CHAPTER VI. DISCUSSION

A. PHYSICO-CHEMICAL PROPERTIES OF THE STREAMS

Water temperatures were much colder in DCK stream due to the presence of riparian trees which completely shade the stream and protect it from being directly exposed to the sun. Downstream increase in temperature is attributed primarily to the felling down of riparian trees, thus exposing the stream from direct solar radiation. Another would be the altitudinal differences between stations as observed by Petr (1977) in East African rivers.

pH readings fell into a narrow range and were slightly to moderately basic. The basic pH of stream in DCK was a surprise as soil pHs above both granite (in these sites) and sedimentary rocks lie between 4.5 and 6.0 (Bishop, 1973). No reason to explain this phenomenon. The basicity of the stream water in BNH on one hand can be accounted to the application of lime ($CaCO_3$) in the surrounding agricultural fields to increase the pH of the soil which became acidic as a result of continuous cultivation, and to the fact that some parts of Mae Sa watershed where BNH is located are limestone in origin (Kubiniok, pers. communication). These also explain why conductivity and alkalinity are very high compared to DCK stream which registered very low conductivity and alkalinity.

The two streams were well-oxygenated with very slight differences in all stations. It is not surprising as water is fast-flowing and very turbulent, and therefore mixing of water is very high which enhances the oxygen conditions of these streams.

The elevated concentrations of nitrate detected in stations 2 and 3 of BNH stream and to some extent, station 1 of DCK stream are believed to have been primarily derived from the wash-off of fertilizers applied to the surrounding fields. Fertilizers in use included organic fertilizer (compost) and synthetic complete fertilizer (15 Nitrogen - 15 Phosphorus - 15 Potassium) which are regularly applied by hilltribe people in their respective fields.

Although phosphorus was generally very low, a relative high concentration in relation to the other stations was recorded in station 2 of BNH stream. Again, this may have come from the fertilizers applied and most probably, from the hilltribe people who are draining their water used in washing their clothes directly into the station 2 of BNH stream.

The relative high BOD_5 values in two downstream stations of BNH stream in relation to the other stations, may be due to the combined effects of agricultural activities and settlement. Nevertheless, the relative high BOD_5 values are much lower than the ranges of BOD_5 values enumerated by Hynes (1960) to indicate water quality. He specified that BOD_5 values of 1-2 mg/l or less is indicative of clean water and 4-7 mg/l for slightly to moderately polluted. Thus, these streams can be classified as clean streams based on this classification. The general low BOD_5 values recorded in these streams can be accounted to the low phosphate concentrations which may have limited the biological oxygen demand. Dudgeon (1984) attributed the greatest BOD_5 values in Lam Tsuen river in March to the reduced river volume and high nutrient loads. But this could not be the case of my streams as nutrient loads were higher in the rainy season during peak discharge.

Seasonal variations of chemical parameters in both streams were also notable. High conductivity and a drop in pH were observed in the dry season. The higher conductivity and a drop in pH in the dry season can be attributed to the reduced flow at this time which reduces the dilution of ions particularly Ca^{2+} and $CO3^{2-}$ from lime applied by the hilltribe people in their agricultural fields and those derived naturally from the limestone around the area. Wetzel (1983) specified that the cations Ca^{2+}, Mg^{2+}, Na^{+} and K^{+} and the anions $HCO3^{-}$, $CO3^{2-}$, $SO4^{2-}$ and Cl^{-} are responsible for the ionic concentrations in water, while nitrogen, phosphorus and iron are usually minor components.

The high rate of wash-off of fertilizers and organic materials from the surrounding agricultural lands during the rainy season as a result of high discharge and elevated erosion may have caused the elevated concentrations of nitrate and phosphate during this time. As you noticed, there was no corresponding increase in conductivity despite of the increase in nitrate and phosphate in the rainy season. This is because nitrogen and phosphorus are only minor contributors to the ionic composition of water except in highly eutrophic water where the concentrations of these two elements are very high. But this could not be the case of my streams as these elements are low. The most probable reason for the lower conductivity in the rainy season, is that maybe during this time, the conductivity was only dictated by the run-off of lime applied to the agricultural fields, as dilution of ions naturally derived from the limestone around the area is very high as a result of high water discharge. Take note that only some parts of the watershed are derived from limestone while most parts are from granite.

