A survey of the mosquito (Diptera: Culicidae) fauna of the Auckland Zoological Park

José G. B. Derraik

Ecology and Health Research Centre, Department of Public Health, Wellington School of Medicine & Health Sciences, University of Otago, P.O. Box 7343, Wellington, New Zealand.
Email: jderraik@wnmeds.ac.nz

Abstract

Following a previous outbreak of avian malaria and avian pox among captive breeding New Zealand dotterel chicks (*Charadrius obscurus*) in the Auckland Zoological Park, a study was carried out to determine the mosquito vectors breeding at the site and to explore their ecology. The survey identified three species: the native *Culex (Culex) pervigilans* Bergroth, and the exotic *Culex (Culex) quinquefasciatus* Say and *Ochlerotatus (Finlaya) notoscriptus* (Skuse). The second species is a known vector for avian malaria and avian pox. *Ochlerotatus notoscriptus* was by far the most abundant and widespread, accounting for 88% of all larvae collected and being present in all natural and artificial containers sampled. The abundance of breeding habitats for mosquitoes at Auckland Zoo requires the adoption of a management programme to reduce the risk of another disease outbreak.

Keywords: Auckland Zoo, mosquito, avian disease

Introduction

New Zealand has 16 mosquito species, but, to date, no outbreaks of mosquito-borne human diseases have been recorded (Ministry of Health 1997). However, one *Alphavirus* (Whataroa virus) has been isolated from the endemic *Culiseta (Climacura) tonnoiri* (Edwards) and *Culex (Culex) pervigilans* Bergroth in South Westland (Maguire *et al.* 1967; Ross *et al.* 1964). Other culicid species have been shown to be competent vectors of Whataroa virus in the laboratory (Holder *et al.* 1999). Hogg *et al.* (1963) provided evidence of Whataroa virus infection in man in Westland, but there has been no subsequent confirmation of the latter, and it is likely to have been mistakenly identified as such.

Experimental and field investigations into the ecology of Whataroa virus indicate the existence of a bird-mosquito cycle (Miles *et al.* 1971). A number of bird species seem to have been infected by Whataroa virus, including the native tui (*Prosthemadera novaeseelandiae*), bellbird (*Anthornis melanura*) and silvereye (*Zosterops lateralis*) (Miles *et al.* 1971; Ross *et al.* 1964). However, there is no evidence of illness or death amongst the birds studied, indicating that the infection is clinically unapparent (Miles *et al.* 1971).

The mosquito-borne diseases that represent a real threat to New Zealand native birds are avian malaria and avian pox. These two diseases were introduced with an efficient vector, *Culex (Culex) quinquefasciatus* Say, to Hawaii, where no mosquitoes were present before this species arrived in 1826 (Laird 1984). The result was disastrous and contributed to the extinction of many native bird species (van Riper *et al.* 1986). New Zealand's avifauna could suffer a similar fate.

Avian pox viruses have a worldwide distribution (Gerlach 1994) and effects can range from mild to fatal (Hansen 1999). Mosquitoes are vectors of avian pox viruses (Hansen 1999), but whether or not this is true of New Zealand species is unknown. Avian pox viruses have been recorded in several bird species in New Zealand, including the royal albatross (*Diomedea epomophora*) (Anon 1998) and the endangered Chatham Islands black robin (*Petroica traversi*) (Tisdall & Merton 1988).

Avian malaria is another arthropod-borne disease where haemoprotozoan agents (*Plasmodium* spp.) are transmitted by mosquitoes. Apart from the worldwide *C. quinquefasciatus*, another vector, *Ochlerotatus (Halaedes) australis* (Erichson), is present in New Zealand. Holder *et al.* (1999) suggested that the occurrence of avian malaria in this country outside the range of those two species could indicate that the native *C. pervigilans* may also be a vector. Though several native species are known to be affected, the overall significance of avian malaria to native birds in New Zealand has not yet been determined (Holder *et al.* 1999). For instance, avian malaria may be a major cause of deaths among endangered yellow-eyed penguins (*Megadyptes antipodes*) on the South Island (Graczyk *et al.* 1995). Host susceptibility to avian malaria

varies, and some widespread species, such as the exotic sparrow (*Passer domesticus*), song thrush (*Turdus philomelos*) and blackbird (*T. merula*) may be asymptomatic carriers (Laird 1950).

In 1996, a simultaneous outbreak of avian malaria and avian pox occurred among New Zealand dotterel chicks (*Charadrius obscurus*) in two captive-rearing institutions (Auckland Zoological Park and Otorohanga Kiwi House) located c. 150 km apart. Ten out of 16 birds died – a significant loss for this endangered species (Jakob-Hoff *et al.* unpublished data).

This study aimed to assess the risk posed by mosquitoes to the captive-rearing programme at the Auckland Zoological Park. An investigation was carried out to establish which species were breeding at the zoo, and to explore their ecology. Information gathered during this study was used to suggest management measures to prevent another outbreak.

Materials and Methods

A survey of the zoo grounds was carried out in summer 2002/3. Mosquito larvae were searched for in most of the available water-holding containers and other potential breeding sites, including ponds with stagnant water and drains. Some animal enclosures were excluded from the survey for safety reasons. Whenever larvae were found, they were collected for later identification. Mosquitoes were also identified from series of 8 oviposition traps (ovitraps) installed as part of another research project (Derraik, unpublished data). Most identifications were carried out on larval stages, but some specimens were reared to adults for confirmation.

