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Limnology in Thailand: present status and future needs

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Introduction

Thai society has traditionally been water based both culturally and agriculturally (JUMSAI 1998). Rice has not only been the staple food but Thailand is also one of the world's major rice exporters. Other aquatic plants have also been significant components of Thai diets including stems of lotus (*Nelumbo nucifera*) and other water lilies (*Nymphaea* spp.), shoots of water morning glory (*Ipomoea aquatica*), water cress (*Neptunia oleracea*) an aquatic *fern* (*Ceratopteris thalictroides*), water caltrops (*Trapa bicornis*) and water chestnut (*Eleocharis tuberosa*). Freshwater fish and crustaceans have also traditionally been major sources of protein in Thailand. But in addition to these well known aquatic food items Thais also traditionally consumed a range of lesser known aquatic foods including a variety of riverine algal species (including *Wolffia*, *Spirogyra* and *Nostoc*) and aquatic insects including giant water bugs (Belostomatidae) beetles (Dystiscidae) and blackflies (Simuliidae) (BURI 1978). Aquatic invertebrates are locally significant dietary components. In the northeastern provinces, especially Isan, a wide range of freshwater insects, crustacea and molluscs (Table 1) are an important protein source as well as being highly valued for their flavour (SANGPRADUP 1982).

Limnological issues

Although water resources are generally abundant in southeast Asia the rapid rate of population growth, industrialisation and the increase in standard of living are already beginning to strain water resources (DAORUENG et al. 1998). In Thailand the uneven pattern of population growth is causing local problems. Thailand has a population of approximately 60 million, of which possibly 10 million reside in Bangkok. Since the greater Bangkok area is also the area of greatest industrial concentration this area has extremely high water requirements. The second largest Thai city is Chiang Mai with a population generally thought to be less than 1 million, which emphasises the dominance of Bangkok as a population centre.

Bangkok is located at the southern edge of the central plains, the major rice growing region in Thailand. Demand for water for Bangkok is now beginning to cause conflict with rice farmers in the region as more and more of the water is diverted to provide for the needs of Bangkok. A review of Thailand's water resources by river basin concluded that several basins close to Bangkok now have demands greater than can be supplied from within the basin (KERDUBON & SETHAPUTRA 1995). Drought is a frequent problem in northern and northeastern Thailand. Ironically villagers from the Doi Tao district badly affected by recent droughts in northern Thailand had been moved to their present location in 1964 to make way for the construction of Bhumipol Dam (*Bangkok Post*, February 16, 1998).

Construction of large reservoirs and reservoir systems is proceeding in Thailand and neighbouring countries such as Laos in order to improve the security of water supplies for irrigation and as a source of hydroelectricity. Several large dams proposed for Laos, such as Nam Theun 2, are intended to provide electricity to Thailand as a means of increasing the foreign exchange earnings for Laos (IMHOF 1997a). The largest scheme currently proposed is the Mekong River so called "run-of-the-river" hydroelectricity project, which would involve up to nine reservoirs being constructed over a 2,000 km length of river (HILL & HILL 1994).

The potential and actual impacts of existing and proposed river regulation projects in Thailand and neighbouring countries have been documented a number of times (e.g. HILL &

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Table 1. Freshwater invertebrates consumed as human food in Thailand.

