

# 1. INTRODUCTION

## Literature review

### 1.1 Peat swamp

#### 1.1.1 What is a peat swamp?

Peat swamp is a particular type of wetland, which is an ecosystem that arises when inundation by water produces soils dominated by anaerobic processes and forces the biota to exhibit adaptations to tolerate flooding. Using sets of plant and animal associations, wetlands can be classified into six basic types, one of which is peat swamp (Keddy, 2000). Peat swamps can be distinguished from other wetland habitats by an accumulation of organic matter called peat. Peat is formed when decomposition fails to keep pace with the production of organic matter. This is a result of water logging, a lack of oxygen or nutrients, high acidity or low temperature (Finlayson and Moser, 1991). Because of the high level of material decomposition, freshwater in the peat swamp is characterized by its acidity and by being brownish in color. The vegetation of tropical peat swamps is dominated by evergreen trees rooted in deep peat (Phengklai *et al.*, 1989). In primary peat swamps, the vegetation is composed of numerous plant species. In contrast to this, the majority of vegetation consists of *Melaleuca* sp., as secondary vegetation type in degenerated peat swamps.

### **1.1.2 The formation of peat swamp**

A possible hypothesis for the development of coastal peat swamps in southern Thailand is that they are initiated by continuous strong winds and waves causing the formation of a raised sandy beach, at short distance from the coastline. During a long period the raised sandy beach would enlarge, extend, and become higher, until it came to converge with the seashore, forming a large shallow inland sea. In the absence of an outlet to the sea, the inland laguna would become a freshwater lake due to the heavy rainfall in the area. The annual native plants, which are adapted to such conditions, would proliferate causing the gradual filling of the lake over a long period of time. Then the pioneer perennial species would follow into the area. Decomposition of plant biomass is a relatively slow process in such a biotope, due to the high content of sodium sulphide in the water preventing the developing of bacteria. The accumulation of organic matter results in a peat layer of varying thickness. The process to form such peat swamps takes thousands of years (Phengkklai *et al.*, 1989).

### **1.1.3 What are the importances of peat swamps?**

Peat swamps play several vital functions in the ecosystem. One of the most important roles is flood control. Peat swamps act as sponges, storing and slowly releasing rainfall and run-off, which result in the reduction of flood peaks. In addition, their vegetation is essential in helping the stabilization of banks and shores, counteracting forces of erosion and sea level rise. Moreover, peat swamps play a key role in ground water recharge and discharge. They also act as a filter for certain kinds of waste and soluble contaminants. These processes are important for controlling storm water run-off, for replenishing supplies of water for human consumption and also in maintaining the flow of ground water. An environment rich in peat swamps

can reduce the potentially harmful impacts of fertilizer use on the landscape, because it acts as a sink, preventing nitrate build-up, which could lead to eutrophication (Finlayson and Moser, 1991). Furthermore, since the peat swamps contain many remarkable species as a result of their long evolution under unique conditions, they contribute significantly to the biodiversity in the biosphere (Chittapun *et al.*, 1999). Besides, the peat swamps also provide food, both flora and fauna, to local residents.

#### **1.1.4 Recent problems on peat swamps**

Peat swamp is a complex ecosystem both in its physical structure and in the relationships that develop among the plants and animals that depend on them. The organisms living there are different from those in other habitats, as they are the evolutionary result of long-term adaptation to the unique conditions in peat swamps. Therefore, disturbing these habitats may have a negative effect on biodiversity. In addition, peat swamps are delicately balanced: even apparently minor changes may be sufficient to cause substantial alteration or degradation. This holds in particular for disruption by human activities (Finlayson and Moser, 1991).

The scale of human impact on wetlands varies from transient or temporary to irreversible. Actions that alter hydrology or substrate are generally more permanent than those that influence only the animal and plant life, although these may, in extreme cases, lead to the local extinction of species. Nowadays, pressures for wetland alteration and loss are increasing in the tropics and developing nations, in spite of growing awareness of their important life and environmental support functions (Finlayson and Moser, 1991).

