Fish Assemblage Patterns in Littoral Zone of Nam Oun Reservoir, Sakon Nakhon Province, Thailand

Ruamruedee Panchan

ABSTRACT

Spatio-temporal variations in fish assemblages in the littoral zone of Nam Oun reservoir, Sakon Nakhon Province, Northeast Thailand were investigated during May 2008 - April 2009 using gillnets with mesh sizes of 20-80 mm. There were six sampling stations around the reservoir. Fish sampling resulted in the collection of 29,151 individuals, comprising of 44 species from 18 families. Twenty-three species were found in all sites with Puntius brevis as the most abundant species. The most abundant numerically was obtained at S6-site (Ban Kok Sung). Species richness, diversity index and relative evenness index were statistically different among sampling sites but not at different months. S4-site (Ban Kudtakab) showed the highest values for species richness and species diversity index. Meanwhile, S1-site (Ban Kok Sa-ad) showed the highest relative evenness index. Cluster analysis and multidimensional scaling (MDS) revealed there are four groups in terms of sampling-sites (25% of similarity level) and three major groups in terms of months of sampling (33% of similarity level).

Key words: fish community structure, littoral, Num Oun reservoir, multivariate analysis

INTRODUCTION

Nam Oun Reservoir is located in Ban Nong-Bua, Phung Khon District, Sakon Nakhon Province, Thailand, approximately 667 km northeast of Bangkok The reservoir was set-up in 1973 across Num Oun River, a tributary of Songkram River, originating from the Phu Phan Range. It is a soil-typed reservoir, with a rain-fed area of 1,100 km^2, maximum water storage of 520 million m^3 and an altitude of 186.76 m above mean sea level. The water surface area is 8,480 ha. (DOF, 1974; 1975). The reservoir is mainly for irrigation, with fisheries as a second benefit, similar to other man-made lakes in the country (Jutagate, 2009). Fish is a source of animal protein and income for the local people around the reservoir. Forty-five fish species from 11 families were reported before the lake was impounded. The most widely caught fish species is *Macrognathus aculeatus* (20.69%) followed by *Channa striatus* (Phavaphutanon and Hirunyawat, 1969).

Department of Fisheries, Faculty of Natural resources, Rajamangala University of Technology ISAN, Sakon Nakhon 47160 Thailand
Contact: ruamruedee@hotmail.com

Thirty-nine fish species from 14 families were reported after impoundment, in which *C. striatus*, *Trichogaster trichopterus*, *Hampala dispar* and *Pristolepis fasciata* were frequently found (Srikomut, 1974). Chookajorn (1989) reported that the fish yield in this man-made reservoir depended on *Cyclocheilichthys repasson*, *Osteochilus hasselti*, *Labeo rohita* and *C. striata*. Meanwhile, 35 fish species from 17 families were collected from the recent Nam Oun Reservoir frame-survey (Nachaipherm *et al*., 2003), in which *Cyclocheilichthys* sp. and *O. hasselti* were the main species caught. From these 3 studies, it was found that at least 13 fish species have disappeared after impoundment, i.e. *Botia horae*, *B. hymenophysa*, *B. modesta*, *Chela laubuca*, *Epalzeorhynchos coatesi*, *Labeo erythrurus*, *Labiobarbus kuhlii*, *Lobocheilus nigrovittatus*, *Mystacoleucus chilopterus*, *Osteocheilus melanoplera*, *Oxygaster siamensis*, *Paralaubuca riveroi* and *Puntius stigmatosoma*, which are mostly rheophilic species.

Studies on the spatial distribution of fish in lakes have emphasized the importance of the littoral zone of either natural or man-made lakes to the diversity of fish species, whereas extensive fisheries has been exploited in these areas (Pierce *et al*., 2001; Brosse *et al*. 2007). Furthermore, many fish species exhibit extensive migrations between the littoral zone and the offshore areas of lakes, i.e. the pelagic zone of the upper water column and the profundal zone of the lower water column, at various life stages and times of the year (Winfield, 2004). This is a similar experience in Thai reservoirs (Prchalová *et al*., 2003). Therefore, the spatio-temporal distribution of fish within a water body is not random. Fish utilize habitats within a water body that are physiologically convenient, in which biotic factors play a role in food availability, predation risk and competition (Prchalová *et al*., 2009). These causes lead to the need for basic quantitative information on the spatio-temporal organization of fish assemblages inhabiting the littoral zones. Thus, the objectives of this study were to (a) investigate the statistical differences in species richness, diversity index, and relative evenness index among sites and at different months, and (b) determine the spatio-temporal variations of fish assemblage structures in the littoral zone by the cluster-similarity method of analysis.