1. DAY-NIGHT FLUCTUATIONS IN SELECTED PHYSICO-CHEMICAL PARAMETERS

There was no remarkable changes in some selected physico-chemical parameters over the whole 24-hour investigation. Nevertheless, slight changes were detected.

Water temperature, as expected was low in the evening as solar radiation is absent. The slight increase in DO in the midnight until early morning is accounted to the low temperature during this time which increases the solubility of oxygen in water.

2. SIMILARITY OF THE TWO STREAMS BASED ON PHYSICO-CHEMICAL PARAMETERS

The dendrogram of all stations yielded two separate groups of streams. BNH stream being influenced by cultivation as a separate group while the relatively pristine stream in DCK was placed in a separate group. The factors responsible for the separation are primarily alkalinity, conductivity and to some extent BOD_5 and nitrate which were notably high in BNH stream and are all due to agricultural activities in the area.

B. BIOLOGICAL RESULTS

1. MACROINVERTEBRATE COMMUNITIES

Most species in the benthos were present in the drift at some stages in their life history. Exceptions are Tricorythidae, Helicopsychidae, Rhyacophilidae, Tabanidae, Ptilodactylidae, Protoneuridae and Erpobdellidae. By contrast, Noteridae, Haliplidae, Limnichidae and Notonectidae were only recovered in the drift net. This can be explained by their rarity in the benthos and their very small number except for Tabanidae which was never recovered in the drift net. This may be due to the habit of Tabanid larvae to inhabit the margins of streams or in the seashore (Scholtz and Holm, 1985; Smith, 1989) which then lessens their tendency to be carried by water, or if they really entered into the drift, they were not caught by the drift net as it was established in the middle of the stream where flow regime was highest. Platyhelminthes, the Nematoda and the Annelida are underrepresented in the drift as these animals are known to be poor drifters. The other groups, particularly the insects, are well-represented in the drift. Within the insect groups, the tendency to drift varies as well. The Ephemeroptera, the Trichoptera and the Diptera are relatively more numerous in the drift, while the Plecoptera and the Coleoptera are relatively more abundant in the benthos. As could be expected, the current-loving Baetidae plays relatively more important role in the drift. The gastropods were only recorded in BNH and station 1 of DCK streams. This reflects the hardness of the water in this stations which favors the existence of these animals.

2. DAY-NIGHT FLUCTUATIONS IN DRIFT

The occurrence of a pattern which includes maximum drift at night has been observed from a number of studies in a variety of rivers (Tanaka, 1960; Waters, 1962; Elliott, 1965; Muller, 1966). Bishop and Hynes (1969) stated that activity in aquatic invertebrates is largely controlled by two physical parameters, light and temperature. In the present investigation, the first factor appears to be the dominant factor controlling the behavior of many aquatic nymphs and larvae and the increase in drift in the night time, as there was very slight changes in temperature throughout the whole investigation period. Light, specifically light intensity rather than wavelength (Bishop, 1969) is the most critical factor responsible for the circadian activity patterns recorded by several authors (Hughes, 1966 and Elliott, 1967a). Negative phototaxis has been recorded for many aquatic insects and serves to maintain these organisms in areas of low intensity. Linked to this are the strong positive thigmotaxis observed in many benthic forms (Bishop and Hynes, 1969), the definite orthokinesis during periods of low illumination and the positive skototaxis observed by Hughes (1966). These mechanisms result in the firm attachment of most of the fauna to the undersides of stones during the day time but at night on release of the exogenous light control they become more active in foraging for food and insects are always visible on the substrate surface if a light is directed onto it at night (Bishop and Hynes, 1969). And in more exposed positions, such animals are more likely to become dislodged and swept into the current. This in turn causes higher drifts in the night time. Dorier and Vaillant (1954) noted that the magnitude of the drift will depend on the amount of food available in particular area, the degree of physical competition for it, and the tenacity of individual. A high density of foragers would result in considerable numbers being forced into marginal feeding areas and locations where increased propensity for wash-off would increase drift.

