

Morphological diversity and some newly recorded plant galls in Tamil Nadu, India

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Abstract

The 'gall', provides food and shelter for its insects and mites. In many cases, the galls induced by the parasites attain phenomenal structural complexity and architectural design which have allured the naturalists. In a survey of plant-galls in Tamil Nadu Forests in South India, we were able to record several remarkable galls of excelling architectural designs and sublime marvels. A few such illustrious galls and new reports are highlighted here.

Keywords: Cecidology, Phytophagous Insects, Plant Galls.

Introduction

Tamil Nadu in India has been considered as a treasure house of insect -inducing plant galls because of its unique biogeographical position, and has all known types of ecosystem. Due to varied topography and altitudinal variation from sea level to the highest mountain ranges and the vast coast line, plant gall diversity is quite versatile.

Galls are any deviation in the normal pattern of plant growth produced by specific reaction to the presence and activity of a foreign organism of animal or plant parasites. Our knowledge of plant-galls dates back to 17th century, and Marcello Malpighi seems to have held the foundation for the scientific perspectives on plant galls.

The present work is planned to give a general idea of the immensely interesting and comparatively unknown mite and insect galls and their morphology, internal structure and to facilitate the identification of the hundreds of these deformities occurring upon numerous plants in all parts of Tamil Nadu.

Research methodology

Map.1. Survey area of plant galls in Tamil Nadu forests



About 15 forest areas were identified for the survey of the galls. Table 1a provides the list of 15 forests surveyed area during our expedition. Most of the areas are true scrub and shola forests. A few places are the foot-hills of the Hills and exhibit all essential features of the scrub forests and few are deciduous forests.

The plants were identified with the help of Flora of Madras Presidency (Gamble, 1957); Flora of Tamil Nadu (Henry *et al.*, 1988); The Plant Book (Mabberley, 2005), and Medicinal plants of India Vol.II Tamil Nadu (Yoganarasimhan, 2000).

Periodical visits to different forests in Tamil Nadu and comprehensive survey of plant galls were made (Map 1). Taxonomic categories of gall bearing plants and gall incidence in relation to plant habits and habitats were surveyed (Table 1a). Data pertaining to gall frequency such as rare, restricted, common and endemic were also recorded. Gall inciting agents were isolated by rearing, for taxonomic identification of insects, mites and fungi. Details pertaining to process of collection, localities of host plants, preservation, fixation, microtomy, microscopy, histochemistry and photomicrographic technique were undertaken (Sass, 1940).

Specimens for the present study were collected mostly from outskirts forests of Chennai and other forest areas of Tamil Nadu. The following Table 1a,b & 2, gives the binomials of the plants, infected organ of plants, gall incitant, gall morphology, and places of collection.

The specimens of the galls and corresponding normal organs bearing the galls were fixed in FAA (Formalin-Acetic Acid-Ethyl alcohol) for microtomy and anatomical studies. Preliminary observations were made with free hand sections or sledge microtome sections. Photomicrographs and critical observations were made on only with paraffin embedded materials sectioned with rotary microtome (Sass, 1950) to the thickness of 8-12 μ m. Sections were stained with Tannic acid - Ferric chloride and Safranin (Foster, 1934); safranin and fast green (Johansen, 1940) and Toluidine blue - O (O'Brien



Table 1a. List of plant galls in Tamil nadu (present study)

