Insects of British Columbia

by Rebecca Loeffler

INTRODUCTION

Insects form an especially important part of river and stream ecosystems. They are the predominant food source for fish and are an integral factor in nutrient cycling. Insects have differing life histories and functions the stream ecosystem. They may be carnivores, herbivores, detritivores, or omnivores. Many are also categorized as omnivore-detritivores because they consume detritus that is composed of both plant and animal materials. For classification purposes, aquatic insects are usually divided into trophic functional groups based on the mechanisms with which they feed. There are shredders, collectors, scrapers, piercers, engulfers (predators), and parasites (Merritt and Cummins 1978). The method of eating strongly influences which channel habitats each functional group will occupy. Scrapers, for instance, are likely to live in a part of the channel that has a rocky substrate, such as cobble, that is near enough to the water's surface to receive enough light for periphyton, an important food source, to grow. Whereas shredders are likely to be found where there is an abundance of organic material such as in leaf litter.

Though all aquatic insects reside in the stream for part of their life, the different taxa reside in the water for various lengths of time, and are directly affected by the conditions of the river system. The type of substrate affects which insects will inhabit the stream, while the stream configuration determines where is a watershed the insects are more likely to be found. In a study of coastal streams in Vancouver, British Columbia, Canada, insects most often occupied riffles and rapids, but were also found in pools, boulder cascades, chutes, and bedrock cascades (Halwas, Church, and Richardson 2003). In the Skeena watershed we will likely find a similar distribution of insects.

