

Short Communication

Immature Diptera (excluding Culicidae) inhabiting phytotelmata in the Auckland and Wellington regions

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Abstract This study records the Diptera fauna (excluding Culicidae) breeding in phytotelmata in the Auckland and Wellington regions of New Zealand, particularly in native forest habitats. Diptera larvae were relatively abundant in the leaf axils of the native epiphyte *Collospermum hastatum*, and in the fallen leaves of the native nikau palm *Rhynchospora sapida*. Chironomidae and Tipulidae were the most common families collected, but larvae of Anisopodidae, Ceratopogonidae, Empididae, Psychodidae, and Syrphidae were also present.

Keywords phytotelmata; Diptera; larvae; Wellington; Auckland

INTRODUCTION

The term phytotelmata (“plant-waters”) was coined by Varga (1928) to describe bodies of water impounded by plants. Kitching (1971) expanded on the classifications from Thienemann (1954) to describe seven different types of phytotelmata based on the type of fluid held by the plant, the part of the plant used, and whether or not the part is still attached to a live plant. These classifications were recently reorganised by Greeney (2001). Some authors have provided comprehensive inventories of particular phytotelma habitats (e.g., Beaver 1985; Yanoviak 2001), whereas Kitching (2000) carried out an in-depth analysis of the fauna and ecology of phytotelmata. According to Fish (1983), over 1500 different species from 26 families of plants worldwide form some sort of phytotelmata. More than 70 families from 11 insect orders have been recorded in phytotelmata, including 13 Diptera families whose larvae are by far the most common and abundant members of such communities (Greeney 2001).

The non-mosquito phytotelmata fauna is still poorly known in New Zealand and globally. The present study was carried out in the Wellington and Auckland regions to obtain an insight into the Diptera fauna breeding in phytotelmata in New Zealand’s native forests and anthropic habitats. Here, we discuss the taxa recorded and the phytotelmata in which they were found. Data on Culicidae were not included, as the mosquito fauna was the focus of independent studies (e.g., Derraik 2005).

MATERIALS AND METHODS

Several native forest sites and anthropic habitats around the Wellington and Auckland regions were visited during an extensive research programme on New Zealand Culicidae. During field sampling, collections were also made of other Diptera breeding in phytotelma habitats such as tree holes, leaf axils, and fallen plant parts. The native epiphyte *Collospermum hastatum* (Liliaceae) is commonly found in coastal and lowland forests throughout the

North Island (Dawson & Lucas 2000). In the Wellington and Auckland regions, canopy specimens of *C. hastatum* were clearly the most abundant source of phytotelm habitats, and were therefore, specifically targeted in one of the Culicidae studies (Derraik 2005). The latter allowed for regular collection of other Diptera larvae from heights of 10–13 m at Otari-Wilton's Bush, in Wellington. To extract the water from *C. hastatum* leaf axils and other phytotelmata, a sampling tool made of an endoscope tube 5 mm wide and 55 cm long, attached to a 50 ml syringe, was used.

The water from leaf axils and other phytotelmata were examined *in situ* by naked eye. All larvae found were taken to the laboratory in small plastic containers, and were separated into recognisable taxonomic units. Not all larvae were retained for identification, and only voucher specimens were preserved in 70% ethanol. Some specimens (as indicated in Table 1) were reared to imagos in the retrieved phytotelm water (without added nutrients, at ambient temperature), in plastic cups in an enclosed laboratory.

Identifications were carried out under a stereomicroscope or compound microscope where appropriate, using a variety of taxonomic literature aids, mainly McAlpine et al. (1981), but also Foote et al. (1991) and Winterbourn et al. (2000). Names of taxa were standardised using Evenhuis (1989). As a result of the difficulty in adequately identifying all of the chironomids, some of the more problematic ones were sent to a specialist (Ian Boothroyd) for confirmation.

RESULTS

All larvae recorded and the respective collection records are presented in Table 1, whereas collection sites are listed and briefly described in Appendix 1. Larvae of seven families were recorded: Anisopodidae, Ceratopogonidae, Chironomidae, Empididae, Psychodidae, Syrphidae, and Tipulidae, comprising c. 30 taxa. Note that culicids were also recorded (e.g., Derraik 2005). Diptera larvae were found in fallen plant parts, tree holes, and leaf axils, with the latter being the most common habitat type owing to the abundance of the native epiphyte *C. hastatum* in native forests. In general, neither specimens nor taxa were particularly numerous in individual phytotelmata inspected, except in the fallen leaves of the endemic nikau palm (*Rhopalostylis sapida*; Arecaceae). Some of the latter were found to impound c. 3 litres of water and contain hundreds of culicid larvae (Derraik

unpubl. data), but also harboured numerous larvae of as many as three other dipteran families.