MATERIALS AND METRODS

Sampling sites and techniques

The study period was from May 2008 to April 2009. Fish sampling was carried out monthly using gill nets (mesh sizes 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75 and 80 mm). There were six sampling sites according to lake zonation (Fig. 1) *viz*., zone 1: upstream zone, a conservation zone (Ban Kok sa-ad (S1) and Ban Dong Kumpho (S2)), zone 2: middle zone, with a wide area of aquatic plants and dead wood (Ban Natun (S3) and Ban Kudtakab (S4)), and zone 3: downstream zone which received the water from Nun Oun stream (Ban Nong Pling (S5) and Ban Kok Sung (S6)). A couple of fishers were assigned as data collectors at each station. Before the project started, data collectors were trained on what information and data to be obtained. All gillnets were set during 03.00 pm- 06.00 pm and lifted at 05.00 am - 07.00 am on the appointed fishing date each month. The fish samples were then packed in ice and taken back to the laboratory at the Department of Fisheries, Faculty of Natural Resources, Rajamangala University of Technology ISAN, Sakon Nakhon (3 km from the lake). Samples were taxonomically identified into species (Rainboth, 1996; Vidthayanon, 2004) counted and weighed (g) before being preserving in 10% formalin.

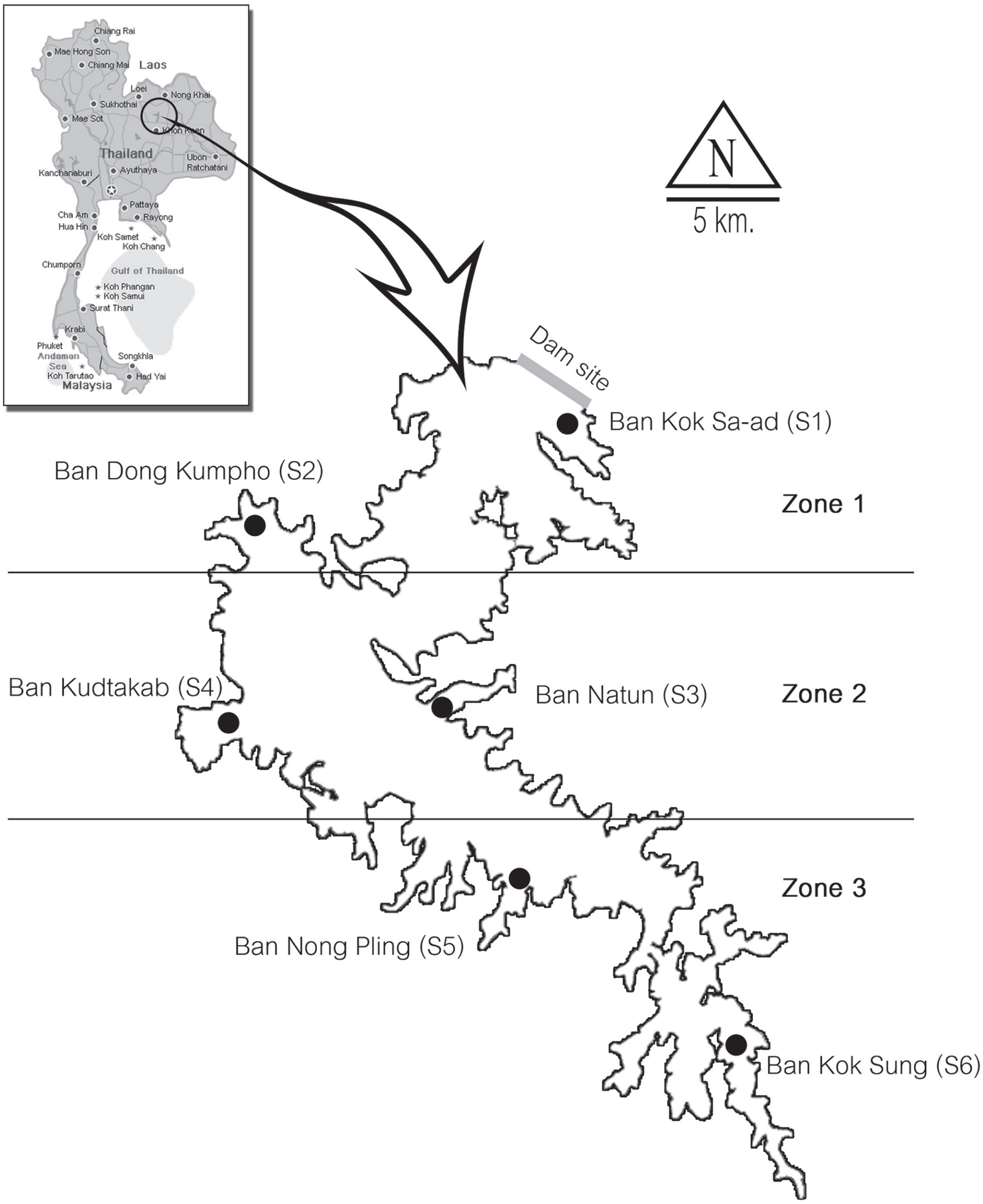

Figure 1. Map of Nam Oun Reservoir and location of sampling stations

Data analysis

Species richness was calculated by using Margalef's index, R (Ludwig and Reynolds, 1988; Clarke and Warwick, 1994) as shown in Eq. (1).

$$R = (S-1)/\ln(n) \quad \ldots\ldots (1)$$

where, S is the total number of species in each sample and *n* is the total number of individuals for all species. Species diversity index was calculated by Shanon-Wiener's index, H′ (Ludwig and Reynolds, 1988; Clark and Warwick, 1994) as shown in Eq. (2).

