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The Identification, Types, Taxonomic Orders, Biodiversity and Importance of Aquatic Insects

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Abstract: The identification, types, taxonomic orders, biodiversity and importance of aquatic insects was reviewed to facilitate sustainable culture fisheries management and practice. Aquatic insects contribute significantly to fresh water ecosystems, one of many groups of organisms that, together, must be considered in the study of aquatic ecology. As such their study may be a significant part of understanding the ecological state of a given ecosystem and in gauging how that ecosystem will respond to stress. Aquatic insects and the larvae attack fish eggs and fry. They also compete for food and space in the pond. However, mosquito larvae are a food for fish. So, some insect larvae can serve to increase fish production. Insect bioagents can control the alligator weed, *Alternanthera philloxeriodes.* The flea beetle *Agasilles hydrophila;* alligator, *Amnothrips andersonu* and the alligator stem borer, *Vegtia mallio* can control the weed effectively. Other insects that can control water hyacinth are nevil (*Nechetina circhbornae*) warmer (*Atustache bruchi*) and hycinthmite (*Orthoguma terebranths*). *Paropoynk alliondis* and *Litodactylus leucogaster* can control the water milfoil, *Myriophyllum spicatium*. The article reviews and discusses the identification, economic importance, life cycle, biodiversity, roles and taxonomic orders of aquatic insects to facilitate sustainable culture fisheries management and practice.

Keywords: Aquatic insects, biodiversity and importance, identification, taxonomic orders, types

INTRODUCTION

Insects constitutes about 70% of all known species of animals are insects. Although they are mainly land animal, they are widespread and adapted to all types of environment. They are also the only invertebrates that can fly (Voshell, 2002). Most insects feed on plant materials, while some feed on animal tissues and wastes. An insect has well defined head, a thorax and an abdomen. The head has six segments and bears a pair of jointed antenna, compound eyes, simple eyes and mouth paths. The thorax has three segments each bearing a pair of jointed walking legs (Smith, 1995). The second and third thoracic segments may also have a pair of wings each. The abdomen has eleven segments and may have sensory and reproductive structures. An insect carries out gaseous exchange by means of a network of open-air tube or trachea inside its body. These tubes have opening called spiracles of the exterior (Thorpe and Covich, 1991). Many insects have a life cycle, where they pass through the following stages; the larva and the pupa do not resemble the adult. Such an insect is said to undergo complete metamorphosis to attain its adult form Peckarsky *et al.* (1990). Some insects undergo incomplete metamorphosis, where the eggs hatch into nymphs, which look like tiny adults. These grow by molting several times to become mature adults (Resh and Rosenberg, 1984).

Aquatic entomology is the study of aquatic insects (Pennak, 1989). Although it is a discipline in its own right, it often interacts with other disciplines or forms an integral part of them. For example many aquatic flies are important as disease vectors; hence aquatic entomology interacts with medical entomology and parasitology. Aquatic insects contribute significantly to fresh water ecosystems, one of many groups of organisms that, together, must be considered in the study of aquatic ecology. As such their study may be a significant part of understanding the ecological state of a given ecosystem and in gauging how that ecosystem will respond to stress.

Insects are of various types in the fishpond (Merritt and Cummins, 1996). Their larvae are serious pest in both fresh and brackish water ponds. There are eleven orders of aquatic insects but the most common ones in fishpond are Coleoptera (beetles), Homeoptera (cicada), Hemptera (bugs) Odonata (dragon flies) and Diptera

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Plate 1: May fly

(flies). Nymph of odonata is very destructive to fish eggs and fry. In most cases, aquatic insects and the larvae attack fish eggs and fry. They also compete for food and space in the pond. However, mosquito larvae are a food for fish. So, some insect larvae can serve to increase fish production. Insect bioagents can control the alligator weed, *Alternanthera philloxeriodes*. The flea beetle *Agasilles hydrophila*; alligator, *Amnothrips andersonu* and the alligator stem borer, *Vegtia mallio* can control the weed effectively. Other insects that can control water hyacinth are nevil (*Nechetina circhbornae*) warmer (*Atustache bruchi*) and hycinthmite (*Orthoguma terebranths*). *Paropoynk alliondis* and *Litodactylus leucogaster* can control the water milfoil, *Myriophyllum spicatium* (Allan, 1995). The identification, economic importance, life cycle, biodiversity, roles and taxonomic orders of aquatic insects was reviewed to facilitate sustainable culture fisheries management and practice.

RESULTS AND DISCUSSION

Aquatic insect's identification: The following aquatic insects include some of those that you might encounter when exploring your pond. This guide is intended to help you identify these insects and to learn some interesting characteristics about each.

Mayfly (Order: Ephemeroptera):
Habitat of nymph: Fresh running water of ponds and streams.

Habitat of adult: Short lived flying insect that mates and then dies.

Characteristics: Distinguished by obvious wing pads on nymph and two tails that remains on the adult. They also do not have leaf like gills along both sides of the abdomen as the mayfly does. The larvae live 1-4 years in water, feeding on debris and small animal life (Resh and Rosenberg, 1984). The last stage molts into a winged form which molts again into the adult. Mating and egg-laying occur quickly over water and the adults die (Plate 1). Oxygen is obtained by single gills under the legs or through the skin surface (Voshell, 2002).

Distinguished from other nymphs by seven pairs of gills along the abdomen. Oxygen is absorbed from water. Nymphs generally have three tails attached to the end of the abdomen. Wing pads are visible on the nymph. Nymphs feed on live and decaying vegetation. Nymphs are a common food source for trout and other fish. Mayfly (Fig. 1) nymphs require 4 to 10 ppm of dissolved oxygen for survival. Nymphs are up to 2.5 cm long. They have three pairs of segmented legs with one claw at the end of each leg (Thorpe and Covich, 1991).

Dragonfly (Order: Odonata):
Habitat of nymph: Ponds marshes and slow moving streams.

Habitat of adult: Fast flying insect.

