10.2478/botlit-2014-0012

DE GRUYTER OPEN

BOTANICA LITHUANICA
ISSN 1392-1665

2014, 20(2): 87–98

OCCURRENCE OF FOLIICOLOUS PARASITIC ALGA *CEPHALEUROS VIRESCENS* ON CULTIVATED ORNAMENTAL PLANTS IN SOUTHERN INDIA

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Abstract

Muthukumar T., Uma E., Priyadharsini P., 2014: Occurrence of foliicolous parasitic alga *Cephaleuros virescens* on cultivated ornamental plants in southern India [Augalų lapus pažeidžiančių parazitinių dumblių *Cephaleuros virescens* paplitimas ant pietinėje Indijos dalyje auginamų dekoratyvinių augalų]. – Both. Lith., 20(2): 87–98.

The algal leaf spot, caused by *Cephaleuros virescens* Kunze, has been reported in a wide range of plant species from the tropical and subtropical areas worldwide. Investigations on the presence of algal infection mostly involved wild plants and plantation crops of economic interest. Nevertheless, limited studies have examined cultivated ornamental plants for the presence of *C. virescens*. During the summer and monsoon seasons of 2011 we examined ten leaves of five plants belonging to 86 ornamental plant taxa in 38 families growing in home gardens in Coimbatore, Tamil Nadu, India for the algal presence. Nine of the 86 plant taxa were found to host the algae *C. virescens*. Although majority of the investigated species are considered as typical hosts of *C. virescens*, its infection was found only in nine plant species. Although the incidence of the algal leaf spot disease was in general low, there was significant variation in the frequency of occurrence of the algal lesions and the lesion size among the investigated plant taxa and seasons. On plants of five species (*Alpinia purpurata*, *Ficus benjamina*, *Ficus elastica* "Variegata", *Michelia champaca, Polyalthia longifolia*), *C. virescens* was found during both seasons, while infections on the remaining four species (*Aglaonema commutatum*, *Dieffenbachia maculata*, *Eucalyptus globulus*, *Syngonium podophyllum*) were observed only during the monsoon. The susceptibility of different plant species in a genus and varieties of a species varied suggesting the host influence on the development of infections in addition to variation attributed to the local environmental conditions.

Keywords: summer, monsoon, season, algal leaf spot, algal rust, pathogenic filamentous green algae, plant diseases.

INTRODUCTION

The green algae of genus *Cephaleuros* belonging to the family Trentepohliaceae, order Trentepholiales of the division Chlorophyta is the most widespread parasitic algae infecting vascular plants. The infections caused by *Cephaleuros* species are often referred to as 'red rust' or 'algal rust' and are often confused with the rust diseases caused by fungi (Chapman, 1976). The algal infections result in lesions that predominantly occur on the adaxial surface of the leaves but could sometimes be found on both leaf sides, as well as on stems and fruits (Marlatt & Alfieri, 1981; Nelson, 2008). Many of these parasitic algae, although occurring on a wide variety of plants, are often overlooked due to their inconspicuous nature (Joubert & Rijkenberg, 1971). In many plant species, the presence of the algae does not cause any serious problem. Nevertheless, 16 species and one variety within the genus *Cephaleuros* can infect cultivated plantation crops such as tea (*Camellia sinensis* (L.) Kuntze) to cause moderate to severe damage (Marlatt & Alfieri, 1981; Thompson & Wujek, 1997; Suto & Othani, 2009). The harmful effects of the algal presence were attributed to (a) depletion

of water and mineral nutrients from the host tissues (Wolf, 1930), (b) secretion of harmful algal metabolites (Joubert & Rijkenberg, 1971), and (c) loss of photosynthetic area due to the necrosis of the green tissue (Safeeulla & Govindu, 1948).

Occurrence of *Cephaleuros* species on different plant species has been reported from various tropical and subtropical parts of the world including Africa, Asia, Australia and North America (Yadav, 1953; Joubert & Rijkenberg, 1971; Marlatt & Alfieri, 1981). The presence of *Cephaleuros* species on plants growing in temperate climatic conditions have also been reported from Japan (Suto & Othani, 2009). However, these algae have not yet been reported in Europe. *Cephaleuros* species has a very wide host range including pteridophytes and angiosperms (Marlatt & Alifieri, 1981; Brooks, 2004; Gokhale & Shaikh, 2012). Marlatt & Alfieri (1981) reported the occurrence of *Cephaleuros* in 165 plant species and cultivars belonging to 53 families in Florida, USA alone. A total of 448 plant species were found to be hosts for these parasitic algae in Pernambuco, Brazil (Batista & Lima, 1949). A review on hosts of *Cephaleuros* species by Jose & Chowdary (1980) indicated the presence of algae on 156 species of dicots, on two monocots and one gymnosperm in India. A total of 63 plant species were reported as hosts for *Cephaleuros* species in Taiwan (Hsieh, 1983). Ezuka & Kibushi (1956) listed 34 arborescent plant species belonging to 20 families as hosts of *Cephaleuros* species from Japan. More recently, the occurrence of *Cephaleuros* species has been reported on 44 arborescent species and one variety belonging to 31 genera and 20 families from Japan (Suto & Othani, 2009). Even so, reports of the occurrence of *Cephaleuros* species on ornamental plants are rare; some of the ornamental hosts were listed by Marlatt & Alfieri (1981) in Florida, USA. Nevertheless, Han et al. (2011) reported a frequent occurrence of the algal rust on *Ficus benghalensis* L., commonly cultivated as an ornamental plant in Korea. In India, the occurrence of *Cephaleuros* has been reported as early as 1879 in tea plantations of Assam (Cunningham, 1879). Later, many workers have reported the hosts of *Cephaleuros* from various parts of India (see Jose & Chowdary, 1980; and references therein). There is no clear consensus about the number of *Cephaleuros* species in India. Three species of *Cephaleuros* (*Cephaleuros parasiticus* Karsten, *Cephaleuros solutes* Karsten and *Cephaleuros virescens* Kunze) have been reported from India. However, Krishnamurthy (2000) considered *C. parasiticus* to be indistinct from *C. virescens* and recognized only the presence of *C. virescens* in India. Recent studies do indicate the occurrence of both *C. parasiticus* and *C. virescens* in India (Ponmurugan et al., 2010; Ramya et al., 2013; Suto et al., 2014).