$$H' = -\sum (p_i \log p_i) \quad \ldots\ldots (2)$$

where, p_i is the relative abundance, i.e. the number of individuals for species *i* divided by the total number of individuals for all species. The relative evenness index, J′, was calculated by Pielou's index (Ludwig and Reynolds, 1988; Clarke and Warwick, 1994) as shown in Eq. (3).

$$J' = H' / H_{max} \quad \ldots\ldots (3)$$

where, H_{max} was the natural logarithm of S

The Kruskal-Wallis chi-square test, a non-parametric method for testing equality of population medians among groups, was used for comparing species richness, diversity index and the relative evenness index among the sampling sites and months of samplings. Tukey's HSD test was used as a tool for analyzing the differences among groups. The degree of similarity index of fish structure community between sites and months was calculated using Bray-Curtis similarity coefficient, based on the number of individuals of each species. Prior to analyses, abundance data were transformed to log (x+1) to normalize distribution and stabilize variances. The resultant similarity matrix was subjected to cluster analysis (group-average mean linkage) and non-metric multidimensional scaling (MDS). How well the sample relationship by the dimensions was indicated by stress values calculated by the MDS procedure, in which MDS will provide a usable picture of sample relationship when value is < 0.2 (Clark, 1993). Statistical analyses were performed by R program (available at http://cran.r-project.org) and cluster-similarity analyses were conducted under library MClust (Fraley and Raftery, 2006).

RESULTS

Spatial assemblage structures and ecological index

A total of 29,151 individuals, comprising 44 species in 18 families were collected (Table 1). Twenty-three species were found in all sites. In terms of individuals per species, *Puntius brevis* was the most abundant species (31.7%), followed by *C. repasson* (17.7%) and *Parambassis siamensis* (16.0%). Sampling site S6 was the most abundant (7,508) followed by S3-site (5,287) and S5-site (5,237). In terms of the number of family in each site, S1-, S4- and S6- sites had the most number with 16 families each, while for the number of species, S4-site was ranked the first (35 species) followed by S3- and S6-sites, with 33 and 32 species, respectively.

Table 1. List of species and number of individuals of each species at each site found in Nam Oun Reservoir. (Species codes are shown in figures 3 and 4.)

Family/Scientific Name	code	S1	S2	S3	S4	S5	S6	Total
Family Notopteridae								
Notopterus notopterus	Nono	76	70	30	105	42	23	346
Family Cyprinidae								
Parachela williaminae	Pawi	-	-	-	-	1	-	1
Luciosoma bleekeri	Lubl	-	-	-	2	-	-	2
Rasbora aurotaenia	Raau	-	15	215	463	2	221	916
Rasbora argyrotaenia	Raar	-	-	9	4	-	1	14
Cyprinus carpio	Cyca	2	-	-	-	-	-	2
Cyclocheilichthys repasson	Cyre	277	659	902	544	1,635	1,130	5,147
Puntioplites proctozysron	Pupr	-	-	1	-	1	6	8
Barbodes gonionotus	Bago	27	7	11	7	-	31	83
Hampala dispar	Hadi	115	81	76	78	26	65	441
Hampala macrolepidota	Hama	2	2	3	4	3	49	63
Puntius brevis	Pubr	358	1,115	1,465	1,196	2,070	3,036	9,240
Puntius orphoides	Puor	2	-	22	4	4	-	32
Cirrhinus microlepis	Cimi	-	1	-	-	-	-	1
Henicorhynchus siamensis	Hesi	34	44	66	124	29	156	453
Labeo chrysophekadian	Lach	4	3	2	-	6	2	17
Labiobarbus leptocheila	Lale	49	465	395	264	340	991	2,504
Osteochilus hasseltii	Osha	68	70	97	147	77	197	656
Osteochilus lini	Osli	5	18	38	118	29	274	482
Family Cobotidae								
Acanthopsis choirorhynchos	Acch	-	-	-	-	1	19	20
Family Loricariidae								
Hypostomus plecostomus	Hypl	1	-	-	-	-	-	1
Family Bagridae								
Mystus multiradiatus	Mymu	29	85	54	74	74	5	321
Mystus singaringan	Mysi	102	54	13	22	28	6	225
Hemibagrus nemurus	Hene	1	1	12	6	3	3	26
Family Siluridae								
Ompok bimaculatus	Ombi	12	15	39	72	17	7	162

Table 1. (continued)

