

# THE PYRALOIDEA OF EUNGELLA: A MOTH FAUNA IN ITS ELEVATIONAL AND DISTRIBUTIONAL CONTEXT

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An intensive, two-season survey of moths along an elevational transect from 200 to 1200 m above sea level was an integral part of the recent Eungella biodiversity survey. The overall results have been published elsewhere. In this paper we examine in finer detail the patterns of distribution and faunistics of one of the dominant taxa from that dataset. The Pyraloidea comprise two families of so-called micro-moths, the Pyralidae and the Crambidae. Overall we sampled more than 7000 individuals of more than 100 species. In spring these were principally in the lowland sites, but the summer samples were more evenly spread across elevations. In both seasons characteristic upland and lowland assemblages were apparent, separating at about 700 m above sea level. These elevational patterns were driven statistically by a small group of abundant species. Focusing on the Pyraustinae-Spilomelinae clade (91 species in our samples) and comparing them with samples from other Australian rainforest locations suggests that the Eungella forests represent the southernmost limits for 24 species, and the northern limits for five species. In other cases, the species is known from sites both north and south of Eungella.

Keywords: Pyraloidea, Spilomelinae/Pyraustinae, Eungella, elevation, distribution

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## INTRODUCTION

The Lepidoptera, the butterflies and moths, are predominantly herbivorous and, within all 'green' ecosystems, play an important role in connecting the primary producing plants to the superimposed animal food-web, principally through the consuming activities of their larvae. Estimates vary, but there may be close to a million species within the Order, most of which are night-flying moths. As a group, the moths are ideal for comparative studies that aim to examine changes in community structure across ecological gradients such as latitude or elevation. The moths are highly speciose in most locations; are readily sampled using light traps; and are relatively well known taxonomically (although large gaps in our knowledge remain).

For all of these reasons, they were one of the focal groups targeted in the recent Eungella biodiversity survey (Ashton *et al.*, this volume). Specifically, we sampled all moths with a forewing length of 1 cm or more, plus additional smaller members of selected families (including the Crambidae and Pyralidae). An analysis of the results for this entire fauna has been presented by Odell *et al.* (2016). These authors found a

clear demarcation between moth assemblages at 800 m above sea level and higher, compared with those at lower elevations (see 'Methods' below) for both spring (November) and late summer (March) samples. The samples collected over two seasons were dominated by four groups of species within the Order – the families Erebidae, Geometridae and Noctuidae, together with the superfamily Pyraloidea. Together, these four taxa (comprising five families) made up 65% of the spring samples and 76% of the late summer catches. In each case the Pyraloidea, *viz.* the families Crambidae and Pyralidae, were the most abundant taxon in both seasons (26% of all moths collected in spring, 35% in late summer) (Figures calculated from Odell *et al.*'s (2016) Table 2).

The Odell *et al.* (2016) analysis further nominated 'indicator species' based on an IndVal analysis (Dufrene & Legendre, 1997) which identifies species that are both restricted to and occur consistently within particular elevational bands. Of particular interest in the present context was the identification of nine species of Pyraloidea among the 23 species' 'predictor set' (*sensu* Kitching & Ashton, 2013) across the two seasons sampled.

For these reasons as well as their intrinsic ecological interest, we have chosen to analyse the catches of Pyraloidea (Pyralidae and Crambidae) in more detail in this paper. We further compare the species distributions of two of the major subfamilies within the Crambidae (Pyraustinae and Spilomelinae) against similar samples collected by us over seven other north-eastern Australian rainforest localities.

The Pyraloidea represent one of the largest groups within the Lepidoptera. Globally, many species remain undescribed and many of the larger genera are in need of revision. Nevertheless, Munroe & Solis (1999) estimated that there were 16,000 described species and at least as many awaiting attention. These authors also confirmed the two subsumed taxa, the Pyralidae and the Crambidae, as full families (following Minet, 1982).

In Australia, and based on the most recent checklists (Nielsen, Edwards & Rangsi, 1996; <https://biodiversity.org.au/afd/mainchecklist>), the described species within the superfamily represent somewhat more than 1200 species (ca 480 of Pyralidae and ca 770 of Crambidae). This establishes the Pyraloidea as one of the more speciose superfamilies in the Australian lepidopterous fauna. Conventionally designated by collectors as ‘micro’-moths, the pyraloids in general are relatively large as adults (at least compared with other ‘micros’ – although some minute forms are placed within the superfamily). The taxon contains some species of considerable economic importance, including the notorious wax-moth (*Galleria mellonella*), a pest of beehives; the flour moth (*Pyralis farinalis*), a pest of stored grain; as well as a wide range of forest and crop pests (lists in Common, 1990; Nielsen *et al.*, 1996).

In a recent multi-locus DNA-based phylogeny of the superfamily, Regier *et al.* (2012) provided evidence for five subfamilies within the Pyralidae (*s.s.*) and twelve putatively monophyletic subfamilies within the Crambidae. Within the Crambidae, their placing of the Schoenobiinae suggests this subfamily is paraphyletic, associated with the Acentrotinae. Their analyses did not include material from the Cymbalomiinae. In the present context they identified the two subfamilies, the Pyraustinae and the Spilomelinae (designated as the single subfamily Pyraustinae (*s.l.*) by Common (1990) and other earlier authors), as forming a clear isolated clade which they refer to as the ‘PS clade’, which also contains the previously recognised, aberrant subfamily, the Wurthiinae. This clade is sister to all the other Crambidae. This is significant here because we have chosen this clade, by far the most speciose within the superfamily, for more detailed analysis (see below).

In this treatment, then, we address four inter-related questions.