Different groups of aquatic insects react to light in different ways. Ephemeroptera for instance are known to be phototactically negative (Elliott, 1967b) while Simuliidae are phototactically positive (Grenier, 1949), in contrast to Hynes' (1975) observation in which *Simulium* drifted maximally at night and also Plecoptera, Ephemeroptera and Trichoptera while Hydracarina and Ostracoda are day active. But maybe his *Simulium* was different species from that of Grenier and in the case of my streams where it has been found to be also day active.

3. MONTHLY VARIATION IN DRIFT

It was suggested by Hynes (1975) that the drift is composed of two distinct faunal elements. One consists of organisms carried away passively in any condition of illumination or current flow. Organisms having this pattern of behavior are assigned to the category of "background drift".

The numbers of the second group in the fauna, the "true drift", appear to be influenced by a variety of factors. The abundance of any species in the fauna will be affected by its abundance in the benthos, but this is masked by two other factors, namely, light and rate of flow.

Seasonal variations in the drift are related to the changes in age and density of the benthos and the physical parameters of the stream. It has been suggested that drift may be regarded as a consequence of movement of a population of a habitat and an outcome of competition for space (Muller, 1954). In keeping with this idea, Dimond (1967) and Pearson and Franklin (1968) have found drift numbers to be directly related to benthic density. In this study, flow and benthic density are the dominant factors determining the amount of drift. The increase in drift in March may have been caused by the high density of the benthos particularly Chironomidae and Baetidae which also dominated the drift during this month as there was no changes in the flow rate of water. The March peak in the number of Diptera, particularly Chironomidae reflected the emergence of many Chironomid adults (Bishop and Hynes, 1969). Elliott (1967a) has suggested that maximum drift occurs at seasons of maximum growth and it may be related to molting or to some activity dependent on the feeding requirements of the different life stages. By contrast, Turcotte and Harper (1982) in their investigations on the drift patterns of a high Andean stream did not detect any correlation between benthos and drift. Similar observations were made nearly everywhere else (Muller, 1966; Elliott, 1967a and Bishop and Hynes, 1969). Hynes (1975) argued that in the tropics, where density of any group is low within the larger heterogeneous populations, such a density-dependent behavioral response may be expected to be less important. But in the case of my streams where Chironomidae and Baetidae are dominant, his argument may not hold true.

The second factor which affects the size of the drift population is current flow. Several studies have shown that high water results in high numbers in the drift and that at low rates, the numbers decrease. Anderson and Lehmkul (1968) and Ulfstrand (1968) have reported gigantic drift numbers at times of spates. Others have observed the opposite, namely low drift with high water and vice-versa (McLay, 1968 and Weninger, 1968). SEMG (1993) on one hand reported that drift index in Zimbabwean river increased parallel to the decreasing water level. The report added that drift index was highest during the lowest water level. Elliott (1967a) observed that drift density did not increase with increasing current even under spate conditions, and Bishop (1973) showed a relatively constant density of drift at different discharges although drift rates were seen to increase with increasing flow volumes. The present investigation indicates that provided the rate of water flow does not rise above a critical level, the tendency for animals is to be dislodged from their substrates by the current when they come out in the night to feed, but as current flow increases to a critical level, the animals may move to increasingly sheltered positions. As a result, the likelihood that they will be swept into the drift may actually decrease if current flow increases. Laboratory experiments by Ambuhl (1959) have shown this phenomenon, with many active riverine organisms such as various mayfly larvae, move to increasingly sheltered positions when current flow increases. McLay (1968) and Weninger (1968) hypothesized that the fauna sought shelter under such conditions, and as the bottom becomes unclogged, some of the fauna move into the interstitial spaces and becomes inaccessible to erosional forces. This probably explains why at the peak of the rainy season when water discharge was very high, drift was very low. Hynes (1975) in his study on the downstream drift of invertebrates in a river in southern Ghana, indicated that when there are high numbers in the drift, there may be an inverse correlation with the rate of flow, whereas when low numbers are drifting there is no correlation. But again, this is only true for streams with lots of microhabitats and with stable substrates where the animals can recruit themselves as water flow increases, as in DCK stream and station 1 of BNH stream where diversity of microhabitats is high. Bishop (1973) observed that at station 2 of Sungai Gombak with more variable microhabitats and a much wider area for recruitment, the correlation coefficient between the quantity of drift and water passing the transect was not significant. But in the case of BNH stream, specifically its stations 2 and 3 where only fine sands and silts are available for recruitment and are characterized by their unstability, the tendency for the animals is to be swept easily even if a slight increase in flow regime occurs. Thus for example, when a stream is in spate, *Simulium* larvae which occupy exposed positions but move fairly slowly, may be unable to migrate and may be torn away. Similarly, if the bottom is unstable, the shelter chosen by other species may be mechanically disturbed, and as a consequence they are carried into positions where they can no longer resist the impact of the water flow (Hynes, 1975). The tendency then is the impoverishment of the stream as its inhabitants have been washed away until recolonization from the upstream takes place. In South Africa, a number of studies have also demonstrated a relationship between the flood season and the amount of invertebrate fauna. In Cape Province, an area of winter rainfall, the Great Berg river suffers much disturbance of its bed, and consequently the fauna is at its lowest level in the winter (Harrison, 1958). Harrison and Elsworth (1958) found that the fauna of stony reaches was far less affected than that of other types of substratum. Presumably elsewhere the rough stony areas provide adequate shelter from fast water. The decrease in drift of these two stations at the onset of the rainy season until early winter may be explained by this phenomenon. Bishop (1973) noted the low drift rate of Sungai Gombak at high discharge after a prolonged high water period when the population had become numerically depleted or had achieved current-resistant niches.

