 38 | 9 |
| Sub O. Apocrita (unid.) | 24 | 5 |
| F. Formicidae | 20 | 4 |
| O. Diptera (total) | 36 | 16 |
| Sub O. Nematocera (unid.) | 4 | 6 |
| F. Tipulidae | 20 | 7 |
| Sub O. Brachycera | | |
| Div. Cyclorrhapha | 18 | 3 |
| O. Orthoptera (total) | 10 | 1 |
| F. Gryllidae | | |
| *Pteronemobius bigelowi* | 8 | 1 |
| F. Acrididae | | |
| *Phauliacridium marginale* | 2 | 0 |
| O. Lepidoptera | 8 | 2 |
| O. Hemiptera (total) | 7 | 5 |
| F. Tibicinidae | | |
| *Amphisalta* sp. | 2 | 0 |
| F. Nabidae | 1 | 0 |
| F. Saldidae | | |
| *Saldula* sp. | 1 | 0 |
| F. Cydnidae | 1 | 0 |
| F. Aphididae | 0 | 1 |
| F. Lygaeidae | | |
| *Cymus novaezelandiae* | 0 | 1 |
| O. Phthiraptera | | |
| Sub O. Mallophaga | I | 0 |
| Larvae (total) | 22 | 14 |
| O. Lepidoptera (unid.) | 6 | 2 |
| F. Noctuidae | 3 | 1 |
| O. Diptera (unid.) | 3 | 4 |
| F. Tipulidae | 2 | 2 |
| O. Coleoptera (unid.) | 2 | 2 |
| F. Elateridae | 2 | 0 |
| Pupae (total) | 12 | 11 |
| O. Lepidoptera | | |
| F. Coleophoridae | | |
| *Coleophora* sp. | 12 | 10 |
| O. Diptera | 0 | 1 |
| Arachnida (total) | 14 | 8 |
| O. Araneae | | |
| F. Dictynidae | 3 | 1 |
| F. Salticidae | 2 | 0 |
| F. Epeiridae | 1 | 0 |
| F. Lycosidae | 1 | 1 |
| Gastropoda | | |
| O. Mesogastropoda | | |
| F. Hybrobiidae | | |
| *Potamopyrgus antipodarum* | I | 0 |
| O. Stylommatophora | | |
| F. Endodontidae | | |
| *Paralaoma Pumila* | 0 | 1 |
| Crustacea | | |
| O. Isopoda | 1 | 0 |
| Unidentified | 20 | 18 |

seven families occurred in fewer than 10% of the pipit gizzards.

2. Volumetric assessment

Invertebrates contributed the bulk of the pipit's food (Fig. I) and were the only food in 28% of the gizzards. In a further 38% of the gizzards, invertebrates comprised 99% of the food present, and in 80 % of the gizzards, comprised 90 % or more of the food. Only in five (9%) of the pipit gizzards did the volume of seeds exceed that of invertebrates.

3. Seasonal variation

Only Diptera displayed a significant seasonal variation in frequency of occurrence, occurring in 93 % of the pipit gizzards in 'spring' (Oct-Nov-Dec) compared with 29% in 'autumn' (Apr-May-Jun) ($X^2 = 4.89$, $P < 0.05$) (see Table 3).

The proportion of gizzards in which invertebrates contributed 75 % or more of the food volume did not vary significantly between seasons, but fewer invertebrates appeared to be taken by pipits in 'summer' and 'autumn' than in 'winter' and 'spring', or conversely, more seeds were consumed in 'summer' and 'autumn'.

*Skylarks*

1. Food items and frequency of occurrence

The order Coleoptera occurred with significantly greater frequency (66 %) in the skylark gizzards than any other invertebrate group ($p < 0.001$ in all cases) (see Table 1). All other major invertebrate groups occurred with statistically comparable frequencies: Diptera (25 %); insect larvae (22%); pupae (17%); Arachnida (13%); and Hymenoptera (14 %). Hemiptera, Lepidoptera and Orthoptera occurred in fewer than 10 % of the gizzards, and a terrestrial snail was found in one gizzard.