Cephaleuros virescens is the most frequently reported algal pathogen of vascular plants worldwide and has the broadest host range among *Cephaleuros* species (Joubert & Rijkenberg, 1971; Wellman, 1972; Nelson, 2008; Gokhale & Shaikh, 2012). Climatic conditions appear to influence the occurrence and distribution of *Cephaleuros* species. Available evidence indicates the distribution of *Cephaleuros* species to be mostly restricted to regions lying between 32°N and 32°S provided the humidity and temperature are optimum for algal growth and reproduction (Joubert & Rijkenberg, 1971). Frequent rains and warm weather are favourable conditions for these pathogens. For example, in Africa and adjoining islands, the distribution of *Cephaleuros* species is restricted to summer rainfall areas where the annual precipitation is not less than 750 mm (Joubert & Rijkenberg, 1971). Even in temperate zones *Cephaleuros* species tend to commonly occur under humid environmental conditions with an annual rainfall over 1700 mm (Suto & Othani, 2009). Development of the algal thallus and necrotic lesions also appears to be related to leaf growth in addition to prevailing environmental conditions (Suto & Ohtani, 2013; Suto et al., 2014). Jose & Chowdary (1980) indicated that frequency of occurrence of *C. virescens* infections may vary between seasons. In the present study, we investigated: (a) the occurrence of *C. virescens* infections on cultivated ornamental plants in Southern India (b) seasonal variation in the frequency of the algal rust and (c) differences in the frequency of occurrence of algal lesions and lesion size among different taxa of ornamental plants.

MATERIALS AND METHODS

During summer (April–June) and monsoon (October–December) seasons of 2011, a total of 86 or-

namental plant taxa belonging to 73 genera and 38 families (Table 1) were examined for the algal leaf spot in different home gardens in Coimbatore (11°16' N and 76°58' E, altitude: 411.2 m above sea level), Tamil Nadu region, Southern India. Coimbatore is characterized by a tropical wet and dry climate as per Köppen climate classification (Peel et al., 2007). The mean maximum air temperatures during non-monsoon and monsoon seasons ranged between 30–35 °C and 29–32°C respectively (Fig. 1a). The mean minimum air temperatures ranged between 19–23°C and 19–22°C during non-monsoon and monsoon seasons respectively (Regional Meteorological Center in Chennai, 2014). The relative humidity ranges between 54%–69% during non-monsoon and 69%–76% during monsoon seasons. The wet season here lasts between October and December (so-called North East monsoon) (Fig. 1b). The average annual rainfall is around 700 mm with contributions from both North East (47.04%) and South West (27.85%) monsoons (Fig. 1b).

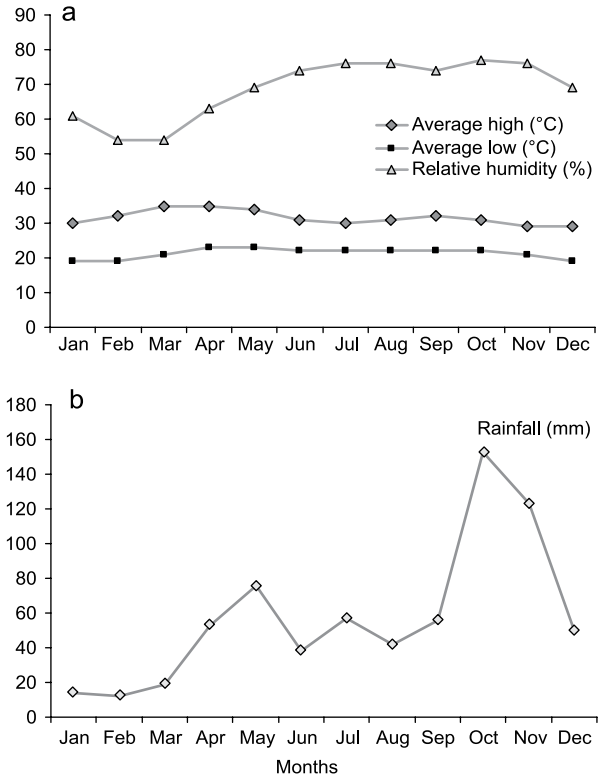

Fig. 1. Meteorological parameters of the study area

The examined taxa included 80 angiosperms, four gymnosperms and two ferns. Five plants were sampled for each taxa and the fifth leaf from the tip in randomly selected branches was observed for the presence of the algal leaf spot. Ten leaves were examined for each plant. The influence of microclimate on the occurrence of algal lesions was examined in *Eucalyptus globulus* Labill., and *Michelia champaca* L. Leaves occurring on the outer part of the tree canopy exposed to full sunlight (periphery) and in the inner shaded part of the canopy (center) were collected and examined for the presence of algal lesions. The percentage of infected leaves was determined using the formula: % infected leaf = number of infected leaves / total number of leaves examined × 100.

