



# Protists, Cyanobacteria, Rotifers and Crustacea from the Hypersaline Ponds of Messolonghi Saltworks (W. Greece)

by  
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# MESSOLONGHI SALTWORKS STUDY AREA – SAMPLING POINTS



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Google earth

2002

Imagery Date: 6/6/2016 38°23'40.83" N 21°24'08.57" E elev 0 m eye alt 1.99 km



**Duration of survey: 6 months (Apr. – Sept. 2015)**

**Salinity range of samples: 50 – 210 ppt**

**Categories of organisms found: 3 Kingdoms (Monera, Protista, Animals)**

**Kingdom Monera: Cyanobacteria 22 species**

**Kingdom Protista: Chlorophyta 5 species, Dinoflagellata 1 species, Diatoms 27 species, Protozoa 51 species**

**Kingdom Animals: Rotifera 9 species, Copepoda 1 species, Anostraca 1 species, Nematoda 1 species**

**TOTAL NUMBER OF SPECIES FOUND: 118**

**Due to:**

**changing salinity**

**intense light**

**shallow ponds**

**low oxygen**

**It is logical to expect  
scarcity of species**

***But because of:***

**The exclusion of  
large predators**

**An astonishing richness  
of species exists**

# CONSIDERING

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THE DRY-FLOODED  
ANNUAL STATE OF  
SALTERN PONDS

THE WATER SUPPLY FROM  
THE LAGOON ONLY

THE ONLY ONE  
CENTURY HISTORY  
OF THE SALTERN

SOME BASIC QUESTIONS ARISE

HOW MANY OF THESE SPECIES ARE ENDEMIC?  
IF NOT ENDEMIC WHERE DO THEY COME FROM?

ANSWER 1

THEY ARE ENDEMIC TO HYPERSALINITY (WEAK POSSIBILITY)

ANSWER 2

LOGICALLY THE WATER OF THE LAGOON OF MESSOLONGHI BRINGS THEM IN

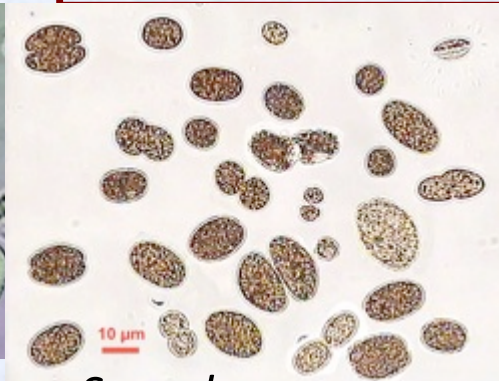
A BROAD SPECTRUM THOROUGH AND LONG LASTING STUDY OF BOTH THE  
LAGOON AND THE SALTERN CAN ELUCIDATE THE SITUATION



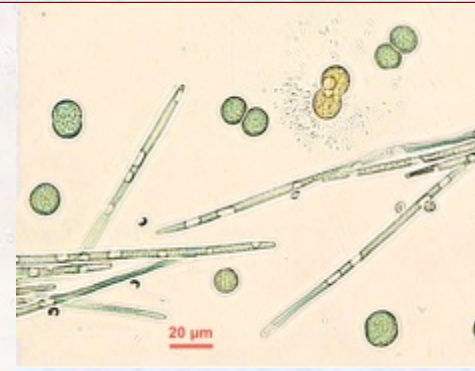
# COCCOID CYANOBACTERIA PLANKTONIC



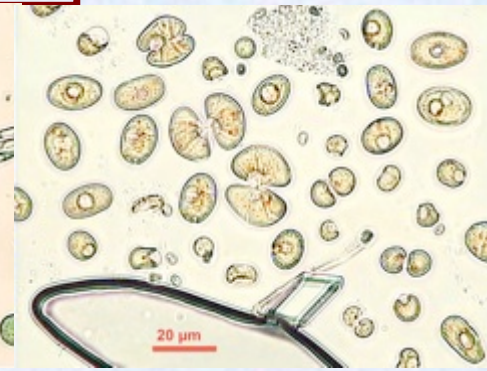
*Cyanothece* sp.



*Synechococcus* sp.

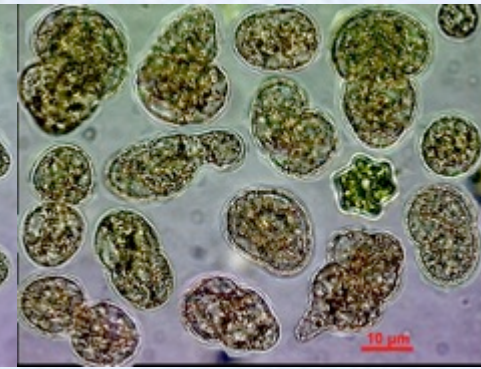
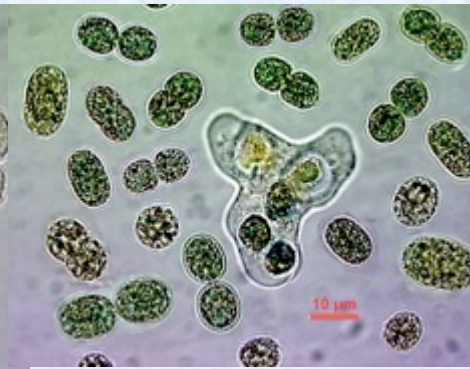
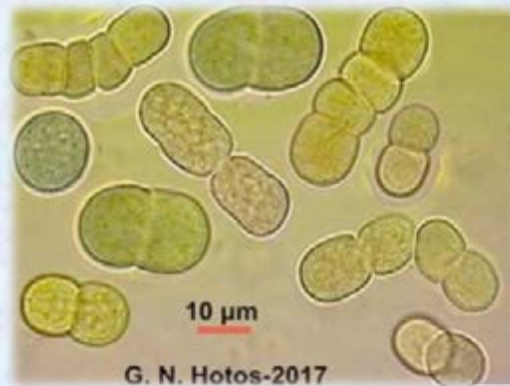


*Aphanothece* sp.



Unidentified

## *Synechococcus* various forms



The most numerous photosynthetic planktonic entities in all salinities

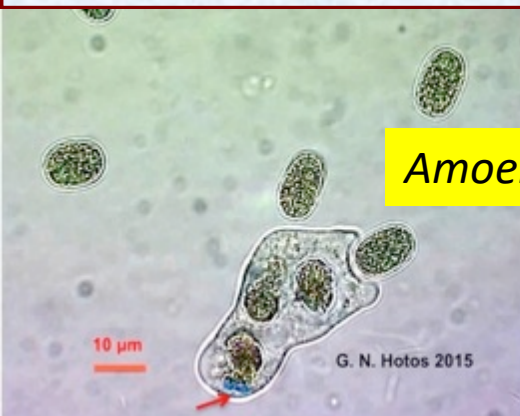
Great variation in cell sizes and forms

Many unidentified species

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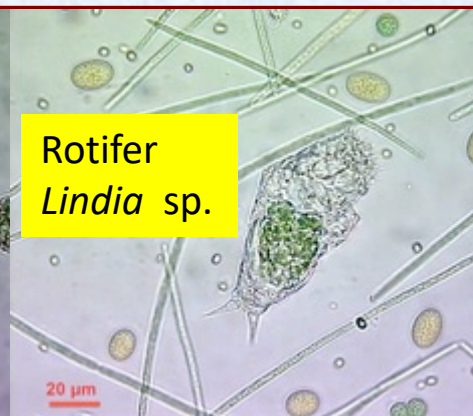
# -COCCOID PLANKTONIC CYANOBACTERIA- THEY ARE FOOD ITEMS FOR VARIOUS HETEROTROPHS



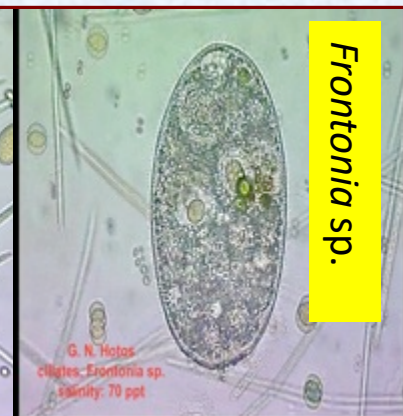
*Amoeba* sp.