The dominance of Chironomidae and Simuliidae in drift in stations 2 and 3 of BNH stream and Baetidae in DCK stream reflect their abundance in the benthos.

The remarkable high drift of station 2 in DCK stream throughout the study and the unclear pattern of diel periodicity can be explained by its relative small size and reduced flow, which reduce its carrying capacity. Competition may be high enabling the others to be more active in foraging for food, thus making them vulnerable to dislodgement. Hughes (1966) and Minshall and Weninger (1968) have described that under reduced flow conditions, there is a breakdown of the normal photo- and thigmotaxes and active movements of insects into the water column, perhaps to seek respiratory relief or to escape continual contact with other individuals. Thus increasing the tendency of these organisms to be drifted by the current regardless of the time of the day. In addition, Muller (1954) and Waters (1966) who both worked on streams in uncleared, forested areas which were not subject to severe flooding, noted that in such streams, particularly with faunas dominated by multivoltine mayflies, the "carrying capacity" of the substrate is likely to be exceeded, with resultant density-dependent drift of excess production.

The natural drift indices in the streams vary from 0.02 to 2.05/m^3 in BNH stream and 0.04 to 2.84/m^3 in DCK stream and compare favorably with other estimates made in the tropics; (1.56 - 1.79) in Malaya (Bishop, 1973); 0.4 - 1.9 in Ghana (Hynes, 1975); 0.03 -0.49 in Florida (Cowell and Carew, 1976) and 0.85 - 3.28 in Ecuador (Turcotte and Harper, 1982) except in Zimbabwe where drift indices varied between 25/m3 during the highest flow to >14,500/m3 during the lowest water level (SEMG Report, 1993). The report attributed the catastrophic drift to the low water level which forced the macroinvertebrates to migrate downstream where water is available. Nevertheless, the drift indices of my streams are of the same order of magnitude as in a temperate system, where drift densities only rarely exceed 10 (Bishop, 1973). The lower minimum value of drift index in my streams can be accounted to the emptying of the net which was only done once every 24 hours. McKaige (1990) who compared two drift net emptying frequencies in Thredbo river in New South Wales in Australia, observed that sampling efficiency was considerably reduced in the 12-hour sample due to net clogging and backwash. Over 40% more invertebrates were collected throughout a 12-hour period when nets were emptied 2-hourly than when emptied after 12 hours. However, she noted that the relative abundance and diversity of invertebrate families were not significantly different.

4. PESTICIDE-INDUCED DRIFT

Many aquatic macroinvertebrates react upon pesticides by disorientation, immobilization (knock-down) or mortality, and float freely downstream. The increase in invertebrate drift or benthic drift following the application of pesticides to running waters has been recognized since the early days of DDT usage (Muirhead-Thomson, 1987).

