EFFECTS OF CHECK DAMS ON WATER QUALITY AND MACROINVERTEBRATE DIVERSITY OF HOM JOM STREAM, LAMPHUN PROVINCE, THAILAND

Todsapon Kositpon and Chitchol Phalaraksh*

Received: Apr 11, 2012; Revised: June 15, 2012; Accepted: June 15, 2012

Abstract

The research was aimed at investigating the effects of check dams on the water quality and the macroinvertebrate diversity in a temporary stream. The study was conducted in the area of Mae Tha District, Lamphun Province, at 11 study sites and the data collection was done during 2 seasons; the dry season (November 2007 - April 2008) and the wet season (May - October 2008). The study of the physical and chemical factors of the water was done and the macroinvertebrates present at each study site were collected in order to study and analyze the biodiversity. All data obtained were used to analyze the relationship and consequences of the aquatic ecosystem and the check dams. The study found that check dams did not hold water at some study sites or did not contain aquatic ecosystems, but it was found that check dams can still result in some irregular factors in the water in terms of DO, turbidity, TDS, conductivity and nutrients. A total of 11 macroinvertebrate orders with 42 families was found, with a greater number found to be present in the wet season than in the dry season. According to the diversity and similarity analysis from the statistics, the results reveal that different types of macroinvertebrates present in the same stream may exist close to one another. The results of this study could conclude that check dams affect the physical and chemical factors of the water and impact on the number and characteristics of the macroinvertebrate communities that live in stream ecosystems.

Keywords: Check dam, macroinvertebrate, aquatic insect, water quality, biodiversity, stream ecosystem

Introduction

Due to the rapid increase of the human population in this age, natural resources have been unwisely used. As a result, many natural resources continue to deteriorate rapidly. In Thailand, there are many ways to restore the natural resources and impose sustainable management, including check dam construction in highland streams. Currently, thousands of check dams have been widely constructed on highland steams, including concrete, rocky, and bamboo check dams. These check dams have been constructed in order to slow down

Department of Biology, Faculty of Science, Chiang Mai University, Chiang Mai 50200, Thailand. E-mail: chitchol@chiangmai.ac.th

* *Corresponding author*

soil erosion and the water current, which would help to restore forests in the long term.

The benefits of check dams have been studied in a variety of ways. Bombinoa *et al.* (2008) studied the vegetation along the water toward check dams in Mediterranean streams. It was found that the vegetation along the water in the vicinity of check dams has a variety of species, while the plant height and the percentage of shaded area increased significantly. This was consistent with the data from Huai Hong Khrai Royal Development Study Center (2007), who reported in 1993 that the forest area in this study center was continuously damaged by fire at a rate of around 200 hectares per year, but after utilizing the distribution system and water storage in the forest resulting from building check dams, during the 10-year period after the development of the check dams, no forest fires occurred. Furthermore, the green natural vegetation area has been expanded. Not only does building check dams add to water conservation, but it is also contributes to the restoration of the land and forest. Some check dam construction has created a format suitable for the stream and the ecosystem as a whole. However, some check dams have been created considering only budget, and did not take into consideration the impacts which occur in the stream ecology, especially the water and the creatures that live in the water of that area. Boix-Fayos *et al.* (2007) studied the effects of check dams and the harvesting and utilization of the land area along the Rogativa Stream in Spain, which flows into the Rogativa Reservoir, from 1957 to 2003, and found that when the check dams were built in the Rogativa Stream in 1976, the volume of water flow (discharge) and amount of sediments had decreased when they were measured again in 1981. In addition, Phanittawongsa (2007) reported that, in general, after a check dam was constructed, the water level and temperature increased, which resulted in lower dissolved oxygen. The form of sediments was also changed from gravel, stone, and sand to silt, clay, and mud. The macroinvertebrate and aquatic plant communities also changed according to the substrate types and water current, which affected the food chain. In addition, Harding (1992) found lower diversity and density of aquatic insect orders Plecoptera, Ephemeroptera and Diptera in streams with check dams constructed than in streams with check dams not constructed.

