

CHAPTER V. RESULTS

1. PHYSICO-CHEMICAL PROPERTIES

The physico-chemical properties of different running waters in the dry season and the rainy season are presented in Tables 1 and 2. Alkalinity and conductivity were higher in the dry season and declined in the rainy season at all sites. The pH in both seasons was between 6.8 and 8.1; mostly the values are neutral.

In the dry season, percent oxygen saturation was observed more than 80% at most sites, but it increased in value in the rainy season. Only in Mae Kha sewage canal, the percent oxygen saturation ranged from 0-20% in dry season and 2-38% in rainy season.

The water flow had higher values in the rainy season than in the dry season at all sites.

Ammonia concentration was related to BOD_5 , with the highest values in the sewage canal in both seasons. BOD_5 had a value about four times higher in the dry season in the sewage canal.

Nitrate concentration in the dry season was higher than in the rainy season. The sewage canal had a higher concentration than the other sites.

Phosphate concentration in the rainy season was higher in concentration in the sewage canal than other sites.

The concentration of nitrate found in this study was less than 1 mg/l except at S1 only in the dry season. These values do not indicate the polluted condition.

Similarity, phosphate concentrations do not indicate the eutrophication condition in this study.

Table 1. Physico-chemical properties of different running water in dry season

site	DO (%)	DO (mg/l)	pH	cond (μscm^{-1})	wtemp ($^{\circ}\text{C}$)	s dep (cm)	depth (cm)	altitu (m)	velo (m/s)
S1	83	6.5	7	109	24.1	clear	10cm	600	0.17
S2	87	6.6	7	383	24.3	"	40	700	0.38
S3	74	5.6	8	112	27.4	"	15	450	0.16
SC1	20	1.4	7	336	30.9	20	80	300	0.01
SC2	1	0	7	956	34.1	15	15	300	0.09
SC3	5	0.3	7	884	30.6	5	100	300	0.11
P1	87	6.1	7	265	30.1	21	100	300	0.20
P2	83	5.7	7	277	32.9	27	150	300	0.23
P3	74	5.2	7	316	32	28	150	350	0.23
IC1	66	4.5	8	428	32.5	clear	50	350	0.00
IC2	190	12.4	8	334	35.5	clear	20	350	0.01
IC3	101	6.9	8	305	34.1	21	120	300	0.00

Site	Ammonia (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Alkalinity (mg/l)	BOD5 (mg/l)
S1	0.24	1.10	0.04	64	1.95
S2	0.00	0.20	0.04	276	2.65
S3	0.00	0.30	0.04	64	3.15
SC1	2.28	0.80	0.07	182	439
SC2	12.9	0.70	0.20	454	444
SC3	12.2	0.50	0.20	424	419
P1	0.00	0.70	0.04	148	2.5
P2	0.00	0.00	0.04	210	2.4
P3	0.00	0.60	0.04	206	3.0
IC1	2.76	0.00	0.08	258	4.4
IC2	0.00	0.20	0.04	212	7.7
IC3	0.00	0.20	0.04	234	5.25

Table 2 : Physico-chemical properties of different running waters
in the rainy season

Site	DO %	DO (mg/l)	pH	cond (μscm^{-1})	wtem ($^{\circ}\text{C}$)	sdep (cm)	velo (m/s)	dept (cm)	altitu (m)	time
S1	98	7.7	6.9	76.4	22.5	15	26	15	600	9.45
S2	98	8	6.8	219	22	45	44	1.10m	700	8.45
S3	97	7.7	7.7	45.5	24.4	3	17.3	25	450	18.35
SC1	38	2.8	6.7	177.6	27.7	29	8	1.10m	300	12.15
SC2	2	0.2	6.8	418	28.8	24	10	120	"	12.55
SC3	13	0.9	6.9	337	28.2	26	8	130	"	14.40
P1	83	6.4	6.8	201	27	12	42	250	"	10.56
P2	93	6.9	7.2	204	29	74	46	300	"	13.40
P3	95	7.1	7.2	198	28	15	42	320	350	13.40
IC1	70	7.7	7.5	157.1	27.6	25	14.7	130	"	18.00
IC2	53	4.0	7.0	206	29.7	30	10	130	"	16.12
IC3	98	7.4	7.4	159.4	27.5	10	15.3	80	"	17.15

Site	Ammonia (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Alkalinity (mg/l)	BOD5 (mg/l)
S1	0.13	<0.02	0.02	45	1.6
S2	0.11	<0.02	0.04	128	3.8
S3	0.10	<0.02	0.17	27	2.9
SC1	0.62	<0.02	0.15	114	130
SC2	3.36	<0.02	0.79	224	90
SC3	2.20	<0.02	0.56	185	100
P1	0.18	<0.02	0.17	136	3.0
P2	0.16	<0.02	0.12	89	2.5
P3	0.19	<0.02	0.16	146	3.2
IC1	0.12	<0.02	0.06	106	0.2
IC2	0.13	<0.02	0.04	107	0.2
IC3	0.28	<0.02	0.12	150	5.2

***** HIERARCHICAL CLUSTER ANALYSIS *****

Dendrogram using Average Linkage (Between Groups)

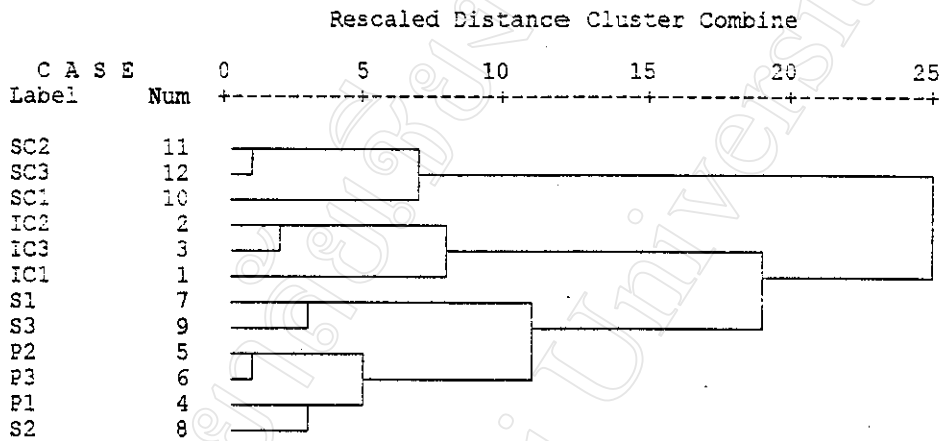


Figure 10. The similarity of different running waters based on physico-chemical properties in the dry season.

***** HIERARCHICAL CLUSTER ANALYSIS *****

Dendrogram using Average Linkage (Between Groups)

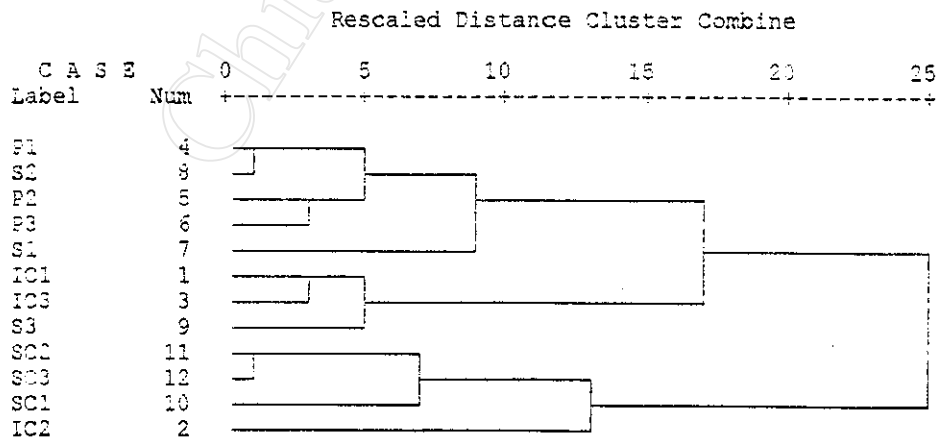


Figure 11. The similarity of different running waters based on physico-chemical properties in the rainy season.

The dendrograms produced by hierarchical cluster analysis of different running waters based on physico-chemical properties (pH, %O₂, BOD, velocity, ammonia, alkalinity and conductivity) in both seasons indicate the major difference between the sewage canal (SC1, SC2, SC3) and the other sites in both seasons (Figures 10 and 11). All sites on the sewage canal were separated from the other sites by their high BOD₅, alkalinity and conductivity.

The physico-chemical properties of the different running waters can be compared with the Surface Water Quality Classification And Standards (Appendix O). The waters from the Ping River and stream were classified in WC_s (Water Classes) 1-3. The water from irrigation canals was classified in WC_s 2-5, and the water from Mae Kha canal was classified in WC 5.

