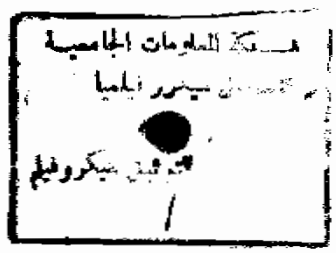
SHAMS UNIVERSITY
Faculty of Science
partment of Botany

STUDIES ON THE ALGAL FLORA OF SOME THERMAL SPRINGS IN EGYPT

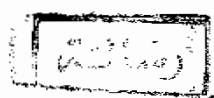
THESIS

Submitted in Fulfilment of the Requirement of Ph. D. Degree in Botany



PRESENTED BY

ADEL FAHMY HAMED ALY
B.Sc. Microbiology-Chemistry (HONS.) 1983
M.Sc. 1989



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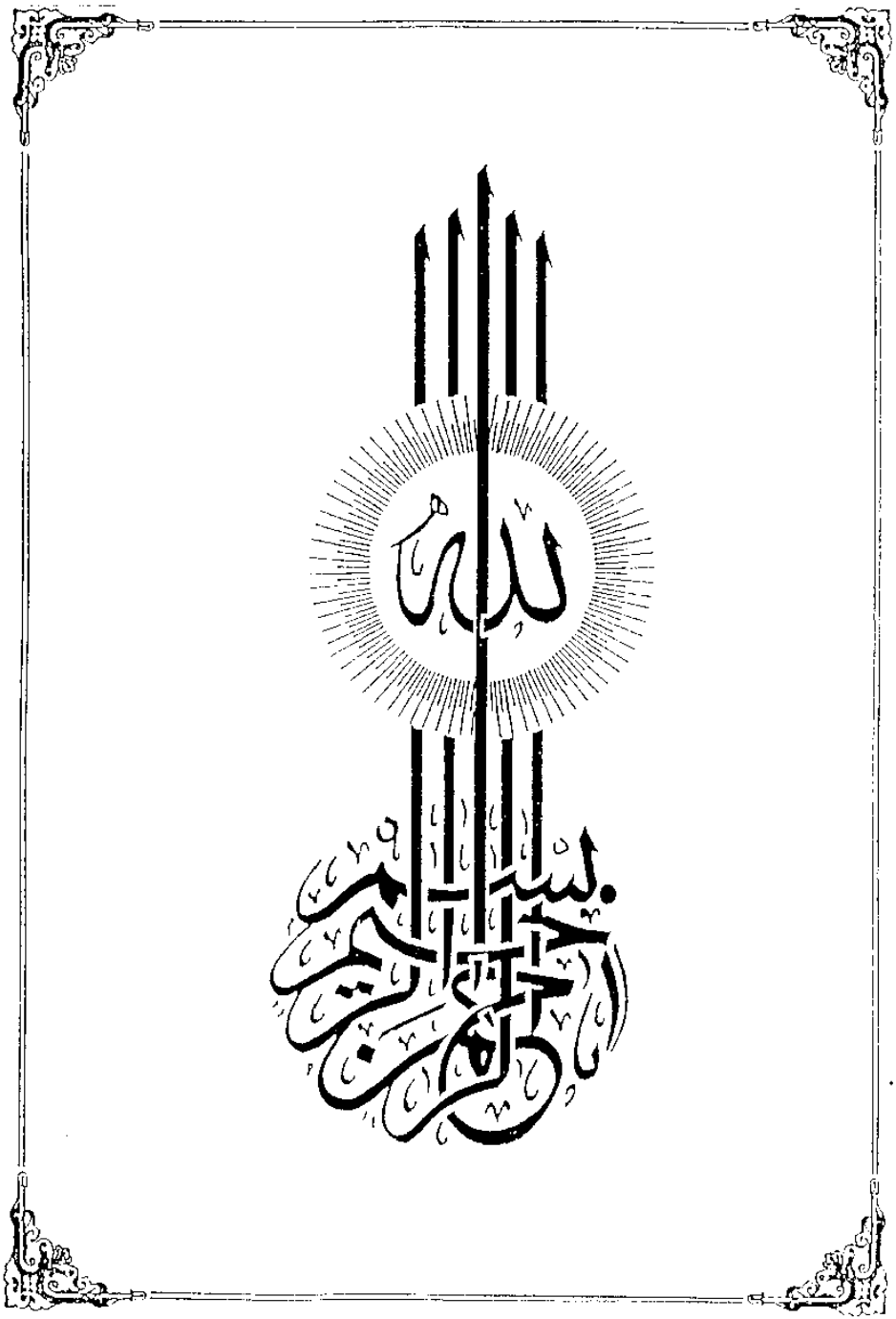

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APPROVAL SHEET

Name : ADEL FAHMY HAMED ALY

Title : Studies on the algal flora of some thermal springs in Egypt.

