
Lake Kuriftu
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Zooplankton Biomass and Production


BIOMASS AND PRODUCTION OF MAJOR ZOOPLANKTON
IN LAKE KURIFTU, ETHIOPIA
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Zooplankton Biomass and Production
5

1. Introduction

- ZP plays important role in AE

Eg.

- Affects water transparency
- Affect suspended algae
- Affects fisheries

- Many fishes depend on ZP during some stages of the developmental cycle.
- 2^0 -production is an increase of biomass including reproductive products within unit of time.
- Important for transfer of energy and materials in AS (Downing, 1984)
- the goal of ecological dynamics in AS (Kimmerer and Mckinnon, 1987)

1. Continued ...

- Few quantitative works on ZP production.
  - L. Uganda 44 mg DW d^{-1} *T. hyalinus production*(Burgis, 1974)
  - L. George 34 mg DW d^{-1} herbivore ZP *production*(Lewis, 1979).
- However poor study in tropical lakes

Reasons

- Mixed population (Rigler & Downing, 1999)
- Need culturing of ZP (Vijerberg, 1989)
- Dominancy by temperate study

1. Continued ...

- In Ethiopia the only studies on ZP production
  - L. Awassa (Seyoum Mengistou, and Fernando 1991)
  - L. Tana (Ayalew Wondie and Seyoum Mengistou 2006)
  - Reasons for poor studies
    - Complex culturing system
    - Immature science
    - Dominancy of phyto and fish studies

2. objectives

- General:
  - To estimate biomass and production of the major zooplankton groups in relation to physico-chemical condition and algal biomass in Lake Kuriftu.

2. Continued ...

- Specific:
- To estimate biomass and production of the major zooplankton species
- To identity which zooplankton species contribute most to secondary production.
- To identify the major factors which are important in determining the biomass and production of zooplankton.
- To provide further baseline data for proper management, fish production and sustainable utilization of Lake Kuriftu.

3. Description of the study area

- Debrezeit crater lake
- altitude of 1860 m, 47 km SE AA.
- at 80 47' N and 390 00' E.
- shallow (6 m) artificial lake formed by diverting and damming Belbela River
- About 850 mm *per annum* rainfall
- *Trees, Accacia abyssinica, Jacaranda mimosifolia* and species of *Eucalyptus* and *Juniperus.*
- Macrophytes, *Passifloraceae* and *Passiflora subpeltata ortega*

3. Continued....

- **Mean air To. 3.5 to 13.8^{0}C, max, 24.0 to 28.4^{o}C**
- **Lake To. 20^{o}C to 27.4^{o}C**
- **Zooplankton**
  - ***Thermocyclops (Thermocyclops consimilis)+++***
  - **rotifers (Brachionus spp)++**
  - **cladocerans (Ceriodiaphnia, Daphnosoma, moina)**
- **Phytoplanktons**
  - **Cyanophyceae (*Microcystis aeuroginesa++)***
  - **Chlorophyceae**
  - **Bacillariophyceae**
  - **Dinophyceae**
  - **Cryptophyceae**
  - **Euglenophyceae**
- Fishes (Personal observation)
  - *Oreochromis niloticus*,
  - *Cyprinius carpio*
  - *Barbus*

3. Continued …

Fig.1 Map of D[illegible]ezeit and crater lakes surrounding Lake Kuriftu (After Lamb, 2001)

Map of Debre-zeit and crater Lakes including Lake Kuriftu (After Lamp, 2001)

Sampling protocol

- Monthly samples from August to May 2009
- Two sites, near-shore (2m depth) and Middle lake (5m depth)
- Monthly ZP sampling by 64-µm, 30 cm mouth opening and 1.2 cm cod end mesh
- 4% formaldehyde preserved
- Live sampling of ZP
- Water sampling for chemicals and phyto. Biomass estimates
- Sampling for Phyto. identification (Lugol's preserved)

4. Continued …

- Secchi depth by standard Secchi disc of 20 cm diameter.
- pH *in situ* with a portable digital pH meter.
- Depth profiles of oxygen and temperature by digital oxygen meter.
- Carbonate-bicarbonate alkalinity by titration with HCl to a pH of 4.5 in the laboratory
- NO_3-N, PO_4-P, SiO_4 in laboratory

4. Continued ...

Laboratory procedures

- *T.consimilis* cultured for biomass estimation
- In 60 ml vessels incubated thermostatically (20 & 25.9 0c)
- fed mixed algal culture (Guillard' s F/2 media)
- Developmental time for egg to nauplii, nauplii to copepodites and copepodites to adults (by observation)

4. Continued ...

- **Phytoplankton Identification**

  Keys on phytoplankton (Whitford and Schumacher, 1973; Gasse, 1986;)

- Zooplankton Identification

  By keys on ZP, (Vogit and Koste, 1978; Van de Velde, 1984; Defaye, 1988 and Fernando, 2002).

Abundance Estimation of ZP

4. Continued …

- 30ml from 210 ml on grid lined Petri-dish
- Three transects counted by microscope(6-50x)
- Counted results extrapolated to m^{-3} of lake water by:

$$V=\prod r^2 d$$

- Where, V is the volume of the water filtered (l).

  r is the radius of the net (m).

  d is the length of the course of the net through the water (m).

Biomass of Phytoplankton

4. Continued …

- chlorophyll a concentration spectrophotometrically from water samples filtered through glass fiber filters (GF/C). Chlorophyll a was extracted from the phytoplankton concentrate with aqueous acetone (90%).

4. Continued …

Biomass and production of rotifers

- the recruitment method (Edmondson & Winberg, 1971).

$P = Px * W$

Where
P = Production
Px = recruitment of new individuals
W = Mean individual body dry weight

$Px = N_f * B$

Where
N_f = number of females
B = finite birth rate

$B = E/De$

Where
E = proportion of eggs per female
De = egg development time

De will be calculated using the formula of Bottrell et al. (1976)

$Ln\ De = \ln a + b.\ln t + c. (\ln t)^2$

Biomasse or dry weight from Biovolume calculassions

4. Continued …

Biomass and production of copepods

- Length (L) of Nauplii, copepodites and Adults from cephalothorax to the end of the abdomen

$DW = 2.257\ L^{2.252}$, DW = dry weight

(Seyoum Mengistou and Fernando, 1991)

zooplankton biomass per m³ as

$B = N \times DW$, N = density per m^3

Zooplankton production per m³ per day as

$$P = (N_e W_e) T_e^{-1} + (N_n \Delta W_n) T_n^{-1} + (N_c \Delta W_c) T_c^{-1}$$

(Winberg et al., 1965)

Daily and Annual P:B ratio also determined

4. Continued …

- **One way analysis of variance (ANOVA) on:**
  - ZP abundance between the two sites
  - ZP abundance among ten months
  - ZP biomass among ten months
  - ZP production among ten months

