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Faecal analysis reveals the insectivorous diet of the Black-breasted Button-quail *Turnix melanogaster*

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The threatened Black- breasted Button-quail *Turnix melanogaster* is thought to have an omnivorous diet comprising seeds and invertebrates; however, very little study has been undertaken to confirm or refute this claim. A thorough understanding of a species' diet is required for its effective conservation management. To determine the species' diet, *T. melanogaster* faeces were collected from within or near platelets found on Fraser Island and in Yarraman State Forest, two different habitats, and analysed microscopically. Analysis showed that *T. melanogaster* has a diet comprised almost entirely of invertebrates and that it preferentially preys upon Dermaptera, Pseudoscorpionida and Coleoptera.

INTRODUCTION

The Black-breasted Button-quail *Turnix melanogaster* is a poorly known bird endemic to the east coast of Australia. It is listed as Vulnerable both nationally (Department of the Environment 2016) and in Queensland (Department of Environment and Heritage Protection 2013). In New South Wales, where it has become increasingly rare and records are few, it is listed as Critically Endangered under the Threatened Species Conservation Act 1995 (Major 2009). It is listed as a Critical species for the Australian Government Department of Environment and Heritage protection, Back on Track Species Prioritisation Framework (Department of Environment and Heritage Protection 2015).

T. melanogaster has been little researched and the exact composition of its diet is unknown. It is thought to be omnivorous, consuming both seeds and invertebrates (Hughes and Hughes 1991; Marchant and Higgins 1995; McConnell and Hobson 1995), the diet of captive individuals includes various arthropods and seeds (Phipps 1976; Mills 1985; Roulston 1992). Smyth and Pavey (2001) noted that the diet of *T. melanogaster* included crustaceans; however, it was not documented how this was determined. A dietary study by McConnell and Hobson (1995) examined the contents of 12 *T. melanogaster* faecal samples collected in May 1993 at Redwood Park, Toowoomba, southeast Queensland. Food items found during the faecal analysis included members of the Araneae, Formicidae, Chilopoda, Diplopoda, Coleoptera and Gastropoda. The dominant components were parts of Formicidae and Coleoptera, remnants of Chilopoda, Diplopoda and Gastropoda being scarce. Prior to the current investigation, McConnell and Hobson's (1995) research was the only study of the diet of *T. melanogaster*. The present paper reports the results of analysis of *T. melanogaster* faeces collected at two locations in Queensland.

METHODS

Study areas

The study was conducted at two locations, Fraser Island and Yarraman State Forest; these populations are 165 km apart. On Fraser Island (25.2398º S, 1534.1325º E) *T. melanogaster* is recorded in littoral forest along the east coast, which receives 1,572 mm of rainfall annually (Australian Bureau of Meteorology 2017). Yarraman State Forest (26.8531º S, 151.9053º E) supports dry rainforest in the form of Araucarian microphyll vine forest and has an annual rainfall of 816 mm (Australian Bureau of Meteorology 2017). These locations were selected because they comprise two different habitat types used by *T. melanogaster*.

T. melanogaster faeces were collected in both study locations from or near platelets, the scrapes made in the substrate by foraging button-quail. The Painted Button-quail *T. varius* has also been recorded at both locations and therefore certain criteria had to be met to ensure that the faeces collected could reliably be attributed to *T. melanogaster.* These criteria were that: (1) faeces were only collected from habitat suitable for *T. melanogaster* and this was either dry rainforest or littoral forest, (2) the presence of *T. melanogaster* was confirmed at each faecal collection location either visually or by the use of remote camera traps, and (3) the faeces included in the analysis had to be the correct size and shape, as previously described for the species (McConnell and Hobson 1995). A study by Lees and Smith (1998) indicated that faeces of *T. melanogaster* were not distinguishable from those *T. varia*. However, the birds in their study were from a captive population fed on an artificial diet and consequently their results cannot be reliably translated to a wild situation. Each faecal sample was stored in a labelled 5 mL plastic, screw-cap, specimen container and frozen as soon as possible after collection. Before analysis, the faeces were softened and broken apart by adding 1 mL of water to each container, which was placed in boiling water for 10 minutes, cooled and shaken vigorously, and the material was preserved by adding 3 mL of methylated spirits.

Samples were inspected using a SZ40 Olympus stereo microscope to identify plant and animal material. Invertebrates were identified by examining key fragments which were diagnostic for the different invertebrate groups (i.e. taxa and less well defined categories, such as insect larvae). The number of invertebrate groups in each sample was counted and recorded.

