



Analysis of Kaua‘i
Invertebrate Benthic Samples

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Analysis of Kaua'i Aquatic Invertebrate Benthic Samples

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INTRODUCTION

The Hawaii Biological Survey (HBS) was contracted by the State of Hawaii, Department of Health (DOH), Environmental Planning Division to conduct an analysis of aquatic invertebrates collected from various streams on the island of Kaua'i. These samples were collected in July and August 2003 by DOH personnel using a modified Surber or bottom sampler (Tetra Tech, Inc. 2004) for later invertebrate analysis. HBS staff conducting the analysis and identifying organisms included Ron Englund, Heather Laedrich, Azadeh Ghotaslou, Keith Arakaki, Anna Scott, and Holly Bollick.

The study was funded through the Department of Health, Environmental Planning Office from USEPA; the CWA 106 WPCP Grant (I-00915004-0) and the Water Quality Management Planning Grant (C6-99939203-1).

METHODS

Aquatic invertebrate analysis for this study was conducted on the contents of 40 one-liter sample bottles collected by the State of Hawaii, Department of Health, from the island of Kaua'i, with sample locations shown in Table 1. The contents of individual sample bottles were analyzed, and any identifiable invertebrates were sorted from other organic debris found in the samples. As these samples contained large amounts of algae and other organic matter, it was necessary to sort and pick invertebrates from the sample. Most of the samples were heavily packed with mainly algae, and consequently invertebrates were closely attached or embedded in the algae. Because of the great quantity of very small invertebrates embedded in the algae, an intensive amount of labor was involved in sorting and removing individuals from the algae. To allow the analysis to be completed within the scope of the budget, it was thus necessary to randomly split the samples, with usually 50% of the sample being split and analyzed. Several sample bottles were packed tightly with algae and invertebrates, and consequently had to be split more than 50% because it was taking three weeks for personnel to sort one only sample bottle. These samples were split one more time, with the result of 25% of the contents being analyzed from that particular bottle. Most samples were split 50%, but if a sample was split differently, it is shown in parentheses on the top of Tables 2-4.

For example, samples that were not split in a 50% quantity included Log #2, mid-Puali d-Net 210 μ , and the lower Limahuli d-Net 210 μ (Tables 2 and 3), while the mid Wailua 425 μ slack net had 100% analysis (Table 3). Any statistical analysis conducted from our results in Tables 2-4 would need to adjust for these varying sample percentages.

The sorting procedure for this analysis was as follows. First, the contents of the one-liter sample bottle were poured into a 0.42 mm sieve and rinsed with 80% ethanol. Next, the sieve contents were poured into a 17 x 22 cm sorting tray, using an ethanol squirt bottle to ensure all invertebrates were rinsed into the tray. The contents of the sorting tray were then separated by a divider that split the contents of the tray in half. When sorting of an individual sample took more

than 3 weeks (in a few of the samples containing extremely high amounts of algae and invertebrates) the splitting process was done twice, with 25% of the sample contents picked out and sorted. Terrestrial invertebrates such as Hymenoptera (ants, bees), Lepidoptera, and others were sorted from the drift material but were not identified or counted, nor were empty pupal cases of aquatic insects. Because many of the specimens were crushed during the collection process, identifications were not possible on some specimens. However, an individual was counted and identified if more than half of the head and body were still recognizable and the head capsule was intact.

After being pulled from algae and other debris, aquatic invertebrates were morpho-sorted and then identified to the lowest taxonomic level possible. The larvae of most Hawaiian aquatic insects have not yet been described, thus most identifications were made at either the family or generic level. Larval Chironomidae are particularly problematic, with few distinguishing characteristics. Identification of chironomid larvae even in Nearctic regions is hampered by the fact that some genera are indistinguishable from each other, keys do not separate early instars, and only a small percentage of larvae in Nearctic regions have been described (Coffman and Ferrington 1995). Chironomid head capsule analysis to the genus level was not in the scope of this project. This is because of the enormous amount of labor that would be involved in preparing the very large number of individuals (i.e., over 1100 individuals in just one of the 40 samples). However, these specimens will be available in the Bishop Museum collection to future researchers if for some reason this analysis needs to be conducted.