S. No.	Name of the Plant with family	Infected organ	Gall incitant	Place of collection	Gall Morphology
1.	<i>Abutilon indicum</i> (L.) Sweet Malvaceae	Stem	Cecidomyiidae	Orakadam Scrub Forest	Rinden -Shoot axis gall *
2.	<i>Acacia caesia</i> W. & A. Mimosaceae	Leaf	Cecidomyiidae	Courtallum Hills	Sea-urchin gall *
3.	<i>Acacia caesia</i> W. & A. Mimosaceae	Stem	Eriophyes (Acarina)	Swami malai, Yelagiri	Cauliflower gall *
4.	<i>Acacia catechu</i> W. & A. Mimosaceae	Leaf	Lobopteromyia	Gingee Yercard	Cup-Saucer gall
5.	<i>Acacia leucophloea</i> (Roxb.) Willd. Mimosaceae	Leaf	Cecidomyiidae	Yercaud Trichy	Legumiform gall
6.	<i>Acacia leucophloea</i> (Roxb.) Willd. Mimosaceae	Leaf & rachis	Eriophyes sp.	Orakadam Scrub Forest	Valvular rachis gall
7.	<i>Achyranthes aspera</i> L. Amaranthaceae	Leaf & vein	Cecidomyiidae	Bodimettu foot hills	Vein-spindle gall
8.	<i>Acronychia pedunculata</i> (Linn.) Miq. Rutaceae	Leaf	Eriophyes sp.	Manalaru	Shallow pouch gall
9.	<i>Aglaiia elaeagnoidea</i> (Juss.) Benth Meliaceae	Leaf	Psyllidae	Courtallum	Leaf pouch gall
10.	<i>Alstonia scholaris</i> (Gaertn.) Britt. Apocynaceae	Leaf	Psyllidae	Kalakadu	Covering growth pouch gall
11.	<i>Angophora costata</i> (Gaertn.) Britt. Myrtaceae	Leaf	Psyllidae	Kalakadu	Abaxial pit gall
12.	<i>Boerhavia diffusa</i> Linn. Nyctaginaceae	Leaf	Cecidomyiidae	Chennai	Foliar bud gall
13.	<i>Cadaba fruticosa</i> (L.) Druce Capparaceae	Leaf & Vein	Cecidomyiidae	Gingee	Leaf - fold covering growth gall
14.	<i>Canthium parviflorum</i> Lam. Rubiaceae	Leaf	Eriophyes sp.	All scrub forest	Covering growth pouch gall
15.	<i>Canthium rheedii</i> DC Rubiaceae	Stem	Cecidomyiidae	Kalakadu	Symmetrical Stem gall
16.	<i>Cassine glauca</i> (Rottl.) Kuntz. Celastraceae	Stem	Cecidomyiidae	Courtallum	Rinden gall
17.	<i>Cinnamomum verum</i> Presl. Lauraceae	Stem	Cecidomyiidae	Thirunelveli	Spindle gall
18.	<i>Cocculus hirsutus</i> (L.) Diels Menispermaceae	Flower	Cecidomyiidae	Vennottiparai & Gingee	Amorphous flower gall
19.	<i>Commiphora caudata</i> Engler Burseraceae	Leaf	Eriophyes sp.	Bodimettu	Tuberculated emergence gall
20.	<i>Connarus wightii</i> Hook. f. Connaraceae	Leaf	Cecidomyiidae	Kalakadu	Twin button gall
21.	<i>Connarus wightii</i> Hook. f. Connaraceae	Rachis	Fungi	Courtallum	Spindle form vein gall *
22.	<i>Crotalaria</i> sp. Papilionaceae	Stem	Cecidomyiidae	Kodaikanal	Agglomerate Rinden gall
23.	<i>Ctenolepis longifolia</i> Clarke Cucurbitaceae	Stem	Cecidomyiidae	Kurumbaram	Fusiform stem gall
24.	<i>Debregeasia longifolia</i> Wedd. Urticaceae	Petiole	Coleoptera	Kodaikanal	Soft rinden gall
25.	<i>Eucalyptus globules</i> Labill. Myrtaceae	Stem, petiole & Leaf	Cecidomyiidae	Orakadam	Moniliform rinden gall
26.	<i>Excoecaria agallocha</i> L. Euphorbiaceae	Stem	Fungus	Kodiakarai	Amorphous rinden gall*
27.	<i>Ficus mollis</i> Vahl. Moraceae	Vein	Cecidomyiidae	Bodimettu	Spindle vein gall
28.	<i>Glycosmis pentaphylla</i> DC. Rutaceae	Leaf	Cecidomyiidae	Kalakadu	Elliptical eruption gall*



Table 1a.(continues) List of plant galls in Tamil nadu (present study)