2. BIOLOGICAL RESULTS

2.1 MACROINVERTEBRATES COLLECTED

The number of families found at each site is presented in Table 3. The total number of macroinvertebrate taxa found in the dry season was 94 families, with the highest number in site S2 followed by S1 and S3. In the rainy season, the total number of macroinvertebrate taxa found declined to 43 families, with the highest number in site S1 followed by IC3, and S2 and S3.

The dendrogram from hierarchical cluster analysis of different running waters based on families found in the dry season (Figure 12) indicated a difference between the stream sites (S1, S2, S3) and the other sites. Site S2 is distinct from all other sites but is closer to sites S1 and S3. In the rainy season, the dendrogram from hierarchical cluster analysis of different running waters based on families found (Figure 14) showed that S1 and S3 were still grouped together but were more similar to P3, whereas S2 was distinct from the other stream sites. The similarity of macroinvertebrates taxa found per area based on the different sites in both seasons are presented in Figures 11 and 13.

Table 3. Number of Macroinvertebrates Families Found/Area
in Different Running Waters

Dry Season		Rainy Season	
Site	Number	Site	Number
1. S2	49 (52.13 %)	1. S1	24 (55.81 %)
2. S1	38 (40.43 %)	2. IC3	17 (39.54 %)
3. S3	18 (19.58 %)	3. S2, S3	15 (34.90 %)
4. P1,SC1	13 (13.83 %)	4. SC1	10 (23.26 %)
5. IC2	10 (10.64 %)	5. P3	7 (16.28 %)
6. IC3	9 (9.57 %)	6. P1	4 (9.30 %)
7. P2,IC1	8 (8.51 %)	7.P2, SC2, SC3	2 (4.65 %)
8. P3	6 (6.38 %)	8. IC1, IC2	0 (0 %)
9.SC2	5 (5.32 %)	Total	43 (100 %)
10. SC3	1 (1.06 %)		
Total	94 (100 %)		

***** HIERARCHICAL CLUSTER ANALYSIS *****

Dendrogram using Average Linkage (Between Groups)

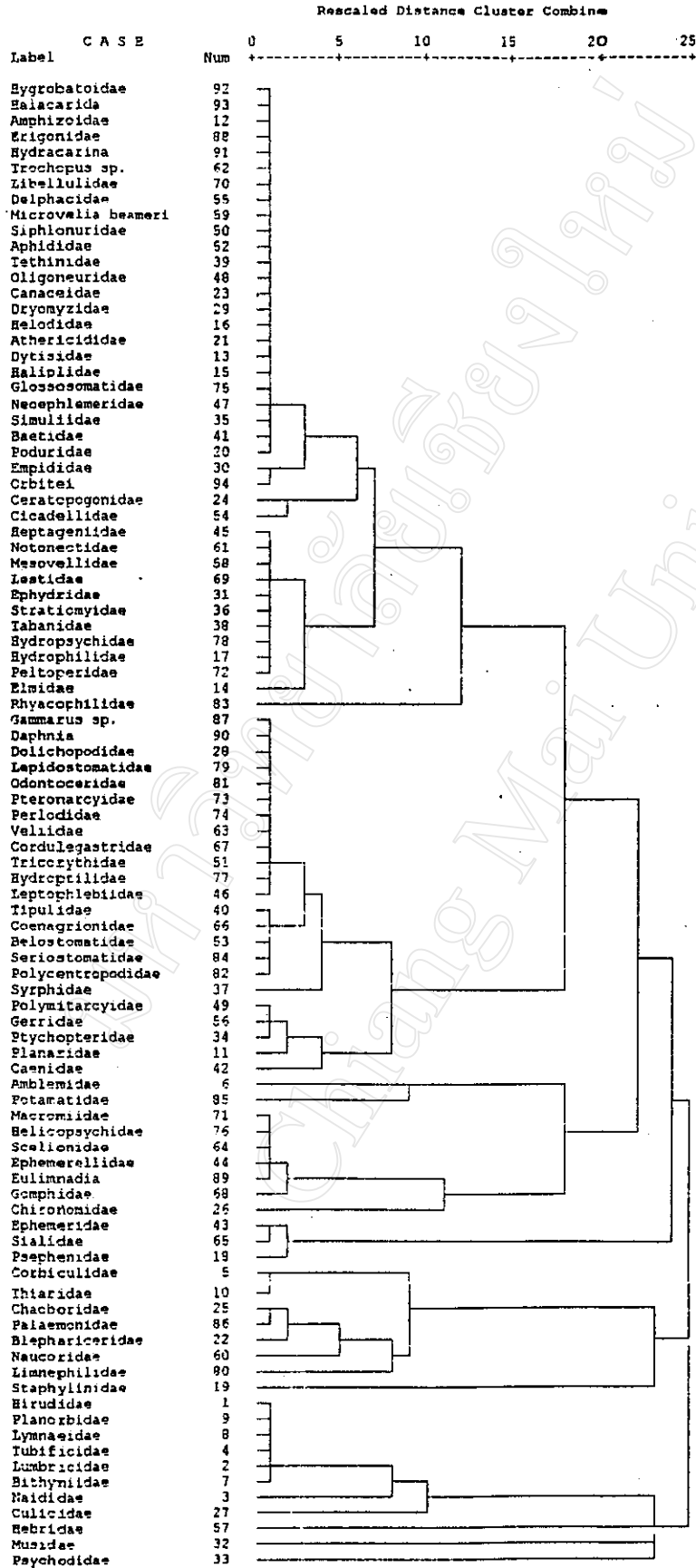


Figure 12. Similarity of families found/area based on the different running waters in the dry season.

***** HIERARCHICAL CLUSTER ANALYSIS *****

Dendrogram using Average Linkage (Between Groups)

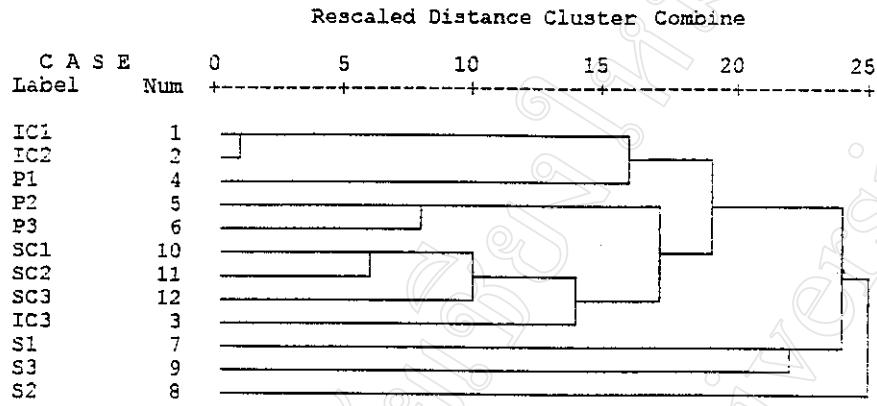


Figure 13. Similarity of different running waters based on number of families found/area in the dry season

***** HIERARCHICAL CLUSTER ANALYSIS *****

Dendrogram using Average Linkage (Between Groups)

