

Thong Pha Phum; Synthesis of the Aquatic Projects with a View to the Future

F.W.H. Beamish

Burapha University, Chonburi
billbeamish@hotmail.com

Abstract: A brief history of the Thong Pha Phum project is presented along with its stated objectives. The potential consequences of anthropogenic activities, often by a well intentioned but uninformed public, on the sustainability of goods and services provided by rivers are discussed along with biological methods of evaluating water quality. A brief review is given of each of the aquatic projects sponsored by BRT and conducted in Thong Pha Phum. This paper concludes with a comment on the information in hand and other information that would be nice to have, along with how this information might be applied to best facilitate the Thong Pha Phum objectives of resource conservation and sustainability through mutual understanding between the community and government on the wise use of natural resources.

Key words: Thong Pha Phum, anthropogenic activities, uninformed public

The West Thong Pha Phum areas compose of three distinct ecoregions, Tenasserim-South Thailand semi evergreen rain forest, Kayah-Karen montane rain forest and Chao Phraya lowland moist deciduous forest. Annual rainfall varies among these three regions from 100 to 400 cm and the overall region supports a large and diverse collection of plant and animal species, although many have yet to be described. Some 30 years ago the local peoples were relocated from their homeland in preparation for the construction of Khao Laem reservoir and an electrical generating plant by the electrical authority of Thailand. The land they now occupy in Thong Pha Phum was donated by the electrical authority of Thailand for their benefit. Recently, these peoples have had to endure additional hardships caused by the construction of a gas pipeline, a project known as the Thai Myanmar Project. From this background has arisen the Thong Pha Phum Project sponsored jointly by the PTT Public Company Limited and the joint Thai Research Fund/BIOTEC Special Program for Biodiversity Research and Training Project or BRT. The Thong Pha Phum Project has as its objectives; to provide an area for interdisciplinary research, to encourage learning through interaction among members of regional communities and researchers with the view to strengthen the community and to support an area for resource conservation. Conservation of endemic biodiversity is seen as important to establish mutual understanding between the community and government on the wise use of

natural resources. Importantly Thong Pha Phum has also been designated a special area in celebration of His Majesty the King's rule of Thailand.

The Thong Pha Phum Project has embraced two major components, aquatic and terrestrial studies. This report is directed only toward aquatic studies, although it is realized that the two are intimately interconnected and that at some stage will need to be integrated for management, resource conservation and possibly ecotourism if deemed advisable. In Thong Pha Phum as elsewhere, watercourses or rivers have greatly influenced the development of human society as they freely provide a continuous supply of essential goods and services or resources as they are commonly called. The goods include freshwater for potable, domestic, agricultural (e.g. irrigation) and industrial needs, food in the form of fish, turtles and waterfowl and large invertebrates such as crabs and shrimp and, importantly, power. Services provided include recreational activities such as swimming, transportation, an efficient disposal system for domestic, agricultural and industrial wastes and ecotourism. However, only watercourses with unimpaired water quality conditions produce the goods and services expected by local residents. With declining water quality, rivers yield fewer and fewer resources.

Water quality impairment can result from direct modification to a river or by exceeding its ability to assimilate specific wastes. Typically, however, water quality

impairment is caused by landscape modification within the watershed. Beyond a certain limit, the replacement of native vegetation with agricultural, silvicultural, industrial and urban land uses affects the functional interactions between a watercourse and adjacent lands. Greater variation in river discharge is a common response (Bishop, 1973). Native vegetation along a river typically is the first to be replaced with buildings, roads and agriculture when rural development occurs within a watershed. This activity may reduce the productivity of watercourses since allochthonous inputs decline which are an important component of the diet of invertebrates and fishes (Dudgeon, 2000). Furthermore, the loss of trees may increase soil erosion leading to increases in turbidity and suspended solids and subsequently, reductions in primary production. When flows slow these materials settle to the bottom, filling interstitial spaces and reducing secondary production of benthic macroinvertebrates as well as some species that are unable to live under these conditions. However, rural development may also promote higher productivity within watercourses. Increased solar radiation from the reduction of canopy will stimulate autochthonous (periphyton) primary production. Added nutrients from adjacent lands may also promote primary production, increasing the potential for increased production of some benthic invertebrates but decreasing that for others. Understanding the relationships among rural, urban and industrial development, water quality and the aquatic inhabitants is essential for social planning and environmental management.