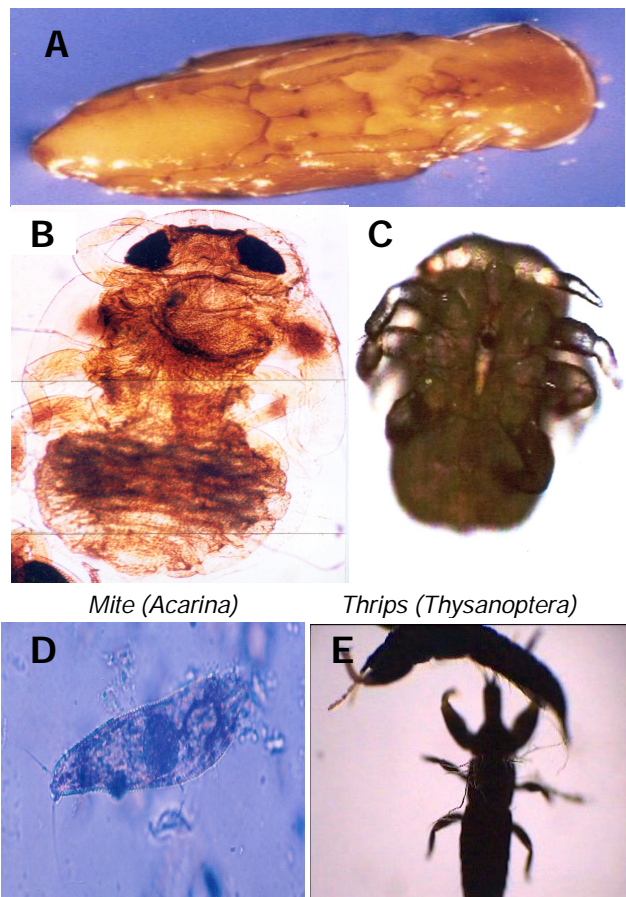
S. No.	Name of the Plant with family	Infected organ	Gall incitant	Place of collection	Gall Morphology
29.	<i>Grewia flavescens</i> Juss. Tiliaceae	Leaf	Eriophyes	Courtallum	Cephalonean Pouch gall *
30.	<i>Gymnema sylvestre</i> R. Br. Asclepiadaceae	Leaf	Cecidomyiidae	Courtallum	Foliage bud gall *
31.	<i>Harpullia arborea</i> Radik. Sapindaceae	Leaf	Cecidomyiidae	Courtallum	Clubshpaed pouch gall *
32.	<i>Hibiscus ovalifolius</i> Vahl. Malvaceae	Leaf	Eriophyes	Salem Elagiri	Perfoliate gall
33.	<i>Holigarna arnottiana</i> Hook. f. Anacardiaceae	Leaf	Cecidomyiidae	Ponmudi	Kammar gall
34.	<i>Holoptelea integrifolia</i> Planch. Ulmaceae	Leaf	Eriophyes	Courtallum	Emergence pouch gall
35.	<i>Jasminum malabaricum</i> Wight Oleaceae	Leaf	Cecidomyiidae	Manalaru	Pincushion gall
36.	<i>Jasminum trichotomum</i> Roth Oleaceae	Leaf	Fungi	Kalakadu	Blister gall
37.	<i>Jatropha curcas</i> L. Euphorbiaceae	Leaf	Eriophyes	Courtallum Ponmudi	Corugated pouch gall
38.	<i>Lanea coromandelica</i> Merr. Anacardiaceae	Leaf	Cecidomyiidae	Orakadam	Sphaeroidal vein gall
39.	<i>Leptadenia reticulata</i> Wight & Arn. Asclepiadaceae	Leaf	Thysanoptera	Vandalur	Leaf curl gall
40.	<i>Mallotus philippensis</i> Mull.-Arg. Euphorbiaceae	Leaf	Psyllidae	Courtallum	Epiphyllous pouch gall
41.	<i>Memecylon edule</i> Roxb. Melastomaceae	Leaf	Thysanoptera	Courtallum	Leaf Margin roll gall
42.	<i>Pongamia pinnata</i> (L.) Pierre Papilionaceae	Petiole	Cecidomyiidae	Tiruporur	Spindle gall
43.	<i>Prosopis spicigera</i> (L.) Druce Mimosaceae	Leaf	Eriophyes	Tiruchi	Foliar covering growth gall
44.	<i>Prosopis spicigera</i> (L.) Druce Mimosaceae	Stem	Lobopteromyia	Tiruchi	Nodular spindle gall
45.	<i>Psychotria</i> sp. Rubiaceae	Leaf	Cecidomyiidae	Kalakadu	Cupular perfoliate gall
46.	<i>Salvadora persica</i> Linn. Salvadoraceae	Stem	Cecidomyiidae	Kodiyakarai	Rinden gall
47.	<i>Scolopia crenata</i> Clos. Flacourtiaceae	Leaf	Cecidomyiidae	Kalakadu	Eruption vein gall
48.	<i>Securenaga leucopyrus</i> Muell.-Arg. Euphorbiaceae	Leaf	Eriophyes	Vandalur	Vermiform gall
49.	<i>Sphaeranthus indicus</i> L. Asteraceae	Stem	Lepidoptera	Kurumbaram	Urticular gall
50.	<i>Terminalia chebula</i> Retz. Combretaceae	Leaf	Cecidomyiidae	Kolli Hills	Perfoliate Pellet gall
51.	<i>Tinospora cordifolia</i> Hook. f. & Thoms. Minispermaceae	Stem	Cecidomyiidae	Thirunelveli	Terminal bud gall
52.	<i>Vernonia gossypina</i> Gamble Asteraceae	Leaf	Cecidomyiidae	Kalakadu	Cotton ball gall
53.	<i>Ziziphus xylopyrus</i> Willd Rhmaceae	Leaf	Cecidomyiidae	Orakadam	Covercone gall