- Do members of the Pyraloidea from the Eungella rainforests form elevation-specific assemblages and, if so, do these reflect the patterns shown by the moth fauna as a whole?
- Are there seasonal differences in elevational patterns shown by the Pyraloidea?
- If there is elevational partitioning, which species are best correlated with the observed patterns?
- How widespread beyond Eungella are members of the dominant subfamilies Pyraustinae and Spilomelinae (the ‘PS clade’) which were encountered?

## METHODS

### *The Eungella Biodiversity Survey*

Details of the study sites and sampling methods have already been presented by Odell *et al.* (2016), and further detail is provided in companion papers (Ashton *et al.*, this volume). Accordingly, summaries only are provided here. The two aforementioned works also contain maps of the sampling sites.

### Eungella National Park

All study sites were located within the rainforest sections of Eungella National Park (21°S, 148°E) and Pelion State Forest located on the Clarke Range some 80 km west of Mackay in central Queensland. Four study plots were established within each of six elevational bands – at 200 m, 400 m, 600 m, 800 m, 1000 m and 1200 m above sea level. In each case, the elevations of plots fell within  $\pm 50$  m of the designated band. Plots were a minimum of 500 m apart. The physical environment of the region and the plots is summarised by Ashton *et al.* (this volume). A 20 × 20 m vegetation reference plot was established at each location, and results from these surveys are in Ashton *et al.* (this volume).

### *Sampling at Eungella*

On two occasions (November 2013 and March 2014), moths were sampled at Eungella using Pennsylvania-style light traps modified for use in rainforest conditions (Kitching *et al.*, 2005). These traps comprise a vertically placed UV-dominant fluorescent tube powered by a 12-volt battery and surrounded by three transparent Perspex vanes. Moths attracted to the light are knocked down by the vanes and collected in a bucket suspended beneath. At each location, traps were hung at both head height and in the canopy

above (after ropes had been suspended there with the aid of a bow and line-throwing arrows). Traps were open all night for three, usually consecutive, nights at each location. Ground and canopy were sampled simultaneously at each location. All moths with a forewing length greater than 1 cm were removed from the catches each day and sorted to 'morphospecies' (i.e. 'species' that exhibited repeatedly recognisable appearances). In the case of the readily recognisable Pyraloidea, any smaller individuals within the samples were also removed and sorted. A reference collection of spread and dried specimens was accumulated during this process.

#### *Analysis of the Eungella Data*

Pyraloid species were extracted from the larger Eungella moth dataset (Odell *et al.*, 2016) to create a 'pyraloid dataset' for each season. This comprised site- and season-specific counts for each morphospecies identified as belonging to either the Pyralidae or Crambidae. Ground and canopy samples were pooled across the three trap nights to form single data points for each site in each season. Counts for each location and season were (log+1) transformed before analysis in order to de-emphasise the few very abundant species (and remove the problem of zero counts for rare species).

Species accumulation curves with associated 95% confidence intervals were generated using the 'vegan' package in R.

Non-metric multidimensional scaling (nMDS) ordinations based on a Bray-Curtis similarity index (Clarke & Gorley, 2006) were calculated using 100 random restarts. Species having the greatest effect on the overall patterns across elevational zones were identified by calculating Pearson's correlation coefficient, selecting species showing values of  $\pm 0.69$  or more (Gerstman, 2003).

#### *Comparative Data*

Earlier studies at other rainforest locations using comparable traps and sampling methodologies have resulted in extensive collections, the data from which are used in this paper to place the Eungella species in their geographical context (at least in terms of our samples). These can be grouped into studies as follows:

##### Cape Tribulation (16.1°S 145.5°E)

Following earlier, more or less casual collecting activities at Cape Tribulation in the 1980s and 1990s, a

one-hectare reference plot was established adjacent to the site of the canopy crane facility in 2000. The vegetation of this site was described by Laidlaw *et al.* (2007). Four light traps were run for four nights within the one hectare during this survey. Considerably later, the canopy crane site itself was the location for a vertically stratified survey in which five traps were disposed at 10 m vertical intervals over a three-week period on two occasions (January and July 2012). Moth data from this survey remain unpublished, but methodological details can be found in the paper by Stork *et al.* (2016) which describes the beetle fauna from the same study.

##### Atherton Tablelands (ca 17.1°S 145.4°E)

The basis for our data from Atherton are the very extensive collections described by Kitching *et al.* (2000), and Orr & Kitching (1999, 2003). That study, based on a survey of 15,600 individual moths (again focusing on macro-moths and Pyraloidea), showed that the quality of rainforest remnants on basalt was reflected in the assemblage structure of the moth species occurring within them. Additional, unpublished surveys were also carried out on other substrate types within the region. Further surveys were made in 2010–2011, assessing the fauna at the 25 ha reference site established by the CSIRO at Robson Creek (17.1°S 145.5°E). Over 1500 moths were collected and sorted over three seasonally contrasting field trips. The tree flora of the Robson Creek site has been described by Bradford *et al.* (2014).

##### Mount Lewis (16.3°S 145.2°E)

Extensive moth surveys were carried out within the forest at Mt Lewis in far northern Queensland in November 2009 and April 2011. As with the Eungella survey, this study established replicated sampling sites along an elevational gradient. A total of 20 sites was assessed on each occasion. A total of 17,200 moths of 1134 species was examined and analysed. The results are presented in Ashton *et al.* (2016).

##### Paluma (18.6°S 146.1°E)

A one-hectare reference plot was established at Paluma in 1999. All trees greater than 5 cm diameter at breast height were surveyed (see Laidlaw *et al.*, 2007) and various insect traps operated over a three-week period. These included four moth traps opened over a three-night period. Only a modest number of moths was collected (<2000 individuals) and the survey was not repeated.