Because of the great number of individual insects found in some samples, and the excessive amount of time involved in sorting specimens from algae and other debris, it became necessary to estimate numbers of some invertebrates with a protocol modified from plankton counts (Hötzel and Croome 1999). The contents of a sorted vial were placed in a clear, divided petri dish that was lying over graph paper. After stirring the contents of the petri dish to ensure uniform distribution, numbers of invertebrates were counted in at least 6 randomly selected cell contents and an average number of individuals was calculated. This average was then multiplied by the total number of cells in the petri dish. Numerous tests of this estimation method found all estimates were within 10%, and usually within 5% of the true value that was determined by counting all individuals in a vial. Estimates are marked in bold on Tables 2-4. Samples will be available in the Bishop Museum collection if it is necessary to provide total enumeration.

Along with using identified specimens from the Bishop Museum collections, the following references were used to identify organisms: Williams (1936), Zimmerman (1948), Hardy (1960), Hardy and Delfinado (1980), Coffman and Ferrington (1995), Westfall and May (1996), Smith (2001), Thorp and Covich (2001), Nishida (2002), and Flint *et al.* (2003).

RESULTS

These results indicate that the modified Surber sampling methodology used obtained a very limited and abbreviated assemblage composed almost entirely of alien species, with the caddisflies by far being the most dominant taxa. Not including incidental adult aquatic insects that were presumably dead individuals collected in the samplers, 12 aquatic insect taxa were identified. Previous surveys of upland Kaua'i streams found at least 59 aquatic insect species (Englund and Polhemus 2001), and this was two years prior to the collections being analyzed in the present study. Adult males of aquatic flies such as two species of *Scatella* and one species of *Procanace* allowed species identification, while the one adult empidid fly (*Hemerodromia* sp.) recovered was unfortunately a female. Of interest was the new island record of *Hydroptila icona*, an invasive caddisfly species that has now rapidly spread to all the major Hawaiian Islands since its first collection in 2001 (Flint *et al.* 2003).

Table 1. Locations of benthic samples analyzed from the island of Kaua'i, this table is modified from Tetra Tech (2004). GPS datum is NAD 83.

Stream Name	Site Code	Date	Time	Elevation	Latitude (N)	Longitude (W)	DOH Log #
Lower Puali	LP	7/20/03	7:30-12:30	Low	22.082778	-159.358417	1
Middle Puali	MP	7/20/03	14:30-17:00	Middle	21.000000	-159.093750	2
Upper Kapa'a	UK	7/21/03	11:30-17:30	Upper	22.104083	-159.393306	3
Middle Kapa'a	MK	7/22/03	15:00-19:00	Middle	22.101222	-159.371083	5
Lower Kapa'a	LK	7/22/03	9:00-14:30	Lower	22.104083	-159.393306	4
Upper Limahuli	UL	7/23/03	11:30-14:40	Upper	22.207444	-159.579278	6
Middle Limahuli	ML	7/23/03	15:30-18:00	Middle	22.211833	-159.576778	7
Lower Limahuli	LL	7/26/03	10:00-12:50	Lower	*	*	11
Upper Hanakāpī'ai	UHa	7/25/03	12:45-14:30	Upper	22.190278	-159.591972	10
Middle Hanakāpī'ai	MHa	7/25/03	8:30-12:30	Middle	22.199556	-159.592194	9
Lower Hanakāpī'ai	LHa	7/24/03	14:00-16:45	Lower	22.207333	-159.596139	8
Upper Hulēi'a/Kamooloa	UH/K	7/28/03	12:30-15:30	Upper	21.991028	-159.465111	12
Lower Hulēi'a	LHu	7/29/03	10:00-13:40	Lower	21.912861	-159.396417	13
Middle Hulēi'a	MHu	7/29/03	15:30-18:00	Middle	21.960861	-159.439694	14
Upper Wailua	UW1	7/30/03	9:45-13:00	Upper	22.062583	-159.466361	15
Middle Wailua	MW1	7/30/03	15:30-18:30	Middle	22.066111	-159.443139	16
Lower Wailua	LW1	7/31/03	11:30-15:45	Lower	22.048722	-159.367889	17
Lower Waipā	LWp	8/2/03	10:00-12:30	Lower	22.196222	-159.515806	20
Middle Waipā	MWp	8/1/03	10:00-13:15	Middle	22.191556	-159.518944	19
Upper Waipā	UWp	8/1/03	14:00-16:30	Upper	22.185583	-159.522167	18