This thesis has been approved by

1- Professoe Doctor : Abd -El Salam Shaaban

2- Doctor : Hassen Mahmoud Gibriel

This thesis has not been submitted for a degree at this or at any other university. The literature cited shows how far I have availed myself of the work of the others.

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INTRODUCTION

INTRODUCTION

The term "spring " has been used to denote the upwelling point of underground water , sometimes arising from small cracks between rocks, sometimes from diffuse marshy regions with one or numerous upwelling points , and sometimes bubbling up at the bottom of ponds. These have been classified by **Steinmann (in Round, 1960)** as rheocrenes , helocrenes and limnocrenes respectively . Geologically a spring can be defined as a fault formed in the earth crust through which the underground water seeps from the bottom to the top by the hydrostatic pressure **(Manning, 1987)**.

The term "thermal spring" is subject to variable meaning. **Gilbert, (1875)** listed as thermal only " those springs which exceeded the mean annual temperature of the air by 15 F.". **Meinzer, (1923)** described thermal springs "of those having a temperature significantly above the mean annual temperature of the vicinity and further subdivided them into hot and warm springs ; hot springs those with a temperature higher than that of the human body and warm springs those with a temperature lower than that of the human body but still above the mean annual temperature. A simpler classification proposed by **Elenkin(cited in Kol, 1932)** where waters below 16^{o}C were classified as hypothermal, between 16 and 30^{o}C as mesothermal and above 30^{o}C as euthermal. Furthermore **Vouk, (1948)** suggests hypothermae are those with temperature enviroments with a range of 0-25^{o}C, euthermae with a range of 25-55^{o}C, and hyperthermae with a range of 55-80^{o}C.An organism whose cardinal points (maximum, optimum, minimum)are entirely within the hyperthermae range is described as macrostenovalent,whereas an organism having the optimum growth in the hyperthermae range, but also existing outside this range, may be called macroeuryvalent.The prefix meso- is used with reference to organisms with optimum growth in the euthermae range and micro- for those in the hypothermae range.

Different studies on the algae of the thermal springs took placed. In the field of physiology and molecular biology , intensive works carried out by(**Jenson *et al.*, 1980 ;Miura *et al.*, 1980 ;Ward and Olson, 1980;Wickstrom, 1980;Yamada and Sakaguchi, 1980; Sandbeck and Ward, 1981; Sawa *et al.*, 1982;Wickstrom and Wickstrom, 1982; Nagashima and Fukuda, 1983; Reed, 1983; Castenholz and Utkilen, 1984 a,b; Wickstrom, 1984; Bateson and Ward, 1985; Stadnichuk *et al.*, 1985; Cohen *et al.*, 1986;Nagashima *et al.*, 1986; Anderson *et al.*, 1987; Richardson and Castenholz, 1987a,b;Bateson and Ward, 1988; Ward *et al.*, 1989;Weller and Ward, 1989; Gracia and Castenholz, 1990; Weller *et al.*, 1990;Ruff and Ward, 1991).**

In the field of taxonomy and ecology of the thermal algae, many researches have been undertaken in different parts of the world where the greatest concentations of thermal springs occur in Czechoslovakia ,Greece ,India, Italy, Japan ,Pakistan and U.S.A. (**Castenholz, 1969;Brock, 1970**).

In Czechoslovakia ,**Rehakova, (1976)** identified 214 fresh -water diatom species,varities and forms from thermal waters in Piestany Spa. Most of them were found to be oligohalobous-indifferent and cosmopolitan species which able to thrive in different environments.

Foged, (1984) studied the diatom flora in 5 springs in Jutland , Denmark. He identified 313 taxa from 36 genera . The pH spectra of the recorded diatoms showed that all 5 localities have great predominance of alkaliphil diatoms.

