

**Addendum to
Non-Insect Aquatic Invertebrate Surveys of Four Windward
O'ahu Stream Systems Impacted by the Waiāhole Ditch**

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INTRODUCTION

The Hawaii Biological Survey (HBS) of the Bishop Museum collected and identified certain stream invertebrates in four windward O'ahu streams in coordination with fish sampling by the Hawaii Division of Aquatic Resources (HDAR). The purpose of these surveys was to develop a baseline inventory of aquatic invertebrate species present in four major windward streams (Waiāhole, Waikāne, Hakipu'u and Kahana) impacted by water diversions from the Waiāhole Ditch. To provide more baseline information on these streams additional surveys of these streams were also conducted, with these surveys ending in December 2002.

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 is being conducted in two phases, with the current first phase involving investigations of all aquatic invertebrates (except for aquatic insects), and the second phase involving freshwater aquatic insects. The second phase of this study is ongoing and will be conducted within the same streams through June 2003. Sampling for this study occurred concurrently with fish surveys by HDAR biologists, and also with algae surveys conducted by Dr. Allison Sherwood of the University of Hawaii.

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'ohē Bay, while Kahana Stream empties into Kahana Bay, the first bay found north of Kāne'ohē 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'ohē 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 four 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 sample stream, dates of sampling, and equivalent HDAR point count site number.

Table 1. Description of sampling areas that includes streams sampled, sampling sites, dates sampled and HDAR sample numbers from HDAR point count datasheets.

Stream (HDAR Site#)	Sample Dates
Uwau (Site 49)	25 Feb 2002
Waianu (Site 8)	25 Feb 2002
Waianu (Site 18)	23 Feb 2002
Waianu (Site 34-38)	25 Feb 2002
Waianu (Site 61)	23 Feb 2002
Waiāhole (Site 30)	21 May 2002
Waiāhole (Site 38)	22 Feb 2002
Waikāne (Site 1)	21 Feb 2002
Waikāne (Site 55)	21 Feb 2002
Hakipu'u (Site 1)	19 Feb 2002
Hakipu'u (Site 13)	19 Feb 2002
Hakipu'u (Site 15)	20 Feb 2002
Hakipu'u (Site 27)	19 Feb 2002
Kahana (Sites 11-12)	20 May 2002
Kahana (Site 34)	20 May 2002
Waikane (below Waiāhole Ditch)	11 Nov 2002
Waikāne (near ocean)	18 Nov 2002
Hakipu'u Stream (near ocean)	4 Dec 2002
Kahana (Nakoa Trail Crossing)	26 Dec 2002
Uwau (above BWS gate)	27 Dec 2002
Waianu (at Reppun taro farm)	27 Dec 2002

METHODS

Biological assessments of Waiāhole, Waikāne, Hakipu'u and Kahana Streams began in February and ended in December 2002. 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, and station numbers were taken from HDAR fish point-count data sheets. Additional sampling started in November 2002, and ended in December 2002. At least 4-5 stations on each stream were surveyed for aquatic Mollusks (snails), Crustaceans, Porifera (freshwater sponges), Platyhelminthes (flatworms), Annelida (Oligochaeta, or freshwater worms), and Annelida (Polychaeta). Occasional spot sampling also occurred during the hike upstream between each new sampling station.

Freshwater invertebrate sampling was also conducted within the same areas as algal sampling by Dr. Allison Sherwood.

Aquatic Invertebrate Sampling

Aquatic invertebrate sampling was conducted according to Englund *et al.* (2000) and Englund and Preston (1999). Invertebrates were collected with fine-meshed dip nets, kick-netting, and Surber (benthic) samplers. Kick netting was similar to using a Surber sample, and involved vigorously disturbing the substrate upstream of a fine meshed aquatic net to displace any aquatic invertebrates inhabiting the stream substrate. The use of frequent kick-netting allowed for a greater sample size and resulted in increased effort for invertebrate collections. Benthic sampling also included collecting individual rocks and using a toothbrush or forceps to remove invertebrates from variously sized stream rocks. Above and below water visual observations for aquatic invertebrates were also conducted as we traveled 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 – AQUATIC BIOTA

The purpose of these surveys was to develop a baseline inventory of aquatic invertebrate 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 invertebrate surveys, while ongoing surveys of aquatic insects will be incorporated into a report that will be finalized in July 2003.