Rotifer  
*Lindia* sp.



Rotifer  
*Pleurotrocha* sp.



*Frontonia* sp.



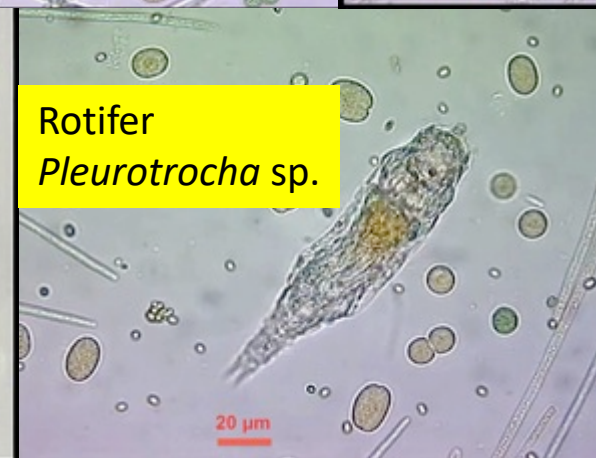
*Condyllostoma* sp.



*Euplotes* sp.

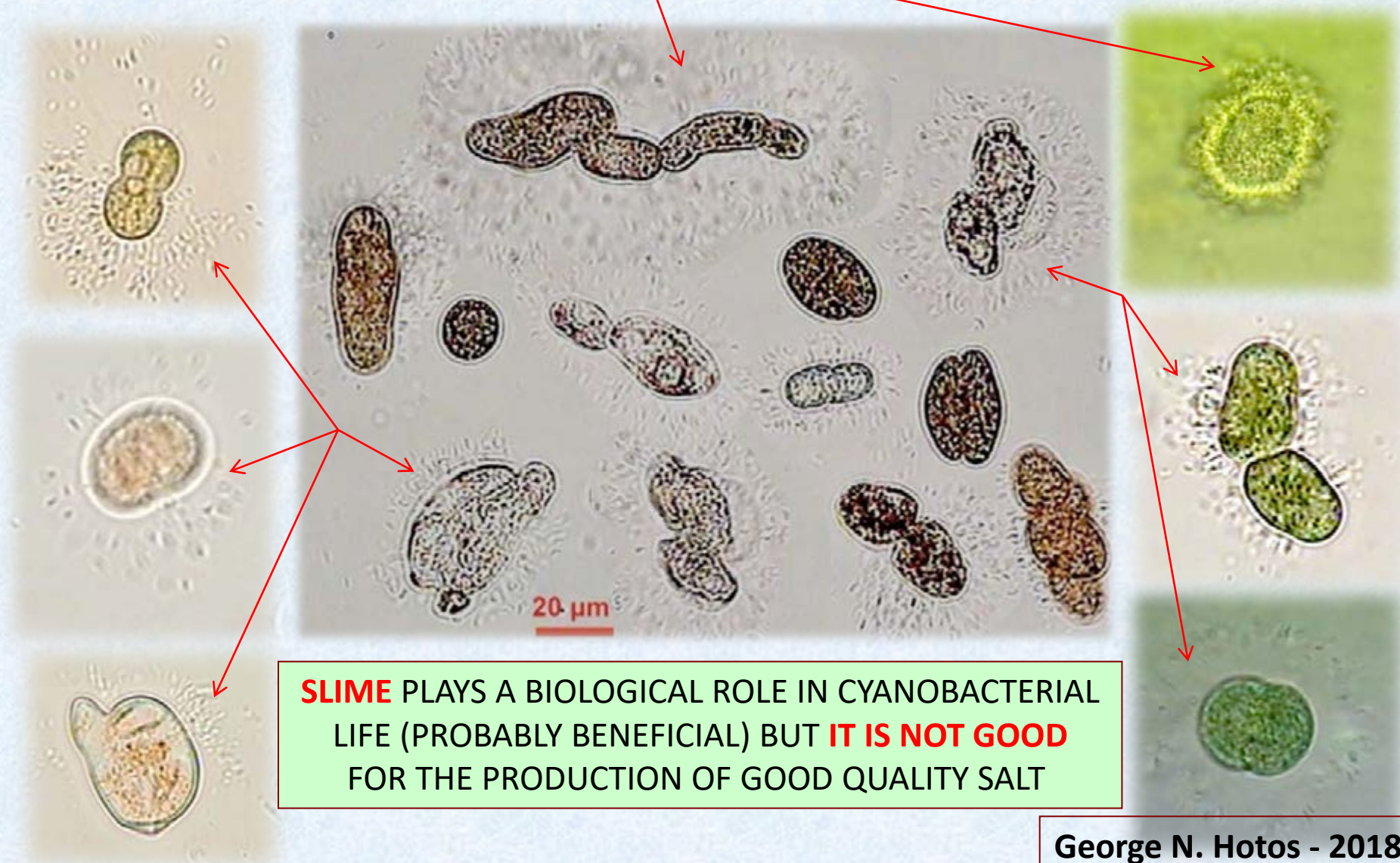


*Climacostomum* sp.?





COCCOID PLANKTONIC **CYANOBACTERIA** PRODUCE AND SECRETE  
MUCILAGINOUS MATERIAL  
THIS IS EVIDENT AS A **SLIME** "CLOUD" AROUND THE CELL