Taxon	Source
Insecta	
Atherix sp. (Diptera: Athericidae)	Buri (1978)
Chironomus sp. (Diptera Chironomidae)	Buri (1978)
Simuliidae (Insecta: Diptera)	Buri (1978)
Hydrous cavistanous (Coleoptera: Hydrophilidae)	Sangpradup (1982), Kwantong (1997)
Cybis limbatus (Coleoptera: Dytiscidae)	Sangpradup (1982), Kwantong (1997)
Cybis rugosus (Coleoptera: Dytiscidae)	Sangpradup (1982)
Eretes sticticus (Coleoptera: Dytiscidae)	Sangpradup (1982)
Anisops sp. (Hemiptera: Notonectidae)	Sangpradup (1982)
Laccotrephes robustus (Hemiptera: Nepidae)	Sangpradup (1982)
Lethocerus indicus (Hemiptera: Belostomatidae)	Sangpradup (1982), Kwantong (1997)
Anax sp. (Odonata: Aeschnidae)	Sangpradup (1982)
Progomphus sp. (Odonata: Gomphidae)	Sangpradup (1982)
Libellulidae sp.	Sangpradup (1982)
Philopotamus sp. (Trichoptera: Philopotamidae)	Buri (1978)
Crustacea	
Streptocephalus sp. (Anostraca)	Sangpradup (1982)
Somanniathelphusa dugasti (Parathelphusidae)	Sangpradup (1982)
Macrobrachium equidens (Palaeomonidae)	Sangpradup (1982)
M. esculentum (Palaeomonidae)	Sangpradup (1982)
M. hainanense (Palaeomonidae)	Sangpradup (1982)
M. javanicum (Palaeomonidae)	Sangpradup (1982)
M. lanchesteri (Palaeomonidae)	Sangpradup (1982)
M. rosenbergii (Palaeomonidae)	Sangpradup (1982)
M. yui (Palaeomonidae)	Sangpradup (1982)
Mollusca	
Pseudodon sp. (Unionidae)	Sangpradup (1982)
Physunio sp. (Unionidae)	Sangpradup (1982)
Ensidens sp. (Unionidae)	Sangpradup (1982)
Corbicula spp. (Corbiculidae)	Sangpradup (1982)
Scabies sp.	Sangpradup (1982)
Pilsbryoconcha sp. (Unionidae)	Sangpradup (1982)
Vivipara sp. (Viviparidae)	

Hill 1994, McCully 1996, Roberts 1993, 1995, Imhof 1998). But several important issues need to be drawn to the attention of limnologists in developed countries. Firstly many of these projects are promoted and constructed by agencies or companies from developed countries who would no longer be allowed to construct similar projects in their home countries. The Norwegian hydropower consultants Norconsult conducted an energy sector study of the Mekong region in 1994, which is being used as a basis for dam financing decisions by the Asian

Development Bank (IMHOF 1997b). The Mekong "run-of-the-river" proposal was developed by the Compagnie National du Rhône from France, and Acres International Limited of Calgary, Canada. From Australia SMEC and HECC, the latter a spin off company from the Hydroelectricity Commission (HEC) of Tasmania, are involved in promoting projects in Laos. The HEC was the agency responsible for flooding Lake Pedder, and thwarted by federal government intervention from building a dam on the Franklin River in Australia.

Secondly, large dams in this region are largely funded by developed countries through agencies such as the World Bank and Asian Development Bank. Thus Nam Theun 2 is to be funded by the World Bank, and funding for the Mekong proposals is likely from the Asian Development Bank (IMHOF 1997a).

Thirdly the environmental impact studies carried out on many of these proposals are astonishingly inadequately resourced and often carried out by consultants who would not seem to be particularly well qualified for the task. The preliminary assessment of the fisheries impact of the proposed Mekong "run-of-the-river" project was based on a one month visit to the region by an American fisheries consultant with no prior publications on the region, and apparently no prior experience there (HILL & HILL 1994, ROBERTS 1995). The environmental assessment for the Pak Mun dam was carried out by an American biological oceanographer apparently lacking in familiarity with the literature on Mekong fish and fisheries following a week of on-site inspection according to ROBERTS (1993). Even where these studies suggest that projects could have major environmental impacts (e.g. HILL & HILL 1994) the concerns appear to be ignored by the proponents (ROBERTS 1995).

These large river regulation projects have in the past decimated fisheries, which provided the livelihood and major protein source for people along the affected river (e.g. ROBERTS 1993). An even more severe impact occurs for those who live in the inundated area who are displaced as a result. Although they are compensated by the government there are recurrent controversies about the adequacy of the compensation and the extent to which compensation monies reach those displaced or whether the money is "diverted" in various ways, for example to "investors" who purchased the land cheaply from locals or who were suddenly recorded as owning land shortly before dam construction plans were announced (e.g. *Bangkok Post*, April 7, 1998)