et al., 1964). Microscopic descriptions of tissues are supplemented with micrographs wherever necessary.

Observations were made on the following phenomena of the gall development. The remarkable degree of specificity of the insects in selecting the type of host-plants, host-organs and tissues, location within the selected organs and feeding technique of the larvae and its bearing in the gall morphology were observed. Growth and development of the tissues of the galled organs which exhibit varying degree of *hyperplasia* and *hypertrophy* and factors underlying such differential growth processes were also recorded.

A change in the structure as well as dimensional values of the vascular, dermal and ground tissues of the organ that bears the gall was studied. Imposition of certain new structures such as sclerotic zone, nutritive zone, irrigating strands etc., upon the galls amidst tissues of altered morphology was noted. Histochemical localization of certain ergastic inclusions as well as structural diversity in the gall tissues as compared to normal tissues were also observed.

Fig. 1. Exomorphic profiles of Insects and Mite Psyllid (Homoptera)



Mite (Acarina)

Thrips (Thysanoptera)

Distribution of galls in Tamil Nadu forests

About fifteen forests areas were surveyed during the present study which includes places like Orakadam, Courtallum hills, Swamimalai, Yelagiri, Gingee, Bodimettu, Manalaru, Kalakadu, Kodaikanal, Kurumbaram, Kodiakarai, Ponmudi, Tiruchi, Kolli Hills and Thirunelveli of Tamil Nadu. Total number of galls recorded was 53. These galls occur on plants belonging to 49 species 45 genera and 32 families (Table 1a,b). The fresh galls were reared and the gall-insects, mites were identified and a few representative cecidzoa (Psyllid, Mite, Thrips and midge) are shown in the Fig.

1.A, B, C, D, E.

Out of 53 galls recorded from 15 forests, 9 galls were found to be recorded for the first time; they are new to science as per the data list found in Plant Galls of India (Mani, 1973, 2000) and other publications (Table 1a).

Galls occur on all growth forms starting from small herbs to large trees. However, the survey showed that the tree species are more affected by galling. The Table 2, gives data pertaining to frequency of gall bearing plants of different habits. Predominance of galls on species seems to be correlated with sustainable availability of tender plant-biomass to feed on as well as to live in for the insects. Herbs offer large quantum of materials to cope up with the needs of the insects.

Table 3. Gall frequency pattern in Tamil Nadu forests

Frequency pattern	Frequency (%)
Restricted distribution (Rare)	20 (37.74 %)
Widely distributed (Common)	28 (52.83 %)
Endemic galls and Rare	5 (9.43 %)
Total	53

Frequency of galls in Tamil Nadu forests shows three basic patterns (Table 3). About 53% of galls were found to permeate widely almost all forest of Tamil Nadu; 38% galls were discontinuous and isolated in distribution. Nearly 9% galls occur in restricted areas and are highly circumscribed. In a sense, these galls may be assigned to be endemic to the forests of Tamil Nadu.

Many galls like the "foliar-blister gall" induced by mites on *Prosopis spicigera*, *Canthium parviflorum* and cancerous callus like fungal gall on *Jasminum trichotomum*, the insect galls on *Salvadora persica* and *Terminalia chebula* are extensively distributed in almost all forests. Psyllid gall on *Alstonia scholaris* is also a common gall.