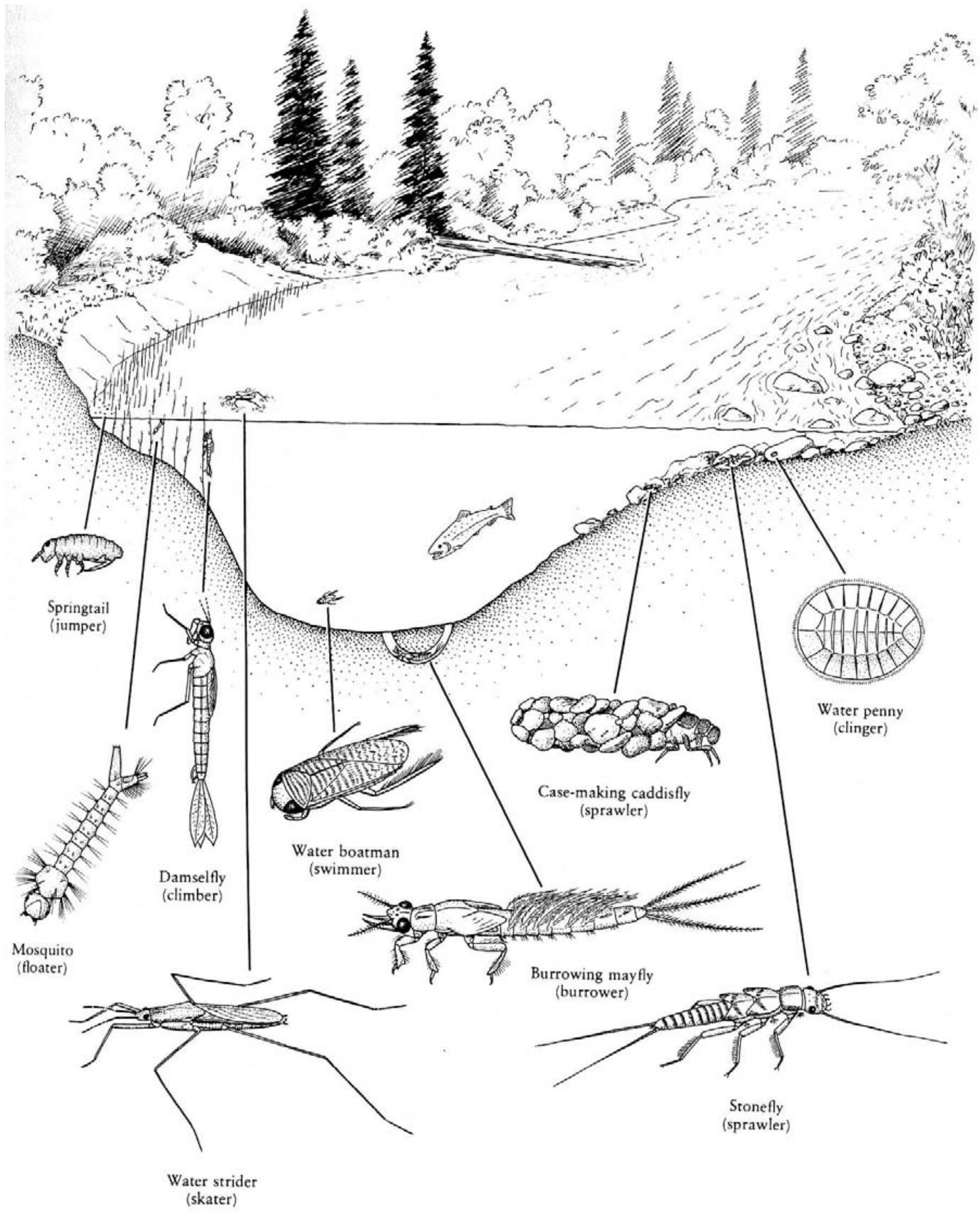


Figure 1: Cross section of a stream, with diagrammatic examples of habitat orientation among aquatic insects. (McCafferty 1981)

As a primary food source for fish, particularly anadromous fish in the Skeena River, it is important to understand the factors that most influence the survivorship of aquatic insects. The remainder of this paper will discuss the habitat types common to the Skeena River, the general life histories and habitat requirements for the major aquatic insect orders, and the effects of flooding and sedimentation on aquatic insects.

HABITAT TYPES

The Skeena River is a large coastal river in British Columbia. Glacial advance and retreat, driven by climate cycles, has sculpted the valleys and canyons of British Columbia and directly affected erosion rates of the mountains. These processes, along with active tectonics, have formed the current topography of the Skeena River watershed and the related landscape (Slotnick, 2004 in this volume for details). The geomorphic history has directly impacted the shape of the river and the variability of habitat types aquatic insects occupy. To date, very little research has been conducted directly on the Skeena River. As a result, data is not available on what habitats are present, but we can assume the Skeena River will approximate other well studied rivers of the region.

The Skeena River does not have an extensive flood plain but rather is confined within a steeply cut valley with narrow banks. The substrate is likely to be dominated by glacial till, which includes gravel, boulders and cobble. Glacial till can also include sand and silt; there may be pockets of finer material as well. The riparian habitat is likely to be heavily forested and relatively undisturbed. There should be plenty of woody debris in the channel to provide habitat for insects as well as other fauna such as fish. The woody debris along with other organic matter in the river and tributaries also influences the habitat type. For instance, Odonata larvae are predatory and seem to have facultative associations with woody debris since much of their prey can be found there (Phillips 1996).

There are five different types of alluvial channel morphologies: cascade, step pool, plane-bed, pool-riffle, and dune-riffle, (Montgomery and Buffington 1997) listed in order from high to low gradient (figure 2). As gradients decrease downstream from the headwaters to the ocean, channel morphologies generally transition from one type to the next resulting in decreasing sediment size downstream (figure 3) (Rice, Greenwood, and Joyce 2001). We will be in the headwaters of the Skeena River, so we will most likely see the channel dominated by coarser sediments and relatively little sand and silt. It is likely that we will see all the channel morphologies along our study reach with the exception of dune-riffle, which is characterized by mainly silt and sand. In the Skeena River we will most likely see plane-bed and riffle-pool reaches interspersed with a few cascades and step-pools, while in the tributaries we should see more cascades and step pools with fewer plane-bed and riffle-pool reaches.

