# Macroinvertebrate drift patterns of two Thai streams

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**ABSTRACT**

From March to October, 1993, macroinvertebrate drift patterns in the disturbed stream in Ban Nong Hoi (BNH) and the relatively pristine stream in Doi Chang Kian (DCK), Chiang Mai, Thailand were compared.

Results show that day-night changes in drift were mainly controlled by light rather than water temperature. Maximum drift was recorded soon after dusk and night drift was generally higher than the day drift.

Baetidae, Chironomidae, Hydropsychidae and Lepidostomatidae accounted for high drift number at night while Simuliidae was found to be day-active.

Monthly invertebrate drift was primarily influenced by benthos density and flow regime of the streams. The highest drift was recorded in March which coincided with the highest population density of the benthos, and the lowest at the peak of the rainy season when the flow regime of the streams was very high.

***Keywords:*** *Macroinvertebrate, drift, stream, Thailand*

## INTRODUCTION

An extensive literature has now been accumulated on macroinvertebrate drift in running water habitats (Waters, 1972), but the bulk of it is from arctic and temperate latitudes (Turcotte and Harper, 1982). Only few studies from tropical regions are known such as those of Bishop (1973) in a small Malayan river, Hynes (1975) in a river of Southern Ghana, Elouard and Leveque (1977) in Ivory Coast, Turcotte and Harper (1982) in a high Andean stream in Ecuador and Dudgeon (1984) in Hongkong.

Although some scattered unpublished literatures are available for the benthic macroinvertebrates in running waters of Thailand such as those of Rajchapakdee (1992) and Sannarm (1993) and the work of Mustow at Doi Inthanon National Park (in press), nothing has been published on the drifting patterns of Thai macroinvertebrates. Thus during the conduct of the author's thesis, the opportunity was taken to investigate the drifting patterns of Thai macroinvertebrates in two small streams.

## THE STUDY SITES

This study was conducted in two separate streams in Northern Thailand. They are of more or less the same in elevation but of different ecological conditions, i.e., one stream is highly influenced by agricultural activities and the other characterized by its relatively pristine conditions.

The first stream representing the disturbed site, called Huai Nong Hoi is located in Ban Nong Hoi, Mae Rim District Chiang Mai which is approximately 98° 50' E and 18° 55'N. Three stations along the stream were selected for the study (Figure 1).

Station 1 is situated upstream at about 1200 m above sea level with a stream width that ranges from 20 to 250 cm. The water is very shallow, fast-flowing and is completely covered with riparian trees common at higher elevations. The substratum is dominated by gravel. The upstream of this station is an agricultural field.

Station 2 is about 1 km downstream of station 1 at an altitude of 1000 m with a stream width ranging from 30 to 150 cm. This station was strongly influenced by agricultural activities, because it is very close to the Highland Coffee Research Station of the Faculty of Agriculture, Chiang Mai University and the vegetable fields

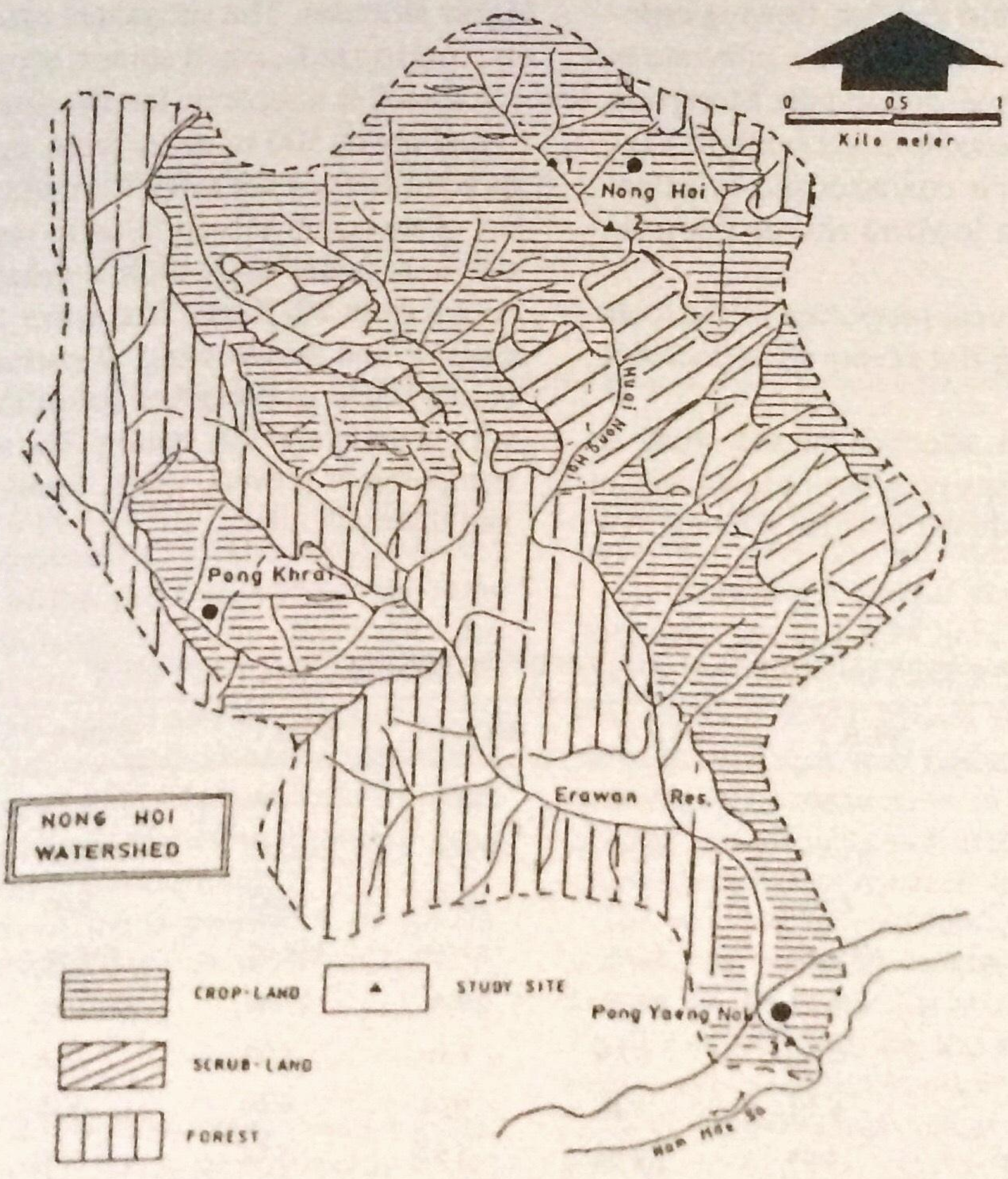


Figure 1. Map of Ban Nong Hei Stream showing the three stations selected for sampling.