The results of this investigation show that application of pesticides to surrounding agricultural fields has acute negative effects on the stream macroinvertebrates. The response of the animal community is certainly influenced by the chemical nature of the pesticide, its concentration, the water quality and current velocities (Baekken and Aames, 1991) and also wind velocity and direction and precipitation. The last two factors coupled with the first two factors appear to be the most important factors that govern the 38-fold increase in drift in the post-spray sampling. During the July 5 spraying, a much greater concentration of pesticides was used which included the mixture of approximately 1 tablespoon of Malathion, small amount of Ecomax and Cupravit (a.i.:copper oxychloride) (fungicide), pesticide stickers and growth hormones in spray tank filled with water (language problems prevented me from knowing the exact concentration of pesticides used). In addition, it was also windy at the time of application so that contamination of the stream from the spray mist was high. All these factors have significantly affected the drift induced by pesticide during the spraying operation. A sharp increase in the number of invertebrates taken in the drift nets was observed within a few hours of pesticide application until it declined 24 hours later and went back to normal. This has been observed in many instances and is related to the high concentrations of pesticides in the first few hours during the application (Muirhead-Thomson, 1987). The bulk of the drift was dominated by Diptera comprising 91% of the total drift, mostly Chironomidae and Simuliidae accounting to 50 and 33% of the total drift, which reflect their dominance in the benthos. Nevertheless, it was observed that the recovery rates of these animals were more than 70% in uncontaminated water. This could partly explain why these animals are very abundant in this station, as they can tolerate the pesticides and their recovery rates are very high, in contrast to the sensitive groups like Ephemeroptera, Trichoptera, Plecoptera and Coleoptera which (Table 5) registered very low recovery. This may account of their impoverishment in this station. The present investigation agrees with those of Heckman

(1982) where he indicated that Chironomidae are typical of habitats exposed to periodic chemical treatments that kill most of the biota while Simuliidae larvae are typical in flowing water, frequently under extreme environmental conditions. With such a great adaptability to extreme environmental conditions, it is not surprising that many members of Diptera have been able to cope with the whole spectrum of modern pesticides. Under the principle outlined by Thienemann (1918) in which he indicated that biotic communities living under conditions of stress have reduced species diversity accompanied by significant increases in the populations of a few species. Under this principle, therefore, the insect group most likely to benefit from the stress placed on a biotic community is this one. Thus, the use of pesticides, after a period of adjustment, can be expected to promote the development of enormous populations of many fly and mosquito species rather than act to control them (Heckman, 1982).

5. DRIFT DIVERSITY

The Shannon diversity index is made-up of two components: richness or the number of taxa and the evenness or distribution of individuals in each taxa. The higher these two values, the higher will be the diversity of the community.

The high diversity of drift in BNH stream at the onset of the rainy season can be explained by the even distribution of individuals which increases the Shannon diversity index. Although the size of the drift in March was high, but the dominance of Simuliidae and Chironomidae reduces the value of diversity. The higher diversity in station 1 of BNH stream throughout the study period can be accounted to the even distribution of taxa and the absence of dominant species. The decreasing trend in diversity in BNH stream towards the peak of the rainy season until the early winter reflected the impoverishment of the stream as a result of spates. Petr (1970) observed the same thing in the Black Volta river in Ghana during the rainy season and he attributed it to the washing out of fauna by spates.

In stations 1 and 3 of DCK stream, the low diversity at the peak of the rainy season is attributed to the low number of taxa that drifted, which has something to do with recruitment of taxa to a more sheltered position when the flow regime was highest as discussed earlier. Nevertheless, diversity increases in the early winter when the flow regime goes back to normal. The low diversity in station 3 throughout the whole investigation period may have something to do with disturbance by agriculture as it is immediately situated in the agricultural fields of Hmong hilltribe. This is also notable in the diversity of benthos.

The diversity of the drift induced by pesticide was low despite of the high number of individuals and taxa that drifted. This is because of the dominance of Chironomidae and Simuliidae which masks the richness of the drift.