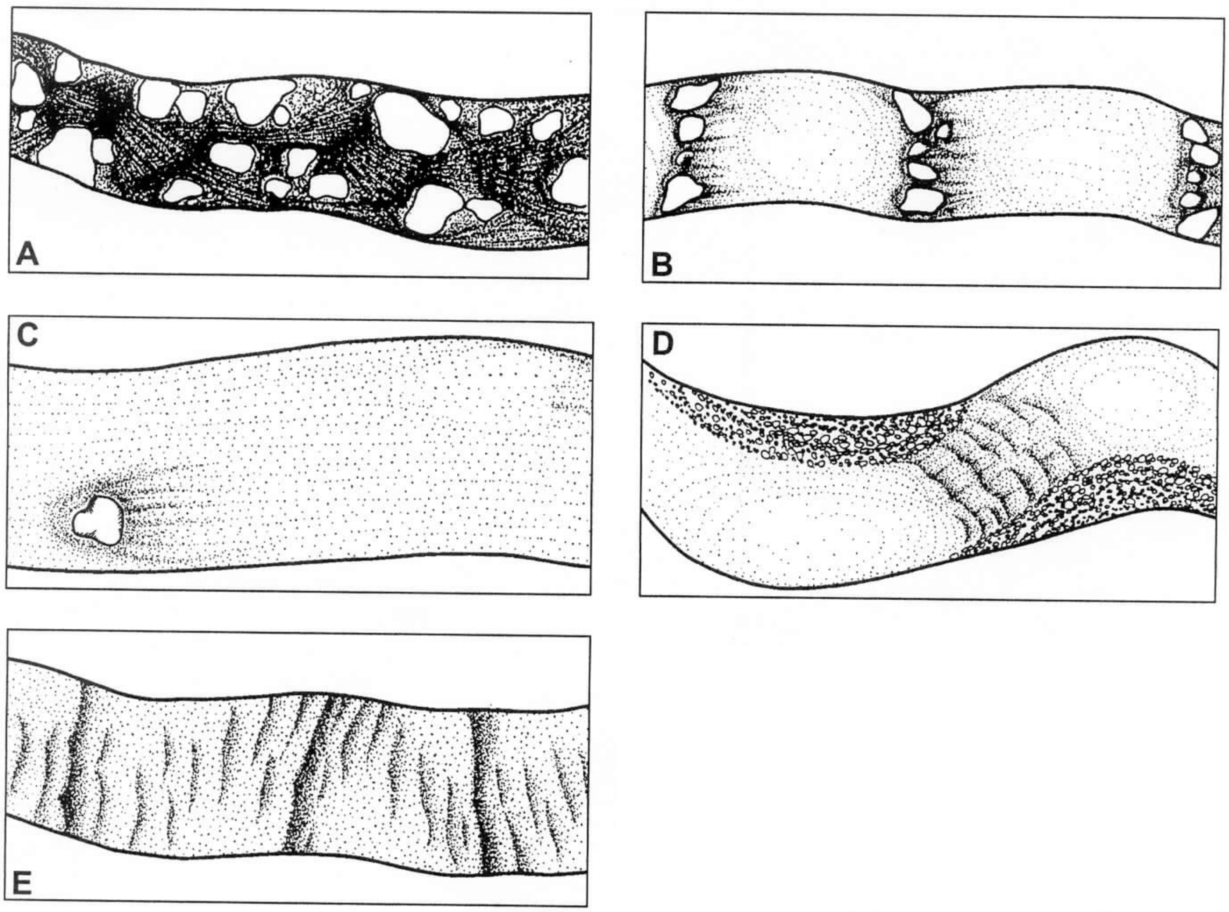


Figure 2: Schematic planform illustration of alluvial channel morphologies at low flow: A) Cascade; B) Step-Pool; C) Plane-Bed; D) Pool-Riffle; E) Dune-Ripple. (Montgomery and Buffington 1997)