Characteristics: Distinguished by large compound eyes with nearly 360° vision in both the nymph and adult stage. Nymphs have "lips" hinged in two places with grasping pincers on the end for catching prey (Allan, 1995). Brown and green bodies tend to provide camouflage and allow the nymph to blend in with the aquatic habitat of plants and pond bottoms. Gills inside

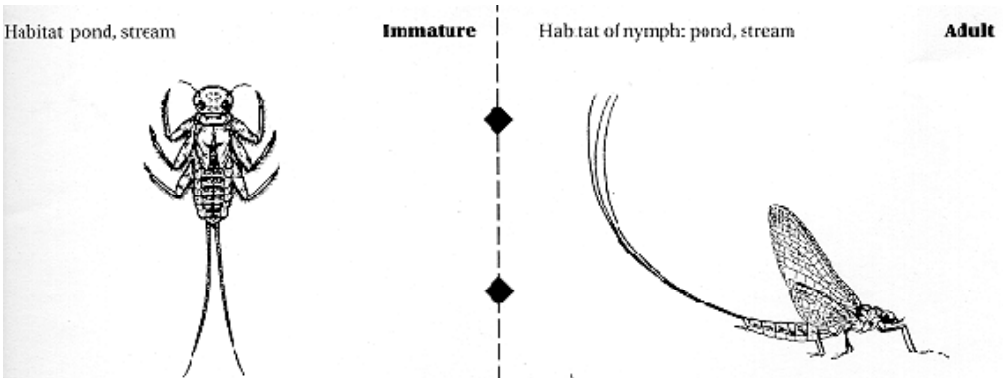

Fig. 1: The may fly

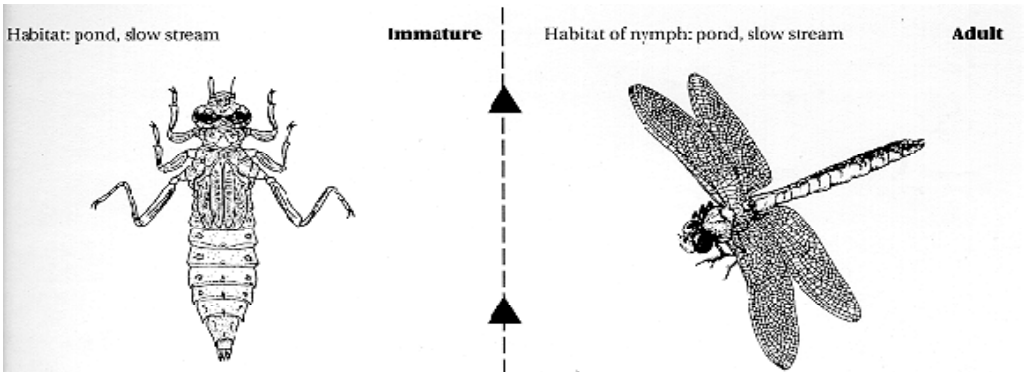

Fig. 2: Dragon fly

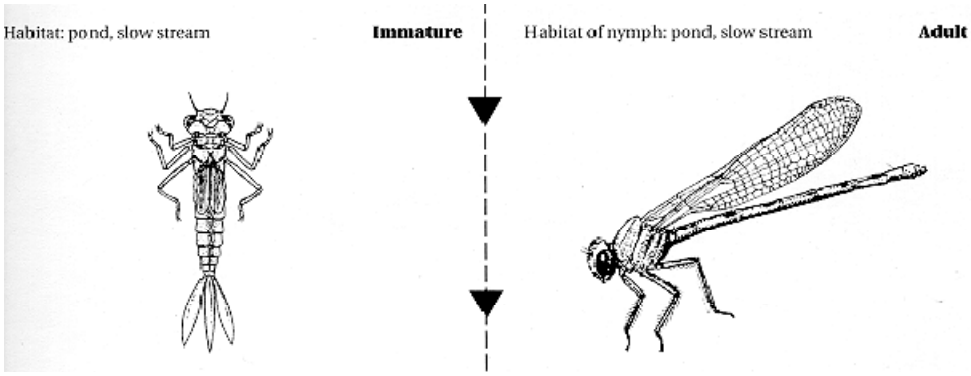

Fig. 3: Damse fly

the abdomen obtain oxygen. Water drawn into the abdomenand through the gills is expelled to propel the nymph through the water. Dragonfly (Fig. 2) nymphs require 4 to 8 ppm of dissolved oxygen for survival. They have three pairs of segmented legs on upper part (thorax) of body. Dragonfly larvae can be distinguished from damselfly larvae by a wide to oval abdomen that may end in wedge shaped extensions. Nymphs are predators and feed on mollusks, other insects, crustaceans, worms, and small fish. Nymphs are a food source for some fish (Smith, 1995).

Damselfly (Order: Odonata; Suborder: Zygoptera):
Habitat of nymph: Ponds, marshes, and slow moving streams.

Habitat of adult: Fast flying insect.

Characteristics: In the same order as dragonflies and similar to dragonflies but generally smaller and more delicate. Distinguished by large compound eyes with nearly 360º vision in both the nymph and adult stage (Pennak, 1989). Nymphs have "lips" hinged in two places with grasping pincers on the end for catching prey. Brown and green bodies tend to provide

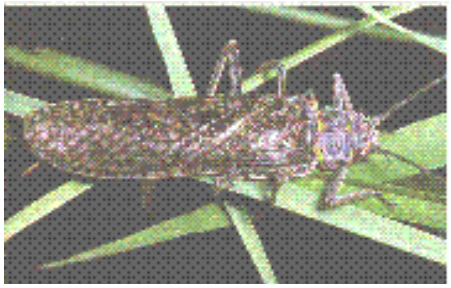

Plate 2: Stone fly

camouflage and allow the nymph to blend in with the aquatic habitat of plants and pond bottoms. Three leaf-like gills at the base of the abdomen obtain oxygen. Damselfly (Fig. 3) nymphs require 4 to 8 ppm of dissolved oxygen for survival (Smith, 1995). Damselfly nymphs can be distinguished from dragonfly nymphs by a narrow body with three gills extending in a tripod formation at the end of body. The three pairs of legs are long and spindly. Nymphs are predators and feed on mollusks, other insects, crustaceans, worms, and small fish. Nymphs are a food source for some fish (Allan, 1995).

