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Freshwater investigations on Apid Island, Inopacan, Leyte, Philippines: results of lithotelmic investigation

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ABSTRACT

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Preliminary investigations of some of the numerous lithotelmata found in the limestone area of Apid Island off the west coast of Leyte revealed the following facts:

- The majority of these lithotelmata are semi- permanent.
- They are partly used for human activities like washing, influencing both the pH values and the biocoenosis.
- pH values under undisturbed conditions range from 7 and 8.
- Water temperature rises and falls according to the diurnal cycle, so does the p H in those lithotelmata invested with filamentous algae of the genus Oedogonium.
- Neighboring lithotelmata show very different faunal composition including species usually showing long developmental cycles like dragonflies.
- Ostrocodes were the most abundant single species group found.
- The main faunal component of a phytotelmata in the form of a water-filled coconut shell were neustic collembola.

Keywords: coral islands. freshwater. lithotelmata. Philippines. phytotelmata

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INTRODUCTION

The ecology of freshwater habitats and communities in the humid seasonal tropics particularly on small islands has rarely been studied.

This investigations on Apid Island, one of the four Cuatro Islas off the west coast of Leyte in the Camotes Sea, is the first ever performed on freshwater ecosystems on this 35.928 ha large island of coralline origin.

The freshwater region of this island is dominated by two main factors: (1) The climate, characterized in this western part of the island of Leyte by no distinct dry season with rainfall relatively evenly distributed throughout the year with up to 2600 mm annual rainfall, an average air temperature of 27°C and about 1,200 mm evaporation (Balzer and Margraf, 1994). (2) The geological formations of highly weathered uplifted coralline limestone rocks. The karstification processes have led to a very rigid landscape with rock surfaces being totally transformed by weathering into small-to-medium and large-sized crevices, gullies and cave-like structures.

A first investigation revealed that no lotic bodies of water in the form of streams or rivulets do exist on Apid island. Also no bigger lentic waters could be detected except for one small pond in an inaccessible gorge. Numerous, small to medium-sized lithotelmata were found in the respective areas of investigation. Also some phytotelmata were recorded and a relatively huge cave with stalagmites and stalactites was detected. No freshwater could be encountered in the accessible part of the cave.

It was therefore decided to investigate primarily lithotelmata and wherever possible phytotelmata to collect data on their physical, chemical and biological status.

The seasonal changes are major influences upon the communities of these mostly semipermanent ponds. While studies on tropical lithotelmata and phytotelmata are very rare no such study was ever performed on Apid Island.

MATERIALS AND METHODS

Morphometric and statistical parameters investigated

Date: August 30-31,1999 Time Schedule: 8:50 a.m. to 10:00 p.m. Altitude above sea level of the investigated sites was from 4 to 10 m. Lithotelmata were selected under the aspect of being invested with algae or not and shadowiness. The physical form of the lithotelmata was depicted in a sketch map. The only phytotelmata found and investigated was an empty coconut shell containing about 100 ml of rainwater. The shell was placed fully exposed to the sun and precipitation on a rocky area. The altitude above sea level of this place was about 8m, the data of investigation was August 30, 1999 at about 9 a.m..

Physical parameters

The temperature was recorded with the help of a minimum-maximum-thermometer or a normal mercury thermometer. Bathymetric profile was measured by laying a transect through the respective lithotelmata. Barometric measurements were done with an integrated barometer and expressed in hPa (HektoPascal). The respective exposure was recorded with an integrated compass. Width, depth of water and sediment thickness were recorded with a tape meter. Shadowiness was estimated in % and drawn into the respective sketch map. Transparency and water color were recorded subjectively.

Biological parameters

Macroscopic visible fauna and flora were recorded and collected for further investigations. With the help of a plankton-net microscopic organisms were collected from the free water space, the bank parts and the sediment. The samples were preserved in Lugol's solution of 5%. Microscopic investigations were performed in the Marine Laboratory of the Visayas State College of Agriculture with the help of a Zeiss Binocular Microscope. Autochthonous organic matter was recorded.

RESULTS AND DISCUSSION

Apid Island, the second largest island of the association of uplifted coralline islands of the *Cuatro Islas*, is too small with its 35.928 ha of land area for any significant lentic or lotic body of water. Another major influential factor is the highly weathered limestone surface of this island, draining away most of the precipitation through its cracks and gullies hardly allowing any surface runoff.

During the two days of investigations, four lithotelmata and one phytotelmata were investigated in an area of the island near the settlement area (Fig. 1). These lithotelmata were selected under the following aspects: (1) larger-sized lithotelmata with >2 m length for its longest transect (Fig. 2); (2) medium-sized lithotelmata with < 1 m length for its longest transect (Fig. 3); (3) medium-to large-sized but shallow lithotelmata with 1-2 m length for its longest transect (Fig. 4); and (4) deep and anthropogenic influenced liyhotelmata (Fig.5).