TABLE 2. *Seeds and the number of gizzards* in *which they were recorded.*

| | Pipits (n = 57) | Skylarks (n = 64) |
|---|---|---|
| F. Leguminosae (total) | 19 | 10 |
| *Trifolium dubium* | 11 | 0 |
| *Trifolium repens* | 9 | 2 |
| *Trifolium pratense* | 5 | 8 |
| F. Gramineae (total) | 14 | 47 |
| *Anthoxanthum odoratum* | 10 | 44 |
| *Cynosurus cristatus* | 3 | 2 |
| *Setaria* sp. | 2 | 0 |
| *Lolium* sp. | 0 | 1 |
| *Poa* sp. | 0 | 1 |
| F. Compositae (total) | 13 | 16 |
| *Cirsium vulgare* | 12 | 12 |
| *Cirsium arvense* | 1 | 1 |
| *Taraxacum officinale* | 11 | 4 |
| *Hypochaeris glabra* | 0 | 1 |
| F. Plantaginaceae (total) | 13 | 7 |
| *Plantago lanceolata* | 12 | 4 |
| *Plantago* sp. | 1 | 3 |
| F. Cyperaceae (total) | 5 | 15 |
| *Carex* spp. | 5 | 15 |
| F. Polygonaceae (total) | 3 | 13 |
| *Polygonum aviculare* | 3 | 14 |
| *Rumex acetosella* | 1 | 4 |
| F. Labiatae (total) | 3 | 0 |
| *Prunella vulgaris* | 3 | 0 |
| F. Cruciferae (total) | 2 | 1 |
| *Sinapsis nigra* | 2 | 1 |
| F. Caryophyllaceae (total) | 1 | 8 |
| *Stellaria media* | 1 | 8 |
| F. Ranunculaceae (total) | 1 | 7 |
| *Ranunculus repens* | 1 | 7 |
| F. Rubiaceae (total) | 1 | 0 |
| F. Solanaceae (total) | 0 | 7 |
| F. Amarantaceae (total) | 0 | 3 |
| *A maranthus retroflexus* | 0 | 3 |
| F. Thymelaeaceae (total) | 0 | 3 |
| *Pimelia* sp. | 0 | 3 |
| Unidentified | 6 | 5 |

Seeds of the plant family Gramineae occurred with significantly greatest frequency (73 %, $p < 0.001$ in all cases) (see Table 2). Seeds from the other plant families important in the diet occurred with statistically comparable frequencies: Compositae (25%); Cyperaceae (23%); polygonaceae (20%); Leguminosae (6%); Caryophyllaceae (13%); Plant~ aginaceae (11 %); Ranunculaceae (11 %); and Solanaceae (11 %). Seeds of each of the remaining three families (Amarantaceae, Thymelaeaceae and Cruciferae) were present in fewer than 6% of the skylark gizzards.

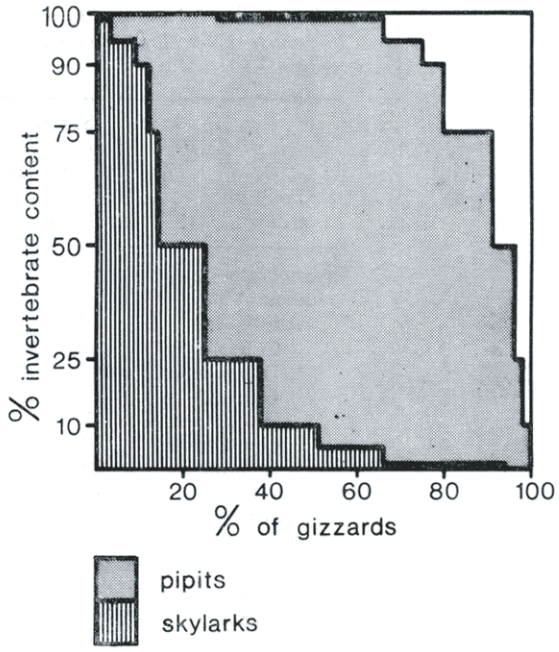


FIGURE 1. *Invertebrate material contained in pipit and skylark gizzards.*

2. Volumetric assessment

Invertebrates contributed little to the bulk of the skylark's food (Fig. 1) and only 16 (25%) of the gizzards contained a volume of invertebrates equal to or exceeding that of seeds. In a further 13 %, invertebrates comprised 25 % of the food present. In 40 (62 %) of the skylark gizzards invertebrates constituted 10% or less of the volume.

