Scientific Note

The mosquito fauna of phytotelmata in native forest habitats in the Auckland region of New Zealand

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New Zealand has a relatively species-poor mosquito fauna, with only 12 native and four introduced species (Derraik 2004a), but little is known about their ecology. Phytotelm-forming plants seem to be rare in New Zealand's indigenous flora, and records of mosquitoes from such habitats are scarce. Derraik (2005a) recently studied the culicid fauna of native forests in the Wellington region. Mosquito larvae were rare in phytotelmata, being scarcely recorded in tree holes and absent from the numerous specimens of the native epiphyte *Collospermum hastatum* (Liliaceae) surveyed. This corroborates Laird's (1990) proposition that larval habitats for mosquitoes in indigenous ecosystems are under-utilized in New Zealand. However, this situation would likely differ in northern regions, where the mosquito fauna is comparatively richer.

Derraik and Slaney (2007) discussed how anthropogenic environmental change may facilitate invasion by exotic mosquitoes and their subsequent establishment in native habitats in New Zealand. As a result, a study examined the effects of forest size reduction and density of the introduced brushtail possum (*Trichosurus vulpecula*) on mosquito communities in the Auckland region (Derraik 2009b). Extensive sampling of phytotelmata was carried out, and this study reports the larval records, which are important in view of the paucity of information on the breeding habitats of New Zealand's culicid fauna.

Eight native forest habitats of varying sizes were studied (see Derraik 2009b for details). Briefly, all potential phytotelm habitats within 5 m on each side of a 1 km transect were surveyed (c.1 ha per site). A ladder was used to extend the search height to c.4 m, also ensuring the inclusion of numerous *C. hastatum*, the main source of phytotelm habitats in Wellington forests (Derraik 2005a). Leaf axils and other phytotelmata were individually inspected, and all water was extracted using a modified syringe (Derraik 2009a). Culicid specimens were identified to species whenever possible.

Few tree holes capable of impounding water were observed. Only eight of these were water-filled, and the only culicid record was from the gnarled roots of a native *Laurelia novae-zelandiae* (Monimiaceae), where approximately 400 ml of water yielded 75 larvae of the introduced *Aedes (Finlaya) notoscriptus* (Skuse). The leaf axils of *C. hastatum* (Figure 1) were the most numerous phytotelm habitats. Of the 470 plants surveyed, 72% (340/470) harbored water, 50% of which were larva-positive although this rate varied significantly among sites (Derraik 2009b). Some *C. hastatum* specimens had 18 water-filled leaf axils, yielding as many as 150 *Cx. asteliae* larvae. However, these habitats were practically monospecific for culicids, as all 1,836 larvae recorded were the native *Culex (Culex) asteliae* Belkin, except for three *Ae. notoscriptus* in two plants.

Fallen leaves of native nikau palms (*Rhopalostylis sapida*, Palmae) were the next most abundant phytotelm habitat. Such leaves were frequently observed in most field sites, impounding as much as three liters of water, averaging 18 water-filled leaves per hectare. Of the 146 water-filled leaves recorded, 28 were positive for culicid larvae (19%) yielding 1,950 larvae of four different species: the native *Culex (Culex) pervigilans* Bergroth, *Cx. asteliae,* and *Maorigoeldia argyropus* (Walker), as well as *Ae. notoscriptus* (Table 1), which was the most frequently recorded culicid, present in 18 leaves (68%, Table 1).

The relative abundance of a species' larvae in nikau leaves often contrasted with its overall distribution in such habitats. The widespread *Ae. notoscriptus,* for instance, represented only 16% of all larvae but was found in more nikau leaves than all other species put together. At Wenderholm this species was recorded in all six larva-positive leaves, but it made up just 5% of the total larval count (Table 1). In comparison, 630 *Cx. pervigilans* larvae were recorded in two leaves (Table 1). It is worth noting that most larva-positive nikau leaves (23/28; 82%) harbored a single culicid species, with only evidence of co-infestation with *Ae. notoscriptus* and *Cx. pervigilans* (3), *Ae. notoscriptus* and *Cx. asteliae* (1), and *Cx. pervigilans* with *Mg. argyropus* (1).