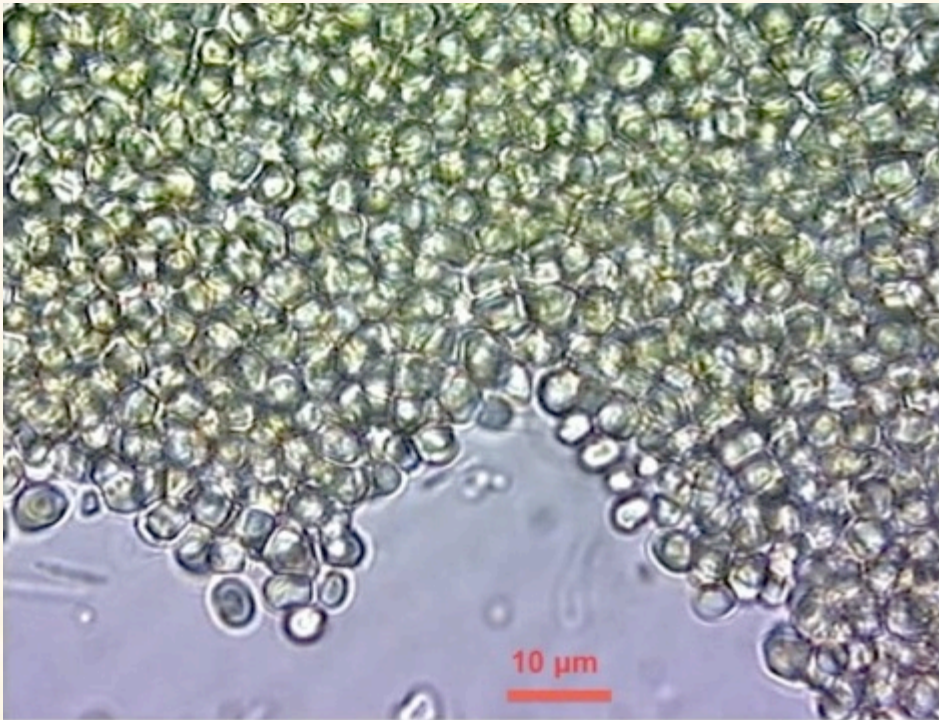




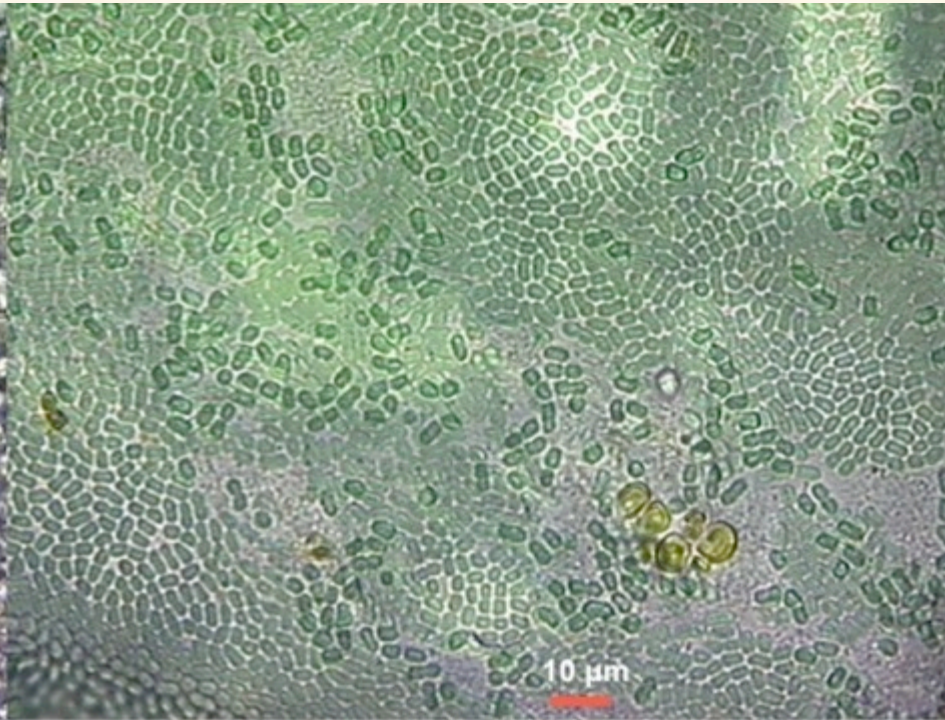
# THE OTHER FORM OF UNICELLULAR COCCOID **CYANOBACTERIA** IS IN **COLONIAL AGGREGATIONS**

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IN HYPERSALINITY THERE WERE NOT FOUND COLONIES EMBEDDED IN  
MUCILAGE



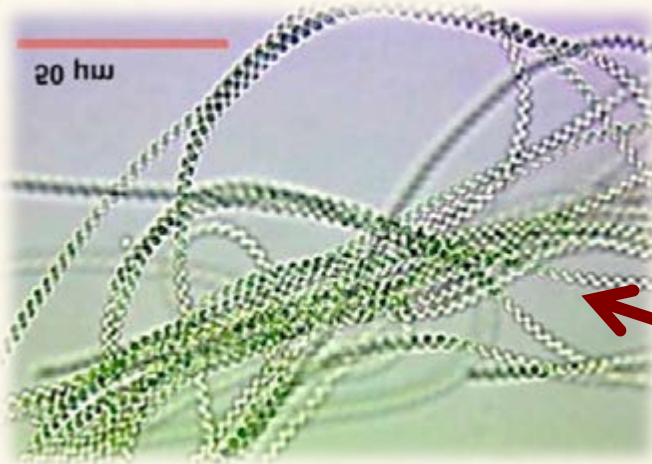
*Microcystis* sp.



*Synechocystis* sp.



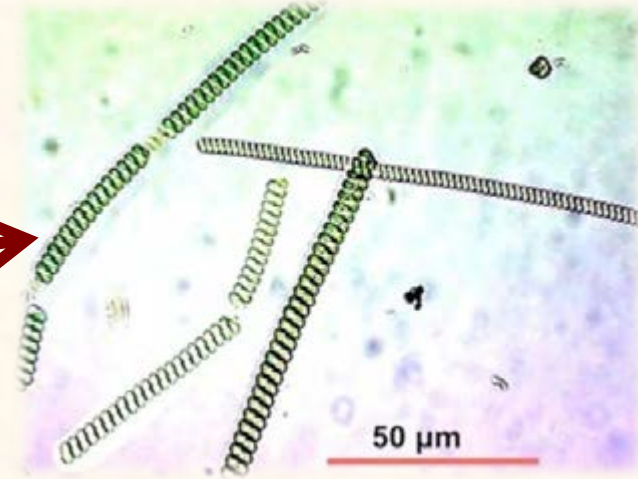
# AN IMPRESSIVE NUMBER OF **FILAMENTOUS CYANOBACTERIA** WAS ALSO RECORDED IN **PLANKTONIC** CONDITION



*Arthrospira (Spirulina)*  
was of the most  
abundant genera

*Spirulina subsalsa*

*Spirulina major*

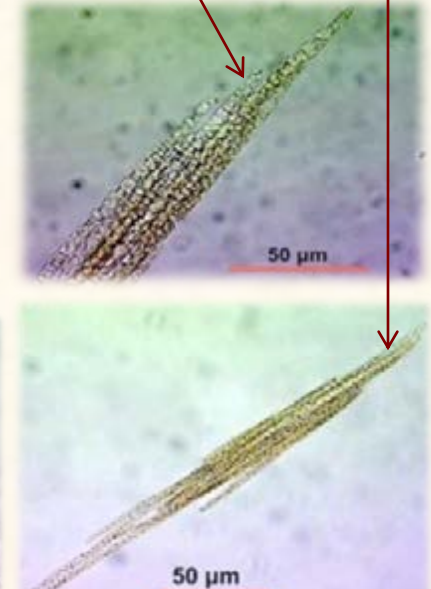
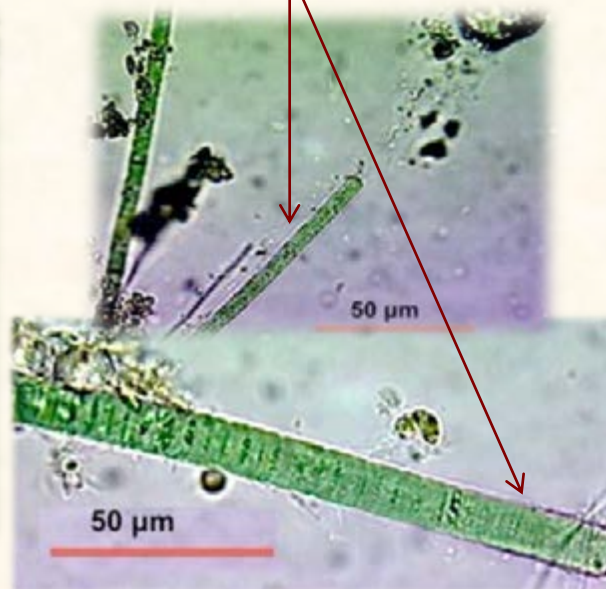
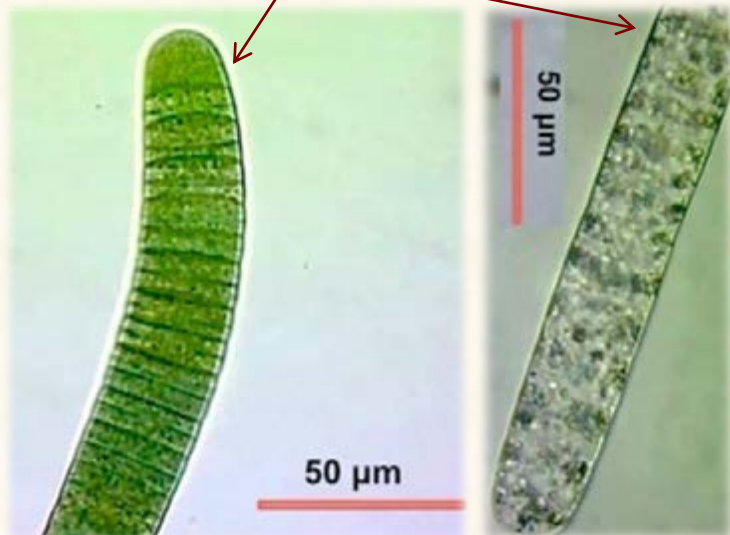


followed in abundance by:

*Oscillatoria*

*Lyngbya*

*Aphanizomenon*

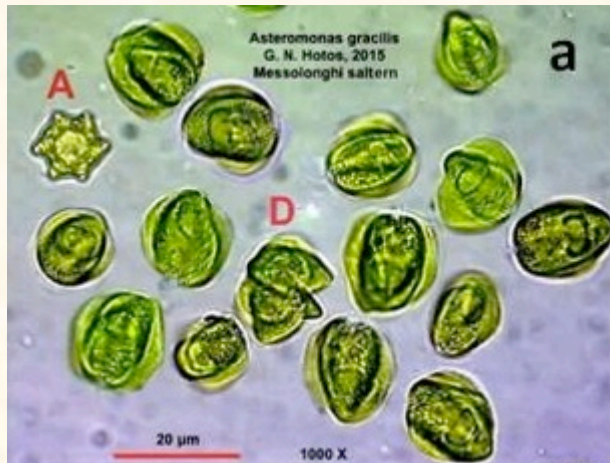




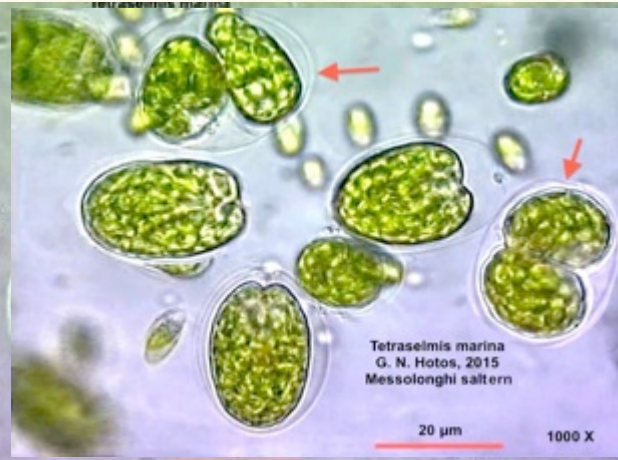
# EUCARYOTIC **MICROALGAE** WERE PROFOUNDLY REPRESENTED BY THE EXTREMELY HALOTOLERANT CHLOROPHYTES:

*Dunaliella salina*, *Asteromonas gracilis* & *Tetraselmis marina*  
and the dinoflagellate *Gymnodinium* sp

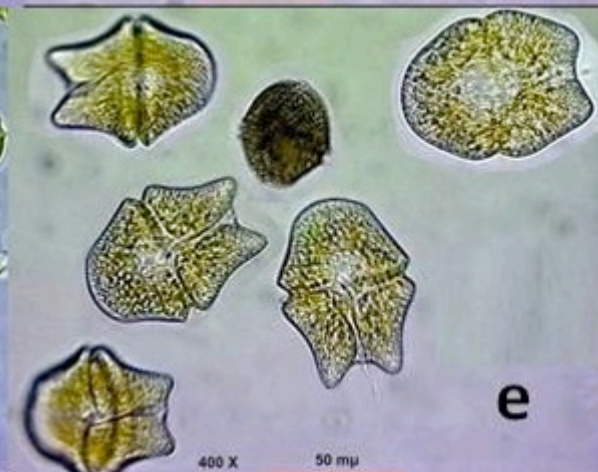
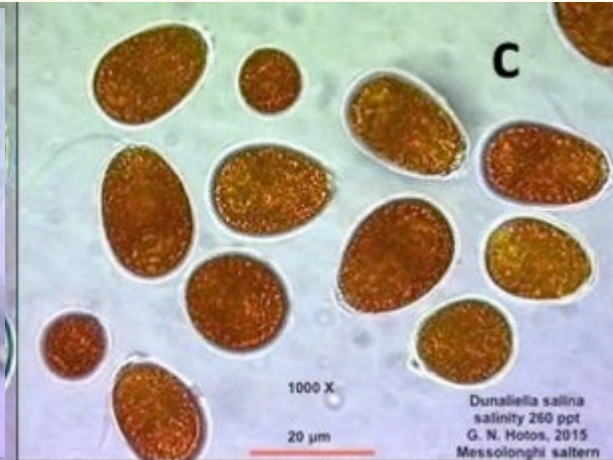
*Asteromonas*



*Tetraselmis*



*Dunaliella*



*Dunaliella*

*Asteromonas*

*Gymnodinium*



*Dunaliella*, *Asteromonas* & *Tetraselmis* CAN ENDURE HARSH CONDITIONS BY FORMING **CYSTS** FROM WHICH FLAGELLATED CELLS EMERGE AGAIN