3. Seasonal variation

Only Coleoptera displayed a significant seasonal variation in frequency of occurrence, occurring in 85% of the skylark gizzards in 'spring' (Oct-Nov Dec) and 22 % in 'autumn' (Apr-May-Jun) ($X^2 = 3.79$, $p = 0.052$) (see Table 3).

The proportion of skylark gizzards in which invertebrates contributed 75% or more of the food volume did not vary significantly between seasons, but fewer invertebrates or conversely more seeds appeared to be taken in 'summer' and 'autumn' than in 'winter' and 'spring'.

*Comparison of diets*

Pipits and skylarks took a similar range of food items. Skylarks consumed 57 % of the identified invertebrate families and 80% of the identified seeds taken by pipits; pipits consumed 73 % of the

TABLE 3. *Percent occurrence of major food groups and percent of gizzards in which invertebrates comprised 75% or more of the food in each 'season'*[1]

| | 'Spring' | | 'Summer' | | 'Autumn' | | 'Winter' | |
|---|---|---|---|---|---|---|---|---|
| Food group | Pipits (n=15) | Skylarks (n=26) | Pipits (n=20) | Skylarks (n=9) | Pipits (n=14) | Skylarks (n=9) | Pipits (n=8) | Skylarks (n=20) |
| Invertebrates | | | | | | | | |
| Insecta | | | | | | | | |
| Adults | | | | | | | | |
| Coleoptera | 87 | 85 | 70 | 56 | 93 | 22 | 50 | 65 |
| Hymenoptera | 60 | 12 | 60 | 33 | 93 | 22 | 50 | 5 |
| Diptera | 93 | 23 | 70 | 33 | 29 | 22 | 50 | 25 |
| Orthoptera | 7 | _[2] | 30 | - | 14 | | 13 | - |
| Lepidoptera | 20 | - | 15 | - | 7 | - | 13 | - |
| Hemiptera | 20 | - | 10 | - | 7 | - | 13 | - |
| Larvae | 40 | 23 | 20 | 22 | 50 | 11 | 63 | 25 |
| Pupae | 13 | 0 | 45 | 11 | 0 | 33 | 13 | 35 |
| Arachnida | 7 | 8 | 15 | 11 | 50 | 0 | 38 | 25 |
| Seeds | | | | | | | | |
| Leguminosae | 33 | 15 | 35 | 22 | 43 | 11 | 13 | 15 |
| Gramineae | 33 | 88 | 30 | 78 | 14 | 56 | 13 | 60 |
| Compositae | 0 | 15 | 40 | 67 | 14 | 44 | 38 | 10 |
| Plantaginaceae | 0 | 12 | 40 | 33 | 36 | 0 | 0 | 5 |
| Cyperaceae | | 0 | - | 11 | - | 56 | - | 45 |
| Polygonaceae | - | 0 | - | 44 | | 56 | - | 20 |
| Caryophyllaceae | - | 12 | - | 22 | - | 33 | - | 0 |
| Ranunculaceae | | 0 | - | 11 | | 11 | - | 25 |
| Solanaceae | - | 4 | - | 0 | - | 11 | - | 25 |
| % of gizzards in which invertebrates comprised 75 % or more of the food | 100 | 23 | 85 | 0 | 86 | 0 | 100 | 15 |

Notes: 1. Monthly data for individual food items available from the Information Section, Wildlife Service, Department of Internal Affairs, Private Bag, Wellington.
2. Dashes indicate food group was not a major constituent in the diet, i.e. it occurred in fewer than 10% of the gizzards.

seeds and 75% of the invertebrate families taken by skylarks.

Hymenoptera, Diptera, Orthoptera and seeds of Leguminosae were taken significantly more frequently by pipits than by skylarks, while the converse was true for seeds of Gramineae, Polygonaceae and Cyperaceae (Table 4). No significant differences were found between pipits and skylarks with respect to other orders (insects) or families (seeds) of foods eaten, but at the species level there were some distinctions, e.g. *Coccinella undecimpunctata* (P. Coccinellidae) was the most frequently occurring coleopteran in the pipit sample, while weevils (P. Curculionidae) contributed most to the skylark total. Similarly, the hemipteran species taken by pipits and skylarks were different.