Therefore, the study of stream ecology in check dam areas through various means is required, such as in terms of water quality or the variety of organisms that live in that water area, in order to establish a database to help in the assessment of the risks to the ecosystem of check dam building. It should be noted that the ecosystem is comprised of various physical and biotic environmental elements, while the 2 elements should be looked at as resources which are related to each other. Therefore, the restoration of any specific resource should be considered for the impacts that may occur with other related resources, in order to make a well-informed decision in terms of the environment and the check dam's worthiness in the long run.

The aim of this research was to investigate the relationship between water quality and the diversity of macroinvertebrates present in a check dam constructed stream - Hom Jom Stream, Mae Tha District, Lamphun Province, northern Thailand.

Materials and Methods

Scope of the Study

This research selected study sites along Hom Jom Stream, Lamphun Province, when the age of the check dam was less than 1 year. The field study was conducted between November 1, 2007 and October 31, 2008. Sampling at the selected study sites in the dry season was carried out in January 2008, whilst sampling was done in the wet season in July 2008.

The Physico-Chemical Factors of the Water

The physical and chemical parameters, including water temperature, total dissolved solids (TDS), electric conductivity (EC), turbidity, and pH were measured under the standard method (Greenberg *et al*., 1999). Dissolved oxygen (DO) and biochemical oxygen demand (BOD_5) were also analyzed by the azide modification of iodometric method (Greenberg *et al*, 1999).

Inorganic nutrients including ammonia-nitrogen (NH_3-N), nitrate-nitrogen (NO_3-N), and ortho-phosphate (o-PO_4^{3-}) were also analyzed by the Nessler method, cadmium reduction method, and ascorbic acid method, respectively (Greenberg *et al*, 1999).

The Study of Macroinvertebrates

Field Study

The macroinvertebrate samples were collected by the 'kick and pick method' (McCafferty, 1981) from the different habitats, including rock, gravel, sand, mud, and leaf litter, from each sampling site. The samples were preserved in 70 % ethanol prior to identification in the laboratory.

Laboratory Work

After the cleaning and sorting process the macroinvertebrate samples were identified by family levels, under a stereomicroscope, using the classification books of McCafferty (1981), Merritt and Cummins (1984), Dudgeon (1999), and Sangpradup and Boonsoong (2006).

Statistical Analysis

All the physico-chemical and macro-invertebrate data were analyzed by diversity index (using the Shannon index) and similarity from cluster analysis; all of the analysis process used the Multivariate Statistic Package program (MVSP) Version 3.1. (Kovach Computing Services, 2012).

Results and Discussion

Study Sites' Data and Characteristics

About 120 m. along the stream were fixed for the study area. This area was located at the Hom Jom Stream, Tha Pa Pao village, Tambon Tha Pla Duk, Mae Tha District, Lamphun Province. The position of the study area was N 18 ° 27.454 ", E 98 ° 13.040" and N 18 ° 27.480 ", E 98 ° 13.007" (Figure 1). The elevations of the study sites were 540 to 520 meters above sea level. The distance between each check dam was estimated at 10–11 m. The type of check dam at H1 and H2 is a folk mixed dam (small size, using little stones and bamboo), H3 is a semi-permanent dam (medium size, using large stones and concrete) and H4 to H11 are permanent dams (large size, using concrete) (Office of the Royal Development Projects Board, 2007).

The drought problem at the Hom Jom Stream was that it typically dried out during the dry season, including study sites H1, H2, H3, H4, H8, and H11. In addition, study site H9 was split into 2 areas: H9-2 (next to H8) and H9-1 (before H10). Furthermore, the stream did not flow continuously and formed some basin conditions (Figure 2). Jirapongsa (1997) noted that the ecological characteristics of water flow were different in terms of the ecology of swamps or stagnant pools of water and were a continuation of the current rate. It was clear that this result was an example of how check dams change aquatic ecosystems.