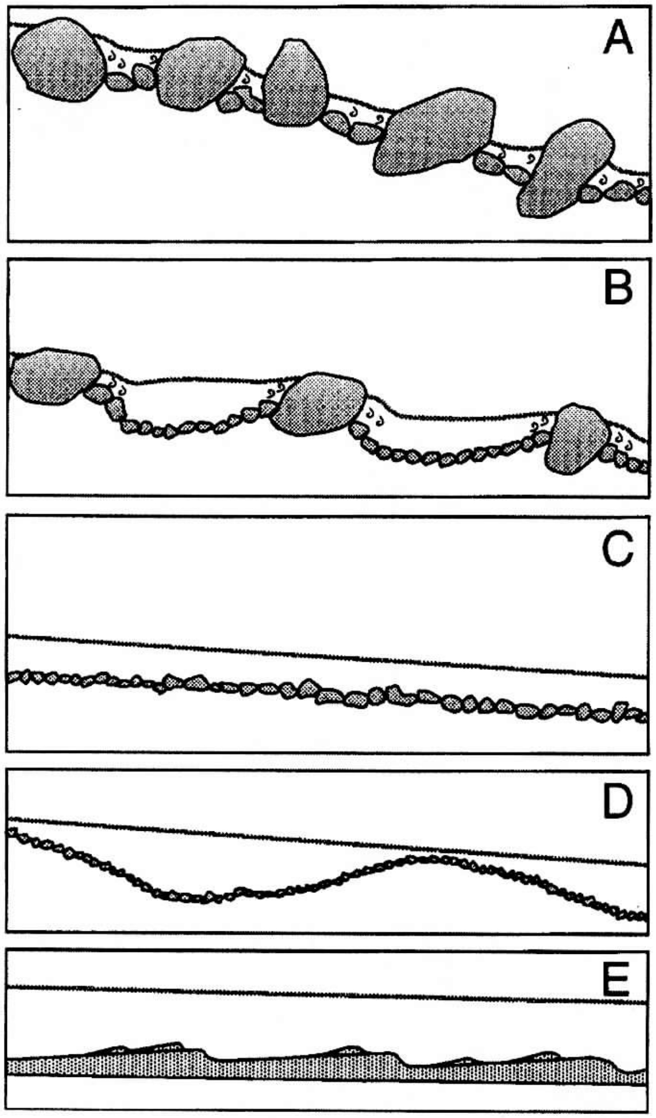


Figure 3: Schematic longitudinal profiles of alluvial channel morphologies at low flow: A) cascade; B) step-pool; C) plane bed; D) pool-riffle; E) dune-ripple. (Montgomery and Buffington 1997)

Within reaches there are four basic stream structures that influence habitat: riffles, pools, undercuts, and bars (Montgomery and Buffington 1997). Riffles are shallow and have a high velocity. They generally have rocky substrates or woody debris causing turbulent water flows that create higher aeration of the water. Higher velocities result in erosion of fine sediments at low flows. In contrast, pools are deeper areas that are depositional zones at low flows. As water flows slowly through pools, sediments, as well as other suspended matter, have a higher likelihood of settling out of the water column. As a result, the substrates in pools will be much finer than those in riffles. Riffles tend to be dominated by cobbles and boulders, while pools tend to accumulate sand and silt. Undercuts and bars are associated with bends in the channel. Undercuts are deep erosional zones which lay on the outside of a curve and can be associated with undercut banks if stabilizing vegetation tops the bank. Water tends to flow fairly quickly around the outside of a bend and entrains loose sediments on the banks. Once the water exits the bend, it slows quickly depositing any suspended sediments. This results in a depositional bar forming downstream of the curve. Bars generally have coarse substrates dominated by cobbles and gravel while undercut banks have a mixture of sediment sizes.