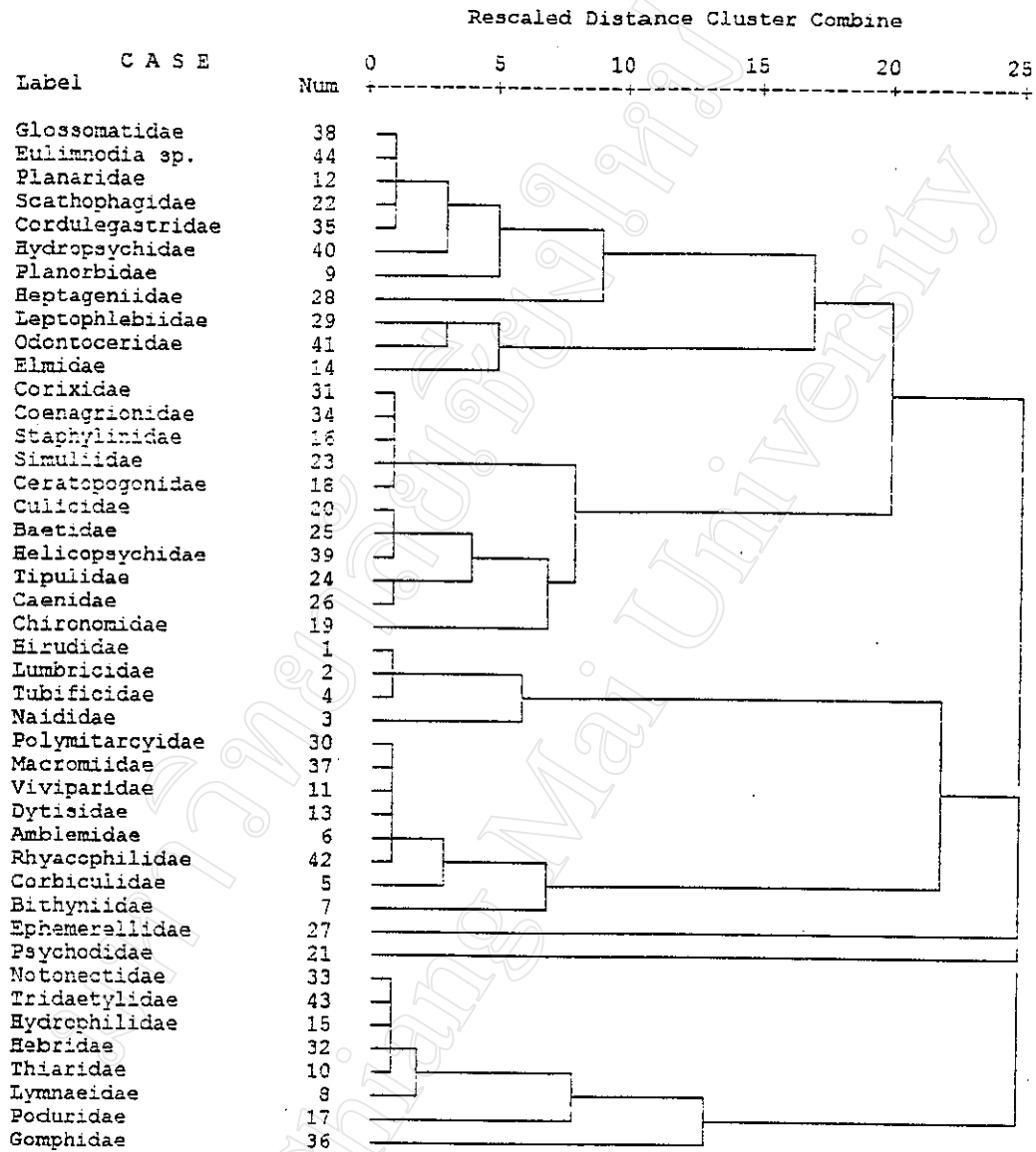


Figure 14. Similarity of all families found/area based on the different running waters in the rainy season

***** HIERARCHICAL CLUSTER ANALYSIS *****

Dendrogram using Average Linkage (Between Groups)

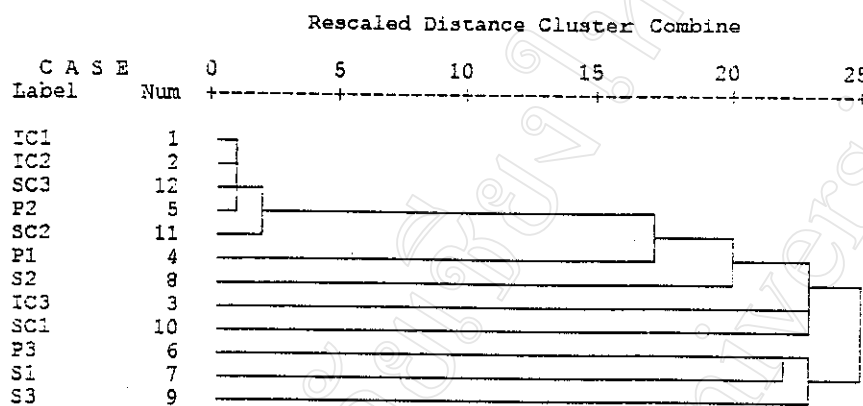


Figure 15. Similarity of different running waters based on number of families found/area in the rainy season

3. HABITAT ASSESSMENT

3.1. THE SCORE OF HABITAT ASSESSMENT

The habitat evaluation was carried out in stream sites (S1, S2, S3) and scores based on habitat parameters ranged from poor to excellent. The habitat parameters comprised primary parameters, secondary parameters and tertiary parameters (see appendix I for detail). The habitat evaluation scores of the stream sites in both seasons by these parameters are presented in Table 4. The column totals score i.e. the combined score from each column at each site was presented in Table 5. The highest score of habitat assessment was presented in S2 with score 95 in dry season and 92.5 in rainy season. The reference site S1 and the stream site S3 have the lower score, respectively.

Table 4. The Score of Habitat Assessment of Stream Sites based on the
Habitat Parameters in the Dry and Rainy Season.

Habitat Parameters	Score of Habitat Assessment					
	Dry Season			Rainy Season		
	S1	S2	S3	S1	S2	S3
Primary Parameters	35	39	11	33	38.5	13
Secondary Parameters	26	29	19	24	28	22
Tertiary Parameters	24	27	21	24	26	23

Table 5 The Column Total Score of Habitat Assessment

Site	Dry Season	Rainy Season
S1	85	81
S2	95	92.5
S3	51	58

3.2 PHYSICAL CHARACTERIZATION

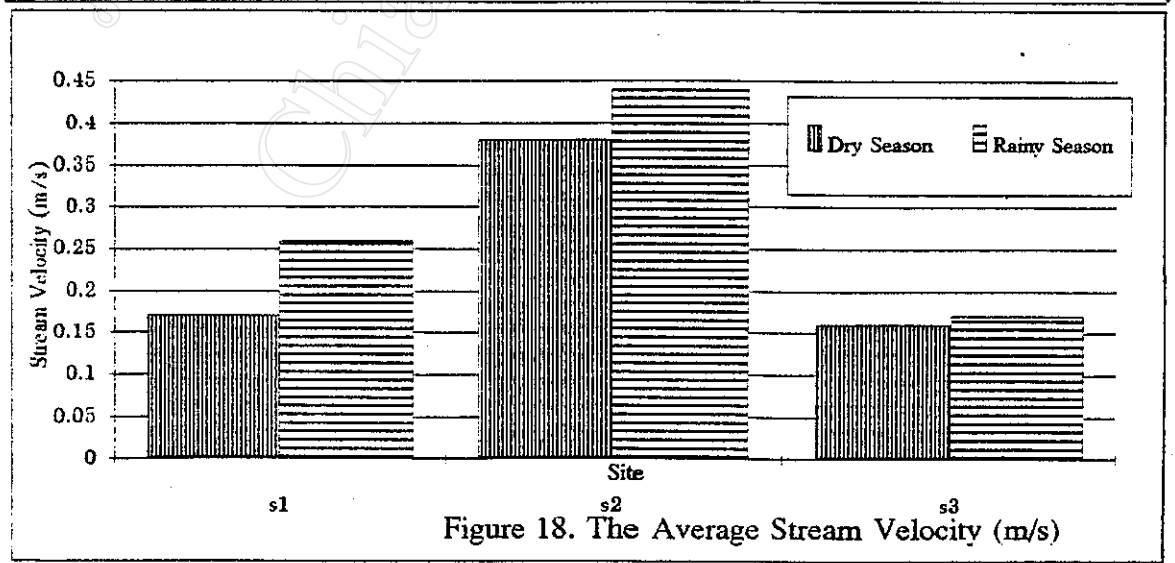
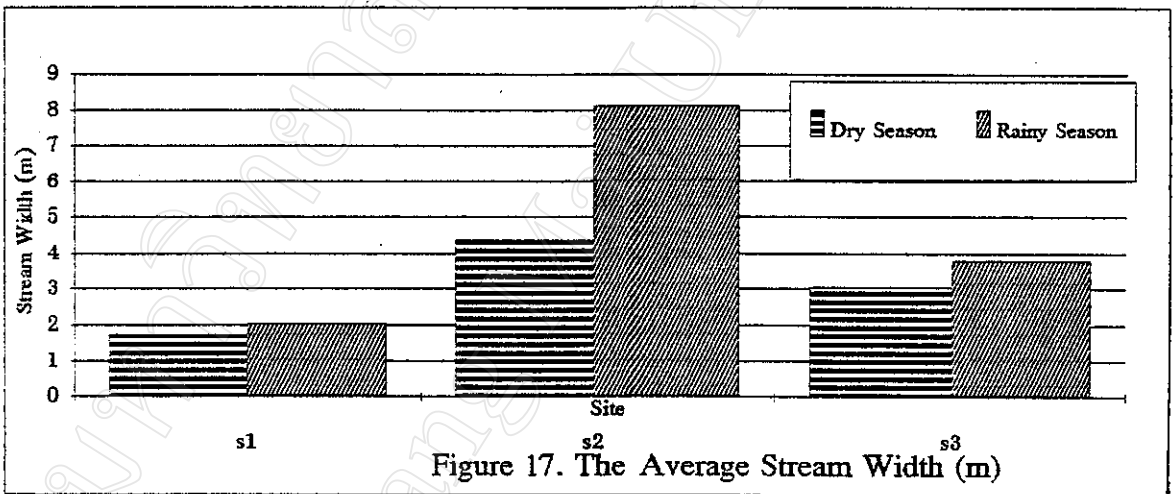
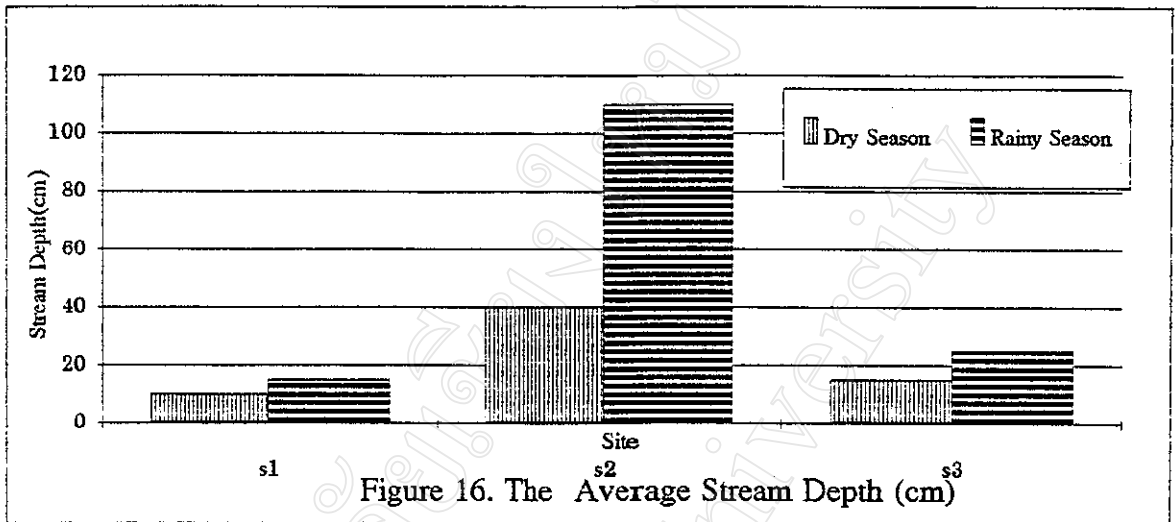
The measurements of stream depth, width and velocity in the dry and rainy seasons are presented in Figures 16, 17 and 18. All stream sites had