In Thailand, the peat swamp areas are gradually deteriorating and decreasing in area rapidly. To date, there are only a few pristine peat swamps

remaining; these are To-daeng in Narathiwat province and Jik in Phuket province. The main causes of peat swamp destruction in Thailand are transformation and invasion. These factors result in area reduction and lead to complete disappearance of some peat swamp areas.

(see:[http://www.wildlifefund.or.th/07\\_Habitats/03\\_peatswam\\_forest/peatswam\\_forest00.html](http://www.wildlifefund.or.th/07_Habitats/03_peatswam_forest/peatswam_forest00.html) and <http://www.zyworld.com/NAKARIN/HTMLbirdhabitat.htm#peat>)

## 1.2 Rotifera

### 1.2.1 What are rotifers?

Rotifers are a cosmopolitan zooplankton group belonging to the Phylum Rotifera, which is composed of more than 2,000 species (Nogrady *et al.*, 1993). This Phylum is typically characterized by an unsegmented, pseudocoelomate, primary bilateral symmetrical body, and a complete digestive system (Nogrady *et al.*, 1993; Miller and Harley, 1996). The members are probably derived evolutionarily from ancestral acoelic turbellarians and related to the gnathostomulids (Starkweather, 1987; Ruttner-Kolisko, 1974 quoted by Segers, 1995-1996).

Rotifers in general can be distinguished from other zooplankton by two unique features: the presence of a corona and a mastax (Nogrady *et al.*, 1993) (Figure 1.1). The corona is an annular band of cilia of the apical hypodermis, which surrounds the apical field. The cilia serve for locomotion and for directing food towards the mouth. The mastax is a muscular organ in the pharynx working for selection, catching and processing of food (Starkweather, 1987; Nogrady *et al.*, 1993; Segers, 1995-1996; Solomon *et al.*, 2002). It consists of a number of hard elements called trophi (Figure 1.2). The trophi is the most important morphological feature used in the

classification and identification of monogonont rotifers to species level (Segers, 1995-1996).

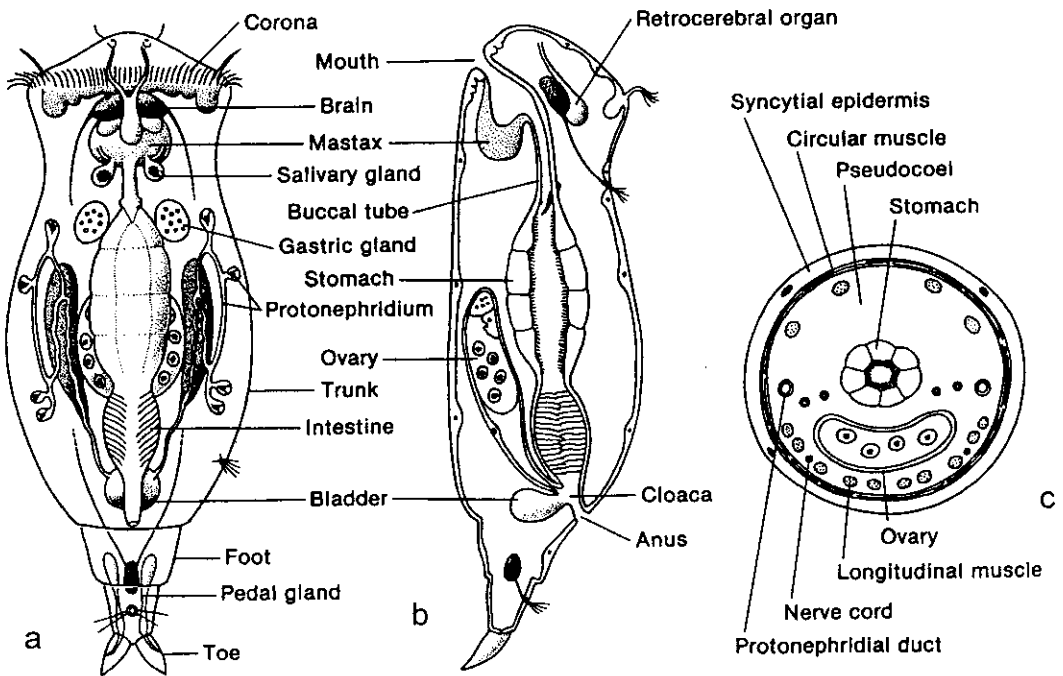


Figure 1.1 Rotifer anatomy; a: Dorsal view, b: Lateral view and c: Cross section

(Ruppert and Barnes, 1994, p. 308).