Tree holes yielded larvae of Chironomidae, Empididae, Psychodidae, Syrphidae, and Tipulidae. As a result of the various sizes and shapes of tree holes observed, these harboured contrasting amounts of water from 5 ml to c. 1 litre (e.g., Derraik 2005). In the Wellington region, Diptera larvae were collected from tree holes only in native trees (especially in *Melicactus ramiflorus*—mahoe; Violaceae), whereas in Auckland, larvae were mostly found in exotic trees located in anthropic habitats. Tree holes in Wellington yielded the only larvae of Empididae (unidentified species) recorded in this study. A tree hole in *M. ramiflorus* also yielded a tipulid larva, and a syrphid larva was collected from a 15-cm-deep puriri moth (*Aenetus virescens*; Lepidoptera: Hepialidae) tree hole in a ngaio tree (*Myoporum laetum*; Myoporaceae).

Tree holes in exotic Moreton Bay figs (*Ficus macrophylla*; Moraceae) at Cornwall Park (Auckland) yielded larvae of two chironomid genera, *Polypedilum* sp. (Chironominae) and *Apsectrotanypus* sp. (Tanypodinae). In the same urban park, a native puriri tree (*Vitex lucens*; Verbenaceae) yielded larvae of *Psychoda* nr. *tridens* (Psychodidae), which were collected from extremely putrid water. At Wenderholm Regional Park two tree holes on exotic coral trees (*Erythrina sykesii*; Fabaceae) harboured tipulids (*Limonia* nr. *vicarians* or *insularis*).

The only phytotelmata corresponding to fallen plant parts encountered in this study were those in fallen nikau leaves in the Auckland region, in which larvae of Anisopodidae, Chironomidae, Psychodidae, and Tipulidae were recorded. The Anisopodidae larvae recorded in this study (*Sylvicola* sp.) were found only in fallen nikau leaves. Larvae of Psychodidae and Tipulidae were the most common specimens in fallen nikau leaves, and apart from unidentified species of both families, there were *Psychoda* sp. and the tipulids *Amphineurus horni* and *Gonomyia* sp.

As previously mentioned, impounded water in the native epiphyte *C. hastatum* was the most widespread source of Diptera larvae in this study in both regions. The leaf axils of *C. hastatum* were found to impound relatively large amounts of water, as much as 78 ml in a single axil (Derraik 2005). Apart from unidentified chironomids and tipulids, these plants were found to harbour larvae of *Apsectrotanypus* sp., a genus regularly recorded in the Wellington region, and two other chironomids, *Polypedilum* sp. and an unidentified species, as well as *Psychoda* nr. *tridens* and *Psychoda* nr. *formosa*. A Ceratopogonidae larvae (*Euprojoannisia* nr.

antipodum) was also recorded. Canopy *C. hastatum* in the Wellington region also harboured larvae of tipulids, including a member of the tribe Eriopterini and possibly *Aphrophila* sp. In the Auckland region, where no canopy *C. hastatum* specimens (above 3 m) were inspected, none of the taxa collected were restricted to a particular site. The chironomid *Apsectrotanypus* sp. was prominent as it was relatively widespread, being present at seven different sites. The other chironomid taxa recorded in *C. hastatum* in Auckland were *Chironomus zealandicus* and an unidentified Tanypodinae, together with the tipulid *Limonia* sp., and an unidentified tipulid species of the Subfamily Limoniinae.

The native flax (*Phormium tenax*; Agavaceae) was the only other native plant to harbour Diptera larvae in its leaf axils, including a Ceratopogonidae larvae, the syrphid *Psilota decessa*, and the chironomid *Podonomus* sp. The leaf axils of three different exotic plant species (two bromeliads and a banana tree) that were located in anthropic habitats, yielded only larvae of the endemic *Chironomus zealandicus* (Chironomidae).