In Greece, **Economou-Amilli, (1976)** carried out taxonomic and ecological research on diatoms of thermal springs. He concluded that,the majority consists of exclusively fresh water species, or of fresh water species which sometimes can be found in brackish water and a small group consists of obligate brackish water species.

Most of the diatoms found were described as eurytherms and there was not any diatom species recorded as a typical representative of thermal springs.

In India, extensive work dealt with systematic enumeration had been done by **Thomas and Gonzalves, 1965a,b,c,d,e ,f,g; Vasishta, 1968 and Patel, 1974**. The limnobiota of the indian effluents were investigated **(Jana, 1973)**. The author grouped the thermal springs of Bakreswar on the basis of temperature into acrothermal and euthermal. She determined a new record from India that diatoms like ***Navicula*** **sp.** and ***Cyclotella*** **sp.** can survive in the temperature range of 43-51°C. **Rao** and **Pattnaik, (1975)** studied the thermal Cyanophyceae of North Orissa . They recorded that ***Phormidium ambiguum*** , ***Oscillatoria sancta*** and ***Oscillatoria chlorina*** were the most predominant taxa that thrived well at temperature range 39-58°C . The study of biota in relation to physico-chemical environments along thermal gradient of a hot spring of Bhimbandh was carried out by **Saha and Munshi, 1980**. They found that the temperature tolerance of different organisms was responsible for the characteristic distribution of biota , where eleven species of Cyanophycophyta were recorded at temperature range of 50-55°C, 14 species of Bacillariophycophyta were found at temperature between 39-55°C while 9 species of Chlorophycophyta were recorded at temperature between 39-43°C. **Adhikary and Sahu, (1985)** identified some of the thermophilic blue green algae in thermal springs of Orissa, these were ***Chroococcus minor, Oscillatoria terebriformis*** , ***Spirulina*** **sp.** ***and Mastigocladus laminosus.*** The thermal springs of Bihar had a blue -green algal character at or above 60°C , but the blue greens were replaced by green algae and diatoms as temperature decreased **(Bilgrami *et al* ., 1985)**. Latter, **Jha and Kumar, (1990)** identified 44 species of Cyanophycophyta from which species of ***Oscillatoria*** and ***Phormidium*** in addition to ***Mastigocladus laminosus*** constituted the dominant flora of Saptadhara and Brahma Kund hot springs.

In Italy, **Margheri *et al.*, (1985)** investigated the photosynthetic microorganisms of the Selinuntine hot springs in Sciacca , Sicily . They recorded that ***Oscillatoria animalis*** was highly distributed taxon in temperature range of 53-55 ^{o}C , ***Oscillatoria chalybea*** acquried the highest percentage of distribution in a hot spring of 35-45^{o}C while ***Oscillatoria limnetica*** was dominated in spring of 15-30^{o}C. Furthermore 6 species of diatoms were identified in spring of 15-30^{o}C and 2 in spring of 35-45^{o}C. The thermal-sulphur springs of Triponzo (Central Italy) were considered as euthermal according to the temperature of water and were described as ***Oscillatoria*** -type from florisitic point of view. As regards salinity, the oligohalbien-indifferent diatoms species formed the majority,but the few halophilic species were often present in much larger numbers as a consequence of the high mineral salt content **(DellUomo, 1986)**.

The Japanese scientist, **Yoneda,(1952)** directed his study to ecological and systematic investigations of the thermal Cyanophyceae. He divided the thermal blue greens as hypothermophilous (15-26^{o}C) , mesothermophilous (26-45^{o}C) , euthermophilous (45-65^{o}C) and hyperthermophilous communities (65^{o}C and more). He stated that , the identified taxa were categorized as common fresh water species, facultative species of great tolerance to various conditions, typical thermal species, brackish or salt water species and tropical species. Such investigation gave an opportunity for dividing the Japanese thermal vegetation based on Cyanophyceae as ***Synechococcus* --type** , ***Cyanidium* - type** , ***Mastigocladus* - type** , ***Oscillatoria* - type** and ***Phormidium* - type.**