6. BENTHOS AND BENTHOS DIVERSITY

Generally, stations 1 and 2 of DCK stream which are not influenced by agricultural activities contain a very rich and unique macroinvertebrate communities with higher population densities, in comparison to station 3 and to that of BNH stream. Although Diptera is dominant, but other orders are also equally important components in the benthos. The taxa present in these relatively pristine stations are indicative of clean-water inhabitants and sensitive taxa. Station 3 of DCK stream which is disturbed by agricultural activities has relatively poor fauna and lower population densities in comparison to the two stations upstream. Nevertheless, the quality of taxa resembles to that of the upstream stations albeit in lower number, which is an indication that if this station has not been influenced by agriculture, its macroinvertebrate communities would be very similar to the upstream stations.

Rajchapakdee (1992) who was doing a study on benthic invertebrates in the two streams in Doi Suthep, situated in the same geographical location of my DCK stream, found that Diptera, Ephemeroptera and Trichoptera are the most important components in the benthos in these two streams, while Plecoptera, Odonata, Coleoptera and Megaloptera are present in low numbers. Her observations are more or less similar to my findings as these three orders are found to be also the dominant groups in the benthos. In addition, she collected from her Surber sampler a combined 64 families of macroinvertebrates, slightly lower than what I collected in my DCK stream, where a total of 67 families were recovered in the Surber sampler. Macroinvertebrates that I collected in DCK stream but were never recovered by Rajchapakdee in Doi Suthep streams are listed in Table 10. On one hand, she collected the families Hirudinidae, Ephemerellidae, Polymitarcyidae, Prosopistomatidae, Siphlonuridae and Glossosomatidae which were never recovered in my DCK stream. Nevertheless, a very high resemblance in terms of community composition was observed between her Doi Suthep streams and my DCK stream.

Station 1 of BNH stream has very different community composition compared to its two downstream stations which are severely influenced by agricultural activities. The taxa present in this station are clean-water dwellers as exemplified by Plecoptera particularly families Perlidae, Peltoperlidae and Nemouridae in these sites, and to some extent Trichoptera which are very abundant in this station. Other taxa are also important components as in DCK stream, although the richness and density are much lower. On the other hand, Diptera particularly Chironomidae and Simuliidae dominated the benthos in stations 2 and 3 of BNH stream while the other sensitive groups such as Plecoptera, Coleoptera, Trichoptera and Ephemeroptera have been severely depleted in number. Some are even totally eliminated like Brachycentridae, Leptoceridae, Philopotamidae, Peltoperlidae, Leuctridae and Psephenidae. These families are very common in station 1 but were never recovered in stations 2 and 3. The uniqueness of station 1 of BNH stream

Table 10. Benthic families collected in Doi Chang Kian stream but were not recovered in Doi Suthep streams[1].

Diptera	Mesoveliidae
Psychodidae	Notonectidae
Empididae	Hydrometridae
Muscidae	Gerridae
Syrphidae	**Lepidoptera**
Plecoptera	Pyralidae
Nemouridae	**Blattaria**
Coleoptera	Epilampridae
Ptilodactylidae	**Platyhelminthes-Temnocephalidea**
Lampyridae	**Nematoda**
Hemiptera	**Nematomorpha**
Veliidae	

1 Comparison from the work of Rajchapakdee (1992) in Doi Suthep streams.

2 Ostracoda and Hydracarina are not listed here as Rajchapakdee did not consider these groups in her study.

in terms of taxa can be attributed to the riparian vegetations which were left intact, serving to reduce the erosion and subsequent siltation of the stream. Second would be the less if not the absence of pesticide contamination as this station is far from agricultural fields, apart from the fact that the dense canopy of the riparian trees serves as interceptor to the pesticide mists coming from the agricultural areas.

A total of 90 macroinvertebrate families was recovered in these two Thai streams, lower than the collection of Bishop (1973) in a small Malayan river, Sungai Gombak, where he collected a total of about 120 macroinvertebrate families including Hydroidea and Collembola which were not considered macroinvertebrates in this study. Bishop's collection in the neighboring Malaysia that were not recovered in Thailand included 39 taxa listed in Table 11. On one hand, 18 taxa were not recorded by Bishop but were recovered in my Thai streams (Table 12). One probable reason why Bishop collected more is that he was sampling the river for almost two years using different techniques while I only did my sampling for about six months employing only two sampling techniques. Another would be the size of his river which is bigger than my streams, not to mention the pristine conditions of the upstream of his river.