BASIC LIFE HISTORIES OF BRITISH COLUMBIA AQUATIC INSECTS

All insects go through multiple life stages. Each stage is part of the metamorphosis between the egg and adult stages. There are many different variations on these life stages with different orders going through different numbers of stages. There are three overarching stages: embryonic development which occurs within the egg, post embryonic development includes all stages in the lifecycle between the egg and reproductive maturity, and adulthood after an insect reaches reproductive maturity (McCafferty 1981). The postembryonic stage can be further divided into the larval, subimago, and pupal stages. It is important to note that not all insects go through all of these stages. The larval and pupal stages are most often aquatic, while the adult stage is most often terrestrial. In the larval stage there are multiple (at least 3) instars during which growth occurs. Maturation also occurs during the larval stage to varying degrees. The subimaginal stage is specific to mayflies and is a winged stage during which maturation occurs; it has only one instar. The pupal stage is found only in more advanced invertebrates and, unlike the larval stage, is primarily for maturation with little growth occurring. The pupal stage also has only one instar. Insects that do not undergo a pupal stage go through what is called incomplete metamorphosis and experience both growth and maturation during the larval stage; this is considered a more primitive form of metamorphosis. Insects that undergo complete metamorphosis, both a larval and pupal stage, are regarded as more advanced. They mainly grow during their larval stages and undergo maturation during the pupal stage (McCafferty 1981).