5. Results

Physicals and some chemicals parameters

				Z_{SD} (m)		Temperature (°c)		Oxygen			
								surface		5m depth	
Months	pH	TA	PA	OP	NS	Surface	5m depth	mg/L	%	mg/L	%
Aug	8.20	2.40	0.20	ND	ND	22.30	24.20	6.46	75	4.95	64
Sep	8.50	2.80	0.00	0.50	0.49	19.40	24.11	6.46	75	4.95	64
Oct	8.60	2.90	0.00	0.51	0.50	24.50	24.52	5.97	78	4.93	64
Nov	8.56	2.50	0.00	0.54	0.52	24.50	22.40	5.50	72	4.03	60
Dec	8.93	2.20	0.00	0.60	0.51	20.80	20.81	4.56	63	4.02	59
Jan	8.59	1.90	0.00	0.51	0.49	20.30	19.74	4.40	62	3.58	44
Feb	8.64	1.90	0.50	0.56	0.54	22.00	20.73	2.80	52	0.95	12
Mar	8.81	2.40	0.40	0.54	0.48	22.10	21.83	4.50	63	3.58	44
Apr	8.34	2.30	0.40	0.41	0.39	23.80	23.83	5.89	77	3.55	43
May	8.31	2.90	0.00	0.39	0.37	24.78	23.00	5.80	76	4.03	60

Mean Z_{SD} = 0.51m
Max. 0.60 december
Min. 0.37 May

Surface To
Mean 22.45°c
Max. 24.78°c May
Min. 19.4°c September

Surface oxygen
Max. 5.97 mg/l, 78 %
O_2 In October
Min. 0.95 mg/l, 12%
O2 In February

Total alkalinity
Max. 2.9meq/l in October
Min. 1.9meq/I in January

pH
Max. 8.95 in December
Min. 8.20 in December

Chemical Parameters

Months	NO_3-N (µg/L)		PO_4-P (µg/L)		SiO_2 (mg/L)		B (mg Chl a m^{-3})	
	NS	OP	NS	OP	NS	OP	NS	OP
Aug	36.67	35.30	12.93	18.28	7.17	7.59	17.12	17.45
Sep	35.00	36.00	8.64	21.80	7.82	8.02	28.40	29.81
Oct	35.00	34.00	20.15	24.96	8.12	7.00	36.97	36.97
Nov	32.60	35.00	9.91	31.96	7.31	10.04	29.68	38.43
Dec	35.00	38.00	9.28	10.96	9.74	8.93	20.04	29.68
Jan	34.30	34.00	13.57	34.96	8.36	10.47	13.62	17.51
Feb	34.00	35.30	28.22	34.96	9.22	8.74	44.27	49.14
Mar	39.30	38.70	37.35	36.96	7.66	8.13	53.03	48.16
Apr	35.00	33.00	19.44	20.90	5.60	6.98	63.73	46.22
May	44.60 Max	41.30	37.00 Max	35.96	6.03	7.21	27.73	17.51

NO_3-N (µg/L):
Max. 44.60 may (NS)
Min. 32.60, Nov (NS)
Mean = 36.15(NS)
Mean = 36.0? (OP)

PO_4-P (µg/L):
Max. 37.00 May (NS)
Min. 8.64 Sept (NS)
Mean = 19.65(NS)
Mean = 17.2? (OP)

SiO_2 (mg/L):
Min. 5.60 April (NS)
Max. 10.47 Jan (OP)
Mean = 7.70(NS)
Mean = 8.31 (OP)

NO3-N > L. Babogaya (1-3), Bishoftu (25), Awassa (7-20) and > L. Ziway (28.1-36.5)

PO4-P < L. Bishoftu (24?), Arenguade (3200), Ziway(90), Chamo(26-91) and > L. Babogaya (1-11), Kilole (2?)

SiO2 < the above lakes except L. Chamo (0-4)

4. Continued . . .

Phytoplankton identified

Phytoplankton group	Species name
Cyanophyceae Cyanobacteria (Blue-green algae)	*Cylindrospermopsis africana* Kom and Kaling
	C. curvispora M. Watanbe
	C. curvispora
	Planktolyngebya tallingii Kom and Kaling
	Planktolyngebya contorta (Lemm.) Anagn. And Kom
	Peridiniopsis elpatiewskyi
	Microcystis aeruginosa Rab.
	Anabaena circinalis Rab.
	Anabaena nygaerdinom.
	Psuedoanabaena sp.
	Raphidiopsis sp.
Chlorophyceae (Green algae)	*Pediastrum simplex* Meyen
	P. duplex Meyen
	P. tetras
	Scenedesmus armatus Chod
	S. acuminatus
	S. denticulatus
	S. dimorphus (Turp.) Kutz.
	S. quadricauda (Turp.) Breb.
	S. bicaudata
	Chlamydomonas reticula
	Coelestrum micropsporum
	C. acutum
	Phacotus lenticularis (Ehr.) Stein
	Monoraphidium minutum
	M. contoratum
	Pseodosphaerocystic lacustris
	P. angustus
	Tetraedron minimum
	T. muticum
	Tetrastrum netercanthium

6 classes
44 spp

Cyanobacteria abundant
Cylindrospermopsis curvispora and *Microcystis aeruginosa*

Green algae diverse group

Diatoms the 3rd group

The other 3 groups poorly present

4. Continued . . .

Bacillariophyceae (Diatoms)	*Thalassiosira sp.* *Cymbella naviculiformis* *Navicula cryptocephala* Kutz *Nitzschia vermicularis*(Kutz.)Grun. *N. rostellate.* *Rhopahodia sp.*
Dinophyceae (Dinoflagellates	*Peridinium sp.*
Cryptophyceae (Cryptomonads)	*Cryptomonas obovata* Skuja *C.marssioni* *C.orata*
Euglenophyceae (Euglenoids	*Phacus longicauda* (Ehr.) Duj. *P.tortus* *Lepocincilis sp.*

Similar to L. Babogaya (32), L. Chamo (44) but < to L. Ziway(67), Awassa (70)