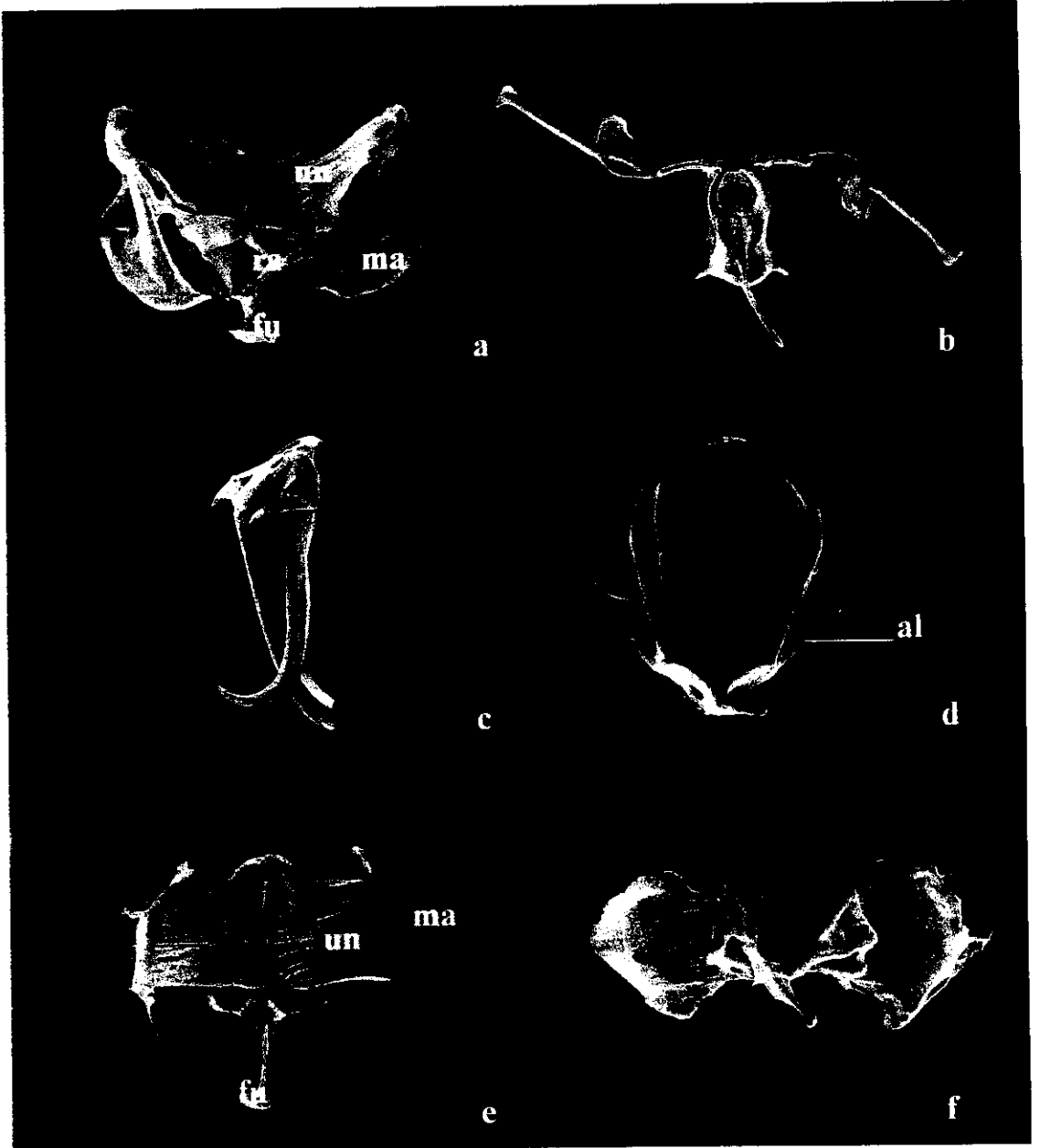


Figure 1.2 Some major types of trophi; a: Malleate trophi of *Brachionus*; b: Forcinate trophi of *Dicranophorus*; c: Virgate trophi of *Trichocerca*; d: Incudate trophi of *Asplanchna*; e and f: Malleoramate trophi of *Filinia* and *Hexathra*, respectively (fu: fulcrum, ra: ramus, ma: manubrium, un: uncus, al: alula).

The Phylum Rotifera can be divided into three classes, Pararotatoria, Bdelloidea and Monogononta (Segers, 2002). This research work focused only on the Monogononta Rotifera, the largest group of Rotifera containing more than 1,600 species (Segers, 2002).

The three classes of rotifers reproduce by three different mechanisms. The class Pararotatoria reproduces exclusively bisexually; gametogenesis occurs by meiosis, with the production of two polar bodies. In Bdelloidea, on the other hand, no males have ever been observed and reproduction is exclusively by asexual parthenogenesis. This involves two equational divisions producing two polar bodies. Monogonont rotifers reproduce both by parthenogenesis and by sexual reproduction called heterogony (Figure 1.3) (Wallace and Snell, 1991; Nogrady *et al.