

New Record of Phytoparasitic Alga, *Cephaleuros diffusus* Thomson & Wujekin (*Trentepohliaceae*, *Chlorophyta*) on *Artocarpus incisus* (Thunb.) L.f., Kerala, India

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Abstract No other pathological symptoms have been identified so far except root and fruit rot caused by fungi in *Artocarpus incisus*. Algal leaf spot by *Cephaleuros* species associated with *Artocarpus incisus* (Breadfruit tree) Kerala, India of the Western Ghats region has not been reported yet. The aim of the study was to explore the alga which causes leaf spot in Bread fruit tree, Kerala. Leaves of the breadfruit tree were found to be damaged internally by the algal growth and found externally as powdery form. Early fruit drop of the plant is a common symptom observed in all parts of Kerala conspicuously during the southwest monsoon season by the infection of alga. The causative algal species was identified as *Cephaleuros diffusus* (*Trentepohliaceae*, *Chlorophyta*) on the basis of morphological and taxonomical characteristics. The species resembles *Cephaleuros virescens*, but can be readily differentiated by filaments size and nature, length and width of sporangia, sporangiophores and gametangia. The present study examined that infection by *Cephaleuros diffusus* in *Artocarpus incisus* caused necrosis in the internal tissues and leading to early fruit drop and falling of leaves. The present study would help to understand the various pathogenic algae which cause leaves and fruits spot in diverse crop plants.

Keywords Bread fruit tree, Pathogen, Southwest Monsoon Season

1. Introduction

Artocarpus incisus (Thunb.) L.f. (1782:411) commonly known as bread fruit tree, belongs to the family *Moraceae* which can be grown under wide range of ecological conditions (Ragone, 1997; Murai et al., 1958). It is pantropical in distribution (Dignan et al., 2004). It is an important staple food crop and a primary component of traditional agro forestry (Ragone, 1997). The bread fruit is high in carbohydrates, minerals and vitamins. The fruit is rich in fibre and so good to control blood sugar in diabetics, reduce blood lipids and control weight (Graham & Bravo, 1981). The tree provides medicine, construction materials and animal feed. It is relatively free of diseases and pests. Root rot and fruit rot of the tree are caused by the fungus, *Phellinus noxius* and *Phytophthora* respectively (Ragone, 1997). No other pathological cause has been identified so far. However, algal leaf spot is a common disease in the breadfruit tree and most severe in Kerala during the southwest monsoon season.

Algal leaf spot is also called green scurf (Alfieri, 1969) because the spots have a crusty or flaky appearance. In

general, algal leaf spot is characterized by greyish, green, brown or orange cushion like marks on the leaf surface. The spot is most noticeable when the algae affect leaves, but also seasonally affects twigs, branches and fruits. Severe infection might lead to localized leaf yellowing and premature drop.

Cephaleuros species is known to be parasitic on several plants in the tropics and subtropics regions (Suto et al., 2014; Pitaloka et al., 2015). It belongs to the division *Chlorophyta*, class *Ulvophyceae*, order *Trentepohliales* and family *Trentepohliaceae* (Guiry & Guiry, 2016). The disease appeared on the leaf surface as burnt orange to brown spots. Stems, fruits, leaves of the tree are infected by the *Cephaleuros* species, which produces a thallus on the leaf surface which bearing sporangiophores and sporangia (Pitaloka et al., 2015).

Cephaleuros species has a wide range of host plants (Sinclair and Lyon, 2005). La Rue (1923) reported that algal leaf spot of rubber plants is caused by *Cephaleuros parasiticus*. La et al. (2009) observed that *Cephaleuros virescens* infected on *Camellia japonica* in Korea. Han et al. (2011) firstly described that *Cephaleuros virescens* diseased on *Ficus benghalensis*. Suto et al. (2014) stated that *C. virescens* and *C. parasiticus* affected the different host plant such as *Polyalthia longifolia* and *Syzygium aromaticum* respectively. Pitaloka et al. (2015) examined that algal leaf spot of Para rubber is caused by *Cephaleuros virescens*.