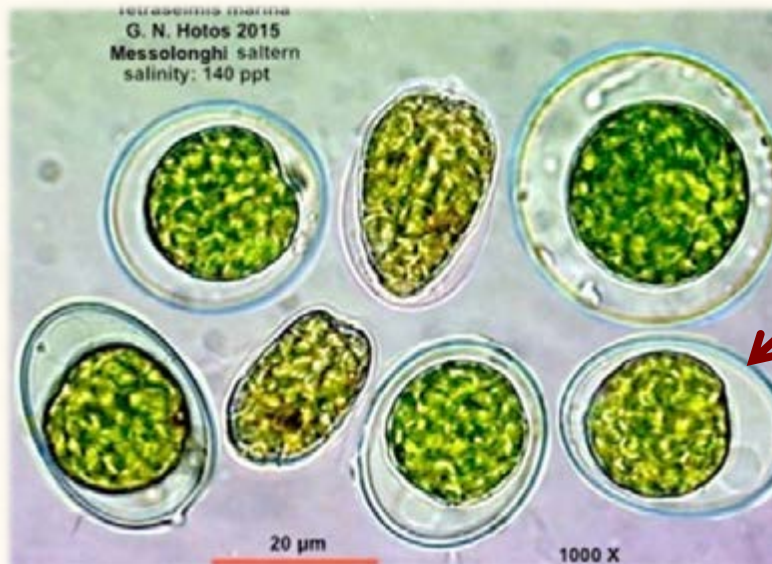


*Asteromonas gracilis*

*Dunaliella salina*

cysts

vegetative cells



*Tetraselmis marina*

palmelloid cysts

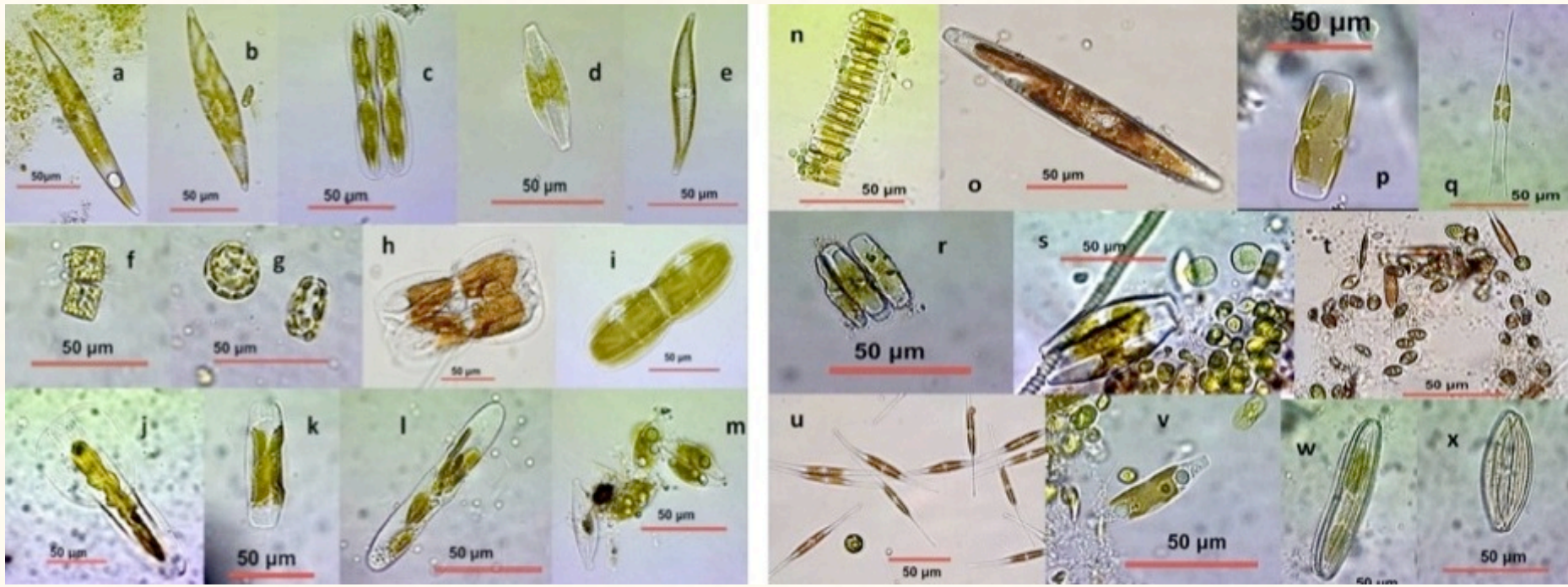


**DIATOMS** (PROTISTA: BACILLARIOPHYTA) WERE NEXT IN ABUNDANCE OF PHOTOSYNTHETIC SPECIES. ONLY PENNATE DIATOMS AND NOT CENTRIC WERE FOUND