Water Quality

The physico-chemical data of the water in the Hom Jom Stream are shown in Table 1. The results were compared between 2 seasons and indicated that air temperature, water temperature, conductivity, and TDS in the dry season were higher than the wet season but turbidity, DO, BOD, and nutrients in the dry season were found to be lower than the wet season. In the dry season, each area of water was standing but changed to flowing in the wet season. In terms of water flow in the wet season, there was a transfer of some substances in the water, such as TDS, DO, or the concentrations in the water, from one point to another, which decreases the amount of these substances so that they are lower than in the standing water in the dry season. In addition, Laohajinda (2003) noted that in running water there was more DO than in standing water, due to the vortex and waves, which occurred when water struck the banks where it was mixed with oxygen at the surface and that increased the amount of DO in the water. This is the reason that DO in the wet season (between 3.4 to 7.2 mg/L) was higher than in the dry season (between 1.6 to 3.8 mg/L).

The amount of physico-chemical factors, such as DO, turbidity, BOD, and nutrients in the 2 seasons were different at each study site. This was caused by the check dams blocking the water from point to point, making the stream to be divided into sections and causing each study area to have different factors for the water. For example, at H9 in the dry season, the area was divided into 2 areas (H9-2 and H9-1) and each area had different physico-chemical factors for the water (for example, the turbidity of H9-2 was 14 NTU, while for H9-1 it was 7 NTU, the DO of H9-2 was 2.4 mg/L, while for H9-1 it was 3.4 mg/L).

This research found that the check dams affected the amount of turbidity when the water flowed slowly. In the dry season, the amount of turbidity upstream was more than downstream from H5 to H11 where the amount of turbidity tended to decrease (turbidity from H5 to H10 is 43, 15, 23, 14, 7, and 6 NTU). Check dams act like a barrier that can block sediment and suspension in the water and, when the amount of turbidity

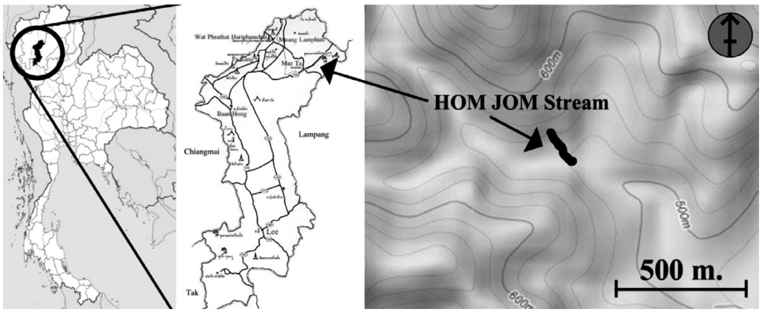

Figure 1. Location of Hom Jom Stream in Tha Pa Pao Village, Tambon Tha Pla Duk, Mae Tha District, Lamphun Province used in this study

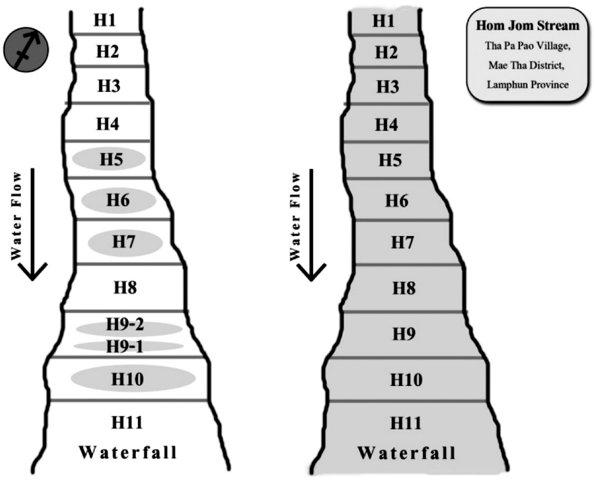

Figure 2. The location of check dams (gray lines) in Hom Jom Stream (Left: dry season, Right: wet season)