The results of these investigations covering some physical, chemical and biological parameters are summarized in Figures 2-5. The data collected can be interpreted as follows: the air temperature during the investigation time ranged between 27°C-33° while the barometric pressure was stable with 1014 hPa. Water temperature was, as expected, highly dependent on sun exposure and time of measurement.

The depth profiles of these relatively shallow ponds of very variable size give an impression of the trough-like forms built over time by weathering influences as found in any rocky limestone area exposed to the action of the rain.

The depth variations found ranged between 0.2 cm and 50.0cm. pH values could be measured at 7-9 during these single measurement investigations of various lithotelmata. It is well known that the pH is highly dependent on any photosynthetic activity of water organisms and therefore the diurnal cycle for pH and the temperature of the water were investigated in two lithotelmata, differing in two parameters: (1) shadowed lithotelmata without any visible filamentous algae (Fig. 6) and (2) sun-exposed lithotelmata with filamentous algae (Fig. 7).

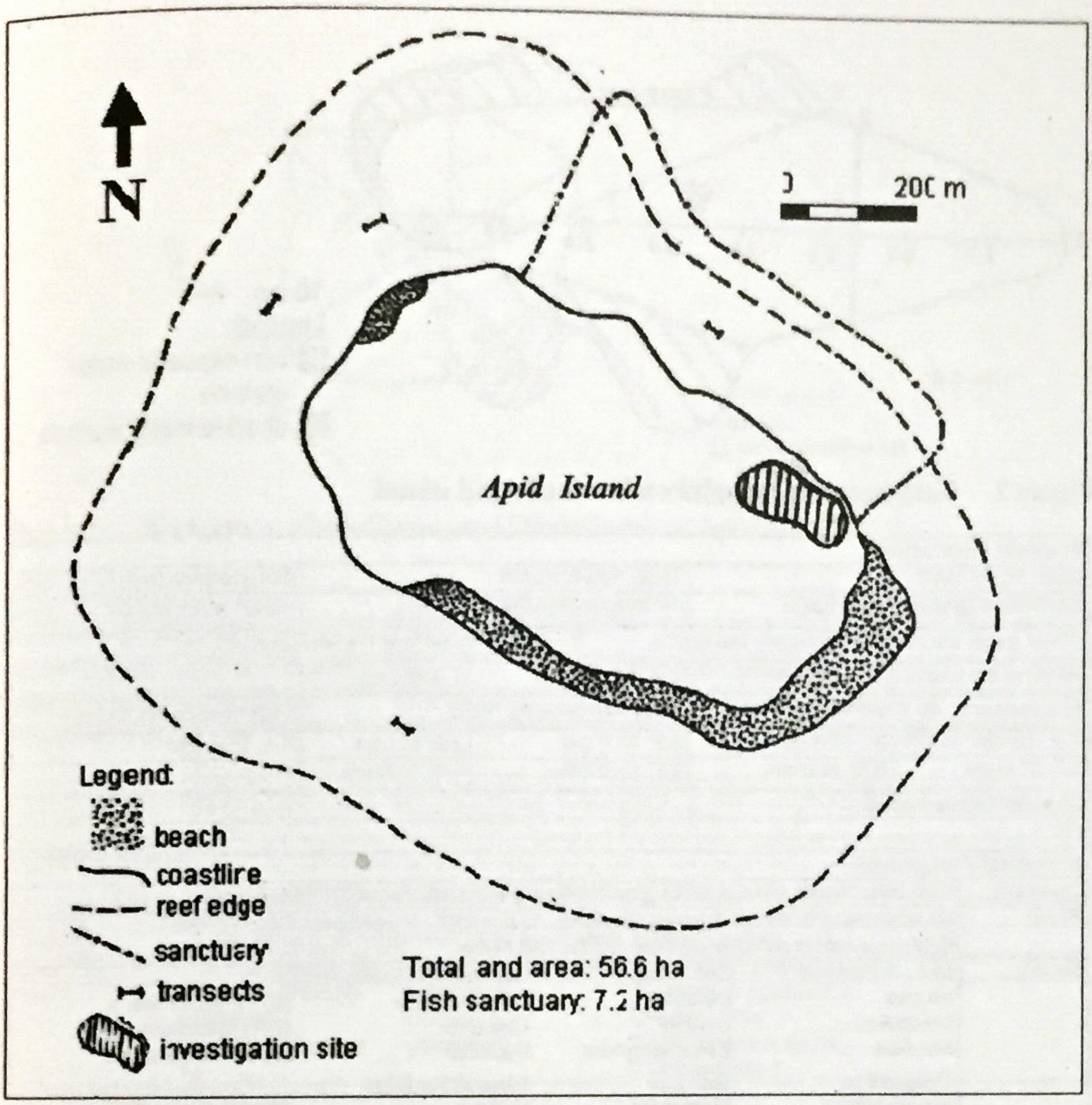


Figure 1. Area of data collection

It is clearly shown that the temperature in the shadowed algae-free lithotelmata has a much narrower oscillation with 27-30°C than in the case of the sun-exposed algae-invested lithotelmata with a temperature range of 27-37°C. Correlated with the photosynthetic activities during daytime is the increase in pH with oscillations between 6.5-7.5 and 6.5-8, respectively.