DISCUSSION

The range of larvae collected in the Auckland and Wellington regions indicates that such fauna appear to follow a worldwide pattern for the main Diptera families breeding in phytotelmata, which are, according to Kitching (2000) and Greeney (2001), the Culicidae, Ceratopogonidae, Chironomidae, Psychodidae, Syrphidae, and Tipulidae. Of these commonly occurring families, with the exception of Culicidae which is also common in northern New Zealand but not discussed here, only Ceratopogonidae and Syrphidae were rare in the phytotelmata examined in this study, with Chironomidae, Psychodidae, and Tipulidae found to be the most species rich families present. We also collected larvae of Anisopodidae, whose presence in phytotelm habitats globally seem to be more restricted (Kitching 2000; Greeney 2001).

Of particular relevance was the collection of Empididae larvae from tree holes in the Wellington region as, based on Kitching (2000) or Greeney (2001), there seem to be no previous descriptions of empidids from phytotelmata. In addition, we recorded numerous larvae of Psychodidae and Tipulidae in fallen plant parts (nikau leaves), and neither families were described from such phytotelmata by Kitching (2000) or Greeney (2001).

The leaf axils of the epiphyte *C. hastatum* provided the most abundant phytotelm breeding habitats in the Wellington and Auckland regions. Only one culicid species (the endemic *Culex astelliae*) seems to regularly use these plants in the Auckland region (Derraik unpubl. data), but the non-culicid Diptera fauna is somewhat more speciose and at least four Diptera families seem to use this larval habitat: Ceratopogonidae, Tipulidae, and most importantly the Chironomidae. The chironomid *Apsectrotanypus* sp. in particular, seems to be the main genus using these leaf axils, as we recorded numerous specimens from at least 22 *C. hastatum* plants in six different forest sites in the Auckland and Wellington regions.

In some of the Wellington forests, tree holes in *M. ramiflorus* were the next most common habitat for container-breeding Diptera, and the fallen leaves of nikau palms were particularly abundant in the Auckland region. Fallen nikau leaves were also found to harbour larvae of four different Culicidae species (Derraik unpubl. data).

An interesting find from this study was the record of syrphid larvae from a hole made by *A. virescens* (New Zealand's largest endemic moth). These holes are abundant in native forests, but they are not likely to be of significance for Diptera breeding. Puriri moth holes are "7-shaped" and the first section of the tunnel slopes up from the entrance (Alma 1977). As a result, they are unlikely to become water-filled, which is probably the reason why such holes are often used as shelter by other non-aquatic native insects.

Even though the data indicated that most of the species collected appeared to display preference for breeding in particular phytotelmata, this study is not comprehensive enough to be definitive. Interestingly, the endemic *Chironomus zealandicus*, a common and widespread species (Freeman 1959), was recorded solely from phytotelmata in exotic plant species, demonstrating an adaptability for exploiting new niches in highly modified habitats. This is also evidenced by the collection of *C. zealandicus* from plastic containers in an Auckland backyard (Derraik & Heath unpubl. data), and by previous records of *C. zealandicus* from oxidation ponds (Forsyth 1971). We have also collected larvae of *Psychoda* nr. *tridens* from water within a used tyre at the Auckland Zoological Park.

The phytotelmata communities in New Zealand are a long way from being adequately described and understood. In the Empididae for instance, little is known about their habits (McAlpine et al. 1981), and

Table 1 List of Diptera larvae collected from phytotelmata in the Auckland (AKL) and Wellington (WLN) regions of New Zealand. PT indicates the types of phytotelmata: tree hole (TH), leaf axil (LA) and fallen plant part (FPP). (CAN) indicates plants in the forest canopy (>10 m). Asterisks indicate taxa with taxonomic identification also based on imago (reared from larvae), whereas the figure in brackets represents the number of phytotelmata in which a particular taxon was recorded. A question mark indicates those taxa with uncertain identification.

