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Mosquitoes breeding in container habitats in urban and peri-urban areas in the Auckland Region, New Zealand

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Abstract

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An investigation into the mosquito fauna breeding in container habitats in the Auckland region (New Zealand) was carried out. Special attention was given to exotic bromeliads. The results suggest that mosquitoes seem to utilize container habitats in urban and peri-urban areas to a high extent. Overall, there was an almost complete dominance of exotic mosquitoes, more specifically *Ochlerotatus notoscriptus*. The results provide further evidence of the major dominance of exotic mosquitoes in anthropic habitats in the Auckland region.

Additional key words: anthropic habitats, bromeliads, larvae, *Ochlerotatus notoscriptus*.

Resumen

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Se condujo una investigación sobre la faunba de mosquitos que se crian en contenedores en la región de Auckland (Nueva Zelanda). Atención especial fue prestada a la bromelias exóticas. Los resultados sugieren que los mosquitos parecen hacer uso intensivo de los contenedores en áreas urbanas y peri-urbanas. En resumen observamos una dominancia casi total de los mosquitos exóticos, específicamente *Ochlerotatus notoscriptus*. Los resultados ofrecen evidencia del dominio evidente de los mosquitos exóticos en habitats antrópicos en la región de Auckland.

Palabras clave adicionales: habitats antrópicos, bromelias, larvas, *Ochlerotatus notoscriptus*.

Introduction

Human activities have been causing dramatic and unprecedented changes to the Earth's ecosystems (Vitousek et al. 1997b). There is an increasing awareness of the consequences of anthropogenic environmental disturbance on human health (Waltner-Toews 2001; Norris 2004; Weinhold 2004; Vasconcelos et al. 2001), with a growing number of disease outbreaks occurring worldwide due to their emergence in new areas or resurgence where once thought to be in decline (Longbottom 1997; Gubler 1998; Gratz 1999).

Human-induced environmental changes can have a major impact on the distribution of mosquito species and associated diseases (Forattini & Massad 1998; Gratz 1999; Tadei et al. 1998). A large number of vector-borne pathogens are affecting human populations as a result of such process, e.g. West Nile virus (Daszak et al. 2004), Rift Valley fever virus (Brown 2004) and Borrelia burgdorferi (causative agent of Lyme disease) (Ostfeld et al. 2002).

Mosquitoes are some of the organisms that seem to benefit from anthropogenic environmental change. For example, the abundance of anopheline vectors of malaria in human-disturbed areas in the Brazilian Amazon, is on average five times that of undisturbed habitats (Tadei et al. 1998). The list of mosquito vector species that have been shown to be favoured by anthropogenic environmental change include *Anopheles darlingi* (Jones 2003), *Anopheles gambiae* (Frankie & Ehler 1978; Nelson 1978), *Anopheles albitarsis* and *Culex nigripalpus* (Forattini & Massad 1998), and *Aedes aegypti* (Frankie & Ehler 1978; Nelson 1978).

Although anthropogenic changes create favourable conditions for some species, they may lead to the displacement of others (Service 1991). Modified habitats appear to favour exotic invaders, but in New Zealand the endemic *Culex* (*Culex*) *pervigilans* Bergroth seems to be a synanthropic species. However, the latter species is an exception, and there is increasing evidence suggesting a mosquito species replacement in the Auckland region, where the exotic *Ochlerotatus* (*Finlaya*) *notoscriptus* (Skuse) is becoming the dominant species in urban areas and in highly fragmented patches of native forest (e.g. Derraik 2004b; Derraik & Slaney 2005; Derraik et al. 2005).

Highly modified environments such as urban areas, provide some advantages for container breeding mosquitoes, especially via the greater availability of artificial larval habitats. In the Auckland region, natural containers also seem to be abundant due to the common presence of exotic plants in home gardens (pers. obs.). New Zealand is still a 'virgin soil' when it comes to mosquito-borne diseases in humans (Derraik & Maguire 2005), and Auckland (the country's largest city) is the most likely site for an arboviral outbreak to occur (Derraik & Calisher 2004; Weinstein et al. 1995). Comprehensive larval records for northern New Zealand culicids are scarce, and the last extensive survey was carried out over 16 years ago (Laird 1990). This study aimed to identify the mosquito species utilising natural and artificial breeding containers in the Auckland region, in particular, to assess whether exotic mosquito species are dominant in urban areas and other human-modified habitats.

