CHAPTER 2

Literature Review

2.1 Trichoptera; caddisflies

Caddisflies, the common name of the aquatic insect from order Trichoptera, the meaning of name refers to many hairs that are usually situated on wings. They are a holometabolous insects which have three distinct life-history stages, with terrestrial adults, aquatic larvae and pupae, and primarily aquatic eggs, this cause them are the richest species of aquatic insect orders. Caddisflies are most closely related to the moth and butterflies, order Lepidoptera. However, the difference character is the wings of caddisflies are covered with hairs, whereas the lepidopteran's wings are covered with scales, and some difference other respects. Recently, there were over 15,000 described Trichoptera species from 46 families were found on all continents except Antarctica (Holzenthal *et al*., 2011).

Larvae stage

The larvae are campodiform or eruciform and either caterpillar-like, have 3 pairs of true legs and abdominal gills, some have an anal hooks. Theirs larvae have three major groups (suborder) divided by life history, Annulipalpia, Spicipalpia and Integripalpia (Morse, 1997, Ross, 1956; 1967, Weaver, 1983; 1984, Weaver and Morse, 1986).

Suborder Annulipalpia are includes all the net-spinning caddisflies including the families in Arctopsychidae, Dipseudopsidae, Hydropsychidae, Philopotamidae, Polycentropodidae and Psychomyiidae. The recognized character is their fixed nets. They usually move within the area of these structures. Sometimes they move freely on currents for consuming or using or use their nets for filtering food. They are predators so, their food was a small animal, algae or small particles of plant and animal detritus that were collected from their nets.

Suborder Spicipalpia includes many distinct groups with different larval habitat such as family Rhyacophilidae and Hydrobiosidae. This group is free-living and predaceous species which do not build any larval structure but pupa. This group called purse-case makers, or microcaddisflies, include family Hydroptilidae that is the smallest sized caddisflies in both larva and adults. The larvae of Hydroptilids are free-living during the first to fourth instars, the fifth instars often inhabit case that are constructed various shapes such as bottle, bivalve or purse shapes. These types of cases are found in all type of aquatic habitats. Saddle-case or tortoise-case makers are represented in family Glossosomatidae that their cases are made with small sand or pebbles, like a tortoise shapes on dorsal view. From cases ventral surface, there were attached by a silk or mineral fragment on substrate for larval filtering.

Suborder Integripalpia or the tube-case maker groups are represented of family Brachycentridae, Goeridae, Helicopsychidae, Leptoceridae, Lepidostomatidae, Limnelphilidae, Molannidae, Sercostomatidae and Uenoidae. The larvae make a variety types and materials of cases, found in all types of aquatic habitats. The larvae are freely movable in current with their mobile cases.

Among the major groups or suborder of caddisflies that related to their phylogeny and biology, the trophic relations are distinct characters of life history as well. Aquatic insects are commonly categorized into trophic groups based on feeding biology (Cummins 1973, Cummins and Klug 1972, Wiggins 1977; 1984) such as collector filterers, collector gatherers, shredders, scrapers, predators and piercers.

Caddisflies larvae are commonly herbivorous; some are omnivorous, using many different materials from aquatic habitat for growth and development. For example, early instars of Phryganeidae are plant feeders, while mature larvae are predaceous; some phryganeid larvae feed on amphibian eggs (Richter, 2000). Pupa of caddisflies is execrating type, body appendages are freely from the body. Almost of pupa often found in the water. On this stage, the mandibles are present but nonfunctional mechanism. Caddisflies larvae are representing the important ecological component of nutrient cycle and energy flow in rivers or lakes and they are food sources for many of aquatic animals (Resh and Rosenberg, 1984).

