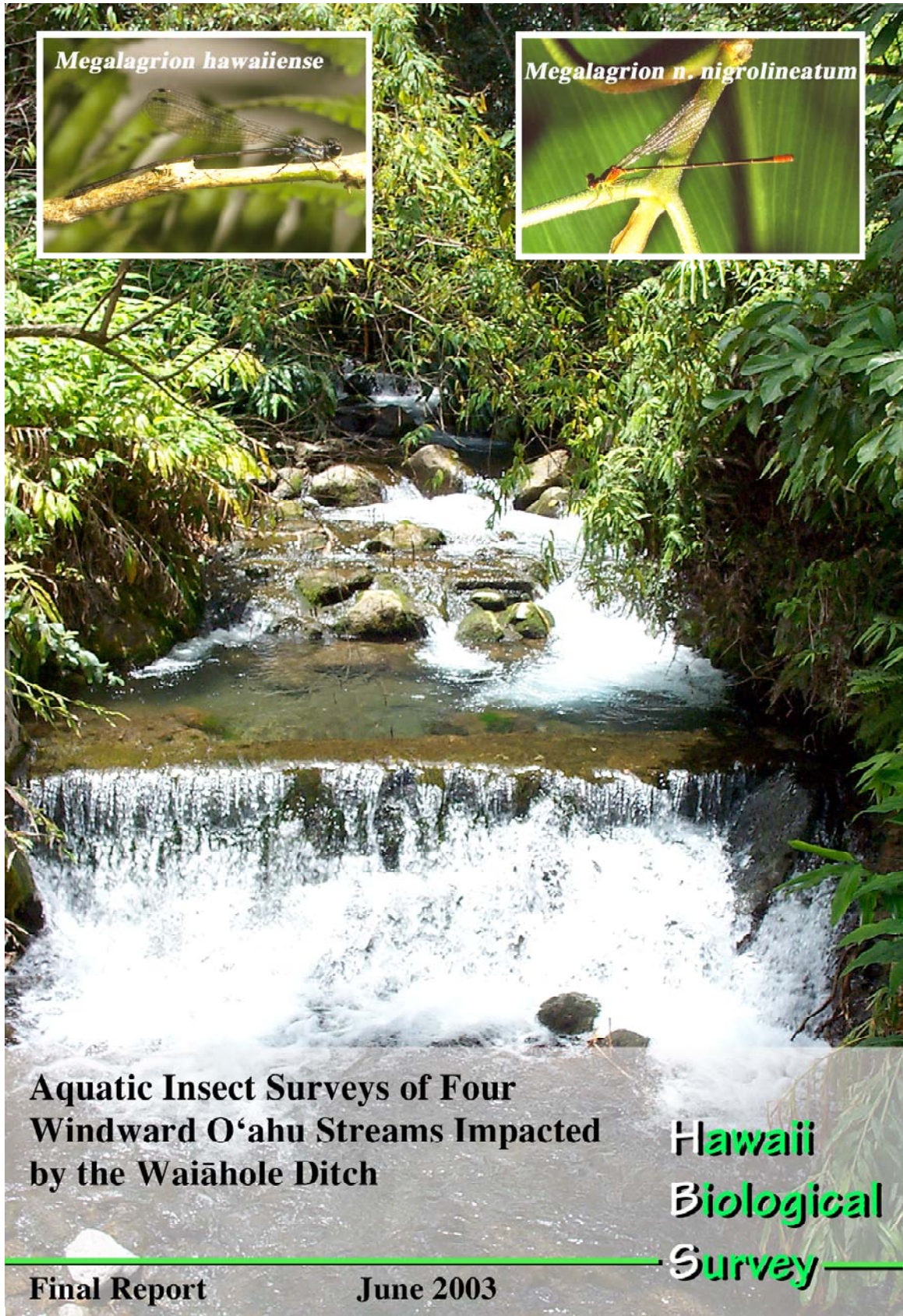


Megalagrion hawaiiense



Megalagrion n. nigrolineatum



**Aquatic Insect Surveys of Four
Windward O'ahu Streams Impacted
by the Waiāhole Ditch**

**Hawaii
Biological
Survey**

Final Report

June 2003

**Aquatic Insect Surveys of Four Windward
O'ahu Stream Systems Impacted by the Waiahole Ditch**

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INTRODUCTION

The Hawaii Biological Survey (HBS) of the Bishop Museum collected and identified aquatic insects in four windward O'ahu streams in coordination with fish sampling by the Hawaii Division of Aquatic Resources (HDAR) and algae sampling by Dr. Alison Sherwood, University of Hawaii. The purpose of these surveys was to develop a baseline inventory of all aquatic invertebrate species present in four major windward streams (Waiāhole, Waikāne, Hakipu'u and Kahana) impacted by water diversions from the Waiāhole Ditch. These surveys were conducted for the Hawaii Division of Aquatic Resources (HDAR) to assess freshwater resources in streams that have historically been diverted by the Waiāhole Ditch. This project was conducted in two phases: 1) first phase involving investigations of all aquatic invertebrates (except for aquatic insects); 2) second phase involving freshwater aquatic insects. This is the second phase of the project. The first phase of sampling non-aquatic insect invertebrates was completed by Englund and Preston (2002).