of the Hmong hilltribe. Vegetables grown include carrots, cabbage and garlic. Fruit trees are also present as minor crops. The water is very shallow and fast-flowing but turbid especially during the rainy season due to the erosional materials from the surrounding agricultural fields. The substrate is dominated by coarse sand and silt. Most parts of this station are exposed because riparian trees have been felled down. Weeds dominate the riparian vegetation.

Station 3 is about 5 km downstream from station 2 with an altitude of 750 m above sea level. Stream width ranges from 120 to 200 cm. The water is very turbid and fast-flowing especially during the rainy season. The substrate is composed mostly of fine sand and silt. Most parts of this station are exposed to direct sunlight. Like station 2, this station is characterized by extensive cultivation with lowland rice as the main crop.

The physico-chemical properties of the three stations in Ban Nong Hoi stream are reflected in Table 1.

The other stream selected for the study to represent the relatively pristine one is situated in Doi Chang Kian, Muang District, Chiang Mai, approximately 98° 54'E and 18° 50'N, immediately where the other Highland Coffee Research Station of the Faculty of Agriculture, Chiang Mai University is located. It is actually not pollution-free, but because of the difficulty in finding a pristine one, this least polluted stream in DCK was then chosen. Three stations were also selected for the sampling (Figure 2).

Station 1 is found about 50 m upstream of the coffee fields at an elevation of 1300 m above sea level. The water is clear, fast-flowing, shallow with a stream width of 70-150 cm. This station is completely shaded by riparian trees common in higher altitudes. The substrates consist of gravels, coarse sands, small stones, roots and litter.

Station 2 is a separate stream running parallel to and about 500 m away from station 1. It is approximately 1 km away from the coffee fields but of the same elevation as in station 1. This station is rather small with a stream width that ranges from 20-70 cm. The water is clear, very shallow and fast-flowing. Riparian trees commonly found in evergreen forest in the area are very abundant in this station. The substrates are composed of gravels, sands, small stones, roots and litter and mud.

**Table 1.** Physico-chemical properties of Doi Chang Kian and Ban Nong Hoi streams[1]

| Parameters | DCK 1 | DCK 2 | DCK 3 | BNH 1 | BNH 2 | BNH 3 |
|---|---|---|---|---|---|---|
| DO (mg/l) | 7.80 | 7.55 | 8.00 | 7.80 | 7.75 | 7.60 |
| % O Sat | 97.45 | 94.35 | 99.60 | 101.00 | 98.25 | 96.70 |
| pH | 8.02 | 8.03 | 8.74 | 8.60 | 8.00 | 8.87 |
| Conductivity (µS/cm) | 85.90 | 33.45 | 33.00 | 358.00 | 509.00 | 317.00 |
| W Temp (°C) | 18.75 | 18.75 | 20.00 | 21.00 | 21.25 | 23.00 |
| $NO^3$ (mg/l) | 0.31 | 0.44 | 1.10 | 1.00 | 1.45 | 1.90 |
| $PO_4^{2-}$ (mg/l) | 0.10 | 0.10 | 0.04 | 0.20 | 0.22 | 0.09 |
| Alkalinity (meq/l) | 1.04 | 1.02 | 1.02 | 3.52 | 3.48 | 3.36 |
| $BOD_5$ (mg/l) | 0.00 | 0.20 | 0.40 | 0.30 | 0.70 | 0.60 |

[1]Average of two samplings. i.e. dry and rainy season.