One of the best means of measuring water quality is through an assessment of the structure and composition of the resident organisms. These plants and animals are continuously exposed to the environmental conditions in a river or reservoir and thus reflect the environmental conditions over a period of time. Algae, benthic macroinvertebrates and fish are known to be sensitive to a wide variety of abiotic and biotic variables (Hellowell, 1986; Hynes, 1970) many of which are altered through land use changes and are functionally dependent on their associated riparian vegetation (Vannote et al., 1980; Cummins, 2001). Consequently they can provide a direct ecological measure of the quantity and quality of goods and services afforded by the local

ecosystem. A marked shift in the community structure of organisms indicates the effect of a specific stress on the ecosystem and signals a reduction in resources and services provided by the river or reservoir.

Armed with such information one might visualize a consortium of local residents, researchers and managers collaborating on a plan which when implemented will allow residents to exploit the appropriate goods and services within the designated limits that will guarantee their sustainability and hence conservation. While desirable to have all the biological pieces in place such is rarely, if ever the case. More often, management plans proceed in the absence of all desirable information aided by any of a variety of statistical procedures that have been employed elsewhere with at least moderate success. However, some basic information is required and this was the task undertaken by BRT.

Perhaps the most basic requisite for all biological studies are taxonomic studies on the organisms themselves for without this basic information there can be no communication. Thailand is blessed with a large and diverse collection of plant and animal species. While many species have had taxonomic designations for some time, others are only now receiving taxonomic recognition and still others must wait for their turn to emerge from taxonomic obscurity. Thong Pha Phum has until recently received relatively little biological attention. However, just knowing the plants and animals, as important as this is, will not provide all of the answers for sustainable management nor conservation. This has been recognized in some of the researches already in place in Thong Pha Phum including some natural history studies, seasonal patterns in abundance, taxa distribution, community structures and bioassessment. In the future, other studies will need to be undertaken. These will include studies such as population size and structure, growth rates and food web dynamics. Because of the obvious importance of diet, food webs may directly exercise considerable influence on resource sustainability. This is an area that has already benefited from earlier researches in the social sciences, particularly in the treatment of data that will allow the understanding of food web compartments and how they affect food web stability.

The task ahead while formidable is not insurmountable. Perhaps what is of most

importance and in shortest supply are ideas for the efficient pursuit of important ecological and management questions to assure the sustainability of the natural resources of Thong Pha Phum.

What do we now know of the aquatic flora and fauna and their habitats in Thong Pha Phum? Several studies have been undertaken and are producing important, although in some cases still preliminary or incomplete information. Two researchers from the Department of Biology at Chiang Mai University, Sutthawan Suphan and Yuwadee Peerapornpisal, have undertaken to identify benthic macro- and micro-algae through quantitative samples collected throughout the year from Huay Khayeng and its tributaries. Their studies have identified a large number of taxa of macroalgae from four divisions and an even large number of microalgae, many to species, from two orders of the Division Bacillariophyta or diatoms. While some measurements have been made of algal habitat these have not yet been associated with the occurrence of algal species nor have seasonal fluctuations in abundance been reported. Macro and micro algae provide both biomass and nutrients to many of the herbivorous and omnivorous aquatic organisms and hence are of fundamental importance to the trophic ecology and food webs in rivers.

Among the crustaceans, the minute planktonic cladocerans serve as the aquatic food basket for many organisms. This is particularly the case in lakes and oceans but cladocerans occur also in rivers, especially the slower moving or lentic regions. Cladocera biodiversity, abundance and habitat were investigated between the headwaters and mouth of Huay Khayeng in Thong Pha Phum by Punnee Sa-ardrit and F.W.H. (William) Beamish from BRT, Bangkok and Burapha University, Bang Saen. Because of their weak swimming ability, cladocera are confined mostly to lentic areas providing for maximum numbers during the rainy season when a sizeable flood plain develops near the mouth of Huay Khayeng. Cladocera were dominated numerically by only three species, *Ceriodaphnia cornuta*, *Diaphanosoma excisum* and *Diaphanosoma sarsi* although many other species occurred in lesser abundance. This study found water current, pH, conductivity and temperature to be of particular importance to cladocera distribution. The study also

recognized assemblages of cladocera and the habitat factors important to their structure. Typically cladocerans are considered major contributors to the trophic ecology of carnivorous organisms, particularly immature individuals, however, the importance of these organisms in the rivers of Thong Pha Phum, while likely to be high, has not yet been investigated.