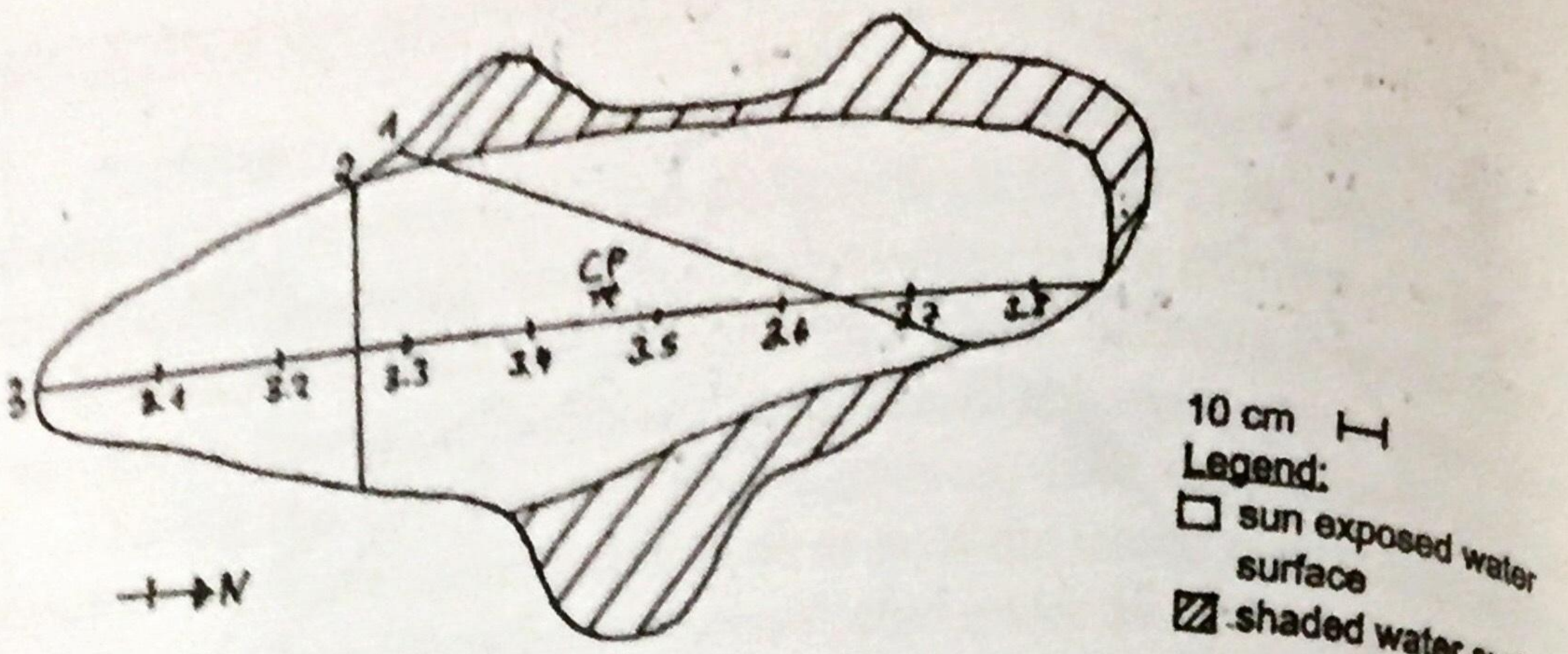
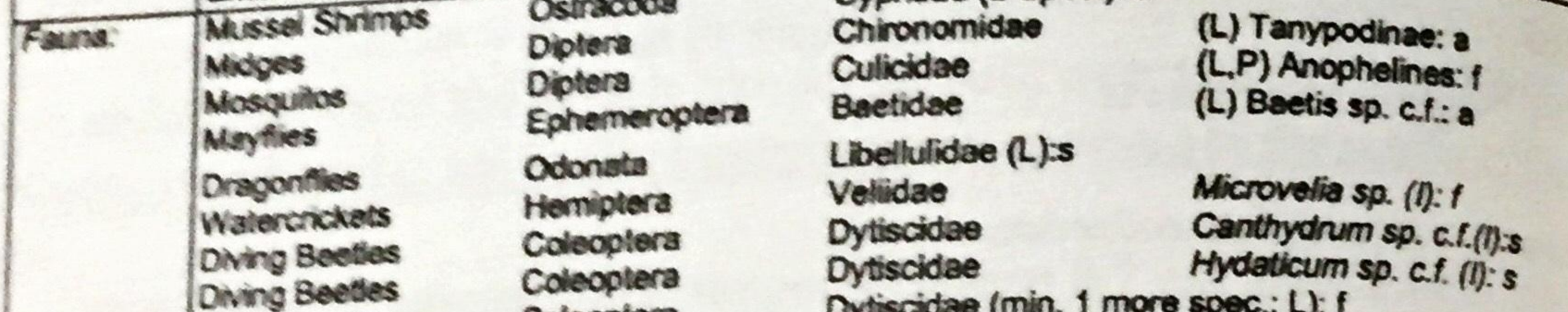


