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Full Length Research Paper

Poophilus costalis Walker (Hemiptera: Cercopoidea: Aphrophoridae): A possible constraint to commercial exploitation of *Lavendula angustifolia* Mill in Kashmir Himalaya with affinity for C_3 photosynthetic plants

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Poophilus costalis **Walker, has been encountered in the biodiversity hotspot region of Kashmir Himalaya. This is the first report of family Aphrophoridae from the region. Nine species of plants under nine genera and seven families were recorded as host plants of the insect, including highly valued cash crop *Lavendula angustifolia* with an infestation level of 30 percent. Sixty five plant species were screened for infestation of the insect, under twenty families; comprising of 39 (60%) C_3, 24 (37%) C_4 and 2 (3%) CAM plants. In none of the cases the insect was associated with C_4 plants. Data interpretation leaves some scope for revisiting Thompson's theory of predilection of spittle bugs for C_4 plants.**

Key words: *Poophilus costalis, Lavendula angustifolia*, aphrophoridae, spittle bugs, C_4 plants.

INTRODUCTION

Lavendula angustifolia (*L. officinalis* Chaix) is an evergreen sub shrub belonging to family Lamiaceae (Labiatae). It is native to Southern Europe and Mediterranean region and is commercially cultivated in Australia, Bulgaria, China, France, Hungary, Portugal, Spain, UK and USA. The plant grows best under temperate and sub temperate climatic conditions. In India, currently cultivation of lavender is confined to Kashmir Valley and the possibility of commercial cultivation of the plant in North and North Eastern states is being explored. In 1983, the plant was introduced in Kashmir Valley and its cultivation was found to be successful (Tajuddin et al., 1983). Taking cue from the paradigm shift and fast growing international market for medicinal and aromatic plants, authorities in Kashmir Valley are encouraging commercial cultivation of lavender by private entrepreneurs. Lavender oil is known for its excellent aroma and is being extensively used by toiletry and perfumery industry in soaps, cosmetics, creams, lotions and perfumes. In pharmaceutical industry it is used to mask smells in propriety medicine and to scent creams; in food industry as a flavoring agent in baked cakes and beverages, (Plant biographies, 1991). The oil is known to possess sedative, carminative, anti-depressive and anti-inflammatory properties. Oil is active against methicillin-resistant *Staphylococcus* (Nelson, 1997; Hammer et al., 1999). Antifungal activity of the oil against *Aspergillus nidulans* and *Trichophyton mentagrophytes* has been documented (Moon et al., 2004). Lavender has had the reputation for being an aphrodisiac. Distilled flower water is recommended by herbalists as vocal restorative, a cleaning agent, a remedy for syncope, loss of appetite, tooth ache, neuralgia, sprains and rheumatism (Plant biographies, 1991). A potential anticancer agent, Perillyl alcohol (POH) has been identified in the oil (Liston et al., 2003; Samaila et al., 2004). The phytophagus aspect of cercopids is also well documented: *Poophils costalis* was recorded as an insect pest on rice, *Oryza sativa* L. in Japan (Nawa, 1914), in India (Nayar, 1976) and on sugar

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cane, *Saccharam sinesis* Raxb in Taiwan (Takano and Yani, 1939) and India (Nayar, 1976). Seven families of broad leaf plants from Kinmen Islands (Taiwan) has been recorded as host plants for *P. costalis* (Shih and Yang, 2002a). Recently thirty seven plant species under ten families and thirty one genera were recorded as host plants of *P. costalis* in Matsu Islands (Shih et al., 2005). There are unpublished reports regarding the attack of insect on a medicinal plant *Withania somanifera* (Aswagandha) from India *Aphrophora horizontalis* Kato and *Aphrophora morablis* Walker were recorded as insect pest of bamboo in China (Wu et al., 1996). In Taiwan *Yushania niitakayamensis* Hayata was reported as host of *A. horzonatalis* (Shih and Yang, 2005). Egwuata and Ita (1982), reported damage on maize in Nigeria. Ajayi (2000), reports wide host range of *Locris ruebens* (*rubra*) including sorghum, maize, millet, rice, sugarcane and numerous grass species. In Brazil 23,000 ha of rice were destroyed by spittle bugs during 1983-1984 (Nilakhe, 1985). In USA, *Poophilus spumarius* L. causes serious stunting in clovers, *Aphrophora permutata* Uhler and *Aphrophora sartogensis* Fitch are important pests of pine (Borror et al., 2005). Reductions up to 70% in yield and estimated monetary losses of US $ 840 – 2100 million, annually are inflicted on neo-tropical sugarcane by grass feeding spittle bugs of several genera (Thompson, 2004).