increased values in the rainy season. Site S2 especially showed big differences between the two seasons.

The inorganic substrate components of stream sites of the dry and the rainy season are presented in Figures 19 and 20. Stream site S2 shows more types of inorganic substrate than the others in both seasons. The substrate types of S2 comprised bedrock, boulder, cobble, gravel and sand-silt. There are four types of substrate for site S1, and only two types in site S3.

The organic substrate components which indicate the relative abundance of detritus and muck-mud in each site are presented in Figures 21 and 22. There are only small differences in percent components between the dry season and rainy season.

The pictures of stream width, inorganic substrate distribution and riparian vegetation of the stream sites(S1, S2, S3) in the dry and rainy seasons are presented in Figures 23-25.



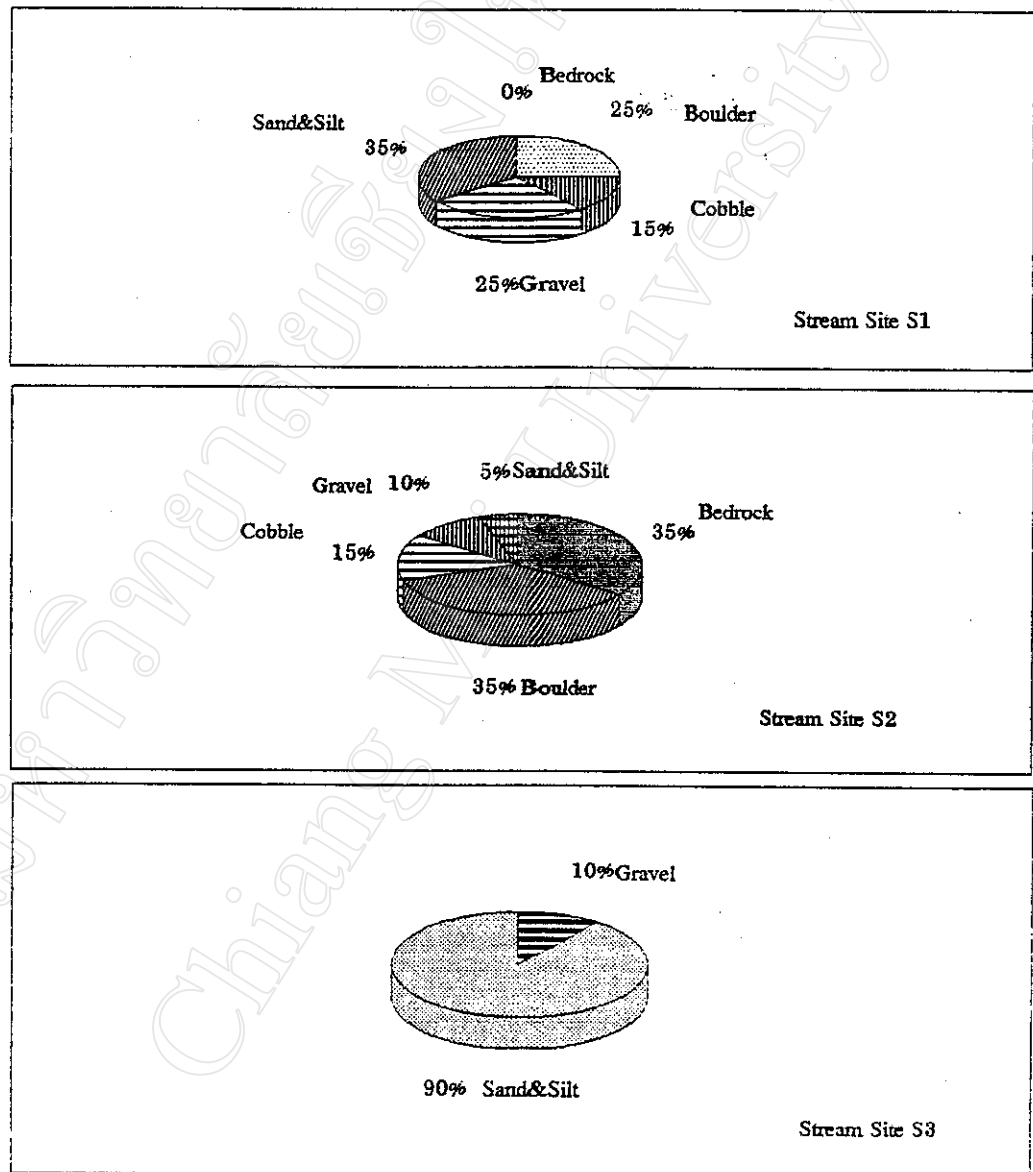


Figure19. The Inorganic Substrate Components of the Stream Sites in the Dry Season.