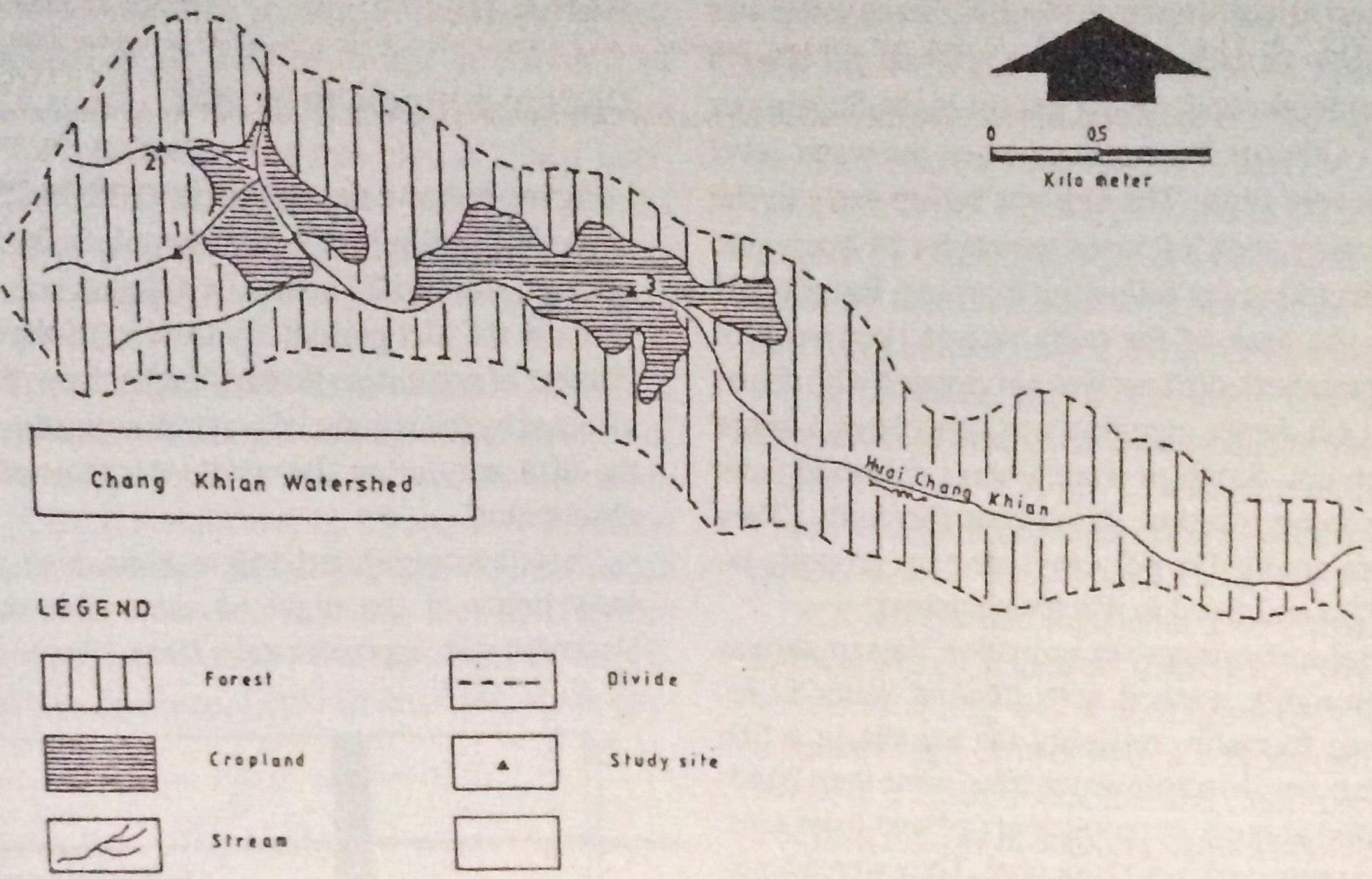


**Figure 2.** Map of Doi Chang Kian Stream showing the three stations selected for sampling.

Station 3 is about 5 km downstream of stations 1 and 2 at an altitude of 1000 m above sea level. The water is turbid and knee-deep in the rainy season, fast-flowing, with a width that ranges from 150-450 cm. Substrates are composed of big stones, sand, gravel and silt. This station is located in the agricultural fields of Hmong hilltribe where rice, corn, vegetables and fruit trees are grown. Most parts of this station are still covered by dense shrubs and some trees.

The physico-chemical properties of stream water in Doi Chang Kian are shown in Table 1.

## METHODS

A drift net was used in the collection of drifting macroinvertebrates. It was approximately 1.8 m long with a mouth aperture of 26 x 13 cm and mesh size of 200 micrometer. A plastic jar was carried on its downstream end. The net was mounted on a steel rod, established and fixed in the stream by pressing the rod into the stream bed.

To observe the diurnal periodicity in drift in these two streams, a 24-hour sampling program was done in stations 1 and 2 of DCK stream and station 2 of BNH stream in March 10. The selection of sites was based primarily on the accessibility and easiness in walking and harvesting the drift net catch at night. The net was emptied on a 4-hourly basis for 24 hours.

The monthly invertebrate drift investigation was carried out in all stations of both streams. During the dry season (in March), only stations 1 and 2 of DCK stream and station 2 of BNH stream were sampled. However, from July until October, sampling was done every 3 weeks in all stations.

The drift net was positioned in each station and fixed into the substrate, in such a way that it covered the whole width of the stream to possibly collect all drifting invertebrates. Since water was shallow in each station, the net was not always completely underwater except in the September 30 - October 2 samplings when the water level was very high. The net was set up early in the morning, then left in the stream for 24 hours, and collected in the following morning. Except during the peak of the rainy season (last week of September), drift net was not clogged with debris and silt, hence clogging was considered a minor problem. Samples were always collected from the same location throughout the study. They were emptied in polyethylene bags properly labelled and fixed in 4% formaldehyde.

Before laboratory examination, the sample was thoroughly washed with flowing water to remove formalin, retaining the sample in a fine mesh net. Macroinvertebrates were then hand-sorted using a stereomicroscope and hand lens, and preserved in 80% alcohol. They were identified up to family level except for Crustacea (Reptantia-Crab), Hydracarina, Nematoda, Nematomorpha and Ostracoda which were placed to higher taxonomic levels.

Drift index was calculated by dividing the total number of organisms per sample with the quantity of water flowing through the drift net during the exposure time. Water quantity was calculated from the mean flow velocity and the cross section of the water body entering the opening of the net. The formula below was used.

$$\text{Drift Index} = \frac{N}{A.V.T.} \quad [N/m^3]$$

where:

| | | |
|---|---|---|
| N | = | total number of organisms |
| A | = | area of net aperture in $m^2$ |
| V | = | water velocity in m/sec |
| T | = | exposure time in second |

## RESULTS

### Diurnal periodicity in drift

Figure 3 shows the day-night changes in drift expressed in $N/m^3$ per 4-hour sample in the three selected sites for 24 hours. Drift index was used to show the diel periodicity instead of the total number of organisms that drifted because drift is affected by the volume of water flowing through the drift net during the whole duration of the observation.

All stations registered drift maxima during the early hours of the night or soon after dusk. Darkness was approximately from 18hr to 6hr