**MOST OF THE DIATOMS WERE BENTHIC BUT WERE PRESENT ALSO IN THE PLANKTON**

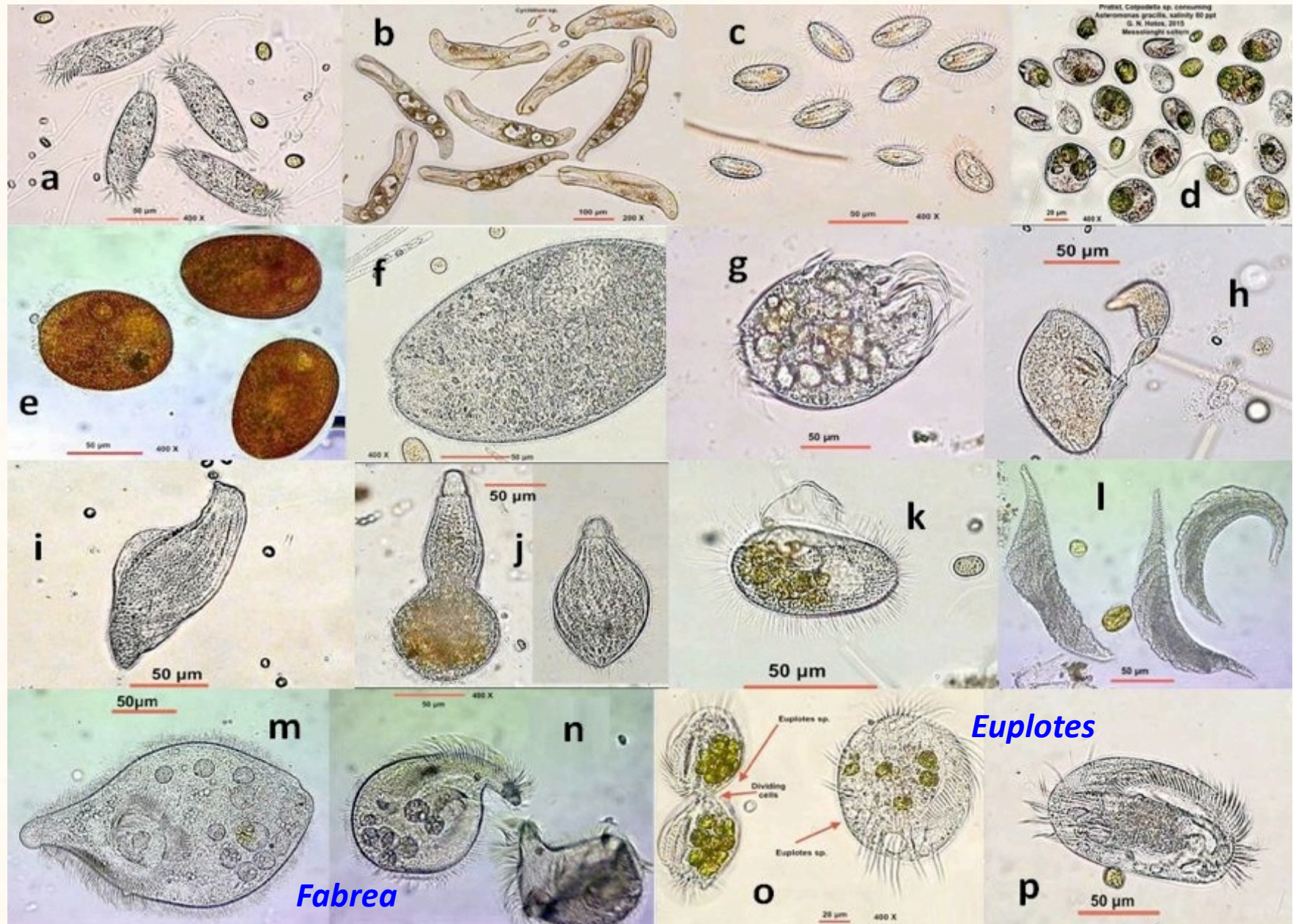
**BASED ON THEIR MORPHOLOGY THERE ARE PROBABLY MANY ENDEMIC STRAINS**

**AN EXTENDED STUDY SHOULD BE MADE FOR THE DIATOMS IN HYPERSALINITY**





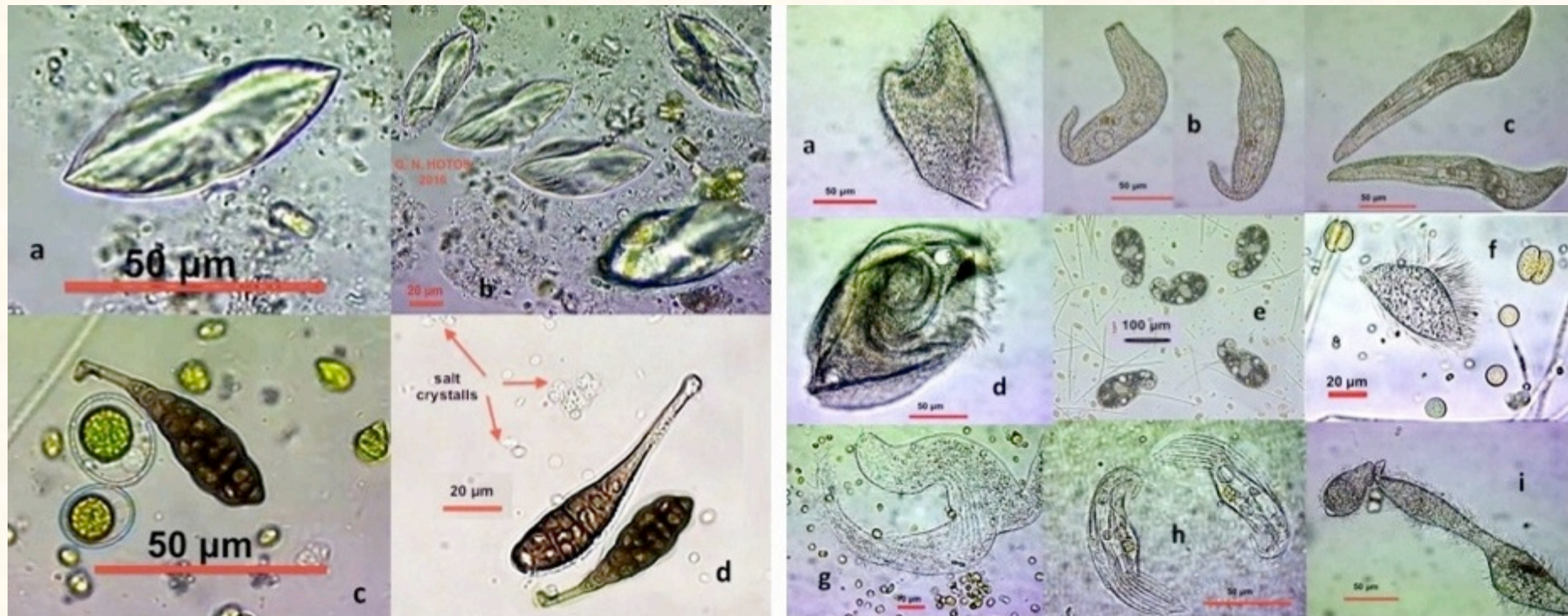
**CILIATE PROTOZOA WERE PRESENT IN ABUNDANCE AND SPECIES RICHNESS  
FOUND IN ALL SALINITIES – MOST ABUNDANT *Euplotes* sp & *Fabrea salina***





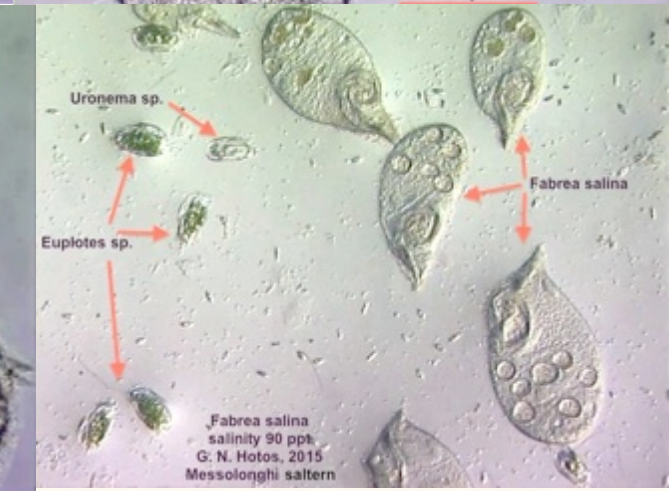
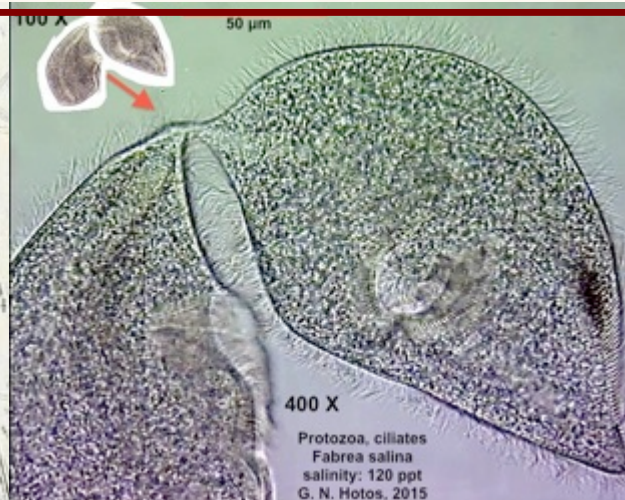
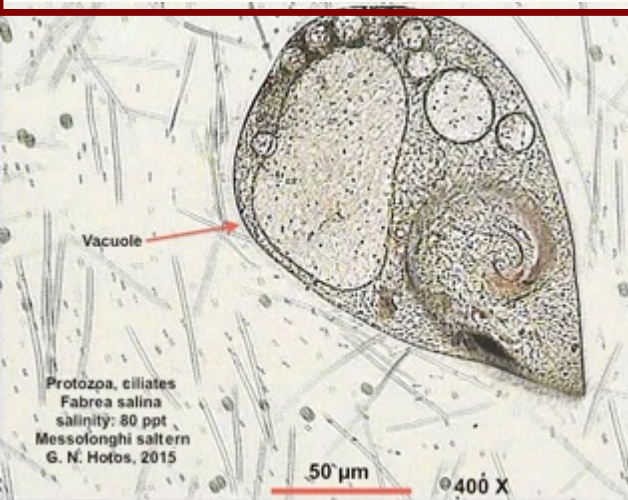
FROM THE COLLECTED **PROTISTS**, MANY SPECIMENS WERE TOTALLY UNMATCHED  
TO THE EXISTED IMAGES FOUND IN THE LITERATURE