### Tamborine (27.9°S 153.2°E)

As part of a 2017–2018 ‘bioblitz’, moths were sampled within patches of both rainforest and wet sclerophyll vegetation at Thunderbird Park, Mt Tamborine (Kitching *et al.*, in press). Light traps were operated at six sites (three in rainforest, three in wet sclerophyll) on each of two occasions, October 2017 and March 2018. A total of 1726 moths was collected.

### Lamington National Park (28.1°S 153.1°E)/Border Ranges National Park (28.2°S 153.1°E)

Twenty reference sites were established along an elevational gradient at both Lamington National Park and Border Ranges National Park (both located within the McPherson Range straddling the Queensland/NSW border). For each transect, four replicate sites were established at each 200 m elevational band from 300 m asl to 1100 m asl. The same protocol as was applied at Eungella was carried out at both these locations: indeed, the protocol applied at Eungella was consciously based on these earlier surveys (and that at Mt Lewis). At Lamington, the sites were surveyed for moths in October 2006 and March 2007, resulting in an assessment of 11,300 individuals of 860+ species (Kitching *et al.*, 2011; Ashton *et al.*, 2011). The Border Ranges transect was sampled in April and November 2010, resulting in catches of 40,850 individuals of 612 species (Ashton *et al.*, 2016).

All reference collections either have been or will be deposited in the Queensland Museum.

### Identification

An attempt has been made to identify all members of the Pyraustinae and Spilomelinae from our samples to the species level based on their phenotypes (i.e. without genitalic dissections or molecular barcoding). This is a challenging task in the absence of illustrated monographs. Fortunately, virtually all named species and those identified but not yet formally named within the incomparable Australian National Insect Collection (ANIC) have been barcoded and the results uploaded to the international BOLD website (<http://www.boldsystems.org/>). This procedure requires that a photograph of each specimen so analysed accompany the on-line molecular data. This resource, in principle, allows almost all known species to be identified by comparison with the photographs, although this remains an arduous and painstaking task. The additional websites maintained by Don Herbison-Evans and Stella Crossley (<http://lepidoptera.butterflyhouse.com.au/>) and that associated with the ANIC itself ([\[amo.ala.org.au/\]\(http://amo.ala.org.au/\)\) are also very useful. Those species in our Eungella collections which also occurred in our early studies on the Atherton Tablelands had been identified by one of us \(AGO\) by direct comparison with the ANIC collection \(see Orr & Kitching, 1999, 2003\). Some genera, notably \*Nacoleia\* and \*Metasia\* within the Spilomelinae, await much needed revision and present particular challenges and uncertainties in identification.](http://</a></p>
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## RESULTS AND DISCUSSION

Table 1 summarises the number of specimens of Pyraloidea encountered at each elevation in the two seasons sampled, with the percentage that each catch represented of the entire moth sample encountered. A total of 2488 pyraloids was sampled in the spring (November), representing 24.7% of our entire sample. Pyraloids were more dominant in the lowland samples (almost 50% of moths encountered at the lowest (200 m) sites) but still represented an eighth of all moths encountered, even at the 1200 m sites. For the late summer (April) samples, 4831 pyraloids were sorted, representing more than 35% of all moths in our surveys. In contrast to the spring samples, numbers were more evenly spread across elevations.

TABLE 1. Numbers (and percentages) of Pyraloidea in spring (November) and late summer (March) samples.

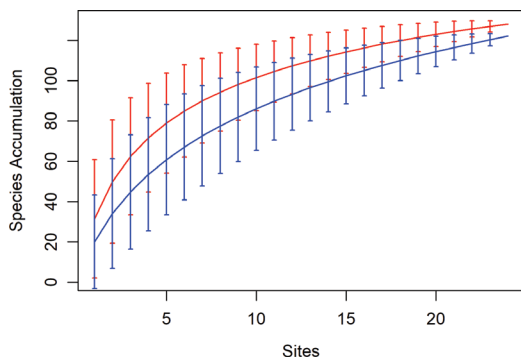
Elevation (m above sea level)	Spring samples	Summer samples
200	789 (49.5%)	728 (44.7%)
400	743 (40.3%)	1065 (44.1%)
600	338 (26.9%)	1223 (43.9%)
800	228 (8.4%)	896 (23.5%)
1000	255 (16.4%)	407 (26.7%)
1200	135 (12.5%)	512 (32.3%)
<b>Overall</b>	<b>2488 (24.7%)</b>	<b>4831 (35.2%)</b>

### *Species Accumulation Curves and Estimated Species Richness*

Figure 1 shows the discovery curves for each of the two seasons' sampling, with associated 95% confidence estimates. In neither case did the curves reach an asymptote, suggesting more species remained to be found. Nevertheless, both showed ‘healthy’ declines in acceleration, indicating that our samples were adequate for the proposed analyses. The curve

for both samples suggests a total richness of something over 130 species.

FIGURE 1. Species accumulation curves for spring (blue) and summer (red) samples for the Pyraloidea sampled at Eungella.



#### Patterns in the Assemblages of Pyraloidea

Figures 2a and 2b show the results of the multidimensional scaling analysis of the pyraloids sampled in spring (2a) and late summer (2b), respectively. Both ordinations show highly significant deviations from random admixture, and both show fundamentally similar patterns. In both spring and late summer, there are distinct assemblages of moth species indicated for both the lower and higher elevations, separating between about the 600–800 m elevations. In the spring (November) data, this distinction is very clear. With a few exceptions, the data points from each elevation cluster together and trend across the ordination plot. Whether this is due to the inevitably greater spatial proximity on the ground of the sites from the same elevational band, or is a real ecological pattern, is moot. Nevertheless, the clear lowland/upland distinction transcends these issues and we accept it as ecologically real. For the late summer (March) results, the lowland/upland separation is also clear, but one 800 m site blurs the clear distinction between lowland and upland.