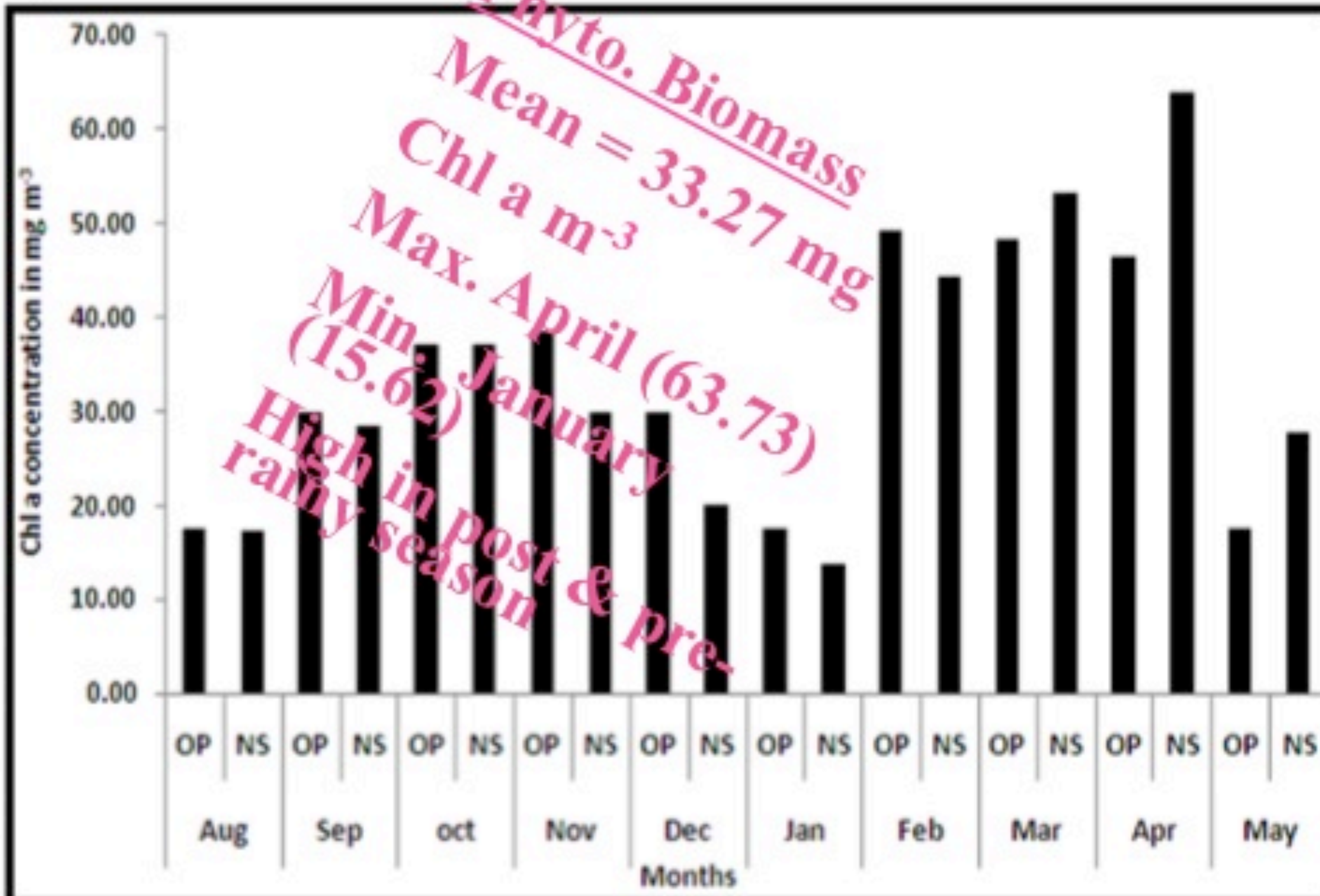


Fig.2. Monthly Chlorophyll a concentration at near shore (NS) and Open water (OP) in Lake Kuriftu.

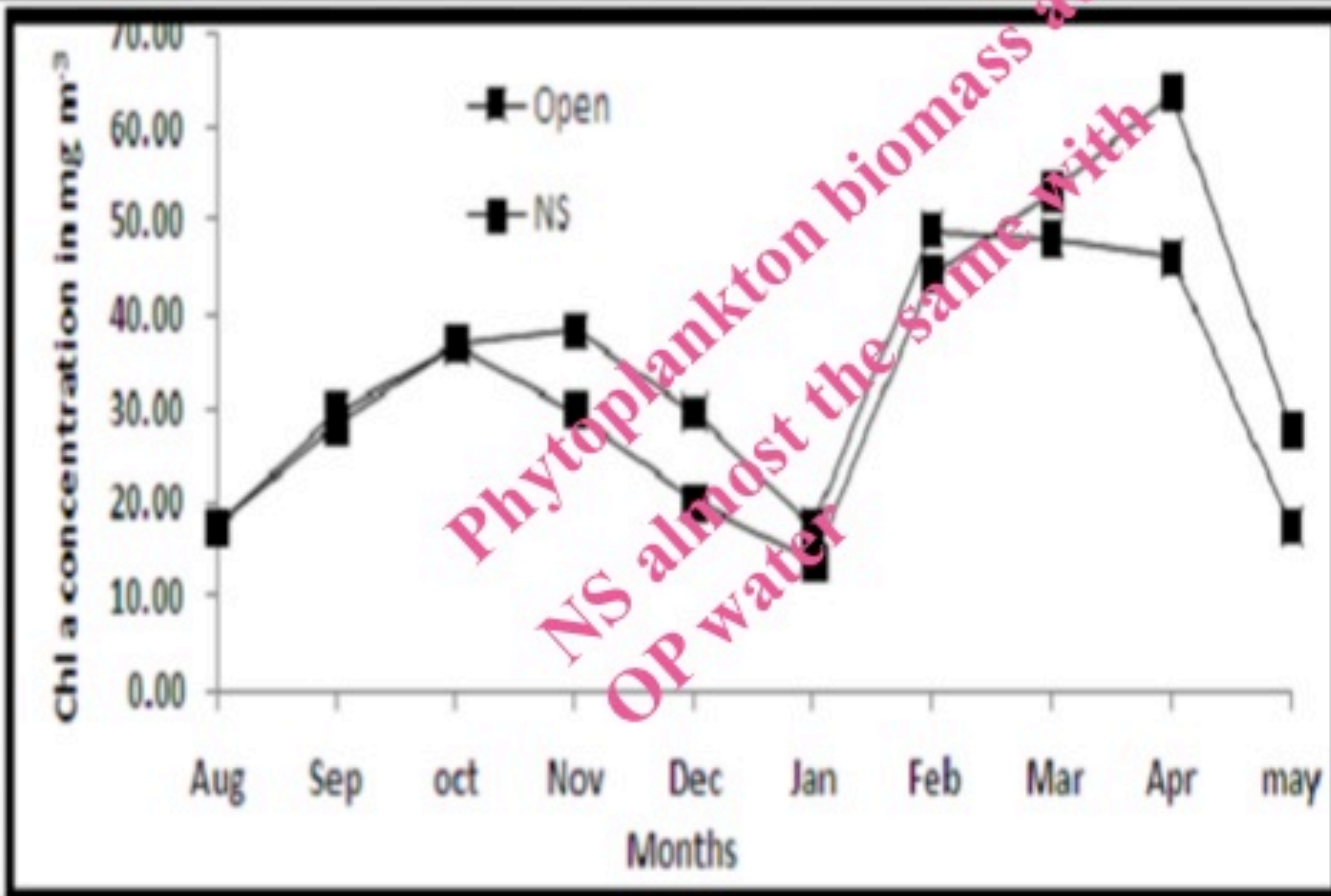
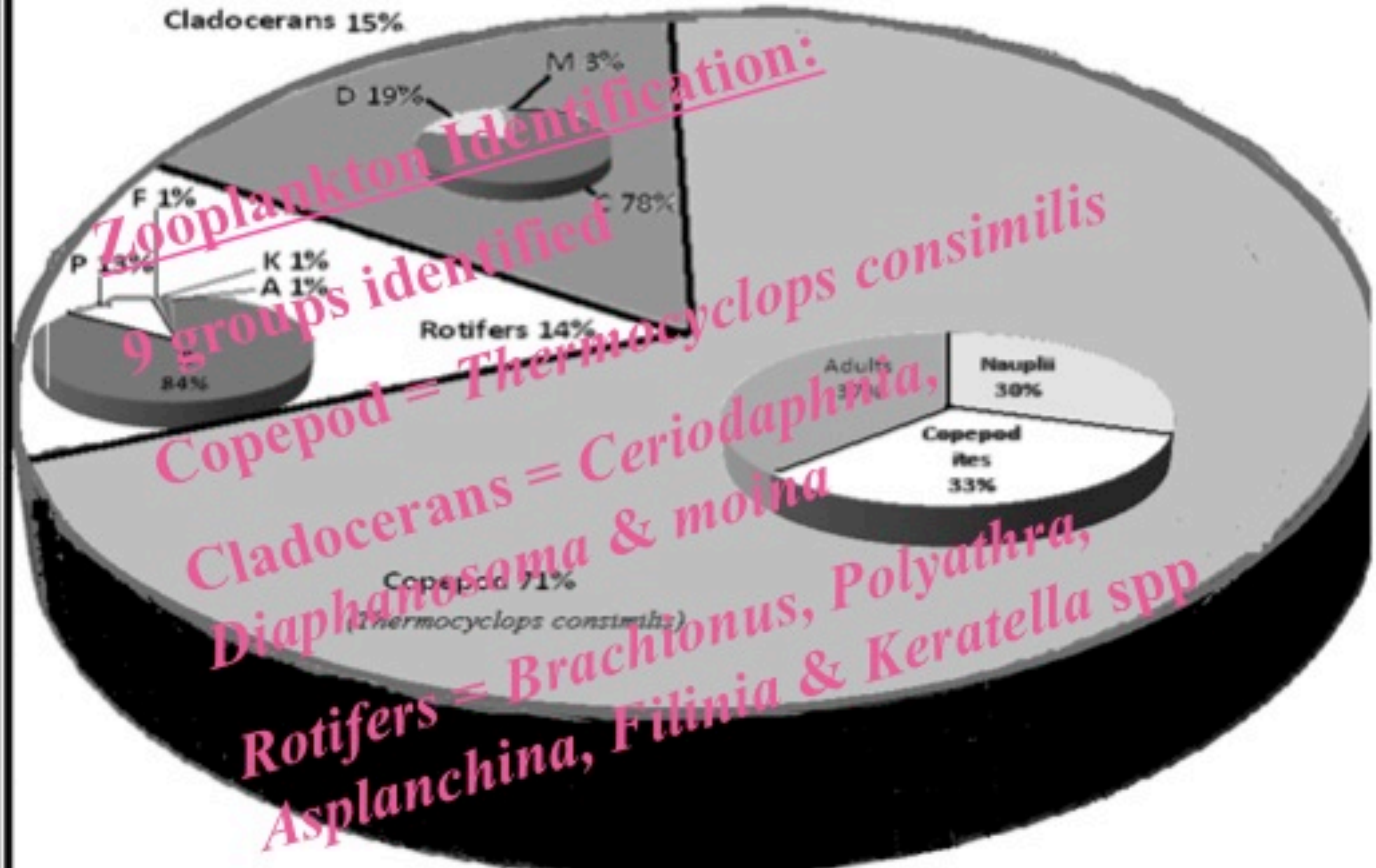