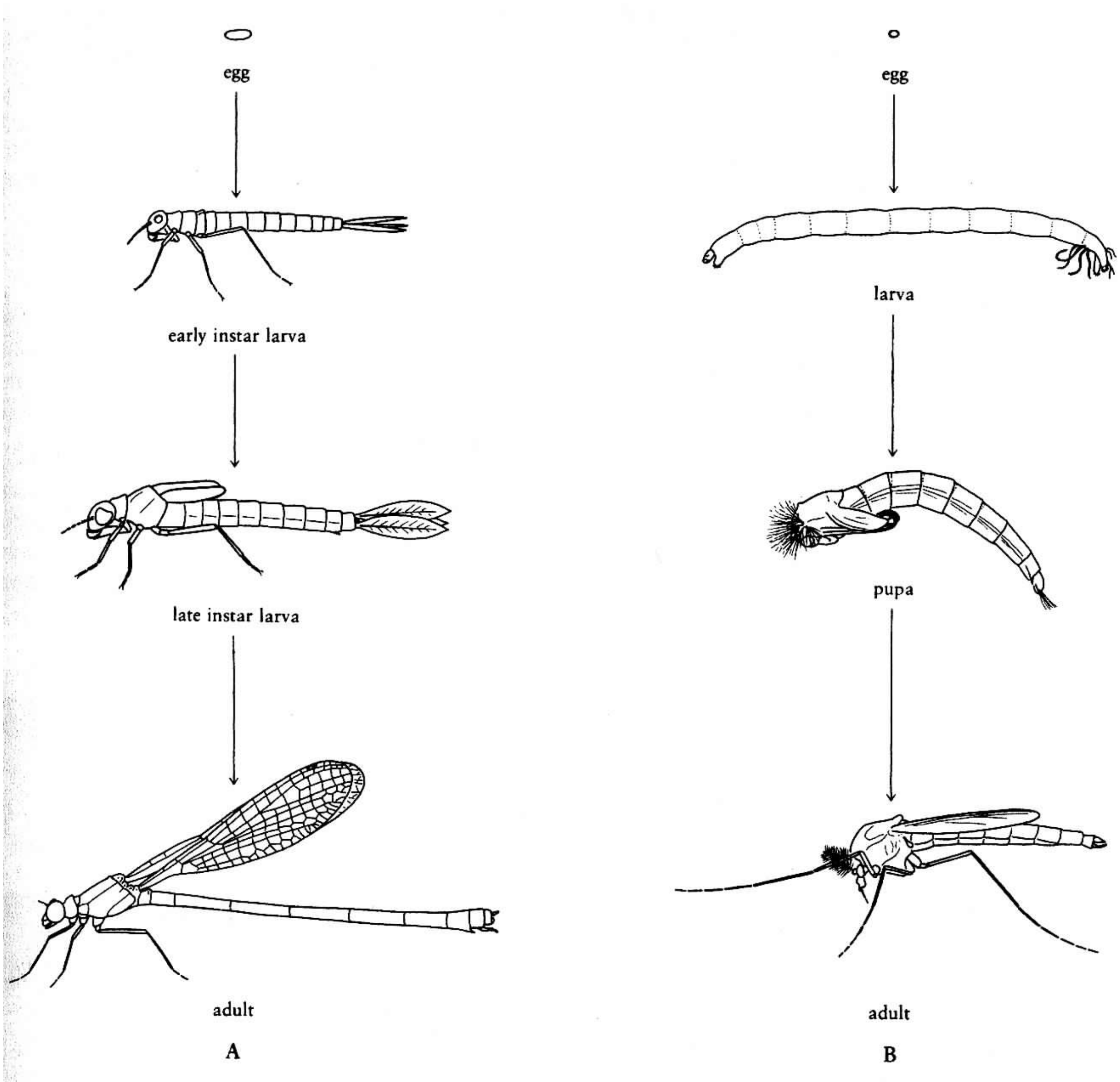


Figure 4: Different metamorphosis. A) incomplete metamorphosis. B) complete metamorphosis. (McCafferty 1981)

Aquatic insects are loosely defined as those which spend at least one life cycle in or on a body of water (McCafferty 1981, Merritt and Cummins 1978). They can be hydropnuestic or aeropnuestic to varying degrees, meaning they extract oxygen from the water or air. There are six primary orders of insects that we are likely to see in the Skeena River. Their general life histories and habitat requirements are discussed below with a focus on the aquatic life stages.

Megaloptera

Picture 1. Fish Fly larvae (MST 2004)

Megaloptera consists of what are more commonly known as alderfies, dobsonflies, and fishflies (Merritt and Cummins 1978). Only the larval stage of the Order Megaloptera occurs in the water. This order undergoes complete metamorphosis, having both a larval and a pupal stage. The larval stage can have nearly a dozen instars and can take from approximately 1-3 years to complete growth, all of which occurs in the aquatic environment. Prepupae migrate to the shore before preparing a cell in which they will undergo transformation. The adults mate and oviposition takes place out of the water. The eggs hatch anywhere from a few days to weeks later and the larvae drop into the water (McCafferty 1981).

Spending the majority of their life under water, Megaloptera can use either hydropneustic or aeropneustic respiration, depending on dissolved oxygen levels. All families have lateral filaments, and the dobsonflies also have tufted gills for oxygen uptake. Some larvae have elongated breathing tubes that allow them to utilize atmospheric oxygen while remaining submerged. They are bottom dwellers and predatory. Some varieties prefer well oxygenated, fast flowing water, but most prefer quiet pools where they hide under woody debris or leaf detritus (McCafferty 1981). We are likely to see the larva of this order in the Skeena River. We can expect to see them in quickly moving riffles and runs as well as in slower moving pools.

Plecoptera

Picture 2. Stonefly Larva (MST 2004)

Plecoptera are more commonly known as stoneflies. They undergo incomplete metamorphosis, spending the larval stage of their life underwater and their adult stage near the water (McCafferty 1981). They remain in the larval stage from three months to one year, and the process involves from twelve to twenty-four instars. They emerge in the summer and generally climb out of the water before transformation occurs. As a result, they are less available as prey to fish and birds during the vulnerable transformation stage than other insects such as mayflies (McCafferty 1981). The Plecoptera life cycle can take from one to three years depending on family. Females generally carry the egg sac on their abdomen before depositing it in the water. Egg sacs are fixed in place on the substrate with either a gel-like substance or a specialized anchoring device (Merritt and Cummins 1978).

Stoneflies can be found in the benthic zones of well aerated waterways with low temperatures. They tend to avoid nutrient-rich waters because they require high levels of dissolved oxygen to survive. They are not active swimmers but rather crawl among the stones, debris and detritus on the channel bed. Plecoptera are generally carnivores though some families are herbivores. They require highly oxygenated water, and thus are more likely to be found in riffles where they can easily move in the interstitial spaces of the sediment (Thompson, Lake and Downes 2001). The ability to seek refuge in the substrate during high flow events, when there is not significant geomorphic change though there may be high hydrologic intensity, but limited sediment mobility allows Stoneflies to better survive periodic flooding than other aquatic insects.