A reference collection was assembled which encompassed the diversity of Insecta, Arachnida, Entognatha, Diplopoda, Chilopoda and Crustacea found at the study sites. This reference collection was collected from both study sites using pitfall traps and Tullgren funnels. Pitfall traps comprised 250 mL plastic containers filled with 50 mL of 40% ethylene glycol. They were left open *in situ* for seven days. At Yarraman, 105 pitfall traps were used and at Fraser Island 50 were employed. The pitfall traps were placed in areas where platelets were evident and faeces had been collected. Leaf litter was collected from each study location and processed in Tullgren funnels. The leaf litter was collected from 105 individual sites in Yarraman State forest and 50 on Fraser Island. At each individual site, 6 L of leaf litter was collected, again in areas where platelets were evident and faeces had been collected. A 60-watt reflector globe was used to heat the Tullgren Funnel, which was operated for seven days. The findings of previous studies using insect fragments to determine avian diet were also used as a reference (Ralph *et al*. 1985; Michalski *et al*. 2011).Reference texts were used to assist in the identification of fragments, including those published by CSIRO (1970), Shattuck (1999), Beccaloni (2009), Bonato *et al*. (2010), Hangay and Zborowski (2010), Lawrence and Ślipiński (2013), Maruzzo and Bonato (2014) and Rentz (2014).

The prey preference of *T. melanogaster* at each study location was calculated using Pearre's Selection Index (V) (Pearre 1982). The index, V, returns a value ranging from -1 (strong negative selection) to +1 (strong positive selection), a selection index of zero indicating that there was neutral selection of prey. Pearre's Selection Index was calculated as:

$$Va = \frac{(a_d * b_e) - (a_e * b_d)}{\sqrt{a * b * d * e}}$$

where *Va* is the Pearre's Selection Index for prey selection of the prey species *a*, a_d is the relative abundance of species *a* in the diet, b_e is the relative abundance of all species other than *a* in the environment, a_e is the relative abundance of species *a* in the environment, b_d is the relative abundance of all species other than *a* in the diet, $a = a_d + a_e$, $b = b_d + b_e$, $d = a_d + b_d$, $e = a_e + b_e$.

Pearre's Selection Index was tested for statistical significance using a chi-squared test:

$$\chi^2 = \frac{(a_d * b_e - a_e * b_d)^2}{(a * b * d * e)}$$

where $n = a_d + a_e + b_d + b_e$. Alpha was set at 0.05.

Pearson's correlation coefficients (*r*) were calculated to determine the strength of the associations between the invertebrates present in the environment and those found in the faecal samples.

RESULTS

Sixty-four faecal samples were collected and examined, and 13 invertebrate groups were identified. The 38 faecal samples from Yarraman State Forest contained 13 invertebrate groups, the mean per sample being 3.6 groups, with a range of 1-8. The 26 faecal samples from Fraser Island contained 11 groups, the mean per sample being 2.8, with a range of 0-6.

Faecal analysis focused on identifying key fragments known to be diagnostic for the different invertebrate groups. Some of the fragments found in the faeces of *T. melanogaster* are shown in Figures 1, 2 and 3. A list of the key fragments with associated notes is given in Table 1. Most key fragments were mandibles, legs, head capsules and other chitinous pieces that are resistant to digestion. Softer fragments, such as wings and abdominal segments, were scarce; however, the integument of Dipteran larvae was frequently recorded. The size of the original prey items was estimated from some fragments. Coleoptera and Hymenoptera prey sizes were estimated using formulae presented by Calver and Wooller (1982) based on the relationship between the head width of the prey item and its total length. The original sizes of Pseudoscorpione specimens were estimated by comparing fragments of chelae in the faeces with those of complete specimens trapped at the same site. A complete snail shell found in faeces was measured, and its metrics are given in Table 2. The size of some prey items recorded in the faecal samples indicated that most of the diet may comprise small invertebrates of <10 mm.