Family/Scientific Name	code	S1	S2	S3	S4	S5	S6	Total
Family Clariidae								
Clarias batrachus	Clba	1	4	2	-	5	3	15
Clarias macrocephalus	Clma	-	-	-	4	-	-	4
Family Belonidae								
Xenentodon cancila	Xeca	2	15	83	150	24	28	302
Family Ambassidae								
Parambassis siamensis	Pasi	705	644	1,221	703	317	1,062	4,652
Family Nandidae								
Pristolepis fasciata	Prfa	205	326	222	284	278	76	1,391
Nandus oxyrynchus	Naox	29	42	62	47	77	1	258
Family Cichlidae								
Oreochromis niloticus	Orni	28	4	41	5	-	35	113
Family Eleotrididae								
Oxyeleotris marmorata	Oxma	91	89	60	74	103	23	440
Family Anabantidae								
Anabas testudineus	Ante	3	3	7	50	1	17	81
Family Helostomatidae								
Helostoma temmincki	Hete	-	-	-	1	-	-	1
Family Belontiidae								
Trichogaster pectoralis	Trpe	-	-	3	24	-	-	27
Trichogaster trichopterus	Trtr	5	-	52	42	-	1	100
Family Channidae								
Channa gachua	Chga	-	-	-	3	-	-	3
Channa striata	Chst	1	2	18	9	2	10	42
Channa micropeltes	Chmi	-	-	-	1	-	-	1
Family Mastacembelidae								
Macrognathus semiocellatus	Mase	-	2	-	-	-	-	2
Macrognathus siamensis	Masi	85	130	54	51	23	21	364
Mastacembelus favus	Mafa	2	1	1	2	1	2	9
Family Tetraodontidae								
Monotrete fangi	Mofa	59	22	11	66	18	7	183
Total no. of individuals		**2,380**	**3,989**	**5,287**	**4,750**	**5,237**	**7,508**	**29,151**
Total no. of families		**16**	**14**	**15**	**16**	**14**	**16**	**18**
Total no. of species		**31**	**30**	**33**	**35**	**30**	**32**	**44**

Species richness (R), species diversity index (H′) and relative evenness index (J′) were significantly different among some sampling sites but not among months of sampling (Table 2). Tukey's HSD test performed on spatial variation is shown in Fig. 2. S4-site (Ban Kudtakab) showed the highest species richness and species diversity index. S1-site (Ban Kok Sa-ad) had the highest relative evenness index.

Table 2. Summary of Kruskal-wallis chi-square test for species richness, diversity index and evenness index of fish community in Nam Oun reservoir

Variate	site		month	
	(d.f. = 5)	*P-value*	(d.f. = 11)	*P-value*
Species richness (R)	13.506	0.019	11.186	0.428
Species diversity index (H′)	15.314	0.009	11.676	0.389
Relative evenness index (J′)	36.245	8.486×10^{-7}	11.591	0.395

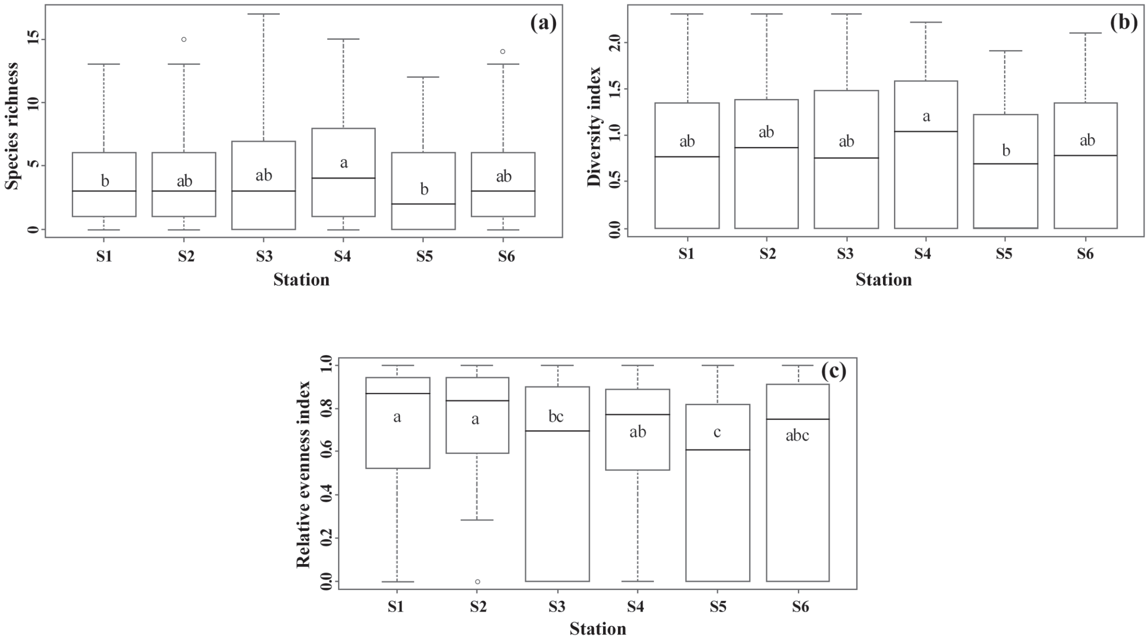

Figure 2. Summary of Tukey's HSD tested the significant of species richness (a), diversity index (b) and relative evenness index (c) at each site sampling

Note: The same letter in a box indicates that the values are not statistically different (Tukey's HSD; α = 0.05)