Trichoptera

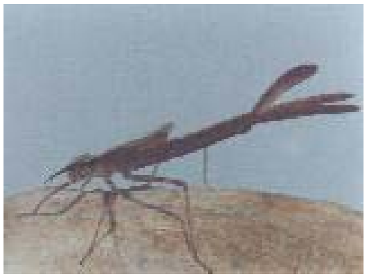
Picture 3. Caddisfly Larva (MST 2004)

Also known as Caddisflies, this particular invertebrate undergoes complete metamorphosis with very distinct larvae and adult stages separated by a pupal transition. They are closely related to Lepidoptera but, unlike Lepidoptera (moths and butterflies), they are adapted for life under water in the larval and pupal stages. Most species have five instars in the larval stage but they may have up to seven. Pupae are encased in a sealed cocoon that is fixed to a solid substrate for approximately three weeks. Larvae and pupae are hydropnuestic and live in the benthic portion of the water column. When they emerge as adults, they swim to the surface and fly away.

Trichoptera are found in the benthic region of both lotic and lentic waterways, where they spin nets to catch food. These nets are attached to fixed parts of the substrate of any size (generally camouflaged). The larvae are omnivore-detritivores subsisting from what is caught in the strands of their nets.

Caddisflies generally have fleshy bodies and are similar in shape to caterpillars. They can be distinguished from other similar taxa by their two anal claws and the presence of cases and nets. The cases are built with the prevalent substrate and are very specific to the taxa.

Odonata



Picture 4. Damselfly larva (MST 2004)

Picture 5. Dragonfly larva (MST 2004)

The order Odonata is comprised of what are commonly known as dragonflies and damselflies. They undergo incomplete metamorphosis with the larval instars residing in the water (McCafferty 1981). There have eight to fifteen instars and may spend up to a couple of years in the water depending on the family and habitat. They are most likely to be found in the shallow slower areas of streams. Larvae are equally likely to be found in woody debris as in benthic regions of the stream (Phillips 1996). Odonata are predatory and tend to either sprawl in the substrate or crawl in the vegetation waiting or looking for prey. It is likely they will be in the slower reaches of the tributaries of the Skeena River.

Ephemeroptera

Picture 6. Mayfly Larva (MST)

Ephemeroptera are commonly known as mayflies. They are a favorite food for salmon and other fish and are likely to be prevalent in the Skeena River and its tributaries. They do not have a pupal stage but are the only insects to have a subimaginal stage which is a non-adult, winged terrestrial stage. The number of instars during the larval stage is highly variable even within a species and often is determined by the local environmental conditions (McCafferty 1981). Some species in northern latitudes or higher altitudes go through a seasonal period of non-development in either the egg or larvae stage (McCafferty 1981). Since the Skeena River is both at northern latitudes and higher altitudes, the local mayflies may go through this diapause.

Most species of mayfly are non-carnivorous, subsisting on detritus and plant matter. They are the preferred food for many carnivorous insects as well as fish, making them an integral part of the freshwater food chain (McCafferty 1981). There are many species of Ephemeroptera, and they reside in widely varied habitats within the water. However, the highest species diversity occurs in smaller rocky-bottomed streams (Merritt and Cummins 1978).

Diptera

Picture 7. Black Fly larva (MST)

Diptera are more commonly known as flies. They are insects which undergo complete metamorphosis with the egg, larval, and pupal stages residing in the water. Some early larval stages may be planktonic, but later instars are generally benthic (Merritt and Cummins 1978). Diptera are found in moderate stream conditions, avoiding habitats with extremes in temperature, salinity, flow and chemistry (Merritt and Cummins 1978). Larvae may build cases or burrow into the sediment, live in or on plants, or live on other orders of insects. They prefer cobble substrate and deep hyporheic habitats (Merritt and Cummins 1978). Black fly larvae are likely to be common throughout the Skeena River and its tributaries in swift-flowing, cold habitats.