Table 1. Physical-chemical factors of each study site

Factors	Study sites																
	H1	H2	H3	H4	H5		H6		H7		H8		H9		H10		H11
	Wet	Wet	Wet	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Wet	Dry (H9-2)	Dry (H9-1)	Wet	Dry	Wet	Wet
Air Temperature (°C)	30.00	29.50	29.50	30.00	36.60	30.00	35.50	30.50	30.00	30.00	31.00	35.10	38.50	30.00	31.50	30.00	29.50
Water Temperature (°C)	24.50	24.50	24.50	25.00	25.00	25.50	34.50	26.50	27.50	26.00	28.00	27.50	30.50	27.80	26.40	22.50	26.00
pH	6.76	5.96	6.47	6.28	6.49	6.67	6.55	6.78	6.92	7.05	6.48	6.47	6.60	6.74	6.84	7.06	6.51
TDS (mg/L)	18.90	19.50	19.20	18.90	80.00	30.20	73.00	58.30	74.00	51.10	50.90	80.00	70.00	56.00	91.00	55.20	61.00
Turbidity (NTU)	32.00	47.00	42.00	68.00	43.10	32.00	15.42	74.00	23.39	67.00	72.00	14.34	6.83	69.00	5.83	84.00	42.00
Conductivity (μS/cm)	31.50	32.60	32.30	31.40	172.80	50.50	153.20	97.90	157.90	76.10	102.00	169.80	155.70	94.50	192.20	92.90	103.60
DO (mg/L)	5.90	3.40	4.90	4.90	2.80	5.40	4.40	6.40	5.00	7.20	6.10	2.40	3.40	6.80	3.40	6.20	6.80
BOD (mg/L)	2.90	2.80	2.90	2.90	1.60	3.00	3.80	3.80	3.00	4.40	3.50	3.00	2.20	3.60	4.20	5.00	3.40
Nitrate-Nitrogen (mg/L)	1.80	1.60	1.00	1.40	0.80	1.30	0.70	1.10	1.00	1.40	1.20	0.90	0.50	1.10	0.50	0.90	1.40
Orthophosphate (mg/L)	0.56	0.66	0.56	0.59	0.97	0.53	0.71	0.60	0.58	0.56	0.63	0.76	0.72	0.59	0.65	0.65	0.77
Ammonia-Nitrogen (mg/L)	0.27	0.35	0.11	0.25	0.66	0.19	0.28	0.40	0.26	0.26	0.23	0.33	0.38	0.20	0.41	0.25	0.18

Note : H1, H2, H3, H4 and H11 have no data in dry season because the water had dried out.

increases, it will affect the characteristics of the stream ecology and the community of aquatic organisms (Phanittawongsa, 2007).

The similarity analysis using the physico–chemical data is shown in Figure 3. There were 3 groups of the study sites over the 2 seasons: Group 1 consisted of all sites in the dry season, Group 2 consisted of upstream sites (H1 to H5) in the wet season, and Group 3 consisted of downstream sites (H6 to H11) in the wet season. The physico–chemical factors that indicated these results were DO, TDS, conductivity, and nitrate-nitrogen. The amounts of nitrate– nitrogen in the dry season were between 0.5–1.0 mg/L, which were lower than in the wet season (between 0.9–1.8 mg/L), and this showed the differences in water quality in the 2 seasons. The amount of DO in the dry season (Group 1) was between 2.4–5.0 mg/L, in the upstream sites (Group 2) in the wet season it was between 3.4–5.9 mg/L, and in the downstream sites (Group 3) in the wet season it was between 6.1–7.2 mg/L. The amount of TDS in Group 1 was between 70–91 mg/L, in Group 2 it was between 19–30 mg/L, and in Group 3 it was between 51–61 mg/L. The amounts of conductivity in Group 1 were between 153.2–192.2 μS/cm, in Group 2 they were between 31.4–50.5 μS/cm, and in Group 3 they were between 76.1–103.6 μS/cm. All of these factors clearly showed the impact from the check dams. In the dry season, with a lesser volume of water, the check dams will decrease the velocity of the water, change some stream sites to be pools and some physico–chemical factors of the water will be changed from normal. They will also decrease the amount of DO and nitrate–nitrogen and increase the amount of TDS, conductivity, and turbidity (especially upstream). In the wet season, with the higher volume of water, some physico–chemical factors of the water were changed, such as DO and nitrate–nitrogen which were increased and TDS and conductivity which were decreased; these were due to seasonal impacts, but the check dams will also make some stream sites different and will impact on the characteristics of the stream and the communities of aquatic animals.