Catchment forest clearance and land degradation is a major political issue in Thailand. About 70% of Thailand is estimated to have been forested in 1936, but the proportion had dropped to 25% by 1982 and would be significantly less now, a substantial change within a single human life span (RAMITANONDH 1989). Legal logging of forests was officially stopped following severe mudslides that killed over 100 people in November 1988 which were partially attributed to excessive logging in steep catchments (*Bangkok Post,* April 19, 1998) but large scale illegal logging is still proceeding. For example in a recent political scandal identified in the press as the Salween scandal it is alleged that approximately 30% of Salween National Park in northern Thailand has been illegally logged. Timber so harvested is taken across the border into Burma and then returned to Thailand as imported timber. There is also significant encroachment into national parks and forest reserves by Hill Tribe people and refugees especially from Burma, who clear the forest for agriculture, and it is argued that this encroachment is often encouraged by business interests who intend to appropriate the land later for agricultural use or illegal tourist resorts. This has led to confrontations between the "forest dwellers" and "lowlanders" who claim that amongst other things their water supplies are being affected by excessive settlements and clearing in the catchments (*Bangkok Post*, May 10, 1998).

Water pollution is widespread and often locally severe. Although there are strong anti-pollution laws enforcement is often inadequate and penalties applied by the courts for infractions are often derisory. For example a tin mine at Klity in Kanchana province contaminated a stream flowing through a national park and

world heritage area and which served as the water supply for a number of villages. Lead levels in the stream water were reported as reaching levels over 0.5 mg/L and sediment levels over 33 g/kg (*Bangkok Post*, June 16, 1998). Over 200 people were reported to have been "severely affected by lead poisoning" through drinking the water and over 50 head of cattle were reported to have been killed (*Bangkok Post*, April 23, 1998). The mine, owned by a former member of parliament from the current governing party, was fined 2,000 baht (approximately US$70) and ordered to be closed (*Bangkok Post*, May 22, 1998). However, this and several other mines in the area have been previously ordered closed for the same reason and have always reopened again shortly afterwards (*Bangkok Post*, May 15, 1998). Shortly after the closure there was already a call in the local press by Mr Chalerm Nurapaves, Director of the Mining Technology Division in the Natural Resources Department, to reopen the mine because the operator deserves a second chance (*Bangkok Post*, July 16, 1998).

Another limnological issue of great concern has been the development of salt-water shrimp aquaculture in non-saline areas. For many years Thailand has had a salt-water shrimp aquaculture industry based on the black tiger prawn (*Penaeus monodon*), but this has been located primarily in coastal and estuarine areas. There had already been concerns expressed in some coastal regions about the clearance of mangrove forests to create these farms (TOOKVINAS 1977), but more recently saline shrimp farms have begun to be established in rice growing areas of the central plain. Shrimp production is more profitable than rice production, and some farmers have been digging unlined ponds and trucking in seawater to grow *Penaeus*. It has been estimated that since salt-water shrimp farming had commenced in the freshwater areas 2 years ago it has expanded to encompass about 144 km^2 (*Bangkok Post*, May 18, 1998). The agriculture minister, Mr Pongpol Adireksarn, ordered a halt to the expansion and relocation of existing farms (*Bangkok Post*, May 20, 1998), but this is being opposed by farmers (*Bangkok Post*, July 8–10, 1998) and it is unclear whether, and to what extent the government will be able to control the industry.

Thai limnological literature

The literature on limnology in Thailand is not easily accessible. While some of the published material is contained in abstracted journals, much is published in the grey literature or local journals with extremely limited circulation. Many Thai universities publish their own university journals, and most of these are not held in libraries of any university other than the publishing university, and sometimes there are not even complete sets in the library of the publishing university. Examples of such journals include the *Suranaree Journal of Science and Technology*, published by Suranaree University, the *Songklanakarin Journal of Science and Technology* published by Prince of Songkla University, and the *Thammasat International Journal of Science*. Limnology in Thailand would benefit significantly if these journals were closed and academics encouraged to publish in more accessible journals such as the *Natural History Bulletin of the Siam Society* or the *Journal of the Science Society of Thailand*.

