Haematococcus pluvialis – A green alga, richest natural source of astaxanthin

Himachal Pradesh (HP) is famous for its scenic beauty and rich biodiversity to tourists, travellers, explorers and scientists. During our algal floristic explorations, we have come across several water bodies such as rivers, streams, ponds, brooks, etc. in this state. Palampur is a town in HP situated at 32°N latitude 76°E longitude and 1325 ft. above sea level with annual temperature of 19°C and annual rainfall of 250 cm and above. Main water sources of this region are from glaciers of Himalayan Dhauladhar mountains. Dominant tree species are deodar, pine and thick, lush green tea gardens. In the month of June 2005, when there was rise in temperature and dry climatic conditions were prevailing, we found that many natural and man-made ponds of this Himalayan region were red in colour (Figure 1) and getting dried with high concentration of green alga *Haematococcus pluvialis* at different growth stages of green vegetative to red sporulation stage, but the dominant was sporulation stage (Figure 1). This alga is reported for its synthesis and accumulation of highest levels of red pigment astaxanthin in nature under stress conditions. The function of astaxanthin is to protect the alga from adverse environmental changes, such as increased UV light photoxidation and evaporation of the water pools in which it lives. Environmental, climatic, physico-chemical and edaphic factors of this region seem to be conducive for the astaxanthin-rich natural alga, which can be exploited at a commercial level. For this, proper understanding of the taxonomy, morphology and culture of *Haematococcus* for astaxanthin production is very essential[1].

Figure 1. *Top*, Pond with *Haematococcus pluvialis. Inset*, Close-up of water surface. *Centre*, Algal cells at different growth stages. *Bottom*, Apple tree.

Astaxanthin, a pink-coloured keto-carotenoid with chemical nature of 3 : 3′ dihydroxy 4 : 4′diketo-β-carotene occurs naturally in a wide variety of living organisms such as aquatic animals, marine algae and even in some bird species[2]. In species such as salmon and shrimp, astaxanthin is considered as essential to normal growth and survival[3]. Though astaxanthin is found in salmon, shrimp, lobster and in a number of bird species of flamingo and quail, it cannot be synthesized by them. It must be provided in the diet like other carotenoids[4]. *Haematococcus pluvialis* is the one alga which synthesizes and accumulates high level of astaxanthin in nature, which is 1000 to 3000-fold higher than salmon fillets.

Astaxanthin has tremendous commercial importance because of its manifold benefits. This pigment is closely related to other well-known carotenoids such as beta-carotene or leutein but has stronger antioxidant activity, at least 10 times higher than beta-carotene, 1000 times more effective as antioxidant than vitamin E[5]. Astaxanthin has important metabolic functions in animals and humans ranging from protection against oxidation of essential polyunsaturated fatty acids, protection against UV light effects, provitamin A activity and vision, immune response, pigmentation and communication to reproductive behaviour and improved reproduction[6]. This is also useful for prevention and treatment of neural damage associated with age-related macular degeneration and effective at treating Alzheimer's disease, Parkinson's disease, spinal cord injuries and other central nervous system injuries[7].

Haematococcus pluvialis, the richest known natural source for astaxanthin and unique properties of astaxanthin, opens very promising possibilities of neutraceutical and pharmaceutical applications for human health and nutrition[8,9].

In India, where increased population rate and poverty face the malnutrition problem, this astaxanthin-rich indigenous alga appears to be a boon. On one side high rate of industrial growth releases high level of carcinogenic components, heavy metals in the natural environment which is leading to the disappearance of natural, beneficial algal population but on the other side the virgin water bodies of the Himalayan region with beneficial microorganisms are living proof of our rich natural resources which can be exploited wisely without disturbing their natural environment and ecological balance. The growth of this micro-alga from green vegetative stage to red sporulating stage is similar to the growth stages of any fruit especially apple of Himachal Pradesh (Figure 1). Therefore, we can conclude that this apple-rich producing state seems to be a promising state for the production of astaxanthin-rich *Haematococcus pluvialis*.

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M. R. SUSEELA*
KIRAN TOPPO

National Botanical Research Institute, Lucknow 226 001, India
**For correspondence.*
e-mail: mrsuseela@yahoo.co.in

Arcellaceans (thecamoebians) from core sediments of Priyadarshini Lake, Schirmacher Oasis, Eastern Antarctica

Arcellaceans (thecamoebians) are predominantly freshwater testaceous protozoans found in different geographical settings, from tropical to arctic latitudes. They are inhabitants of mosses, damp soils, freshwater lake bottoms, floating algal mat, etc. and depend upon other protistans, flagellates, diatoms and fragments of mosses and lichens for food supply[1–3]. Their studies in India have been reviewed recently[4]. Certain morphotypes occurring in glacial and periglacial regimes are useful palaeoclimatic indicators. Reported occurrences of 'thecamoebians' from Antarctic environment are not known. The present study is an attempt at identifying arcellaceans in lacustrine sediment core retrieved by indigenously developed coring device by the Antarctica Division of the Geological Survey of India.

The periglacial milieu of Schirmacher Oasis in Central Dronning Maud Land, East Antarctica is characterized by typically deglaciated landscape interspersed with more than hundred freshwater lakes (Figure 1). These have been systematically classified and numbered as proglacial, landlocked or inland and epiglacial lakes that occur in well-defined lineament and glacial basins formed during the late Pleistocene–Holocene period[5]. Priyadarshini Lake (L-49) is one of the largest landlocked lakes having about 0.75 km^2 water spread area, which has been studied with respect to biological, sedimentological, hydrogeochemical and limnological aspects in recent years[6–13].

During the austral summer of 2002–03, a shallow sediment core of about 50 cm length was recovered from Priyadarshini Lake (Figure 2) using an indigenously designed and fabricated system. After natural desiccation over a period of six months, the core length was reduced to 32 cm. In all, five samples (Figure 3) were macerated using standard procedures and dried at low temperature (60 to 80°C). The dried material was examined under Leica MZ 12 Stereozoom Microscope (by A. K. M.). Samples L 49/2 (from 20 to 26 cm) and L 4/3 (from 14 to 20 cm) contain 'thecamoebians' (Figure 4), which were subsequently studied under Leo 440 Scanning Electron Microscope and are described below.

Subphyllum: Sarcodina Schmarda 1871.
Class: Rhizopoda von Sieboid 1845.
Subclass: Lobosa Carpenter 1861.
Order: Arcellinda Kent 1880.
Superfamily: Arcellacea Ehrenberg 1830.
Family: Arcellidae Ehrenberg 1830.
Genus: Arcella Ehrenberg 1830.

Arcella patens Antarctica n. subsp. (Figure 4 *a*, *b*).

Material: One test from sample L 49/2, Priyadarshini Lake, E. Antarctica.

Diagnosis: Test very small, ovoid cylindrical, slightly compressed, membranous, hyaline, translucent, aperture large elliptical invaginate, aperture rim narrow, texture minutely cancellate in light microscope, thecal plates irregularly shaped, height two-thirds of width.

Diameter: 75 μm; height: 50 μm (Figure 3 *a*, *b* – Holotype).