Compared to the more thoroughly studied Hawaiian aquatic insects, relatively little taxonomic research has been conducted on the non-insect invertebrate fauna of Hawaiian streams. This lack of knowledge has led to uncertainty in species identification and also if a given taxon is native or introduced. Nonindigenous aquatic species have been brought into Hawai‘i both accidentally and intentionally, and species of undetermined geographic origin are termed cryptogenic (Carlton 1996), with cryptogenic species usually assumed to be introduced. Although they can be common in O‘ahu streams such as the Kaukonahua (R. Englund, pers. obs.), freshwater sponges were not observed within any of the streams sampled during this study.

A total of nine species of aquatic macrofauna have been identified for this study, and a complete list of species including their geographic origin can be found in Table 2. Two native aquatic species (*Hyalella azteca* and *Atyoida bisulcata*), one cryptogenic (*Ferrisia sharpi*), and six introduced aquatic species were identified during this survey. Because sampling was benthic in nature, e.g., concentrating on assessing the biota in the stream substrate, some prominent macroinvertebrates were not included in Table 2, such as *Macrobrachium grandimanus*



Melanooides tuberculata

or *M. lar*. However, the presence or absence of these large macroinvertebrates was noted by HDAR personnel during random point counts conducted at the same stations. Additionally, introduced parasitic fish leeches such as *Myzobdella lugubris* inhabit the streams sampled during this survey (Font 1997), but they were not collected during benthic sampling because these parasites are only found attached to free swimming fish, and are not normally found in the stream substrate.

Table 2. Results of Hawaii Biological Survey, Bishop Museum surveys conducted for non-insect aquatic invertebrate species in four streams affected by the Waiāhole Ditch, O‘ahu Island. Site numbers conform to HDAR fish count sample numbers.

Taxon	Uwau Site 49	Waianu Site 8	Waianu Site 18	Waianu Sites 34-38	Waianu Site 61	Waiāhole Site 3	Waiāhole Site 30 (21 May 2002)	Waiāhole Site 38	Waikāne Site 1	Waikāne Site 55-60	Hakipu‘u Site 1	Hakipu‘u Site 13	Hakipu‘u Site 15	Hakipu‘u Site 27	Kahana Sites 11-12	Kahana Site 34	Status ¹
Platyhelminthes																	
Turbellaria																	
<i>Dugesia</i> sp.?	X	X	X	X	X	X	X	X	X	X	X	X	X	X			Int
Annelida																	
Oligochaeta																	
Megascolecidae sp. 1		X			X			X	X		X	X			X	X	Int
Mollusks																	
Ancylidae																	
<i>Ferrissia sharpi</i>											X	X					Cry
Corbiculidae																	
<i>Corbicula fluminea</i>			X														Int
Planorbidae																	
<i>Planorbella duryi</i>			X					X									Int
Thiaridae																	
<i>Melanoides tuberculata</i>			X							X	X						Int
<i>Tarebia granifera</i>									X			X	X				Int
Crustaceans																	
Amphipoda																	
<i>Hyaella azteca</i>	X		X			X	X							X			Ind
Atyidae																	
<i>Atyoida bisulcata</i>	X	X	X			X	X	X	X	X		X		X		X	End

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

Table 3. Results of Hawaii Biological Survey, Bishop Museum additional surveys conducted for non-insect aquatic invertebrate species in four streams affected by the Waiāhole Ditch, O‘ahu Island.

Taxon	Waikāne (Below Waiāhole Ditch)	Waikāne near ocean	Hakipu‘u near ocean	Kahana (Nakoa trail crossing)	Uwau (above BWS gate)	Waianu (Reppun taro area)	Status ¹
Platyhelminthes							
Turbellaria							
<i>Dugesia</i> sp.?	X	X	X	X	X	X	Int
Annelida							
Oligochaeta							
Megascolecidae sp. 1	X				X		Int
Mollusks							
Ancylidae							
<i>Ferrissia sharpi</i>			X				Int
Corbiculidae							
<i>Corbicula fluminea</i>						X	Int
Lymnaeidae							
Lymnaeidae sp.				X	X		Cry
Thiaridae							
<i>Melanoides tuberculata</i>		X	X	X	X	X	Int
<i>Tarebia granifera</i>							Int
Crustaceans							
Amphipoda							
<i>Hyalella azteca</i>	X						Ind
Atyidae							
<i>Atyoida bisulcata</i>	X				X		End