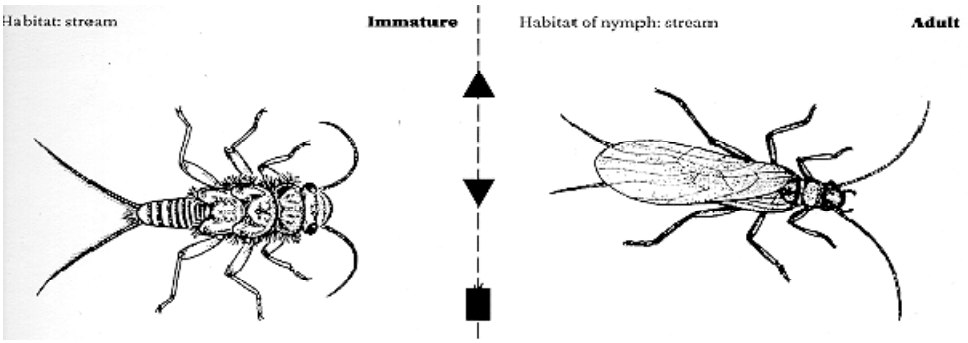

Fig. 4: Stone fly

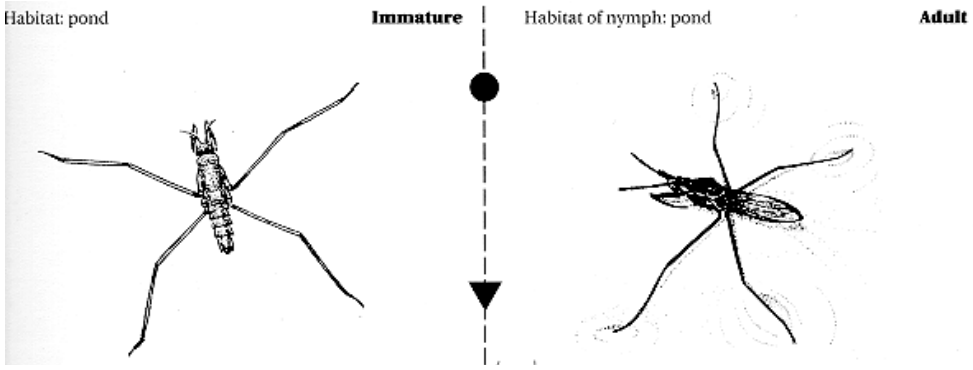

Fig. 5: Water strider

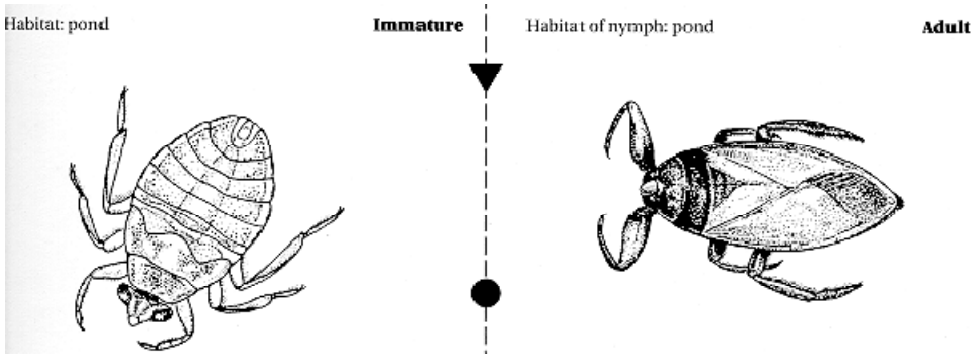

Fig. 6: The giant water bug

Stonefly (Order: Plecoptera):
Habitat of nymph: Cold lakes or fast moving streams.

Habitat of adult: Flying insect.

Stonefly (Plate 2) habitat is stream sides and shores of lakes and ponds. Eggs deposited in masses in water; larvae mature in 1-4 years, adults live 2-3 weeks.

Stonefly (Fig. 4) nymphs require 8 to 10 ppm of dissolved oxygen for survival. They have two long antennae much longer than the head. They have three pairs of segmented legs that end in small hooks (Pennak, 1989). The nymph appears to be flattened in shape for crawling along and under stones. Nymphs feed on decaying plants and animals or other small macro invertebrates. Nymphs are a food source for some fish (Resh and Rosenberg, 1984).

Water strider (Order: Hemiptera):
Habitat of nymph: Ponds and slow moving streams.

Habitat of adult: Ponds and slow moving streams.

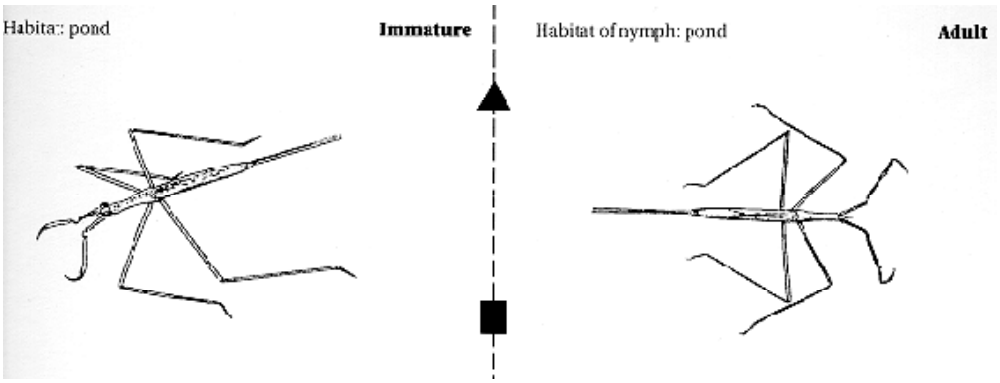

Fig. 7: Water scorpion

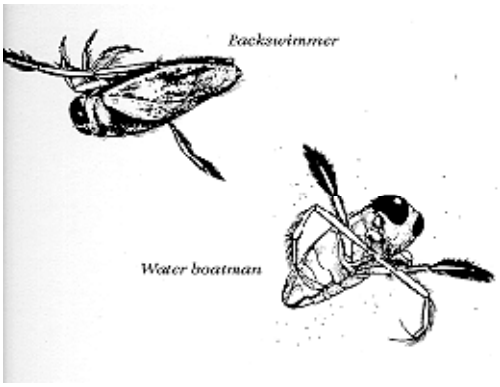

Fig. 8: Water boatmen (below) and backswimmers (top)