IT IS PROBABLE THAT NEW SPECIES CAN BE DESIGNATED AFTER SPECIAL STUDIES



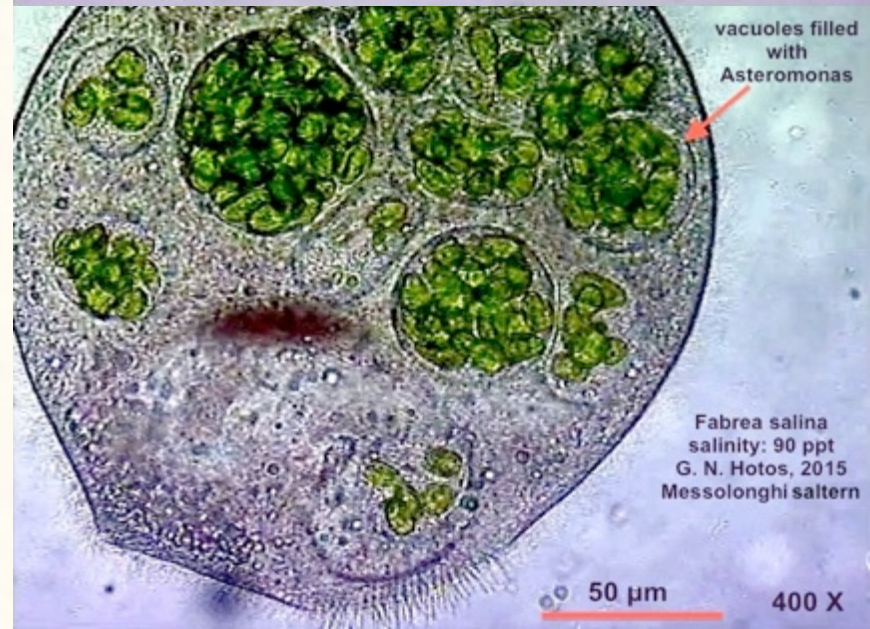
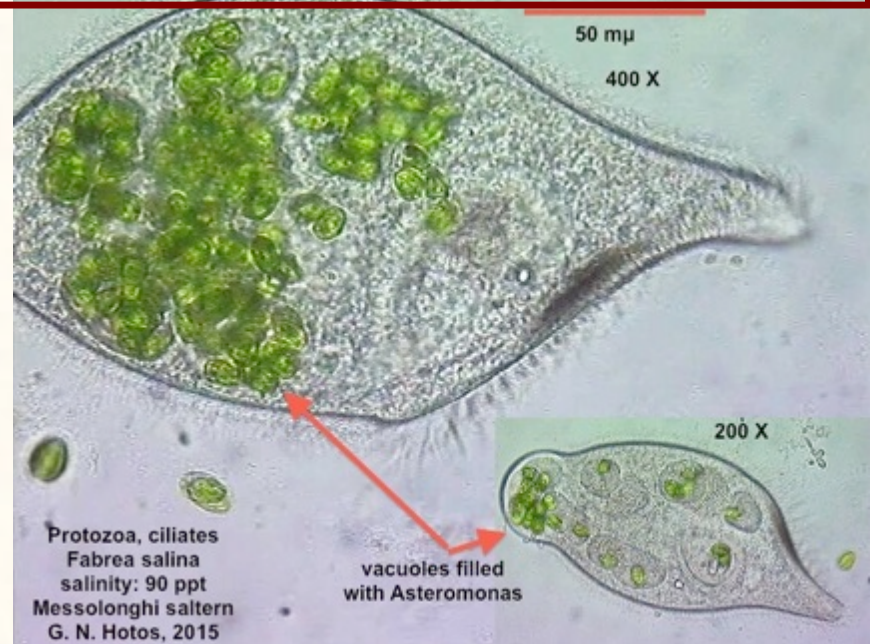
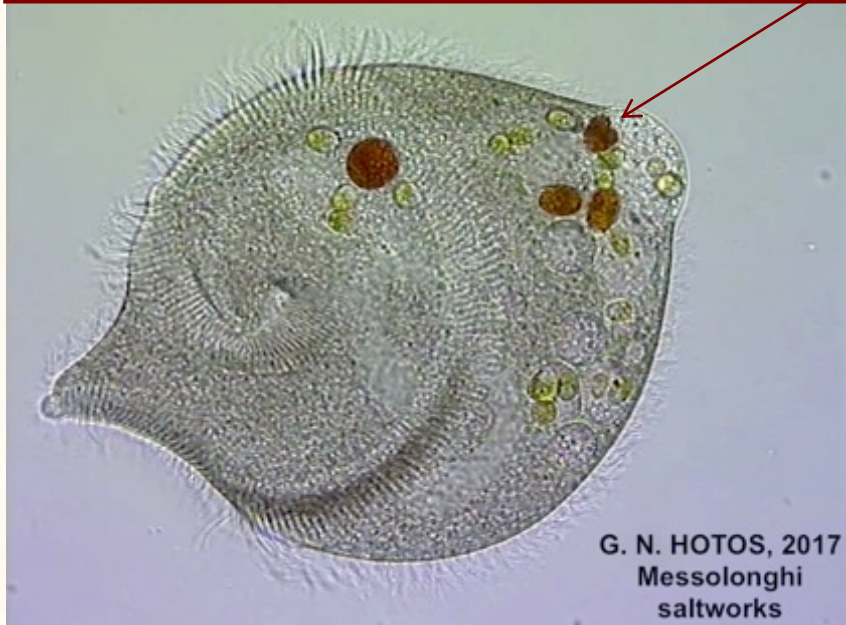


AMONG CILIATES *Fabrea salina* IS THE DOMINANT SPECIES  
 FOUND EVEN AT 200 ppt SALINITIES  
 IT'S A BIG CILIATE 200-300  $\mu\text{m}$   
 CAN BE USED AS LIVE FOOD IN MARINE FISH HATCHERIES





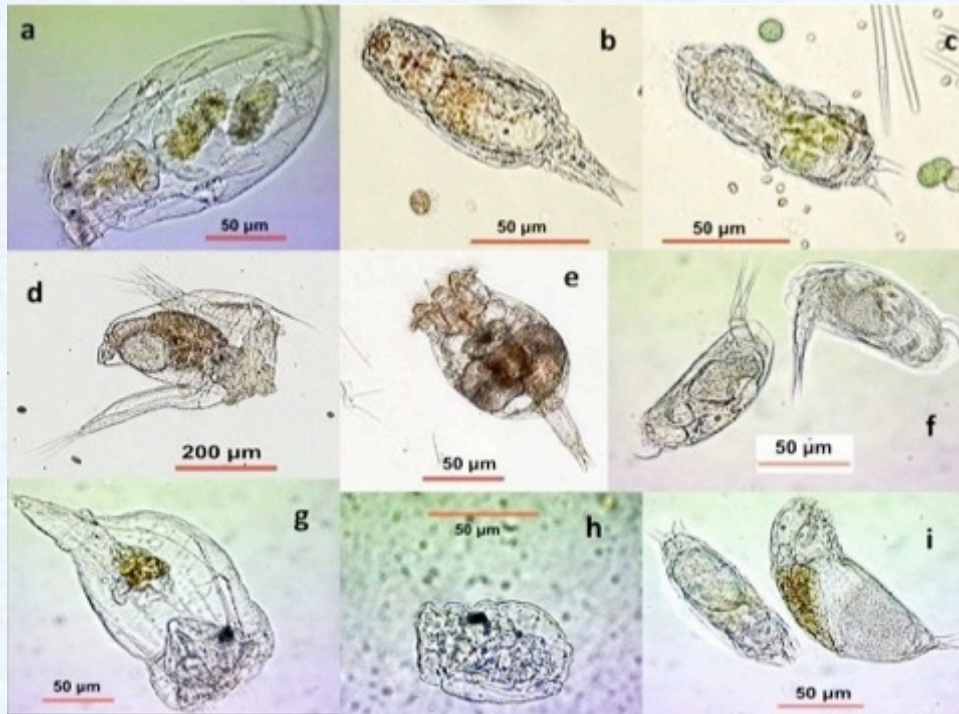
***Fabrea salina* IS A VORACIOUS CONSUMER OF MICROALGAE  
INCLUDING *Dunaliella salina***



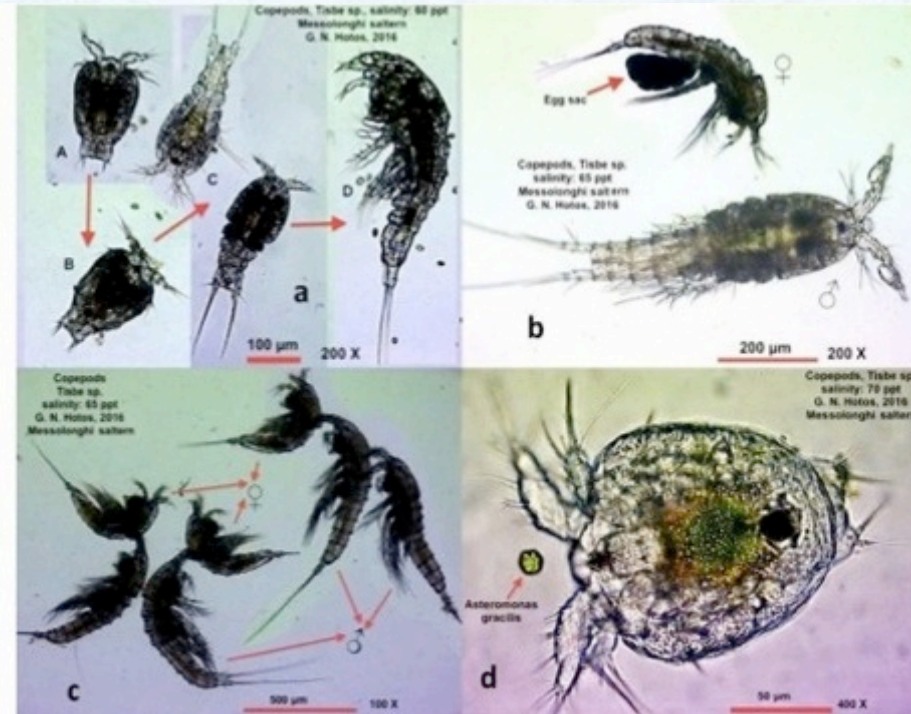


A LOT OF METAZOANS MAINLY **ROTIFERS**, **COPEPODS** AND OF COURSE **ARTEMIA** WERE FOUND IN HYPERSALINITY EXCEPT FOR ARTEMIA, THEIR BIOLOGICAL ROLE IN PRODUCTIVITY OF THE SALTURNS IS TO BE ELUCIDATED – THEY ALL CAN BE USED AS LIVE FOOD IN HATCHERIES

