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Lunar rhythm in the planktonic biomass of the Nicco Park lake, Bhubaneswar

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Abstract: *The lunar cycle imparts certain stimulatory effects on the rhythmic behaviour of plankton and their life processes by which they actively migrate to the surface and gradually sink as the moon fades. This may also result in morphological changes in organisms, such as Lorica which becomes smaller towards the full moon night by changing the size of postero-lateral spines and surface area. In addition, cyclomorphic forms have been observed in zooplankton, which appears to be a suitable achivement for swarming and for the differentiation of sex by secondary sexual characteristics. Lunar rhythm in plankton appears to be governed by an internal clock, that is the "Biological clock".*

Key words: *Lunar rhythm, Planktonic components, Nicco Park lake.*

Introduction

The plankton content of water shows a cyclic pattern of daily activity as reported by George (1961), Michael (1966), Verma (1967), Agarwal (1980), Jakher *et al*. (1982), Patra *et al*. (1986) and Nayak and Gochhait (1990). Richardson (1952) reported that the vertical movements of organisms may be a direct response to change in light intensity. Enright and Hamner (1967) found evidence of endogenous control in several species of planktonic crustaceans by demonstrating the persistance of vertical movements in constant dim light. However, lunar rhythm is a phenomenon associated with the life processes of the plankton showing a specific response to light in term of phototaxis. Those which are positive to phototaxis report their maximum rhythmic activities during day light and others being negative in phototaxis are more active in dark. The present paper deals with the effect of lunar cycle on the ethological pattern of plankton communities in Nicco Park lake, Bhubaneswar city, Orissa.

Materials and Methods

Plankton (phyto and zooplankton) samplings were made from the littoral and limnetic zones of the Nicco Park lake, Bhubaneswar city, Orissa (Lat. 20º-15'N- Long. 85º-52' E) during a lunar period i.e., 5th November, 2002 to 4th December 2002 at 2000hr. Collections were made from 100 litres water sample by a plastic bucket of 10 litres capacity and transferring into a plankton net made of bolting silk cloth (No.25, mesh size 64μ). 100 litre of water sample was reduced to 50ml of concentrated sample by filtration through the plankton net and was preserved in 5% formaldehyde.

During the operation, a subsample of 1ml from the stock was drawn on to the plankton counting cell (1ml capacity). Organisms per litre of water were calculated using formulae as suggested by Edmonson (1995). Qualitative and quantitative estimations were made by a Sedgewick-Rafter type counting cell as per Fritsch (1965) and Tilden (1968). All the organisms encountered were represented in absolute number. Observations were also made regarding plankton vertical migration, behavioural pattern, swarming, cyclomorphosis and population densities. Marginal water samples were collected during winter (November and December) between 0800 to 1000 hr as well as during the lunar cycle (5th November to 4th December) at 2000hr and were subjected to analytic procedures as described by Welch (1962) and APHA (1998).

Results and Discussion

The phytoplankton (flora) and zooplankton (fauna) exhibited fluctuations in population numbers during the course of the study (Table 1,2,3). Seven species of Chlorophyta, two species of Cyanophyta and four species of Baccilariophyta were reported which formed 37.25-40.26% of total plankton stock (Table 3). Zooplankton groups consists of four species of Protozoa, four species of Rotifera, four species of Cladocera and two species of Copepoda. Copepoda (*Heliodiaptomus viddus* Gurney and *Mesocyclops leuckartii* Claus.) were the dominant organisms among the zooplankton and *Volvox globator* Ehrenb. was dominant in the phytoplankton group. The number of zooplanktons increased gradually at the surface from the new-moon night (5th November 2002) reaching the population maxima (349 n/l) on full moon night (19th November 2002). The number of zooplankton were the lowest on 4th December 2002 (the previous day of new-moon night). Phytoplankton populations did not exhibit such a well defined increase in number. Vertical migration of *Volvox golbator* Ehrenb. and *Euglena spirogyra* Ehrenb. appeared to be increasing with the advancement of the lunar period. Physicochemical parameters of the ambient water while sampling the plankton during lunar cycle showed favourable which may have certain effect on lunar rhythmicity of plankton (Table 4).

Several authors have reported different rhythmicity in fresh water organisms (Michael, 1966; Verma, 1967; Patra *et al*., 1978; Agarwal, 1980; Jakher *et al*., 1982; Majumdar, 1982; Nayak and Patra, 1982; Patil and Gandir, 1982; Patra and Nayak, 1982; Patra *et al.*, 1984; Patra *et al.,* 1986; Choudhury

Table – 1: Qualitative and quantitative analysis (number per litre nl^{-1}) of phytoplankton in a lunar cycle (2002).