Although the overall patterns shown by the pyraloid fauna were similar across the two seasons that we sampled, the particular species most highly correlated with these patterns differed except in one case.

#### Species That Correlate Strongly with the Overall Pattern

Table 2 lists those species for which patterns of occurrence correlated most strongly with the overall pattern for the super-family. Figures 3 and 4 show the patterns of occurrence for these species across the elevations

sampled. For the spring samples, five species showed correlation coefficients higher than 0.69; for the late summer samples, four species met this criterion.

For the spring assemblage, four of the five highly correlated species were Crambidae-Spilomelinae, with the fifth being an acenotropine (also Crambidae). Three of the five species are Australian endemics, with *Margaresticha sphenotis* and *Tetridia caletoralis* having widespread tropical Old World distributions. Figure 3a–e illustrates the abundances levels of each of these species at each of the elevations sampled. Three of the five species (Figures 3a, 3b & 3c) show that the species concerned were clearly associated with lowland sites. *Heterogramma holophaea* (Figure 3d) and *Nacoleia glageropa* (Figure 3e) occurred across all elevations but favoured higher (*N. glageropa*) and lower (*H. holophaea*) sites, respectively.

FIGURE 2. Visualisation of the data on Pyraloidea abundances using non-metric multidimensional scaling following calculation of Bray-Curtis similarities: (a) spring samples (November 2013); (b) late summer samples (March 2014).

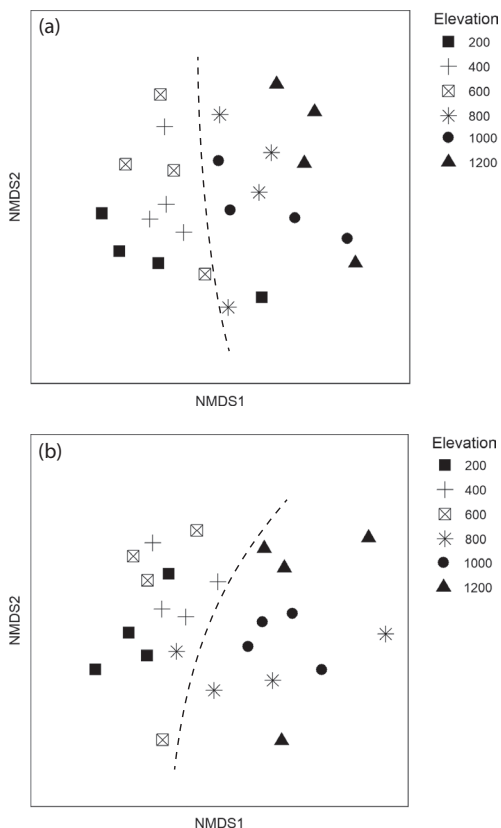
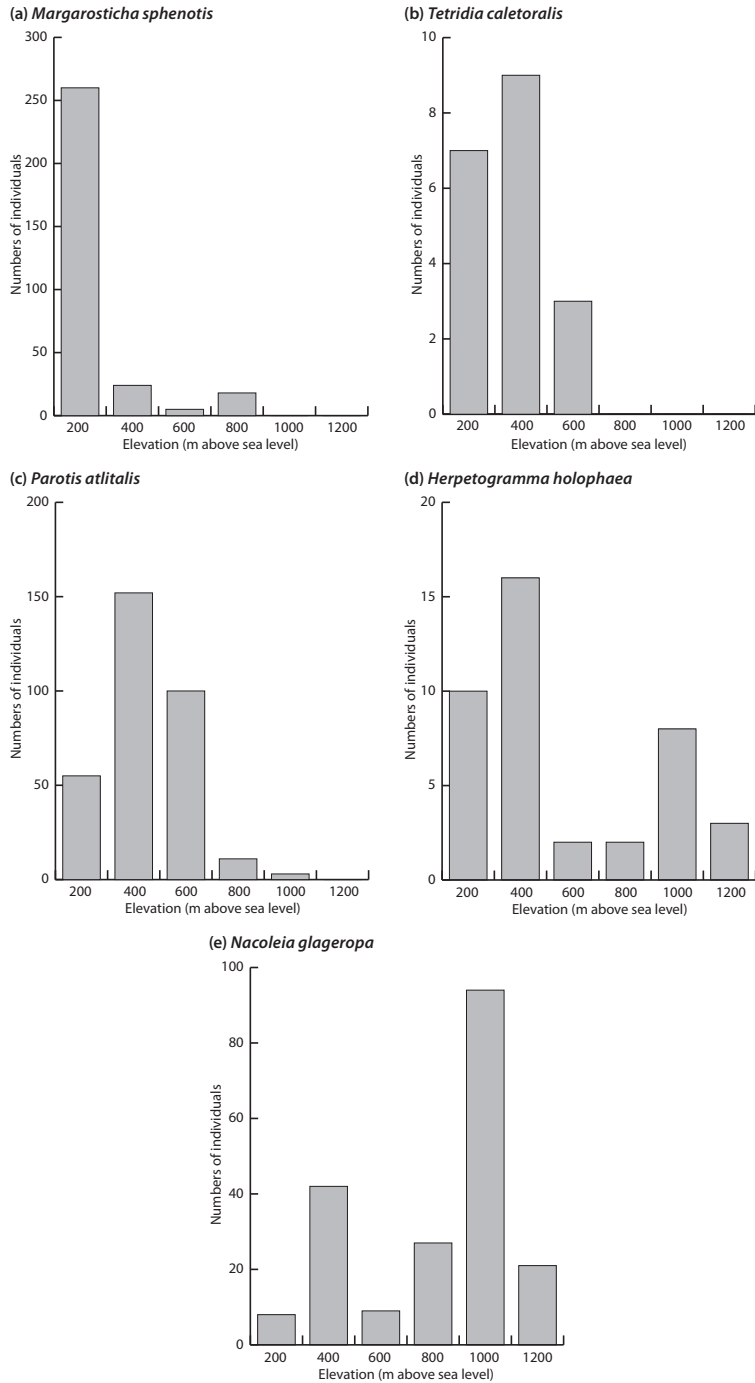