Adult caddisflies are winged insect, ranging in length from 1.5-40 mm, are also characterized by the possession of long antennae, vestigial mandibles, wing covered with hairs and distinct maxillary and labial palpi. While most are colored in somber shades of brown, gray, or yellow, some are very brightly colored with green, red, orange, yellow, or silver hairs or iridescent scales on the wings (Holzenthal *et al.*, 2007) The mouth parts of adult caddisflies are reduced but, are highly specialized and provide a unique for the order. The labrum is present, but small. Mandibles are absent or highly reduced. The maxillae are also highly reduced, but the maxillary palps are prominent. They usually have three to five segments, but some occur six such as, in Calamoceratidae. In each leg appear prominent tibial spurs, usually numbering 3 on the forelegs and 4 on each of the other legs. Spur occurrence are use for identification (spur formula) at various taxonomic levels (Malicky, 2010), for example, 4-3-3 is referring to the number of apical spurs on foreleg, mid legs and hind legs. The abdomen consists of 10 segments without lateral appendages except the male genitalia and female ovipositor, except in several families of adult caddisflies that have a pair of glandular appendages on fifth sterna (Djernaes, 2011). Recently, the best morphological identified characters of adult caddisflies present in male genitalia, undistinguished in female. Slightly, some female could be identified in species level by external morphological character such as, wing color, wing venation or wing pattern, for example in genus *Macrostemum*; with a black shape pattern on the yellow background wing, genus *Oecetis*; with a wing venation and a spot on theirs wing.

Most caddisflies, in temperate latitudes, species are univoltine with complete a single generation each year (Wiggins, 2004). In fact, there have many factors to play a role in emergences time and also influence a flight period, courtship and oviposition, such as temperature, photoperiod, precipitation, barometric pressure and lunar cycles (Flint and Masteller, 1993 and Pescador *et al*., 1993). Caddisflies are nocturnal, flying occurs at dusk or dawn. Adults disperse only a few meters laterally from the stream (Peterson *et al*., 1999).

Caddisflies constitute an important component of lotic ecosystem, both in richness and abundance (Angrisano and Sganga 2009). The group exhibits a high degree of endemism, which makes them extremely sensitive to environmental disturbances. Several studies address some relevant aspects of their ecology and distribution, as well as their response to habitat impoverishment (Miserendino, 2001; Miserendino and Brand, 2007). Moreover, caddisflies species have been also used successfully in assessing physical and organic pollution (Chantaramongkol, 1983 and Morse, 2004). Natural disturbances such as floods, fires, or droughts are factors of most intact freshwater ecosystem and regulate the population size and species diversity (Lytle and Poff, 2004).

2.2 Trichoptera and man-made freshwater ecosystem

Many aquatic insects, caddisflies as well, play the ecological roles in virtually all freshwater ecosystems such as, processing organic matter, transporting energy along the stream channels, also the flood plain and into the stream bed (Hynes, 1970; Malmqvist, 2002). Their activities can alter water quality, patch dynamics and flow patterns across multiple scales (Wiens, 2002) while their biological interactions often have significant affects on community structure (Williams and Feltmate, 1992; Williams, 2006). Caddisflies are occupying in wide range of freshwater ecosystem and habitats such as, lotic ecosystem; running water, rivers, streams, lentic ecosystem; lakes, ponds, wetlands, spring, pools, puddles and phytotelmata, even an artificial human made environment habitats such as, dam.

Dam construction was the one reason of caddisflies diversity loss, and also discharges of pollutants, agricultural and urban pollution, riparian cover loss and changes in flow regimes (Houghton and Holzenthal, 2010). Arscott *et al*. (2003) investigated to compare and contrast floodplain morphology, aquatic habitat structure, physico-chemical characteristics and Trichoptera community relationships in tributaries of the Tagliamento catchment, Italy. Trichoptera abundance in the forested flood plain was higher, as was taxa richness (27 taxa), than in the open flood plain (16 taxa). Bredenhand and Samways (2009) studied the impact of Klein Plaas dam on the Eerste River, South Africa, the results showed that the number of Trichoptera was higher on upstream than on downstream in many global regions.

Although, dam construction was the greatest way to storage and manage water for human living, but nowadays, dams represent one of the most significant human disturbances in the lotic hydrological cycle. In the location that water is over used, its quality degraded or hydrological regimes modified, the natural environment deteriorates, habitats are destroyed and ecological functions are lost. It is estimated that inter-basin transfers and water withdrawals for supply and irrigation have fragmented 60% of the world's rivers (Revenga *et al*., 2000).

In 20th century, an increasing of environmental awareness has led to the recognition that the management of water resources includes a responsibility to protect the users of water, and the natural resources that depend on water, from over-utilization or impacts that cause degradation.