In Pakistan, **Ali *et al.*, (1983)** investigated the hot sulphur springs at Lakki and identified 62 species of algae belonging to Cyanophycophyta, Bacillariophycophyta and Chlorophycophyta. At the same locality , **Leghari** and **Thebo, (1983)** recorded 21

species of Cyanophycophyta and classified the thermal spring of Lakki as ***Oscillatoria*-type.**

In Saudia Arabia, the algal distribution along the length of Tanoumah hot spring was studied by **Arif, (1989)** where 71 species (37 Cyanophycophyta, 24 Chlorophycophyta, 10 Bacillariophycophyta) were recorded. He found that the blue-green alga that dominated between 56-45°C was ***Synechococcus lividus*** ; below 45°C at the end of the spring, blue-green algal mats mainly composed of ***Oscillatoria boryana*** **and** ***Oscillatoria geminata*** . While green algae and diatoms were observed, particularly at the spring periphery where the temperature fall gradually to 25°C.

In South Africa, taxonomic notes on the diatoms of the Gross Barmen thermal springs were determined **(Schoeman and Archibald, 1988).** They commented about their results that, all diatoms identified were found to be cosmopolitan and regarded as meso- to oligohalobiens for salinity classification.

In Spain, **Seoane, (1990)** had carried out a taxonomic study of algae from the thermal spring of Torneiros and the distribution of the algae from the source to the thermic gradient (74-23°C). A total of 26 taxa were identified . The author found that the most outstanding in terms of biomass were ***Lyngbya lutea*** , ***Phormidium tenue*** , ***Spirogyra*** **sp.** , ***Oedogonium*** **sp. and** ***Ulothrix*** **sp** . **Sabater,** and **Roca, (1990,1992)** had studied the composition of diatom assemblages together with physicochemical variables of thermal Pyrenean spring . This spring of 36.5°C and showed an unusual ionic composition where the pH approached 10 and the water had a high relative concentration of sodium chloride and sodium bicarbonate , while the nitrate concentration was usually low .

In United States of America,**Tilden, (1898)** presented an annotated list with drawings of thermal algae of Yellowstone National Park,warm springs at Salt Lake City, natural sulphur spring at Banff and hot springs in the region of the Cascade

mountains. Most of the flora was belonging to Cyanophycophyta which intermingled with filaments of Chlorophycophyta. The life at high temperatures which dealt with organisms that living in hot springs was discussed by **Brock, (1967)** who found that, the upper temperature limit of the photosynthetic procaryotes (blue- green algae) was ranged between 73-75^{o}C whereas that of eucaryotic algae was found between 56-60^{o}C. He interpretated the existance of the organisms in the thermal environment due to the molecular mechanism of thermophily i.e. related to the function and stability of cellular membrans. **Mann *et al.* ,Stockner, (1967)** and **Mosser** and **Brock,** (1971) elucidated a systematic approach to sampling of the benthic algae of selected thermal springs in Yellowstone National Park . **Kullberg,** (1971) studied the algal distribution in six thermal springs effluents of western Montana. He stated that, most species can be described as mesoeuryvalent i.e. their growth accomplished in the range of 25-55^{o}C but also found in the hyperthermae range. **Tison** and **Kleyn, (1979)** determined the microbial ecology of Olympic hot springs in Olympic National Park . These were found to be a meteoric- low salinity , alkaline springs which supported the growth of ***Phormidium laminosum*** , ***Oscillatoria terebriformis*** and ***Synechococcus lividus.*** Great attenstion on the diatom flora of the Goshen warm springs, Blue lake warm spring, Cowy hot spring and Queens Bath warm spring was taken by the diatomists **(Clair and Rushforth, 1977; Kaczmarska and Rushforth, 1982; Ekins** and **Rushforth, 1986;** and **McMillan** and **Rushforth, 1987).** The Goshen warm spring, its diatom flora consisted of one hundered twenty-one species where the flora dominated by the genera ***Achnanthes, Fragilaria, Synedra, Navicula, Cymbella, Terpsinoe, and Nitzschia.*** The Blue Lake warm spring was found to be mesothermal and brackish. It contained a very rich diatom flora with a significant number of marine and brackish taxa as well as fresh water species. The Cowboy hot spring was found to be dominated by ***Nitzschia frustulum*** followed by ***Achnanthes exigua, Nitzschia***