STUDY AREA

A complete description of Waiāhole, Waikāne, Hakipu'u and Kahana watersheds can be found in Englund et. al (2002) and Filbert and Englund (1995). Three of these streams, Waiāhole, Waikāne, and Hakipu'u, drain into Kāne'ohe Bay while Kahana Stream empties into Kahana Bay, the first bay found north of Kāne'ohe Bay. These streams originate as amphitheater-headed valleys along the steep crests of the central western Ko'olau mountain range. Because of the close proximity of the Ko'olau mountain range to the ocean, channel lengths for Kāne'ohe Bay streams are abbreviated when compared to the longer leeward O'ahu stream channels. This also leads to steeper stream gradients and a relatively straight, non-sinuuous stream channel when compared to leeward O'ahu Ko'olau mountain stream channels. Hydrologic conditions of these windward O'ahu streams have been greatly altered by stream diversions and groundwater wells (Takasaki et al. 1969). This has resulted in the loss of numerous springs flowing into these streams and decreased streamflow (Miyagi 1963; Devaney et al. 1976). It should be noted that Waianu and Uwau Streams are tributaries of Waiāhole Stream, and thus hydrologically are part of the same watershed. Table 1 denotes stream sampled, dates of sampling, and GPS points (WGS 84).



Waiahole: 500 ft, HECO pump station



Kahana: 190 ft, *Megalagrion hawaiiense* habitat

Table 1. Streams sampled, sampling sites, GPS waypoints, and dates sampled.

Stream	GPS (WGS 84)	Dates Sampled
Waiāhole 800 ft (Gate 31)	N 21.47326° W 157.88454°	21 May 2002; 11 Nov 2002; 30 April 2003
Waiāhole 500 ft (HECO station)	N 21.47111° W 157.88029°	22 Feb 2002; 21 May 2002; 11 Nov 2002; 30 April 2003
Uwau 160 ft	N 21.48472° W 157.87028°	23 Feb 2002; 25 Feb 2002; 27 Dec 2002
Waianu 150-200 ft	N 21.48178° W 157.86118°	23 Feb 2002; 25 Feb 2002; 27 Dec 2002
Waikāne 680-800 ft	N 21.49976° W 157.88944° N 21.50202° W 157.88609°	21 Feb 2002; 18 Nov 2002; 11 Nov 2002; 4 Mar 2003;
Hakipu'u 20-120 ft	N 21.50852° W 157.85595° N 21.50880° W 157.86126°	19 Feb 2002; 20 Feb 2002; 4 Dec 2002; 6 Mar 2003;
Kahana 60-410 ft	N 21.52808° W 157.89952° N 21.52360° W 157.89724°	20 May 2002, 26 Dec 2002, 3 April 2003,

METHODS

Biological assessments of Waiāhole, Waikāne, Hakipu'u and Kahana Streams began February 2002 and ended April 2003. Sampling took place during periods of dry and mostly sunny weather and streams were generally sampled at low basal flow. Sampling occurred concurrently with HDAR biologists. At least 4-5 stations on each stream were surveyed for aquatic insects. Occasional spot sampling and visual observations of aquatic insects also occurred during the hike upstream between each new sampling station. Aquatic insect sampling was also conducted within the same areas as algal sampling by Dr. Alison Sherwood.

Aquatic invertebrate sampling was conducted according to Englund and Arakaki (2003) and Englund and Preston (1999). Invertebrates were collected with aerial nets, fine-meshed dip nets, kick-netting, and Surber (benthic) samplers. Kick netting was similar to using a Surber sample and involved vigorous displacement of the substrate upstream of a fine meshed aquatic net to displace any aquatic insects inhabiting the stream substrate. The use of frequent kick-netting allowed for a greater sample size and resulted in increased effort for aquatic insect collections. Benthic sampling also included collecting individual rocks and using a toothbrush or forceps to remove insects from variously sized stream rocks. Above and below water visual observations for aquatic insects were also conducted as we moved between sampling stations. Sampling effort was focused on all suitable aquatic habitats such as splash zones around riffles and cascades, wet rock faces associated with springs and seeps, waterfalls, nearby wetland areas associated with the streams, and variously-sized stream substrates. All aquatic habitats were sampled. Invertebrate specimens were stored in 75% ethanol and subsequently transported to the Bishop Museum Entomology laboratory for curation and identification. Voucher specimens are currently housed in the Bishop Museum collection.