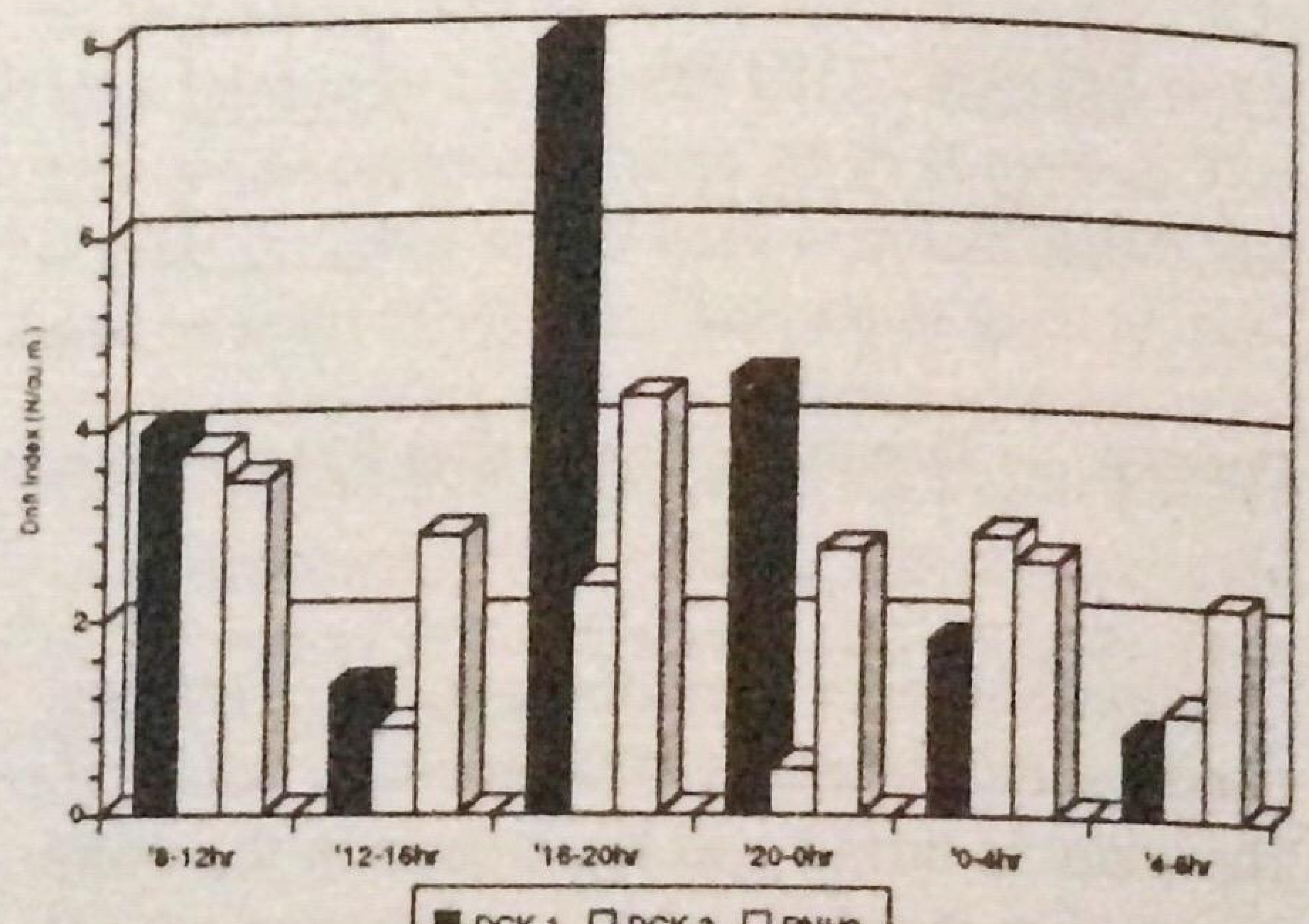


**Figure 3.** Day-night changes in drift in stations 1 and 2 of Doi Chang Kian stream and station 2 of Ban Nong Hoi stream (March 10, 1993).

during the sampling. The remarkable increase in drift was very evident in station 1 of DCK stream where a very high drift was recorded at 20hr. Station 2 of BNH stream also showed the same trend although the increase was lower in magnitude. On the other hand, station 2 of DCK stream with a very much reduced flow at the time of sampling, exhibited a continuous fluctuation in drift for the whole 24-hour sampling period. However, there was also a slight increase in drift at 20hr. A decline in drift in the morning was observed in all stations except in station 2 of DCK stream which had a second peak at 4hr due to Chironomidae, but this also declined later. Table 2 illustrates that drift sizes and indices were generally higher at night time (16hr-4hr) than during day time (4hr-16hr) except in station 2 of DCK.

The bulk of the drift was dominated by Baetidae, Lepidostomatidae and Chironomidae which comprised 22, 17 and 17% of the total drift in station 1 of DCK stream and 32, 10 and 15% in station 2. In contrast, Simuliidae and Chironomidae dominated the drift in station 2 of BNH stream comprising 42 and 27% in the total drift, respectively. Baetidae, Lepidostomatidae, Hydropsychidae and Chironomidae exhibited high drift numbers and indices at night with the highest numbers recorded between 20hr to 0hr. Simuliidae recorded high drift numbers and indices during daytime (Table 2). Interestingly, more families were collected in the evening except in station 2 of DCK stream which did not increase.

**Table 2.** Day-night drift of selected macroinvertebrate families[1].

| Family | Night | Day |
|---|---|---|
| Baetidae | 167 (61%) | 106 (39%) |
| Lepidostomatidae | 106 (69%) | 48 (31%) |
| Hydropsychidae | 85 (75%) | 29 (25%) |
| Chironomidae | 211 (67%) | 105 (33%) |
| Simuliidae | 98 (38%) | 162 (62%) |

[1]Taken from the total number of individuals for each family in selected sites per night or day netting.

## Monthly variations in drift

The monthly variation in drift in BNH stream is reflected in Figure 4. Drift index was very high in March as observed in station 2, and lowest in September 5 in station 1 at the onset of the heavy rain when the flow regime started to increase, and in October 2 in stations 2 and 3 at the peak of the rainy season, respectively, when the current flow and water discharge were at their peaks (Figure 5). The high drift in March was dominated by Chironomidae and Simuliidae. However, drift indices tended to increase in the early winter (October 22) in stations 1 and 2. The increase in station 1 was mainly due to Baetidae while that of station 2 was accounted to Chironomidae which comprised 81% of the total drift.

DCK stream also registered a very high drift index in March. It then declined in July when the second sampling was done (Figure 6). This remarkably high drift in March was attributed to Baetidae, Lepidostomatidae and Chironomidae. The drift indices in stations 1 and 3 both tended to decline towards the rainy season except on September 3 sampling when drift index increased. This coincided with the coming of the first rain and caused a slight increase in flow regime of the stream. The increase in station 1 was due to Chironomidae and Ostracoda, while that of station 3 was due to Tubificidae which comprised 37% of the total drift. In contrast, station 2 showed an increase in August 13 and then declined at the onset of the September rain, with the lowest drift recorded at the peak of the rainy season when the water discharge was very high (Figure 7). Nevertheless, all stations exhibited an increase in drift in the early winter as observed earlier in BNH stream. The increase in early winter was attributed mainly to Baetidae.