The algal lesions and macroscopic features of the algal thalli were examined and measured with a ruler scale using a magnifying glass (5×). Leaves with algal lesions were free hand sectioned transversely with a razor blade and the sections (approximately 15 µm) were stained with Safranin and mounted with glycerine to investigate the fine morphology of the algal thalli. Morphological characteristics of the algae were recorded under an Olympus BX 51 microscope (400×) fitted with a Prog Res 3 digital camera. Species identification was made using identification keys provided in Wolf (1930) and Suto & Othani (2009). The terminologies used are those of Thompson & Wujek (1997).

Dimensions of algal filaments, setae and sporangia (n = 50) were assessed using a calibrated ocular micrometer. The number of lesions on each leaf and their dimensions were also measured (n = 50). Data on lesion number and size were subjected to Analysis of Variance (ANOVA) to assess differences among the host species and between seasons (Zar, 2010). Post hoc analysis included Duncan's Multiple Range test using SPSS for Windows (version 9.0).

RESULTS

Of the 86 plant taxa examined, the external symptoms caused by *C. virescens* were present on leaves of *Alpinia purpurata* (Vieill.) K. Schum., *Aglaonema commutatum* Schott, *Dieffenbachia maculata* (Lodd.) Sweet, *E. globulus*, *Ficus benjamina* L., *Ficus elastica* L. "Variegata", *M. champaca, Polyalthia longifolia* (Sonn.) Thwaites, and *Syngonium podophyllum* Schott (Table 1).

The presence of the algal lesions was restrict-

Table 1. Occurrence of parasitic alga *Cephaleuros virescens* in ornamental plants of southern India (+, presence and -, absence)

Family	Species	Seasons	
		Summer	Monsoon
Acanthaceae			
	Sanchezia nobilis Hook.f.	-	-
Anacardiaceae			
	Mangifera indica L.	-	-
Annonaceae			
	Artabotrys hexapetalus (L.f.) Bhandari	-	-
	Polyalthia longifolia (Sonn.) Thwaites	+	+
Apocynaceae			
	Adenium obesum (Forssk.) Roem. & Schult.	-	-
	Allamanda neriifolia Hook.	-	-
	Tabernaemontana divaricata (L.) R.Br. ex Roem. & Schult.	-	-
Araceae			
	Aglaonema commutatum Schott	-	+
	Alocasia clypeolata A. Hay	-	-
	Alocasia macrorrhizos (L.) G. Don	-	-
	Alocasia sanderiana W. Bull	-	-
	Anthurium andraeanum Linden ex André	-	-
	Caladium bicolor (Aiton) Vent.	-	-
	Colocasia esculenta (L.) Schott	-	-
	Dieffenbachia maculata (Lodd.) Sweet	-	+
	Epipremnum aureum (Linden & André) G.S. Bunting	-	-
	Monstera deliciosa Liebm.	-	-
	Spathiphyllum floribundum (Linden & André) N.E.Br.	-	-
	Syngonium podophyllum Schott	-	+
Arecaceae			
	Caryota urens L.	-	-
	Chamaedorea elegans Mart.	-	-
	Dypsis lutescens (H. Wendl.) Beentje & J. Dransf.	-	-
	Phoenix roebelenii O'Brien	-	-
	Washingtonia filifera (Linden ex André) H. Wendl. ex de Bary	-	-
Asparagaceae			
	Sansevieria trifasciata Prain	-	-
	Beaucarnea recurvata Lem.	-	-
	Chlorophytum comosum (Thunb.) Jacques	-	-
	Dracaena marginata hort. 'Tricolor'	-	-
	Dracaena reflexa Lam.	-	-
Balsaminaceae			
	Impatiens balsamina L.	-	-
Begoniaceae			
	Begonia maculata Raddi	-	-
	Begonia rex Putz.	-	-
Commelinaceae			
	Tradescantia pallida (Rose) D.R. Hunt	-	-
	Tradescantia spathacea Sw.	-	-
	Tradescantia zebrine Bosse	-	-
Crassulaceae			
	Kalanchoe blossfeldiana Poelln.	-	-
Cycadaceae			
	Cycas circinalis L.	-	-
	Cycas revoluta Thunb.	-	-
Cyperaceae			
	Cyperus alternifolius L.	-	-
Euphorbiaceae			
	Codiaeum variegatum (L.) Rumph. ex A. Juss.	-	-
	Euphorbia pulcherrima Willd. ex Klotzsch	-	-
Fabaceae			
	Cassia fistula L.	-	-
	Delonix regia (Hook.) Raf.	-	-
Heliconiaceae			
	Heliconia pendula Wawra	-	-
Hydrangeaceae			
	Hydrangea macrophylla (Thunb.) Ser.	-	-
Lamiaceae			
	Plectranthus scutellarioides (L.) R.Br.	-	-