Species name	New-moon phase	Full-moon phase	Post full-moon phase	Full-dark phase
	5th Nov - 12th Nov	13th Nov - 19th Nov	20th Nov - 26th Nov	27th Nov - 4th Dec
Group Chlorophyta				
Euglena spirogyra (Ehrenb.)	4-20	17-28	19-11	11-3
Pandorina morum (Mull.)	4-8	6-11	9-5	5-0
Volvox globator (Ehrenb.)	3-20	18-35	21-13	19-5
Spirogyra longata (Vauch.)	2-9	5-13	10-5	5-0
Cosmarium botrylis (Mengh)	3-8	4-11	5-4	5-2
Chlorella vulgaris (Beij.)	3-11	13-19	14-6	6-1
Ulothrix zonata (Kutz.)	2-13	5-10	7-4	4-9
Total	21-89	68-127	85-48	55-20
Group Cyanophyta				
Oscillatoria simplicissima	4-13	7-20	14-8	9-5
Microcystis aeruginosa (Kutz.)	2-10	12-6	6-8	7-0
Total	6-23	19-26	20-16	16-5
Group Baccilariophyta				
Gomphonema lanceolatum (Ehrenb.)	4-12	9-21	12-6	6-3
Navicula cuspidata (Kutz)	0-7	9-11	10-7	4-8
Nitzschia closterium (Ehrenb.)	7-11	9-17	13-11	7-2
Pinnularia viridis (Ehrenb.)	15-25	20-37	30-24	16-8
Total	26-55	47-86	65-48	33-21

Table – 2: Qualitative and quantitative analysis (number per liters nl^{-1}) of zooplanktons in a lunar cycle during 2002.

Species name	New-moon phase	Full-moon phase	Post full-moon phase	Full-dark phase
	5th Nov - 12th Nov	13th Nov - 19th Nov	20th Nov - 26th Nov	27th Nov - 4th Dec
Protozoa				
Amoeba radiosa (Ehrenb.)	0-4	2-7	3-9	2-5
Arcella gibbosa (Pennard)	1-3	4-8	7-5	5-3
Difflugia corona (Wallich)	3-8	11-21	17-9	4-0
Paramoecum caudatum (Ehrenb.)	6-12	8-14	7-3	2-3
Total	10-27	25-50	34-26	13-11
Rotifera				
Brachionus calcyflorus (Pallas)	2-11	7-10	5-9	2-9
Brachionus forficula (Wierzeski)	3-8	10-15	13-6	3-8
Keratella tropica (Apstein)	5-12	13-20	15-8	9-5
Filina longiseta (Ehrenb)	6-13	13-5	10-21	19-7
Total	16-44	43-50	43-44	33-29
Cladocera				
Simocephalus vetulus (Schoedler)	8-18	9-20	15-9	4-6
Daphnia carinata (King)	10-36	24-44	32-24	14-2
Moina micrura (Kutz)	4-16	10-18	14-10	16-6
Ceriodaphnia rigaudi (Richard)	5-10	8-16	9-13	5-7
Total	27-80	51-98	70-56	39-21
Copepoda				
Heliodiaptomus viddus (Gurney)	33-80	60-91	66-19	25-14
Mesocyclops leuckartii (Claus)	20-35	27-60	40-25	31-13
Total	53-115	87-151	106-44	56-27

et al., 1991, 1992; Ahmad and Singh, 1993; Yousuf and Farooq, 1994). The rhythmicity in these organisms are dependent on variations in light intensity, temperature and transparency.

Table – 3: Lunar rhythm in average standing stock and % distribution of phytoplankton and zooplankton at Nicco Park Lake during 2002 (5^{th} Novmber - 4^{th} December).

Plankton (nl^{-1})	**Lunar period**			
	New-moon phase	**Full-moon phase**	**Post full-moon phase**	**Full-dark phase**
	5^{th} Nov - 12^{th} Nov	**13^{th} Nov - 19^{th} Nov**	**20^{th} Nov - 26^{th} Nov**	**27^{th} Nov - 4^{th} Dec**
Chlorophyceae (nl^{-1})	55	98	67	38
Cyanophyceae (nl^{-1})	15	23	18	11
Bacillariophyceae (nl^{-1})	41	67	57	27
Total phytoplankton (nl^{-1})	111	188	142	76
Percentage (%)	37.25	40.26	40.11	39.79
Protozoa (nl^{-1})	19	38	30	12
Rotifera (nl^{-1})	30	47	44	31
Cladocera (nl^{-1})	54	75	63	30
Copepoda (nl^{-1})	84	119	75	42
Total zooplankton (nl^{-1})	187	279	212	115
Percentage (%)	62.75	59.74	59.89	60.21
Total plankton (nl^{-1})	298	467	354	191

Table – 4: Certain physico-chemical parameters of the ambient water during lunar cycle, 2002 (Sampling at 2000 hr).