Figure 2. Sketchmap of large lithotelmata of Apid island

Physical Parameters			
Date: 30.08.1999	Time: 10:08:00 AM		Altitude: 8 m a.s.l.
Barometric pressure: 1014 hPa	Air temperature:30 °C		Water temp.: 27°C
Water color: transparent to slightly tea-brown		Depth at Central point: 27 cm	
Width of transects:	T. 1: 125 cm	T.2: 53 cm	T.3:265 cm
Shadowness: 40 % permanently shadowed by overhanging rocks			Sediment depth: 0.5 cm
3.0: 0.0 cm	3.1: 9.0 cm	3.2: 12.0 cm	3.3: 8.0 cm
3.5: 27.0 cm	3.6: 14.0 cm	3.7: 11.0 cm	3.8: 11.0 cm
Chemical Parameters			
pH: 8			
Biological Parameters			
Overview:	High allochtonus input in POM (particulate organic matter) and CPOM (coarse p. o. m.)		
Flora:	No macroscopic visible filamentous algae, submerged, or emergent macrophytes Extensive root bundles of exteme shrubs and herbs		
Fauna:	Mussel Shrimps	Ostracoda	Cypridae (2 Spec.): a
	Midges	Diptera	Chironomidae (L) Tanypodinae: a
	Mosquitos	Diptera	Culicidae (L,P) Anophelines: f
	Mayflies	Ephemeroptera	Baetidae (L) Baetis sp. c.f.: a
	Dragonflies	Odonata	Libellulidae (L):s
	Waterchickets	Hemiptera	Veliidae *Microvelia sp. (I)*: f
	Diving Beetles	Coleoptera	Dytiscidae *Canthydrum sp. c.f.(I)*:s
	Diving Beetles	Coleoptera	Dytiscidae *Hydaticum sp. c.f. (I)*: s
	Diving Beetles	Coleoptera	Dytiscidae (min. 1 more spec.; L): f
	Wat.Scavenger8.	Coleoptera	Hydrophilidae (I): s

Legend:
(L): larvae (I): Imagines f: few individuals a: abundant s: single individuals