Seeds of Caryophyllaceae, Ranunculaceae and Solanaceae occurred as major constituents in the diet of the skylark, and Lepidopteran insects were important in the pipit's diet, but none of these groups could be compared statistically between the birds. However, Lepidoptera appeared to be taken more frequently by pipits (14 %) than by skylarks (3%), while skylarks appeared to take seeds of Caryophyllaceae (13% compared to 2%), Ranunculaceae (11% compared to 2%), and Solanaceae

TABLE 4. *Food groups for which significant differences in frequencies of occurrence were determined between pipits and sky/arks.*

| Food group | % occurrence in pipits (n=57) | % occurrence in skylarks (n=64) | $X^2$ | Significance p< |
|---|---|---|---|---|
| Invertebrates | | | | |
| Hymenoptera | 67 | 14 | 21.48 | 0.001 |
| Diptera | 63 | 25 | 10.21 | 0.005 |
| Orthoptera | 18 | 2 | 8.48 | 0.005 |
| Seeds | | | | |
| Leguminosae | 33 | 16 | 3.95 | 0.05 |
| Gramineae | 25 | 73 | 14.30 | 0.0001 |
| Polygonaceae | 5 | 20 | 5.17 | 0.025 |
| Cyperaceae | 9 | 23 | 3.92 | 0.05 |

(11 % compared to 0%) more frequently than pipits.

Volumetrically, pipits consumed significantly more invertebrates than did skylarks ($X^2$ = 35.60, $p < 0.001$). In pipits, invertebrates constituted 75% or more of the food in 91 % of the gizzards, but in skylarks only 14 % of the gizzards contained 75 % or more invertebrates.

Significant seasonal differences between pipits and skylarks in frequencies of occurrence of food groups are given in Table 5. In 'autumn' (Apr-May-Jun), pipits consumed Coleoptera and Hymenoptera more frequently than did skylarks. In 'spring' (Oct-Nov-Dee), Diptera occurred more frequently in pipits, while seeds of Gramineae were taken with greater frequency by skylarks. Although it could not be tested statistically, pipits took Arachnida more frequently in 'autumn' than did skylarks (50% occurrence compared to 0 %).

Throughout the year pipits appeared to consume a greater bulk of invertebrates than did skylarks (Table 3), but this was not tested statistically.

## DISCUSSION

### *Pipits*

Buller (1888) stated that the diet of pipits consisted of insects and their larvae, small earthworms, and occasionally minute seeds. Oliver (1955) added to this list spiders and Crustacea, and commented that the pipit is very useful in horticulture and agriculture due to its consumption of large numbers of grass-grubs (larvae of the beetle *Odontria),* Oliver also included a report of pipits eating cattle ticks in milking shed yards. Reischek (1885) and Falla *et al.* (1979) regarded pipits as being almost entirely insectivorous, although noting that they take some seeds also. Moeed (1975), in the only previous quantitative study, found adult Coleoptera, Hemiptera, Diptera and Lepidoptera, Lepidoptera larvae, Arachnida and seeds of six plant species in a sample of five pipits collected at Christchurch International Airport. Coleoptera and Hemiptera occurred most frequently. Seeds formed 75% or more of the items contained in the gizzards, but Moeed considered that as most of the seeds were much smaller than the invertebrates, their volume in the diet was less.

As diets are likely to vary with time, season, location and availability of prey, and because sample sizes and methods usually differ between food studies, comparison of my results with those of others must be limited. However, several of the species or genera recorded by Moeed *(loc. cit.)* were the same as those recorded in this study *(Coccinella undecimpunctata, Coleophora, Stellaria media, Polygonum* and *Trifolium),* and I too found Coleoptera to be one of the most frequently occurring invertebrate groups. In addition to the insect orders that he observed, I recorded Hymenoptera and Orthoptera. Mason (1971) also found grasshopper remains (F. Acrididae) in five of 12 pipits he collected from the Southern Alps of Canterbury.

