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MACROINVERTEBRATE COLONIZATION OF HESTER-DENDY SAMPLERS IN DIFFERENT ORIENTATIONS TO WATER FLOW

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Hester-Dendy (multiple-plate) invertebrate samplers have been widely used in ecological monitoring studies (Fullner 1971, Mason et al. 1973, Cover and Harrel 1978). Hester-Dendy samplers, first designed by Hester and Dendy (1962), have been modified by increasing the number of plates per sampler from eight to 14 and varying the distance between plates (Fullner 1971). Parsons and Tatum (1974) suggested that sampler plates should be round rather than square, so that colonized samplers could be stored in plastic bags of preservative. Weber (1973) recommended that round plates of 2.5-cm and 7.5-cm diameter be alternated on the sampler. Harrold (1978) recommended alternating the orientation of the smooth and rough sides of plates on samplers to increase invertebrate colonization.

Although much work has been done to improve the design of Hester-Dendy samplers and to compare them to other sampling methods (Fullner 1971, Mason et al. 1973, Fredeen and Spurr 1978, Tsui and Breedlove 1978), no work has been done on how colonization of samplers is affected by their orientation to water flow. Hester-Dendy samplers are usually oriented with the plates parallel to the direction of water flow (Fullner 1971, Cover and Harrel 1978), but no standard orientation has been proposed (American Public Health Association 1980). The orientation of samplers to water flow must affect water velocities over the plate surfaces. Water velocity is known to be an important factor influencing the distribution and abundance of aquatic invertebrates (Merritt and Cummins 1984). Beckett and Miller (1982) compared the colonization of Hester-Dendy samplers set with the plates parallel to the flow in areas of slow and fast current. They reported that the water velocity over the sampler had a significant affect on invertebrate colonization. Our study was conducted to test whether the orientation of benthic Hester-Dendy samplers to water flow affected macroinvertebrate colonization.

Macroinvertebrates were sampled in Dana Creek, a tributary of the Tuolumne River, in the eastern area of Yosemite National Park, California. Samplers were placed in Dana Creek (Sec. 6, T1S, R1E) at an elevation of 2,877 m in a riffle area with a surface velocity that ranged from 0.15-0.30 m/s and averaged 0.26 m/s. At the study site, the creek was 8.5 m wide and ranged in depth from 10-24 cm. The stream substrate was predominantly 2-5 cm gravels.

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We used Hester-Dendy samplers with 8, 76.2-mm square plates, 3.2 mm thick, separated by spacers (25.4 mm square and 6.4 mm thick) and held together with an eye bolt. Samplers were assembled with the rough side of all plates oriented away from the eye end of the eye bolt.

A nylon cord for anchoring samplers was secured with stakes to the stream bottom, perpendicular to the direction of water flow. Samplers to be held parallel to the direction of water flow were connected to the nylon cord by two 16 cm sections of wire, one on each end of the eye bolt through the sampler. Samplers in the parallel orientation were mounted so that one edge of each sampler plate was in contact with the substrate. Samplers to be held perpendicular to the direction of water flow were connected to the nylon cord by one 16 cm length of wire from the eye end of the sampler bolt. Thirty samplers were installed across the stream riffle, at least 16 cm apart, during each of two 28 day colonization periods (28 June 1981-26 July 1981 and 26 July 1981-23 August 1981). The orientation of adjacent samplers was alternated. The Environmental Protection Agency recommends a 6-week colonization period (Weber 1973), but Tsui and Breedlove (1978) indicated that the diversity and number of insects on samplers declines after 30 days.

Samplers were collected after colonization by gently lifting each sampler off the substrate and enclosing it in a plastic bag. Once a sampler was sealed in a bag, the anchoring wires were cut. The sampler and the contents of the bag were placed into a sorting tray. Samplers were disassembled and all obvious invertebrates were removed. The surfaces of all sampler parts were then gently scrubbed with a plastic bristle scrub brush in the sorting tray. All invertebrates were filtered from the water in the sorting tray and preserved in 70% ethyl alcohol. Insects were keyed to family using Lehmkuhl (1979).

Data were analyzed using a chi-squared goodness of fit analysis (Zar 1984). For a given orientation, invertebrate colonization of samplers (numbers of genera) was not significantly different between the two sampling periods (X^2, $P > 0.25$). Data from the two sampling periods was combined prior to analysis of the effect of orientation.

For nine of the 12 insect families collected, no difference in abundance on samplers was observed with respect to orientation (Table 1). More Ephemerellidae colonized samplers with plates set perpendicular to the direction of flow. Edmunds et al. (1976) reported that ephemerellids occurring in fast flowing waters usually are found in protected crevices in the substrate. This may explain why more ephemerellids were collected with the perpendicular orientation, which provides more crevices protected from the stream flow. More Rhyacophilidae colonized samplers with plates parallel to the flow. Wiggins (1977) noted that rhyacophilids are usually found in high velocity areas. Beckett and Miller (1982) found more hydropsychid larvae on Hester-Dendy samplers from areas of higher velocity. However, we found no significant difference in the colonization of hydropsychid larvae, even though samplers with plates parallel to the water flow should have higher water velocities between the plates than samplers in the perpendicular orientation. Perlidae colonized samplers in the perpendicular orientation only, suggesting they prefer areas protected

Table 1. Mean number of invertebrates collected per sampler with 30 Hester-Dendy samplers oriented parallel or perpendicular to the direction of water flow.

		Parallel to flow		Perpendicular to flow	
Order	Family	$\bar{x}$	SD	$\bar{x}$	SD
Ephemeroptera	Ephemerellidae[1]	1.33	0.21	1.57	0.28
	Heptageniidae	0.83	1.14	0.73	1.33
	Baetidae	13.33	3.64	12.33	3.60
	Leptophlebiidae	0.03	0.18	0.10	0.30
Trichoptera	Hydropsychidae	0.20	0.50	0.17	0.35
	Rhyacophilidae[1]	0.36	0.86	0.20	0.55
Diptera	Simuliidae	1.43	2.60	0.97	1.37
	Chironomidae	4.61	3.01	4.73	2.64
Plecoptera	Perlodidae	2.20	1.76	1.60	1.72
	Peltoperlidae	0.90	1.25	1.00	1.37
	Perlidae[1]	0.00	0.00	1.20	0.48
Coleoptera	Dryopidae	0.07	0.36	0.03	0.30

[1]Significantly different X^2 test, $P < 0.05$.

from water currents.

Structural modifications of Hester-Dendy samplers may influence the effect of sampler orientation on colonization. If the size of alternate plates is reduced or the distance between plates is increased, water velocities between plates will increase for samplers in the parallel orientation. This may lead to even greater differences in invertebrate colonization than we observed.

In summary, for some insect families the orientation of Hester-Dendy samplers to the direction of water flow can have a significant affect on the abundance of macroinvertebrates that colonize them. Uniform orientation of samplers may reduce variability in invertebrate colonization, but alternating orientations may offer a broader range of microhabitats for colonization.

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