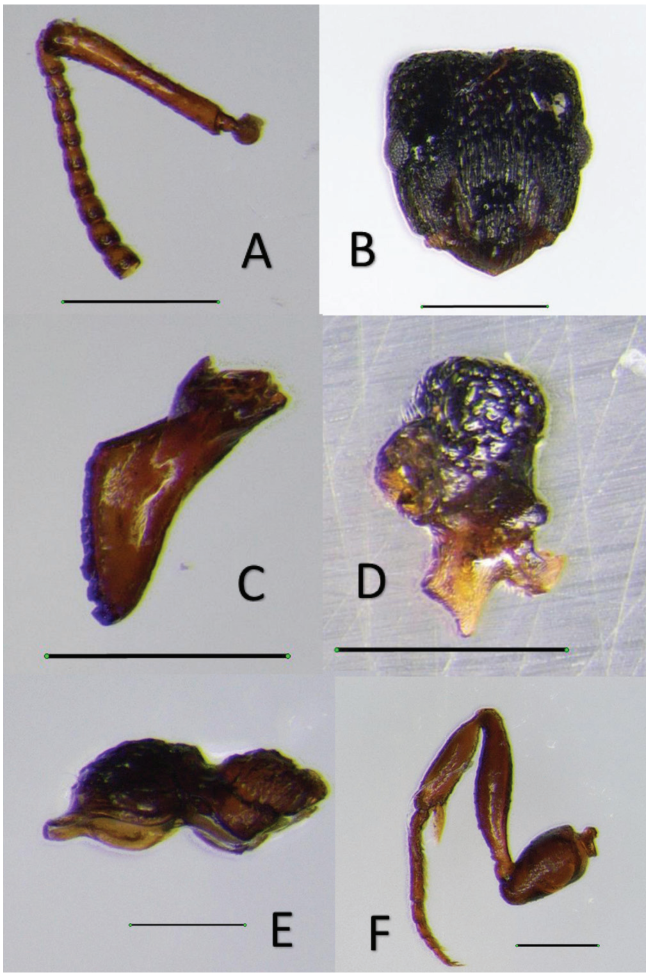

Figure 1. *Formicidae fragments found in the faeces of T. melanogaster, the horizontal line below the item represents 500 µm. A) antennae; B) head capsule; C) mandible; D) petiole; E) mesoma; F) leg.*

Fraser Island

In faecal samples from Fraser Island, Coleoptera (88.5%) was the most frequently observed invertebrate group, Dermaptera (53.8%) and Araneae (42.3%) were also frequently observed (Figure 4), whilst insect larvae (3.8%), Blattodea (3.8%) and Gastropoda (3.8%) were only occasionally found.

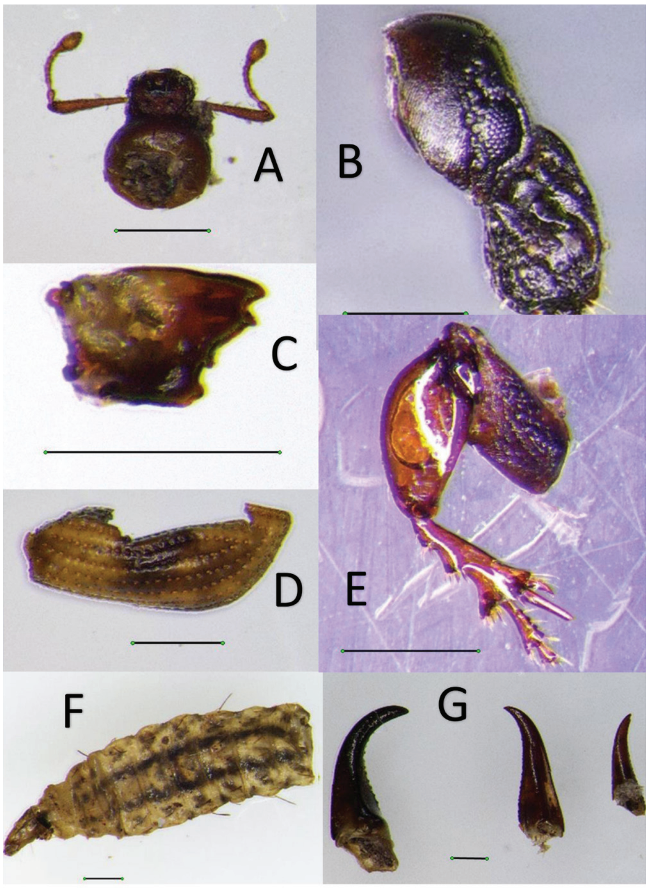

Figure 2. *Insect fragments (other than Formicidae) found in the faeces of T. melanogaster; the horizontal line represents 500 µm. A) head; (Coleoptera: Curculionidae); B) Head (Coleoptera: Curculioniodea); C) mandible, (Isoptera); D) elytron, (Coleoptera); E) leg (Coleoptera); F) larva, (Diptera); G) cerci (Dermaptera).*