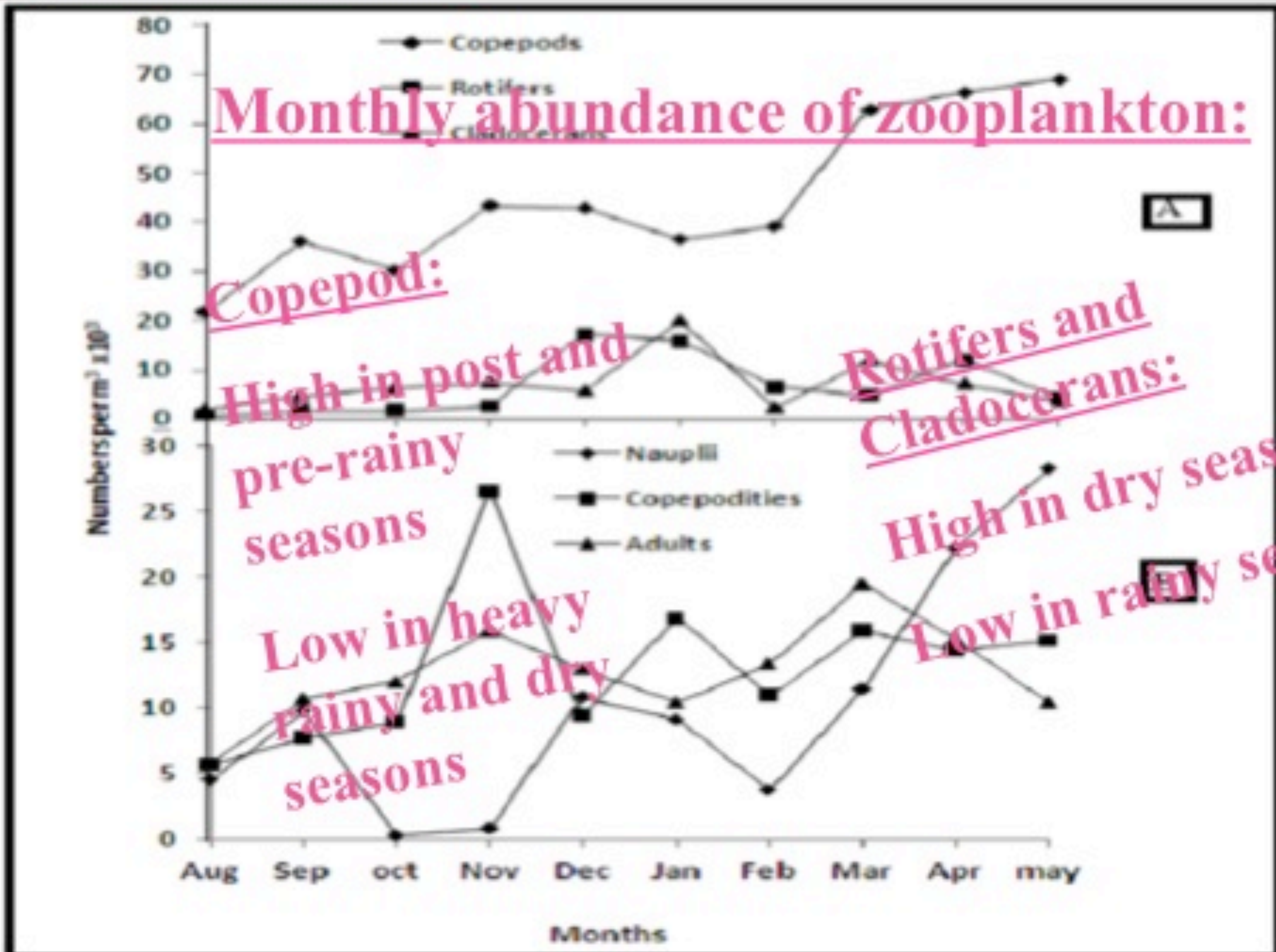
Fig.3. Comparative chlorophyll a concentration at near shore (NS) and open water (OP) in Lake Kuriftu

5. Continued ...



Ceriodaphnia (C), moina (M), Diaphanosoma (D), Aspalancha spp (A), Brochionus spp (B), Keratella spp (K), Polyathra spp (p)and Flina spp (F)

Monthly abundance of zooplankton:



Copepod:

High in post and pre-rainy seasons

Low in heavy rainy and dry seasons

Rotifers and Cladocerans:

High in dry seasons

Low in rainy seasons

Fig5. Mean numerical densities of copepods, rotifers and cladocerans (A) and stages of *T.consimilis* (B) in Lake Kuriftu.

Temporal and spatial variation of zooplankton abundance

Table 7. One-way analysis of variance for Copepods, Rotifers and Cladocerans between sampling sites (A) and between months (B).