Table 1 continued

Family	Species	Seasons	
		Summer	Monsoon
	Ocimum sanctum L.	-	-
Lomariopsidaceae			
	Nephrolepis exaltata (L.) Schott	-	-
Magnoliaceae			
	Michelia champaca L.	+	+
Malvaceae			
	Hibiscus rosa-sinensis L.	-	-
Moraceae			
	Artocarpus heterophyllus Lam.	-	-
	Ficus benghalensis L.	-	-
	Ficus benjamina L.	+	+
	Ficus benjamina L. 'Chimera'	-	-
	Ficus benjamina L. 'Curly'	-	-
	Ficus elastica L. 'Variegata'	+	+
	Ficus microcarpa L.f.	-	-
	Ficus religiosa L.	-	-
Myrtaceae			
	Callistemon citrinus (Curtis) Skeels	-	-
	Eucalyptus globulus Labill.	-	+
	Psidium gujava L.	-	-
Nyctaginaceae			
	Bougainvillea glabra Choisy	-	-
Oleaceae			
	Jasminum sambac (L.) Aiton	-	-
	Nyctanthes arbor-tristis L.	-	-
Orchidaceae			
	Acampe praemorsa (Roxb.) Blatt. & McCann	-	-
	Cymbidium bicolor Lindl.	-	-
	Dendrobium Sw. cv. 'Sonia'	-	-
	Phaius tankervilleae (Banks) Blume	-	-
	Spathoglottis plicata Blume	-	-
	Vanda testacea (Lindl.) Rchb.f.	-	-
Piperaceae			
	Peperomia obtusifolia (L.) A. Dietr.	-	-
Podocarpaceae			
	Podocarpus macrophyllus (Thunb.) Sweet	-	-
Polypodiaceae			
	Drynaria quercifolia (L.) J. Sm.	-	-
Rosaceae			
	Rosa hybrida E.H.L. Krause	-	-
Rubiaceae			
	Gardenia jasminoides J. Ellis	-	-
	Ixora coccinea L.	-	-
	Mussaenda erythrophylla Schumach. & Thonn.	-	-
Rutaceae			
	Citrus limon (L.) Osbeck	-	-
	Murraya koenigii (L.) Spreng.	-	-
Santalaceae			
	Santalum album L.	-	-
Urticaceae			
	Pilea mollis Wedd.	-	-
Verbenaceae			
	Citharexylum spinosum L.	-	-
	Duranta erecta L.	-	-
Xanthorrhoeaceae			
	Aloe vera (L.) Burm.f.	-	-
Zamiaceae			
	Zamia furfuracea L.f. ex Aiton		
Zingiberaceae		-	-
	Alpinia purpurata (Vieill.) K. Schum.	+	+