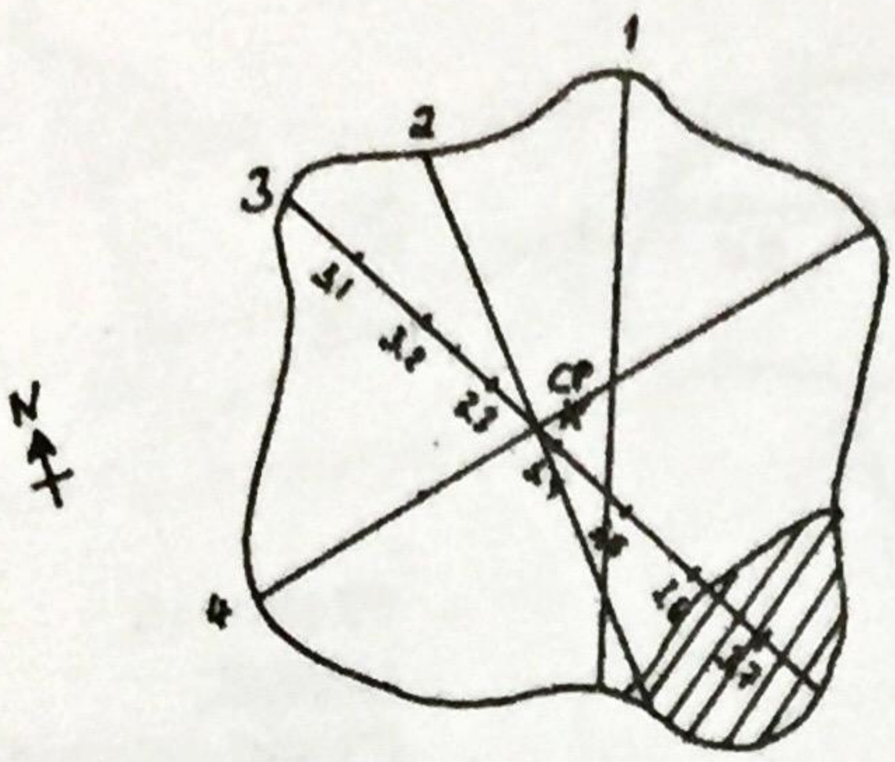
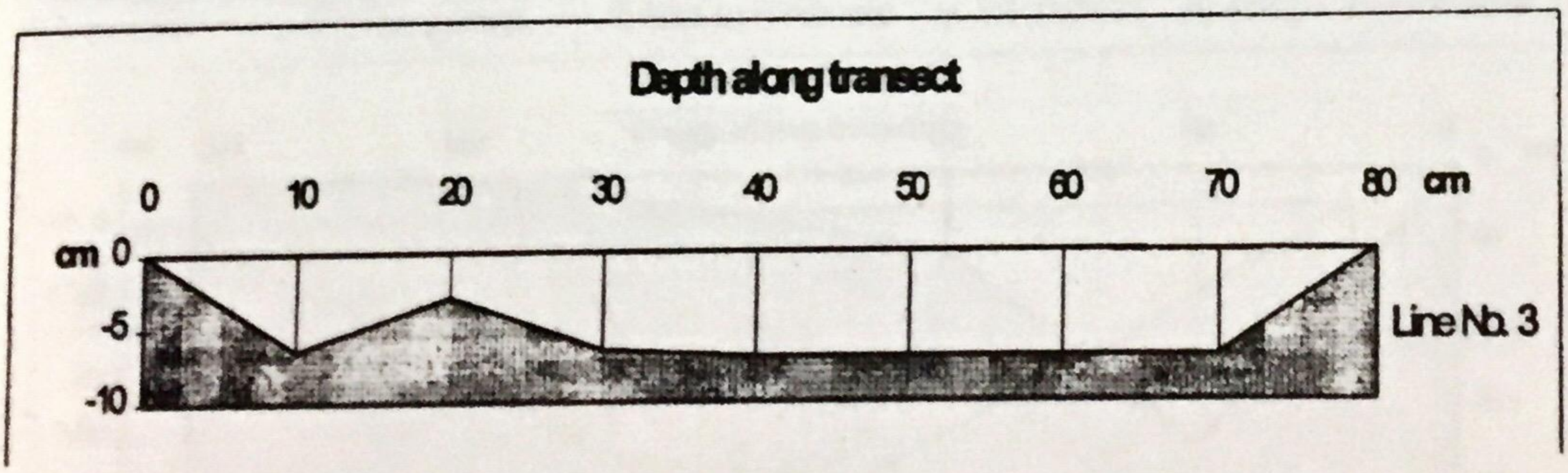


Figure 3. Sketchmap of medium-sized lithotelmata of Apid island

Physical Parameters				
Date: 30.08.1999		Time: 8:20:00 AM		Altitude: 5 m a.s.l.
Barometric pressure: 1014 hPa		Air temperature: 27 °C		Water temp.: 30°C
Water color: tea-brown to transparent			Depth at Central point: 4 cm	
Width of transects:	T. 1: 70 cm	T.2: 70 cm	T.3: 80 cm	T.4: 80 cm
Shadowness: 20 %				Sediment depth: 0.5 cm
3.0: 0.0 cm	3.1: 6.5 cm	3.2: 3.0 cm	3.3: 6.5 cm	3.4: 7.0 cm
3.5: 7.0 cm	3.6: 7.0 cm	3.7: 7.0 cm	3.8: 0.0 cm	
Chemical Parameters				
pH: 7				
Biological Parameters				
Overview:	High input of allochthonus POM (particulate organic matter)			
Flora:	No macroscopic visible filamentous algae or other water plants			
Fauna:	Mussel Shrimps	Ostrapoda	Cypridae (2 species): a	
	Midges	Diptera	Chironomidae	
	Jumping Beetles	Coleoptera	(L) Chironomus sp.: a	
			(L) Helodidae: s	

Legend:
(L): larvae (I): Imagines f: few individuals a: abundant s: single individuals