Certain galls such as rinden gall on *Abutilon indicum*, pouch gall on *Aglaia elegendia* pit gall on *Angrophora costata*, twin button gall on *Conarus wightii*; foliage bud gall on *Gymnema sylvestris*, clubshaped gall on *Harpullia arborea* leaf margin roll gall on *Memecylon edule* are found to be rare and localized in distribution.

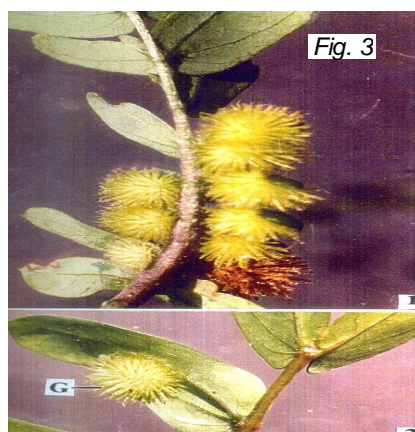
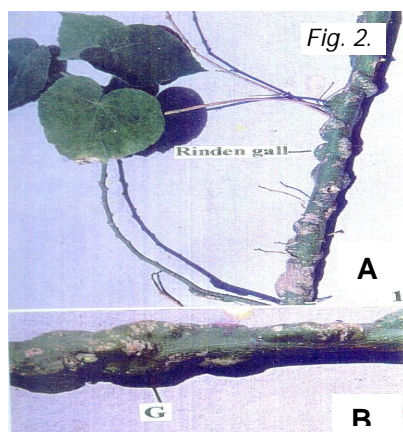
Extremely curious and complex galls on *Acacia caesia*, *Commiphora caudata*, *Excoecaria agallocha*,

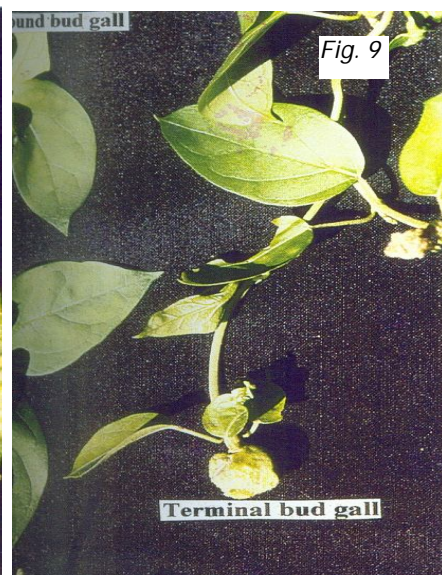
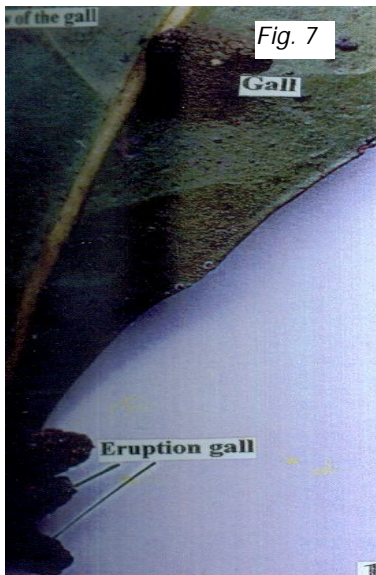
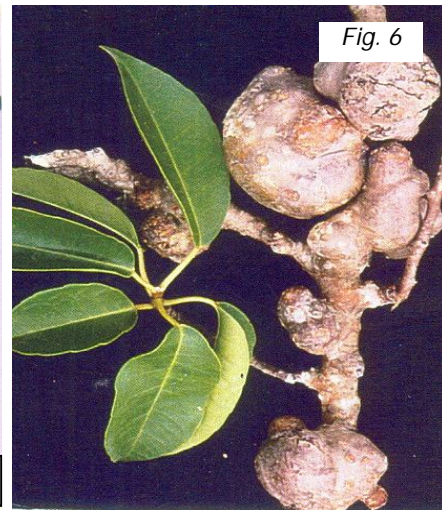
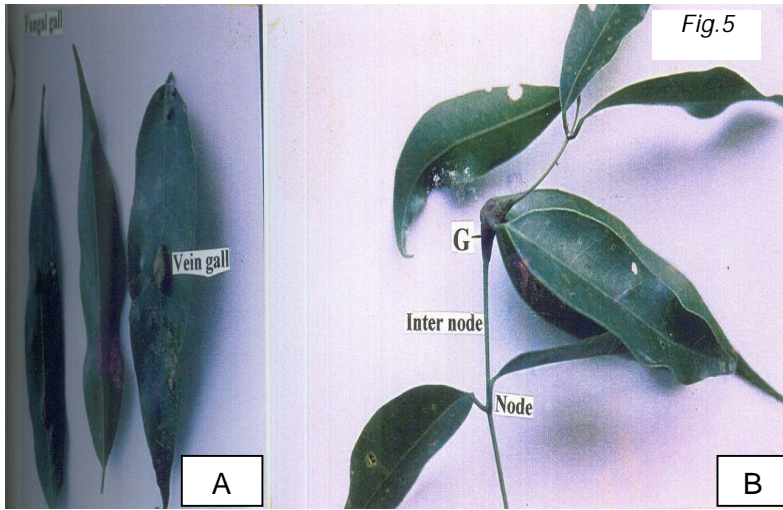
Table 2. Growth habit vis-a-vis galling