Macroinvertebrate Data

Forty-two families of 11 orders were identified in this study (Table 2). Within this number, 25 families in 7 orders were identified from the dry season and 35 families in 10 orders were found in the wet season. In the dry season, orders and families of macroinvertebrates were lower than in the wet season because the wet season had a higher amount of nutrients, for instance the amount of nitrate–nitrogen was higher than in the dry season. Peterson *et al.* (1993) referenced by Noikhong (2003) studied the effect of increasing the concentration

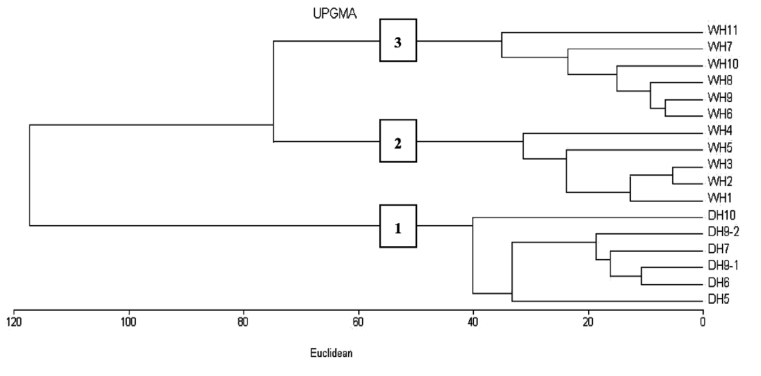

Figure 3. Similarity of water quality over 2 seasons (D: dry season, W: wet season)

Table 2. List of macroinvertebrates found in the dry and wet seasons

Phylum Class Order	Family	Dry season	Wet season
P.Mollusca			
C.Gastropoda			
O.Basematophora	Ancylidae	/	-
C.Pelecypoda			
O.Veneroida	Sphaeriidae	-	/
P.Arthropoda			
C.Crustacea			
O.Decapoda	Parathelphusidae	-	/
C.Insecta	Heptageniidae	/	/
O.Ephemeroptera	Leptophlebiidae	/	/
	Ephemeridae	/	/
	Ephemerellidae	-	/
	Caenidae	/	/
	Baetidae	/	/
O.Plecoptera	Perlidae	-	/
O.Trichoptera	Leptoceridae	/	/
	Hydropsychidae	-	/
	Polycentropodidae	/	/
	Goeridae	-	/
	Brachycentridae	-	/
	Grossosomatidae	/	/
O.Odonata	Coenagrionidae	/	/
	Corduliidae	/	/
	Libellulidae	/	-
	Macromidae	/	-
	Chlorocyphidae	-	/
	Gomphidae	-	/
O.Hemiptera	Gerridae	/	/
	Nepidae	/	/
	Naucoridae	/	/
	Notonectidae	/	-
	Corixidae	/	/
	Veliidae	/	/
	Belostomatidae	-	-
	Pleidae	/	/
O.Coleoptera	Dytiscidae	/	-
	Helodidae	/	-
	Hydrophilidae	-	/
	Elminthidae	-	/
	Psephenidae	-	/

Table 2. List of macroinvertebrates found in the dry and wet seasons (cons)