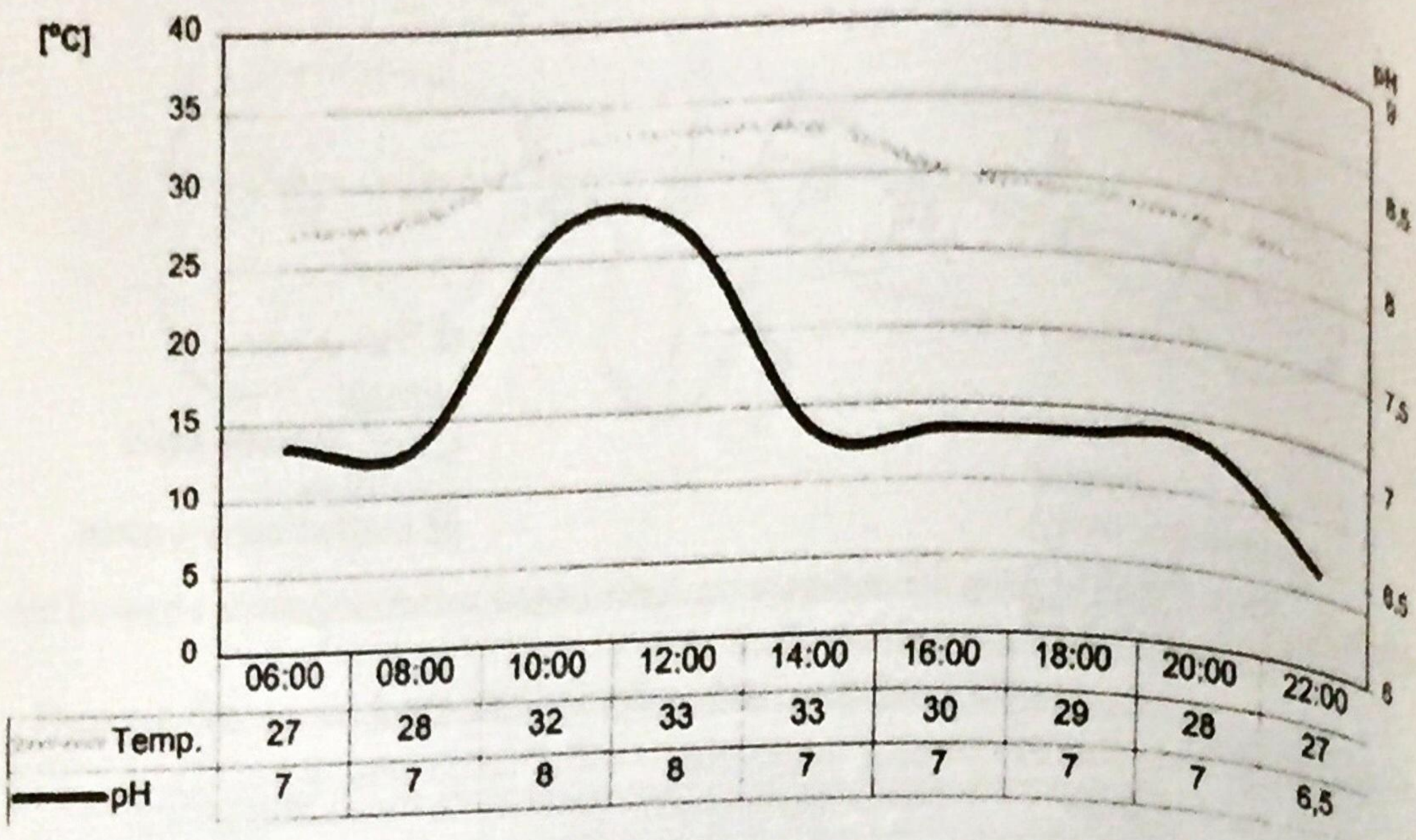


Figure 6. Daily variation of pH and water temperature of a sun exposed and flat lithotelmata rich in algae on Apid island