*, 1993).

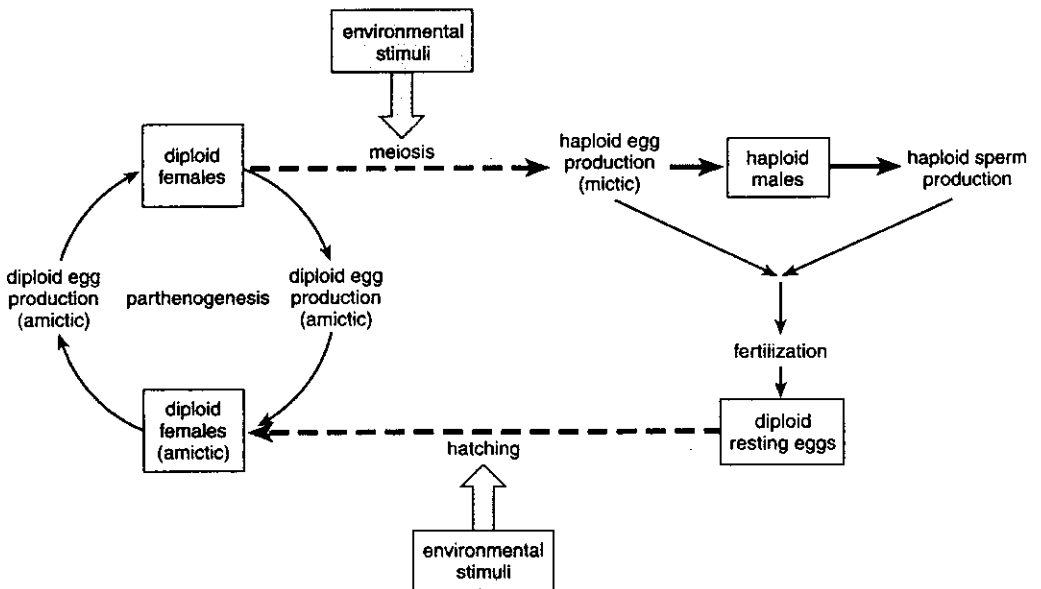


Figure 1.3 The life cycle of monogonont rotifers (Pechenik, 2000, p. 196).

Reproduction in Monogononta rotifers is dominated by asexual parthenogenesis; amictic females produce diploid eggs, which develop into amictic females. Sexual reproduction is triggered by the occurrence of adverse conditions or as a result of specific environmental cues. Amictic females will produce mictic females giving haploid eggs. Unfertilized haploid eggs will develop into males producing sperm. When haploid eggs are fertilized, these will develop into thick-shelled eggs, called resting eggs. These eggs will accumulate in the sediment and are able to survive through periods of adverse conditions. When favorable conditions return, they hatch as amictic female, which will start reproducing parthenogenetically (Wallace and Snell, 1991).