Family	Subfamily	Species	PT
Anisopodidae	Anisopodinae	<i>Sylvicola</i> sp.	FPP
Ceratopogonidae	Forcipomyiinae	<i>Euprojoannisia</i> nr. <i>antipodum</i> Hudson	LA
		Unidentified sp.	LA
Chironomidae	Chironominae	<i>Chironomus zealandicus</i> Hudson	LA
			LA
		<i>Polypedilum</i> sp.	LA
		Unidentified sp.	TH
	Podonominae	<i>Podonomus</i> sp.	LA
	Tanypodinae	<i>Apsectrotanypus</i> sp.	LA
			LA
			TH
		Unidentified sp. A	FPP
		Unidentified sp. B	LA
Empididae	?	Unidentified sp. 1	TH
	?	Unidentified sp. 2	TH
	?	Unidentified sp. 3	TH
Psychodidae	Psychodinae	<i>Psychoda</i> sp.	FPP
		<i>Psychoda</i> nr. <i>formosa</i> Satchell	LA
		<i>Psychoda penicillata</i> Satchell	LA
		<i>Psychoda</i> nr. <i>tridens</i> Satchell	LA
			TH
		Unidentified sp. A	FPP
		Unidentified sp. B	FPP
Syrphidae	?	Unidentified sp.	TH
	Eristalinae	<i>Psilota decessa</i> Hutton	LA
Tipulidae	Limoniinae	? <i>Amphineurus</i> (<i>Nothormosia</i>) <i>horni</i> Edwards	FPP
		? <i>Aphrophila</i> sp.	LA
		Eriopterini sp.	LA
		? <i>Gonomyia</i> sp.	FPP
		<i>Limonia</i> sp.	FPP
			LA
		<i>Limonia</i> (<i>Dicranomyia</i>) nr. <i>vicarians</i> Schiner or <i>insularis</i> Mik	TH
		Unidentified sp.	LA
			TH

Plant species	Locality	Total no. specimens recorded	Region	Date
<i>Rhopalostylis sapida</i> (nikau palm—fallen leaf)	Logues Bush	6 (1)	AKL	Mar 2003
	McElroy Scenic Reserve	1 (1)	AKL	Mar 2003
	Wainui farm	5 (1)	AKL	Mar 2003
<i>CollospERMUM hastatum</i>	Otari-Wilton's Bush	1 (1)	WLN	Jan 2002
<i>Phormium tenax</i> (flax)	Nga Manu Reserve	6 (2)	WLN	Nov 2001
<i>Musa</i> sp. (banana tree)	Kohimarama (backyard)	10* (1)	AKL	Jan 2003
<i>Alcantara vinicolor</i> (exotic bromeliad)	Oratia (Landsend)	4* (1)	AKL	Jan 2003
unidentified exotic bromeliad	Kelston (backyard)	1* (1)	AKL	Dec 2002
<i>CollospERMUM hastatum</i> (CAN)	Otari-Wilton's Bush	15 (1)	WLN	Feb 2002
<i>Ficus macrophylla</i> (Moreton Bay fig)	Cornwall Park	19 (2)	AKL	Apr 2003
<i>CollospERMUM hastatum</i>	Kaitoke Regional Park	4 (2)	WLN	Nov 2001
<i>Phormium tenax</i> (flax)	Nga Manu Reserve	6 (2)	WLN	Nov 2001
<i>CollospERMUM hastatum</i> (CAN)	Otari-Wilton's Bush	27* (9)	WLN	Nov 2001– Apr 2002
<i>CollospERMUM hastatum</i>	Cascade-Kauri Park	40* (6)	AKL	Jan–Feb 2003, Apr 2004
	Logues Bush	3* (1)	AKL	Mar 2003, Apr 2004
	McElroy Scenic Reserve	11* (4)	AKL	Mar 2003
	Tapu Bush Rd	5 (1)	AKL	Mar 2003
	Wenderholm Regional Park	9 (1)	AKL	Mar 2003, Apr 2004
<i>Ficus macrophylla</i> (Moreton Bay fig)	Cornwall Park	4* (1)	AKL	Apr 2003
<i>Rhopalostylis sapida</i> (nikau palm—fallen leaf)	McElroy Scenic Reserve	1 (1)	AKL	Apr 2004
<i>CollospERMUM hastatum</i>	Otari-Wilton's Bush	2 (1)	WLN	Jan 2002
<i>Melicytus ramiflorus</i> (mahoe)	Otari-Wilton's Bush	4 (1)	WLN	Jan 2002
<i>Melicytus ramiflorus</i> (mahoe)	Otari-Wilton's Bush	2 (1)	WLN	Jan 2002
<i>Griselinia littoralis</i> (broadleaf)	Wellington Zoo	(1)	WLN	Jan 2002
<i>Rhopalostylis sapida</i> (nikau palm—fallen leaf)	Cascade-Kauri Park	1* (1)	AKL	Jan 2003
<i>CollospERMUM hastatum</i> (CAN)	Otari-Wilton's Bush	1 (1)	WLN	Mar 2002
<i>CollospERMUM hastatum</i>	Otari-Wilton's Bush	1 (1)	WLN	Jan 2002
<i>CollospERMUM hastatum</i> (CAN)	Otari-Wilton's Bush	6 (2)	WLN	Jan 2002
<i>Vitex lucens</i> (puriri tree)	Cornwall Park	4* (2)	AKL	Apr 2003
<i>Rhopalostylis sapida</i> (nikau palm—fallen leaf)	McElroy Scenic Reserve	1 (1)	AKL	Apr 2004
<i>Rhopalostylis sapida</i> (nikau palm—fallen leaf)	McElroy Scenic Reserve	40 (1)	AKL	Apr 2004
<i>Myoporum laetum</i> (ngaio)	Otari-Wilton's Bush	1 (1)	WLN	Nov 2001
<i>Phormium tenax</i> (flax)	Nga Manu Reserve	4 (3)	WLN	Nov 2001
<i>Rhopalostylis sapida</i> (nikau palm—fallen leaf)	McElroy Scenic Reserve	1 (1)	AKL	Apr 2004
<i>CollospERMUM hastatum</i> (CAN)	Otari-Wilton's Bush	10 (1)	WLN	Nov 2001
<i>CollospERMUM hastatum</i> (CAN)	Otari-Wilton's Bush	1 (1)	WLN	Nov 2001
<i>Rhopalostylis sapida</i> (nikau palm—fallen leaf)	McElroy Scenic Reserve	6 (1)	AKL	Apr 2004
<i>Rhopalostylis sapida</i> (nikau palm—fallen leaf)	McElroy Scenic Reserve	17 (2)	AKL	Apr 2004
<i>CollospERMUM hastatum</i>	McElroy Scenic Reserve	6 (1)	AKL	Mar 2003
	Wenderholm Regional Park	1 (1)	AKL	Mar 2003
<i>Erythrina sykesii</i> (coral tree)	Wenderholm Regional Park	5* (2)	AKL	Mar 2003
<i>CollospERMUM hastatum</i>	Cascade-Kauri Park	2 (1)	AKL	Feb 2003
	Logues Bush	1 (1)	AKL	Mar 2003
	Wainui farm	2 (1)	AKL	Mar 2003
<i>Melicytus ramiflorus</i> (mahoe)	Otari-Wilton's Bush	1 (1)	WLN	Nov 2001