Source	SS	DF	MS	F	P Value
(A)			Copepods		
Between Sites	17196207.3	1	17196207	0.04918	0.82700
Error	[illegible]256330	18	349680907		
total	6311452538	19			
			Rotifers		
Between Sites	10235514	1	10235514	0.2[illegible]	0.64805
Error	[illegible]14998	18	47495278		
total	[illegible]5150512	19			
			Cladocerans		
Between Sites	477[illegible]2.05	1	47738[illegible]	0.12339	0.729465
Error	[illegible]371540	18	3860[illegible]		
total	701145170	19			
(B)			Copepods		
Between Months	4[illegible]0	9	47067[illegible]	2.30001	0.09559
Error	[illegible]828	10	200381183		
total	631[illegible]0338	19			
			Rotifers		
Between Months	674672643	9	74[illegible]27	3.93556	0.02189
Error	190477869	10	190[illegible]		
total	865150512	19			
			Cladocerans		
Between Months	516843137	9	57427015	[illegible].11592	0.045599
Error	184302033	10	18430203		
total	701145170	19			

Between sites

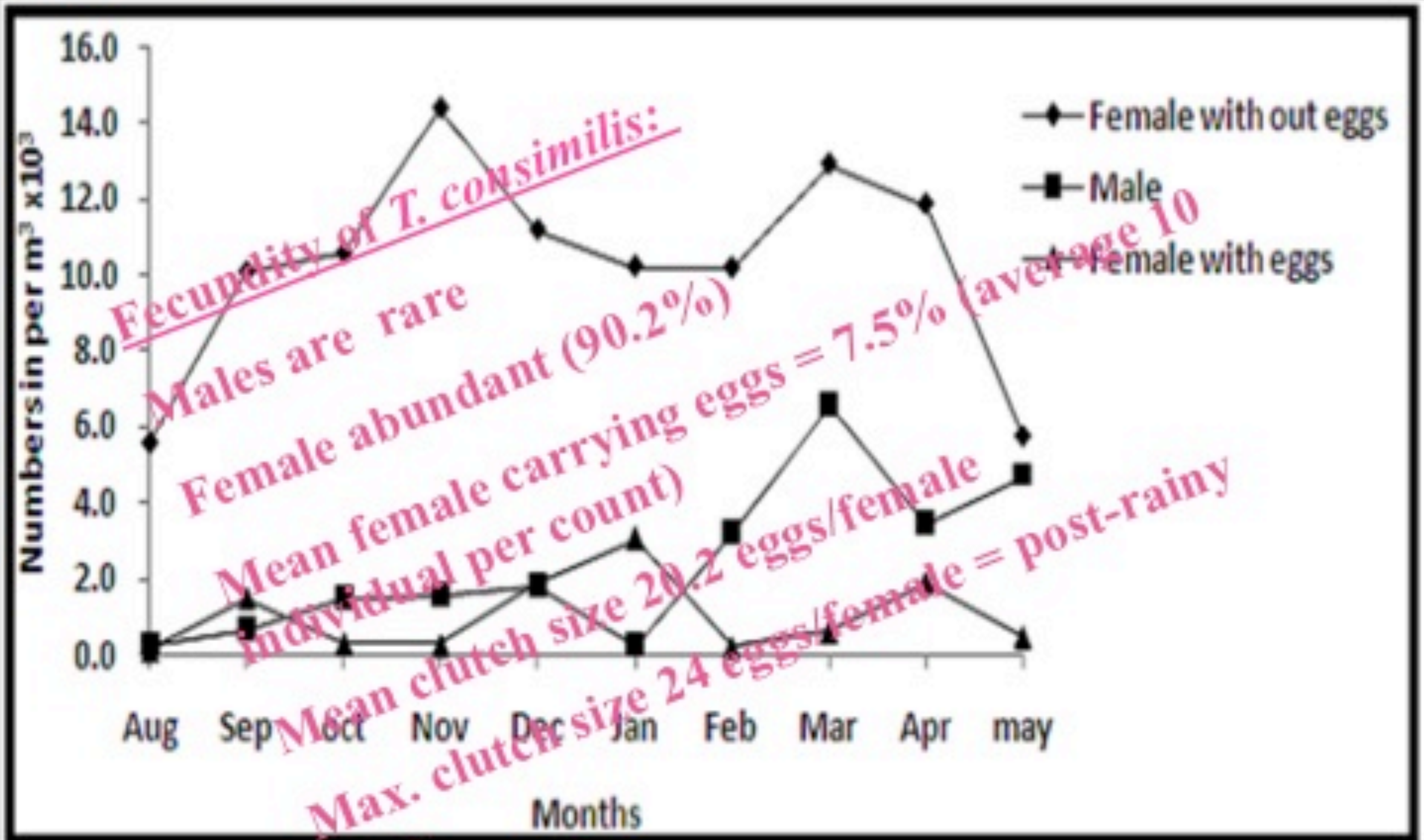
All zooplankton group were not significant

Among ten months

Copepod = insignificant

Cladocerans and rotifers significantly different

5. Continued ...



Fecundity of T. consimilis:

Males are rare

Female abundant (90.2%)

Mean female carrying eggs = 7.5% (average 10 individual per count)

Mean clutch size 20.2 eggs/female

Max. clutch size 24 eggs/female = post-rainy time

Fig8. Mean numerical densities of female without eggs, male and female with eggs of *T consimilis* in the adult count in Lake Kuriftu for the period August 2008 to May 2009.

5. Continued ...

Table 8. Developmental time (days) of Different stages of *T. consimilis* in Lake Kuriftu.

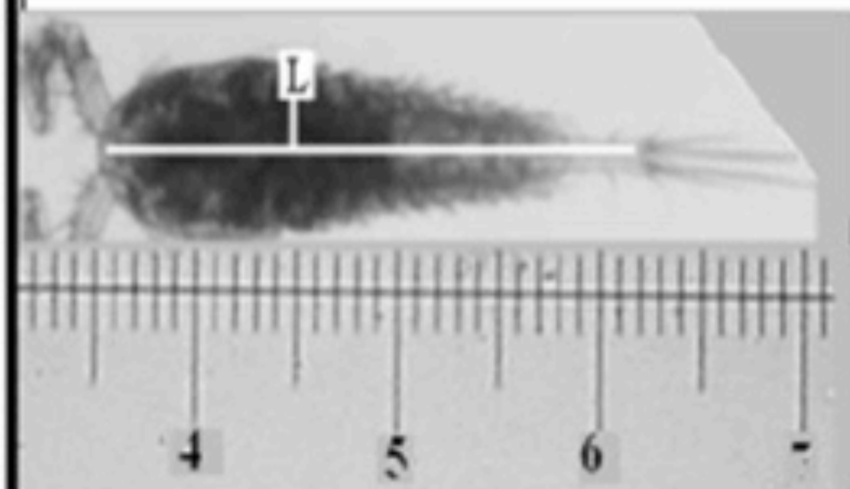
Duration of development of *T. consimilis*

stages	20°c	25.6°c
Egg to nauplii (stage IV)	2.1	1.75
Nauplii to copepodites (stage IV)	5.5	4.20
Copepodities to adult	13.2	10.10
Total	21.4	16.05

5. Continued ...

Dry weight estimate of *T. consimilis*

stages	N	Length (L) in mm	WW in µg	DW in µg
Eggs	2	0.064±0.002	0.021	0.0046
Nauplii	25	0.23±0.20	0.038	0.082
Copepodities	25	0.55±0.18	2.67	0.59
Adult male	17	0.75±0.19	5.36	1.18
Adult female	20	0.78±0.11	5.85	1.29
Adult mean			5.60	1.23