Materials and Methods

Container habitats were sampled during the Southern Hemisphere summer (Jan-Mar 2003) in a variety of urban and peri-urban sites in Auckland. Sampled areas mainly included public parks and house backyards. Exotic bromeliads were specifically targeted, as it was of interest to have an insight into the utilisation of such plants by mosquitoes in New Zealand, given their importance to culicids in other parts of the world (Frank 1983; O'Meara et al. 1995; Pittendrigh 1948).

Occupancy rates and presence/absence of larvae were assessed per container, and in the case of plants on a per plant basis. All larvae collected were taken to laboratory and identified using a key to the Culicidae of New Zealand (Snell 2005).

Results and Discussion

A total of 284 water-filled container habitats were examined throughout Auckland, 169 (60%) of which harboured mosquito larvae. The occupancy rate of artificial containers was 89% (66/74) in comparison to 49% for phytotelmata (103/210). Five species were recorded: the exotic *Ochlerotatus notoscriptus* and *Culex* (*Culex*) *quinquefasciatus* Say, and the endemic *Culex* (*Culex*) *asteliae* Belkin, *Culex pervigilans* and *Maorigoeldia argyropus* (Walker) (Table 1). The dominance of *Oc. notoscriptus* was somewhat marked, as it was present in 160 (95%) of the 169 infestations described (Table 1). Culex pervigilans was the second most common species, present in 28, with the remaining three species being rare (Table 1). There were 34 double infestations, with *Cx. pervigilans* and *Oc. notoscriptus* accounting for most of them (22; 65%). The second most frequent co-infestation of container habitats was that of *Cx. asteliae* and *Oc. notoscriptus* in phytotelmata (8; 24%), with other co-occurrences being rare. No indigenous species were recorded together.

The leaf axils of exotic bromeliads were highly exploited by *Oc. notoscriptus*, which was recorded in 68 (96%) of 71 larva-positive plants. *Culex asteliae* was the sole species collected from three plants, and overall it was recorded in 11 (15%) bromeliads (Table 1). The frequency and abundance of mosquito larvae varied among different bromeliad species, with the smaller species accounting for most of the water-filled plants with no mosquito larvae. In contrast, the relatively large *Alcantarea* spp. stood out, with all 24 plants inspected harbouring high densities of culicid larvae. The leaf axils of *Alcantarea imperialis* (Carrière) in particular, were large (c.500 ml) and all plants harboured hundreds of *Oc. notoscriptus* larvae.

Table 1. List and frequency of mosquito species recorded in phytotelmata and artificial breeding containers in urban and peri-urban areas in the Auckland region.

		Phytotelmata (n = 210)			Artificial (n = 74)		
Origin	Mosquito species	Bromeliads	Tree holes	Banana palms	Used tyres	Plastic Containers	Others
Native	*Culex (Culex) asteliae* Belkin	11	-	-	-	-	-
	Culex (Culex) pervigilans Bergroth	-	9	4	3	6	6
	Maorigoeldia argyropus (Walker)	-	1	-	-	-	2
Exotic	*Culex (Culex) quinquefasciatus* Say	-	-	1	-	-	-
	Ochlerotatus (Finlaya) notoscriptus (Skuse)	68	21	9	32	21	9

Culex asteliae larvae were also recorded co-infesting five *A. imperialis*. *Culex pervigilans* was not recorded in any bromeliads, but was recorded in the leaf axils of four banana trees (Table 1), which the species co-infested with *Oc. notoscriptus*.

There were 24 water-filled tree holes recorded, 23 (96%) of which contained mosquito larvae. Most tree holes were in exotic trees, eight in the long and large root buttresses of Moreton Bay figs (*Ficus macrophylla* Desfontaines ex Persoon; Moreaceae), six in coral trees (*Erythrina sykesii* Barneby & Krukoff; Fabaceae), and five in cut bamboos. *Ochlerotatus notoscriptus* was again the dominant species present in 21 (91%) larva-positive tree holes, with *Cx. pervigilans* recorded in nine (43%) tree holes (Table 1), seven of which (30%) harboured both species. *Ochlerotatus notoscriptus* was present in the five cut bamboos, one of which (in the Waitakere Ranges area) it co-infested with *Mg. argyropus*.