Assemblage patterns

The cluster analysis and multidimensional scaling (MDS) of each site based on abundance of each species showed that assemblage patterns could be divided into four groups. Sampling sites S2, S3 and S4 were grouped together into group I, with a similarity level of 25%, whereas the other 3 sites were divided into 3 groups, i.e. group II (S5), III (S6) and IV (S1) (Figs. 3a and 3c). There were relative similarities in the order of dominant species among groups. However, substantial difference in relative abundance of species among groups was observed, as shown in the percentage of relative abundance (%RA) (Fig. 3b). *P. brevis* (26.95±0.89), *P. siamensis* (18.01±2.57), *C. repasson* (15.01±1.79), *Labiobarbus leptocheila* (8.23±1.80), *P. fasciata* (6.12± 1.15), and *Rasbora aurotaenia* (4.73±2.73) were the dominant species in group I. Meanwhile, *P. brevis* (39.53), *C. repasson* (31.22), *L. leptocheila* (6.49), *P. siamensis* (6.05) and *P. fasciata* (5.30) were the most dominant species in group II (S5). *P. brevis* (40.44), *C. repasson* (15.05), *P. siamensis* (14.15), *L. leptocheila* (13.20) and *Osteochilus lini* (3.65) were the most dominant species in group III (S6). Lastly, *P. siamensis* (29.62), *P. brevis* (15.04), *C. repasson* (11.64), *P. fasciata* (8.61) and *H. dispar* (4.83) were the most dominant species in group IV (S1) (Fig.3b).

For the temporal approach, results showed that assemblages could be divided into three major groups with similarity level of 33% (Figs. 4a and 4c), in which the main classified factor was the variation in the percentage of relative abundance species in each month. Group I consisted of 4 months *viz*., February, March, December and January. In this group, *P. siamensis* (30.41±3.32), *P. brevis* (22.89±3.90), *C. repasson* (14.36 ±1.41), *P. fasciata* (5.90±2.26), *L. leptocheila* (5.50±1.80) and *O. hasselti* (3.02±0.71) were the dominant species. April, May, June and September were included in group II, in which *P. brevis* (43.20±3.61) was the most dominant for all months of sampling in this group followed by *C. repasson* (15.88±0.67), *L. leptocheila* (10.66±3.00), *P. siamensis* (6.24±2.91), and *P. fasciata* (4.38±1.05). Lastly, the remaining 4 months (i.e. July, August, October and November) were grouped together into group III. The order of dominant species in this group was the same with group II i.e. *P. brevis* (22.62 ±2.24) followed by *C. repasson* (24.10±4.91), *L. leptocheila* (10.20±0.90), *P. siamensis* (9.65 ±1.56), and *P. fasciata* (5.25±0.40). (Fig.4b)