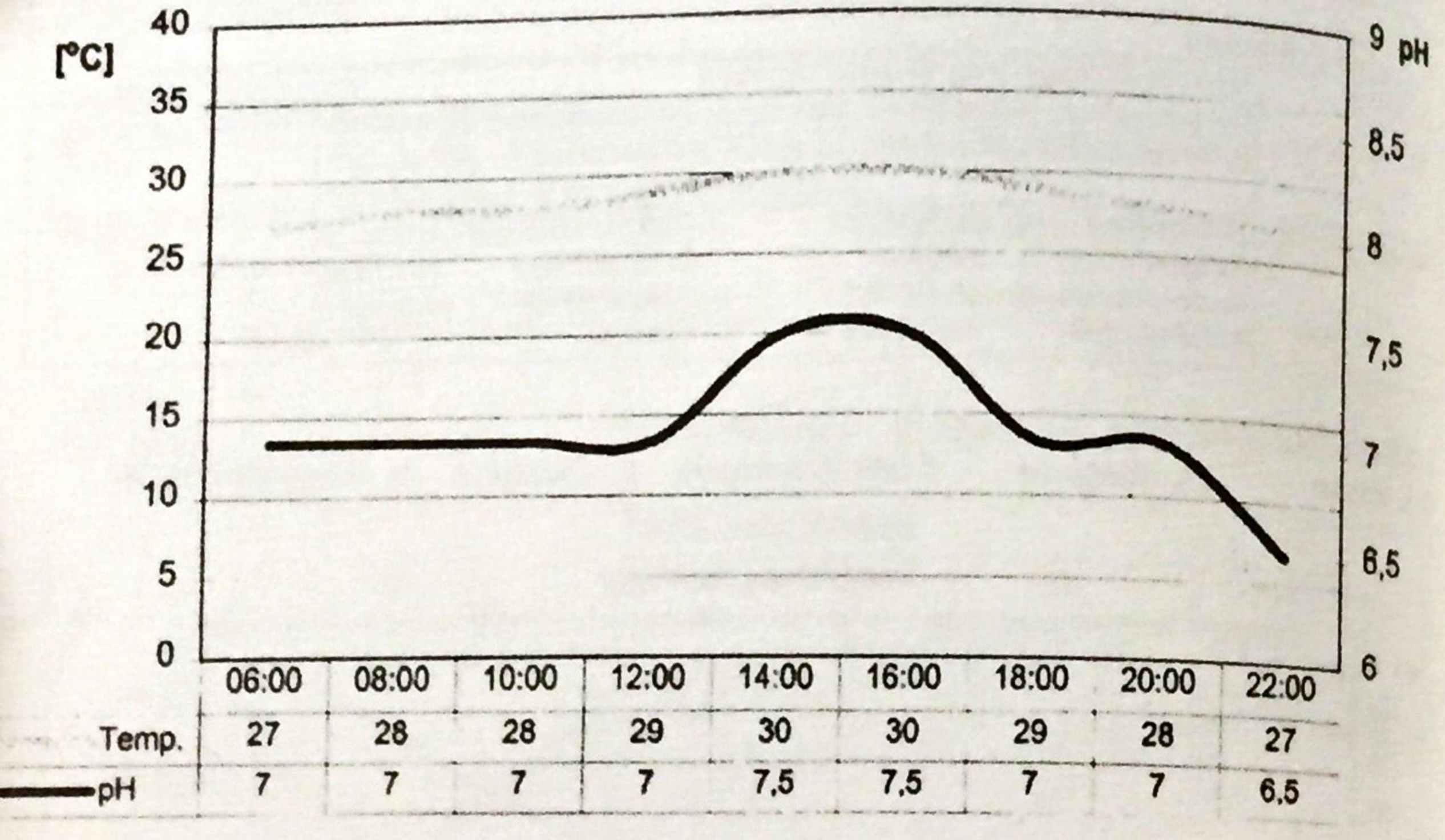


Figure 7. Daily variation of pH and water temperature of a shadowed medium size lithotelmata without algae on Apid island

The fauna of these small ponds was much more diverse than the flora. While no submerged macroscopic visible macrophytes were found except for the filamentous algae belonging to the genus of Oedogonium sp. (Class Oedogoniophyceae; Ordo Oedogoniales), more than 20 different species of aquatic fauna belonging to 13 families could be identified. It was remarkable to find very significant differences in the composition and the abundance of faunistic elements in the various lithotelmata, sometimes even located very near each other. To reveal the anthropogenic influence as indicated by a relatively high pH value found during the preliminary investigation different lithotelmata or ponds were scrutinized concerning their pH-values and the temperature (Fig. 8).

It can be clearly shown that all these lithotelmata not used for human activities like washing or rinsing of clothes have pH-values around 7 (Nos. 1-6; Nos. 16-22), while all the others show a sometimes relatively high alkalinity with maximum values up to pH 11 (Nos. 11-12).