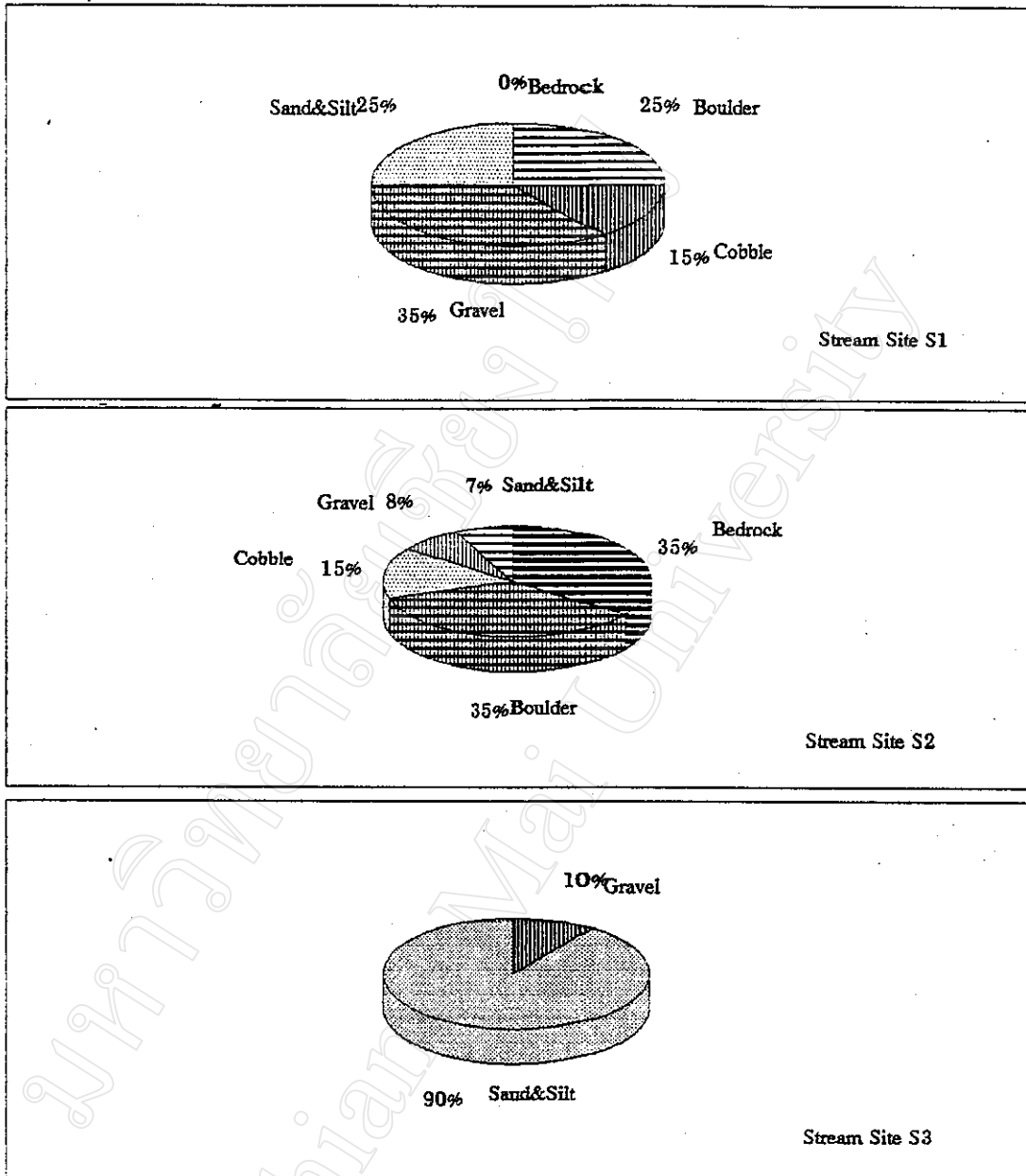


Figure 20 . The Inorganic Substrate Components of the Stream Sites in the Rainy Season.