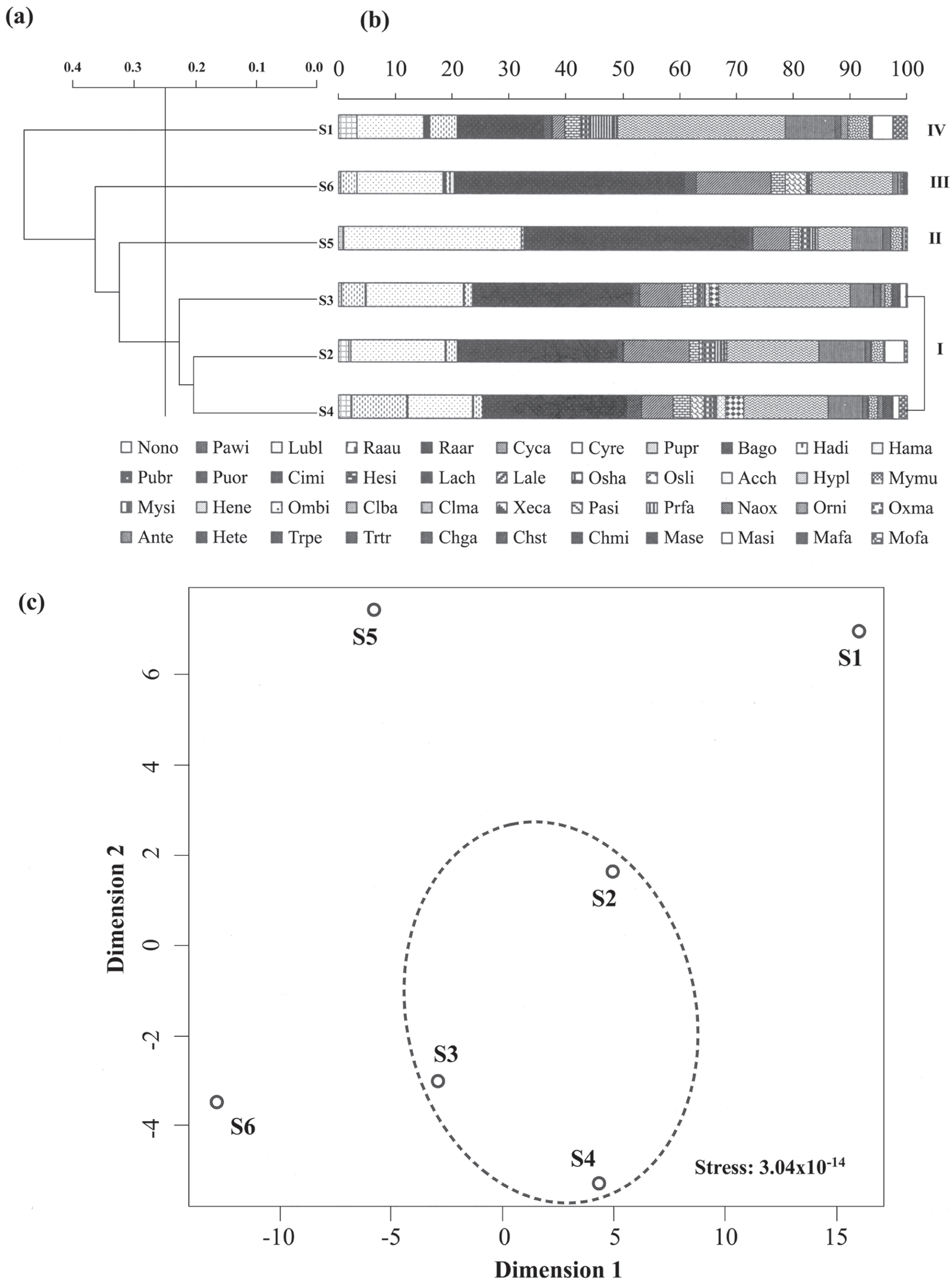

Figure 3. Dendrogram of cluster analysis based on the number of individuals of each species at each site (S1-S6) in Nam Oun Reservoir during May 2008-April 2009.
(a) Assemblages divided into four groups at 25% level of similarity,
(b) Percentage of relative abundance of fish species and
(c) Multidimensional scaling analysis. Abbreviations as given in Table 1.