Phase	**Water temp (°C)**	**Weather**	**Colour**	**Odour**	**Transparency (cm)**	**pH**	**DO (mg/l)**	**Free CO_2 (mg/l)**	**Total alkalinity (mg/l)**	**Chloride (mg/l)**
New-moon phase (5^{th} Nov-12^{th} Nov)	23.0	Bright	Green	Stagnant	15.0	7.4	2.1	40.92	140	55.20
Full-moon phase (13^{th} Nov-19^{th} Nov)	21.5	Bright	Green	Stagnant	15.5	7.2	2.0	41.80	139	55.38
Post Full-moon phase (20^{th} Nov - 26^{th} Nov)	22.0	Bright	Green	Stagnant	14.5	7.4	2.1	39.6	138	56.10
Full dark phase (27^{th} Nov-4^{th} Dec)	22.0	Bright	Green	Stagnant	15.25	7.3	1.9	39.72	140	55.38

As the study was carried out during winter (November and December), the physico chemical parameters (Table 5) (pH, temperature, dissolved oxygen, transparency hardness and others) were favourable in the water to provide suitable background for the increase in the population of plankton during this period (Patra *et al*., 1986). Although phytoplanktons during winter are numerically greater than zooplankton, they did not respond to lunar cycles in a measurable manner. This may be due to the absence of solar energy for their photosynthetic activities in the water during night hours and possibly a vertical movement downward. Therefore, their population density becomes less than expected during night time. On the otherhand, it may be opined that due to the slow movement of phytoplankton, they become the food of zooplankton as their swarming increases.

Zooplankton populations increased in number as lunar cycle advanced (Fig. 1,2). Moon light is possibly the factor responsible for the vertical upward and downward movement of the zooplankton. Further, this may also be associated with their negative geotactic nature (Welch, 1962; Pennak, 1944; Naylar and Smith, 1957; Bohra, 1977 and Jakher *et al*., 1982) and suppressed by a negative phototaxis nature of the zooplankton during day hours and expressed at night (Parker, 1902). It is likely that the zooplankton activity is oriented to a band of optimum moon light intensity and they adjust their upward and downward movement accordingly (Cushing, 1951; Hardy and Bainbridge, 1954). In fact, these small organisms are consumed by the higher consumer level of the food chain. So they hide during the day hr in the substratum to escape from predators and come to the surface at night searching for food. On the contrary, reproduction is a vital process of life associated from the lower to higher organisms. The sexual activities of the organisms can be carried out in the night while the fear of predation is reduced and grazing is potentially more.

Almost all the zooplankton is reported to come to the surface in new moon phase when the illumination and temperature are low. Maximum populations of cladocera and copepoda reported during the lunar period may be associated with their activity and large population dynamics. During the full-

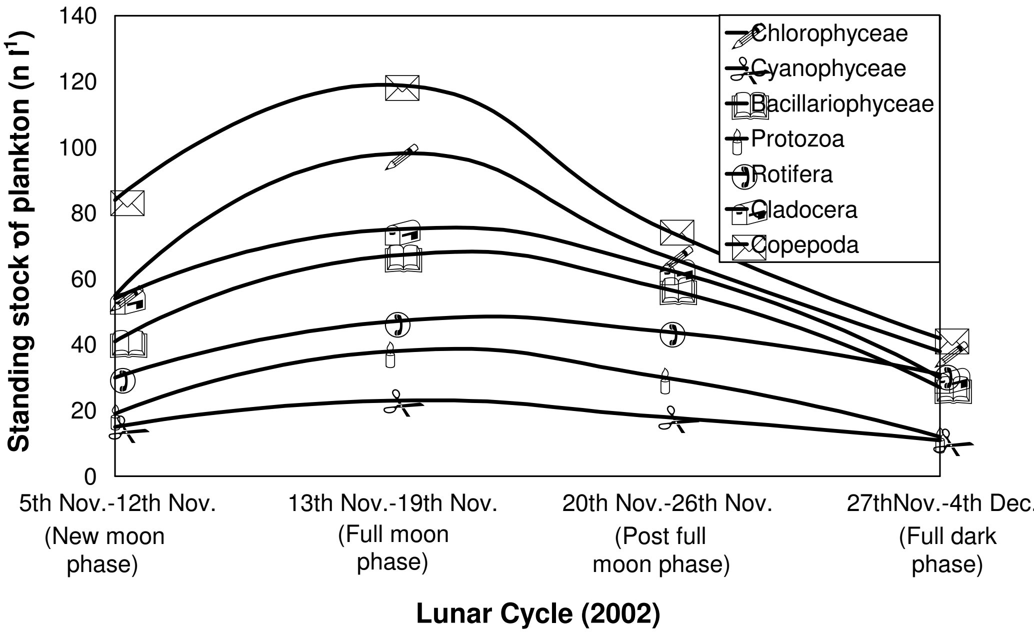

Fig. 1: Quantitative variations (nl-1) in the phytoplankton and zooplankton groups at Nicco Park lake during a lunar rhythm.