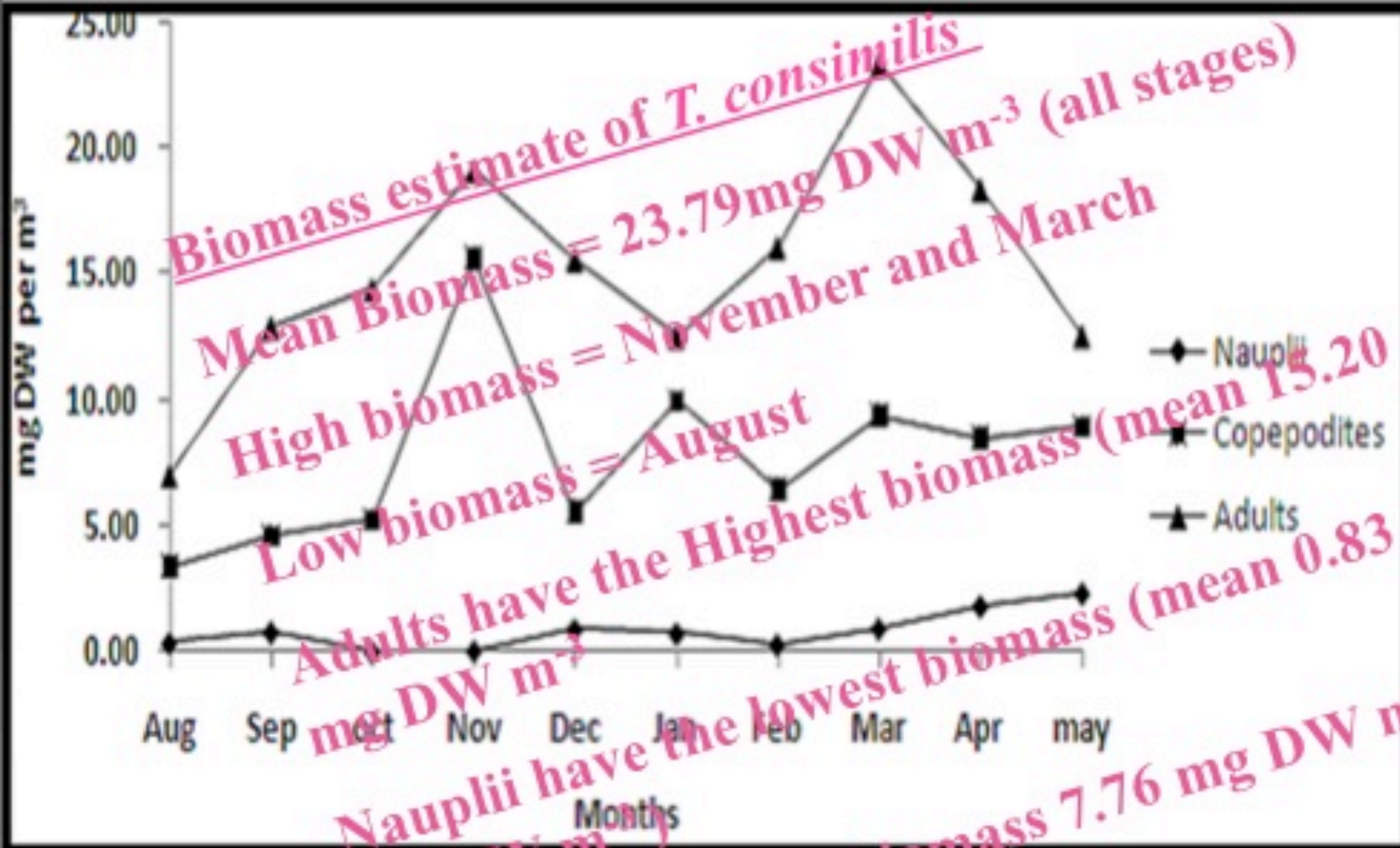


⇨ Ocular Micrometer

$$WW = 10.227 L^{2.249}$$

$$DW = 2.257 L^{2.252}$$

5. Continued ...



Biomass estimate of *T. consimilis*

Mean Biomass = 23.79mg DW m^{-3} (all stages)

High biomass = November and March

Low biomass = August

Adults have the Highest biomass (mean 15.20 mg DW m^{-3})

Nauplii have the lowest biomass (mean 0.83 mg DW m^{-3})

Copepodites mean biomass 7.76 mg DW m-3

Fig9. Standing biomass (mg DW m^{-3}) of nauplii, copepodites and adult of of T.consimilis in Lake Kuriftu

5. Continued ...

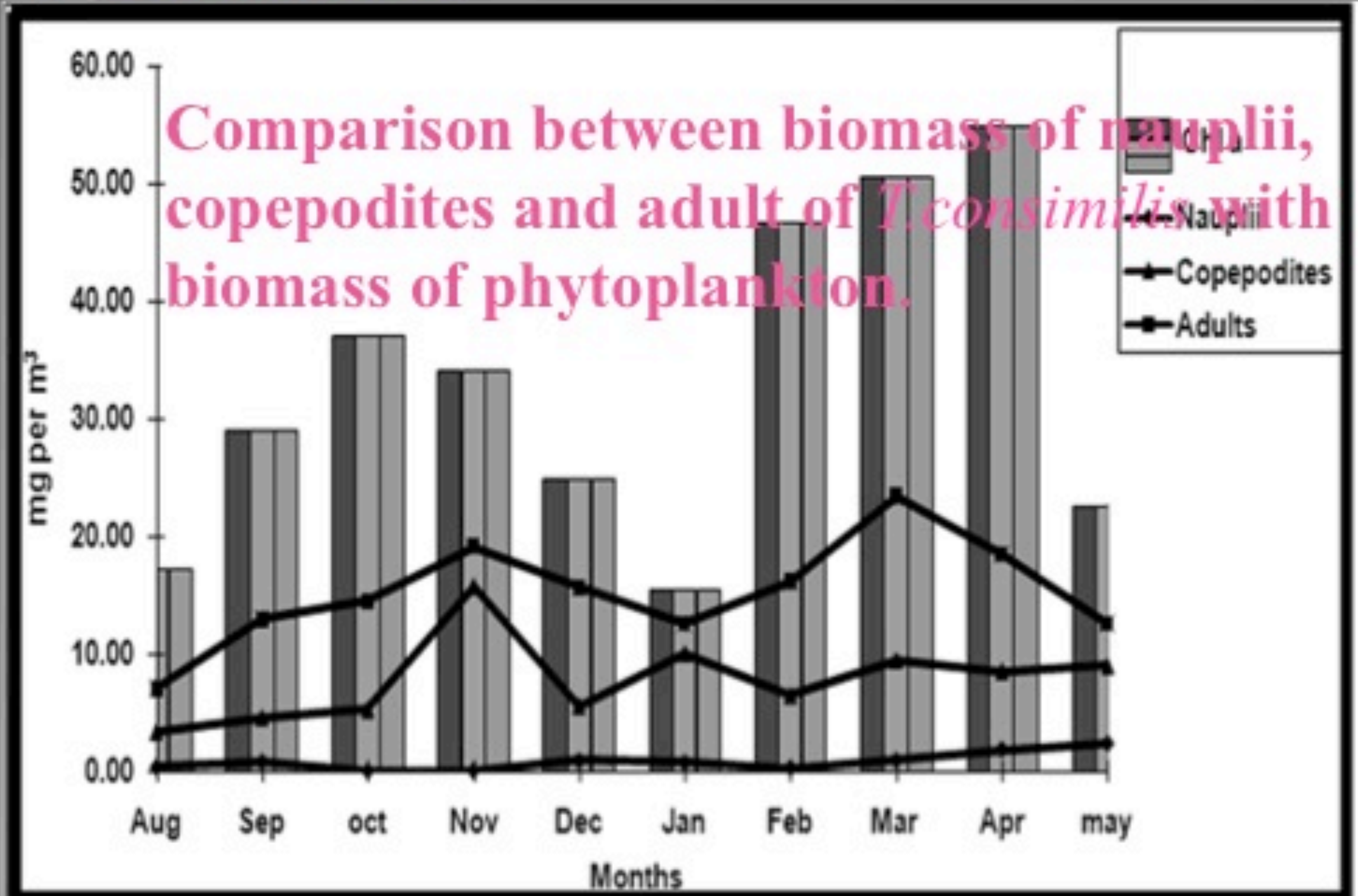


Fig 10. Comparison between biomass of nauplii, copepodites and adult of *T.consimilis* with biomass of phytoplankton in Lake Kuriftu.