Characteristics: Water striders (Fig. 5) appear to skate across the water surface. Their legs can pick up vibrations of other organisms. Oxygen is absorbed by spiracles or specialized holes in their skin surface.

Giant water bug (Order: Hemiptera; Family: Belostomatidae):
Habitat of nymph: Ponds and slow moving streams.

Habitat of adult: Ponds and slow moving streams.

Characteristics: The Giant Water Bug (Fig. 6) gets oxygen through a snorkel like breathing tube that extends to the water surface. They have three pairs of jointed legs. The front pair has a modified hook for catching and holding prey. Giant Water Bugs may be up to 8 cm in size. True predators in the aquatic environment, Giant Water Bugs will attack prey that is 20 times larger in size (Thorpe and Covich, 1991).

Water scorpion (Order: Hemiptera; Family: Nepidae):
Habitat of nymph: Ponds and slow moving streams.

Habitat of adult: Ponds and slow moving streams.

Characteristics: Water Scorpions (Fig. 7) get oxygen through long breathing tubes at the base of the abdomen. They look more like sticks than like insects. They are up to 10 cm in length. They have three pairs of jointed legs. The front pair has a set of single hooks for capturing and holding prey (Pennak, 1989).

Water boatman (Order: Hemiptera):
Habitat of nymph: Ponds, running water of streams and intertidal marshes.

Habitat of adult: Ponds, running water of streams and intertidal marshes.

Characteristics: Water Boatmen (Fig. 8) have middle and hind legs covered with long swimming hairs. They eat decaying matter as well as other animals. Because they rely on atmospheric oxygen many species are tolerant of pollution and can live in oxygen-poor environments. Atmospheric oxygen is trapped as an air bubble (or plastron*)* beneath microscopic hairs (Merritt and Cummins, 1996).

Backswimmer (Order: Hemiptera):
Habitat of nymph: Ponds, running water of streams and intertidal marshes.

Habitat of adult: Ponds, running water of streams and intertidal marshes.

Characteristics: Backswimmers (Fig. 8 top) have middle and hind legs covered with long swimming hairs like water boatman but swim on their back.

Mosquito (Order: Diptera):
Habitat of larvae: Generally ponds, marshes, lakes and slow moving steams some species have adapted to fast moving streams.

Habitat of adult: Small flying insect.

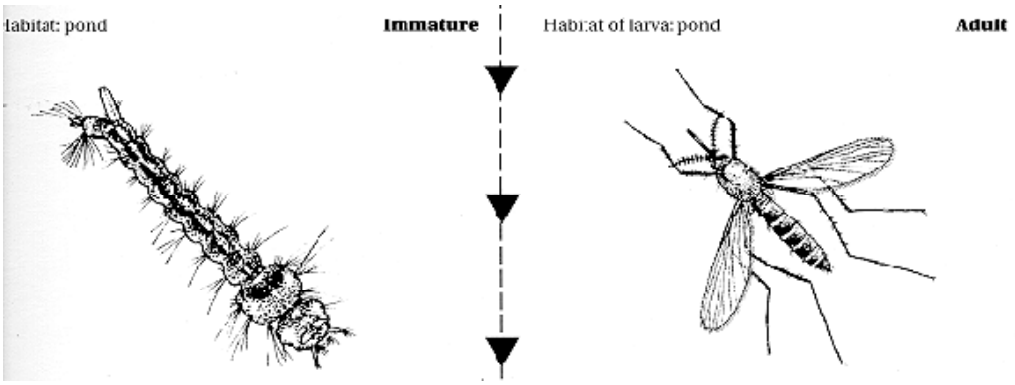

Fig. 9: Mosquito larvae and adult

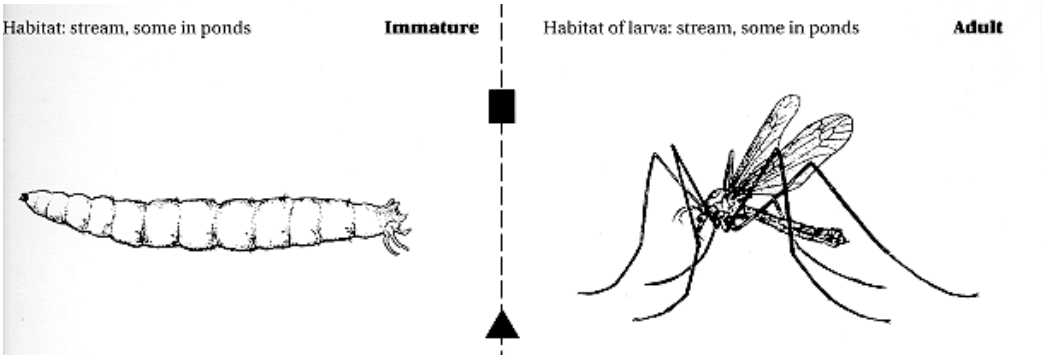

Fig. 10: Larvae and adult of flying insect

Plate 3: Chiromidae

Larvae have a small siphon or snorkel tube to acquire oxygen from the air. They can tolerate waters with very low levels of dissolved oxygen. Mosquito (Fig. 9) larvae can tolerate levels of dissolved oxygen of less than 4 ppm. Larvae are a food source for fish (Allan, 1995).