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

Platyhelminthes

One species of flatworm in the family Turbellaria, *Dugesia* ? sp., was ubiquitous and found in nearly all streams and all sites sampled during this study. *Dugesia* ? sp. was commonly found even at the higher elevation study areas, such as the heavily flowing section of Waiāhole (Site 30, sampled 21 May 2002) Stream near the HECO substation. *Dugesia* sp. was abundant here in this extremely highly flowing and turbulent section of Waiāhole Stream, and the restored stream appeared to have no effect on this introduced invertebrate species. Although *Dugesia* sp. and other Tricladida flatworms are highly predaceous (Kolasa 1991), no information exists regarding the effects of this species on native Hawaiian stream biota. In contrast to high densities of this species being found at virtually every sampling station, very low numbers of *Dugesia* ? sp. were found in the Kahana Stream, Nakoa trail stream crossing area.

Annelida

One species of earthworm in the family Megascolecidae was commonly encountered during this study (Table 2). This species is relatively small compared to other earthworm species commonly found in Hawaiian streams. No native species of terrestrial or freshwater Oligochaeta are found in the Hawaiian Islands. These worms are considered terrestrial but can live for extended periods of time in both aquatic and mud or moist-soil habitats (Dr. L.G. Eldredge, Bishop Museum, pers. comm.). Most of the worms collected during this study were buried deep in the substrate in fast riffle zone areas of the streams, indicating they likely were not recently accidentally washed into the stream.

Crustaceans

Only one native species of atyid shrimp ‘ōpae kuahiwi (*Atyoida bisulcata*), was collected during benthic sampling undertaken during this study. Several other native and introduced shrimp species are found in these streams, and although these species were not collected during benthic sampling, they were observed and noted by HDAR fish biologists conducting random snorkel point-counts. Another indigenous species of native crustacean, the aquatic amphipod, was also commonly collected during benthic sampling. The rapidly spreading (Englund and Cai 1999) introduced grass shrimp (*Neocaridina denticulata sinensis*) was not found in any of the streams sampled during the present study, and all streams sampled had robust and healthy populations of the native atyid shrimp ‘ōpae kuahiwi. Recruits of ‘ōpae kuahiwi as small as 6-7 mm were abundant and collected during benthic sampling in lower sections of most of the streams surveyed during this study.



Mollusks

The native freshwater mollusk fauna of the Hawaiian Islands includes very few species, most in the families Lymnaeidae and Neritidae (Cowie *et al.* 1997). However, a greater number of alien species has been introduced to the islands (Cowie 1997, 1998) and these species now dominate the mollusk fauna of most freshwater ecosystems, especially those that have been modified for human use. A total of four species of snails, one species of clam, and one species of freshwater limpet were identified during this survey (Table 2). Of these mollusk species, four are introduced and the status of the freshwater limpet, *Ferrisia sharpi*, is cryptogenic (uncertain), but most likely an introduction. The lymnaeid snail species found in Kahana and Uwau Streams also has a cryptogenic origin. The species of introduced snails collected during the present study are all widespread throughout the Hawaiian Islands, as is the introduced Asiatic clam (*Corbicula fluminea*). Apple snails (*Pomacea*) are a pest species of great concern (Cowie 2001), and although they were collected in large numbers in lower Waikāne Stream immediately adjacent to Kamehameha Highway by R. Englund in 1995 (Lach and Cowie 1999) none were observed in the same areas during 2002, or in any of the areas surveyed during this study.

Little is known about the biology of the very small (< 6 mm) and inconspicuous *F. sharpi*, and although originally described from Hawaii this species is broadly distributed throughout the tropical Pacific (Cowie 1997). *Ferrisia sharpi* appears to be mainly limited in distribution to streams near urban areas, and is also highly tolerant of alien species and disturbed water quality conditions, and all of these indicators provide some evidence this species is introduced. This tiny limpet likely has little detrimental effect on native stream organisms, especially considering that it is generally found in disturbed streams.

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