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Table 2. Results of Hawaii Biological Survey, benthic aquatic invertebrate analysis for State of Hawaii Department of Health of surveys conducted on Kaua'i, stations 1-9. Bold numbers are estimates (+/- 10%) from samples with excessive numbers of individuals.

Taxon	Low Puali 210 d-net	Low Puali 425 slack	Mid Puali 210 d-net (25%)	Mid Puali 425 slack	Up Kapaa 210 d-net	Up Kapaa 425 slack	Low Kapaa 210 d-net	Low Kapaa 425 slack	Mid Kapaa 210 d-net	Mid Kapaa 425 slack	Up Limahuli 210 d-net	Up Limahuli 425 slack	Mid Limahuli 210 d-net	Mid Limahuli 425 slack	Low Hanakap. 210 d-net	Low Hanakap. 425 slack	Mid Hanakap. 210 d-net	Mid Hanakap. 425 slack	Status ¹	
Amphibians																				
<i>Bufo marinus</i>					1															Int
Fish																				
<i>Clarias fuscus</i>							1													Ind
<i>Gambusia affinis</i>							2													Int
Mollusks																				
Bivalvia							2						1							Int
Gastropoda sp.					4		2													Cry
<i>Neritina granosa</i>							12					1								End
<i>Corbicula fluminea</i>	2																			Int
<i>Ferrissia sharpei</i>	2																			Int
<i>M. tuberculata</i>			5	5					2											Int
Lymnaeidae					4									1						Cry
<i>Physidae</i> sp.																		1		Int
Crustaceans																				
<i>Atyoida bisulcata</i>					3		2		16	23		6			1	1	30			End
<i>M. grandimanus</i>								1												End
Amphipoda																				
<i>Hyallega</i> sp.					2				3											Cry
Ostracoda	20		71		1		86		11											Cry
Copepoda	1						310													Cry
Annelida																				Cry
Polychaeta																				
<i>Namalcystis</i> sp.	1	2																		Cry
Oligochaeta																				
Lumbriculidae					1										2	3	3	1		Cry
Naididae		1			247	227	275	88	220	45	43	8	84	73	33					Cry
Hirudinea					6	1								1						Int
Turbellaria																				
<i>Dugesia</i> sp.							13		25	26	35	4	85	59						Int
Acari																				
Hydrachnida	3	2		1	11		8						31	3	7					Cry

Analysis of Kaua'i Aquatic Invertebrate Benthic Samples

Table 2 (cont.). Results of Hawaii Biological Survey, benthic aquatic invertebrate analysis for State of Hawaii Department of Health of surveys conducted on Kaua'i, stations 1-9. Bold numbers are estimates (+/- 10%) from samples with excessive numbers of individuals.