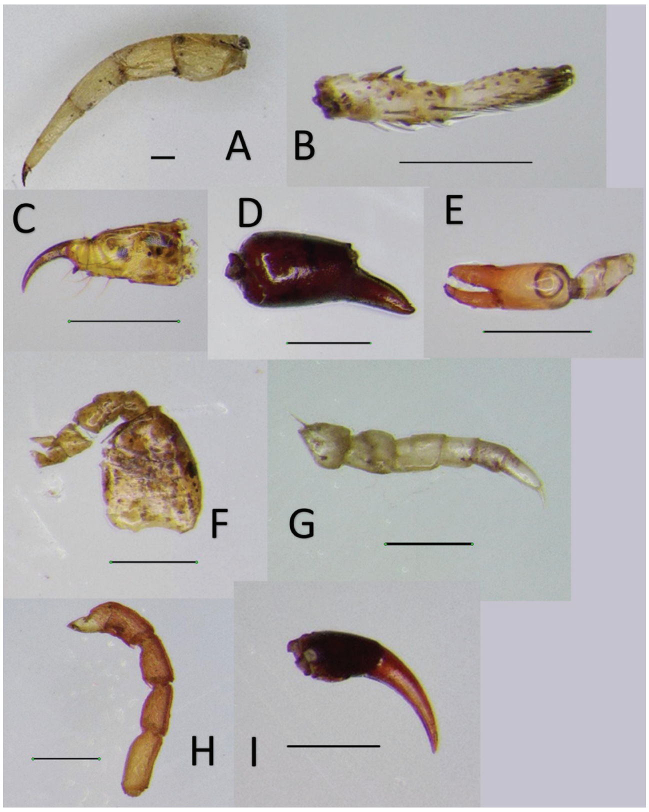

Figure 3. *Figure 3. Arthropod fragments (other than Insecta) found in the faeces of T. melanogaster; the horizontal line represents 500 µm. A) leg (Chilopoda); B) terminal portion of leg (Araneae); C) forcipule (Chilopoda); D) chela with moveable piece separated (Pseudoscorpione); E) chelae (Pseudoscorpione); F) head with one antenna attached (Chilopoda); G) leg (Diplopoda); H) leg (Acari: Trombidiidae); I) fang (Araneae).*

Some Coleopteran fragments were identified as belonging to the family Curculionidae. The invertebrate groups detected in the faeces of *T. melanogaster* on Fraser Island are shown in Figure 4. The samples were dominated by invertebrate remains, which comprised >99% of 13 samples. All faeces contained sand, vegetation (in the form of leaves, roots and other fibrous material) comprised 5-20% of nine samples, and unidentified seeds were present in four and feathers in seven samples.

The abundance of the various invertebrate prey in the environment where faecal sampling took place was reflected in the faeces of *T. melanogaster* (Figure 4). The correlation between the large invertebrates (≥ 2.5 mm) recorded from Fraser Island in the pitfall traps and Tullgren funnels combined and the invertebrates present in the faeces was significant (r = + 0.55, n = 21, $P < 0.01$). The invertebrates found in the faecal samples represented 55% of the large (≥ 2.5 mm) invertebrate diversity recorded on Fraser Island from the pitfall traps and Tullgren funnels.

Coleoptera (present in 88.5% of faecal samples) and Dermaptera (present in 53.8%) were the only two invertebrate groups significantly positively selected by *T. melanogaster* at Fraser Island ($P < 0.05$). The Pearre's Selection Indeces for Coleoptera ($V = 0.208$, $\chi^2 = 5.449$, $P < 0.05$) and Dermaptera ($V = 0.301$, $\chi^2 = 11.445$, $P < 0.01$) were significant (Table 3). Nine groupswere found to be significantly rejected or avoided ($P < 0.05$), namely Diptera, Hemiptera, Hymenoptera (other than Formicidae), Formicidae, Lepidoptera, Orthoptera, unidentified insect larvae, Acari and Isopoda (Table 3). None of these invertebrate groups were present in more than 35% of faecal samples.

Yarraman State Forest

Formicidae (97.4%) were a major component of *T. melanogaster* faeces collected from Yarraman State Forest, being absent from only one faecal sample. Coleoptera (84.2%) and insect larvae (50.0%) were also frequently found in the faeces and Isoptera (5.3%), Blattodea (7.9%) and Acari (7.9%) were occasionally recorded (Figure 5). Insect larvae were recorded in 20 of the 38 faecal samples; of these, 15 were Dipteran larvae belonging to the family Stratiomyidae (Soldier fly) and the remainder were possibly Coleoptera larvae, based on mandible and leg morphology. A leg belonging to an Acari species was identified to the family Trombidiidae (Red velvet mite). Several Coleoptera fragments were identified as being ascribable to the family Curculionidae (weevil). Plant material was infrequent in the Yarraman State Forest faecal samples, being present in only one sample of which it comprised < 2%. The remaining 37 faecal samples contained >99% of the undigested invertebrate material. Feathers were present in 37.5% of faecal samples.