MATERIALS AND METHODS

Random surveys were carried out in various cultivated and wild avenues of Kashmir Valley ranging in altitude from 1570 to 2700 mts, during the years 2007 to 2009. Sixty five genera/ species of plants under twenty families were screened randomly to work out the host plant spectrum of *P. costalis* (Table 1). In the cultivated avenues nymphs were caged on the infested host plants with the help of nets. In case of plants in wild, the infested plants with fourth or fifth instar nymphs were cut along with the froth. To keep plant cuttings succulent and to avoid desiccation the cuttings were placed in zipped polythene envelopes in lab for rearing under natural conditions. The envelops were periodically unzipped twice in twenty four hours to remove the mist and suffocation. Adults thus reared from the lab and field nets were preserved in the form of pinned dry mounts (Figure 2) and in part in 70% ethanol along nymphs for microscopic examination. Identification up to the species level was achieved by genitalial dissection and examination of male insects. Identification was confirmed by comparison with the identified insect collection housed at Insect Identification Service Division of Entomology, Indian Agricultural Research Institute, PUSA, New Delhi, India. Host plants were identified from the centre of Plant Taxonomy, Department of Botany, University of Kashmir, Srinagar, India. Merely the plants from which the nymphal samples were collected for rearing were regarded as the host plants.

RESULTS

Identification of adult insects reared from different host plants, localities and months revealed that they all belonged to a single species, *P. costalis* Walker, 1851.Out of the sixty five plant genera/species screened, only nine species of plants under nine genera and seven families were recorded as host plants of the insect (Table 1). Perusal of literature revealed that some of these might be new host records of the insect. The insect became active from the middle of May when foamy spits with first instar nymphs begin to appear. By the middle of June, insect was quite abundant and the blooming stage was reached in the month of August and this activity lasted till mid September when the spits are no longer cited. Heavy infestation was recorded on Lavender during the month of August. 30% of the plants were infested by the nymphs, infestation being heavier towards the shady portion of the fields. 1-3 branches of each plant were infested and each spittle harbored 1 to 3 nymphs (Figure 1). Young plants of *Robinia pseudoacacia* growing along the periphery of the crop in field station of Regional Research Laboratory (CSIR), Banura, Pulwama, Kashmir-India, were also heavily infested. In Dachigam National Park Srinagar, the bug was on prowl during the month of August on *Indigofera heterantha* and the shrub presented a snow clad picture/view due to the frothy masses of the insect. During the course of study, insect was found to be most prevalent on *Indigofera heterantha*, followed by *L. angustifolia, Cichorium intybus, Daucuss carota, Dipsacus inermis, Cannabis sativa, R. pseudoacacia, and Rumex hastatus.* In terms of economic loss infestation on lavender is of prime importance while as the other host plants recorded are of minor importance. Most of these grow in wild with small fragmented or separated populations being used as fodder, wild vegetables, folk medicine, etc. Out of the sixty five plants screened twenty four plants were C_4 (37%) two CAM (3%) and thirty nine plants (60%) were C_3 plants. The insect thus showed greater specifity towards C_3 plants although quite a good number of plants with C_4 fixation were present (Table 1).

DISCUSSION

P. costalis, is widely distributed in Afro-tropical, Palaertic and Oriental regions. It is known from various parts of India as well like Bengal, Assam, Allahabad, etc. But this is the first report of the family from Kashmir Himalaya. Present record is significant from zoogeographical view point and fills the gap in geographical distribution of the species.

It is believed that high infestation of bugs on the crop might have a direct negative bearing on the quality and quantity of oil production, apart from the potential hazard of bacterial and viral disease transmission. Severin (1950) reported spittle bugs as vectors of Pierce's disease virus. Murty et al. (1994) reported yellow leaf blotch of sorghum due to feeding activity of spittle bugs. Surface sterilized and macerated nymphs of *Locris rubens* on isolation yielded *Zanthomonas* sp (Akpa et al.,

Table 1. Classification as per CO_2 fixation of plants screened during the study and host plant recorded by Shih et al., (2005).