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Sunpapao *et al.* (2016) and Pitaloka *et al.* (2015) surveyed the occurrence of *C. virescens* in *Nephelium lappaceum* and Durian plants respectively in Thailand. Sunpapao *et al.* (2015) surveyed the occurrence of phytoparasitic algae, *C. diffusus* on the leaves of *Acasia* in Thailand.

The disease caused by the *Cephaleuros* has been reported from various places such as Hawaii, America, Japan, Africa, Panama and Florida (Rindi *et al.*, 2006; Suto and Ohtani, 2009; Marlatt and Campbell, 1980). However the report on the pathogenic algae was scarce in India, particularly from Kerala. So the present study fills the vacuum.

2. Materials and Methods

Twenty eight specimens of algal spot bearing leaves from the different breadfruit trees were collected from the different parts of Kerala (10° 00'N- 76° 25' E) during all the three seasons such as southwest monsoon, northeast monsoon and summer seasons. Macroscopic features of lesions and thallii of algae were observed under stereomicroscope. Sections were made by hand with a razor blade, placed in a drop of Shear's fluid on a glass slide with a cover glass sealed to observe through the Trinocular microscope (Suto *et al.*, 2014). Microscopic features of thalli and the associated parts were observed by using the Olympus LX 400 Trinocular microscope and photographs were taken by using BioLinkz Cmos Cam (3.0m pixels) attached to the microscope. Sporangiphore, sporangia, zoospore etc. were observed and took measurements and compared with that of the most related *Cephaleuros* species. A voucher specimen of algal leaf spot affected twig was deposited in the Catholicate College Herbarium (CATH), Pathanamthitta, Kerala, India (Accession no. 12001). The permanent slides of the identified alga, *Cephaleuros diffusus* was also kept in the Phycotechnology centre Herbarium (CAPH), Department of Botany, Catholicate College, Pathanamthitta, Kerala, India with accession number (CAPH 118 & 119)

3. Result

Leaf spot by phytoparasitic alga, *C. diffusus* was the firstly noted algal disease in *Artocarpus incisus* from Kerala, India. A preliminary investigation of the lesions of the leaf was associated with pathogenic algal growth. The leaf spots on the upper leaf surface seemed as orange areas, approximately 1-4 mm diameter (Fig. 1 A). Plant tissue of the affected regions withers and dies beneath the algal spots. Twigs and fruits (Fig. 1 C) of the tree were also affected.

Transverse sectioning revealed that thalli were sub cuticular or sub epidermal growth through leaf tissue and caused necrosis of cells (Fig. 1D). Filaments are short and cylindrical with irregularly shaped, 17- 41 µm long and 4-15 µm width. Disk of thalli are composed of open filamentous. Setae rarely found as cylindrical filaments. No thalli grown

on the lower leaf surface. Sporangiphores forming head cell with sporangia on the top (Fig. 1F). Also produce sporangiate laterals, zoosporangia and suffultory cells. Sporangia were spherical in shape, dark orange, 12.5 – 30.5 µm long and 12.5 – 22.5 µm width (Fig. 1D & F). The sporangiphores were sparsely produced on the upper leaf surface, solitary or in a tuft of 250- 439 µm long and 10-12.5 µm width.