While Buller (1888) and Oliver (1955) stated that small earthworms are taken by pipits, Moeed (1975) did not find earthworm remains in the pipit gizzards he examined, but suggested that this may have been

TABLE 5. *Food groups for which significant differences were determined between pipits and skylarks in their frequencies of occurrence within 'seasons'.*

| Food group | 'Season' | % occurrence in pipits | % occurrence in skylarks | $X^2$ | Significance p< |
|---|---|---|---|---|---|
| Coleoptera | 'Autumn' | 93 (n=14) | 22 (n=9) | 4.19 | 0.05 |
| Hymenoptera | 'Autumn' | 94 (n=14) | 22 (n=9) | 4.19 | 0.05 |
| Diptera | 'Spring' | 93 (n=15) | 23 (n=26) | 9.62 | 0.005 |
| Gramineae | 'Spring' | 33 (n=15) | 89 (n=26) | 4.23 | 0.05 |

because his samples were obtained during summer, when earthworms were not present in the top soil. My study failed to find earthworms in any gizzard, irrespective of season.

Volumetrically, the proportions of invertebrates to seeds recorded in this study, both seasonally and overall, support the views of other authors that invertebrates contribute most to the bulk of the pipit's food.

The frequencies with which I recorded grassgrubs in my sample are inconsistent with the numbers Oliver (1955) claimed pipits consume. Unidentified Coleoptera larvae occurred in two gizzards and adult Melolonthinae remains in one other, but none could be identified as being *Odontria* sp. nor as being the common grassgrub *Costelytra zealandica*. the adult of which Moeed (1975) recorded as being taken. Adult *Pyronota* were identified in two gizzards; the larvae of some species of this genus can cause pasture damage similar to that done by *Costelytra zealandica* (Ferro, 1976). Other potential insect pests (as in Ferro, 1976) that occurred in the pipit gizzards included larvae of the families N octuidae and Tipulidae, *Lacon variabilis* and *Co!eophora*.

*Skylarks*

Thomson (1926) and Oliver (1955) stated that skylarks feed largely upon seeds, including most kinds of grain, sometimes small fruits and, when the young are being reared, insects and worms.

Bathgate 0897) considered that skylarks are graminivorous, but Hilgendorf 0918) reported that they are almost purely insectivorous in the Canterbury mountains (1500 m in altitude), although he also reported that in agricultural districts poisoned grain scattered over a field of sprouting wheat kills more larks than sparrows, thus indicating that they may also take seeds.

Moeed (1975), in a sample of nine skylarks collected at Christchurch International Airport, recorded adult insects of the orders Coleoptera, Hemiptera, Diptera, Lepidoptera and Orthoptera, Lepidoptera larvae, Arachnida, and seeds from six plant families. Of the invertebrates, Coleoptera, especially Curculionidae and Carabidae, occurred most frequently. Geraniaceae, Gramineae, and Caryophyllaceae were the most frequently recorded groups of seeds. While small seeds were eaten more frequently than invertebrates (except in January), Moeed considered that, volumetrically, insects contributed more to the skylark's food than seeds.

In addition to the insect orders that Moeed (1975) observed, I recorded Hymenoptera. Coleoptera (especially Curculionidae) were the most frequently occurring invertebrates in my study as in Moeed's. Four of the seed groups Moeed recorded (Gram ineae, Caryophyllaceae, Polygpnaceae, and Legum inosae) I also recorded, in addition to eight other families, but Gramineae occurred with significantly greatest frequency.

Insects of the genus *Coleoptera,* and seeds of the genera *Polygonum* and *Trifolium* were common to both studies, as were seeds of the species *Stellaria media* and *Anthoxanthum odoratum*.

Seasonally, and overall, my study found that seeds contributed much more to the bulk of the skylark's food than did invertebrates, as Thomson (1926) and Oliver (1955) suggested, but in contrast to Moeed's (1975) observation and that of Hilgendorf 0918).

Seasonal variation in the quantities of invertebrates and seeds consumed by skylarks was not significant, but there was an indication that more seeds may have been consumed in 'summer' and 'autumn' than at other times of the year. Seed production is likely to be at its peak in summer, although *Anthoxanthum odoratum* seeds somewhat earlier (Lambrechtsen, 1972) and contributed exclusively to the Gramineae consumed in the 'spring' period.