RESULTS AND DISCUSSION

The purpose of these surveys was to develop a baseline inventory of aquatic insect species present in the four major windward streams (Waiāhole, Waikāne, Hakipu'u and Kahana) impacted by water diversions from the Waiāhole Ditch. The current study presents the results of freshwater aquatic insect surveys. Nonindigenous or alien aquatic species are those that have been brought into Hawai'i both accidentally and intentionally. Species of undetermined geographic origin are termed cryptogenic (Carlton 1996) and are usually assumed to be introduced. Taxa with only females collected could not be identified to the species level as males are generally needed for species identification of most aquatic flies (Diptera).

A total of 39 species of aquatic insects were identified for this study with 23 native species and 16 introduced species found in the streams examined. A complete list of species collected during this survey, including their geographic origin can be found in Table 2. The areas containing the highest percentages of native aquatic insects were found in the uppermost reaches of Waiāhole and Waikāne Streams with percent of native species ranging from 71% (Waikāne) to 80% (upper Waiāhole). The percentage of native aquatic insect fauna found in these two streams now compares favorably with that found Pelekunu Stream, Moloka'i (74-81% native species), perhaps one of the most pristine streams remaining in the Hawaiian archipelago (Englund 2001, Englund and Arakaki 2003). Figure 1 provides a comparison of aquatic insect species numbers in Waiāhole Stream between 1995 and 2003.

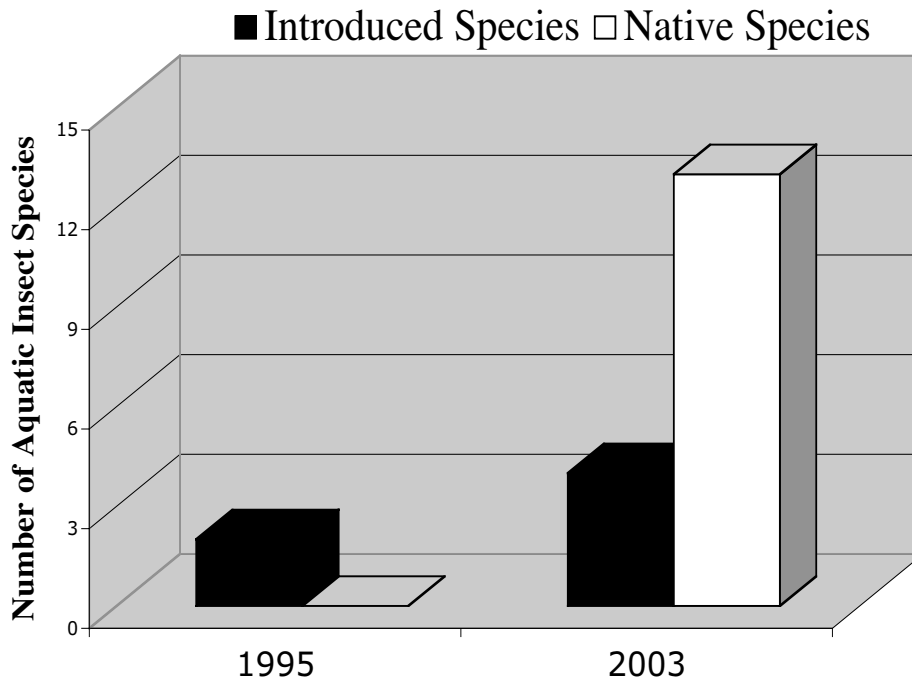


Figure 1. Number of aquatic insect species in main Waiāhole Stream, (500 ft elevation) immediately after flow increases in 1995 (Filbert and Englund, 1995), and after 8 years of augmented flow in 2003.

Aquatic Insect Surveys of Windward O'ahu Stream Systems Impacted by the Waiāhole ditch

Table 2. Results of Hawaii Biological Survey, Bishop Museum 2002-2003 aquatic insect surveys conducted in Waiāhole, Waikāne, Hakipu'u and Kahana Streams.