Ephemeroptera particularly Baetidae was the most dominant drifters in all stations in DCK stream and station 1 in BNH stream while Diptera particularly Chironomidae and Simuliidae composed much of the drift in stations 2 and 3 of BNH stream. Station 2 of DCK stream always had a remarkably high drift index for the whole duration of the study in comparison to other stations of both sites.

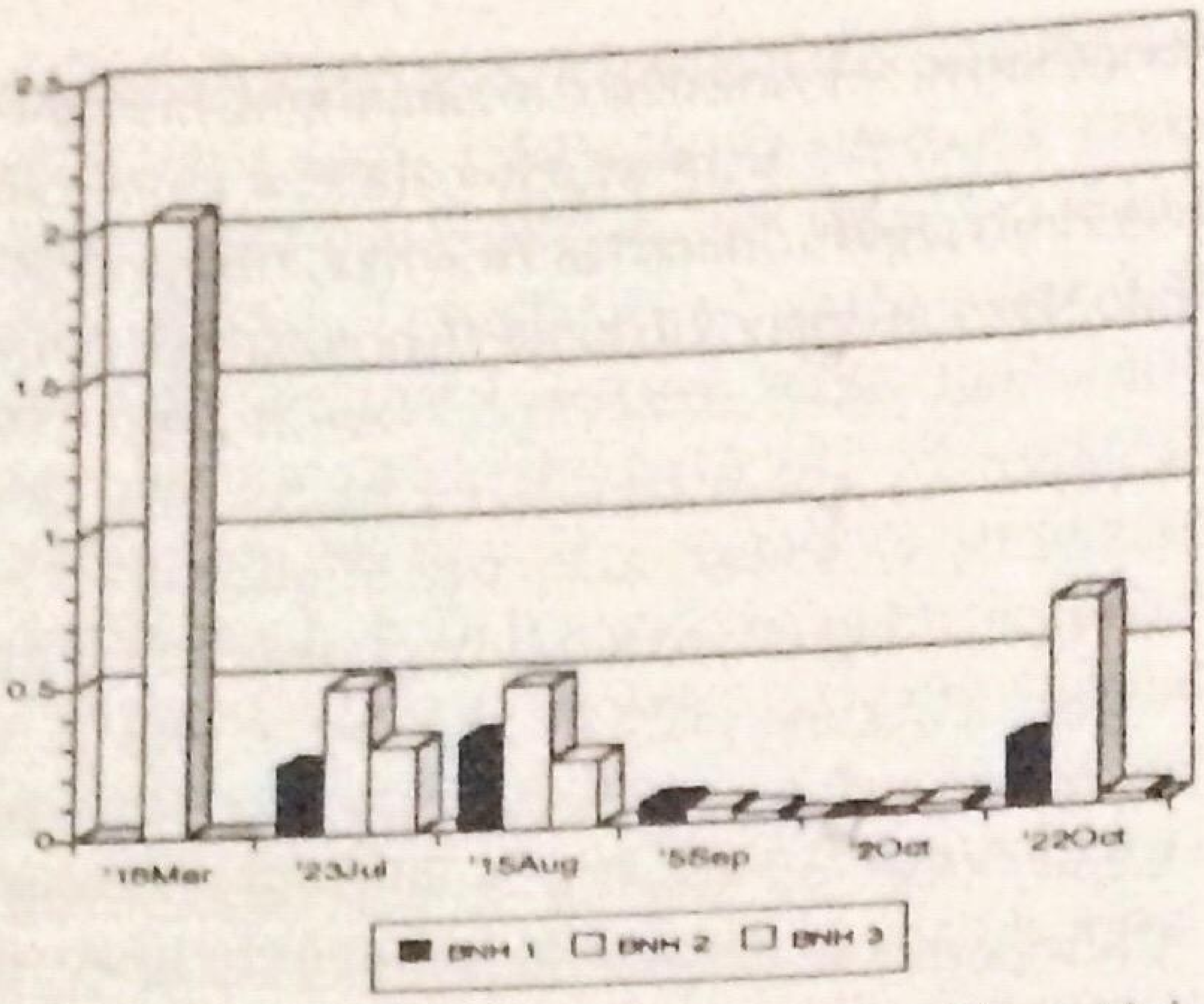


**Figure 4.** Monthly drift indices in Ban Nong Hoi stream.

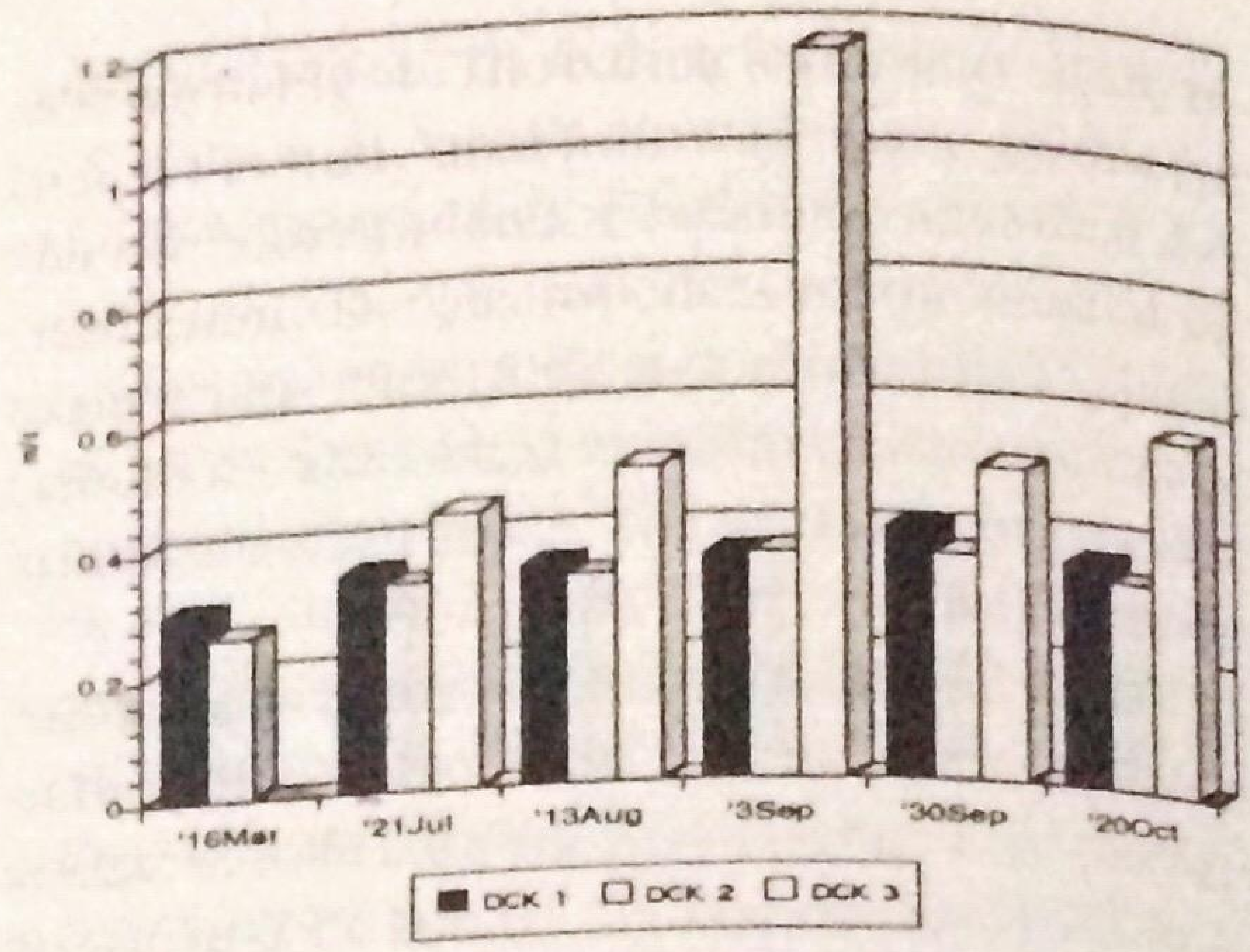


**Figure 5.** Monthly flow velocity in Ban Nong Hoi stream.

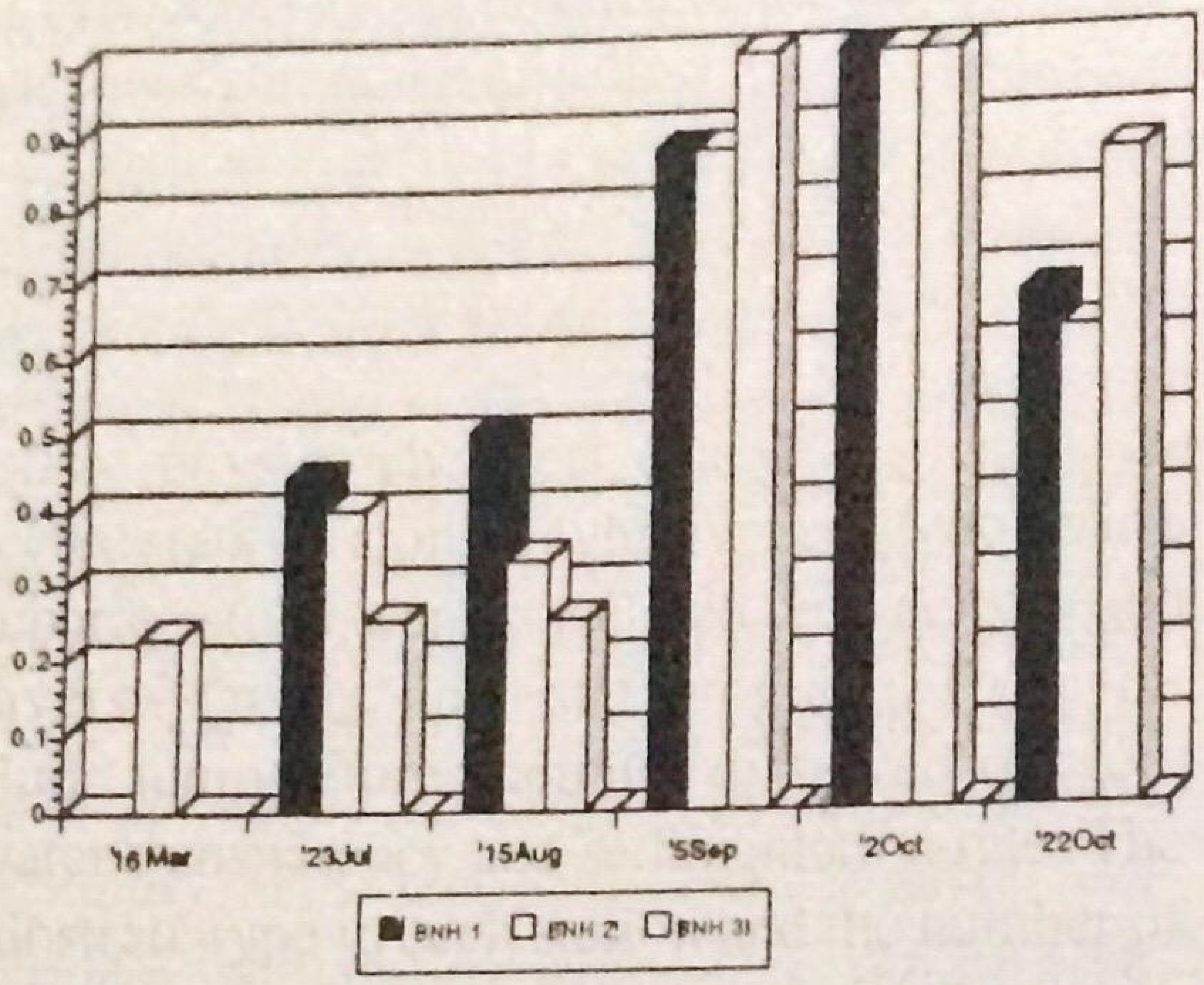


**Figure 6** Monthly drift indices in Doi Chang Kian stream.

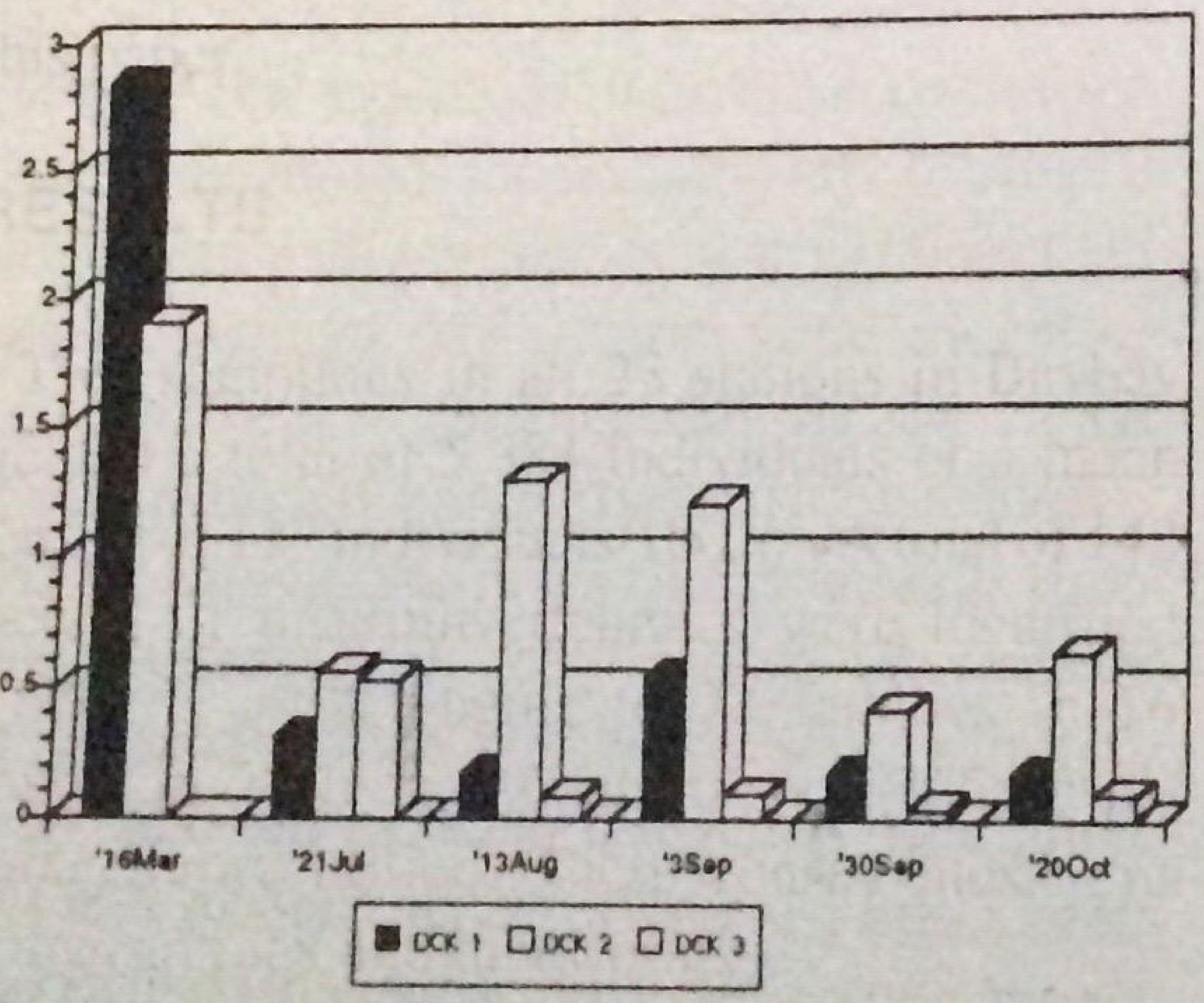


**Figure 7.** Monthly flow velocity in Doi Chang Kian stream.

## DISCUSSION

### Diurnal periodicity in drift

The occurrence of a pattern which includes maximum drift at night has been observed from many 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 force