Resting eggs (diapause form) are the product of sexual reproduction, which is cued by variety of stimuli that are directly or indirectly predictive of environmental deterioration. As favorable conditions return or as a result of specific cues, they develop and hatch to reestablish their population again. These dormant forms represent a biodiversity bank as the eggs survive through adverse environmental conditions, preserve species diversity and provide a reliable colonization source when conditions improve. The biodiversity bank assures genetic continuity through periods of environmental adversity. It means that resting eggs represent a bank, like the seed pool of plants, from which recolonization of the environment can occur at a later time (Pourriot and Snell, 1983; Ricci, 2001).

The duration of the period of dormancy is different not only among species but also among clones of the same species. The emergent rotifers can be observed within a few hours or after several months of incubation. These phenomena depend on environmental conditions. Two hatching patterns can be observed. First, the eggs



hatch individually at more or less regular intervals over an extended period of time. This pattern could be adaptive in environments where conditions that are favorable for population growth occur unpredictably. This strategy spends more in wasted hatching. The alternative pattern is synchronous hatching of large numbers of eggs over a short period of time, in response to some environmental cues. An advantage of this pattern is that no wasted hatching under unsuitable environmental conditions will occur, therefore this pattern could be adaptive to predictable environments (Pourriot and Snell, 1983).

### **1.2.2 What are the roles of rotifers?**

Rotifers can be found in freshwater, brackish water and saline water of both aquatic and semi-aquatic habitats, however they are predominantly freshwater inhabitants. Because rotifers are the most diverse group of freshwater metazoan, and a diverse component of freshwater ecosystems, they play a major role in most types of such habitats. Fundamentally, as a primary consumer of phytoplankton, rotifers convert energy and matter to organisms in higher trophic levels. In addition, as a result of their high reproductive capacity and high feeding rates, rotifers play a pivotal part in energy flow and nutrient cycling. Since they are small in size (0.006-1.00 mm), highly nutritious (proteins 58 - 72%, lipids 21.31% of their dry mass) and easily produced in mass quantity (reaching to 50,000 and 500,000 individuals/liter), rotifers are suitable as food for first period of exogenous feeding aquatic animal larvae (Lubzens *et al*, 1993). Additionally, because of their widespread occurrence and range of environmental preference, rotifers can be used as bioindicators of the trophic state of water bodies (Mäemets, A., 1983; Pontin, 1993; Marneffe *et al.*, 1998; Duggan *et al.*, 2001). Recently, rotifers, especially *Brachionus calyciflorus* and *B. plicatilis*, have

been employed as test organisms for toxicological studies as a consequence of their cosmopolitan distribution, their short generation time and their use in easily mass culture (Wallace and Snell, 1991; Janssen *et al.*, 1993; Ferrando *et al.*, 1993; Fernández-Casalderrey *et al.*, 1993; Nogrady and Rowe, 1993). These aspects of rotifers render them particularly interesting as study organism.

### 1.2.3 A study of Rotifera in Thailand

The study of Rotifera in Thailand has intensified recently. As with most investigations on specific taxonomic groups, most studies so far focused on taxonomy using samples collected from various freshwater habitats such as lakes, reservoirs, canals, rivers, roadside canals and rice fields (Koste, 1975; Boonsom, 1984; Segers and Sanoamuang, 1994; Sanoamuang *et al.*, 1995; Sanoamuang, 1996; Pholpunthin, 1997; Segers and Pholpunthin, 1997; Sanoamuang and Segers, 1997; Pholpunthin and Chittapun, 1998; Sanoamuang, 1998; Sanoamuang and Savatentalint, 1999; Sanoamuang and Savatentalint, 2001). However, special habitat types such as peat swamps have been overlooked in the initial studies. Peat swamps are very special. They take thousands of years to form, and are characterized by their brownish and acid water (Phengklai *et al.*, 1989). Recently, interest in the rotifer fauna of peat swamp areas has increased (Chittapun *et al.*, 1999; Chittapun *et al.*, 2001; Segers and Chittapun, 2001; Chittapun *et al.*, 2002; Chittapun *et al.*, 2003). Up to date, 154 rotifer species have been recorded from eight peat swamps in southern Thailand. This number contains many species that had not been documented from Thailand or neighboring countries before. In addition, six species were new to science: *Colurella sanoamuangae* Chittapun, Pholpunthin and Segers, *C. psammophila* Segers and Chittapun, *Encentrum pornsilpi* Segers and Chittapun and *Lepadella desmeti* Segers