Table 11. Taxa collected by Bishop (1973) in Sungai Gombak, Malaysia but were not recovered in my two Thai streams.

Hydroidea	**Hirudinea**	Epallagidae	Stenopsychidae
Pelecypoda	Glossiphonidae	Chlorocyphidae	Goeridae
Sphaeriidae	**Amphipoda**	Protostictidae	Calamoceratidae
Unionidae	**Orthopthera**	Platycnemididae	Limnocentropodida
Viviparidae	Tridactylidae	Amphipterygidae	Hydroptilidae
Gastropoda	**Ephemeroptera**	**Hemiptera**	**Coleoptera**
Ampullaridae	Siphlonuridae	Corixidae	Hydraenidae
Ancylidae	Oligoneuriidae	Helotrephidae	Torrindicolidae
Oligochaeta	Ephemerellidae	Dipsocoridae	**Diptera**
Haplotaxidae	Potamanthidae	Nepidae	Dolichopodidae
Phreodrilidae	Neoephemeridae	**Trichoptera**	Tetanoceridae
Enchytraeidae	Prosopistomatidae	Psychomyiidae	
Mcgascolccidac	**Odonata**	Glossosomatidac	

Table 12. Taxa collected in Doi Chang Kian and Ban Nong Hoi streams, Thailand not recorded by Bishop (1973) in Malaysian river.

Nematomorpha	**Hemiptera**	**Coleoptera**	Culicidae
Bivalvia	Hebridae	Chrysomelidae	Chaoboridae
Corbiculidae	Mesoveliidae	Curculionidae	Muscidae
Odonata	**Lepidoptera**	Limnichidae	Thaumaleidae
Lestidae	Noctuidae	Noteridae	Tabanidae
Plecoptera	**Trichoptera**	**Diptera**	
Capniidae	Limnephilidae	Ephydridae	

DCK stream has more diverse benthic community compared to BNH stream, and station 1 of BNH stream has always a remarkable high diversity compared to the two stations downstream. The high diversity in DCK stream is attributed to the richness of the benthos as a result of its relatively pristine environment. The high diversity of station 1 in BNH stream can be attributed to the absence of the dominant taxa and the high number of taxa collected which are due to the diversity in microhabitats. Clesceri et al. (1989) indicated that most aquatic habitats, particularly free-flowing streams and rivers with acceptable water quality and substrate conditions support diverse macroinvertebrate communities with a reasonable balanced distribution of species among the total number of individuals present. On the other hand, the low diversity recorded in stations 2 and 3 of BNH stream can be attributed to the extensive agricultural activities in these areas which favor the growth of most Dipterans specifically Chironomidae and Simuliidae that dominated the benthos which accounted to 42 and 33% of the total number of individuals collected in the dry season and 34 and 43% in the rainy season, respectively. The sensitive taxa such as most members of the orders Ephemeroptera, Plecoptera, Trichoptera and Coleoptera, however, are eliminated leading to the impoverishment of these two stations. The Dipteran dominance can be explained to their very high recovery rates to pesticides (>70%) regularly applied, as mentioned earlier, and the types of substrates (composed only of sand and silt) which favor their existence. Hynes (1970) noted that the presence of silt reduces and changes the fauna. Earlier, Sprules (1947) was able to observe this effect on insects when beavers built a dam across a stream in Ontario, Canada on which he was quantitatively trapping insects. The dam raised the water level by about 40 cm and caused the deposition of sandy silt. This reduced the total number of insects emerging, especially of Ephemeroptera, Plecoptera and Trichoptera, and it increased the proportion of Chironomidae. In Russian rivers also, particularly the Oka and rivers in Caucasus and Central Asia, Shadin (1956) found that the deposition of silt or sand on stony substrate reduces their fauna, even when the deposits remain for only part of the year. Similarly, continual deposition of fine clayey silt on to muddy substrate in the Vaal river, South Africa, has been considered to be responsible for the poverty of fauna there (Harrison et al., 1963). Dudgeon (1984) also attributed the downstream decreases in numbers of benthic taxa in Lam Tsuen river in Hongkong to silt deposition which he said clogs the interstitial pore spaces and tends to reduce the complexity of the substrate habitat. Bishop (1973) indicated that the direct effects of large erosion loads on invertebrates are little known, but abrasion and interference with respiration, particularly in gilled taxa, are likely. He added that indirect effects alter microhabitats by filling-in interstitial areas and burying the fine detritic materials that make-up a dominant diet item of many taxa.