controlling the behavior of many aquatic nymphs and larvae and the increase in drift at night, as there was very slight change in temperature throughout the whole investigation period. Light specifically light intensity rather than wavelength is the most critical factor responsible for the circadian activity patterns recorded by several authors (Hughes, 1966; Elliott, 1967a). Negative phototaxis has been recorded for many aquatic insects and serves to maintain these organisms in areas of low light 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 daytime. However, upon release of the exogenous light control at night, they become more active in foraging for food, and insects are always visible on the substrate surface if light is directed onto it at night (Bishop and Hynes, 1969). In more exposed positions, such animals are more likely to become dislodged and swept into the current. This in turn causes higher drifts at night. Dorier and Vaillant (1954) noted that the magnitude of drift will depend on the amount of food available in a particular area, the degree of physical competition for it, and the tenacity of the individual. 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 is known to be phototactically negative (Elliott, 1967b) while Simuliidae is phototactically positive (Grenier, 1949). This contrasted to the observation of Hynes (1975) that *Simulium* including Plecoptera, Ephemeroptera and Trichoptera drifted maximally at night. The present investigation showed that Simuliidae is day active.

## Monthly variations in drift

Seasonal variations in drift are related to the changes in age and density of the benthos and the physical parameters of the stream. Muller (1954) suggested that drift may be regarded as a consequence of movement of a population of a habitat and an outcome of competition for space. In keeping with this idea, Dimond (1967) and Pearson and Franklin (1968) found drift numbers to be directly related to benthic density. Results of these studies suggest that water flow and