Growth habit	No. of Plants
Climbing herbs	5
Herbs	16
Shrubs	13
Trees	19
Total	53

Table 1b. Description of plant galls (new record)

Plant Names	Gall morphology	Figure
<i>Abutilon indicum</i> (L.) Sweet [Malvaceae] Herbaceous weed. Cecidomyiidae (Diptera) Rinden Shoot axis gall	Stem gall; internodal, unilateral rinden gall, blisterlike, extensive, longitudinally agglomerate, smooth, greenish when young, brownish and warty when old, indehiscent; exit holes circular.	2. A, B
<i>Acacia caesia</i> W. & A. [Mimosoideae] A straggling, thorny shrub Gall Type - I Sea urchin leaf gall Cecidomyiidae (Diptera) Gall Type - II <i>Eriophyes</i> sp. (Acarina) Amorphous bunched cauliflower gall	Foliar gall greenish yellow on the leaflets. A remarkable gall simulating the 'sea-urchin'; spherical, hypophyllous, gall studded with straight, rough, pointed vascularised bristles; one or more galls per leaflet; closely occurring, Leaf-gall; irregular, tuberculate, lobed, amorphous mass formed by deformed leaflets which fuse together forming an involuted, yellowish green body.	3. 4.
<i>Connarus wightii</i> Hook. f. Fungal gall Spindle form vein gall	Gall occurs on the veins petiole and tender stem. The foliar gall is epiphyllous, vermiform, spindle shaped, black, smooth, hard, indehiscent, along the veins and off the veins. Stem and petiole galls fusiform, spindle shaped cylindrical, extending vertically for long distance, black, smooth, hard, indehiscent, surface becomes warty in old galls.	5. A, B
<i>Excoecaria agallocha</i> L. [Euphorbiaceae] Mangrove tree. Fungus gall	Stem gall; occurs on thick branches, trunk of the tree and tender shoots. Galls are very huge and abundant, ranging from small spherical lateral bulging to highly crowded, agglomerate huge mass of irregular shape and size. The trunk of the tree above the ground level is masked by large masses of irregular and agglomerated extensive gall.	6.
<i>Glycosmis pentaphylla</i> (Retz.) DC. [Rutaceae] Cecidomyiidae (Diptera) Wild shrub; aromatic; fruits edible. Elliptical eruption gall	Hypophyllous foliar gall, mostly abutting the midrib; elliptical or cylindrical, coarsely warty, dark brown, solid, hard, indehiscent, eruption gall; solitary or in close series; slightly lopsided.	7.
<i>Grewia flavescens</i> Juss. [Tiliaceae] Large shrub. <i>Eriophyes</i> sp. (Acarina) Cephalonean-lobed pouch gall	Epiphyllous, pedicellate, cephalonean, freely lobed pouch gall; highly crowded; diffuse in distribution; surface hairy, gall thin and hollow, gall chamber folded along the inner surface; indehiscent, yellowish green.	8.
<i>Gymnema sylvestre</i> (Retz.) R. Br. [Asclepiadaceae] Twining shrub of considerable medicinal properties. Cecidomyiidae (Diptera) Fused foliage bud gall	Spherical galls occurring in the terminal or axillary buds. Young leaves and leaf primordia of the bud get fused into a globular mass with short stalk; gall pale green or yellow; surface hairy and uneven.	9.
<i>Harpullia arborea</i> (Blanco) Radlk. [Sapindaceae] Large, evergreen tree. Cecidomyiidae (Diptera) Club shaped eruption pouch gall	Hypophyllous, erupting gall, mostly on the veins. Club shaped pouch gall prostrating on the leaf surface; basal part narrow and cylindrical gradually expanding into a club shaped body; hollow and utricular and brittle; shining, yellow or reddish brown;	10.