and Chittapun from Mai-khao peat swamp, Phuket province; *Keratella taksinensis* Chittapun, Pholpunthin and Segers from To-Daeng peat swamp, Narathiwat province and *Lecane kunthuleensis* Chittapun, Pholpunthin and Segers from Kun-Thu-Lee peat swamp, Suratthani province. This result suggests that peat swamp ecosystems have a special rotifer fauna, possibly as a result of their long history and unique ecological characteristics. Therefore, more attention should be paid to the conservation of such areas for the future.

### **Research questions**

As a result of anthropogenic activities in peat swamps, some areas have been transformed by construction such as reservoirs and airport construction, to the extent that some have completely disappeared. Therefore, in order to reveal the effect of human activities on biodiversity in peat swamp areas, this work was initiated by the study of the impact of human activities in peat swamp areas by using monogonont rotifers as a test group. This study was performed by investigating the species composition of Rotifera from five coastal peat swamps in Phuket province, Southern Thailand. Then, in order to assess the influence of anthropogenic factors on the freshwater community, a multivariate analysis was performed on rotifer communities and the environmental variables affecting these, using data collected in these five peat swamps. In addition, to evaluate the capacity of freshwater communities to restore after perturbation, the recruitment capacity of resident rotifers was investigated by performing experiments on the hatching of resting eggs present in the sediment.

## **Hypothesis**

Human activities will decrease the diversity of coastal peat swamp ecosystems, as indicated by Rotifera Monogononta.

## **Objectives**

This research consists of four parts, which have all been conducted to obtain knowledge on the following aspects of the rotifer fauna:

### **Part 1: Taxonomy and biogeography of coastal peat swamp Rotifera**

The results of previous studies of the rotifer fauna of peat swamp habitats suggests that these are a special habitat type containing a highly diverse rotifer taxocoenosis. Therefore, to contribute to the information on peat swamp rotifers in Thailand, this research is primarily aimed to further document the rotifer species diversity of five coastal peat swamps in Phuket province, southern Thailand.

### **Part 2: Rotifer diversity in coastal peat swamps**

Our research aims at investigating quantitative aspects of rotifer diversity in different types of peat swamp. The objective of this part is to analyze different aspects of rotifer biodiversity: actual species richness in each area, some diversity indices and complementarity, in the five peat swamps.

### **Part 3: Ecology of coastal peat swamp Rotifera**

Considering the scarcity of knowledge on rotifer ecology in tropical regions, and the unique characteristics of peat swamp areas promoting a diverse rotifer fauna, a detailed study of rotifer ecology is called for. To contribute to the knowledge of

ecology of Rotifera in Thailand, this study will attempt to identify the important environmental variables and understand how they act on rotifer communities in coastal peat swamps. In addition, human activities take place in some peat swamps, which may result in profound effects such as salinisation, transformation and agricultural pollution. In order to monitor changes in environmental conditions and understand how these activities affect the rotifer communities in peat swamps, this research also intends to investigate anthropogenic effects on the composition of the rotifer fauna.

#### **Part 4: Recruitment of rotifer resting egg bank**

Rotifers have resting eggs that enable them to survive through periods of adverse conditions. This implies that rotifer communities have the ability to recover, by hatching of resting eggs, after restoration of habitats disturbed by human activities. To investigate the capability of recovery in disturbed peat swamps, the viability of the resting egg bank in the sediment of a disturbed peat swamp was tested.