It is therefore clear that the impoverishment of the two downstream stations of BNH stream can be partly attributed to the loss of microhabitats as a result of siltation from the erosion of the surrounding agricultural lands. By contrast, in DCK stream where the environment is relatively pristine and the diversity of microhabitats is high, the benthic diversity is also high.

Estimate of the erosion hazard in station 2 of BNH by Solle (1994) who is working on the erosion hazard mapping of the whole Mae Sa watershed using the Universal Soil Loss Equation (USLE), revealed that this station has a very high erosion rate of 148.73. He added that erosion rate of >60 has been considered very high. He attributed it to the steepness in slope and the kind of crops (vegetables) planted without practicing any proper soil management. This is the reason why siltation in this station is very high, leading to the loss of microhabitats, which in turn reduces the diversity of the benthos.

Seasonal changes in the diversity of benthos were also observed. The low diversity in stations 1 and 2 of DCK stream in March despite of the high density of the benthos can be accounted to the dominance of Chironomidae and Baetidae, with the former accounting to 34 and 52% in the benthos in the two stations mentioned. These are all associated with the emergence of these two taxa at this time of the year. Nevertheless, in the rainy season, diversity increases because the two dominant taxa have been reduced in number with Chironomidae accounting only to 7 and 5% in the benthos in stations 1 and 2, respectively. By contrast, station 2 of BNH stream has low diversity in the rainy season which again indicates the impoverishment of the fauna due to spates. This phenomenon can also be observed in the monthly drifts of macroinvertebrates in stations 2 and 3 of BNH stream which were declining at the onset of the rainy season until in the early winter.

7. STATISTICAL PACKAGE FOR SOCIAL SCIENCES (SPSS) PROGRAM RESULTS

Community association, using rotated factor analysis from the SPSS program, clearly indicates that the stream conditions especially the types of substrates altered by agricultural activities affect the distribution of stream macroinvertebrates. For example, all taxa common in sandy and silty substrates in stations 2 and 3 of BNH stream are grouped together while the clean water inhabitants commonly found in the first two stations of DCK stream with more diverse microhabitats, are placed in a separate group.

Cluster analysis also was able to identify the post-spray sampling from that of the pre-spray samplings, and between the rainy season from that of the dry season drifts. Also, the disturbed stream in BNH from that of the clean stream in DCK. And finally, it was able to segregate the clean stations from that of the disturbed stations regardless of seasons based on the benthic composition of the two streams. Stations 1 and 2 of DCK stream for instance, were always grouped together regardless of season. This is because of the very high similarity of benthic communities.

In conclusion, it is clear that regular application of pesticides to the surrounding agricultural fields has profoundly affected the stream macroinvertebrates by eliminating the sensitive groups and favoring the perpetuation of the tolerant taxa with very high recovery rates. The losses of microhabitats through the siltation of the stream from the erosion of the surrounding agricultural fields also play a very significant role in changing the community structure of the benthos. Enrichment of the stream, primarily from fertilizers seems not to be a serious problem in the area. However, various subtle effects may have been occurring which was not detected during the course of the investigation.

As it is now clear that pesticides and losses of microhabitats through siltation are the two primary factors that altered the macroinvertebrate communities and the physico-chemical properties in the stream of BNH, it is therefore recommended that the rate of erosion in the BNH watershed and the siltation of the stream should be studied in detail.

Pesticide analysis of the stream water at different times should also be undertaken. By doing these two detailed studies, one can therefore separate and quantify the impact caused by these two factors.