Results

A large number of mosquito habitats were found, which held breeding populations of three species: the native *C. pervigilans*, and the exotics *C. quinquefasciatus* and *Ochlerotatus (Finlaya) notoscriptus* (Skuse). The last was by far the most widespread species, being recorded in all but one of the 54 larva-positive habitats (excluding ovitraps) (Table 1).

The occupancy rate of suitable artificial containers (excluding ovitraps) was 100%, as all 30 water-filled containers encountered were larva-positive (Table 1). All of these contained larvae of *O. notoscriptus*, while seven also contained *C. pervigilans* (Table 1). The most abundant type of artificial containers were discarded tyres (17/30), all of which harboured larvae, mostly *O. notoscriptus* (Table 1). Three tyres also contained *C. pervigilans* (Table 1). A variety of other containers harboured *O. notoscriptus* larvae, including abandoned plastic saucers, the rim of a plastic lid, and even a steel tub used constantly for cooling hot metals outside a workshop.

A variety of natural breeding containers were also found (Table 1), in which the only species recorded was *O. notoscriptus*. The most abundant natural containers were numerous specimens of exotic bromeliads and the native epiphyte *Collospermum hastatum* along the "rainforest" boardwalk. Both plant types are capable of retaining water in their leaf axils, which are suitable mosquito breeding sites. The occupancy rate of natural containers was lower than that of artificial ones, with about 15% of bromeliads and 25% of *C. hastatum* plants being larva-positive (Table 1).

A number of drains were inspected, and a group of three was found to contain culicids at very high densities. Two contained larvae of both *O. notoscriptus* and *C. quinquefasciatus*, while the third also contained *C. pervigilans*. All three species were recorded in the ovitraps, though only *O. notoscriptus* was commonly present, making up 88% of the 3020 larvae identified. Ovitraps showed that there was continuous mosquito oviposition (and hence presence) throughout the sampling period, with peak activity in March (Derraik unpublished data).

Discussion

The major concern is the presence of *C. quinquefasciatus* at the site, whose larval numbers were substantial in some man-made drains surveyed. This species is a major vector of avian malaria and avian pox, and it is the likely vector of the diseases that killed New Zealand dotterel chicks in the 1996 outbreak. The native *C. pervigilans*, collected at the Zoo from a variety of larval breeding habitats, is not known to be a disease vector, but it may have a role in the transmission of avian malaria (Holder *et al.* 1999), and research is urgently needed to address this issue. *Ochlerotatus notoscriptus*, the most abundant species at the Auckland Zoo, is an important vector of *Dirofilaria immitis* (canine heartworm) and a potential vector

Table 1. Collection records of mosquito larvae from the Auckland Zoological Park. The number of particular species associations recorded for each habitat is indicated. Unless otherwise stated, all natural container habitats refer to leaf axils.

Habitat Type	Larval Habitat Description [n]	*Ochlerotatus notoscriptus*	*Culex pervigilans*	*Culex quinquefasciatus*
Artificial container	Abandoned bathtub [1]	X	X	
	Bucket with plant [2]	X	X	
	Hot metal cooling tub [1]	X		
	Plant pot [1]	X		
	Plastic saucer [2]	X		
	Plastic lid rim [1]	X		
	Polythene sheet pool [1]	X	X	
	Polythene sheet pool [4]	X		
	Used tyre [3]	X	X	
	Used tyre [14]	X		
Artificial habitat	Drain [1]	X	X	X
	Drain [2]	X		X
Natural container	Bamboo [4]	X		
	Banana tree [3]	X		
	Bromeliad [6]	X		
	Collospermum hastatum [6]	X		
	Melicytus ramiflorus (tree-hole) [1]	X		
Natural habitat	Waterfall pond [1]		X	

of myxomatosis virus (Lee & Bugledish 1999).

Mosquito-borne diseases that affect people are also of concern. The abundant and widespread *O. notoscriptus* originated from Australia, where it is a probable urban vector of Ross River virus (Russell 1995; Watson & Kay 1997), Barmah Forest virus (Watson & Kay 1999) and Rift Valley Fever (Turell & Kay 1998). Derraik and Calisher (2004) have recently suggested that the species could play a significant epidemiological role in a Ross River virus outbreak. The Auckland Zoo could become an important focus for the spread of disease, where the contact between infected person, vector, and reservoir would be maximized. The latter role could be played by wallabies (*Macropus* spp.) resident at the zoo, as macropods are the primary vertebrate hosts of the virus in Australia (Russell 2002). Another potentially more important host is the Brushtail Possum (*Trichosurus vulpecula*). These animals are extremely abundant in urban and peri-urban areas and would most likely aid the spread of the disease, as they are competent intermediate hosts of RRV (Boyd *et al.* 2001; Kelly-Hope *et al.* 2002).

Mosquitoes in New Zealand appear to underutilise containers for breeding (Laird 1990). However, the 100% occupancy rate of artificial containers and the abundance of larvae in ovitraps and other

habitats indicate they are a very suitable environment for mosquito breeding at the Auckland Zoo. A recent study at the Wellington Zoo indicated that the density of mosquitoes there was much higher than in native habitats (Derraik *et al.* 2003), possibly because of a higher density of available hosts.

As a result, a mosquito control programme should be established at the Auckland Zoo. Such a programme would reduce the risk to both animals and humans, and hence prevent the development of disease foci in surrounding areas. Moreover, disease control per se is not the only reason to control the mosquito fauna. The author experienced extreme discomfort while working in many areas at the zoo, caused by the constant attack of dozens of mosquitoes at any given time. This is likely to be a nuisance to the general public visiting the zoo. It is also likely that most animals are subjected to significant levels of mosquito-related stress within their enclosures.

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