Several investigations have focused on that taxonomically and ecologically important group of organisms collectively known as benthic macroinvertebrates, consisting mostly of crustaceans, insects and annelids. Many species are represented in this macrocommunity or assemblage of organisms and collectively they are major energy contributors and consumers in river biodynamics. Despite their importance, comparatively little is known of their taxonomy and ecology in many regions of the world. Thailand is no exception. However, the Thong Pha Phum Project is fortunate to have several experts focus their taxonomic expertise on several invertebrate groups.

Diversity and abundance of aquatic insects were examined in Huay Khayeng on several occasions over approximately one year and related to a large number of habitat characteristics by Sutthinee Jitmanee and Chitchol Phalaraksh from the Department of Biology, Chiang Mai University. Approximately 197 insect taxa from 10 orders were identified. The Order Trichoptera or caddisflies contributed the greatest number of taxa while Ephemeroptera or mayflies contributed the greatest number of individuals. Not unexpectedly, high altitude sites that were visually and chemically classified as undisturbed were statistically distinct from sites considered to be variously disturbed based on their chemical properties. Ordination statistics applied to the insect data recognized two groups, one located in the forest and considered undisturbed and a second in urban areas, again supporting the potential usefulness of bioassessment in evaluating water quality. The taxonomy of the aquatic and semi aquatic bugs known as Heteroptera was given a huge boost through the effort of three scientists from the Department of Biology, Chulalongkorn University, Chariya Lekprayoon, Marut Fuangarworn and Ezra Mongkolchaichana. They have collected Heteroptera from lotic and wetland locations in Thong Pha Phum over a period of approximately two years. From these

collections they have so far identified a large number of species that they propose may be present in Thong Pha Phum and related their presence and abundance to specific environmental features. This will be of great benefit to the assignment of sensitivity values so important to the development of a bioassessment model based on Thai environmental criteria. These identifications have also contributed new distribution records. A lasting contribution has been the production of practical and simple-to-use taxonomic keys to the identity of adult water bugs to the level of family in Thong Pha Phum region. These are accompanied by useful descriptions of family characteristics including habitat.

The identity of species of stone flies or Order Plecoptera as well as black flies, Order Diptera, Family Simuliidae in Thong Pha Phum has been unveiled through the contributions of Jariya Chanpaisaeng, Jumnungjit Phasuk and Korakot Damrak from the Department of Entomology at Kasetsart University. They collected from both undisturbed and disturbed regions of rivers at monthly intervals over the course of a year. These studies have resulted in the identity of nine taxa of stoneflies, some identified to species, and their assignment to undisturbed and disturbed habitats. They have also identified 17 species of blackflies along with their habitat.

Seasonal feeding dynamics of the common river shrimp in Thong Pha Phum. *Macrobrachium yui*, was examined in Huay Khayeng by Sumpun Tongnunui from the Department of Biology, Burapha University. His research examined diet, feeding schedule and rates of gastric evacuation in relation to shrimp size and season. The objective of this unfinished research is to examine the trophic dynamics of shrimp, in particular how much energy they consume and how much they contribute to river bioenergetics. Preliminary estimates of their relative abundance and size distribution have been made as their biomass represents a sizeable portion of that contributed by invertebrate animals in Huay Khayeng.

Several studies have undertaken projects to provide information on and, ultimately a model with which to evaluate the wellness of water or bioassessment. In this regard, Boonsatien Boonsoong, Siriporn Saeheng, Prayut Udonphimai and Vongwiwat Tanusilp of the Department of Biology, Khon Kaen University collected benthic

