Habit (Clinger) Attribute List: Documentation of methods for deriving the list

Robert Wisseman, Aquatic Biology Associates, Inc., June 13, 2012

Karr's Benthic Index of Biotic Integrity (BIBI) for benthic macroinvertebrates uses the total number of "clinger" taxa as one of 10 metrics to evaluate the biological health of streams (**http://www.pugetsoundstreambenthos.org/**). For the second iteration of this index for Puget Sound Lowland streams, the classification of "clingers" is being updated and refined.

Cummins et al. (2008) categorize aquatic insects by their habit or mode of existence (locomotion, attachment or concealment). Taxa associated with a particular habit category exhibit morphological, physiological and behavioral adaptations to various microhabitats in freshwater ecosystems. Categories are:

Skaters	"Skate" on the surface film of water bodies, e.g. water striders (Hemiptera: Gerridae)
Planktonic	Found primarily in the water column where they float or swim, e.g. phantom midges (Diptera: Chaoboridae) or water fleas (Crustacea: Cladocera).
Divers	Actively swim in the water column and return to the surface to obtain oxygen. They may spend time crawling or clinging to submerged substrates, e.g. water boatman (Hemiptera: Corixidae) and predaceous diving beetles (Coleoptera: Dytiscidae).
Swimmers	Benthic dwellers that exhibit frequent "minnowlike" swimming in the water column. Between swimming episodes they usually cling to benthic surfaces or submerged vegetation, e.g. many baetid mayflies (Ephemeroptera: Baetidae).
Clingers	"Representatives have behavioral (e.g. fixed retreat construction) and morphological (e.g. long, curved tarsal claws, dorsoventral flattening, and ventral gills arranged as a sucker) adaptations for attachment to surfaces in stream riffles and wave-swept rocky littoral zones of lakes (Examples: Ephemeroptera: Heptageniidae; Trichoptera: Hydropsychidae; Diptera: Blephariceridae)." Cummins et al. (2008).
Sprawlers	Inhabit surfaces of floating leaves or on the surface of fine sediments, e.g. caenid mayflies (Ephemeroptera: Caenidae).
Climbers	"Climb" up the stems and leaves of submerged plants, roots and woody debris, e.g. aeshnid dragonfly larvae (Odonata: Aeshnidae).
Burrowers	"Burrow" into fine sediments or tunnel into plant stems, leaves or roots, e.g. many chironomid midges (Diptera: Chironomidae) and segmented worms (Oligochaeta).

This of course is an artificial classification system where the lines between groups are often blurred depending on the particular taxon and life stage. Aquatic insects that are clearly skaters, planktonic, divers or burrowers most of the time can be unambiguously classified using these categories. Sharp distinctions between swimmers, clingers, sprawlers and climbers is not always evident. This lack of distinction is often reflected in the tabular listing of ecological traits for genera and species in Merritt, Cummins & Berg (2008) under the "Habit" category. Multiple habit categories are frequently provided for a genus (e.g. swimmers; clingers), with the presumption that the first one listed is the dominant mode. The application of the habit categories by the various chapter authors in Merritt, Cummins & Berg (2008) is inconsistent, reflecting how authors interpreted and applied the habit classification system differently.

Our interpretation of "clingers" focuses on **taxa that possess morphological adaptations (including use of silk) that allow them to maintain position (cling) to surfaces of substrates while directly exposed to water current in erosional habitats.** Substrates may be rock surfaces, woody debris or submerged moss and vascular plants. Adaptations include streamlined body forms, tarsal claws or hooks for grasping, various bodily modifications to form suction discs, and use of silk as lassos or to construct attached retreats.

We see sprawlers, climbers and burrowers as more restricted to depositional habitats, or if found in erosional habitats to be shielded from the current, e.g. by burrowing into fine sediment between or beneath rocks or foraging inside leaf packs.

The "swimmer" category is problematic and we do not recognize it as a valid category for our purposes. We see planktonic and diver taxa as the true swimmers that actively "swim" and many feed in the water column. Typically they are associated with the benthos for brief periods (e.g. water boatman or predaceous diving beetle adults foraging on the benthos, then returning to the surface for oxygen) or resting on the bottom during diurnal quiescent periods (phantom midges).