Sphaeranthus indicus and *Vernonia gossypina*, seem to be endemic to some of the isolated scrub forests of Tamil Nadu.

The gall insects are preferential not only in their choice of the plant species; they are also highly specific to the plant organs and tissues. Table 4, shows that lamina or the Leaf-blade is the most favoured organ for galling. Nearly 60 % of galls are of foliar galls; stem galls including shoot apex are next to the foliar galls; other organs are meagre in galling.

Table 4. Plant organs bearing the galls

Plant organs bearing galls	Total No. recorded
Stem, petiole and leaf	1
Flower	1
Petiole, rachis	1
Vein, midrib	6
Stem	12
Lamina	32
Total	53

The gall-inducing guild of organisms and their frequency data are presented in the Table 5.

Table 5. Gall insect index & their gall frequency

Causative organisms	No. of Plants
(Moth) Lepidoptera	1 (1.89 %)
(Weevil) Coleoptera	1 (1.89 %)
(Thrips) Thysanoptera	2 (3.77 %)
(Psyllid) Homoptera	4 (7.55 %)
(Midge) Cecidomyiidae	31 (58.49 %)
(Mite) Acarina	11 (20.75 %)
Fungi	3 (5.6:6 %)

Table 5 shows different group of insects and mites that produce galls in the forests. Several factors can be attributed to the gall-midges for their predominance of gall inducing traits (58%). The gall midges generally possess well-developed salivary apparatus. The gall - midges can feed on wide range of plant organs from apical bud to hard stem. The gall midges seem to possess adaptability to thrive in a wide range of ecological ambience.

Conclusions

Though the gall-population status and infestation rate are low in the forests of Tamil Nadu, the morphological spectrum and structural complexity of the galls are splendid and alluring. Many of the galls were found to be strictly endemic and circumscribed to limited areas within the forests surveyed. For example, several curious complex galls on the leaflets of *Acacia* spp; and the leaf fold-fused galls on *Angophora costata*, *Glycosmis pentaphylla*, *Harpullia arborea* and *Sphaeranthus indicus* are seem to be rare and restricted to certain areas in the forests of Tamil Nadu. Many galls are predominant and widespread not only in Tamil Nadu but also elsewhere in India. Galls on *Acacia leucophloea*, *Cinnamomum verum*, *Ficus mollis*, *Holigarna arnotiana*, *Pongamia pinnata* and *Prosopis spicigera* are some of the wide spread galls.

Gall incidence ratio with reference to the host habits and host organs revealed that the tree species and

leaves were found to bear more galls (Table 2, 4) than shrubs and herbs and other organs of the plant. It seems that higher rate of incidence of galls on the trees and leaves may be attributed to availability and suitability of biomass for the insects to choose to their choices.

The phytophagous guild of insects endowed with gall inducing traits, the *Dipteran* insects dominate over other insects and the Mites occupy the second place (Table 5). The gall-midges have evolved adaptive strategies to thrive with the adversities of the semiarid ecological milieu and to feed on a variety of host-plant species. The mites being microscopic wingless organisms, are easily dispersed by wind and are limited in their nutritional and dwelling requirements. These aspects may be attributed to the success of the mites to be a codominant in the forest ecosystem.

The morphological spectrum of galls of the forests exhibits variation ranging from the simplest *erineal* gall, caused by the *mites*, simple *leaf fold / leaf roll* gall by the *thrips* to highly complex galls involving coordinated growth of two or more leaflets and fusion of tissues during cecidogenesis.

High degree of specificity of host plants, host organs / tissues, morphological exposition and internal organisation with reference to the gall inducing agents is the striking phenomenon observed in the present study. Even though it is a pathological in nature, the galls are useful tool to identify the Angiospermic plants in the absence of floral characters in some extent during our enumeration of plants in various forest regions.

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