Status	Plant family	Genera and species
C_4	Poaceae	(*Saccharum sinensisr* Roxb.), *Saccharum officinarum* L.), (*Sorghum bicolor* (L.) Moench), (*Chaetochloa italic.* Scribn. *var. germanica Scribn,* properly called (*Setaria italica*(L.) P. Beauvois), *Aristida* L., *Arthraxon* P.Beauv., *Bothriochloa* Kuntze, *Capillipedium* Stapf, *Chrysopogon* Trin., *Cymbopogon* Spreng., *Cynodon* Rich., *Digitaria* Haller, *Echinochloa* P. Beauv., *Eragrostis* N.M. Wolf, *Imperata* Cyr., *Paspalum* L., *Pennisetum* Rich., *Themeda* Forssk., *Zea mays* L.,
C_3		*Triticum aestivum* L., (*Oryza sativa* L) , *Avena byzantine* L.,
C_3	Commelinaceae	(*Commelina diffusa* Burm F.)
C_3	Asteraceae	*Lactuca dissecta* D.Don+, *Achillea millefolium* L., *Arctium lappa* L., *Artemisia sp, Inula racemosa* Hook.f., *Sassurea costus* (Falc.) Lipsch., *Cichorium intybus* L.+, *Centaurea iberica* Trevir. ex Spreng., (*Ageratum conyzoides* L.), (*A.houstonianum* Mill.), (*Ambrosia artemisiifoli* L.), (*Artemesia capillaries* Thunb.), (*Aster ciliosus* (Turez.) Hand-Mazz.), (*Bidens pilosa*), (*Chrysanthemum indicum* L.), (*Crassocephalum rabens* (Juss.Exjacq.) S.Moore), (*Emilia sonchifolia* (L.)DC.), (*Erigeron Canadensis* L), (*Gynura elliptica* Yabe and Hayata), (*Lactuca indica* L), (*Parthenium hysterophorus* L), (*Siegesbeckia orientalis* L), (*Tridax procumbens* L),(*Veronia cinerea* (L.) Less), (*Wedelia chinensis* (Osb.) Mar),(*W. prostrate* (Hook. Et. Arn.) Hemsl), (*Youngia japonica* L. DC.).
C_4		*Chrysanthellum* Persoon
C_3	Lamiaceae (Labiatae)	(*Hyptis suaveolens* (L.)Poir), (*Lavendula sp),* (*Melissa officinalis* L.), *Lavendula anguistifolia* Mill+
C_3	Boraginaceae	(*Messerschmidia argentea* (L.) Johnston), *Arnebia benthamii* (Wall.ex G.Don) I.M.Johnston, *Myosotis arvensis* (L.) Hill
C_4	Cleomaceae	*Cleome* L.
CAM	Convolvulaceae	(*Ipomoea batatas* (L.),(*I. pescaprae* (L.) Sweet Subsp. *basiliensis* (L.) Ooststt)
C_3	Fabaceae	*Indigofera heterantha* Wall. ex Brandis+ , *Robinia pseudoacacia* L.+ , (*Sesbania sp*), *Trigonella foenum-graceum* L., *Glycine max* (L.) Merr., *Phaseolus lunatus* L., *P. vulgaris* L., *Pisum sativum* L., *Vicia faba* L., *V. mungo*L., *V. radiate*L., *Lupin sp, Trifolium alexandrinum*L.
C_3	Mimosaceae	(*Mimosa pudica* L.)
C_3	Moraceae	(*Humulus scandens* (Lour.)Merr)
C_3	Casuarinaceae	(*Casuarinas equisetifolia* L.), (*C. fraseriana* Mig), (*C.glauca* Sieber ex Mig.)
C_3	Cannabaceae	*Cannabis sativa* L.
C_3	Polygonaceae	*Rumex hastatus* +, *Polygonum* L. *sp,* Rheum L. Sp
C3	Ranunculaceae	*Dipsacus inermis L.*
C3	Crassulaceae	*Sedum.* Sp
C3	Amaranthaceae	*Celosia argentea L.*
C4		*Amaranthus L., Gomphrena, Kochia Roth*
C3	Chenopodiaceae	*Chenopodium alba L.*
C3 + CAM	Euphorbiaceae	*Euphorbia* sp

Table 1. Contd.