Cranefly (Order: Diptera; Family: Tipulidae):
Habitat of larvae: Ponds, lakes, and marshes.

Habitat of adult: Flying insect (Fig. 10).

Characteristics: Larvae are plump, long, and cylindrical. Larvae may be up to 10 cm in length. At the end of the abdomen are spiracles or breathing holes that look like fingers. The larvae will move to the water surface to breathe oxygen from the air (Merritt and Cummins, 1996). The abdomen of some species is flattened. The back end usually has several small extensions or lobes. Often the small head is not visible and is hidden within the first segment of the body. Larvae are a food source for fish.

Midges (Order: Diptera; Family: Chironomidae):
Habitat of larvae: Bottom sediments of lakes, ponds, or streams.

Habitat of adult: Small flying insect.

Characteristics: Chironomidae (Plate 3) are small mosquito-like insects, midges and the like which inhabit marshes and ponds, woodlands, meadows, gardens near water. Eggs lay in water after mating swarm; larvae eat decaying plant matter. Mature larvae float to surface and pupate; adults released at surface.

Larvae are up to 1.5 cm in length (Fig. 11). Larvae bodies are usually thin, slightly curved, and segmented. They have one pair of tiny fleshy prologs below the head and one pair at the back end. The end sometimes

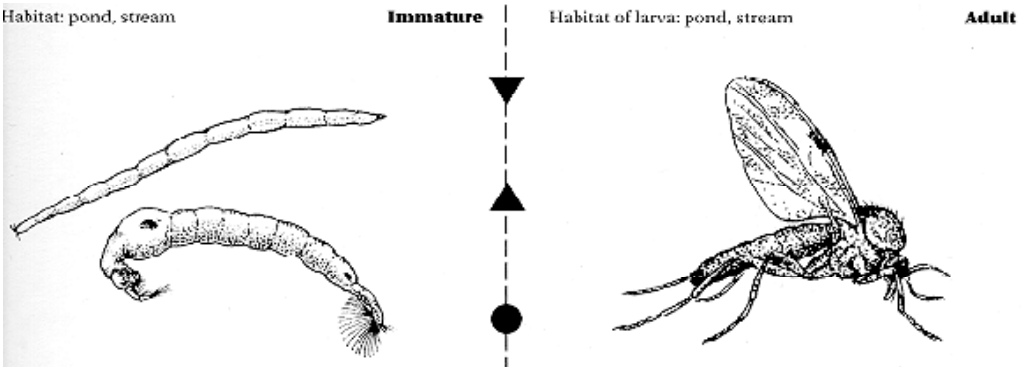

Fig. 11: Larvae and adult chiromidae

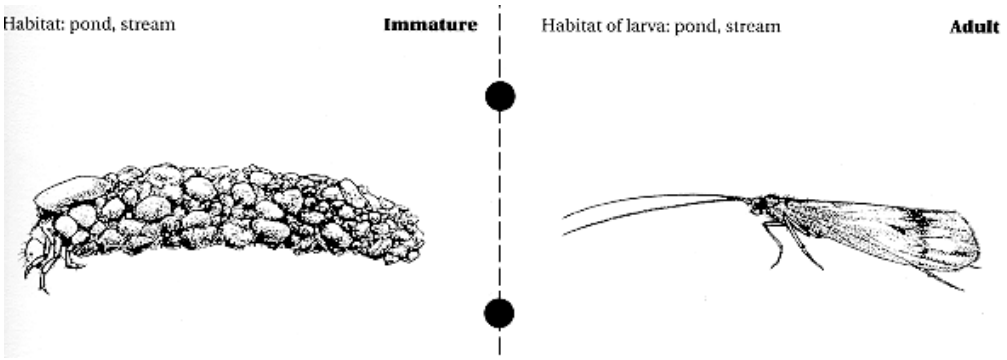

Fig. 12: Caddisfly larvae

Plate 4: Caddish fly

has tiny tufts or extensions. They feed on smaller larvae, decaying matter, and microorganisms. They are an important component of the aquatic food web. Larvae are a food source for fish. Typically, midge larvae live in the bottom sediments of lakes and streams. Their remains form organic ooze (Allan, 1995).

Two main groups of midges are distinguished by their method of obtaining and storing oxygen. Midges that are red in color are termed blood midges. They can store oxygen in their body fluid with a compound similar to hemoglobin (Merritt and Cummins, 1996). This provides the distinguishing red color for blood midges. Blood midges can tolerate very low levels of dissolved oxygen. Other midges obtain oxygen from the air with breathing tubes. Both blood midges and other midges are distinguished from other aquatic fly larvae by a thin uniformly wide segmented body. Midges can tolerate levels of dissolved oxygen of less than 4 ppm.

Caddisfly (Order: Trichoptera):
Habitat of larvae: Streams and ponds

Habitat of adult: Land dwelling flies.

Characteristics: Many caddisfly larvae (Fig. 12) can be recognized by soft bodies which are covered by tube like cases that the larvae build from twigs, leaves, grasses, pebbles and sand grains. Some larvae do not build cases where the current is not strong such as ponds. Larvae maybe up to 4 cm in length (Merritt and Cummins, 1996). They have three pairs of segmented legs on the upper-middle part of the body and two small fleshy extensions at the end of the abdomen that end in a small hook. Filamentous gills may be present on the underside or the end of the abdomen. They have a characteristic motion know as the "Caddisfly Dance" of

wiggling back and forth and up and down. Different species have different feeding habits. Some live on dead leaves and decaying matter, others feed on plants, and some prey on other organisms. Oxygen is absorbed through the body surface. Larvae and the pupae are common food sources for trout and other fish.

Adults (Plate 4) are often seen around porch lights near water and mistaken for moths; the larvae build cases of sand grains or plant fragments and crawl over stream bottoms or weave small nets to catch prey in current. Adults are short-lived or rarely eat (Plate 2).

Maggots (Rat-tailed maggot) (Order: Diptera):
Habitat of larvae: Streams and ponds.