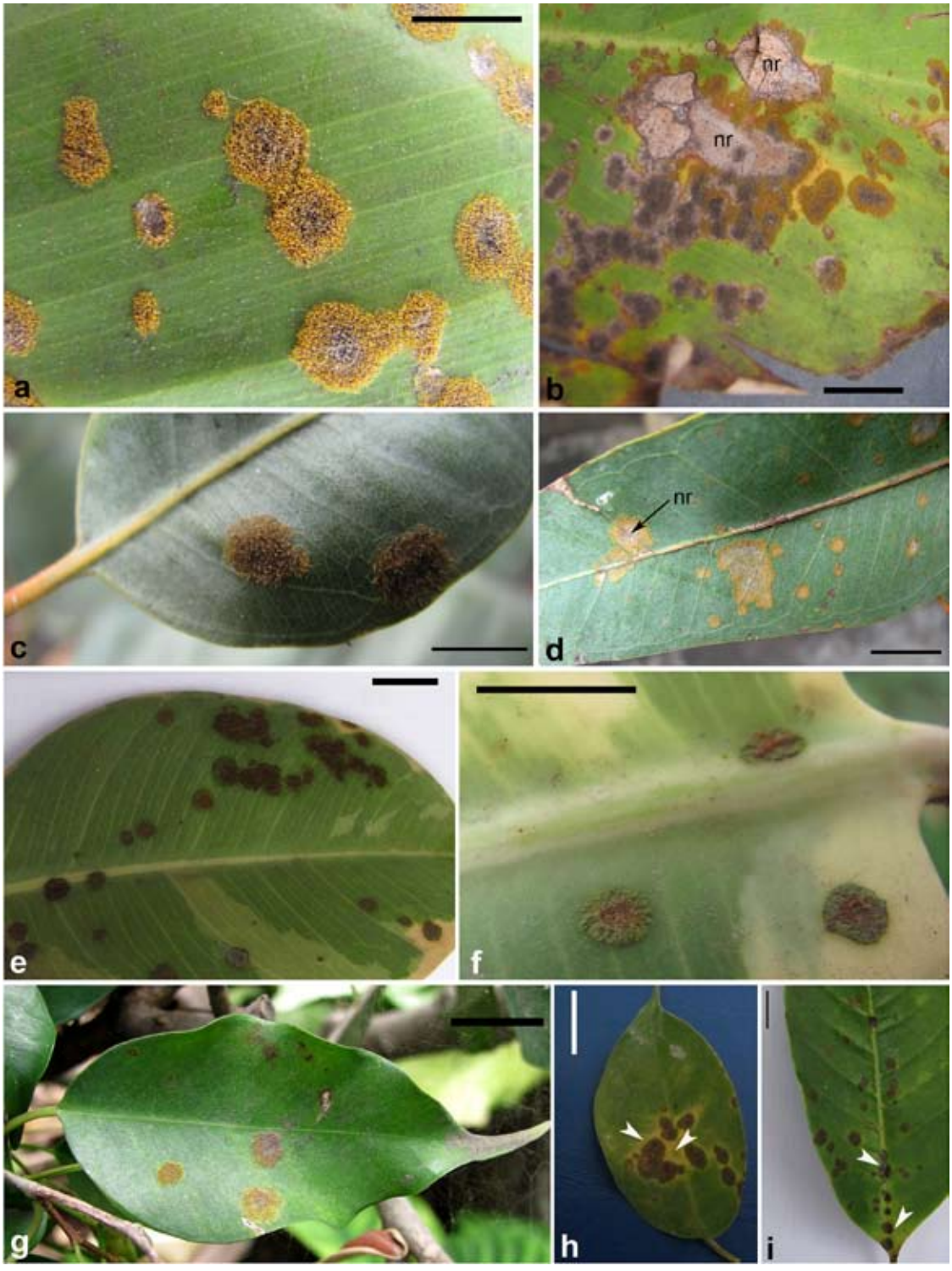

Fig. 2. Lesions caused by *Cephaleuros virescens* on different hosts: (a) – velvety algal lesions on the adaxial leaf surface of *Alpinia purpurata*; (b) – Necrotic regions (nr) on leaf of *A. purpurata*; (c & d) – algal lesions on the abaxial (c) and adaxial (d) leaf surface of *Eucalyptus globulus* (note the necrotic spot (nr) on the adaxial leaf surface); (e & f) – algal lesions on the adaxial (e) and abaxial (f) leaf surfaces of *Ficus elastica* 'Variegata'; (g & h) – algal lesions without (g) or with yellow halo (white arrows, h) on the adaxial leaf surface of *Ficus benjamina*; (i) – algal lesions along the main veins (white arrows) in *Michelia champaca*. Scale bars = 10 mm

ed to monsoon for *A. commutatum*, *D. maculata*, *E. globulus*, and *S. podophyllum*. The algal lesions were predominantly present on the upper leaf surface (Fig. 2a, d, e, g–i) although in some plants (*A. purpurata*, *F. elastica* and *E. globulus*) they also occurred on the lower leaf surface (Fig. 2b, c, f). The lesions were more or less circular and raised (e.g., *A. purpurata, F. elastica*) or flat (e.g., *F. benjamina*, *M. champaca*) discs with entire or crenate margins (Fig. 2a, c, f). The mean number of lesions ranged from 1.02 (*F. benjamina*) to 26.9 (*A. purpurata*) per leaf and differed significantly among plant species ($F_{8,441}$ = 23.718; $p < 0.001$). The frequency of lesion occurrence was significantly influenced by season ($F_{1,490}$ = 651.850; $p < 0.001$); on all five plant species examined significantly more lesions per leaf were formed during monsoon than during summer (Fig. 3a). The increase in the number of lesions per leaf between seasons ranged from 94% (*P. longifolia*) to 288% (*A. purpurata*). Mean diameter of the algal lesions ranged from 1.26 (*A. purpurata*) to 1.56 mm (*F. benjamina*) in summer and 3.22 mm (*P. longifolia*) to 4.22 mm (*F. elastica*) in monsoon. Lesions formed during monsoon were significantly larger than those formed during the summer season ($F_{1,490}$ = 510.261; $p < 0.001$) (Fig. 3b). The increase in lesion diameter between seasons ranged from 110% (*F. benjamina*) to 230% (*F. elastica*). Lesion size varied significantly ($p < 0.001$) also among the examined plant species ($F_{8,441}$ = 651.80).

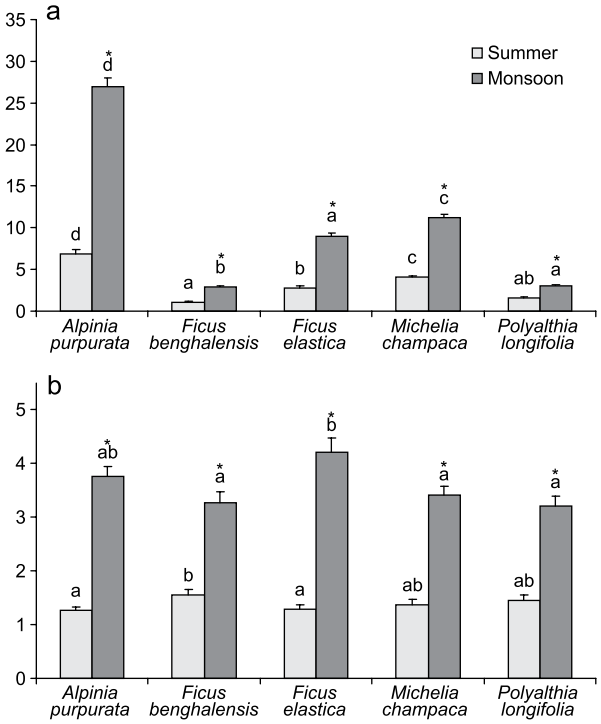

Fig. 3. Mean number per leaf (a) and diameter (b) of lesions caused by *Cephaleuros virescens* on leaves of different hosts during summer and monsoon seasons. Bars are means ± 1 S.E. Bars labeled with different letter for a season are significantly ($p < 0.05$) different from each other according to Duncan's Multiple Range test. Asterisks on top of the bars indicate a significant between-season variations for a given plant taxon