macroinvertebrates seasonally from two rivers, Huay Khayeng and Huay Team and measured water quality. Coincident with land use was a reduction in number of sensitive taxa and a change in community structure. In particular, taxa in Ephemeroptera, Plecoptera and Trichoptera declined while members of the Chironomidae family increased from undisturbed forested habitat to habitats near regions of the river subjected to residential and agricultural use. Riparian land use exerted the greatest influence on stream benthic community composition and abundances. A companion bioassessment study was undertaken by Punnee Sa-aradrit, William Beamish and Chunte Kongchaiya of PSU Natural History Museum, Prince of Songkla University and Department of Biology, Burapha University, again based mostly on benthic macroinvertebrates and water quality. Measurements were made at many sites and on many rivers in Thong Pha Phum and beyond over an extended time frame. The number of taxa and individuals, while highly variable among sites, tended to be higher in reference than assessment sites within orders, the numerically dominant families were similar across reference and assessment sites, although the total number of families within the Orders Diptera, Ephemeroptera and Trichoptera was the higher across the reference sites. Assemblage structure was similar between reference and assessment sites. Several bioassessment methods were applied including taxa richness, rarefaction curves, biotic (e.g. Hilsenhoff, 1982, 1987), diversity (Wiener, 1948; Shannon, 1949), similarity indices (e.g. Morisita-Horn in Wolda, 1981; Novak and Bode, 1992) and multimetric methods (e.g. Karr, 1990; Barbour et al., 1997; Griffiths, 1999; Davies, 2000) in searching for a relatively simple bioassessment method to evaluate ecosystem health of Thai rivers. Most methods did not separate assessment and reference sites. However, the metrics developed for the Rapid Bioassessment Method (Barbour et al., 1997) identified a degree of impairment not recognized by the other methods. Unfortunately sensitivity and tolerance values critical for the application of the Rapid Bioassessment method are mostly unavailable for Thai fauna and had to be adopted from North American fauna. Canonical correspondence analysis was effective in identifying factors affecting composition of benthic macroinvertebrates, with the important

factors being alkalinity, discharge, conductivity, phosphate, ammonia and water velocity.

The identity of fish fauna and their abundance in the rivers of Thong Pha Phum was the unintentional beneficiary of an ecological study conducted by William Beamish and Chunte Kongchaiya, Department of Biology, Burapha University. A total of 70 taxa were identified, 61 to species as well as several species of the Family Balitoridae that may represent new species. The Family Cyprinidae dominated in numerical abundance and species richness followed distantly by the families Balitoridae and Channidae. Silurids tended to be slightly more abundant in the larger rivers but for many fishes, river size did not seem to be important. Species richness is discussed briefly in relation to water quality, the important factors including elevation, ambient ionic concentrations and cover.

Fish ecology was the subject of a multifaceted study in Thong Pha Phum and elsewhere in central Thailand by William Beamish, Chunte Kongchaiya, Belinda Ward-Campbell and Ron Griffiths, Department of Biology, Burapha University. Seasonal changes in fish abundance and assemblage composition was followed in Huay Khayeng. Relatively low abundances in the rainy season when discharge was high were related to feeding and reproduction migrations away from the study areas. Important environmental characteristics were identified for fishes found in rivers throughout Thong Pha Phum and elsewhere in central Thailand along with species distributions and populations estimates, the latter based on the depletion method of Carle and Strub (1978). Species richness and numerical abundance were dominated by cyprinids followed by silurids and balitorids. Habitat factors of importance to species distribution and abundance are discussed. Species coexistence was examined and related to resource sharing, facilitated through morphological adaptations and ontogeny. Morphological adaptations associated mainly with the mouth and digestive system direct species to forage on different dietary items with adaptations to body and fin morphology enhancing maneuverability or swimming performance, both variously associated with prey capture and predator avoidance.

Obviously from this brief summary, aquatic research in Thong Pha Phum is off to a fine start but much remains to be done. It is

important to emphasize that much of the information collected so far and summarized in this report has not been published and some is still incomplete. Publication is of critical importance. Acceptance of a new species requires publication in a refereed scientific journal. While this may not be a prerequisite for all information there is no question that the peer review process forces good things to happen to scientific information. In order for information, and its interpretation to pass through the rigors of peer review it often must undergo modification from that presented in reports where critical review seldom occurs. Without being subjected to this process otherwise good and useful information may fail to gain credibility. Thus, completion of incomplete studies and publication of completed studies that remain as reports are important next steps. With this in place it will be appropriate to critically evaluate the information in hand together with that already available in the scientific literature and appropriate to this project. This will save time and resources and, likely contribute to the pool of ideas to meet the challenges set forth for Thong Pha Phum. At this stage more taxonomic information on Thai fauna and flora would be welcome. Perhaps of even greater importance is ecological information which is in short supply. This might include bioenergetic studies or models, dynamic food webs, population and mortality models and environmental interactions. It might soon be profitable to employ the services of someone skilled in Decision Analysis (Hilborn et al., 1994) to prioritize future biological and social science research. This would also encourage the participation of members of the community as well as social scientists and economists. Should ecotourism be a consideration, representation should soon be solicited so that they may have early involvement. At regular intervals project objectives will need review as will the paths on how best to achieve them. Members of the community are also critical to the success of the Project so as not to lose sight of the needs and wishes of the people of Thong Pha Phum.

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