Taxon	Waianu 150-300 ft	Uwau 160 ft	Waiāhole 500 ft	Waiāhole 800 ft	Waikāne Stream	Hakipu'u Stream	Kahana Stream 80-400 ft	Status ¹
Aquatic Insects								
Anisoptera (Dragonflies)								
Aeschnidae								
<i>Anax strenuus</i>					X			End
Libellulidae								
<i>Nesogonia blackburni</i>				X				End
<i>Pantala flavescens</i>							X	Ind
<i>Orthemis ferruginea</i>	X							Int
Zygoptera (Damselflies)								
Coenagrionidae								
<i>Ischnura posita</i>			X					Int
<i>Ischnura ramburii</i>							X	Int
<i>Megalagrion hawaiiense</i>				X	X		X	End
<i>Megalagrion n. nigrolineatum</i>							X	End
Heteroptera (True Bugs)								
Notonectidae								
<i>Buenoa pallipes</i>							X	Int
Saldidae								
<i>Saldula exulans</i>			X	X	X		X	End
<i>Saldula procellaris</i>					X			End
Veliidae								
<i>Microvelia vagans</i>	X	X	X		X		X	End
Diptera (Flies, gnats)								
Canacidae								
<i>Canaceioides angulatus</i>				X				Int
<i>Procanace wirthi</i>			X	X				End
Ceratopogonidae								
<i>Dasyhelea hawaiiensis</i>			X				X	End
Chironomidae								
<i>Clunio</i> sp. nr. <i>vagans</i>				X				End
<i>Cricotopus bicinctus</i>					X	X	X	Int
<i>Orthocladus</i> sp.			X		X	X		End
Dixidae								
<i>Dixa longistyla</i>					X			Int
Dolichopodidae								
<i>Campsicnemus brevipes</i>			X				X	End
<i>Campsicnemus</i> sp.					X			End
<i>Condylostylus longicornis</i>						X		Int
<i>Chrysotus longipalpus</i>						X		Int

Aquatic Insect Surveys of Windward O'ahu Stream Systems Impacted by the Waiāhole ditch

Table 2 (cont). Hawaii Biological Survey, Bishop Museum 2002-2003 aquatic insect surveys conducted in Waiāhole, Waikāne, Hakipu'u and Kahana Streams.

Taxon	Waianu 150-200 ft	Uwau 160 ft	Waiāhole 500 ft	Waiāhole 800 ft	Waikāne Stream	Hakipu'u Stream	Kahana Stream 80-400 ft	Status ¹
Ephydriidae								
<i>Brachydeutera ibari</i>	X					X		Int
<i>Scatella cilipes</i>			X		X		X	End
<i>Scatella clavipes</i>			X				X	End
<i>Scatella hawaiiensis</i>			X		X			End
<i>Scatella oahuense</i>			X	X	X		X	End
Psychodidae								
<i>Clogmia albipunctata</i>						X		Int
Sciaridae								
Genus sp.						X		Cry
Tethinidae								
<i>Dasyrhicnoessa insularis</i>			X					Ind
Tipulidae								
<i>Erioptera bicornifier</i>						X		Int
<i>Limonia advena</i>			X			X		Int
<i>Limonia jacobae</i>			X	X			X	End
Tipulidae sp.							X	End
Trichoptera (Caddisflies)								
Hydropsychidae								
<i>Cheumatopsyche analis</i>	X	X	X	X	X	X	X	Int
Hydroptilidae								
<i>Hydroptila icona</i>							X	Int
<i>Hydroptila potosina</i>	X	X	X		X	X	X	Int
Lepidoptera (Aquatic Moths)								
<i>Hyposmocoma</i> sp. 1 ^a			X	X				End
Total: Int.+ Nat. + Cry. Spp.	5	3	17	10	14	11	18	
Total Native Aquatic Species	1	1	13	8	10	1	12	
(%) Native Aquatic Species ¹	20	33	76	80	71	10 ²	67	

¹End = Endemic, Ind = Indigenous, Int = Introduced, Cry = Cryptogenic, Pur = Purposeful

²Cryptogenic species not included in percent native species calculation

^aNarrow, pointy, cone-shaped case

Thus, the upper reaches of both Waiāhole and Waikāne Streams have a native insect fauna that currently compares favorably to free-flowing streams unimpacted by alien species, in contrast to the insect fauna prior to stream flow restoration. This is especially remarkable for Waiāhole Stream when comparing the status of aquatic insects in upper Waiāhole shortly after flow restoration in 1995 (Figure 1). Since 19 December 1994 flows in the mainstem Waiāhole Stream (and other tributaries and Waikāne Stream at later dates) have been augmented to varying degrees with water from