The algal colonization of *A. purpurata*, *E. globulus* and *F. benjamina* in the present study resulted in the necrosis and coloration surrounding the algal thallus. The colour of lesions' varied from green (*F. elastica*) to pale orange (*A. purpurata*) to light brown (*F. benjamina*) with a dark brown center (Fig. 2a). The lesions tended to coalesce when they were formed close to each other resulting in larger necrotic patches (Fig. 2b, d), while leaves exposed to light developed a yellow halo surrounding the lesions (Fig. 2h). In *M. champaca*, the lesions mostly occurred along the mid rib and large veins (Fig. 2i). The percentage of infected leaves was higher in the center of tree canopies than at the periphery for *M. champaca* (52% *vs*. 16%) and *E. globulus* (25% *vs*. 7%).

The algal structures emerging from the leaf surface included setae and sporangium (Fig. 4a). The thallus was subcuticular (Fig. 4b, c), setae were slender, filamentous, 2–4 celled, and produced in tufts of 2–8 (Fig. 4a). The setae measured 23–(94.92 ± 6.43)–198 µm in length and 3–(5.72 ± 0.241)–9 µm in width. The filamentous cells were cylindrical 18–(40.1 ± 1.919)–68 µm long and 6–(13.84)–25 µm wide. In certain setae, the second or third cell swelled to form a gametangium-like structure (Fig. 4e). In the central portion of the thallus, the filaments were compacted to form pseudoparenchymatous ramuli (Fig. 4d). Sessile sporangium or gametangium was absent. Sporangiophores projecting from the leaf surface were erect or slanting, 71.4–(162.36 ± 6.11)–242.76 µm long and 10.2–(16.56 ± 1.86)–23.15 µm wide, 2–4 celled, solitary or in tufts of three to five (Fig. 4f). Head cells terminal on the sporangiophores with four to six sporangiate laterals, sporangia and their suffultory cells (Fig. 4g). Sporangia elliptical 21.42–(25.85 ± 0.36)–28.56 µm × 16.66–(22.51 ± 0.37)–26.18 µm, yellow to orange.