Habitat of adult: Land dwelling flies.

Characteristics: Larvae have a long snorkel-like tail (Fig. 13) that draws in oxygen from the atmosphere. The body is cylindrical. Tolerates low oxygen levels. It is a scavenger and feeds off dead decaying matter.

Predaceous diving beetle (Order: Coleoptera; Family: Dytiscidae):
Habitat of larvae: Slow moving waters.

Habitat of adult: Slow moving waters.

Characteristics: Larvae have six jointed legs. The body is segmented with a narrow collar behind the head. Abdomen may have filaments but not hooks. The head has large crescent shaped mandibles or mouthparts (Fig. 14).

Use of aquatic insects in environmental protection: It would be difficult to overestimate the importance of aquatic insects as food items for other animals, particularly in the food webs associated with wetland environments. Many fishes, amphibians, shorebirds, waterfowl and other animals forage heavily on both the aquatic and terrestrial stages of aquatic insects, which are essential to their survival (Thorpe and Covich, 1991). It is imperative that society fully understand the potential consequences of the uses and alterations of the earth's natural environment. Environmental scientists have come to realize that uses or changes of waterways and lakes may have dire short-term or even irreversible long-term effects, not only on the quality of water itself but also on aquatic ecosystems (Voshell, 2002).

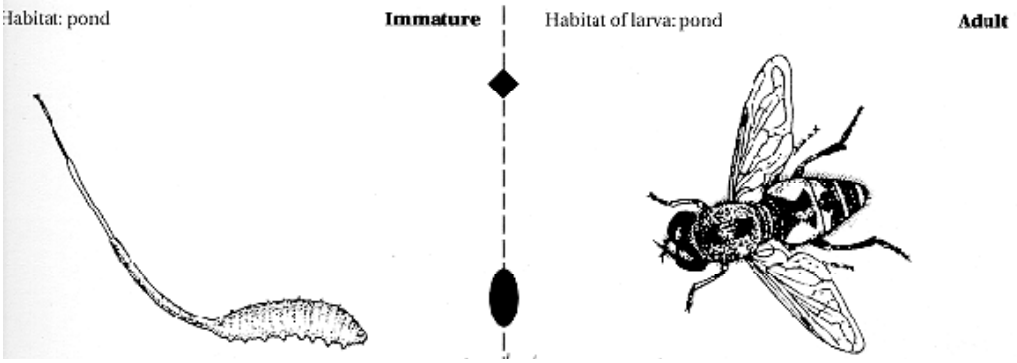

Fig. 13: Land dwelling fly larvae and adult

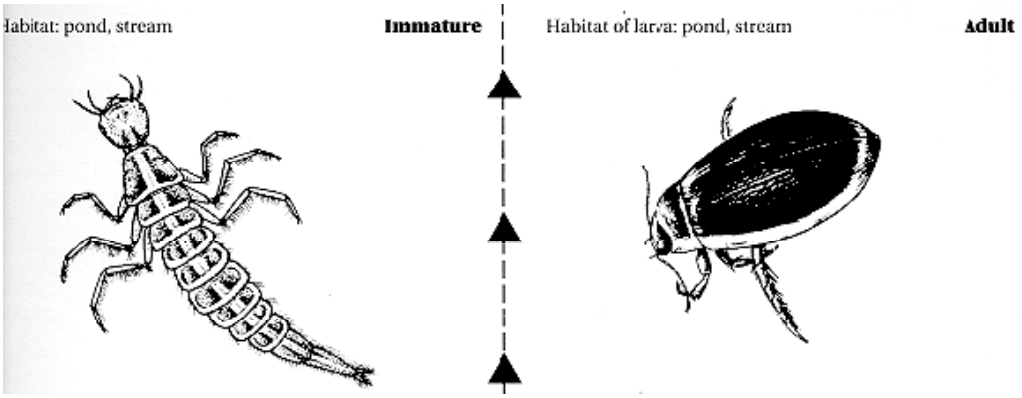

Fig. 14: Larvae and adult coleoptera

As a result, research has been employed to ascertain the effects of perturbations on our water resources and to increase our knowledge about the makeup of natural communities of aquatic organisms and their relation-ships with natural environments (Smith, 1995). To this end, aquatic organisms that may be affected by an impending alteration or activity are often surveyed as part of an environmental assessment or impact study. This should be done, for example, before impounding a river to create a reservoir; before dredging a stream; before constructing power plant cooling facilities, sewage treatment plants, or factories that may deliver potentially toxic effluents into a river or lake; before mining or deforestation activities; or before spraying chemicals over wetlands and forests. Measurements of the richness and diversity of aquatic insect species in relationship to the chemical and physical characters of their environment provide very usable indices for such baseline studies and are commonly made for these purposes.

Aquatic insects and other bottom-dwelling organisms in freshwater systems are also monitored in order to gauge subtle and profound effects that changes in water quality have on aquatic life. Changes in the composition of bottom-dwelling communities, as measured both qualitatively and quantitatively, will reflect, to various degrees, either non-optimum or intolerable quality shifts that result from the addition of pollutants to the water. Sources of such pollutants may be continual, intermittent, or accidental, and they may originate either from precise points or from large areas.

Bio-monitoring of this sort has some decided advantages over chemical and other types of water analysis. Bottom-dwelling insects and other invertebrates, by their very nature, maintain a relatively stable position in the aquatic environment. Thus the community composition can reflect either previous or long-range shifts in water quality. Analysis of water chemistry or of highly mobile aquatic animals such as fishes tends to reflect the quality of water only at the times that samples are taken. Aquatic insects are also used in bioassay work. Laboratory bioassays are performed to determine the toxicological effects of pesticides on aquatic insects. The pesticides may be those that are intentionally used in aquatic or adjacent environments for the control of mosquitoes and other pests or they may be those that inadvertently find their way into aquatic ecosystems, for example, via agricultural runoff. Such bioassays are commonly used to ascertain effects on non-target aquatic insect species, and thus have a direct relationship to environmental protection. In addition, several aquatic insects are studied in the laboratory in order to determine the mode of action of pesticides and the relative tolerances that these insects have for pollutants, such as heavy metals, organic enrichment, and heated waters (Thorpe and Covich, 1991).