Dams constitute blocks for longitudinal exchanges along fluvial systems and so result in term of discontinuities, in the river continuum concepts by Ward and Stanford, 1995. The river continuum concept encompasses the linkages upstream and downstream from a spring source to the coastal zone. This concept includes the gradual natural changes in river flows, water quality and species, that occur along the rivers length. Nutrients and sediment generated in the headwaters are recycled downstream, driving plant growth and biotic productivity. River engineering projects, such as dams, can break this continuum causing radical changes in flows, water quality and stopping the movement of species (Pett, 1984; Davies and Day, 1998). This in turn changes sediment and nutrient regimes and alters water temperature and chemistry, with consequent ecological and economic impacts. Flow regimes are the key driving variable for downstream aquatic ecosystems. Flood timing, duration and frequency are all critical for the survival of communities of plants and animals living downstream. Small flood events may act as biological triggers for fish and invertebrate migration: major events create and maintain habitats by scouring or transporting sediments.

One of hydroelectric dam studies case, Munn and Brusven (1991) reported that Trichoptera community was occurred in the regulated reach immediately below the dam, reflected by greatly reduced of diversity and abundance values and by shifts in functional relationships. And the non-regulated river exerted a major reduce effect on the Trichoptera below its confluence with the regulated reach. Perry *et al.* (1986) investigated on influence of altered temperature and food regimes on the life histories of *Hydropsyche oslari* and others two species, compared in two regulated river systems in northwestern Montana, USA. Population densities of caddisflies and growth rates between regulated and reference stations were observed.

Doi Suthep-Pui and Doi Inthanon National Parks, Chiang Mai Province, Thailand had been the most general studies area for Trichoptera. Probably these areas, contain quite high and relatively clean streams with various macrohabitats. Early pioneer for Trichoptera studies in Thailand were from Malicky and Chantaramongkol (1999), One hundred and thirty-one species were recorded including 96 specimens as new species. Bunlue (2012) has compiled secondary data for constructing a Thai Trichoptera Database, 1,004 species of Trichoptera have been recorded belonging to 105 genera and 28 families. Most of secondary data from previous studies covered northern Thailand area (Prommi, 1999; Chaibu, 2000; Klaytong, 2000; Chaiyapa, 2001; Nuangchalerm, 2001; Cheubarn and Chantaramongkol, 2002; Thapanya, 2004; Changtong, 2005; Nawvong and Chantaramongkol, 2005; Thamsenanupap, 2005; Cheapudee, 2006 and Nuntakwang, 2006) and some from southern area in Thailand (Luadee, 2002; Luadee and Prommi, 2011). There were at least 43 published (untiled 2012) studies on Trichoptera in Thailand, but few studies founded on a large dam.

Prommi and Thani, 2014 reported 27 species of caddisflies founded on Pasak Cholasit dam on central Thailand including 7 families followed by Hydropsychidae, Leptoceridae, Ecnomidae, Psychomyiidae, Philopotamidae, Dipsuedopsidae and Xiphocentronidae. In addition, the abnormality of *Amphipsyche meridiana* larvae were occurred on Phasak Jolasit dam which affected by some contaminants from the outlet (Prommi, 2011).

After mentioned, the dam constructed could be changed the environmental structure of freshwater ecosystem, physical or chemical, even the small constructed building by human. The flow of the tributary stream from natural were modified by the dam or some constructed that block the water flow, this situation was widely happens and make the lotic ecosystem to be a lentic ecosystem which altered many freshwater organism. This research was focused on the affects of a flow modification from the Mae Ngat Somboonchol dam which regulated by human for investigated the upstream and downstream Trichoptera composition in the stream.

2.3 Affects to upstream and downstream

Pett, 1984 was described the greatest framework for assessing, the impact of dam on river ecosystems to upstream and downstream according to river order (Figure 2.1). While, the first-order impacts are the abiotic effects that occur immediately with dam closure and influence the transfer of energy and material, such as changes in flows, water quality and sediment load, into and within the downstream river and connected ecosystems. The second-order impacts are the abiotic and biotic changes in upstream and downstream ecosystem structure and primary production, which result from first-order impacts. These depend upon the characteristics of the river prior to dam closure, this situation will take time over year. The third-order impacts are the long time biotic changes resulting from the integrated effect of all the first- and second-order changes, including the impact on species close to the top of the food chain such as, invertebrate, fish, birds and mammals. Complex interactions may take place over many years before any new ecological equilibrium is achieved.