Examples given by Cummins et al. (2008) for the "swimmer" category (Ephemeroptera: Siphlonuridae, Leptophlebiidae) are primarily benthic and associated with fine sediments in depositional habitats. They swim in the water column for brief periods seeking new areas to forage in. They are sprawlers or climbers associated with the benthos while feeding. Waltz & Burian (2008) in their listing of ecological traits classify most of the baetid mayflies (Ephemeroptera: Baetidae) first as swimmers, then clingers. Many baetids do actively release themselves from benthic substrates and swim upwards into the current to enter the stream drift for dispersal to new areas for foraging. They briefly use swimming and drifting for dispersal, not feeding, and spend most of their time associated with the benthos. Those genera and species of baetids associated with erosional habitats spend most of their time clinging to and feeding off hard surfaces. Their streamlined shape and tarsal claws allow them to maintain position while directly exposed to currents. Thus, they have morphological adaptations for "clinging" and spend most of their time doing so. We classify them as clingers.

Merritt, Cummins & Berg (2008) categorize only aquatic insects as to habit. We extend their classification here to include non-insect taxa encountered in Puget Sound Lowland streams that we consider to be clingers, i.e. **possess morphological adaptations that allow them to maintain position (cling) to surfaces of substrates while directly exposed to water current in erosional habitats.**

Where we deviate from Merritt, Cummins & Berg (2008) classification of habit is outlined below.

Ephemeroptera (Waltz & Burian 2008 chapter, Table 11A)

Ameletidae; *Ameletus* is listed as swimmer, clinger (Table 11A). Designated here as clinger.

Baetidae: Most genera listed as swimmer, clinger (Table 11A). Designated here as clinger, except for genera primarily associated with depositional habitats (e.g. *Centroptilum*).

Ephemerellidae: Most listed as clingers (Table 11A). Almost all genera and species are designated here as clingers, except *Ephemerella aurivillii* and *Timpanoga* which are mostly associated with depositional habitats and not considered to be clingers.

Leptophlebiidae; *Paraleptophlebia*: Listed as swimmers, clingers, sprawlers (Table 11A). This genus is primarily associated with depositional habitats as a sprawler and not considered to be a clinger here. Since *Paraleptophlebia* is the dominant Leptophlebiidae taxa found in Puget Sound Lowland streams, we also do not designate the family as a clinger.

Odonata: (Tennessen 2008 Table 12A). Most genera are listed as burrowers, climbers or sprawlers. *Argia* is listed as climbers-clingers-sprawlers in Table 12A. We designate *Argia* as a clinger here.

Plecoptera: (Stewart & Stark 2008, Table 14B).

Chloroperlidae are listed as “generally clingers” at the family level with no listings of habit under genera (Table 14B). Though most genera are found in erosional habitats, they are generally shielded from the direct current (e.g. found in pores and crevices in the hyporheos or within leaf packs). We do not designate them as clingers.

Peltoperlidae; *Yoraperla* is listed as “generally clingers-sprawlers” in Table 14B. We view *Yoraperla* larvae as being mostly shielded from direct current in leaf packs and moss and do not designate it as a clinger.

Pteronarcyidae are listed as “generally clingers-sprawlers” in Table 14B. We see pteronarcid larvae as being mostly shielded from direct current in leaf packs and crevices and do not designate it as a clinger.

Trichoptera: (Morse & Holzenthal 2008, Table 18A).

Limnephilidae: *Allocosmoecus, Cryptochia*, and *Dicosmoecus* are listed as sprawlers (Table 18A). Designated here as clingers because they cling with their tarsal claws to hard surfaces in strong currents or cling to woody surfaces above the waterline.

Rhyacophilidae: Primarily clingers, but a few species are associated with detritus accumulations or leaf packs and not directly exposed to currents and thus not included under the clinger category.

Diptera: (Courtney & Merritt 2008, Table 22B).

Athericidae; *Atherix* is listed as sprawlers-burrowers in Table 22B. Designated here as a clinger because they use hooks on legs to cling to rock surfaces in current.

Empididae are listed as generally sprawlers-burrowers at the family level but some genera as clingers in Table 22B. All genera designated here as clingers here because they use hooks on legs to cling to surfaces in current.

Thaumaleidae are listed as clingers in Table 22B. Not designated as clingers here because larvae are most often found on wetted surfaces out of the current, and adhere to surfaces by surface tension.