Phylum Class Order	Family	Dry season	Wet season
O.Diptera	Chironomidae	/	/
	Culicidae	/	/
	Simuliidae	-	/
	Tipulidae	-	/
	Ceratopogonidae	/	/
	Athericidae	-	/
O.Lepidoptera	Pyralidae	-	/
total Order		**7**	**10**
total Family		**25**	**35**

Note : / = found, - = not found

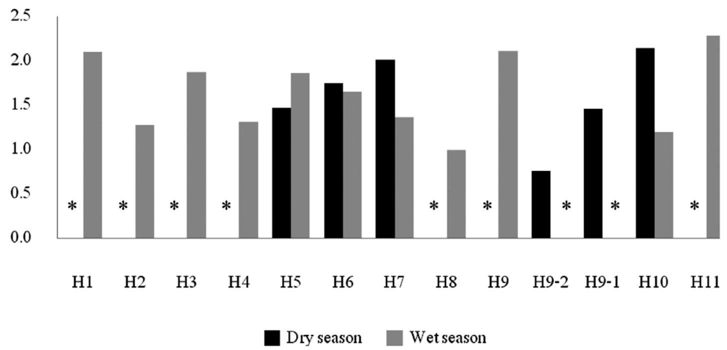

Figure 4. Diversity index of each study site (* = No data)

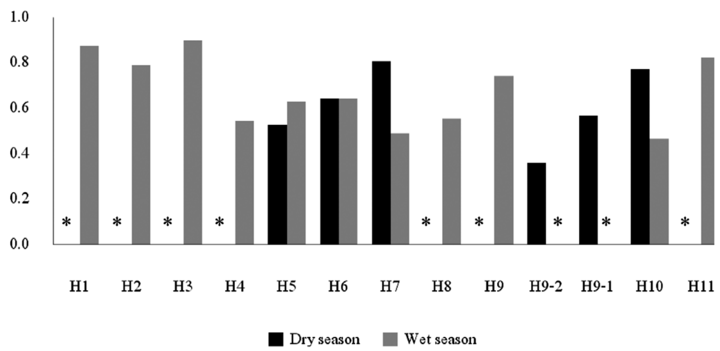

Figure 5. Evenness of each study site (* = No data)

of nitrate-nitrogen to the biological processes and population in each level in the food web of the stream system for 4 summers and found that the number of species of macroinvertebrates in the wet season were higher than in the dry season with less water. Considering the macroinvertebrates in the study area, the types of macroinvertebrates found in each area from upstream to downstream (H1 → H11) were similar in the 2 seasons but there was a discontinuity of the type and number of macroinvertebrates in the same stream even though each area was not very far apart. This was caused by the physico-chemical factors of the water in each area being different. As a result, the percentage of macroinvertebrates found in each area varied.

Figures 4 and 5 showed the diversity index and evenness of the macroinvertebrates (analyzed by MVSP 3.1, using the Shannon index) of each study site during the dry season and the wet season. In the dry season, the families diversity index was between 0.754 to 2.146, while the evenness values ranged from

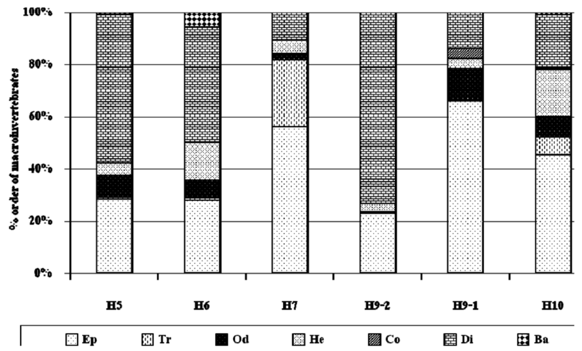

Figure 6. Order percentage of macroinvertebrates found in dry season (Ep = Order Ephemeroptera, Tr = Order Trichoptera, Od = Order Odonata, He = Order Hemiptera, Co = Order Coleoptera, Di = Order Diptera, Ba = Order Basematophora)