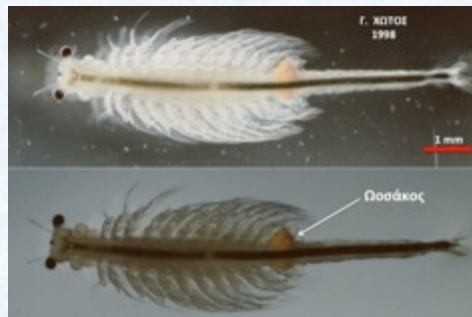
## ROTIFERS



## COPEPODS



## ARTEMIA



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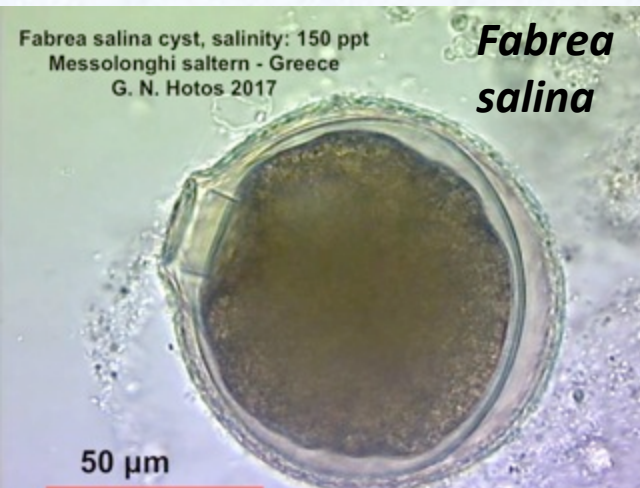


**MANY ORGANISMS IN HYPERSALINITY CAN REMAIN  
FOR LONG PERIOD IN THE SEDIMENT IN  
CRYPTOBIOSIS  
BY MEANS OF ENCYSTMENT OR RESTING EGGS  
THIS IS THEIR MODE OF SURVIVAL  
CONFRONTING DESICCATION**

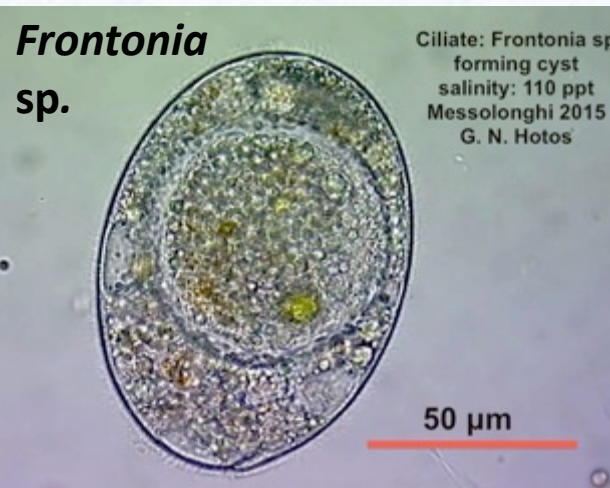


*Unknown*

50 μm



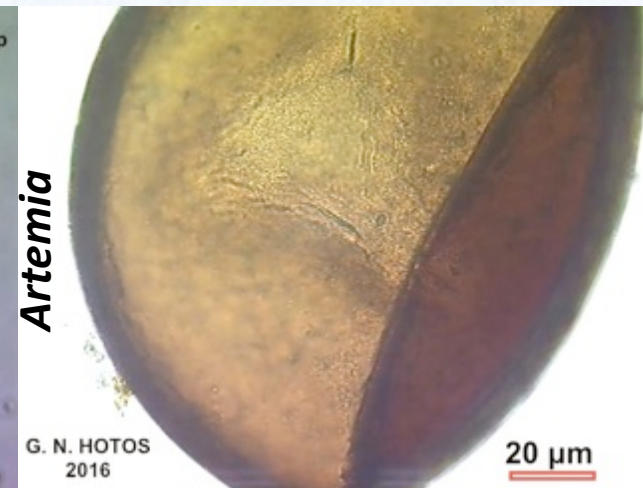
*Fabrea  
salina*



*Frontonia  
sp.*

Ciliate: Frontonia sp  
forming cyst  
salinity: 110 ppt  
Messolonghi 2015  
G. N. Hotos

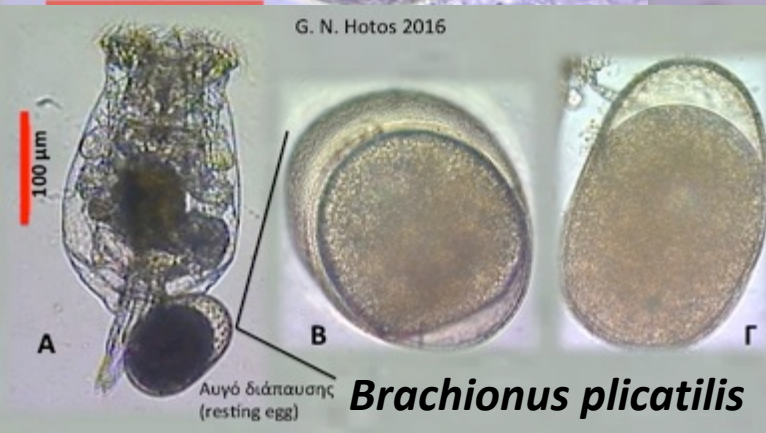
50 μm



*Artemia*

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2016

20 μm



G. N. Hotos 2016

*Brachionus plicatilis*

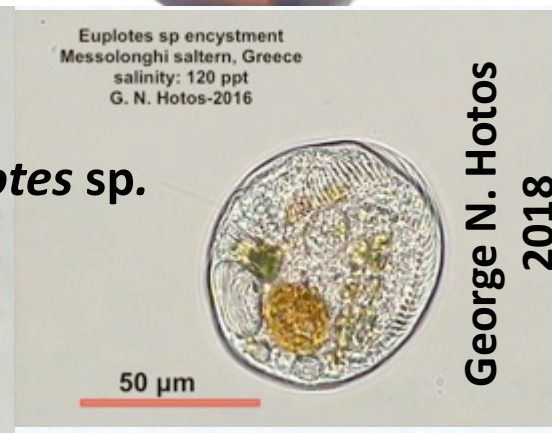
Αυγό διάπαυσης  
(resting egg)



Euplotes sp., encystment  
salinity: 115 ppt  
Messolonghi saltern Greece  
G. N. Hotos-2016

50 μm

*Euplotes sp.*



Euplotes sp encystment  
Messolonghi saltern, Greece  
salinity: 120 ppt  
G. N. Hotos-2016

50 μm

George N. Hotos  
2018





**THANK YOU  
FOR YOUR ATTENTION**

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