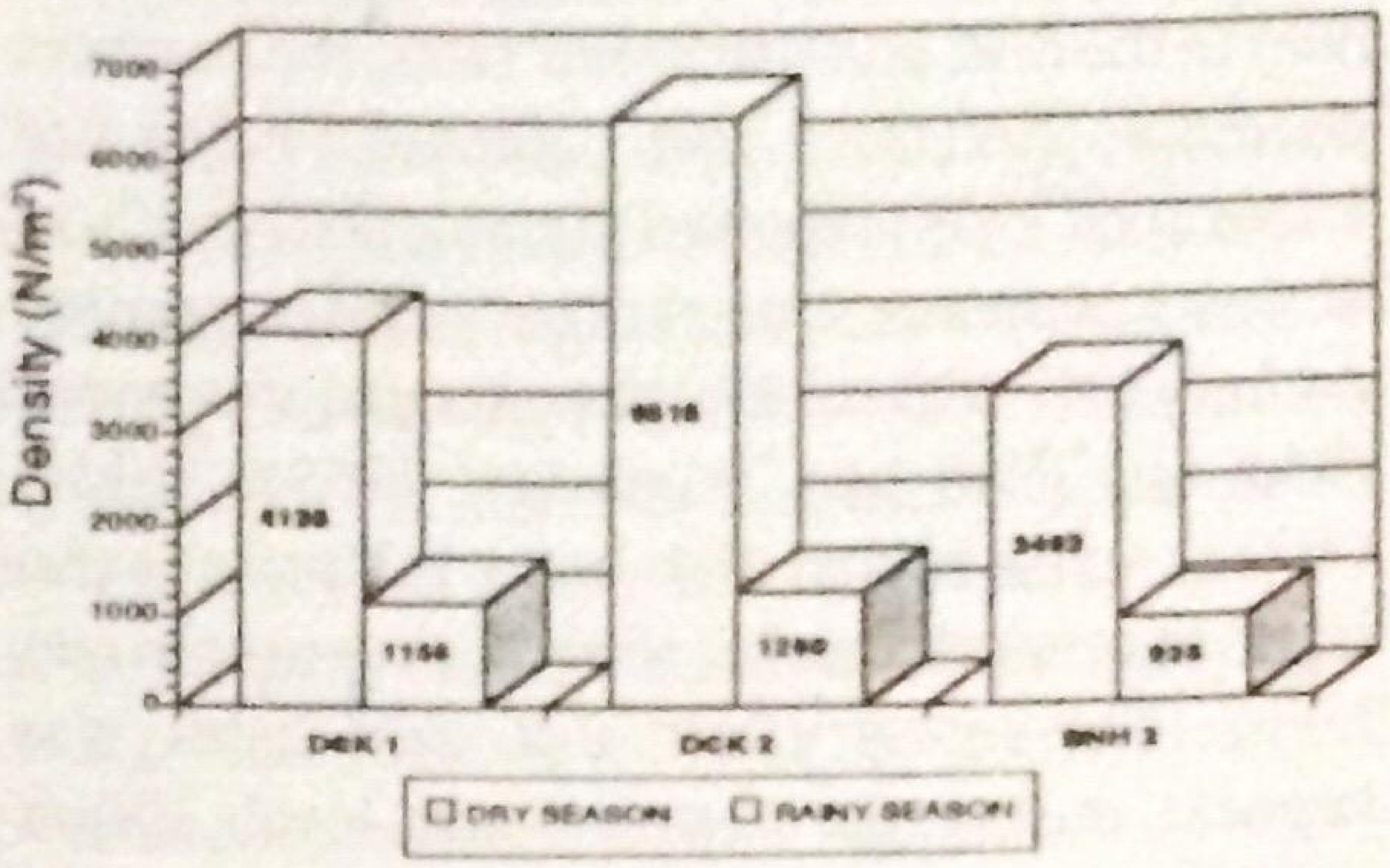


Figure 8. Benthos density in stations 1 and 2 of DCK stream and station 2 of BNH in two seasons.

benthic density are the dominant factors dictating the amount of drift. The increase in drift in March may have been caused by the high density of the benthos (Fig. 8) particularly Chironomidae and Baetidae which also dominated the drift during this month, as there was no change in the flow rate of water (Tuyor, 1994). The March peak in the number of Diptera, particularly Chironomidae reflected the emergence of many chironomid adults (Bishop and Hynes, 1969). Elliott (1967a) suggested that maximum drift occurs during seasons of maximum growth and may be related to molting or some activity dependent on the feeding requirements of the different life stages. By contrast, Turcotte and Harper (1982) did not detect any correlation between the benthos and drift patterns of a high Andean stream. Similar observations were made nearly everywhere else (Muller, 1966; Eliott, 1967a; Bishop and Hynes, 1969). In the tropics, where density of any group is low within the more heterogeneous populations, Hynes (1975) argued that such a density-dependent behavioral response may be expected to be less important. But this could not be the case of these Thai streams where Chironomidae and Baetidae are dominating the benthos (Tuyor, 1994).

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) reported gigantic drift numbers at times of spates. Others observed the opposite, namely low drift with high water and vice-versa (McLay, 1968 and Weninger, 1968). SEMG (1993) 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. Bishop (1973) showed relatively constant density of drift at different discharges although drift rates increased with increasing volumes. The results of the present investigation indicate that if the rate of water does not rise above a critical level, the animals tend to be dislodged from their substrates by the current when they come out at 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) showed that 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 seek shelter under such conditions, some of the fauna move into the interstitial spaces as the bottom becomes unclogged and they become inaccessible to erosional forces. This probably explains why drift number was very low at the peak of the rainy season when water discharge was very high. In his study on the downstream drift of invertebrates in a river in southern Ghana, Hynes (1975) indicated that when high, drift number is inversely correlated with the rate of flow, whereas when low, there is no correlation. But this may only be true for streams with diverse microhabitats and with stable substrates for recruitment when water flow increases. Bishop (1973) observed that at station 2 of Sungai Gombak in Malaysia with more variable microhabitats and much wider area for recruitment, the correlation coefficient between the quantity of drift and water passing the transect was not significant. In the case of BNH stream specifically stations 2 and 3 where only fine sands and silts are available for recruitment and are characterized by their instability, animals tend to be swept easily even if flow regime increase slightly.

The remarkable high drift in station 2 of DCK stream throughout the study and the unclear pattern of diel periodicity may be explained by its relatively small size and reduced flow, which probably reduced its carrying capacity. Competition may be high, which enabled others to be more active in foraging for food, thus making them vulnerable to dislodgement. Hughes (1966) and Minshall and Weninger (1968) observed 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. This increases the tendency of these organisms to be drifted by the current regardless of the time of the day.

The natural drift indices in the two streams vary from 0.02 to 2.05/m$^3$ in BNH stream and 0.04 to 2.84 in DCK stream and are comparable to other estimates made in the tropics; (1.56-1.79) in Malaysia (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). The lower minimum value of drift indices in Thai streams may be attributed to the emptying of the net which was only done once every 24 hours. McKaige (1990) compared two drift net emptying frequencies in Thredbo river in New South

Wales in Australia and 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 every 2 hours than when emptied after 12 hours. However, she noted that the relative abundance and diversity of invertebrate families were not significantly different.

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