Aquatic insects for which sufficient toxicological data are available have some potential for being used in field bioassays. That is, caged stock populations could be implanted at various points in a stream-for example, at the source (or supposed source) of a pollutant, upstream from the source, and downstream from the source. The relative mortality of these implanted populations could then be used as pollution indicators. Certain fish species have been commonly used in such field bioassays. There are many methods for sampling aquatic insect populations: screens, nets, artificial substrate samplers, grabbing devices and dredges. Most of these are used in both fresh and salt water environments. A few of these are shown on the accompanying Aquatic Insect Sampling Devices (Allan, 1995).

A modification of the substrate sampler in which the substrate is made of leaves rather than being artificial. The leaves used are generally those of the gamble oak which provide flat surfaces like the plate sampler, which have nooks and crannies like the rocks, but which also are organic and attract insects which eat organic matter. Most aquatic insects are considered benthic because they are found associated with the bottom or with a substrate, but they occupy virtually every possible niche within their habitat. Some are clingers, clinging to the substrate with grasping claws or disks; the sprawlers crawl along the protected surfaces of the substrates; climbers reside on aquatic plant stems and other shoreline substrates; burrowers burrow into the soft bottom; floaters and swimmers are not associated with a substrate for attachment. The water skaters seen on many streams are examples of this type (Allan, 1995).

Life cycle: Aquatic insects, like other insects, go through life cycles (Fig. 15) which include embryonic (egg) stages as well as post-embryonic stages which may include larvae, pupae etc. and leading to the sexually mature adult stage. The term for passing from one stage to the next is metamorphosis (Thorpe and Covich, 1991).

Although the majority of insect species live in terrestrial environments, an appreciable number of species live in freshwater environments, such as swamps, ponds, lakes, springs, streams, and rivers (Voshell, 2002). These underwater species are often inconspicuous and relatively unknown to most people. Freshwater habitats are challenging places for small-bodied animals to live, but various species of aquatic

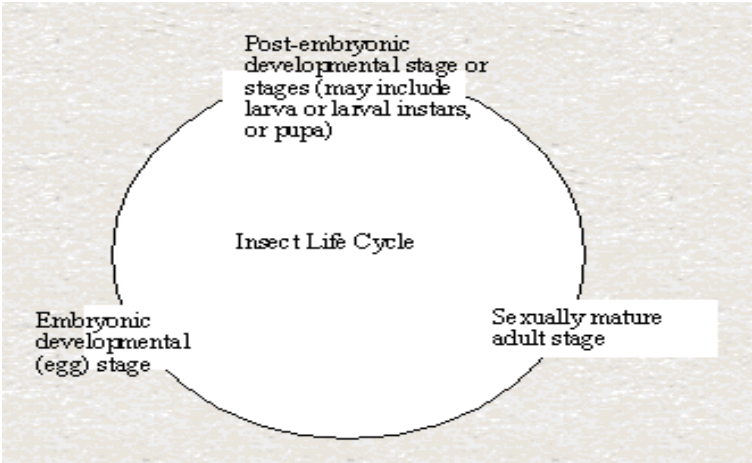

Fig. 15: Insect life cycle

insects have a wide assortment of adaptations that enable them to be successful. Nowhere is this more evident than in small streams that alternately have swift, rocky segments (called riffles) and slow, sandy segments (called pools). Streams offer some advantages for the insects that live there, but not all insects are capable of existing in the harsh physical conditions of a stream, or at least not everywhere in a stream (Peckarsky *et al*., 1990). Watersheds (drainage basins), which contain freshwater as it flows in channels from high to low elevation, are important ecosystems that provide valuable services to humans (Resh and Rosenberg, 1984). Aquatic insects play ecological roles that are essential for these ecosystems to function properly. Thus, aquatic insects are an important component of biodiversity. The purpose of this exercise is to study some of the special adaptations that aquatic insects have for successful existence in running waters and to relate that information to the concept of biodiversity (Smith, 1995).

Biodiversity: Biodiversity is the variety of life forms, i.e., the number of species and the natural processes of which these living things are a part. The natural processes include the ecological roles that livings things perform in ecosystems. Thus, biodiversity is not just the number of species living somewhere; it is also what they do there. Ecosystem services are the essential roles played by organisms in creating a healthful environment for humans. Ecosystems (both natural and managed) can be thought of as factories or businesses, both of which produce goods and services. In this analogy, the roles of living organisms in ecosystems are like the jobs of people in a factory or business. Without workers doing their jobs effectively, no goods or services are produced in a factory or business (Resh and Rosenberg, 1984). If biodiversity is not maintained, ecosystems will not be able to provide the services that the existence of human society depends upon. Examples of services from terrestrial ecosystems are regulation of atmospheric gases (oxygen versus carbon dioxide) and creation of soil. Examples of services from stream ecosystems are:

- Drinking water
- Recreation (swimming, fishing)
- Food (commercial fisheries in large rivers)
- Habitat for species that we value and want to conserve aesthetics
- Delivering water of appropriate quality and composition to estuaries

The roles of aquatic insects: Some of the major roles that participants in this exercise should be able to understand and relate to their field and laboratory observations are:

- Breaking down large pieces of detritus from surrounding terrestrial vegetation (shredders)
- Scraping excess algae from the rocks and other solid substrates (scrapers)
- Filtering particles out of suspension in the water (collector-filterers)
- Mixing the bottom sediments (burrowers)
- Keeping the populations numbers of other invertebrates under control (predators)
- Serving as essential food for water birds, fish, and other animals that we value (prey)

Taxonomic orders: Truly aquatic insects are those that spend some part of their life-cycle closely associated

with water, either living beneath the surface or skimming along on top of the water (Resh and Rosenberg, 1984). Aquatic insects can be found in the following taxonomic Orders; Collembola, the Springtails; Ephemeroptera, the Mayflies; Odonata, the Dragonflies; Plecoptera, the Stoneflies; Hemiptera, the true Bugs; Neuroptera/Megaloptera, the Dobsonflies, Alderflies, and Spongillaflies; Trichoptera, the Caddisflies; Lepidoptera, the butterflies and Moths; Coleoptera, the Beetles and Diptera, the true Flies (Smith, 1995).