Taxon	Low Puali 210 d-net	Low Puali 425 slack	Mid Puali 210 d-net (25%)	Mid Puali 425 slack	Up Kapaa 210 d-net	Up Kapaa 425 slack	Low Kapaa 210 d-net	Low Kapaa 425 slack	Mid Kapaa 210 d-net	Mid Kapaa 425 slack	Up Limahuli 210 d-net	Up Limahuli 425 slack	Mid Limahuli 210 d-net	Mid Limahuli 425 slack	Low Hanakap. 210 d-net	Low Hanakap. 425 slack	Mid Hanakap. 210 d-net	Mid Hanakap. 425 slack	Status ²
Aquatic Insects																			
Zygotera																			
Coenagrionidae sp.	2				3				1										Cry
<i>Ischnura ramburii</i>				1			3								2				Int
Heteroptera																			
Saldidae																			
<i>Saldula exulans</i>												2							End
Coleoptera																			
Hydrophilidae					1														Cry
Diptera																			
Canacidae (larvae)					13		2						1		4	6	3	1	End
<i>Procanace wirthi</i> (adults)															2	7		2	End
Chironomidae	2	1	24	2	1043	278	308	108	4	251	339	313	1074	439	496	128	184	64	Cry
Empididae																			
<i>Hemerodromia</i> sp.		1			108	60	41	99	3	41	53	92	136	119	22	4	28	28	Int
Ephydriidae (larvae)					9	1									4		1		Cry
<i>Scatella kauaiensis</i> (adults)							2												End
Tipulidae		7			2	6	2	9		2		9	1	7	18		18	5	Cry
Trichoptera																			
Hydropsychidae																			
<i>C. analis</i>	8	5			370	40	1092	1353	142	551	972	737	3256	808	62	374	352	130	Int
Hydroptilidae																			
<i>Hydroptila icona</i>		3			10	92	642	1359			4			301	76	11	63	15	Int
<i>H. potosina</i>					210	21			7	27	76	239	299	55				37	Int
<i>Oxyethria maya</i>							26						2		22				Int
Lepidoptera																			
<i>Hyposmocoma</i> sp.					2														End

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

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Table 3. Results of Hawaii Biological Survey, benthic aquatic invertebrate analysis for State of Hawaii Department of Health of surveys conducted on Kaua'i, stations 10-17. Bold numbers are estimates (+/- 10%) from samples with great numbers of individuals.

Taxon	Up Hanakap. 210 d-net	Up Hanakap. 425 slack	Low Limah. 210 dnet (25%)	Low Limahuli 425 slack	Up Komooloa 210 d-net (25%)	Up Komooloa 425 slack	Low Huleia 210 d-net	Low Huleia 425 slack	Mid Huleia 210 d-net	Mid Huleia 425 slack	Up Waitua 210 d-net	Up Waitua 425 slack	Mid Waitua 210 d-net	Mid Waitua 425 slack(100%)	Low Waitua 210 d-net	Low Waitua 425 slack	Status ¹
Amphibians																	
<i>Bufo marinus</i>									5	1							Int
Fish																	
<i>Clarias fuscus</i>									1								Ind
<i>Gambusia affinis</i>									1								Int
Mollusks																	
Bivalvia sp.							2		2								Int
Gastropoda sp.								3									Cry
<i>Neritina granosa</i>																	End
<i>Corbicula fluminea</i>										2							Int
<i>Ferrissia sharpei</i>																	Int
<i>M. tuberculata</i>							1		34	25							Int
Lymnaeidae				2	27	12											Cry
Crustaceans																	
<i>Atyoida bisulcata</i>	1		1	1						13						9	End
<i>M. grandimanus</i>								1									End
<i>M. lar</i>															1		Int
Amphipoda																	
<i>Hyallela</i> sp.				1			9	1	370	7				1	4	1	Cry
Ostracoda					15	2	14		157							1	Cry
Copepoda			1												2		Cry
Tanaidacea							49	51									Cry
Annelida																	Cry
Polychaeta																	
<i>Namalycystis</i> sp.									2	2					1		Cry
Oligochaeta																	
Lumbriculidae				1				1					1	1			Cry
Naididae			40		315	750	45	3		60	78		2	2	12		Cry
Hirudinea							1										Int
Turbellaria																	
<i>Dugesia</i> sp.			31					1	114	37	7	1					Int
Acari																	
Hydrachnida			3		6			2			60	1					Cry
Aquatic Insects																	
Zygoptera																	
Coenagrionidae sp.															1		Cry
<i>Ischnura ramburii</i>									4								Int

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Table 3 (cont). Results of Hawaii Biological Survey, benthic aquatic invertebrate analysis for State of Hawaii Department of Health of surveys conducted on Kaua'i, stations 10-17. Bold numbers are estimates (+/- 10%) from samples with great numbers of individuals.