the larvae of only two empidid species have been described for New Zealand (Dumbleton 1966). Our records illustrate that further research is necessary to fill the vast knowledge gap on phytotelmata breeding species in this country. Extensive sampling of such habitats is not particularly laborious, but adequate identification of species and consequent taxonomic description is problematic and time-consuming.

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Appendix 1 Short description of the collection sites and their approximate coordinates. Note that all sampling sites were located at low altitudes.

Location	Short description of collection site	Approximate coordinates
Cascade-Kauri Park	Pristine kauri-podocarp-hardwood forest	36°53'35"S, 174°30'30"E
Cornwall Park	Urban park with numerous mature exotic trees	36°53'50"S, 174°47'10"E
Kaitoke Regional Park	Pristine coniferous-broadleaf forest	41°03'20"S, 175°11'30"E
Karori Wildlife Sanctuary	Regenerating coniferous-broadleaf forest	41°17'50"S, 174°44'50"E
Kelston house	Urban backyard	36°53'40"S, 174°38'35"E
Kohimarama house	Urban backyard	36°51'30"S, 174°50'40"E
Logues Bush Reserve	Kauri-podocarp-hardwood forest	36°15'45"S, 174°35'10"E
McElroy Scenic Reserve	Regenerating kauri-podocarp-hardwood forest	36°27'30"S, 174°41'30"E
Nga Manu Reserve	Small pristine remnant of native swamp forest	40°51'48"S, 175°03'30"E
Oratia (Landsend)	Exotic plant nursery near the Waitakere Ranges Regional Park	36°56'30"S, 174°36'30"E
Otari-Wilton's Bush	Pristine and regenerating coniferous-broadleaf forests	41°16'00"S, 174°45'00"E
Tapu Bush Rd.	Modified fragment of regenerating podocarp-hardwood forest	36°15'30"S, 174°38'00"E
Wainui farm	Modified and small fragment of podocarp-hardwood forest	36°36'00"S, 174°36'30"E
Wellington Zoo	Urban zoological park	41°19'20"S, 174°47'00"E
Wenderholm Regional Park	Coastal tarairi (<i>Beilschmiedia taraire</i>) forest	36°32'30"S, 174°42'35"E