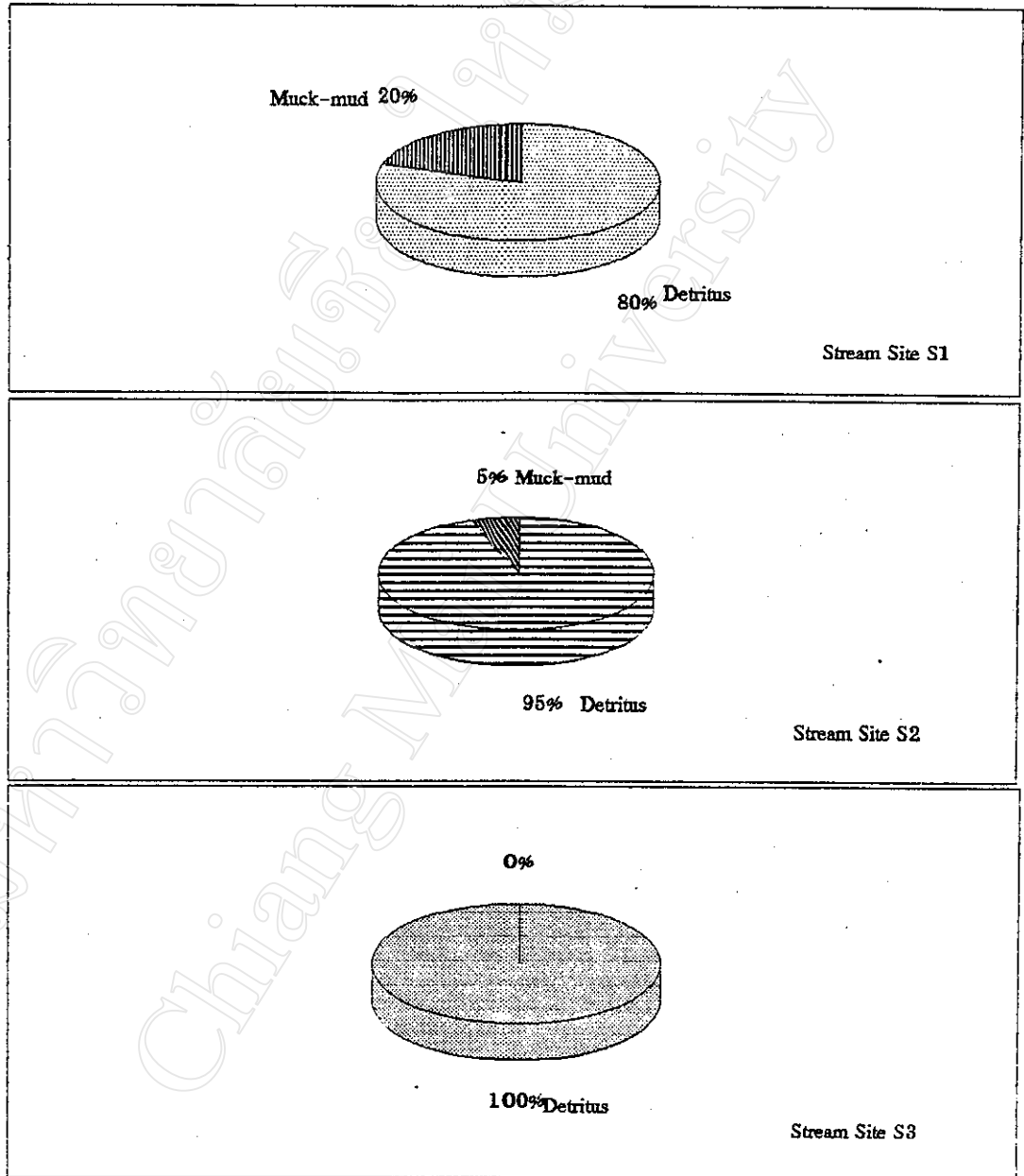


Figure 21. The Organic Substrate Components at Stream Sites in the Dry Season

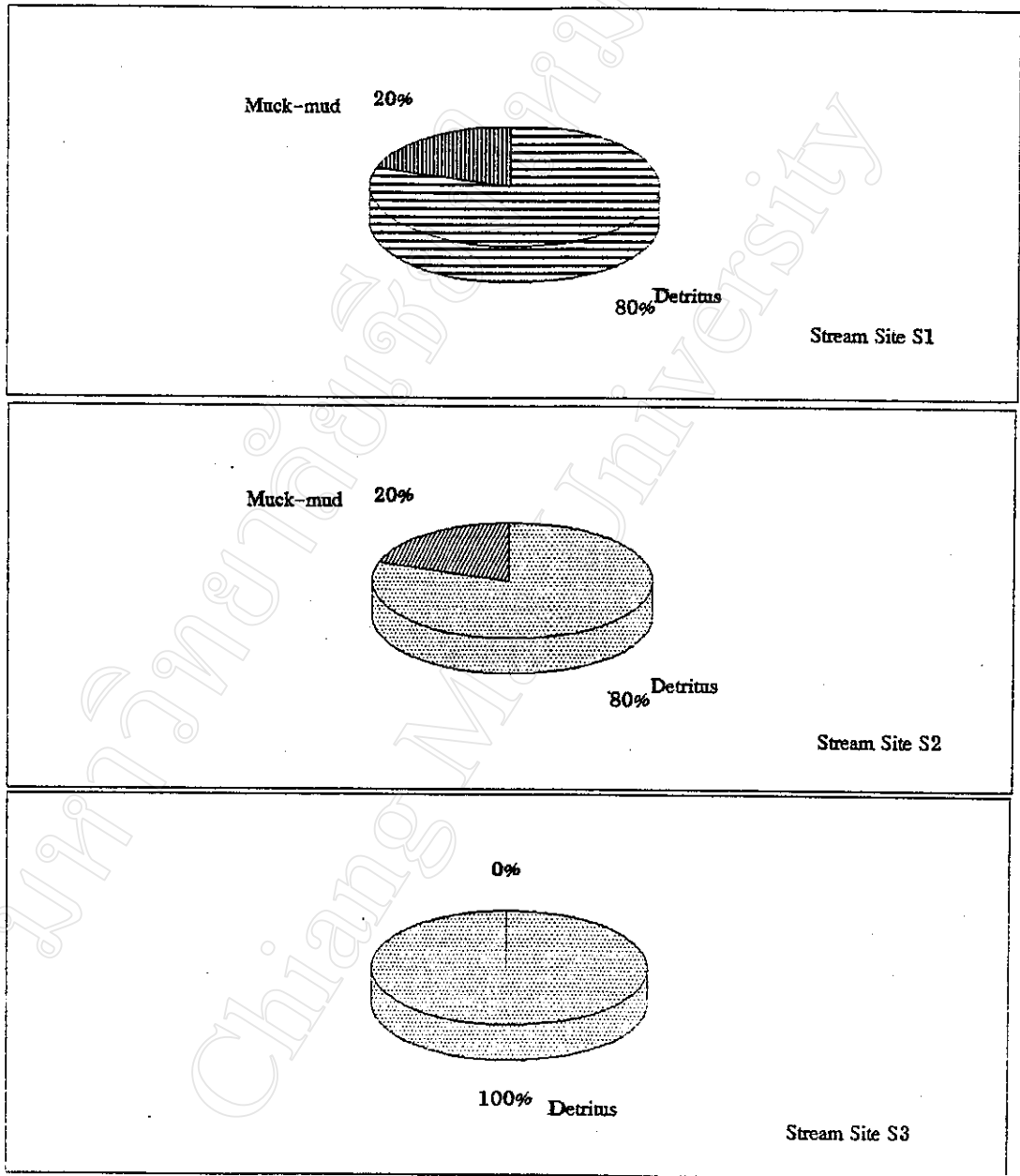


Figure 22 . The Organic Substrate Components at Stream Sites
in the Rainy Season

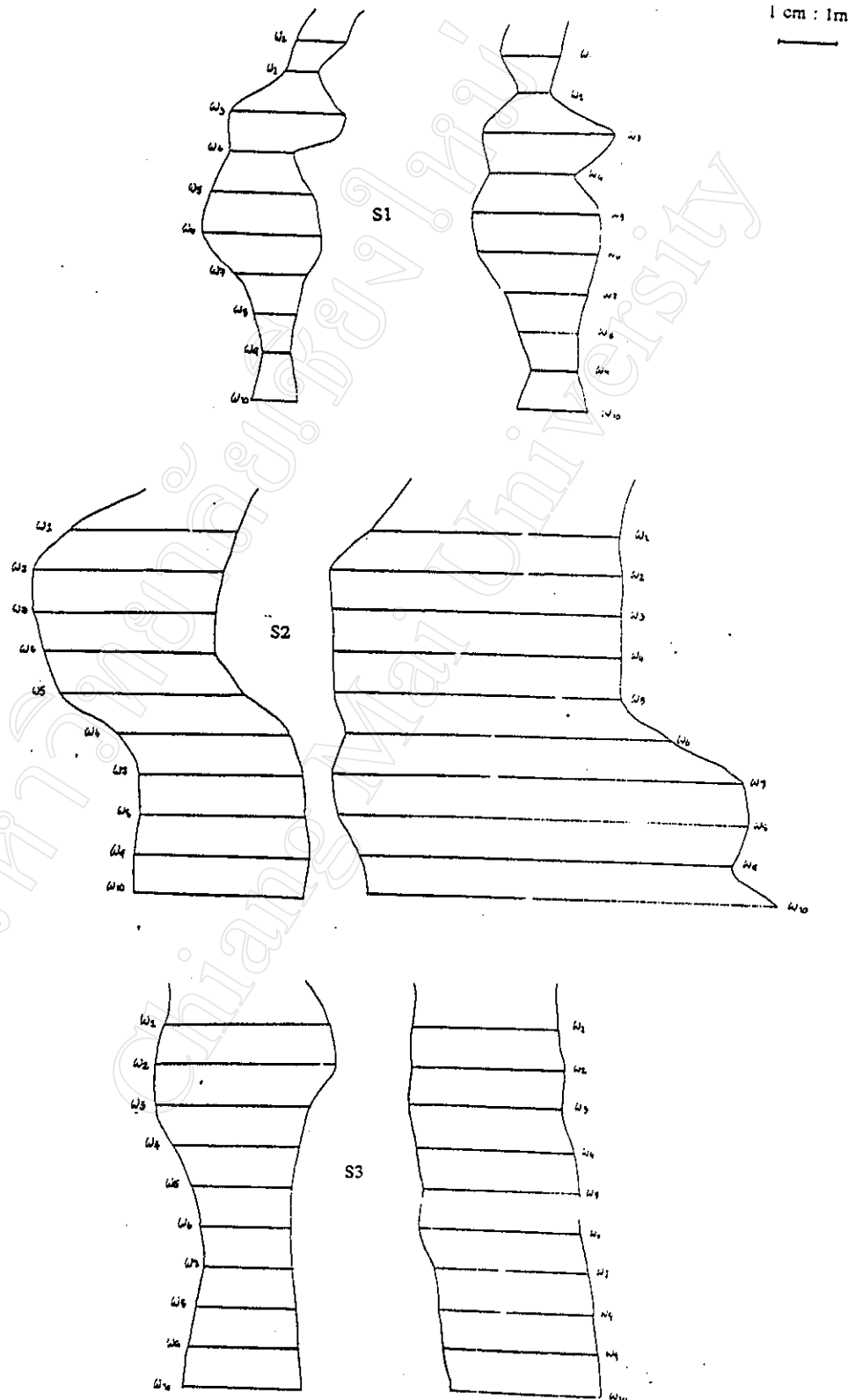


Figure 23. The Stream Width of Transects(w_1 - w_{10}) at Stream Sites in the Dry Season (left) and the Rainy Season (right).

1 cm : 1m

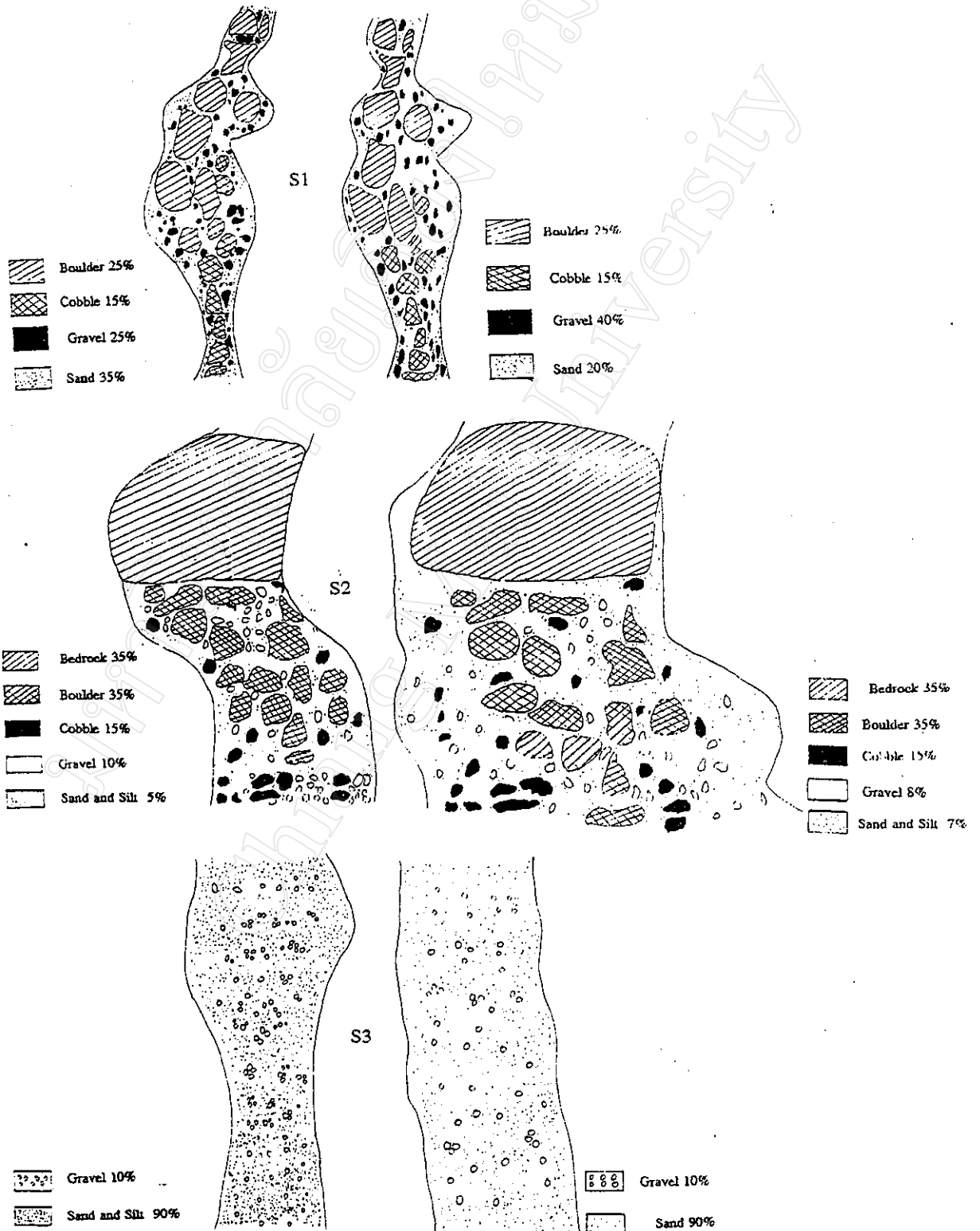


Figure 24. The Distribution of Inorganic Substrate at Stream Sites in the Dry Season (left) and the Rainy Season.