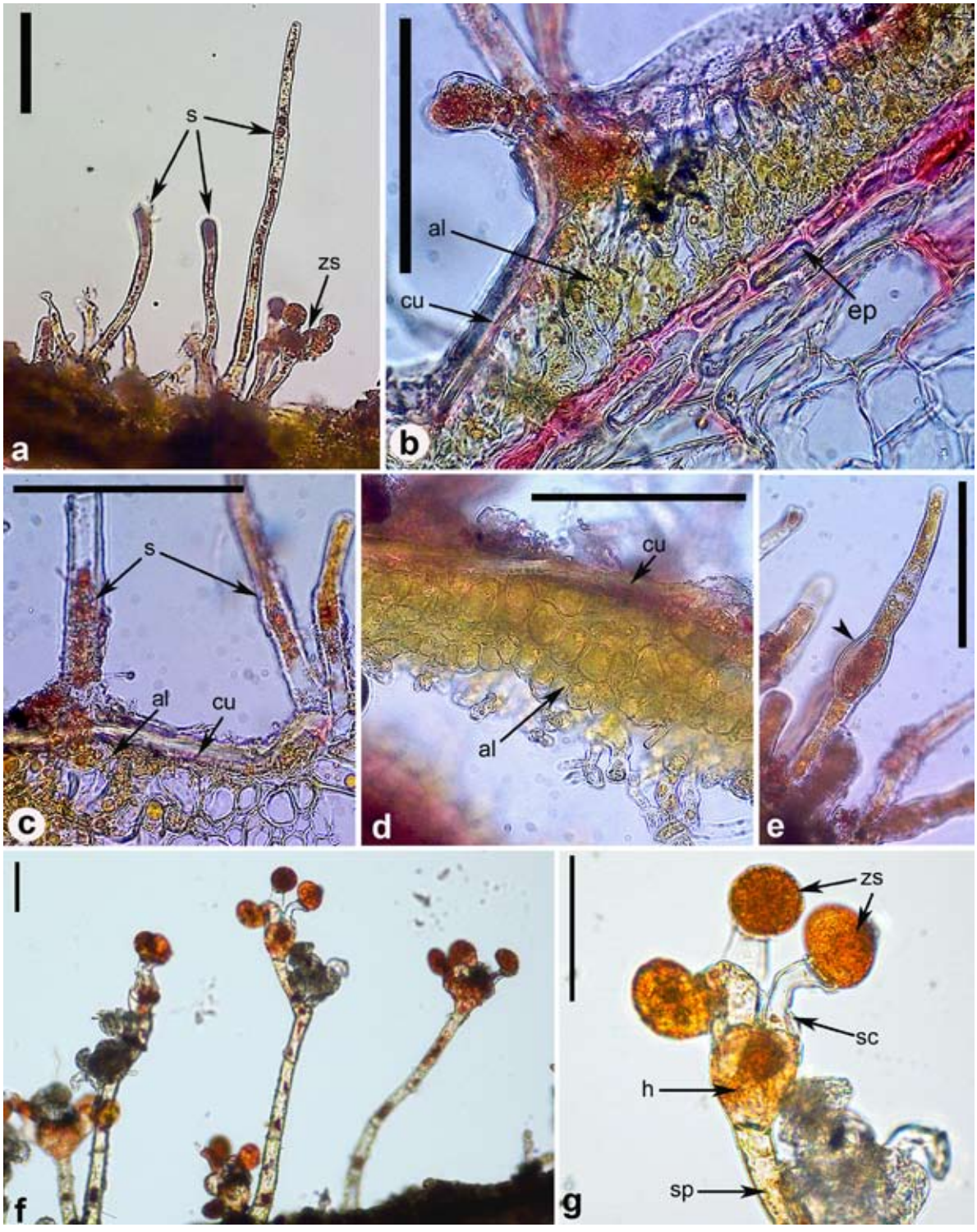

Fig. 4. Morphology of *Cephaleuros virescens*: (a) – algal thallus on leaf of *Ficus benjamina* with setae (s) and zoosporangia (zs); (b) – a transverse section of *Ficus elasitca* 'Variegata' leaf showing leaf cuticle (cu), algal zone (al) and epidermis (ep); (c) – cuticle (cu), algal zone (al) and setae (s) in *F. benjamina* leaf; (d) – pseudoparenchymatous algal thallus (al) with the host cuticle (cu) in *F. elastica* 'Variegata'; (e) – swollen gametangium-like cell (arrow head) in *Polyalthia longifolia*; (f) – zoosporangia emerging from leaf surface of *Alpinia purpurata*; (g) – zoosporangia with sporangiophore (sp), head cell (h), suffultory cell (sc) and sporangia (zs). Scale bars = 50µm

DISCUSSION

In the present study, nine plant species, including four woody and five herbaceous taxa (approximately 10%), were found to be host for *C. virescens*. This is in agreement with the general assumption that *C. virescens* had a relatively wide host range compared to other *Cephaleuros* species (Suto & Othani, 2009; Gokhale & Shaikh, 2012). To our knowledge, *A. purpurata, E. globulus* and *S. podophyllum* are newly reported hosts for *C. virescens*. Earlier, Brooks (2004) reported the presence of another parasitic alga *Cephaleuros kamenii* on leaves of *A. purpurata* growing in Tutuila, Main Island of the U.S. Territory of American Samoa. Many plant taxa that were previously reported to be typical hosts for *C. virescens* (e.g., *Psidium gujava* L., *Citrus limon* (L.) Osbeck, *Mangifera indica* L.) lacked symptoms of the algal infections, despite their occurrence in the same environment along with *C. virescens* infected plant species. Brooks (2004) indicated that unhealthy, crowded, poorly maintained plants tend to have larger lesions caused by *Cephaleuros* species as compared to sound, sparsely growing plants. The low incidence of the algal infection in the home gardens inspected during the present study could therefore be due to growth conditions and soundness of the cultivated ornamentals.

Results of the present study clearly suggest different susceptibility of plant taxa within a genus. For example, among other *Ficus* taxa examined, *C. virescens* occurred only on leaves of *F. elastica* and *F. benjamina*. Further, the two varieties of *F. benjamina*, 'Chimera' and 'Curly' lacked the algal infection in spite of occurring in the same locality with algal rust infected *F. elastica* and *F. benjamina*. Such variations in the susceptibility of plant species and varieties to algal infection have been reported also for *Citrus* (Malagi et al., 2011) and guava (*P. gujava*) (Marlatt & Campbell, 1980).

In the present study, the occurrence of the algal lesions was restricted to the monsoon season in several plant species suggesting that optimum environmental conditions might be mandatory for the disease development in certain susceptible hosts. The variation in the frequency of lesion occurrence and their size among host plant taxa confirms the observations of Suto & Ohtani (2013) who also reported variations in size of lesions caused by different *Cephaleuros* species (including *C. virescens*) in different tree hosts. In addition, the observed increase in the number of lesions per leaf during monsoon is in good agreement with the observations by Salleh & Kamsari (1994), in Sungai Buluh, Malaysia where the frequency and severity of *C. virescens* infections on *Hevea brasilensis* (Willd. ex A. Juss.) Müll. Arg., increased from July to October following the increase in rainfall. Moreover, Marlatt & Campbell (1980) showed that sporulation of *Cephaleuros* species infecting guava cultivars in Florida, USA readily occurred during July–September, a period of the greatest rainfall. Such changes in the intensity of infection have also been noted for *Cephaleuros parasiticus* on tea plants where the infection varied both within and between localities (Prasanth et al., 2005).