Bathgate (1897) stated that skylarks do little harm despite being graminivorous. However, Thomson (1922) commented that the skylark is considered by farmers to be the most destructive introduced bird after the sparrow, particularly in spring when they uproot wheat and other grains, seedling cabbages, turnips, and other farm plants. Oliver (1955) reported also an instance of about 5,000 young tobacco plants being pulled up by skylarks but suggested that the beneficial aspects of eating insects are not always taken into account. Potential insect pests (as in Ferro, 1976) that occurred in the skylark gizzards in my study included larvae of the families Noctuidae and Tipulidae, *Pyronota* and *Coleophora*.

*Assessment of competition between pipits and skylarks*

Pipits and skylarks are similar in appearance and appear to occupy very similar niches. Both species inhabit open country and are frequently found together. The results of this study show that there is overlap in the food items eaten. Taken together, all of these similarities raise the question: do pipits and skylarks compete?

At present there is only sufficient information available to consider whether there is competition between the birds for food. The considerable overlaps that were observed in the invertebrates and seeds taken by pipits and skylarks in this study

immediately suggest that interspecific competition could be occurring. However, closer scrutiny of the utilisation of the food groups concerned by the two birds revealed that within the broad groups there was considerable partitioning of the resource:

(a) significant differences were observed in the occurrence of three insect orders (Hymenoptera, Diptera and Orthoptera) and the seeds of four plant families (Leguminosae, Gramineae, polygonaceae and Cyperaceae) and apparent differences in another insect order (Lepidoptera) and the seeds of three other plant families (Caryophyllaceae, Ranuncu laceae and Solanaceae);

(b) although no significant differences were found between pipits and skylarks in the occurrence in their diets of the orders Coleoptera and Hemiptera, there were differences in the frequencies of occurrence of the species contributing to these orders;

(c) seasonally (in 'autumn' and 'spring'), there were significant differences between pipits and skylarks in the frequencies of occurrence of three insect orders (Coleoptera, Hymenoptera and Diptera) and the seeds of one plant family (Gramineae) and an apparent difference in the occurrence of one other major invertebrate group (Arachnida).

Taken individually, none of these differences, even if large, can be regarded as satisfactory evidence that pipits and skylarks do not compete for food. However, considering all of the differences, overall, seasonal and compositional, in the food groups most frequently consumed by each species (i.e. Coleoptera, Hymenoptera and Diptera in pipits and Coleoptera and Gramineae in skylarks) and in addition the overall and seasonal differences in the volumetric proportions of invertebrates and seeds consumed by pipits and skylarks, it seems likely that there is little, if any, competition between the two species at Huiarua Station, assuming that there was no shortage of food in the study area. However, have the diets of pipits and skylarks developed as a result of past interspecific competition?

Accounts from other authors, both in New Zealand and in Britain, although generally of a qualitative nature, suggest that the food types recorded in my pipit and skylark samples, and the relative importance of invertebrates and seeds in each, are not unique.

In Britain, Morris (1903) suggested that Richard's pipit *(Anthus richardi* Vieillot 1818, synonymous with *Anthus novaeseelandiae)* consumes a diet of flies, grasshoppers, and other insects. Witherby *et al.* (1958) reported that Richard's pipit takes insects (small Diptera, Hymenoptera (e.g. *Ichneumon),* Coleoptera (e.g. *Coccinella),* Orthoptera (grasshoppers) and Lepidoptera (butterflies)), larvae and vegetable matter, and in winter, worms also. Of the skylark (in Britain), Morris (1903) stated that its food consists of grains, grasses or seeds, occasional berries, and also insects, caterpillars, snails and worms. Collinge (1924) found that of the food consumed by skylarks in a year, animal matter formed 46 % and vegetable matter 54 %, by volume.

Although my study found that skylarks consumed a greater relative proportion of seeds to invertebrates than did Collinge's, his study nevertheless did not show animal matter to be of any greater importance in the diet of skylarks than vegetable matter.

It appears then, that the differences in the diets of pipits and skylarks, as described in this study, cannot be regarded as having resulted from inter-specific competition and therefore it is unlikely that the local disappearance of pipit populations in parts of New Zealand can be attributed to displacement by skylarks through competition for food.