EFFECTS OF DISTURBANCE ON HABITAT

High water flows and sediment loading are common seasonal events in the rivers of British Columbia. These occurrences can have significant effects on the habitat availability for all fauna in the river systems. Specifically, disturbance can have direct effects on aquatic insects, which in turn, indirectly affects fish. Many aquatic insects live on the channel bed and are subject to substrate movement that can result from high flow volumes. Sediment movement can dislodge insects and in the most extreme cases of sedimentation, entombment can occur (Strand and Merritt 1997). High water flows and flood events produce large volumes of water and often create high water velocities. While high velocities can literally sweep insects downstream, if there are high sediment loads in the water then, as velocity decreases, the sediments settle out of the water column, entombing or burying the insects.

Higher sediment levels can also inhibit the reproductive abilities for the insects that oviposit in the substrate. A significant drop in survivorship has been found with high sediment loading and deposition, Gleason (2002) found a “99.7% reduction in total invertebrate emergence” with a 50% increase in sediment cover. Caddisflies as collectors are particularly sensitive to high sediment loads. They have been shown to have significantly reduced survival rates in high sediment flows (Strand and Merritt, 1997). High sediment loads have also been shown to adversely affect net-spinning Trichoptera (Hydropsychidae) through clogging, ripping, and burying of the nets (Runde 1999). This lead to decreased food acquisition, respiration, and fitness, and an increase in energy expenditure. Although studies regarding the effects of sedimentation on other taxa of insects are limited, similar results on sensitive species may be expected to occur.

Higher than normal water flows can also have detrimental effects on the habitat availability. Higher water velocities can sweep away substrates, caddisfly nets, and insects. Though flooding has the initial effect of lowering the abundance of macroinvertebrates, most taxa return to pre-flood levels within a matter of months for most families (Robinson 2003). Plecoptera in particular showed positive reactions to flooding as post flood densities were higher than pre-flooding (Robinson 2003). Stoneflies are less likely to decline because they can seek refuge under rocks during flood events (Thompson 2001), and turbulent waters can have higher dissolved oxygen levels than normal flows.

The most important impacts of flooding are those that influence the substrate and shape of the channel, which provides aquatic habitat. Floods often move substrates, scour and abrade the streambed, remove plants and organic matter, and kill, injure and displace biota (Thompson 2001). However, impact of a flooding on habitat is based more on the geomorphic change in the stream than on the hydraulic power of the flood (Nislow 2002). The number and location of riffles, pools and bars often adjust dramatically following high disturbance floods. In a study by Robinson, Lake and Downes (2001) streams with solid rock beds showed less disturbance to the benthic community during floods than did those with highly mobile glacial till. Habitats that remain stable through moderate to large sized floods can be essential to most aquatic insects.

The Skeena River is a non-regulated watershed and is, therefore, subject to seasonal high flows and flooding. Though high flows can disrupt the substrate and seem detrimental to the benthic community flooding is a natural occurrence that the ecosystem has adapted to. Even in high flow events with significant geomorphic change, the insect populations often return to their pre-flood levels or greater after some period of time (depending on the species) (Robinson 2003, Nislow 2002). Streams and rivers that are controlled and no longer subject to flooding that are required by some species important habitat components such as large woody debris. Regulated systems also lack sediment and movement such as erosion and scour of fine particles that keep interstitial spaces open for species such as stoneflies. Although flooding can seem detrimental in the short-term, it has benefits to the stream ecosystem in the long-term (Robinson 2003).

CONCLUSION

The Skeena is a cold, swift, large river. It provides habitat for a wide variety of fish, plants, mammals, and insects. The insects are an important part of the freshwater food chain in the Skeena. There are many different types of insects we can expect to see in the Skeena River, with Megaloptera, Ephemeroptera, and Diptera being the most likely orders. The life histories of these insects are important because they determine when the insects are found in the river as well as what habitat types they are adapted to. Because the Skeena River is largely isolated with pristine habitat and few anthropogenic influences, we are not likely to see excessive sedimentation or water quality impacts that are often present in developed watersheds. Natural disturbances such as seasonal flooding can be detrimental both the habitat and the insects, however, they also provide new habitat and are an important part of the Skeena River. We will see a wide variety of habitats, but riffles and runs will likely support the highest diversity of species.

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