FIGURE 3. Species from the spring survey at Eungella National Park and Pelion State Forest, Queensland, that show a Pearson correlation with the overall ordination results  $>0.69$ : (a) *Margarosticha sphenotis* (Crambidae: Acentropinae); (b) *Tetridia caletoralis* (Crambidae: Spilomelinae); (c) *Parotis atlitalis* (Crambidae: Spilomelinae); (d) *Herpetogramma holophaea* (Crambidae: Spilomelinae); (e) *Nacoleia glageropa* (Crambidae: Spilomelinae).



In the late summer samples, of the four species that correlated highly with the overall pattern (Figure 4), three are spilomelines with the fourth a pyraline pyralid. *Camptomastix hisbonalis* is widely distributed beyond Australia. *Nacoleia glageropa* is only known from Australia. The pyralid, *Endotricha pyrrhocosma*, is known from Queensland and Papua New Guinea. The distribution of *Palpita austrannulata* in Australia is hard to ascertain, as this species was separated from the widely distributed *P. annulata* relatively recently (Inoue, 1996) and many earlier records are under the old name. Figure 4a–d illustrates the abundances of these four species across elevations. All were found at each of the elevations but showed clear preferences. *Endotricha pyrrhocosma* (Figure 4a) favoured

mid-elevations (400–600 m). *Palpita austrannulata* (Figure 4d) favoured the lower elevations. *Nacoleia glageropa* (Figure 4c) and *Camptomastix hisbonalis* (Figure 4e) favoured the higher elevations.

The patterns shown in Figures 3 and 4 inevitably reflect relative abundance as well as elevational preferences. The differences between the two seasons suggest that as the warmer, wetter summer progresses, so some species expand their populations to exploit the more mesic conditions. Only *Nacoleia glageropa* appeared to show preferences for higher elevations in both seasons. At all other locations at which we have encountered this species (from Lamington to the Atherton Tablelands, see Table 3), it has been at upland sites.

FIGURE 4. Species from the late summer survey at Eungella National Park and Pelion State Forest, Queensland, that show a Pearson correlation with the overall ordination results  $>0.69$ : (a) *Palpita austrannulatus* (Crambidae: Spilomelinae); (b) *Endotricha pyrrhocosma* (Pyralidae: Pyralinae); (c) *Nacoleia glageropa* (Crambidae: Spilomelinae); (d) *Camptomastix hisbonalis* (Crambidae: Spilomelinae).

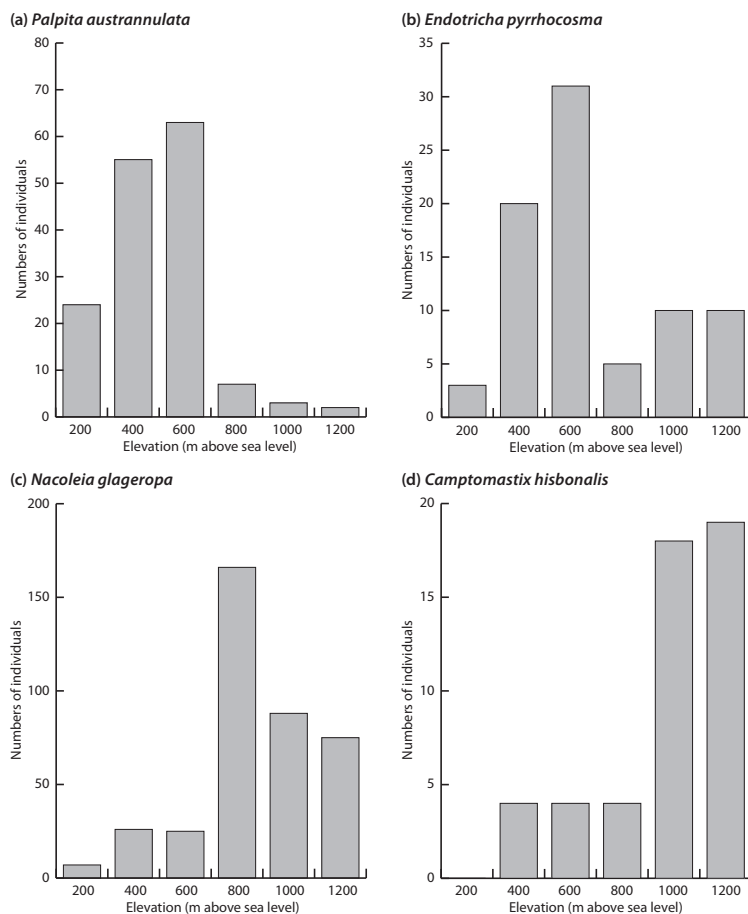


TABLE 2. Pyraloid moth species from Eungella National Park that correlated highly (Pearson's  $r > 0.69$ ) with the assemblage pattern shown by either MDS Axis1 or MDS Axis2 for the ordination of the entire pyraloid assemblage.