In the present study, the zoosporangia of *C. virescens* were formed on leaves of five plant taxa both during the monsoon and the summer seasons. This contradicts observations where zoosporangia formation was restricted to monsoon season alone which lasts from June to December. In Assam, India, the infection of *C. virescens* on stems of tea has been reported to occur during July to November and the zoospores were formed in April–May next year (Mann & Hutchinson, 1907). Similarly, the development of *C. virescens* zoosporangia on various broad-leaved trees in Varanasi, India, was reported to occur from July to September and early winter (Chowdary & Jose, 1979). Studies from other regions also indicate zoosporangia formation to vary with local climatic conditions. In *Magnolia grandiflora* L., growing in Florida, USA, *C. virescens* infection developed during late September and early October, whereas the zoosporangia were formed only in May, next year (Wolf, 1930). Suématu (1962) also reported that zoosporangia of *C. virescens* colonizing several broad-leaved trees in Wakayama Prefecture, Japan were formed from May to November and the zoospores were released in July. Suto & Ohtani (2013) showed that in Matsue Shimane Prefecture, Japan, the infections by different *Cephaleuros* species on various tree species occurred from April to July, and the zoospores were produced the next year. These observations clearly show that algal spread, infection and reproduction are dependent on environmental (climatic) conditions.

Interestingly, Thompson & Wujek (1997) have concluded that *C. virescens* causes no harm to its hosts and elicits no response of any kind from the host tissues, although necrosis (lesions) observed during the present study clearly showed the ability of this alga to cause the so-called 'red rust' disease on some of the ornamental plants and to reduce their economical and aesthetical value. Our observation is in accordance with Suto & Othani (2009), who showed that *C. virescens* colonization on *M. grandiflora* and *Persea thunbergii* (Siebold & Zucc.) Kosterm resulted in the necrosis of the epidermal and palisade cells of the host beneath the algal thallus. Suto et al. (2014) suggested that the stain surrounding the algal lesions and thallus might be caused by the pigments produced by the host tissue in response to fungal invasion. Other symptoms of *C. virescens* include the confinement of the algal spots mostly to the upper leaf surface and orange to brown raised velvety appearance of the spots (Nelson, 2008; Suto et al., 2014). Chapman & Good (1983) reviewed the host specificity of *Cephaleuros* species and interactions between a host and the algae, and indicated that several physiological and pathological problems are yet to be resolved. For example, there is no clear restriction of the algal leaf spot to a particular plant taxonomic group. Likewise, there is an apparent lack of uniformity among the susceptible host plants and often infected plants lie side by side with uninfected plants for very long time (Chapman & Good, 1983). Therefore, biochemical and physiological investigations are necessary to understand the host specificity in *Cephaleuros* species and the exact nature of the algal-host relationship (Chapman & Good, 1983).

CONCLUDING REMARKS

During the present study, the infections by *C. virescens* were found on a limited number of plant taxa. Several plant taxa that are considered to be typical hosts for *Cephaleuros* lacked externally visible symptoms of the algal rust. Defining the host range and their susceptibility to the algal infections is of primary importance to control the damage caused by the parasitic algae in susceptible plant species. There was a significant variation in the frequency of occurrence of algal lesions and lesion size among the investigated plant species and seasons. In order to understand the exact role of host species and environmental factors on the host-algal interaction, extensive inoculation experiments are required to understand the physiological and biochemical basis of the association.

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AUGALŲ LAPUS PAŽEIDŽIANČIŲ PARAZITINIŲ DUMBLIŲ *CEPHALEUROS VIRESCENS* PAPLITIMAS ANT PIETINĖJE INDIJOS DALYJE AUGINAMŲ DEKORATYVINIŲ AUGALŲ

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Santrauka

Lapų dėmėtligė, kurią sukelia parazitiniai *Cephaleuros virescens* Kunze dumbliai, yra plačiai paplitusi ant įvairių augalų, augančių tropikų ir subtropikų regionuose. Sukėlėjas dažniausiai tirtas ant laukinių augalų ir kultūrinių, ekonomiškai svarbių augalų. Tuo tarpu *C. virescens* paplitimas ant dekoratyvinių augalų yra kur kas mažiau ištirtas. Parazitinių dumblių tyrimams mėginiai surinkti vasarą ir lietinguoju sezonu nuo 86 dekoratyvinių augalų rūšių, augančių 37 privačiuose soduose Coimbatore, Tamil Nadu (Indija). Buvo renkama po 10 lapų nuo penkių skirtingų tos pačios rūšies augalų. Nors dauguma tirtų dekoratyvinių augalų yra tipingi šių parazitinių dumblių šeimininkai, *C. virescens* buvo rasta tik ant devynių rūšių augalų. Lapų pažeidimo šiais dumbliais dažnumas ir dydis varijavo tarp skirtingų augalų bei atskirais sezonais, tačiau apskritai ligos išplitimas ant dekoratyvinių augalų buvo nedidelis. *C. virescens* pažeidimai ant penkių augalų rūšių (*Alpinia purpurata*, *Ficus benjamina*, *F. elastica* ‚Variegata', *Michelia champaca, Polyalthia longifolia*) buvo aptinkami visu tyrimų laikotarpiu, tuo tarpu ant keturių rūšių (*Aglaonema commutatum*, *Dieffenbachia maculata*, *Eucalyptus globulus*, *Syngonium podophyllum*) parazitas buvo randamas tik lietinguoju periodu. Augalų jautrumas parazitiniams dumbliams priklausė nuo augalo šeimininko genties ar rūšies bei varijavo priklausomai nuo vietinių aplinkos sąlygų.