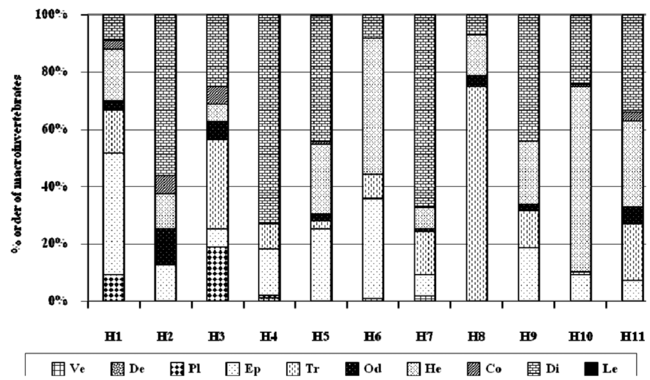

Figure 7. Order percentage of macroinvertebrates found in wet season (Ve = Order Veneroida, De = Order Decapoda, Pl = Order Plecoptera, Ep = Order Ephemeroptera, Tr = Order Trichoptera, Od = Order Odonata, He = Order Hemiptera, Co = Order Coleoptera, Di = Order Diptera, Le = Order Lepidoptera)

0.363 to 0.810. The study points out that the families diversity index and evenness of H9-2 was lower than the others. A similarity analysis determined that the next section was consistent (Figure 8), while the H9-2 totals differ significantly when compared with the others. In the wet season, the families diversity index was found to be between 0.994 to 2.288, while the evenness values ranged from 0.467 to 0.901 and there was a ratio of 1 in 2 to 1 in 3 in the families diversity index. However, at H2, the evenness showed a ratio of 2 in 3 in the families diversity index. The results showed that there was a variety of macroinvertebrates in the water during the dry season and the wet season, but the barrier of the check dams resulted in a variety of organisms in the water being incoherent at each study area.

When using the percentage of macro-invertebrates in each order, the results from Figures 5 and 6 showed the positive relationship with the similarity analysis using the macroinvertebrate data (Figure 8) in the dry season. While H9 was divided into 2 areas: H9-2 and H9-1, when comparing them, the percentage of orders appeared to differ significantly from the areas that were not far apart.

From Figure 8, the cluster analysis using the macroinvertebrate data involved 6 groups in 2 seasons. The Group 1 area consisted of H5, H6, and H10 in the dry season, and H4 and H5 in the wet season. The Group 2 area consisted of H7 in the dry season and H1, H2, H3, H8, H9, and H11 in the wet season. The Group 3 area consisted of H7 in the wet season. The Group 4 area consisted of H9-1 in the dry season. The Group 5 area consisted of H10 in the wet season and the Group 6 area consisted of H9-2 in the dry season. These results oppose the previous cluster analysis using the physico–chemical data and showed the varieties of the characteristics of the study sites in the stream and confirmed that the barrier of the check dams significantly affected the variety of living organisms in the water.

Conclusions

Check dams are human constructions that affect stream ecology. In the dry season, there was less discharge and the check dams made the water flow more slowly or changed running water to standing water. And in the wet season, the check dams made conditions and readings at some sites of the stream different. The check dams also affected the characteristics of the stream ecosystem, such as the water properties and the communities of aquatic organisms. When water quality is decreased, it will have an effect on the community of aquatic organisms by changing the types and numbers of animals that will affect the food chain and ecosystem.