Species	Family-subfamily	Pearson correlation	Biological notes
SPRING SAMPLES			
<i>Margarosticha sphenotis</i>	Crambidae-Acentropinae	0.75	Aquatic larvae. Restricted to Australia (NSW, NT, QLD).
<i>Tetridia caletoralis</i>	Crambidae-Spilomelinae	0.69	Food-plants unknown in Australia, recorded from Dipterocarpaceae in Asia. Distributed from India and China to Queensland.
<i>Parotis atlitalis</i>	Crambidae-Spilomelinae	0.84	Larvae feed on <i>Glochidion</i> (Euphorbiaceae). Distributed from SE Asia to New South Wales.
<i>Herpetogramma holophaea</i>	Crambidae-Spilomelinae	-0.77	No food-plants known. Restricted to Australia (QLD).
<i>Nacoleia glageropa</i>	Crambidae-Spilomelinae	-0.76	No food-plants known. Restricted to Australia (QLD, NSW).
LATE SUMMER SAMPLES			
<i>Palpita austrannulata</i>	Crambidae-Spilomelinae	0.86	No food-plants known. Separated from widely distributed <i>annulata</i> by Inoue (1996).
<i>Endotricha pyrrhocosma</i>	Pyralidae-Pyralinae	-0.85	No food-plants known. Restricted to Queensland and PNG.
<i>Nacoleia glageropa</i>	Crambidae-Spilomelinae	-0.85	No food-plants known. Restricted to Australia (QLD, NSW).
<i>Camptomastix hisbonalis</i>	Crambidae-Spilomelinae	-0.78	No food-plants known. Widely distributed in eastern Asia. In Australia recorded from New South Wales and Queensland.

*The Pyraustinae-Spilomelinae (P-S) Clade at Eungella and its Biogeographical Context*

Table 3 lists those members of the Pyraustinae-Spilomelinae clade (*sensu* Regier *et al.*, 2012) identified from our Eungella samples. It further indicates which of these species were encountered in our various other studies at rainforest sites in Queensland (plus Border Ranges NP, NSW). It must be emphasised that this comparison (Columns 3–10) is based *only* on our collections. Further, many other species within the clade were encountered at sites other than Eungella; this table is solely an attempt to put the Eungella species into their broader context. Full results on the other sites will be published elsewhere. The final two columns indicate the broader distribution recorded for these species in Australia and beyond. These have been constructed using the databases available in *The Atlas of Living Australia* (<https://www.ala.org.au/>) and the BOLD website alluded to earlier (<http://www.boldsystems.org/>).

A total of 91 species of the P-S clade of Crambidae has been identified in our samples from Eungella.

In itself this is remarkable, representing about 20% of the described Australian fauna. Of these 91, 28 species occurred, in addition, in our samples from both north and south of Eungella. Forty of the species occurred in our samples only from sites to the north of Eungella, and eight exclusively from more southerly sites. Finally, fifteen of the species encountered were unique to Eungella. We stress again that these patterns are based solely on our collections over the last two decades. With respect to the data from within Australia, however, we note that the sites we have examined to the south of Eungella have essentially all been in the same extended Border Ranges Massif and its outliers (Mt Tamborine, Lamington NP and Border Ranges NP). In contrast, the more northerly sites that we examined (Cape Tribulation, Mt Lewis, the Atherton Tablelands and Paluma) represent several rainforest isolates. There are small rainforest patches between Eungella and south-eastern Queensland: Kroombit Tops and the Conondale Ranges come to mind. The moth fauna of these locations awaits attention.



TABLE 3. Pyraustinae and Spilomelinae encountered in the Eungella Biodiversity Survey.  
 Note: Records in Columns 3–10 are based on presence or absence and ONLY on surveys by the Kitching Laboratory (see text).  
 Asterisked designations correspond to those in the BOLD database (see text).

GENUS	SPECIES	EUNGELLA	LAMINGTON	BORDER RANGES	TAMBORINE	PALUMA	ATHERTON TABLELANDS	MT LEWIS	CAPE TRIBULATION	PREVIOUS KNOWN AUSTRALIAN DISTRIBUTION (collated from <i>Atlas of Living Australia</i> and BOLD database)	KNOWN WIDER DISTRIBUTION (collated from BOLD database)
<b>Pyraustinae</b>											
<i>Ebulea</i>	<i>epicroca</i>	■								SE Queensland	none
<i>Hyalobathra</i>	<i>minosalis</i>	■			■		■			Sunshine Coast to Cape York	none
<i>Hyalobathra</i>	<i>crenulata</i>	■			■					QLD/NSW Border to Cape York	none
<i>Uresiphita</i>	<i>ornithopteralis</i>	■		■			■			Throughout; Norfolk Island	none
<b>Spilomelinae</b>											
<i>Aethaloessa</i>	<i>calidalis</i>	■					■			SE Queensland to Cape York	East & SE Asia; Pacific
<i>Agathodes</i>	<i>paliscia</i>	■								SE Queensland; Western Australia	none
<i>Agrioglypta</i>	<i>eurytusalis</i>	■						■	■	Cairns region	Tropical & subtropical Asia
<i>Agrioglypta</i>	<i>zelimalis</i>	■						■	■	Sunshine Coast to Cape York	Tropical Asia; New Caledonia
<i>Agrioglypta</i>	<i>itysalis</i>	■						■	■	Far northern Queensland	Tropical Asia
<i>Agrioglypta</i>	<i>excelesalis</i>	■						■	■	Cape York	Tropical Asia
<i>Analyta</i>	<i>apicalis</i>	■						■	■	Cape York	India; Sri Lanka; Taiwan
<i>Archernis</i>	<i>callixantha</i>	■						■	■	Southern NSW to Townsville	New Guinea
<i>Arthrochista</i>	<i>hilaralis</i>	■						■	■	SE Queensland to Cairns	East & SE Asia
<i>Ategumia</i>	<i>adipalpis</i>	■								SE Queensland	India; China; Japan; SE Asia
<i>Bradina</i>	<i>mannusalis</i>	■								SE Queensland	none
<i>Camptomastix</i>	<i>hisbonalis</i>	■								SE Queensland	China to PNG