C_3	Caryophyllaceae	*Lychnis coronaria* (L.) Murr. ex Desr.
C_3	Zygophyllaceae	*Peganum harmala* L.
C_3	Scrophulariaceae	*Picrorhiza kurrooa* Royle ex Benth., *Verbascum thapsus* L.
C_4		*Tribulus* L.
C_4	Portulaceae	*Portulaca oleracea* L.
C_4	Cyperaceae	*Cyperus* L., *Fimbristylis* Vahl
C_3	Dipsacaceae	*Dipsacus inermis*+
C_3	Apiaceae	*Daucus carota* L.+

Plant genera and species within braces, as host plant records of the insect by Shih et al.(2005), Plant genera and species without braces, as screened by authors; plants with+ ve sign as host plants recorded by the authors.CAM : Crassaulecean acid metabolism.

Figure 1. Nymph in spit.

Figure 2. Pinned Adult.

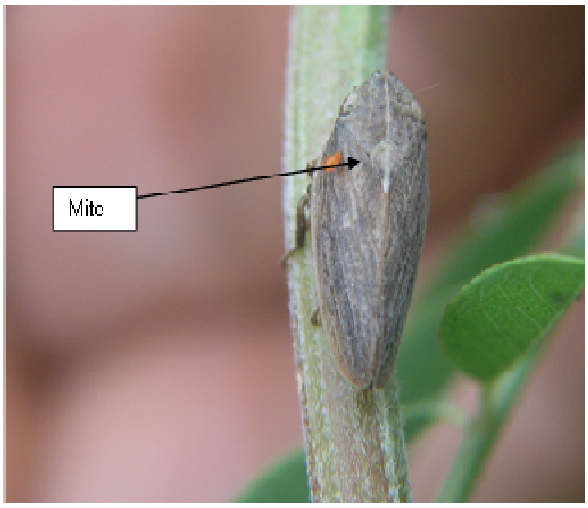

Figure 3. Mite infested adult.

1995, 1996).

Enjoying microclimatic and safe niches in frothy masses bio-control of the nymphs seems practically impossible. However, during this study a few observations were made where in an unidentified minute red colored mite was noticed on the wings of some adult bugs resting on the branches of *I. heterantha* (Figure 3). Since the observations were very few it seems to be a case of chance incidence rather than an established association. In view of remarkable ability of the bug to execute high leaps, cultural control in terms of clean cultivation by removing the wild hosts of the insect from the periphery of Lavender fields may produce spectacular results and reduce the pest populations to a great extent. Rosseto et al. (1978) reported damage to rice fields by spittle bugs that were adjacent to pastures in Brazil. Thus keeping in view the growing trend of Lavender cultivation

and its future prospects in Valley, a thorough study on surveillance, ecology and biology of insect would be of paramount importance to make cultivation of Lavender on commercial scale a success.

The study revealed that all the host plants recorded during the study are C_3 plants and in no case the insect was found to be associated with C_4 plants, both in the wild and cultivated avenues. Although, among the host plants the bug was on prowl on *I. heterantha*, a nitrogen fixer, but on *R. pseudoacacia,* another nitrogen fixer infestation was least second only to *Rumex hastatus*. We also analyzed the host plant data of 37 plant species for the insect by Shih et al. (2005) from Matsu Islands Taiwan. Out of the total 37 host plants recorded, thirty one (84%) plants were C_3, five (13.5%) were C_4 and one (3%) plants showed CAM fixation. Among the host plants only two (5.4%) were nitrogen fixers. The insect thus has very little affinity for C_4 plants. The host spectrum dynamics of Shih et al. (2005) is thus coherent with present study. Data analysis seems to be coherent with the above results and is statistically significant ($P < 0.01$). Thus, there seems to be some scope for corroboration in Thompson's theory of predilection of spittle bugs for C_4 plants. It might be possible that the theory may not be applicable under temperate conditions or the deviance may be specific to the species under consideration- *P. costalis*. The Lavender cultivation in Kashmir is still in infancy and in near future is likely to get established as a cultivated crop, keeping in view the percentage of infestation (30%), the pest has a good scope on the crop and in future might prove a serious threat to its commercial cultivation.

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