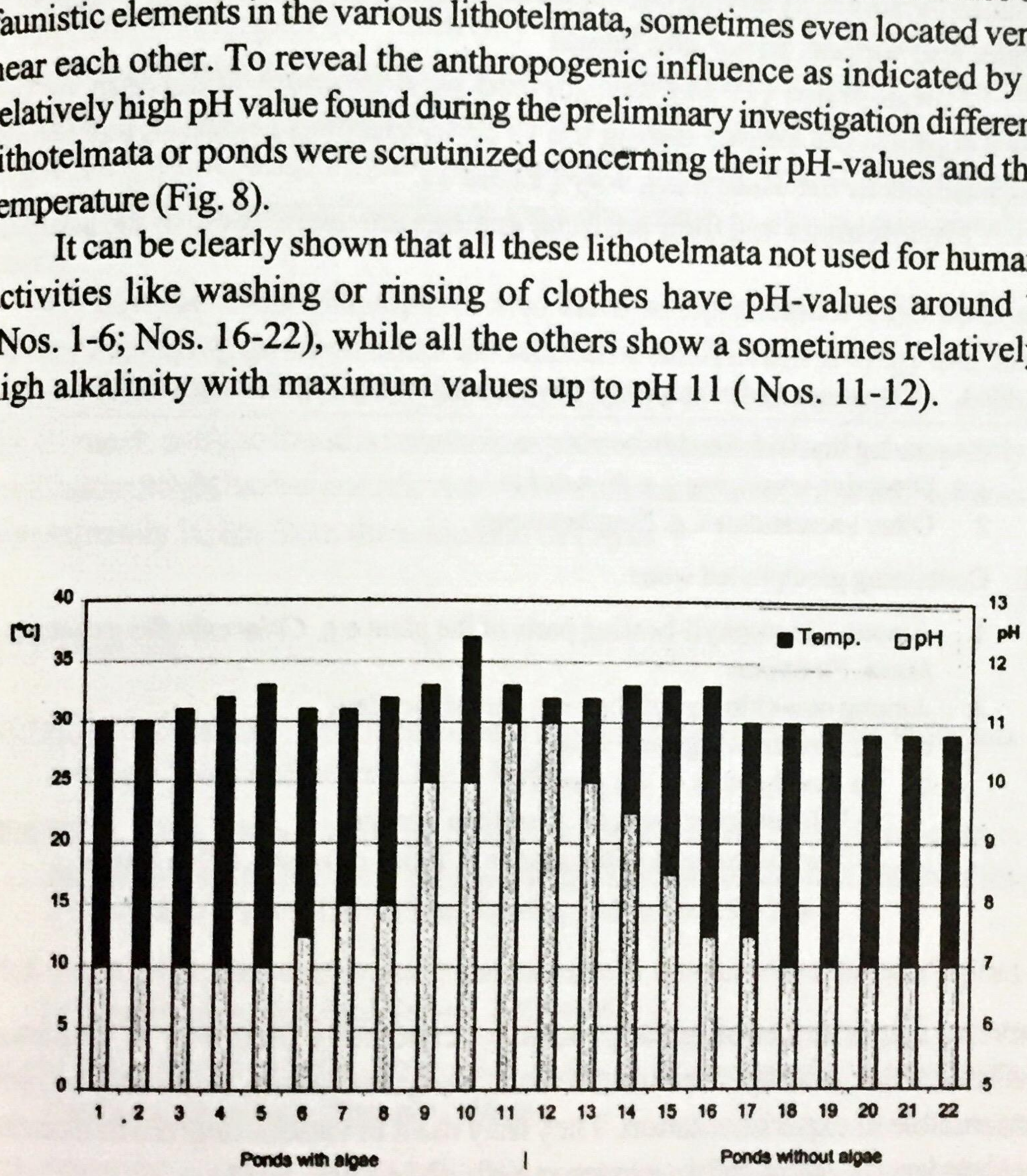


Figure 8. Comparison of pH and water temperature of several lithotelmata on Apid island under natural and anthropogenous influence

Phytotelmata in form of a water-filled coconut shell

Phytotelmata are structures formed by plants such as modified leaves, leaf axils, flowers, bracts, stem holes, open fruits or open coconut shells that impound water or liquid derived from plant secretions or rainwater (Kruegel, 1995). The term phytotelmata has been introduced by Varga (1928) who noticed the similarity among pitcherplants, bromeliads, in their ability to impound water and support an aquatic fauna.

Thienemann (1934) categorized phytotelmata according to the investigation performed during the 1928/29 German Limnological Sunda Expedition in the following way (Table 1).

Phytotelmata and their artificial analogs are useful tools in the study of several important ecological processes, especially their way of dispersal, colonization, and species interaction: They are small, relatively simple, amendable to experimentation. They may exist in various degrees of isolation and undergo ecological processes rapidly (Maquire, 1971).

The mean water temperature was recorded to be 32°C. The pH was 6. The mean volume of the water was >100 ml. Coarse particulate organic matter

Table 1. Categories and examples of phytotelmata (after Thienemann, 1934)

I. Containing liquid derived from plant secreations
   1. Digestive secreation e.g. *Nepenthes*
   2. Other secreatioms e.g. Zingiberaceae

II. Containing precipitated water
   1. Among Chlorophyll-bearing parts of the plant e.g. *Colocasia Bromeliaceae, Musa, Pandanus*
   2. Among non-chlorophyll-bearing part of the plant
      a. In blossoms e.g. *Raff lesia*
      b. In woody parts of the plants
         b.1 In stems or trunks e.g.bamboo stamps
         b.2 In fallen parts of the plant e.g. fallen coconuts, fallen leaves.

(POM) content was relatively high. No macroscopic visible filamentous algae nor microscopic single-celled algae could be detected. The most abundant faunal components were two species of insects belonging to the Ordo of Collembola.

Numerous individuals of the families Paronellidae and Sminthuridae were found in the ratio of 3:1. Most probably the neustic collembola species occupied as opportunistic organisms relatively quickly this very small niche. No Copepoda or Ostracoda, commonly found in nearby lithotelmata, could be observed. The most astonishing factors can be summarized as follows: even neighboring lithotelmata do show a completely different set of communities; ostracodes are, in some lithotelmata very abundant; in others, completely absent.

On how the mussel shrimps reached these semipermanent water bodies is a very interesting question under the aspects of small island ecology and the stepping stone theory. However, the exclusiveness of *Oedogonium sp*. as the only filamentous algae found is not easily explained. Aerial drift and subsequently aerial fallout might have some relevance in the colonization of these lithotelmata approximately 10 km from the mainland of Leyte.

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