Chironomidae: Genera and groups that are known to build tubes and attach to surfaces in erosional habitats and directly exposed to the current are designated here as clingers.

Non-insects: Pennak (1989) and Thorp and Covich (2001) were the primary references used for the biology of freshwater non-insects.

Turbellaria (flatworms) are designated here as clingers because they cling to hard surfaces by mucus and cilia, directly exposed to current.

Gastropoda (snails) are designated as clingers here since they often adhere to hard surfaces directly exposed to current. Though some taxa are primarily associated with depositional habitats, they still attach themselves to surfaces by the mucus they secrete in their foot.

Hydra (hydroids) are generally sessile organisms that attach themselves to hard surfaces in current with a basal disc and are designated here as clingers.

Hirudinea (leeches) utilize a suction disc to attach to hard surfaces or to the bodies of fish and are designated as clingers here.

References

Adler, Peter H. & Douglas C. Currie 2008. Chapter 25 Simuliidae. Pages 825-845. In Merritt, Richard W., Kenneth W. Cummins & Martin B. Berg (editors) 2008. An Introduction to the Aquatic Insects of North America. Kendall/Hunt Publishing Company, Dubuque, Iowa, 1158 pages.

Byers, George W. & Jon K. Gelhaus 2008. Chapter 23 Tipulidae. Pages 773-800. In Merritt, Richard W., Kenneth W. Cummins & Martin B. Berg (editors) 2008. An Introduction to the Aquatic Insects of North America. Kendall/Hunt Publishing Company, Dubuque, Iowa, 1158 pages.

Courtney, Greg W. & Richard W. Merritt 2008. Chapter 22 Aquatic Diptera Part one. Larvae of aquatic Diptera. Pages 687-722. In Merritt, Richard W., Kenneth W. Cummins & Martin B. Berg (editors) 2008. An Introduction to the Aquatic Insects of North America. Kendall/Hunt Publishing Company, Dubuque, Iowa, 1158 pages.

Cummins, Kenneth W., Richard W. Merritt & Martin B. Berg 2008. Ecology and distribution of aquatic insects. Pages 105-122. In Merritt, Richard W., Kenneth W. Cummins & Martin B. Berg (editors) 2008. An Introduction to the Aquatic Insects of North America. Kendall/Hunt Publishing Company, Dubuque, Iowa, 1158 pages.

Ferrington, Leonard C., Martin B. Berg & William P. Coffman 2008. Chapter 26 Chironomidae. Pages 847-989. In Merritt, Richard W., Kenneth W. Cummins & Martin B. Berg (editors) 2008. An Introduction to the Aquatic Insects of North America. Kendall/Hunt Publishing Company, Dubuque, Iowa, 1158 pages.

Flint, Oliver S., H.H. Neunzig & Elwin D. Evans 2008. Chapter 16 Megaloptera and Aquatic Neuroptera. Pages 425-437. In Merritt, Richard W., Kenneth W. Cummins & Martin B. Berg (editors) 2008. An Introduction to the Aquatic Insects of North America. Kendall/Hunt Publishing Company, Dubuque, Iowa, 1158 pages.

Huryn, Alexander D., J. Bruce Wallace & Norman H. Anderson 2008. Habitat, life history, secondary production, and behavioral adaptations of aquatic insects. Pages 55-103. In Merritt, Richard W., Kenneth W. Cummins & Martin B. Berg (editors) 2008. An Introduction to the Aquatic Insects of North America. Kendall/Hunt Publishing Company, Dubuque, Iowa, 1158 pages.

Mackie, Gerald L. 2007. Biology of Freshwater Corbiculid and Sphaeriid Clams of North America. Ohio Biological Survey, Bulletin New Series, Volumn 15, Number 3, 436 pages.

Merritt, Richard W. & Donald W. Webb. 2008. Chapter 22 Aquatic Diptera Part two. Pupae and adults of aquatic Diptera. Pages 723-771. In Merritt, Richard W., Kenneth W. Cummins & Martin B. Berg (editors) 2008. An Introduction to the Aquatic Insects of North America. Kendall/Hunt Publishing Company, Dubuque, Iowa, 1158 pages.

Merritt, Richard W., Kenneth W. Cummins & Martin B. Berg (editors) 2008. An Introduction to the Aquatic Insects of North America. Kendall/Hunt Publishing Company, Dubuque, Iowa, 1158 pages.