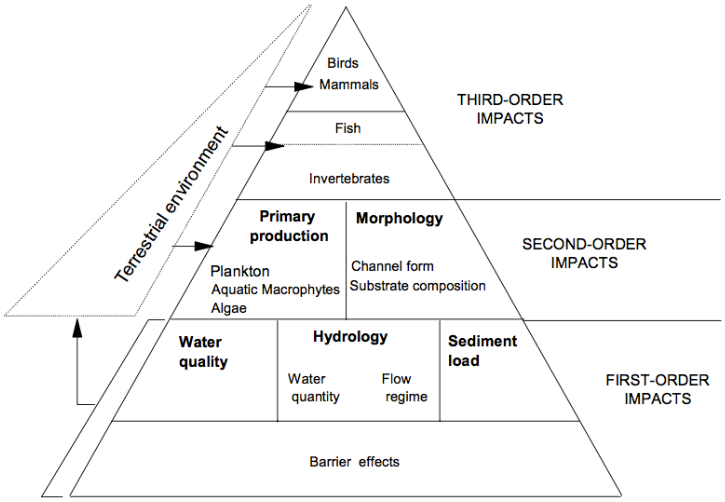

Figure 2.1 A framework for assessing the impact of dams on river ecosystems (modified from Petts, 1984).

From upstream area, the construction of a dam results in post-impoundment phenomena that are specific to reservoirs and do not occur in natural lakes. Non-earth storage dams often have a bottom outlet. That may allow both sediment flushing and water releases from deep below the surface, but its management cannot move sediment out enough. Reservoirs act as thermal regulators that may fundamentally alter the seasonal and short-term fluctuations in temperature that are characteristic of many natural rivers. Depending on geographical location, water retained in deep reservoirs has a tendency to become thermally stratified (Hutchinson, 1957). Many reservoirs retain a large proportion of the sediment load supplied by the drainage basin (Mahmood, 1987).

Dams and barrages used to divert water, especially for irrigation, reduce the downstream flow and prevent floods. The hydrological changes result many impacts such as, reduction of nutrients at river mount, nutrient trapped behind dams and regulated flow pattern of the river (Figure 2.2).

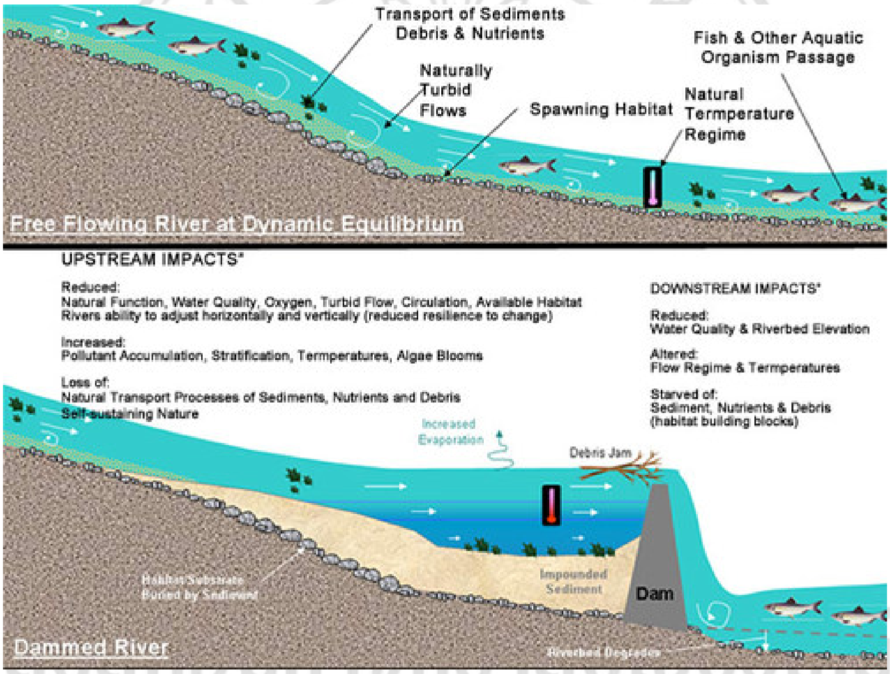

Figure 2.2 Hydrological changes on dammed river. (modified from Roberts, 2007)