5. Continued ...

T. Consimilis production

Mean 0.78 mg DW m^{-3} d^{-1} (all stages)

Max (1.21 mg DW m^{-3} d^{-1}) in November and May

Min (0.33 mg DW m^{-3} d^{-1}) in August

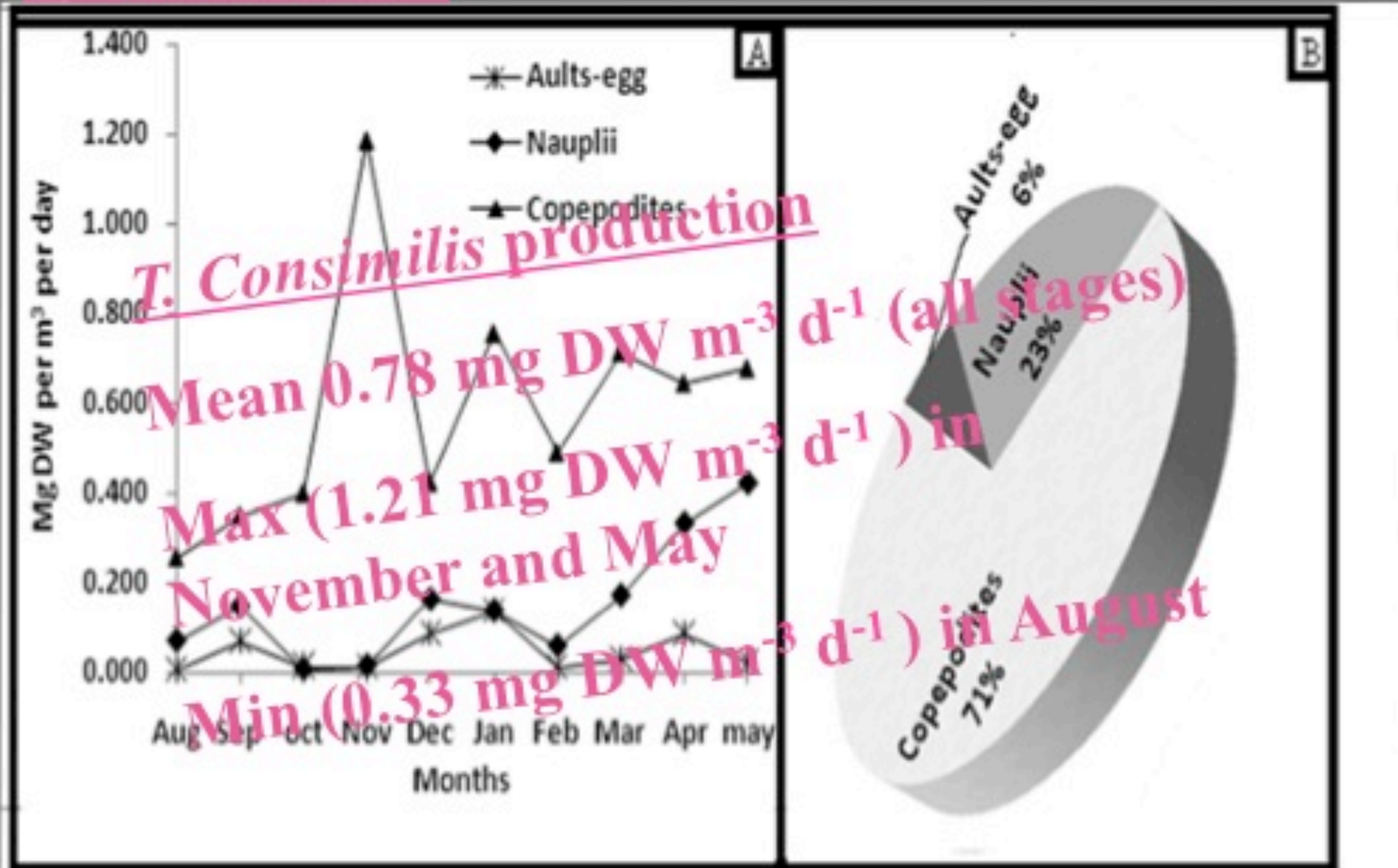


Fig.11. production (mg DW m^3) (A) and percentage contribution (B) of nauplii, copepodites and adults-eggs of *T.consimilis* in Lake Kuriftu for the period August, 2008 to May, 2009

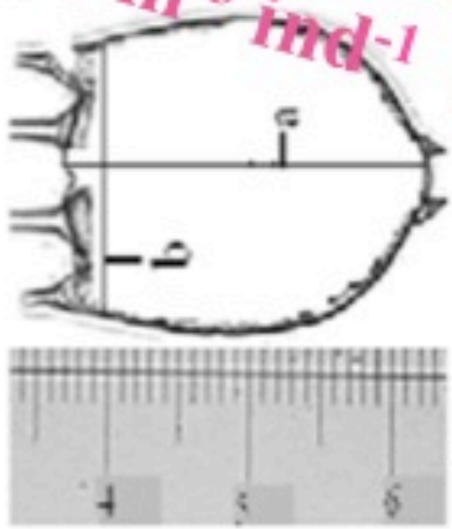
5. Continued ...

Rotifers (*Brachionus calyciflorus*) dry mass µg DW m^{-3} ind^{-1} estimation

Species	Geometric formula used	Measurements for formula	Dimensions	Biovolume	Factor	Biomass
Brachionus calyciflorus	Cylinder $=\pi r^2 h$	a = h b = 2r	a = 155 b = 60	438030	26%	0.11