Table 1

Key fragments of invertebrates found in the faeces of T. melanogaster that were used in identification.

Invertebrate group	Structure	Notes
Coleoptera	Elytra	Found as fragments, distinctive microsculpture of stria and strial punctures giving a pitted appearance.
	Legs	Strongly chitinized, variable but usually identifiable structure. Enlarged femur and tibia outer edge often toothed. Basal tarsomes often with tarsal pads, often with two claws.
Coleoptera: Curculionoidae	Head	Frontoclypeal region extended, forming a slender rostrum.
	Antennae	Elbowed antennae - subgeniculate, not to be confused with Formicidae antennae.
Hymenoptera: Formicidae	Head	Distinctive shape, eyes usually present on lateral edges of head. Antennae sockets and frontal carina distinctive, mandibles often absent.
	Mesoma	Variable in shape, sutures between pronotum, mesonotum and propodeum often visible. Leg attachments visible on ventral surface.
	Petiole	Upper surface protruding upwards (node) from attachment to gaster and propodeum. Subpetiolar process may be present.
	Leg	Comprises five segments: coxa, trochanter, femur, tibia and tarsus. Femur and tibia elongated. Tibial spur often present between junction of tibia and tarsus. Tarsus consists of five segments ending in claws.
	Antennae	Elbowed antennae, consisting of longer section - scape, and many shorter sections - funiculus.
	Mandibles	Highly variable, but typically consists of outer margin (smooth), masticatory margin (serrated edge created by teeth and denticels), basal angle and basal margin.
Diptera: Stratiomyidae	Larva	Elongated, flattened with obvious protruding head, and shagreen integument.
Chilopoda	Legs	Only five distal segments of leg recorded; trochanter, femur, tibia, tarsus and pretarsus. Entire structure was faint orange in coloration.
	Forcipules	Modified leg with distinctive shape. Tarsungulum curved and ending in sharp point and usually darker than other structures. Denticle present, folds between tarsungulum, tibia, femur and trochanter-prefemur evident.
Diplopoda	Leg	Segments of leg mostly of similar length though decreasing in width towards the terminal segment. Eight distinct section; coxa, trochanter, prefemur, femur, postfemur, tibia, tarsus and claw.
	Tergite	Usually broken and incomplete, however complete segments consisting of dorsal and ventral tergites were found forming a distinctive ring structure.
Isoptera	Mandible	Always found detached from head. Strongly sclerotised distinctive shape and arrangement of teeth.
Araneae	Legs	Always found in fragments. Surface is covered in fine and thick bristle-like hairs. Most distinctive were two claws at the terminal portion of the tarsus. Leg segments were straight-sided and not tapered at joints as in other arthropods.
	Fang	Found separated from remainder of chelicera. Curved structure leading to sharp point.
Acari: Trombidiidae	Leg	Covered in fine red setae. Legs with seven segments; coxa, trochanter, femur, genu, tibia and tarsus. Tip of tarsus (ambulacrum) rounded.
Blattodea	Head	Usually a triangular shape. Deep antenna sockets rostral to compound eyes. 'Y'-shaped ecdysial lines between eyes terminating in ocelliform spot.
Dermaptera	Cerci (forceps)	Smooth outer (convex) edge and serrated inner (concave) edge. Distinctive articulative groove on dorsal surface where cercus attaches to abdomen, triangular cross-section pointing dorsally.
Pseudoscorpiones	Chelae	Found entire or with moveable finger separated. Inside margin of fingers with many minute teeth. Specimens in this study were an orange or red colour.
Snail	Shell	Small fragment of shell. Distinctive shape and concentric spiralling structure.

Table 2

The size (total length (mm)) of various prey items found in the faeces of T. melanogaster.