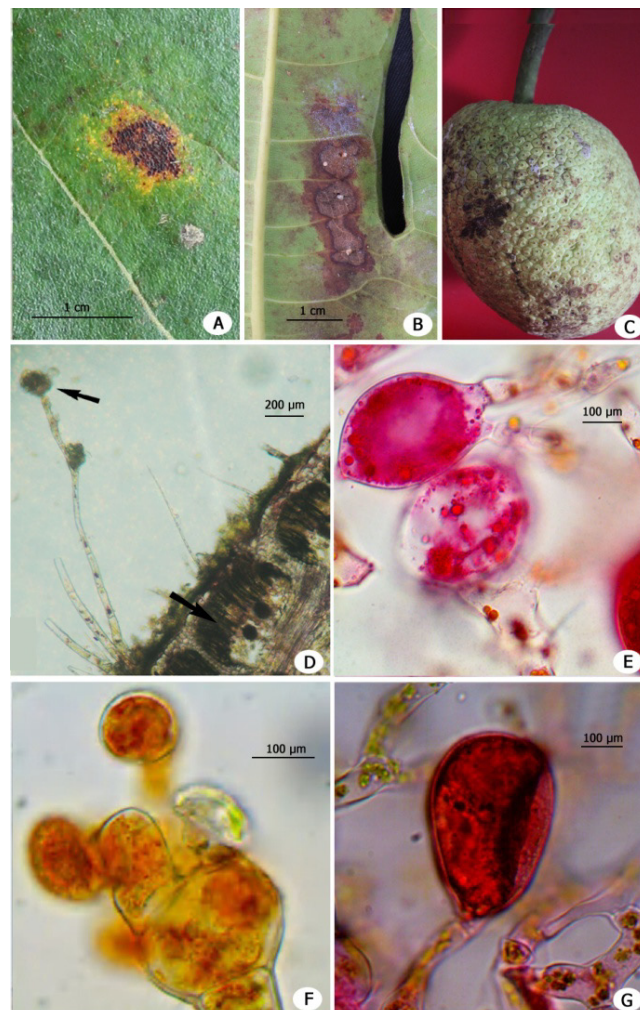


Figure 1. A. Affected leaf of *Artocarpus incisus* (Adaxial). B. Affected leaf (abaxial). C. Affected fruit. D. Anatomy of affected leaf with sporangiphore and sporangium of *Cephaleuros diffusus*. E. Gametangium. F. Sporangium. G. Gametangium (enlarged view)

It was observed that algal spots were more predominant in southwest monsoon season as compared to other seasons. All the samples showed the sign of symptoms during southwest monsoon season, while in other seasons sign of symptoms were less significant.

The pathogen of the present study, *C. diffusus* possesses certain unique features with that of its closely related species, *C. virescens*. The thalli raised as spot (versus circular disk), filamentous cells as short cylindrical to irregular (versus long cylindrical), Length/width of a filament varied from 17- 41 µm long to 4-15 µm width (versus 22-79 µm long to 7-24 µm width), sporangium appeared as spherical to elliptical

(versus elliptical), Length/width of a sporangium varied from 12.5 – 30.5 µm long and 12.5 – 22.5 µm width (versus 17-27 µm long to 15-21 µm width) and Length/Width of sporangiophores varied from 250- 439 µm long and 10-12.5 µm width (versus 70-240 µm long and 12-14 µm width.) Considering these unique features, the present pathogen is identified as *Cephaleuros diffusus*.

4. Discussion

Spreading of algal disease is due to various environmental conditions such as frequent rains and warm weather (Han et al., 2011; Sunpapao et al., 2016). The present findings agreed by the report of Sinclair and Lyon (2005) that unusual environmental conditions might promote the viability of the pathogens in the host plants. Southwest monsoon of Kerala, followed by extreme summer promoted rapid infection in all parts of the *Artocarpus* particularly on leaves. The pathogen has the ability to withstand in the infected plant debris also. The pathogen was identified as *C. diffusus* because of the morphological features and it has been agreed with the description of Sunpapao et al. (2015) and Thompson and Wujek (1997).

It is seen that lesions produced by *C. parasiticus* are appeared on both leaf surfaces. While in *C. diffusus* and *C. virescens*, lesions are appeared on upper leaf surface only. In the present report also infection by *C. diffusus* observed on the upper surfaces of leaves. *C. parasiticus* infects the leaf sub epidermally and intramatrically only (Sunpapao et al., 2015). *C. diffusus* caused necrosis of epidermis, mesophyll cells and palisade tissue of the leaves.

Krishnamurthy (2000) reported that there is only one species of *Cephaleuros* in India and neighboring countries. According to him *C. parasiticus* is not distinct from *C. diffusus* by the morphological features. But Guiry and Guiry (2016) reported that *C. diffusus* and *C. parasiticus* are separate species. Sunpapao et al. (2015) reported the main differences of *C. diffusus* from that of closely related species, *C. virescens*. In the present investigation also, similar features of the *C. diffusus* was observed and recorded.

5. Conclusions

The present study witnessed the infection of *Cephaleuros diffusus* in *Artocarpus incisus* caused necrosis in the internal tissues of breadfruit tree and consequently caused early fruit drop and falling of leaves leading to crop loss mainly in southwest monsoon season, Kerala, India.

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