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## REFERENCES

BATHGATE, A. 1897. Notes on acclimatisation in New Zealand. *Transactions of the New Zealand Institute* 30: 266-79.

BULL, P. C.; GAZE, P. D.; ROBERTSON, C. J. R. 1978. *Bird Distribution in New Zealand. A Provisional Atlas*. 1969-1976. The Ornithological Society of New Zealand Inc., Wellington. 254 pp.

BULLER, W. L. 1888. *A History of the Birds of New Zealand*. Volume I. Published by the author, Westminster. 2nd edition. 250 pp.

COLLINGE, W. E. 1924-27. *The Food of Some British Wild Birds*. Published by the author, York. 427 pp.

DORE. A. B. 1920. The occurrence of malaria in the native ground lark. *New Zealand Journal of Science and Technology* 3: 118-9.

FALLA, R. A.; SIBSON, R. B.; TURBOTT, E. G. 1979. *The New Guide to the Birds of New Zealand*. Collins, Auckland and London. 247 pp.

FERRO, O. N. 1976. Pasture Pests. *In:* Ferro, D. N. (Editor). *New Zealand Insect Pests*. pp 105-27.

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Lincoln University College of Agriculture, New Zealand. 311 pp.

FITZGERALD, B. M. 1964 (unpublished). *Ecology of Mustelids* in *New Zealand*. M.Sc. thesis, University of Canterbury, Christchurch.

Fox, N. C. 1977 (unpublished). *The Biology of the New Zealand Falcon* (Falco novaeseelandiae *Gmelin*. 1788). Ph.D. thesis, University of Canterbury, Christchurch.

GUTHRIE-SMITH, H. 1972. *Birds of the Water, Wood and Waste*. Whitcombe and Tombs Ltd., Wellington. 207 pp.

HAMEL, J. 1972. Pipits, skylarks and rainfall. *Notornis* 19 (1): 20-5.

HILGENDORF, F. W. 1918. Notes from the Canterbury College Mountain Biological Station. *Transactions and Proceedings of the New Zealand Institute* 50: 133-44.

LAMBRECHTSEN, N. C. 1972. *What Grass* is *That?* New Zealand Department of Scientific and Industrial Research, Information Series No. 87. 136 pp.

MASON, P. C. 1971 (unpublished). *Alpine grasshoppers (Orthoptera: Acrididae) in the Southern Alps of Canterbury, New Zealand*. Ph.D. thesis, University of Canterbury, Christchurch.

MOEED, A. 1975. Food of skylarks and pipits, finches and feral pigeons near Christchurch. *Notornis* 22 (2): 135-42.

MORRIS, F. O. 1903. *A History of British Birds*. Volume II. John C. Nimmo Ltd., London. 5th edition. 288 pp.

NEWTON, P. 1969. *Big Country of the North Island*. A. H. and A. W. Reed, Wellington. 247 pp.

OLIVER, W. R. B. 1955. *New Zealand Birds*. A. H. and A. W. Reed, Wellington. 2nd edition. 661 pp.

QUINN, P. J. 1971. Suspected case of bird pox in a small population of New Zealand pipits. *Notornis* 18 (3); 217.

REISCHEK, A. 1885. Observations on the habits of New Zealand birds, their usefulness or destructiveness to the country. *Transactions of the New Zealand Institute* 18: 96-104.

STIDOLPH, R. H. D. 1974. Decline of pipit in Wairarapa. *Notornis* 21 (I): 79-80.

THOMSON, G. M. 1922. *The Naturalisation of Animals and Plants* in *New Zealand*. University Press, Cambridge. 607 pp.

THOMSON, G. M. 1926. *Wildlife in New Zealand. Part II. Introduced Birds and Fishes*. New Zealand Board of Science and Art, Manual No.5. Government Printer, Wellington. 110 pp.

WESTERKOV, K. 1953. Bird pox in a New Zealand pipit. *Notornis* 5 (5): 168-70.

WITHERBY, H. F.; JOURDAIN, F. C. R.; TICEHURST, N. F.; TUCKER, B. W. 1958. *The Handbook of British Birds*. Volume I. H. F. and G. Witherby Ltd., London. 8th edition. 348 pp.