Prey Item	Total length (mm)
Coleoptera	7.5
Curculionidae	9.1, 10
Formicidae	2.2, 2.7
Pseudoscorpiones	3, 6.2
Gastropoda	0.68

The abundance of invertebrate prey items collected in the environment where faecal sampling took place was again reflected in the faeces of *T. melanogaster* (Figure 5). The correlation between the large invertebrates (≥2.5 mm) collected at Yarraman State Forest and the invertebrates present in the faeces was significant ($r = +0.77$, $n = 24$, $P < 0.001$). The invertebrate groups identified in the faeces represented 52% of the large invertebrate (≥2.5 mm) diversity recorded at the site from pitfall traps and Tullgren funnels.

Dermaptera (present in 28.9% of faecal samples) and Pseudoscorpiones (in 13.2%) were the only invertebrate groups that were significantly positively selected ($P < 0.01$) by *T. melanogaster* at Yarraman State Forest. Pearre's selection

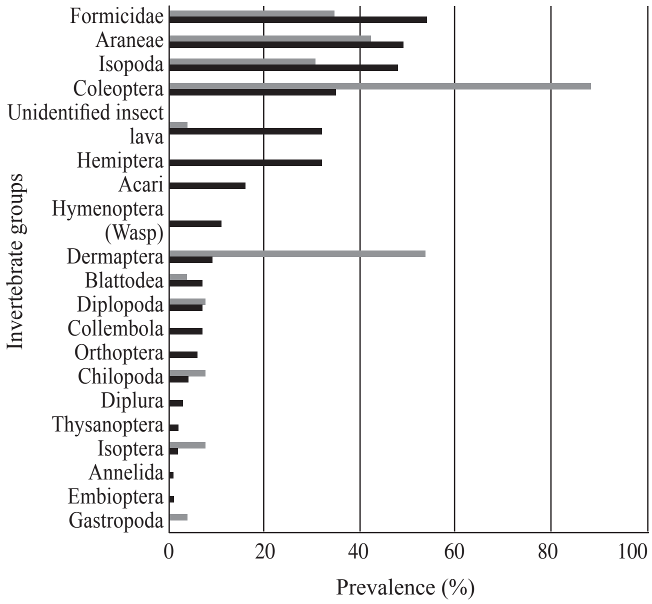

Figure 4. *The prevalence of invertebrates (%) (dark) collected on Fraser Island compared with that found in the faeces of T. melanogaster (light) at the same location.*

Table 3

Pearre's index for prey selection of T. melanogaster on Fraser Island, where the highlighting indicates statistical significance at P < 0.05.

Invertebrate Groups	Pearre's Index (*V*)	Chi Square (χ2)	*P*
Blattodea	-0.077	0.742	0.39
Coleoptera	0.208	5.449	0.02
Collembola	-0.195	4.801	0.03
Dermaptera	0.301	11.45	<0.01
Diplura	-0.129	2.113	0.15
Diptera	-0.228	6.545	0.01
Embioptera	-0.076	0.720	0.40
Hemiptera	-0.379	18.12	<0.01
Hymenoptera (other than Formicidae)	-0.238	7.128	0.01
Hymenoptera (Formicidae)	-0.205	5.295	0.02
Isoptera	0.120	1.812	0.18
Lepidoptera	-0.228	6.545	0.01
Orthoptera	-0.194	4.725	0.03
Thysanoptera	-0.106	1.424	0.23
Unidentified insect larvae	-0.402	20.33	<0.01
Unidentified insects	-0.076	0.720	0.40
Acari	-0.282	10.02	<0.01
Araneae	-0.067	0.557	0.46
Chilopoda	0.066	0.544	0.46
Diplopoda	0.005	0.003	0.96
Isopoda	-0.179	4.049	0.04

indeces for Dermaptera (V = 0.194, χ^2 = 7.472, P < 0.01) and Pseudoscorpiones (V = 0.179, χ^2 = 6.487, P < 0.01) were both significant. (Table 4). Nine invertebrate groups were significantly rejected or avoided (P < 0.05), namely Blattodea, Collembola, Diplura, Diptera, Hemiptera, Hymenoptera (other than Formicidae), Lepidoptera, Orthoptera and Araneae (Table 4).

Table 4

The Pearre's index for prey selection by T. melanogaster at Yarraman State Forest determined from faecal samples. Highlighted values were statistically significant (P < 0.05).