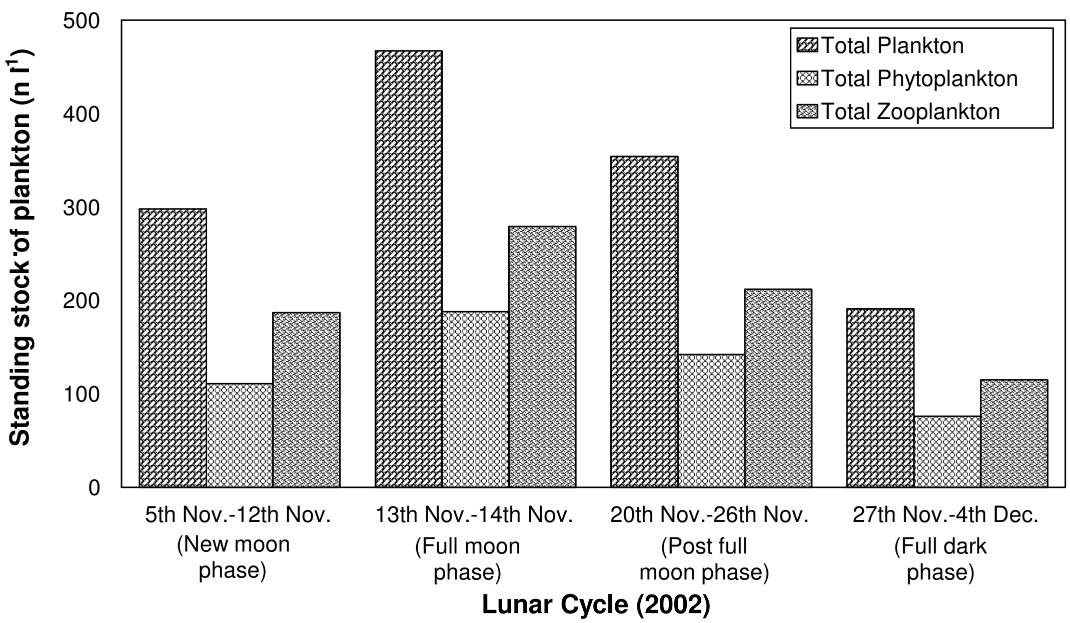

Fig. 2: Quantitative variations (nl-1) in total planktonic components of Nicco Park lake during a lunar rhythm.

Table – 5: Certain physico-chemical parameters of Nicco Park lake at 0800 h to 1000 h during winter season (November and December, 2002)

Month	Water temp. (°C)	Weather	Colour	Transparency (cm)	pH	DO (mg/l)	Free CO_2 (mg/l)	Total alkalinity (mg/l)	Chloride (mg/l)	Total solids (mg/l)
November	24.0	Green	Slight greenish	31.5	7.3	2.010	41.80	122	55.38	1950
December	22.5	Green	Slight greenish	32.0	7.6	2.034	39.6	124	58.22	1800

moon, they were reported (50%) abundant in comparison with whole plankton stock. Thus, it may be concluded that the lunar cycle imparts a stimulating effect on their life processes by which they actively migrate to the surface and then gradually decrease as the phase of the moon decreases. This is a continual cyclic process from one lunar period to another and their maximum and minimum migration is governed ultimately by lunar rhythm. Probably, an induced stimulus, that is, lunar taxis may result in mass migration and swarming. Thus, "taxis" does not always result in morphological changes, but the ethophysiology may have been affected.

In relation to the lunar advancement, morphological changes of form have been reported in Rotifera, Cladocera and Copepoda. *Brachionus forficula* Wierzeski, *Brachionus calcyflorus* Pallas, *Keratella tropica* Apstein, showed variation in the size of *Lorica*, being smaller towards the full-moon, changing the size of postero-lateral spines, and a general reduction in surface area towards the full-moon. *Moina micrura* Kutz, *Daphnia carinata* King and *Mesocyclops leuckartii* Claus have been reported to have variations of shape and size of their bodies and appendages. *Mesocyclops* exhibited the maximum cyclomorphosis with structural changes, where four different forms were identified. The cyclomorphic forms may be achieved for reproductive purposes as swarming may be a nuptial response and for the suitable differentiation of sex where it is the secondary form of the bodily structure, for fulfilment of their sexual goal.

It may be summarized that the lunar rhythm acts on the eco-physiology of the plankton in freshwater ecosystem which ultimately might be governed by hormones (genetically based) and accordingly followed by the internal clock, otherwise called "Biological clock".

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