This study indicated a scarcity of tree-hole habitats in Auckland's native forests, similar to what was observed by Derraik (2005a) in the Wellington region. This appears to be a feature of New Zealand's native flora, contrasting to

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Figure 1. Cluster of *Collospermum hastatum*.

some introduced trees that provide numerous such habitats (Derraik 2005b). Nonetheless, there seems to be considerable variation in the density of tree holes among forest types, particularly as a result of age stand. In addition, a recent study in Westland and central South Island indicated that in some forest types most tree holes were in the canopy (Blakely and Didham 2008), although their ability to harbor water as culicid larval habitats was not assessed.

It appeared that the most abundant phytotelm habitats were the leaf axils of *C. hastatum*. However, *Cx. asteliae* seems to be the only culicid utilizing these plants to a significant extent. In fact, this native mosquito seems to rely on these plants, being rarely found in other larval habitats within native forests. In relation to Laird's (1990, 1995) claim of underutilization of natural container habitats in New Zealand, it does not appear to apply to the leaf axils of *C. hastatum* in the Auckland region. However, Laird's propositions seem to apply in *C. hastatum* in native forest further south as previously shown (Derraik 2005a), where *Cx. asteliae* is not known to occur.

Although *Cx. asteliae* seems to be the only mosquito species regularly utilizing *C. hastatum* in the Auckland region, these plants harbored at least three other Diptera families: Ceratopogonidae, Tipulidae, and especially Chironomidae (Derraik and Heath 2005). Interestingly, the exotic *Ae. notoscriptus* can be sporadically found in *C. hastatum* in anthropic habitats (Derraik 2004b). It is possible that these plants lack oviposition cues for *Ae. notoscriptus* females, which may not be attracted to *C. hastatum* leaf axils due to particular physical characteristics of these habitats. The response of *Ae. notoscriptus* females, however, may differ in areas with lower availability of breeding habitats or higher competition for the latter, where this species seems to oviposit to a larger extent in *C. hastatum* (Derraik 2004b). Alternatively, natural compounds may be secreted into its leaf axils, which can work as attractants or repellents (Bentley and Day 1989). Such chemicals may act as attractants to *Cx. asteliae* but not to other culicids, as it is known to occur for culicids associated with the leaf axils of particular host plants in South America (Lounibos and Machado-Allison 1993). Similarly, extensive surveys in the United States showed that the leaf axils of the teasel (*Dipsacus laciniatus*; Dipsacaceae) do not seem to be utilized by mosquitoes (Baumgartner 1986) even though isolated records of culicids from such plants have been reported in the country (Means 1973) (which Baumgartner failed to explain), and they commonly harbor the malaria vector *Anopheles maculipennis* Meigen in Russia (Borob'ev 1960).

It is worth highlighting that disregarding *C. hastatum* leaf axils, *Ae. notoscriptus* was the main container-breeding species in the native forest habitats studied in the Auckland region, as it was the case in Wellington (Derraik 2005a). This introduced species is a potential disease vector of human and animal diseases (Derraik 2004a), and is becoming the predominant culicid breeding in container habitats in urban and suburban areas in the Auckland region, where it thrives in association with exotic plants and artificial containers (Derraik 2005b).

Interestingly, fallen nikau leaves were the main larval habitats for most container breeding mosquitoes in the sites studied being, for example, the only phytotelmata harboring *Mg. argyropus* and at relatively high densities. It is therefore surprising that Pillai (1965), Belkin (1968), and Laird (1995) failed to mention the presence of *Mg. argyropus* in such phytotelmata. It is clear that considerably more data are needed on the ecology of mosquitoes in New Zealand, and their utilization of phytotelmata in native habitats.

Table 1. Mosquito records from nikau leaves in native forest habitats in the Auckland region. Values indicate number of larvae collected, and the number of leaves where a species was recorded is in brackets.

Field Site	*Aedes notoscriptus*	*Culex asteliae*	*Culex pervigilans*	*Maorigoeldia argyropus*
Cascade-Kauri Park	1 (1)	64 (1)	40 (2)	463 (5)
Goldies Bush	0	0	0	9 (1)
Logues Bush	45 (3)	0	0	0
McElroy Reserve	102 (2)	12 (1)	0	0
Pohuehue Reserve	2 (1)	0	0	0
Tapu Bush	0	0	0	0
Wainui farm	102 (6)	0	61 (2)	0
Wenderholm Regional Park	53 (6)	0	996 (2)	0
Overall	305 (19)	76 (2)	1,097 (6)	472 (6)

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