Invertebrate Groups	Pearre's Index (*V*)	Chi Square (χ2)	*P*
Archaeognatha	-0.075	1.242	0.27
Blattodea	-0.216	10.61	<0.01
Coleoptera	0.111	1.268	0.26
Collembola	-0.386	33.06	<0.01
Dermaptera	0.194	7.472	0.01
Diplura	-0.148	4.839	0.03
Diptera	-0.359	28.64	<0.01
Embioptera	-0.105	2.455	0.12
Hemiptera	-0.310	21.36	<0.01
Hymenoptera (other than Formicidae)	-0.203	9.166	<0.01
Hymenoptera (Formicidae)	0.035	0.305	0.58
Isoptera	-0.044	0.502	0.48
Lepidoptera	-0.320	22.77	<0.01
Orthoptera	-0.147	4.796	0.03
Psocoptera	-0.105	2.455	0.12
Thysanoptera	-0.091	1.852	0.17
Unidentified insect larva	-0.043	0.579	0.45
Unidentified insect	-0.117	3.051	0.08
Acari	-0.023	0.170	0.68
Araneae	-0.223	11.39	<0.01
Pseudoscorpiones	0.179	6.487	0.01
Scorpiones	-0.075	1.242	0.27
Chilopoda	0.105	2.031	0.15
Diplopoda	0.101	1.731	0.19
Isopoda	-0.122	3.510	0.06

DISCUSSION

Thirteen invertebrate groups were identified in *T. melanogaster* faeces at Yarraman State Forest and Fraser Island. Previously, wild *T. melanogaster* have been documented as preying upon Aranae, Formicidae, Chilopoda, Diplopoda, Coleoptera and Gastropoda (McConnell and Hobson 1995). Captive colonies are frequently fed live invertebrates, including Coleoptera, Dermaptera, Orthoptera and Isopoda (Roulston 1992). The current study extends the known diet of *T. melanogaster* to comprise the following invertebrate groups: Acari, Araneae, Blattodea, Chilopoda, Coleoptera, Dermaptera, Diplopoda, Diptera (larvae), Formicidae, Gastropoda, Isopoda, Isoptera and Pseudoscorpiones.

The size of the original prey items was estimated from some of the fragments found in the faeces. Coleoptera were the largest prey detected, with a specimen estimated to be 10 mm long. Large Pseudoscorpiones up to 6.2 mm were also found, but there was evidence of small invertebrate prey items in the diet. A single Formicidae fragment was judged to be equivalent to a 2.2 mm invertebrate and we also found a Gastropod shell as small as 0.68 mm. The size of some prey items in the faecal samples indicated that most of the diet may comprise small invertebrates of <10 mm.

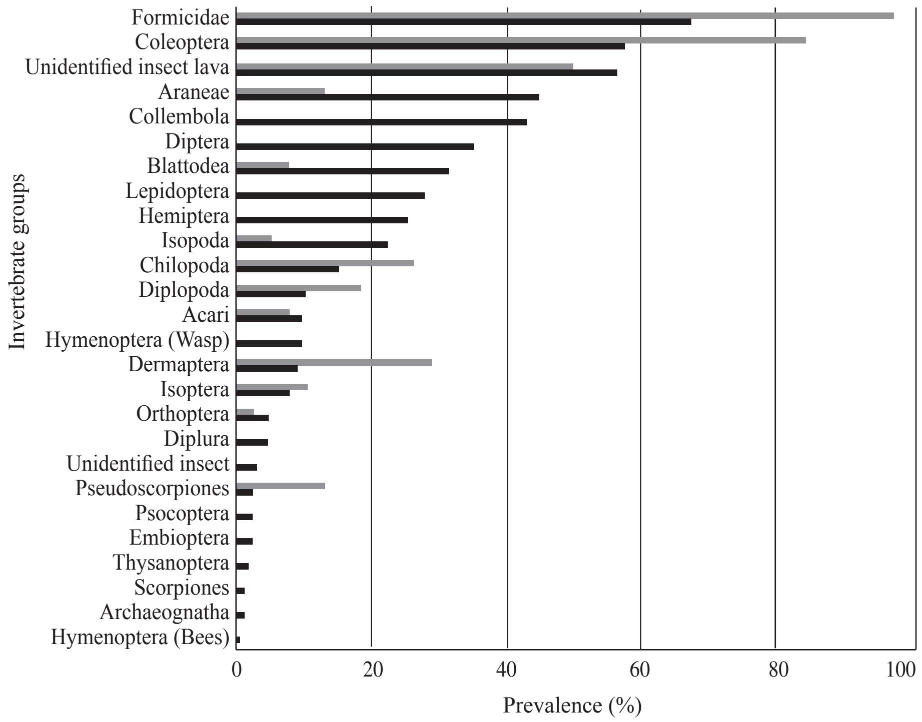

Figure 5. *The prevalence of invertebrates (%) (dark) collected at Yarraman State Forest compared with that found in the faeces of T. melanogaster (light) at the same location.*