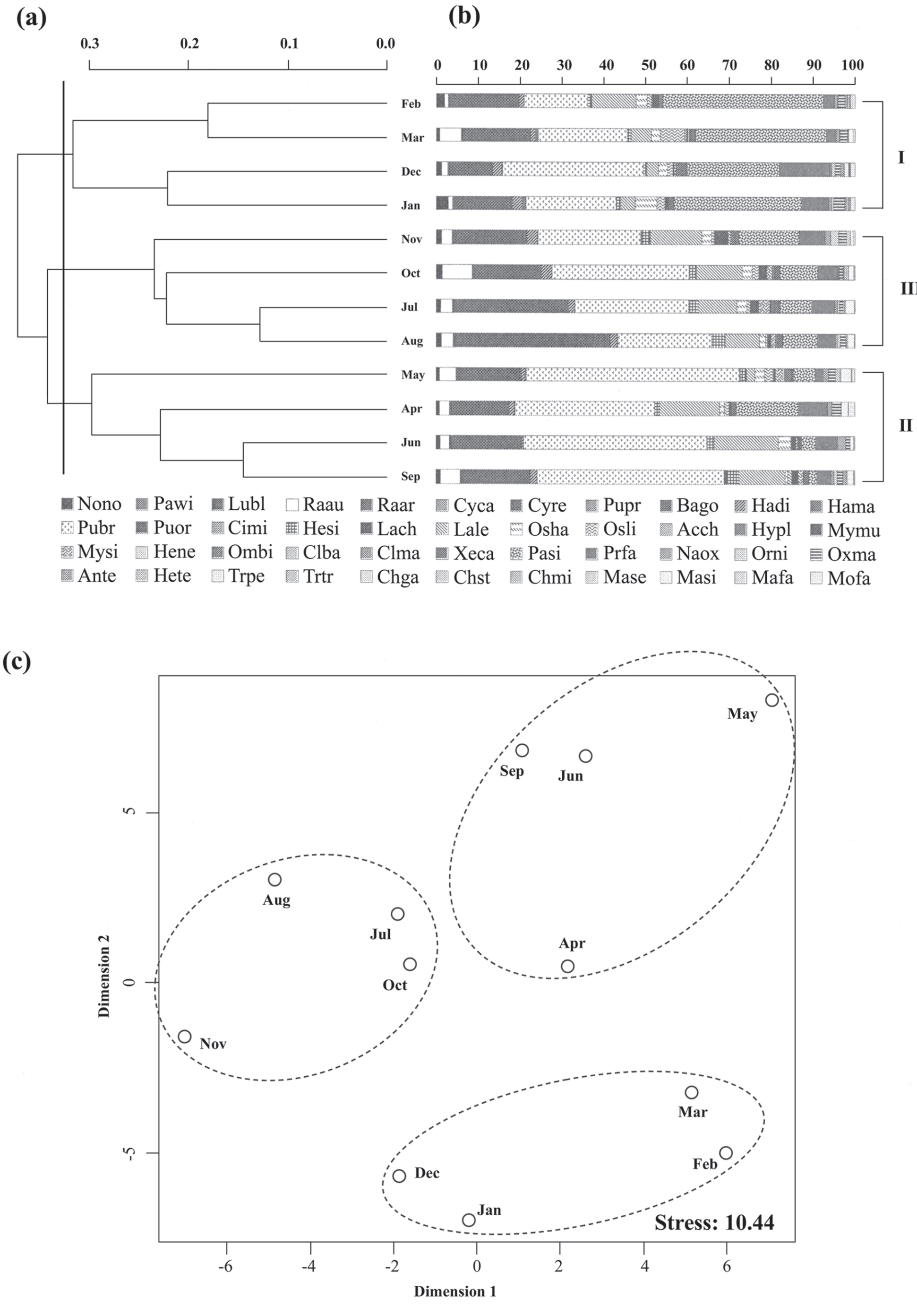

Figure 4. Dendrogram of cluster analysis based on the number of individuals of each species in each month of sampling in Nam Oun reservoir during May 2008-April 2009.
(a) Assemblages divided into three groups (I-III) at 33% level of similarity,
(b) Percentage of relative abundance of fish species and
(c) Multidimensional scaling analysis. Abbreviations as given in Table 1.

DISCUSSION

Dominance by cyprinid fish is very common in Thai reservoirs since more than 50% of fish assemblages are dedicated to this fish group (Jutagate, 2009). Differences in recorded species in this study are comparable to previous reports i.e. Srikomut (1974), Nachaipherm *et al*.(2003) could be due to the changes in ecology and sampling techniques, i.e. gear selectivity and sampling site selection. Nevertheless, for fish sampling in the lake, gillnetting (with various mesh sizes) was suggested to reasonably cover the entire species composition in the littoral zones (Sutela *et al*., 2008). The species richness and diversity index according to months and stations were highest at S4-site (Ban Kudtakab), located in the middle zone of reservoir, due to a wide area of aquatic plants and dead wood which are appropriate to serve as living-, feeding- and spawning-grounds. The relative evenness index was highest at S1-site (Ban Kok Sa-ad) indicated that this site had the proportion of abundance among fish species and distribution pattern in each species closely more than another site.

Variations in spatio-temporal in fish assemblages could be due to the lake ecosystem *per se* and fish life history patterns. Winfield (2004) mentioned that fish populations and their assemblages are complicated by the strong spatial heterogeneity of lake. Such heterogeneity in the horizontal distributions of features including macrophytes and bottom sediments often results in patchy distributions of fish species. Moreover, fish may either reside permanently in the littoral zone or enter and leave it on diel, seasonal or ontogenetic time scales. The temporal variation, thus, depends greatly on the purpose behind the fish's presence in the littoral zone (e.g. feeding, reproduction and avoidance of predators) and on the prevailing environmental conditions, which may themselves change over timescales (Fischer, 1999; Hölker *et al*. 2002). De Graaf *et al*. (2005) mentioned that annual migration upstream to spawn on shallow gravel beds at the confluence or in small rivers of the reservoir dwelling cyprinids during short periods in rainy season, i.e. June to August, is commonly observed and this causes the variation in fish assemblages. In this study, however, variations in assemblage are mostly due to percentage of relative abundance of fish species rather than the difference in species composition. This is a common phenomenon in shallow lakes, where the littoral zone occupies a vast area (Saowakoon, 2009) unlike large lakes in both tropical (e.g. Prchalová *et al*., 2003) and temperate (Brosse *et al*. 2007) areas, where fish assemblage in littoral zone is always uncertain.

In conclusion, the spatio-temporal variations of adult fish in Nam Oun Reservoir based on the percentage of relative abundance of individual species imply that almost all, if not all, species in this lake occupied the littoral zone. To sustain the ecosystem's integrity, regulation on the optimum water level with appropriate seasonal fluctuation is necessary (Sutela and Vehanen, 2008). Moreover, anthropogenic stress such as land use should be taken into account for the effect on fish assemblage in any littoral zone around the lake (De Silva *et al*., 2001). There are a number of important issues that should be further developed including an understanding of the littoral zones of lakes in Thailand such an assemblage of the "age 0+" fish and the purpose of individual species in utilizing the littoral zone. These support information will be useful for sustainable fisheries management in lakes.

ACKNOWLEDGEMENTS

This study was funded by the National Research Council of Thailand (NRCT), Grant No. 04110260. Manuscript preparation and statistical analyses were supervised by Assoc. Prof. Dr. Tuantong Jutagate, Ubon Ratchathani University. The author would like to thank the staff at the Department of Fisheries, Faculty of Natural Resources, Rajamangala University of Technology ISAN, Sakon Nakhon Campus and all local fishermen in Nam Oun Reservoir for their friendship and assistance during the field trips.

LITERATURE CITED

Brosse, S., G. D. Grossman and S. Lek. 2007. Fish assemblage patterns in the littoral zone of a European reservoir. **Freshwater Biology** 52: 448-458

Chookajorn,T. 1989. Fish yield models for Thai reservoirs. **National inland fisheries institute, Department of fisheries.** 19 pp. (in Thai)

Clark, K.R. 1993. Non-parametric multivariate analyses of changes in community structure. **Australian Journal of Ecology** 18: 117-143.

Clark, K. R., and R. M. Warwick. 1994. Changes in marine communities: an approach to statistical analysis and interpretation. **Plymouth: Plymouth Marine Laboratory.** 144 pp.