Collembola: The springtails are very small insects that have been around for a very long time. This is one of the oldest insect orders with fossil remains known from the Devonian period over 345 million years ago. The Collembola are strange-looking little insects that can sometimes be found in large numbers jumping around on the surface of the water where there is vegetation or organic detritus like leaves washed against the shore. These insects have evolved a jumping device composed of a furcula and tenaculum which allows them to leap many times their own length.

Ephemeroptera: The Mayflies are well known to fly fisherman because they are one of the favorite foods of trout when they emerge as adults. Most of their lives are spent as nymphs living sometimes for several years under the water before emerging as adults to mate and lay eggs in a few h or at most a few days. This is where the order got its name, from the "ephemeral" nature of the insects' adult life. Mayflies are the only insects known to molt after reaching a winged form. After emerging from the water they live briefly as a winged form called a sub imago which molts again to the adult form Peckarsky *et al*. (1990).

Odonata: The Odonates are the insects commonly known as dragonflies and damselflies. They are all predators, both as nymphs and adults, and the adults can significantly reduce mosquito populations by scooping them out of the air with their basketlike arrangement of legs. Odonate larvae have unusual mouthparts that can be extended to capture prey. These are ancient insects that have been around since before the age of the dinosaurs. Some Odonate fossils from the Carboniferous period had wingspans of over a meter! These insects were larger than many modern hawks!

Plecoptera: The Plecoptera are called stoneflies, likely due to the fact that nymphs are very common beneath the stones of rivers and streams. Another ancient order, the stoneflies prefer colder, fast running water and are one of the most common orders you will find in the small tributary streams of the Connecticut River. The nymphs of stoneflies look very much like the adults with the exception of the wings, which are not present in the nymph.

Hemiptera: The Hemiptera you find in the river are surely the insects you want to treat with the most respect because many of them are capable of inflicting a very painful bite. They range in size from tiny insects called Water-measurers in the family Hydrometridae to the huge Belostomatidae, or Giant Water Bugs, which can reach 7 cm or more in length. The majority of aquatic Hemipterans are predators and this can be seen from their raptorial forelegs and sharp piercing mouthparts. The most formidable of these insects is a small round bug called a Creeping Water Bug. The bite of this bug is easily as painful as a hornet sting and probably more. Others you might find include the Water Scorpions, Backswimmers, Water Boatmen and Water Striders. All of these insects are common in the Connecticut River, usually in places where the water is slow-moving and emergent vegetation is present.

Megaloptera and neuroptera: These large insects, commonly known as alderflies or dobsonflies, can be quite striking both as larvae and as adults. The immature form of the dobsonfly is what fishermen call a "hellgramite". These fierce larvae can be over three inches long and are equipped with strong mandibles with which they can deliver quite a pinch. They are common in rocky, fast moving areas of the river where they live by hunting down and eating other aquatic animals. When they become adults they still look formidable because many of the adult males have grossly exagerated jaws. These however are mainly for show and cannot be used to pinch like the jaws of the larvae can (Pennak, 1989).

Trichoptera: The common name of the Trichoptera is "caddisfly" which means case-bearer. Many of these insects build cases to live in from various materials they find in the river such as stones, twigs, leaves or sand. Here is a picture of just some of the cases that you might find while exploring the river. The average size of these cases is about 1.5 cm in length.

Lepidoptera: There are only a few Lepidoptera, the butterflies and moths that are truly aquatic. Most that will be found in the Connecticut River are Noctuid moths that live as larvae in the stems of aquatic plants. Many beautiful butterflies and moths will, however, be found associated with the river and it always pays to

keep an eye out for them as they can be one of nature's most rewarding sights.

Coleoptera: Coleoptera is Latin for "shield-wing" and if you've ever looked closely at a beetle you know how they acquired their name. Beetles have the front wings modified into hardened covers which shield the rear wings from damage. Flying beetles use only their rear wings to fly, the front wings just open in order to get out of the way. There are more species of beetles in the world than there are of any other group of animals or plants (Resh and Rosenberg, 1984). To date more than 300,000 species of beetle have been described. The aquatic beetles are very diverse and interesting. Predaceous diving beetles are common in the river, some nearly an inch long. These are generally harmless to humans but all insects should be handled with care because some can deliver painful bites. The whirligig beetles are very common and can often be found swimming together on the surface of calm water in large groups. These beetles have an interesting adaptation to living on the water surface. They have evolved to be "four-eyed", with one pair of eyes above the water and another below. If you look carefully you can see that in this picture of a Gyrinid, or whirligig beetle. Other beetles that might be found in the river are Elmid, or riffle beetles, Psphenid, or water-penny beetles, and the little heart-shaped Haliplids, or crawling water beetles. Look how different a Haliplid larva is from a Haliplid adult!

Diptera: Diptera means "two wings" and this name refers to the true flies. Some of Humankind's least favorite insects are aquatic Diptera, mainly the ones that like to feed on our blood. These include the Tabanids, which are the horseflies and deerflies, the Culicids, or mosquitoes, and the Simuliids, the biting black flies (Pennak, 1989). Since many of these insects transmit diseases like Malaria and Dengue fever a great deal of effort has gone into research on controlling them. While a great deal of progress has been made, flies still cause more people to become sick than any other source of disease. Some of the interesting adaptations flies have used to colonize the aquatic habitat include breathing tubes, silken tunnels, and ventral suction cups (Allan, 1995).

CONCLUSION

Adequate knowledge of the identification, economic importance, life cycle, biodiversity, roles and taxonomic orders of aquatic insects facilitates sustainable culture fisheries management and practice.

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