Taxon	Up Hanakap. 210 d-net	Up Hanakap. 425slack	Low Limah. 210 dnet (25%)	Low Limahuli 425 slack	Up Komooloa 210 d-net (25%)	Up Komooloa 425 slack	Low Huleia 210 d-net	Low Huleia 425 slack	Mid Huleia 210 d-net	Mid Huleia 425 slack	Up Waitua 210 d-net	Up Waitua 425 slack	Mid Waitua 210 d-net	Mid Waitua 425 slack(100%)	Low Waitua 210 d-net	Low Waitua 425 slack	Status ¹
Diptera																	
Canacidae (larvae)		7		1							2	1					End
<i>Procanace wirthi</i> (adults)		1										1					End
Chironomidae	60	618	750	498	562	365	221	83	455	82	458	48	147	136	98	90	Cry
Empididae																	
<i>Hemerodromia</i> sp.	3	80	4	4	101	46	26	44	141	94	33	17	3		5		Int
Ephydriidae (larvae)									1		1						Cry
<i>Scatella cilipes</i>																2	End
Tipulidae		5	1	15	1	5	1		9	5	3			1			Cry
Trichoptera																	
Hydropsychidae																	
<i>C. analis</i>	149	754	631	191	431	595	892	786	108	523	410	654	56	128	62	201	Int
Hydroptilidae																	
<i>Hydroptila icona</i>	1	242	28	14	65	5	90	169	96	275	141	10			1		Int
<i>H. potosina</i>	26		93			53			574	6							Int
<i>Oxyethria maya</i>			5		45	11			28	2					2		Int

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Table 4. Results of Hawaii Biological Survey, benthic aquatic invertebrate analysis for State of Hawaii Department of Health of surveys conducted on Kaua'i, stations 18-20. Bold numbers are estimates (+/- 10%) from samples with great numbers of individuals.

Taxon	Up Waipa 210 d-net	Up Waipa 425 slack	Mid Waipa 210 d-net	Mid Waipa 425 slack	Low Waipa 210 d-net	Low Waipa 425 slack	Status ¹
Mollusks							
Gastropoda sp.					1		Cry
<i>M. tuberculata</i>					1		Int
Crustaceans							
<i>Atyoida bisulcata</i>	1	4					End
Amphipoda							
<i>Hyallega sp.</i>							Cry
Ostracoda					3		Cry
Copepoda					1		Cry
Annelida							Cry
Polychaeta							
<i>Namalcystis sp.</i>					3		Cry
Oligochaeta							
Lumbriculidae		2			1	1	Cry
Naididae	633	76	45	4	41	17	Cry
Hirudinea					2		Int
Turbellaria							
<i>Dugesia sp.</i>	1		1		2		Int
Acari							
Hydrachnida	12						Cry

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Table 4 (cont.). Results of Hawaii Biological Survey, benthic aquatic invertebrate analysis for State of Hawaii Department of Health of surveys conducted on Kaua'i, stations 18-20. Bold numbers are estimates (+/- 10%) from samples with great numbers of individuals.

Taxon	Up Waipa 210 d-net	Up Waipa 425 slack	Mid Waipa 210 d-net	Mid Waipa 425 slack	Low Waipa 210 d-net	Low Waipa 425 slack	Status ¹
Aquatic Insects							
Zygotera							
Coenagrionidae sp.					1		Cry
<i>Ischnura ramburii</i>							Int
Diptera							
Canacidae (larvae)			1	12		2	End
Procanace (adults)							End
Chironomidae	1133	729	598	475	142	412	Cry
Empididae							
<i>Hemerodromia</i> sp.	30	25	11	35	12	34	Int
Ephydriidae (larvae)			2	2			Cry
<i>Scatella kauaiensis</i> (adults)							End
Tipulidae	3		1	13		6	Cry
Trichoptera							
Hydropsychidae							
<i>C. analis</i>	704	550	929	535	543	542	Int
Hydroptilidae							
<i>Hydroptila icona</i>	186	245	282	146	32		Int
<i>H. potosina</i>							Int
<i>Oxyethria maya</i>	76				22		Int

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