For the purposes of this paper we have reviewed the entire contents of the *Natural History Bulletin of the Siam Society* and the *Journal of the Science Society of Thailand*, we have also carried out a search of *Current Contents* for the past 5 years, and reviewed the contents of as many of the Thai university journals as we could access. We have classified the Thai literature into several categories: taxonomic, survey, toxicology, fisheries, ecological and environmental impact. The taxonomic literature includes papers describing taxa as well as keys, we have also included in this category the descriptions of biological oddities such as accounts of unusually large or albino specimens (e.g. WONGRATANA 1988a,b). The survey literature includes accounts of the biota of particular areas (e.g. WATANASIT 1995, 1996) sometimes with incomplete taxonomic differentiation and some accounts of the physical nature of the habitats sampled. The toxicology literature is almost entirely determinations of LC_{50} values

for various freshwater species, invariably conducted using static tests (e.g. LEELHAPHUNT et al. 1987, JANTATAEME et al. 1996). The fisheries literature includes accounts of fishing technologies and species harvested as well as environmental impact assessments on fisheries (e.g. ROBERTS 1993, HILL 1995, ROBERTS & BAIRD 1995,) we have included here literature on the Mekong River based on studies carried out in sections of the river in Laos, Burma and Kampuchea close to Thailand, since these are likely to be relevant to Thailand. We also included papers on dolphins within our fisheries category. Under ecological literature we include studies of the ecology of particular species, communities and processes (e.g. MUSTOW et al. 1997). Under environmental impacts we have included environmental impact assessments, reviews of assessments and polemical literature as long as it was concerned with ecological impacts, rather than just sociopolitical effects. Our categories are not exclusive, we have recorded papers on the impact of river regulation on fisheries under both fisheries and environmental impact.

The bibliography will be published elsewhere (CAMPBELL & PARNRONG in prep), but it is clear that there is a dearth of papers dealing with ecological studies. Overwhelmingly the literature is dominated by taxonomic studies primarily conducted by non-Thais, and surveys which are primarily lists of taxa collected at a particular locality or series of localities (Table 2).

Table 2. A survey of Thai limnological literature: the proportion of papers published in five categories.

Category	% of published papers
Taxonomy & systematics	34
Biological or physicochemical survey	26
Ecotoxicology	4
Fisheries	9
Environmental impact	15
Ecology	12

Problems for limnology

The Thai university system is in the process of rapid expansion. Numerous new universities have been created often from former teacher training colleges. The expansion of institutions has been accompanied by an extraordinary building program that has seen most Thai universities develop campuses which would be the envy of most universities in developed countries. Most Thai universities are also relatively well equipped with analytical instrumentation and computer facilities. Unfortunately access to information is poor. Many universities have multiple libraries, often faculty based, but invariably journal holdings are inadequate to support research. While all public universities have internet access, the access lines are usually inadequate with line speeds often falling below 50 bps which makes internet searching impractical. Finally, the teaching loads of Thai academics are very heavy so that it is difficult to carry out research during normal working hours, and salaries are very low, so that many academics must work several jobs in order to support their families, making it difficult to carry out research outside normal class times.

As a result of these factors there is no research culture established in the science faculties of most Thai universities. In a recent comparison of four southeast Asian countries Thailand rated higher than the Philippines, Malaysia and Indonesia in the number of scientific papers published in international journals and higher than Malaysia and Indonesia in the number of citations to published papers (MERVIS & NORMILE 1998). However the number of papers produced is low. Based on a search of four data bases over the period 1985–1994, RUENWONGSA & PANIJPAN (1995) found that Mahidol University produced on average 0.31 publications per academic staff member per year, Chulalongkorn University produced 0.09, and all other universities less than 0.05. This indicates that there are very few Thai science academics who can serve as research role models for junior staff.

If science research, and particularly limnological research activity is to become fully estab-

lished in Thailand a number of changes will have to occur in the Thai tertiary education sector. Firstly, there will need to be a reallocation of expenditure away from buildings and into libraries. In view of the expense of libraries it would be preferable to establish a national system rather than attempting to provide broad-spectrum libraries at every institution, but every university requires sufficient basic journals in each major field of teaching to allow undergraduates to become familiar with journal use.

Secondly, Thai universities need to establish a research culture. The only way this could be done in the short term would be by institutions establishing close relationships with research universities in other cultures. The linkages need to be long term, and at the level of faculty or institution, and allow frequent and substantial staff exchange. Thus the "research culture" of the research university would be imported. Interactions at the level of individual researchers alone cannot achieve this change in the research culture. The only way that such interactions could occur would be by the two institutions establishing joint courses, or by foreign universities offering their courses through Thai universities. Foreign universities offering courses in Thailand would not influence the research culture in Thai universities unless they were offered through, and in conjunction with, Thai universities with Thai staff involvement.

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