Body

a = length
b = width



Ocular Micrometer

5. Continued ...

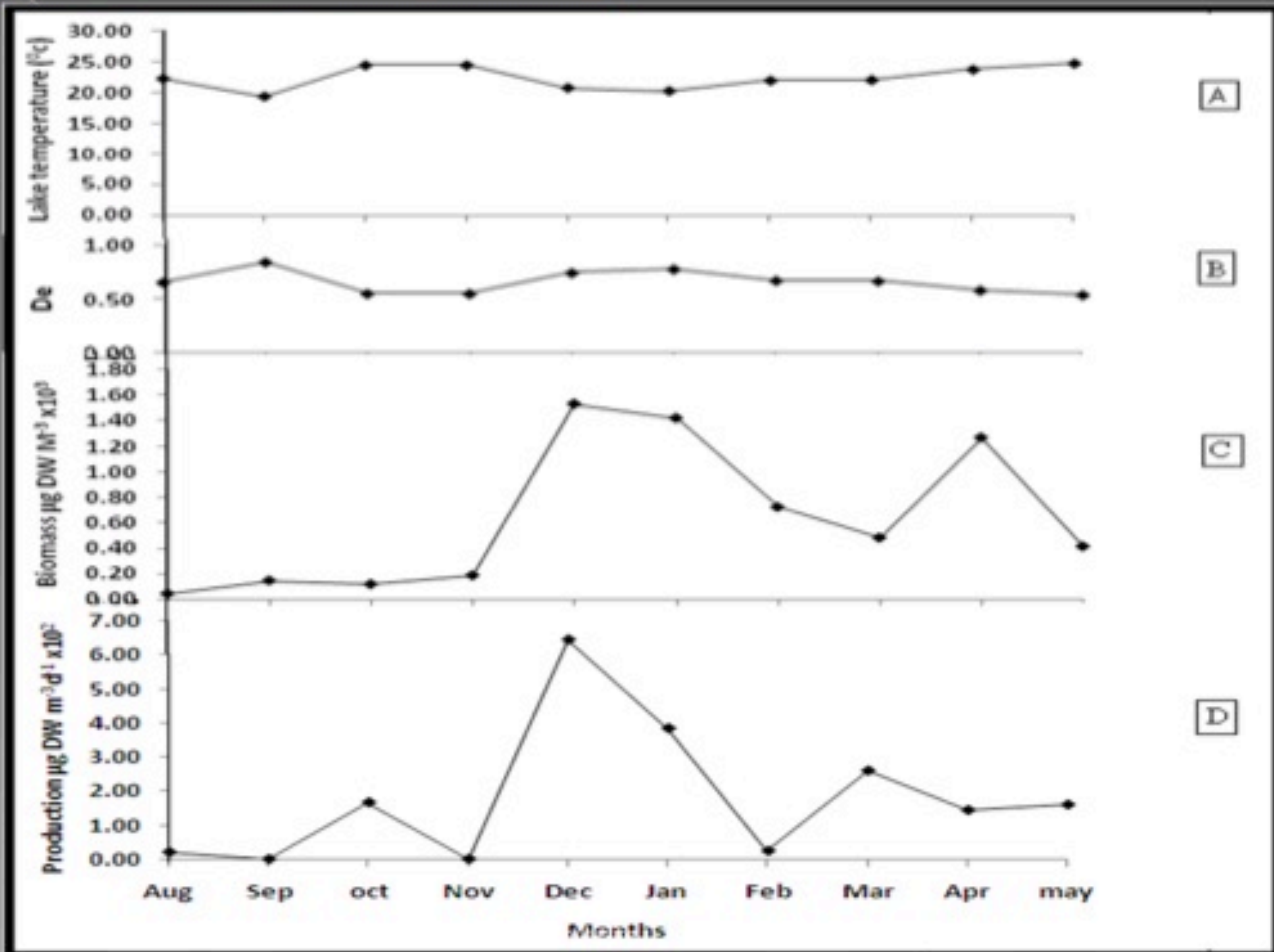
Biomass and production of B. calyciflorus

Months	To.(°c)	(N) in m^{-3}	Eggs in m^{-3}	Biomass	De	B	P_{II}	P
Aug	22.30	335.40	123.85	36.89	0.66	0.56	187.46	20.62
Sep	19.40	1271.55	0.00	139.87	[illegible]	0.00	0.00	0.00
Oct	24.50	1012.55	842.18	111.38	[illegible]	1.49	1512.29	166.35
Nov	24.50	1644.70	0.00	180.9[illegible]	0.66	0.00	0.00	0.00
Dec	20.80	13937.85	4384.29	1533.16	0.75	[illegible]	5864.17	645.06
Jan	20.30	12918.45	2724.70	1421.03	0.78	0.27	3492.28	384.15
Feb	22.00	6543.90	148.62	719.83	0.68	0.03	219.56	24.15
Mar	22.10	4339.35	1585.28	477.33	0.67	0.54	2361.06	259.72
Apr	23.80	11522.65	767.87	1267.49	0.59	0.11	1307.52	143.83
May	24.78	3715.50	792.64	408.71	0.55	0.39	1453.45	159.88
Mean	22.45	5724.19	1136.94	629.66	0.66	0.38	1639.78	180.38

Biomass:
In µg DW m^{-3}
Mean 629.66
Max. 1533.16, December (dry)
Min. 36.89, August (rainy)

Production
in µg DW m^{-3} d^{-1}
Mean = 180.88
Max. 645.06, December
Min. 0.00, September and November

5. Continued ...



Lake temperature (°c)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
A
De
1.00
0.50
0.00
B
Biomass μg DW M-3 x10³
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
C
Production μg DW m-3d-1 x10²
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
D
Aug
Sep
oct
Nov
Dec
Jan
Feb
Mar
Apr
may
Months

General Discussion

- L.Kuriftu dominated by
  - Cyanobacteria and green algae
- Factors
  - hydrological conditions
- water input-output through runoff from precipitation and evaporation
  - Phyto biomass
  - nitrate and phosphate, which must have resulted from their high external and internal input into the trophogenic zone.

General Discussion

- ZP cominity dominated by Thermocyclops copepods (T. consimilis)
  - Total species diversity of ZP is low as compared to other tropical lakes.
  - ZP in TL usually dominated by copepods (Burgis 1973; Serruya and Pollingher, 1983; Payne, 1987)
  - diversity of ZP are as a whole low (Richerson et al., 1977; Fernando, 1980a; lewis, 1979).

- **Reasons for dominancy of copepods**
  - **muted seasonality of TL favors for copepods over cladocerans (Allan, 1976).**
  - **The k-selected nature of their life history**
  - **moderate rate of increase**
  - **less susceptibility to predation**
- **competitive advantage in seasonally stable tropical lakes.**

(Twomply and Lewis, 1987).

- **Other factor**
- **Feeding plasticity of copepods**
  - **Mesocyclops**
    - **animals and plants origin (Jamieson, 1980)**
    - **even on detritus and dead crusteceans (Papinska, 1985).**
  - **Thermocyclops**
    - **predominately herbivores**
    - **cladocerans and chironomids (Decarvalho, 1984)**
    - **bacterial suspension (Finlay et al., 1987; Payne, 1987).**

General Discussion

General Discussion

- Copepod biomass &production are low in L.kuriftu
  - But relatively high phyto.biomass
- Possible reasons
  - Small body size and low abundance
  - Lake temperature (on development rate) (Landry, 1975).
    - Quality of food (on reproductive parameters)
    - Primary Productivity
    - Bacteria
    - Detritus

(Lapert, 1985, Checkley ,1980, Burns 1988)

- respiratory loss of primary producers
- (Carmouze et al.1983, Burgis and Dunn, 1978)

CONCLUSION AND RECOMMONDATIONS

- Conclusion
  - High phyto biomass
  - Copepod dominancy
  - Low ZP biomass and production
    - Quality of food
    - Temperature
  - Rotifers contribute significantly to productivity (energy cycling)
  - Small size but quick turnover times

Recommendations

- Further studies to
  - Transfer of fraction of carbon from phyto to fish and the respiratory loss of 10 producers to
    - evaluate the secondary production
    - construct models on energy and carbon flux through the ZP
  - Thus
    - to evaluate the carrying capacity for zooplanktivore fish
  - the productive power of the lake and its efficiency as a fishing ground.

- L.Kurift is exposed to eutrophication
- loading of nutrients
  - phosphorous containing detergents and increasing wastewaters use (from nearby hotel
  - fertilisers (from Kale Hiwot farm),
  - erosion in the watershed
- Therefore there is a need to prevent loading of these nutrients to the lake before creating serious problems in this aquatic ecosystem.


Thank You
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THE END