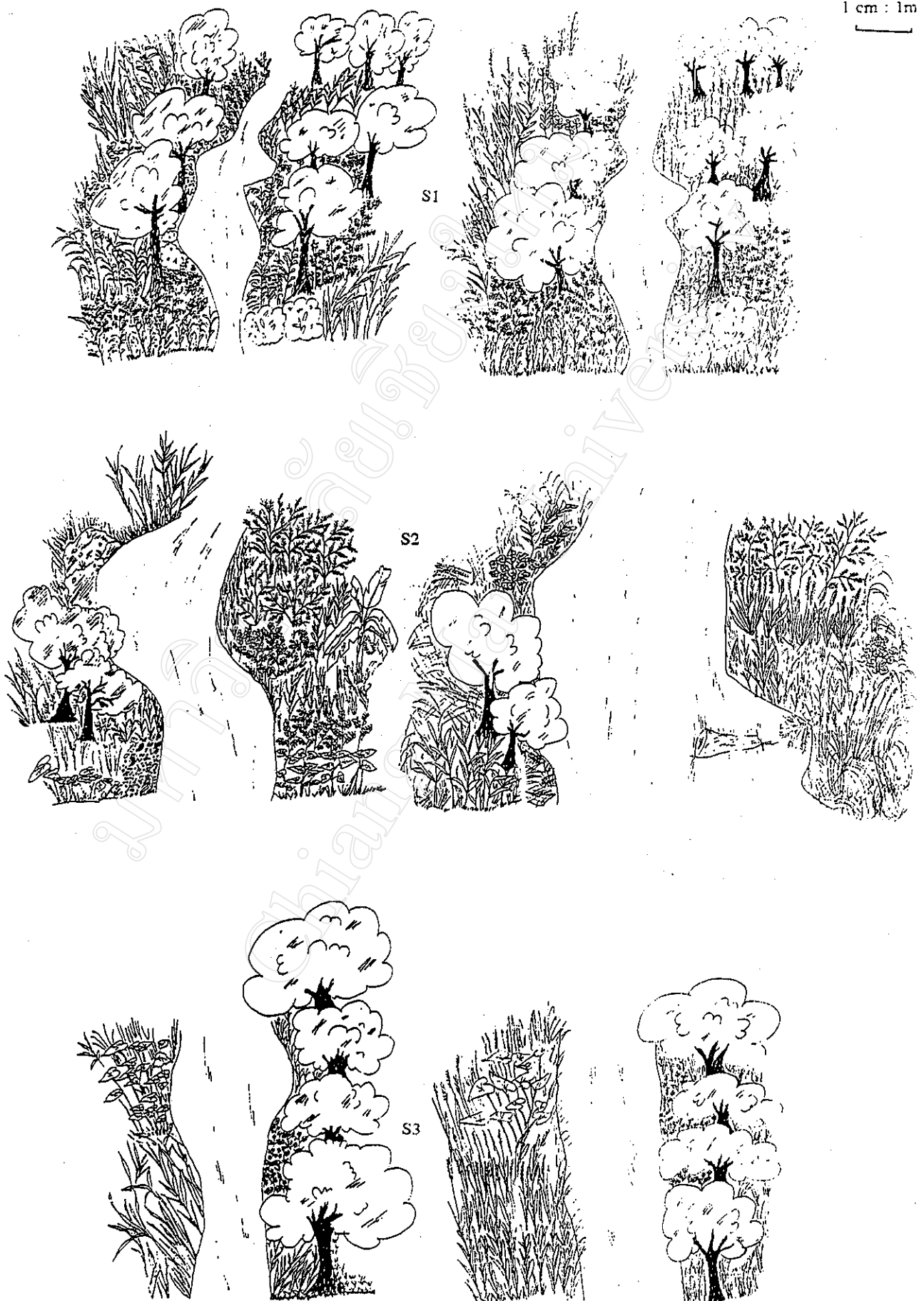


Figure 25. The Riparian Vegetation at Stream Sites in the Dry Season (left) and Rainy Season (right).

3.3 THE HABITAT ORIENTATION OF THE

MACROINVERTEBRATES FOUND(THE STREAM SITE S2)

Habitat degradation at the stream site S2 in the rainy season affected the families found. The stream site S2 had the highest number of families found per unit area (49 families)(Table 6)in the dry season, but in the rainy season only 17 families were found at that site.

Table 6. Number of Families Found/Area at Stream Sites

in the Dry and Rainy Season.

Site	Number of families found/area	
	Dry Season	Rainy Season
S1	38	24
S2	49	17
S3	18	15

The reduction in number of families may be caused by seasonal changes and also the road construction in the rainy season.

Some families were present at site S2 in the dry season and absent in the rainy season (e.g. Heptageniidae, Glossosomatidae, Peltopelidae) (Appendix A-H). Glossosomatidae and Peltopelidae prefer to live on the surface of stones (McCafferty, 1983). Oligoneuriidae just lay on the sand waiting to collect the prey using filtering hairs (Figure 26). The increased water flow was in the rainy season (Figure 17) may disturb the habitats or food supply of the macroinvertebrates and some families were absent or replaced by the others (e.g. Hydrophilidae) (Figure 27).

3.4 THE HABITAT QUALITY AND BIOLOGICAL CONDITION

The result of biological condition (number of families found per area) at site (reference site) was present as 100 percent and calculate the others as percent of reference of the two seasons. (Table 7)

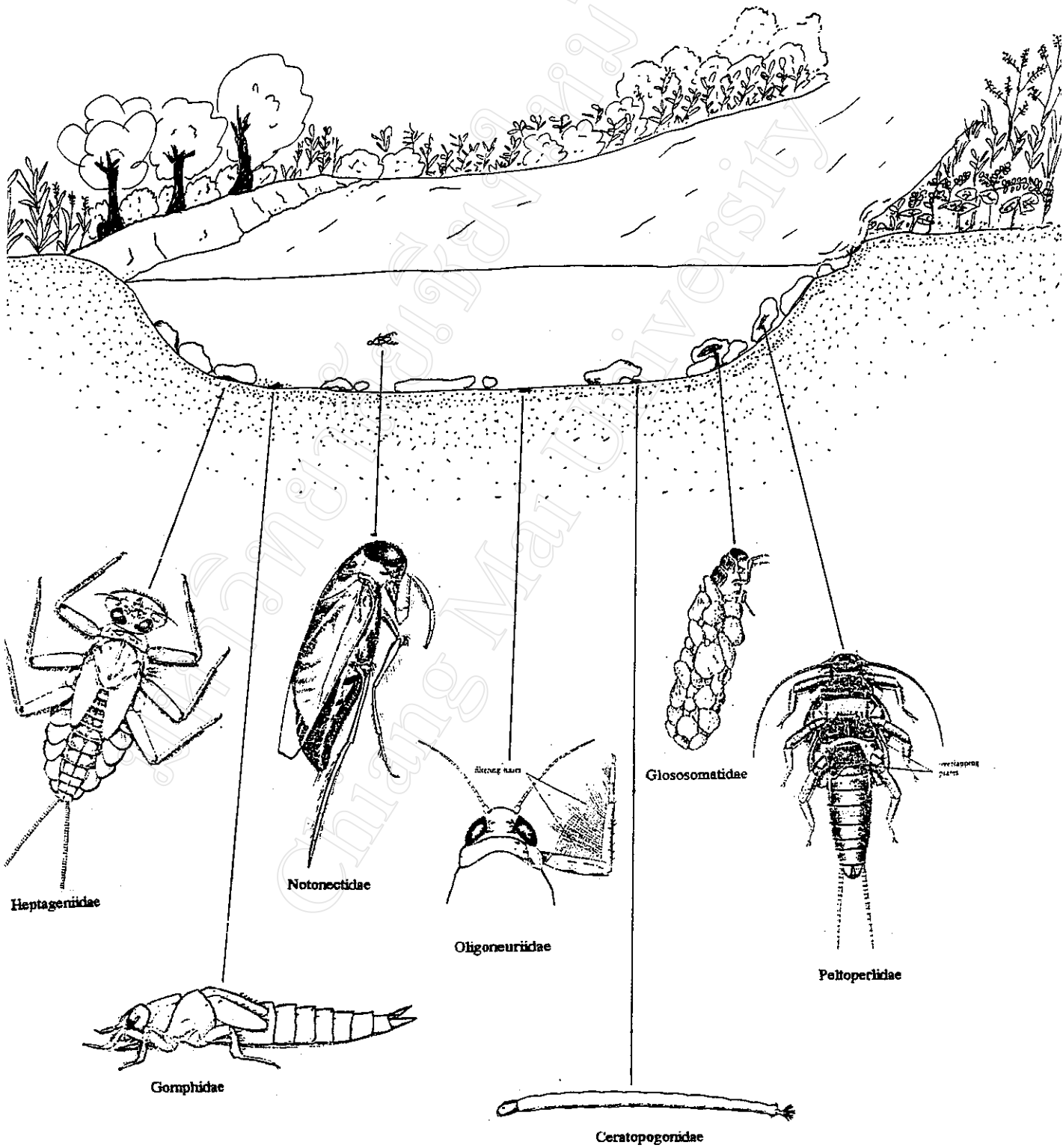


Figure 26. Cross section of a stream (S2), with diagrammatic examples of habitat orientation among aquatic insects. (Dry Season)