GENUS	SPECIES	EUNGELLA	LAMINGTON	BORDER RANGES	TAMBORINE	PALUMA	ATHERTON TABLELANDS	MT LEWIS	CAPE TRIBULATION	PREVIOUS KNOWN AUSTRALIAN DISTRIBUTION (collated from <i>Atlas of Living Australia</i> and BOLD database)	KNOWN WIDER DISTRIBUTION (collated from BOLD database)
<i>Chabula</i>	<i>acamavelsis</i>									SE Queensland	Tropical and subtropical Asia
<i>Cirrhoerista</i>	<i>brizoalis</i>									Coastal: All Queensland	India to Taiwan; SE Asia; New Guinea
<i>Cirrhoerista</i>	<i>aetherialis</i>									Central to far northern Queensland	none
<i>Cnaphalocrocis</i>	<i>medinalis</i>									Central NSW to NT	East & SE Asia; a widespread pest
<i>Cnaphalocrocis</i>	<i>bilinealis</i>									SE Queensland to Cape York	Africa; China; Sri Lanka; SE Asia
<i>Conogethes</i>	<i>punctiferalis</i>									Adelaide; southern NSW to Kimberleys	Indian subcontinent; SE Asia; pest of fruit
<i>Conogethes</i>	<i>haemactalis</i>									Northern NSW to Cape York	no information
<i>Conogethes</i>	<i>pluto</i>									Coastal: SE Queensland to NT	SE Asia; Solomons
<i>Cotachena</i>	<i>histricalis</i>									Tropical Queensland	Indonesia; Solomons; New Guinea
<i>Cotachena</i>	<i>altensis</i>									Far northern Queensland	Solomons
<i>Diaphania</i>	<i>indica</i>									West, north and east coasts	Southern Asia; worldwide pest
<i>Dracaenura</i>	<i>horochroa</i>									Cape York	New Guinea
<i>Dysallacta</i>	<i>negatalis</i>									SE Queensland to Townsville	Tropical and subtropical Asia; Africa
<i>Dysallacta</i>	ANICI*									unpublished	none
<i>Ectadiosoma</i>	<i>straminea</i>									SE Queensland; tropical Queensland	none
<i>Eurybela</i>	<i>trophoessa</i>									Victoria to Queensland	none
<i>Eusabena</i>	<i>monostictalis</i>									Cape York	Ambon; New Guinea
<i>Glaucomoe</i>	<i>deductalis</i>									Far northern Queensland	Sri Lanka; Taiwan; New Guinea
<i>Glycythyma</i>	<i>chrysoxycta</i>									Sunshine Coast to Cape York	India to Japan
<i>Glyphodes</i>	<i>onychinalis</i>									SE to central Queensland	Tropical & subtropical Asia; Africa; Pacific

GENUS	SPECIES	EUNGELLA	LAMINGTON	BORDER RANGES	TAMBORINE	PALUMA	ATHERTON TABLELANDS	MT LEWIS	CAPE TRIBULATION	PREVIOUS KNOWN AUSTRALIAN DISTRIBUTION (collated from <i>Atlas of Living Australia</i> and BOLD database)	KNOWN WIDER DISTRIBUTION (collated from BOLD database)
<i>Glyphodes</i>	<i>multilinealis</i>									Tropical Queensland	New Guinea; Pacific Islands; Japan
<i>Glyphodes</i>	<i>stolalis</i>									Eungella northwards to NE Australia	Tropical & subtropical Asia; Africa; Indian Ocean Islands
<i>Glyphodes</i>	<i>cosmarcha</i>									SE Queensland, NSW	Thailand; PNG
<i>Glyphodes</i>	<i>caesalis</i>									Cairns northwards	Tropical & subtropical Asia; New Guinea
<i>Glyphodes</i>	<i>canthusalis</i>									Central NSW to Cape York	Tropical & subtropical Asia
<i>Glyphodes</i>	<i>conjunctalis</i>									Far northern Queensland	New Guinea; Molluccas
<i>Glyphodes</i>	<i>microra</i>									Central NSW to Cape York	none
<i>Glyphodes</i>	<i>flavizonalis</i>									Coastal: Northern NSW to Cape York	none
<i>Haritalodes</i>	<i>derogata</i>									Coastal: Sydney to Townsville	Africa; East & SE Asia; New Guinea
<i>Herpetogramma</i>	<i>licarsialis</i>									Coastal: SE NSW northwards, and westwards to Perth	Old World Tropics
<i>Herpetogramma</i>	<i>holophaea</i>									Queensland; NT	none
<i>Herpetogramma</i>	<i>stultalis</i>									SE Queensland	Africa; East & SE Asia; New Guinea
<i>Herpetogramma</i>	<i>cf stultalis</i>									n/a	n/a
<i>Herpetogramma</i>	<i>hipponalis</i>									Far northern Queensland; NT	East Asia; Guadalcanal; New Guinea
<i>Herpetogramma</i>	<i>cynaralis</i>									Southern NSW to SE Queensland	Japan; Sri Lanka; SE Asia
<i>Herpetogramma</i>	<i>exculta</i>									SE Queensland; far NE NSW	none
<i>Hymenoptychis</i>	<i>sordida</i>									Northern Queensland	Tropical & subtropical Asia; Africa; Pacific
<i>Maruca</i>	<i>vitrata</i>									Coastal: Central NSW; Queensland; NT	Pan-tropical
<i>Merodictya</i>	<i>marmorata</i>									Coastal: Victoria to Cairns	none