Ochlerotatus notoscriptus was also the mosquito species most frequently recorded in a variety of artificial containers, especially used tyres, but also roof gutters, broken bottles, concrete basins, metal drums, and a variety of plastic containers (Table 1). *Ochlerotatus notoscriptus* was present in all 32 water-filled used car tyres inspected, three of which also harboured *Cx. pervigilans* larvae (Table 1). Two infestations of artificial containers by *Mg. argyropus* were recorded at a property close to the borders of the Waitakere Ranges Regional Park, where the species co-infested a broken bottle and a small concrete trough with *Oc. notoscriptus* (Table 1). Ceramic receptacles (bird baths and pots) were the only type of artificial breeding containers singly infested by *Cx. pervigilans*, without *Oc. notoscriptus*.

The results of this investigation suggest that mosquitoes in the Auckland region seem to utilize container habitats in urban and peri-urban areas to a high extent. Used tyres and plastic receptacles were some of the preferred artificial larval habitats. Exotic bromeliads and tree holes in large exotic trees were also an abundant and important source of phytotelm habitats for culicids in the region, and should be of relevance for a mosquito control programme.

Not much is known about the bionomics of the endemic *Cx. asteliae*, apart from its apparent reliance on the leaf axils of the native epiphyte *Collospermum hastatum* (Colenso) (Liliaceae) plants as larval habitats (Belkin 1968; Derraik 2005; Laird 1995). *Culex asteliae* seems to have some resilience to habitat change, as it was recorded in exotic bromeliads in anthropic habitats. However, all records occurred in properties adjacent to native forest fragments of the Waitakere Ranges Regional Park (where its host plant is common), and these might have been cases of isolated oviposition from individuals moving out from the forest fringe. Laird (1995) also described *Cx. asteliae* from artificial containers in close proximity to *C. hastatum* specimens.

The endemic *Mg. argyropus* was recorded in both artificial and natural containers, but, similarly to *Cx. asteliae*, these records occurred in sites adjacent to Waitakere Ranges Regional Park. According to Hayes (1974) and Pillai (1965) *Mg. argyropus* is not capable of surviving outside large sections of native forest, and this species appears to have become rare and have a limited and disjointed presence in the North and South Islands (Snell et al. 2005). Both *Mg. argryropus* and *Cx. asteliae* are among the native species negatively affected by anthropogenic environmental change, and which seem to be displaced by the removal of indigenous forest cover.

The remaining native species recorded was *Cx. pervigilans*, which is New Zealand's most widespread mosquito. Although it is commonly found in anthropic habitats, this study gave some indication that this species is not a container breeder per se, as suggested by Belkin (1968) and Derraik & Slaney (2005). The same appears to apply to the exotic *Cx. quinquefasciatus* in the region, as both species seemed to be frequently present in drains and ground pools in the same locations where they were absent from exotic bromeliads and most artificial containers. Laird's (1990) survey indicated that artificial containers were highly exploited by *Cx. pervigilans*.

Overall, there was an almost complete dominance of exotic mosquitoes, more specifically *Oc. notoscriptus*, breeding in container habitats in anthropic environments in the Auckland region. In Australia, *Oc. notoscriptus* is the predominant peridomestic mosquito (Foley et al. 2004), and the same pattern is being observed in northern New Zealand .

It is clear that New Zealanders are unaware of mosquito breeding habits and basic control measures, and unwittingly provide a large supply of larval mosquito habitats. Plastic containers, buckets and pots are common features in private properties, and these are often left upright and filled with rainwater. *Ochlerotatus notoscriptus* is a potential disease vector (Derraik 2004a; Derraik & Calisher 2004), and the artificial and natural containers commonly found in urban and peri-urban areas provide an abundance of suitable habitats for this species. There seems to be therefore, a need for a public education campaign to mitigate general mosquito nuisance, and also to reduce the risk of a mosquito-borne disease outbreak.

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