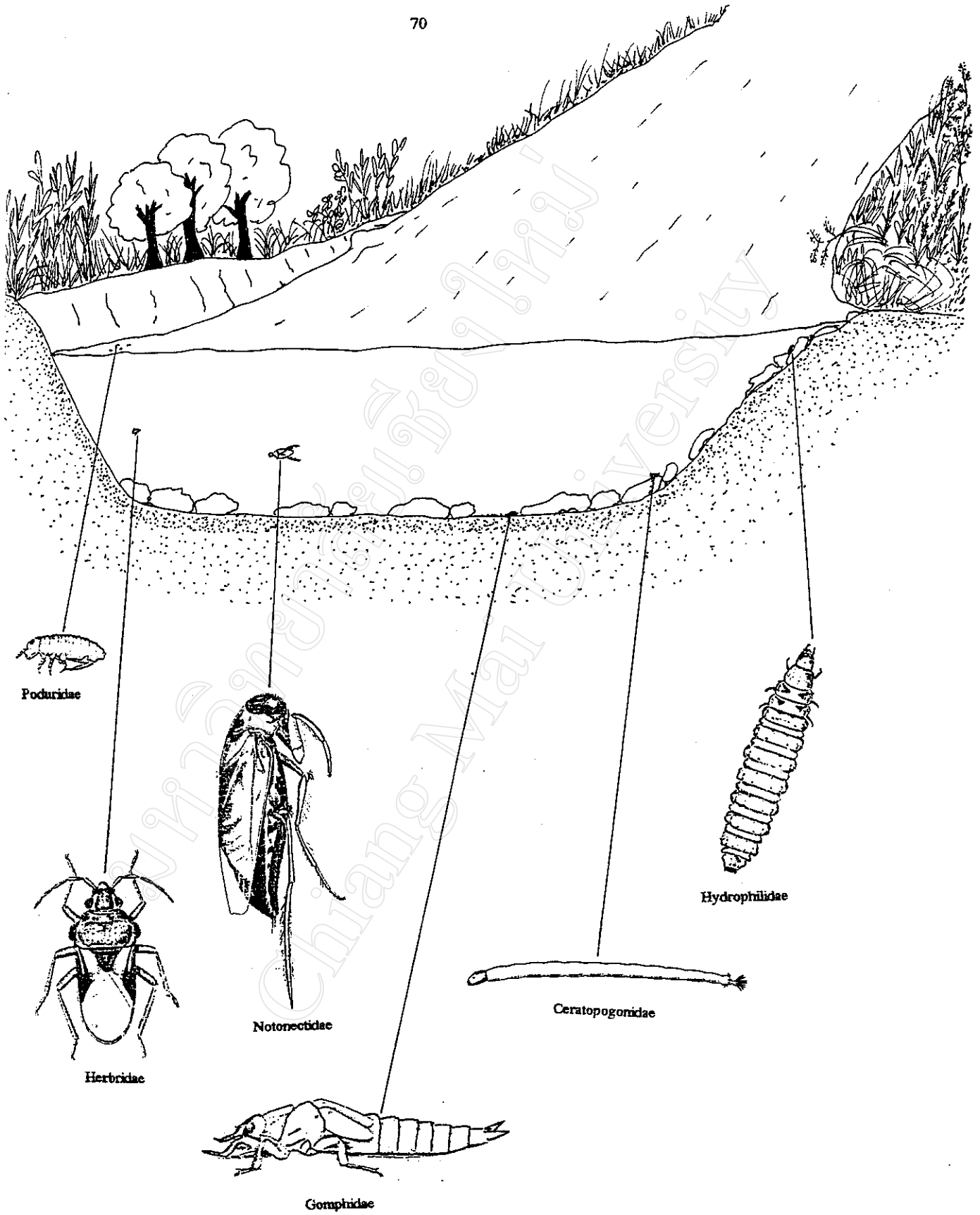


Figure 27. Cross section of a stream (S2), with diagrammatic examples of habitat orientation among aquatic insects. (Rainy Season)

Table 7. Biological Condition (% Reference)

Site	Biological Condition		% Reference	
	Dry Season	Rainy Season	Dry Season	Rainy Season
S1	38	24	100	100
S2	49	17	128.95	70.84
S3	18	15	47.37	62.50

The score of habitat assessment as presented in Table 5 was calculated as percentage habitat quality relative to the reference site for the two seasons as indicated in Table 8.

Table 8. Habitat Quality (% Reference)

Site	% Reference	
	Dry Season	Rainy Season
S1	100	100
S2	111.64	114.20
S3	60	71.61

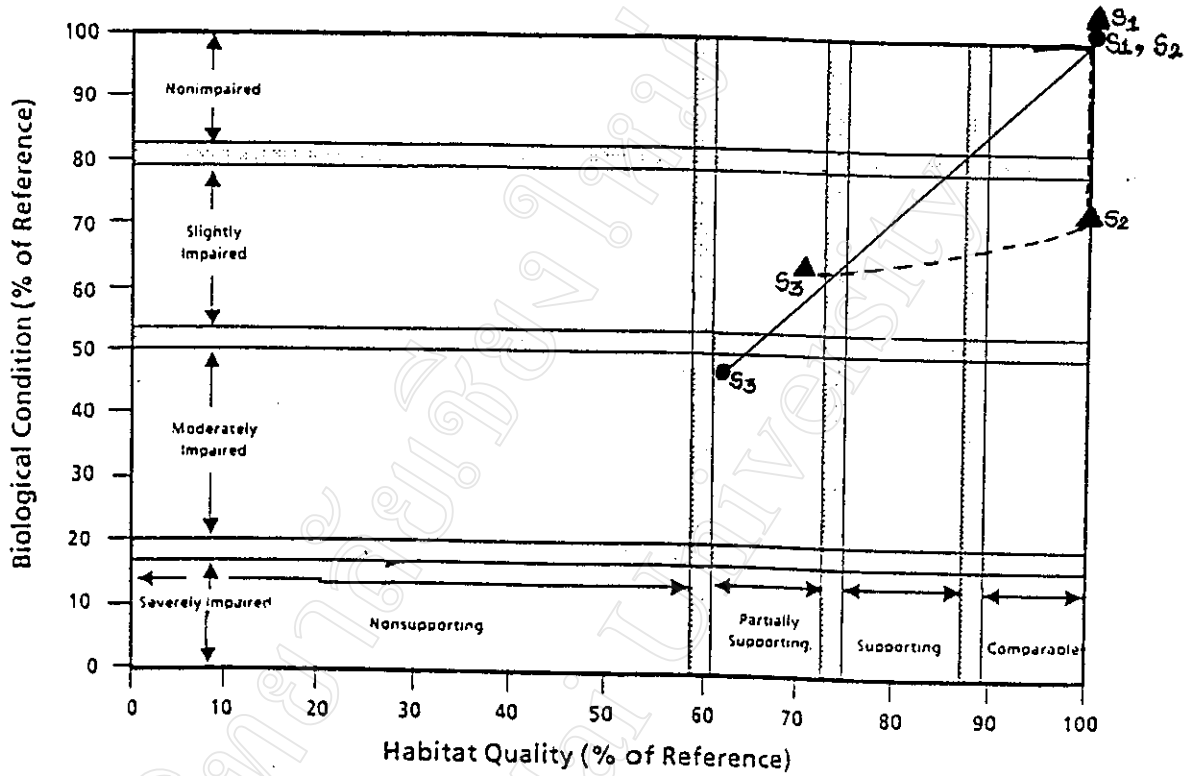


Figure 28. The Relationship Between Habitat and Biological Condition.

● Dry Season
 ▲ Rainy Season

The relationship between biological condition (% of Reference) and the habitat quality (% of Reference) is shown in Figure 28, discriminating the water quality impact from habitat degradation.

The relationship indicates the general relationship of biological condition to habitat quality in the absence of water quality effects in the dry season. In the rainy season the curve represents a situation where organic pollution or toxicants will adversely affect biological condition regardless of the quality of the habitat. Despite the road construction in the rainy season, the habitat quality score at site S2 did not decrease, suggesting that even though the number of families decreased, the overall habitat quality was still high. However, the biological condition score did decrease at site S2 in the rainy season.