De Silva, S. S., U. S. Amarasinghe, C. Nissanka, W. A. D. D. Wijesuriya, and M. J. J. Fernando. 2001. Use of Geographical information systems as a tool for fish yield prediction in tropical reservoirs: case study on Sri Lankan reservoirs. **Journal of Fisheries Management and Ecology** 8: 47-60.

De Graaf, M., Nentwich, E., Sibbing, F.A., Osse, J.W. 2005. Lacustrine spawning, is this a new reproductive strategy among 'large' African cyprinid fishes? **Journal of Fish Biology** 66: 1214-1236

DOF. 1974. Fisheries and economic status of local people in Lum Thakhong Reservoir, Lum-phapueng Reservoir, Nakhonratchasrima Province, Lum Poa Reservoir, Kalasin Province, Num Oun Peservoir, Sakon Nakhon Province and Sirinthon reservoir, Ubonratchathani Province. **Annual report 1974: Fisheries management unit, Department of fisheries.** 70 pp. (in Thai)

DOF. 1975. Survey of fish statistic from large reservoir in North-east of Thailand. **Annual report 1975: Fisheries management unit, Department of fisheries.** 125-127. (in Thai)

Fraley C. and A. E. Raftery. 2006. **MCLUST Version 3 for R: Normal Mixture Modeling and Model-Based Clustering.** Technical Report no. 504, Department of Statistics, University of Washington.

Fischer, R .1999. Otolith microstructure during the pelagic, settlement and benthic phases in burbot. **Journal of Fish Biology** 54:1231-1243.

Hölker, F., S. Haertel, S. Steiner, T. Mehner. 2002. Effects of piscivore-mediated habitat use on growth, diet and zooplankton consumption of roach: an individual-based modelling approach. **Freshwater Biology** 47: 2345-2358.

Jutagate, T. 2009. Reservoir fisheries in Thailand *In*: **Reservoir Fisheries in Asia and Pacific.** (eds. De Silva S. S. and Amarasinghe U.S.), pp. 96-113 : NACA, Bangkok.

Ludwig, J. A. and J. F. Reynolds.1988. Chapter 8. Diversity indices. In **Statistical Ecology. A primer on methods and computing.** John wiley & Sons, New York. 85-104.

Nachaipherm, J., S.Nuengsit, P. Rukaewma, W. Taruwan, S. Nakkaew and S. Sinsoontorn. 2003. Fisheries activities and catch assessment of three reservoirs: Nam oon in Sakon Nakhon Province, Kaeng Lawa in Khon Kaen Province and Hui Muk in Mukdahan Province. Thailand. **Proceeding of the 5th Technical Symposium on Mekong Fisheries.** 185-193.

Pierce C.L., M.D. Sexton, M.E. Pelham and H. Liao. 2001. Dynamics of the littoral fish assemblage in Spirit lake, Iowa, and implications for prey availability for piscivores. **North American Journal of Fisheries Management** 21: 884–896.

Phavaphutanon, O. and S. Hirunyawat. 1969. Fisheries biological surveys in Oun River. **Annual report 1969: Fisheries Research Unit Department of fisheries.** 15 pp. (in Thai)

Prchalová M., V. Draštík, J. Kubecka, B. Sricharoendham, F. Schiemer and J. Vijverberg. 2003. Acoustic study of fish and invertebrate behavior in a tropical reservoir. **Aquatic Living Resources** 16: 325–331.

Prchalová M., J. Kubečka, M. Čech, J. Frouzová, V. Dra tík, E. Hohausová, T. Jůza, M. Kratochvíl, J. Matěna, J. Peterka, M. Říha, M. Tu er, M. Va ek. 2009. The effect of depth, distance from dam and habitat on spatial distribution of fish in an artificial reservoir. **Ecology of Freshwater Fish** 18: 247–260.

Rainboth, W.J. 1996. FAO species identification field guide for fishery purpose . **Fishes of the Cambodian Mekong.** Rome, FAO. 265 p.

Saowakoon S. 2009. **Fisheries management in the irrigated man-made lakes in Thailand: case studies in Huay Saneng and Ampuen reservoirs, Surin Province.** Ph.D. Thesis, Ubon Ratchatahni University, Ubon Ratchathani. 297 pp.

Srikomut, S. 1974. Hydrological and fisheries survey in oon reservoir. **Annual report 1974: Fisheries research unit, Department of fisheries.** 39-49. (in thai)

Sutela, T., M. Rask, T. Vehanen, and A. Westermark. 2008. Comparision of electrofishing and NORDIC gillnets for sampling littoral fish in boreal lakes. **Lakes & Reservoir: Research and Management** 13: 215-220.

Sutela, T., T. Vehanen. 2008. Effect of water-level regulation on the nearshore fish community in boreal lakes. **Hydrobiologia** 613: 13-20

Vidthayanon, C. 2004. **Manual of freshwater fish. Sarakadee.** Bangkok. 232 pp. (in thai)

Winfield, I. J. 2004. Fish in littoral zone: ecology threats and management. **Limnologica** 34: 124-131.