Coleoptera, Formicidae and Dermaptera were consistently recorded in the faeces of *T. melanogaster* at both study locations, whilst other arthropods, such as Araneae and unidentified insect larvae, were moderately common. It is evident from this study that *T. melanogaster* are, or at least appear to be, generalist insectivores and are not discriminatory in their diet selection. This would suggest that they are not restricted by any one food resource. The species does, however, appear to be a specialist in its foraging style; the creation of platelets restricts it to invertebrate prey which can be found in the leaf litter or at the soil surface. Apparently, dietary preference does not limit the distribution of *T. melanogaster,* but prey availability might. As the invertebrate prey items were found in leaf litter, it is reasonable to suggest that the presence and type of leaf litter is a vital habitat requirement of *T. melanogaster*.

At both locations surveyed, the invertebrates recorded in the environment were reflected in those found in the faeces in terms of diversity and relative abundance. At Fraser Island 55% of the large invertebrate (≥2.5 mm) diversity recorded in the environment was also recorded in *T. melanogaster* faeces, and at Yarraman State Forest the corresponding figure was 52%. The abundance of invertebrate groups in the faeces was significantly correlated with that in the environment, suggesting that *T. melanogaster* utilise a large proportion of the invertebrate food resources in their environment.

Pearre's Selection Index indicated that *T. melanogaster* were preferentially preying upon certain invertebrate groups and rejecting others. At both locations, there was positive selection for Dermaptera, whilst at Yarraman State Forest *T. melanogaster* positively selected Pseudoscorpiones and at Fraser Island there was positive selection for Coleoptera. At both locations, there was significant rejection or avoidance of both adult Lepidoptera and Diptera, although Dipteran larvae were recorded in the faeces. Both Lepidoptera and Diptera are known to be attracted to the ethylene glycol preservative used in the pitfall traps (Robacker and Czokajlo 2006; Ni *et al*. 2008); this provides an explanation for the abundance of these insects in the pitfall samples, which contrasts with their absence from the faecal samples. Other invertebrate groups are potentially similarly attracted to the preservative, creating a bias in the pitfall method of assessing invertebrate diversity and abundance in the environment. This would alter Pearre's Selection Index, as the invertebrates trapped would appear more available to *T. melanogaster* than they normally are in the leaf litter.

The analysis of *T. melanogaster* faeces provides conclusive evidence of their predation on invertebrates: very little was observed to suggest that plant material constitutes a significant part of their diet as suggested by Marchant and Higgins (1995). However, some seed remains were recorded in the faeces, indicating that at times the diet is omnivorous, although the volume of such remains and/or other plant material in the diet appeared minimal. Faeces collected from Yarraman State Forest overwhelmingly comprised invertebrate material; only one faecal sample contained (a minimal amount of) plant material. The absence of plant material in these samples indicates that *T. melanogaster* in this region were insectivorous. However, more plant material was found in the faecal samples from Fraser Island; 34% contained 5-20% plant material in the form of rootlets and leaf fragments, and there was evidence of seeds in 15% of the samples. Plant material could potentially have been ingested while capturing invertebrates, or it may have been picked up with the faeces by the researchers upon collection, as it was noted during the collection of faeces that small pieces of dirt and plant material from the substrate were attached to the outside of damp faeces. This was seen more frequently at Fraser

Island, as the leaf litter layer was deeper and therefore the faeces were on a layer of decaying vegetation; this contrasted with faecal samples at Yarraman State forest which were on bare soil. The feather barbs present in about half of the faeces from both sites were probably the result of the bird ingesting fragments of feather during preening.

Limitations

There are limitations in this research. In describing a bird's diet from faecal analysis, it should be noted that there will be a bias toward prey items which are resistant to digestion (Calver and Wooller 1982; Jenni *et al*. 1990), such as Coleoptera. This may lead to an over-representation of such prey items and an under-representation of others, such as Isoptera, which have a soft integument and are therefore easily digested. This study was also performed in the some of the warmer months of the year (September-November) when rainfall was prevalent. Thus there is a possibility that the study occurred during a seasonal increase in invertebrate activity, as rainfall is a factor in the increase in abundance and diversity of invertebrate species (Gullan *et al*. 2010). The diet of *T. melanogaster* may be different in the cooler months of the year when insect activity is lower, and consequently seasonal patterns of invertebrate activity would be worth investigating to assess whether the *T. melanogaster's* diet varies during the year.

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