Morse, John C. & Ralph W. Holzenthal 2008. Chapter 18. Trichoptera genera. Pages 481-552. In Merritt, Richard W., Kenneth W. Cummins & Martin B. Berg (editors) 2008. An Introduction to the Aquatic Insects of North America. Kendall/Hunt Publishing Company, Dubuque, Iowa, 1158 pages.

Pennak, Robert W. 1989. Fresh-Water Invertebrates of the United States: Protozoa to Mollusca. Third Edition. John Wiley & Sons, Inc., New York. 628 pages.

Poff, N. LeRoy, Julian D. Olden, Nicole K.M. Vieira, Debra S. Finn, Mark P. Simmons & Boris C. Kondratieff 2006. Functional trait niches of North American lotic insects: traits-based ecological applications in light of Phylogenetic relationships. Journal of the North American Benthological Society 25(4): 730-755.

Polhemus, John T. 2008. Chapter 15 Aquatic and semiaquatic Hemiptera. Pages 385-423. In Merritt, Richard W., Kenneth W. Cummins & Martin B. Berg (editors) 2008. An Introduction to the Aquatic Insects of North America. Kendall/Hunt Publishing Company, Dubuque, Iowa, 1158 pages.

Puget Sound Stream Benthos http://www.pugetsoundstreambenthos.org/

Solis, M. Alma 2008. Chapter 19 Aquatic and semiaquatic Lepidoptera. Pages 553-569. In Merritt, Richard W., Kenneth W. Cummins & Martin B. Berg (editors) 2008. An Introduction to the Aquatic Insects of North America. Kendall/Hunt Publishing Company, Dubuque, Iowa, 1158 pages.

Statzner, Bernhard, Kerstin Hoppenhaus, Marie-Francoise Arens & Phillippe Richoux 1997. Reproductive traits, habitat use and templet theory: a synthesis of world-wide data on aquatic insects. Freshwater Biology 38: 109-135.

Stewart, Kenneth W. & Bill P. Stark 2008. Chapter 14 Plecoptera. Pages 311-384. In Merritt, Richard W., Kenneth W. Cummins & Martin B. Berg (editors) 2008. An Introduction to the Aquatic Insects of North America. Kendall/Hunt Publishing Company, Dubuque, Iowa, 1158 pages.

Tennessen, Kenneth J. 2008. Chapter 12 Odonata. Pages 237-294. In Merritt, Richard W., Kenneth W. Cummins & Martin B. Berg (editors) 2008. An Introduction to the Aquatic Insects of North America. Kendall/Hunt Publishing Company, Dubuque, Iowa, 1158 pages.

Thorp, James H. and Alan P. Covich (editors) 2001. Ecology and Classification of North American Freshwater Invertebrates. Second Edition. Academic Press, New York, 1056 pages.

Vieira, Nicole K.M., N. LeRoy Poff, Darren M. Carlisle, Stephen R. Moulton II, Marci L. Koski & Boris C. Kondratieff 2006. A database of lotic invertebrate traits for North America. U.S. Geological Survey, Data Series 187, Http://pubs.water.usgs.gov/ds187

Wallace, J.R. & E.D. Walker 2008. Chapter 24 Culicidae. Pages 801-823. In Merritt, Richard W., Kenneth W. Cummins & Martin B. Berg (editors) 2008. An Introduction to the Aquatic Insects of North America. Kendall/Hunt Publishing Company, Dubuque, Iowa, 1158 pages.

Waltz, Robert D. & Steven K. Burian 2008. Chapter 11 Ephemeroptera. Pages 181-236. In Merritt, Richard W., Kenneth W. Cummins & Martin B. Berg (editors) 2008. An Introduction to the Aquatic Insects of North America. Kendall/Hunt Publishing Company, Dubuque, Iowa, 1158 pages.

White, David S. & Robert E. Roughley 2008. Chapter 20 Aquatic Coleoptera. Pages 571-671. In Merritt, Richard W., Kenneth W. Cummins & Martin B. Berg (editors) 2008. An Introduction to the Aquatic Insects of North America. Kendall/Hunt Publishing Company, Dubuque, Iowa, 1158 pages.

Whittier, Thomas R. & John Van Sickle 2010. Macroinvertebrate tolerance values and an assemblage tolerance index (ATI) for western USA streams