GENUS	SPECIES	EUNGELLA	LAMINGTON	BORDER RANGES	TAMBORINE	PALUMA	ATHERTON TABLELANDS	MT LEWIS	CAPE TRIBULATION	PREVIOUS KNOWN AUSTRALIAN DISTRIBUTION (collated from <i>Atlas of Living Australia</i> and BOLD database)	KNOWN WIDER DISTRIBUTION (collated from BOLD database)
<i>Nacoleia</i>	<i>amphicedalis</i>									QLD/NSW Border to Cape York	none
<i>Nacoleia</i>	<i>glageropa</i>									SE Queensland	none
<i>Notarcha</i>	<i>aurolinealis</i>									Central NSW to Cairns	Hong Kong; SE Asia
<i>Omiodes</i>	<i>origoalis</i>									no information	NE India; SE Asia
<i>Omiodes</i>	<i>nigriscripta</i>									Townsville northwards	New Guinea
<i>Omiodes</i>	<i>diemenalis</i>									Coastal: Central NSW northwards to Queensland, NT	East & SE Asia, New Guinea, Pacific
<i>Palpita</i>	<i>austrounionalis</i>									Cape York	New Guinea
<i>Palpita</i>	<i>austrannulata</i>									Cape York, NT	none
<i>Palpita</i>	<i>limbata</i>									Central NSW northwards	Rennell Island; Guadalcanal
<i>Palpita</i>	<i>margaritacea</i>									Coastal: Victoria to SE Queensland	none
<i>Parotis</i>	<i>suralis</i>									Coastal: Central Queensland	West Pacific Rim
<i>Parotis</i>	<i>incurvata</i>									NE NSW; SE Queensland	Loyalty Islands; SE Asia
<i>Parotis</i>	<i>atitatis</i>									NE NSW; south central Queensland	SE Asia
<i>Piletocera</i>	<i>meekii</i>									Central Australia (and elsewhere?)	Indonesia
<i>Pleuroptya</i>	<i>symphonodes</i>									Cape York	none
<i>Pleuroptya</i>	<i>balteata</i>									NE NSW; SE Queensland	Temperate & tropical Old World
<i>Pleuroptya</i>	ANIC2*									n/a	n/a
<i>Procedema</i>	<i>inscisalis</i>									Coastal: All Queensland	India; China; SE Asia; New Guinea
<i>Prophantis</i>	<i>adusta</i>									Far northern Queensland	India; China; Japan; SE Asia; New Guinea

GENUS	SPECIES	EUNGELLA	LAMINGTON	BORDER RANGES	TAMBORINE	PALUMA	ATHERTON TABLELANDS	MT LEWIS	CAPE TRIBULATION	PREVIOUS KNOWN AUSTRALIAN DISTRIBUTION (collated from <i>Atlas of Living Australia</i> and BOLD database)	KNOWN WIDER DISTRIBUTION (collated from BOLD database)
<i>Prorodes</i>	<i>mimica</i>									SE Queensland	India; SE Asia; New Guinea
<i>Protonoceras</i>	<i>leucocosma</i>									Coastal: SE NSW to NT	none
<i>Pygospila</i>	<i>bivittalis</i>									Cape York; Darwin	India; China; SE Asia; New Guinea
<i>Pygospila</i>	<i>tyres</i>									Coastal: Queensland; NT	India; China; SE Asia
<i>Rehimena</i>	<i>auritincta</i>									Queensland; NW Australia	none
<i>Rehimena</i>	<i>leptophaes</i>									NSW; ACT; Queensland	none
<i>Rhimphalea</i>	<i>sceletalis</i>									Coastal: All Queensland	Old World tropics
<i>Sameodes</i>	<i>cancellalis</i>									Queensland to Cape York	Tropical & subtropical Asia; Africa; Pacific
<i>Sisyrophora</i>	<i>pleifferae</i>									Eungella to Cape York	India; Taiwan; SE Asia
<i>Spoladea</i>	<i>recurvalis</i>									Throughout; Christmas Island	Cosmopolitan; mostly tropical
<i>Stemorrhages</i>	<i>amphitritalis</i>									SE Queensland	India; SE Asia
<i>Stemorrhages</i>	<i>marthesiusalis</i>									NE NSW; SE Queensland	India; Sri Lanka
<i>Syllepte</i>	<i>ochrotozona</i>									Coastal: Central Queensland northwards	none
<i>Talanga</i>	<i>sabacusalis</i>									Townsville northwards	SE Asia; New Guinea
<i>Talanga</i>	<i>sexpunctalis</i>									Northern NSW	SE Asia; New Guinea (unresolved species complex)
<i>Terastia</i>	<i>subjectalis</i>									NE NSW; SE Queensland	Indian and Pacific Ocean margins
<i>Tetridia</i>	<i>caletoralis</i>									Cape York	India; Sri Lanka; China; Japan; SE Asia; New Guinea

Comparing our results with what is known from other records and databases both within Australia and beyond, we can identify situations where *Eungella* is the northernmost known point of the species' distribution or, conversely, its southernmost point. For 24 species, *Eungella* appears to represent the species' southern limit, either in Australia and/or beyond. For five species, our *Eungella* records represent the northernmost incidence known. We stress that these results are necessarily limited by the quality of the databases on which they are founded (and, indeed, on the quality of our collection data). Nevertheless, it confirms the idea that *Eungella* represents the point of contact between southern and northern faunas, with the tropical faunas predominating. The number of Australian endemics among our list (just 23 out of 91) is

unusually low. Adding the seven species we encountered which also occur in the Australasian islands to the north (New Guinea, Solomons, Moluccas), we still only find about a third of species which are endemic to the biogeographic region. This suggests that the Pyraloidea (or at least that section within which our fauna belongs) is predominantly a clade of the Old World tropics, with our fauna having many Oriental affinities.

We commend the P-S clade for further attention by future workers. Not only are its members attractive and common, they are relatively large as 'micros' go and a majority can be recognised on the basis of wing patterns alone. Clearly some genera are in need of more detailed taxonomic analysis and, in this regard, some of our identifications must be regarded as tentative.

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