Gate 31 of the Waiāhole Ditch. Aquatic insect surveys were conducted in Waiāhole Stream shortly after flow augmentation from February to August 1995 (Englund and Filbert 1995) in the same locations and using identical methodologies as used in the current study. Filbert and Englund (1995) found only two species of introduced aquatic insects in Waiāhole Stream at the HECO pump station area (500 ft elevation) during five months of monitoring. Unlike the area around Gate 31 where ditch leakage prior to the 1994 flow augmentation provided some aquatic insect habitat, the reach of Waiāhole Stream at the HECO pump station area was virtually dry (except during heavy rains). However, the present study found 13 native species of aquatic insects at the HECO pump station area. It is of great interest that 76% of the 17 aquatic insect taxa currently found at this station were native species, whereas surveys conducted in 1995 found no native species in the same area. This significant finding establishes that native aquatic insect fauna are adaptable and will return to an aquatic habitat if stream flow is restored. Eight years after flow augmentation it is apparent that native aquatic insects have returned to upper Waiāhole Stream in similar percentages and numbers of species as in some of the most pristine stream systems in Hawai'i.

Overall, native taxa were found in higher percentages in the upper elevation areas of each stream. For example, Hakipu'u Stream maintains a much lower natural baseflow because of its smaller size than the other watersheds examined in this study and concurrently had a depauperate aquatic insect fauna with only 10% native species—the lowest percent of native taxa found in the present study. The areas of lower Waianu and Uwau Stream also had lower amounts of native species, ranging from 20% for the former and 33% for the latter (Table 2).

Kahana Stream, however, maintains rare and endemic insects at some of the lowest elevations recorded on O'ahu, and is one of the most important streams for maintaining native aquatic insect biodiversity on this island. Although not observed during this survey, the very rare O'ahu endemic *Megalagrion leptodemas* was observed here as recently as the mid 1990s (Englund 1999). As it often takes many collection trips to observe or collect the rare Hawaiian damselfly species, further efforts are needed to verify this species is still found in the Kahana watershed.

However, two other native damselfly species were observed in Kahana Stream at exceptionally low elevations providing hope that *M. leptodemas* populations still remain in Kahana Stream. For example, the blue O'ahu color form of *Megalagrion hawaiiense* was collected at an elevation of as low as 190 ft in Kahana Stream during this study, and also found in the upper elevations of Waikāne Streams. Formerly, *Megalagrion* damselflies were found from the very lowest portions of Hawaiian streams where they enter the ocean (Polhemus and Asquith 1996), but are now absent from virtually all low-elevation O'ahu streams because of alien fish introductions into lowland aquatic habitats (Englund 1999). The formerly common at low elevations (Polhemus and Asquith 1996) but now rare O'ahu native damselfly *Megalagrion hawaiiense* was collected at a current record low O'ahu elevation of 190 ft in Kahana Stream (Table 3). Repeated site visits were necessary to find and collect the native *Megalagrion* damselflies during these surveys because of either poor weather conditions, seasonal abundance (particularly with *M. hawaiiense*), or because the species are now

rare. Identical to the 1995 surveys (Filbert and Englund 1995), three of the four watersheds examined during the present study contained *Megalagrion* damselflies, and with the exception of Kahana Stream they were present in the uppermost headwater areas. Native damselflies were not observed in Hakipu'u Stream both in 1995 and in 2003, most likely because this stream substantially differs from the other streams, and had a very poor aquatic insect community, with only 10% native species. Hakipu'u does not emerge from the dike headwalls as do the other stream assessed during this study but instead emerges as a series of diffuse and small low elevation (300 ft) springs containing high densities of alien poeciliid fish.

Table 3. GPS readings where native *Megalagrion* damselflies were collected during 2003-2003 surveys conducted in Waiāhole, Waikāne, Hakipu'u and Kahana Streams, O'ahu.

Species	Stream	GPS (WGS 84)	Date Observed	Number Collected/Observed
<i>M. hawaiiense</i>	Waiāhole 800 ft (Gate 31)	N 21.47326° W 157.88454°	30 April 2003	1 observed
<i>M. hawaiiense</i>	Waikāne, 680 ft	N 21.50202° W 157.88609°	4 Mar 2003;	5 collected
<i>M. hawaiiense</i>	Kahana, 190 ft, elevated seep	N 21.52808° W 157.89952°	3 April 2003	1 collected
<i>M. n. nigrolineatum</i>	Kahana, 220 ft-elevated side trib.	N 21.52882° W 157.89870°	3 April 2003	3 collected
<i>M. n. nigrolineatum</i>	Kahana, 410 ft	N 21.52360° W 157.89724°	3 April 2003	8 collected

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