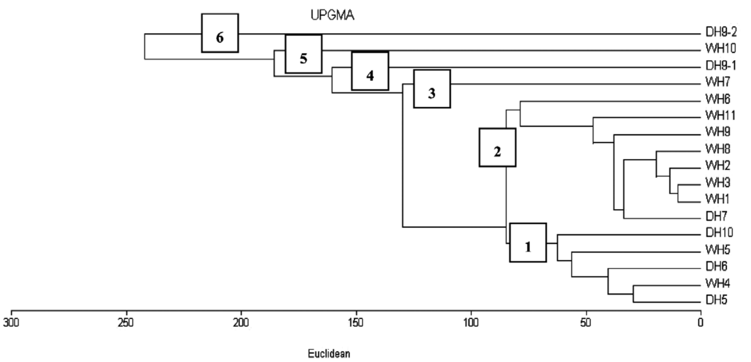

Figure 8. Similarity of macroinvertebrates over 2 seasons (D: dry season, W: wet season)

Acknowledgements

We would like to thank the Thailand Research Fund and Siam City Cement Public Company Limited for their financial support. Thanks are also extended to the members of the Freshwater Biomonitoring Research Laboratory for their assistance in sampling and macroinvertebrates identification.

References

Boix-Fayos, C., Barberá, G.G., López-Bermúdez, F., and Castillo, V.M. (2007). Effects of check dams, reforestation and land-use changes on river channel morphology: case study of the Rogativa catchment (Murcia, Spain). Geomorphology, 91: 103 – 123.

Bombinoa, G., Gurnellb, A.M., Tamburino, V., Zemaa, D.A., and Zimbonea, S.M. (2008). Sediment size variation in torrents with check dams: effects on riparian vegetation. Ecol. Eng., 32: 166–177.

Dudgeon, D.D. (1999). Tropical Asian Streams: Zoobenthos, Ecology and Conservation. Hong Kong University Press, Hong Kong, 844p.

Greenberg, A.E., Eaton, A.D., and Clescerl, L.S. (1999). Standard Method for Examination of Water and Waste Water. American Public Health Association, Washinhington DC, 1134p.

Harding, J.S. (1992). Discontinuities in the distribution of invertebrates in impounded South Island River, NewZealand. Regul River., 7(4): 327–335.

Huai Hong Khrai Royal Development Study Center. (2007). Area of Operations. Available from : irrigation.rid.go.th/rid1/ HongKhrai/ site.htm. Accessed date: June 24, 2007. (in Thai)

Jirapongsa, B. (1997). A Preliminary Study on Ecological Structure of Khwae Noi Stream. Naresuan University, Phitsanulok, 60p. (in Thai)

Kovach Computing Services (2012). Product Information. Availible from: http://www.kovcomp.co.uk/mvsp/MVSP3ProdInfo1.pdf. Accessed date: June 14, 2012

Laohajinda, N. (2003). Ecology: Basic of Environmental Education. Kasetsart University Publisher, Bangkok, 292p. (in Thai)

McCafferty, W.P. (1981). Aquatic Entomology. Science Books International, Inc,, Boston, Mass., 448p.

Merritt, R.W. and Cummins, K.W. (1984). An Introduction to the Aquatic Insects of North America. Kendal/Hunt Publishing Co., Dubuque, IA, 862p.

Noikhong, W. (2003). Use of Benthic Insects as Indicators for Water Quality in Some Areas of Nan River, Nan Province, [B. Special Project]. Faculty of Science. Chiang Mai University. Chiang Mai, Thailand, 52p. (in Thai)

Office of the Royal Development Projects Board. (2007). Check Dam in Difference Characteristics. Government House, Dusit. Bangkok, 32p. (in Thai)

Peterson B.J., Deegan, L., Helfrich, J., Hobbie, J.E., Hullar, M., and Moller, B. (1993). Biological responses of a tundra river to fertilization. Ecology, 74(3):653-672.

Phanittawongsa, N. (2007). The Upstream Dam Construction and Its Impact on Stream Ecosystems. Availible from: www.siamensis.org/files/checkdam_stream.pdf. Accessed date: May 9, 2007. (in Thai)

Sangpradup, N. and Boonsong, B. (2006). Identification of Freshwater Invertebrates of the Mekong River and Tributaries. Mekong River Commission, Vientiane, 276p. (in Thai)