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Utility of plant galls

M. Gopi

Department of Plant Biology & Plant Biotechnology, Guru Nanak College (Autonomous), Velachery, Chennai – 600 042, India
lmk_gopi@yahoo.com

Abstract

Background/Objectives: The forest signifies the most intrinsic ecosystem complex. The ecological relationship of various components of the forest ecosystem is subtle and far to seek. Plant galls are outburst of repulsive reactions of the plant tissues to the stimulus incited by certain guild of phytophagous insects. In many cases, the galls induced by the parasites attain phenomenal structural complexity and architectural design which have allured the naturalists.
Methods/Statistical Analysis: To understand the mechanism involved in the morphogenesis and histogenesis in the normal growth of plant, cecidogenetic studies, similar to tissue culture and experimental methods, may also provide useful information and throw light on our perception of growth and development of plants.
Findings: The many plant galls are found to have medicinal properties. They have been used in traditional Indian Systems of medicine, especially Siddha and Ayurvedha. The gall nut of a *Cynipid* insect on the leaves of *Quercusinfectoria*, horn-shaped foliar gall on *Pistasiaintegrima* by *Psyllid* insect are popular gall drugs. Many fungal galls are also edible and eaten by tribals in many places.
Application/Improvements: Many practical applications may be attributed to ratiocinate the study of plant galls. Certain galls are said to be edible and some galls also claimed to be traditionally used as drugs.
***Keywords*:** Insects, Mites, Natural dye, Plant Galls and *Ziziphusmauritiana.*

1. Introduction

The rich and highly varied flora of the Indian sub-continent is remarkable for the occurrence of different types of plant galls [1] and it also offers an exceptional opportunity for studying these structures by biologists (Figure 1). Man's knowledge of plant galls dates back to the seventeenth century. Marcello Malphigi seemed to have initiated the scientific inquiry of these neoplastic outgrowths. Cecidology, as a separate discipline of biological significance, was first founded by [1]. His publication on 'Plant Galls of India' [2] is the outcome of nearly five decades of exploration and intensive and extensive studies on them. In this monograph, he has given a definition of galls, followed by a brief outline of the gross morphological features of galls, gall bearing plants and plant organ, gall inducing organisms and gall types. Even now, lacunae exist in the various aspects of cecidological studies in India such as (i) enumeration of a large number of unrecorded galls (ii) studies pertaining to their structural diversities and ontogeny (iii) biochemical basis of cecidogeny (iv) biology and taxonomy of cecidozoa and (v) host specificity and (iv) beneficial aspects of economic utility. Inspite of considerable amount of work carried out in India, much scope seems to remain for further extensive studies on plant galls, especially in the useful aspects of mankind. This fact prompted the present investigation.

2. Materials and Methods

The materials for the present investigation were collected from various places of Tamil Nadu (Kavalur, Javadhu Hills, Kodaikanal, Kolli Hills, Nilgiri Hills) in different seasons of a year. Both normal and affected plant parts were collected in the field. Host plants were identified with the help of different floras like [3-7], Plant galls of India [2] was referred to identify the galls and their incitants, which were already reported and to ascertain the unrecorded ones. The mature galls and also those of normal ones were separately fixed in FAA (Formalin – 5 ml + Acetic acid – 5 ml and 70% Ethyl Alcohol 90 ml). Fresh materials were used for morphological study and photography. The materials were dehydrated and paraffin infiltration by customary methods [8]. The collection of materials was utilized for preliminary phytochemical analysis, Nutraceutical as well as extraction of natural dye analysis.

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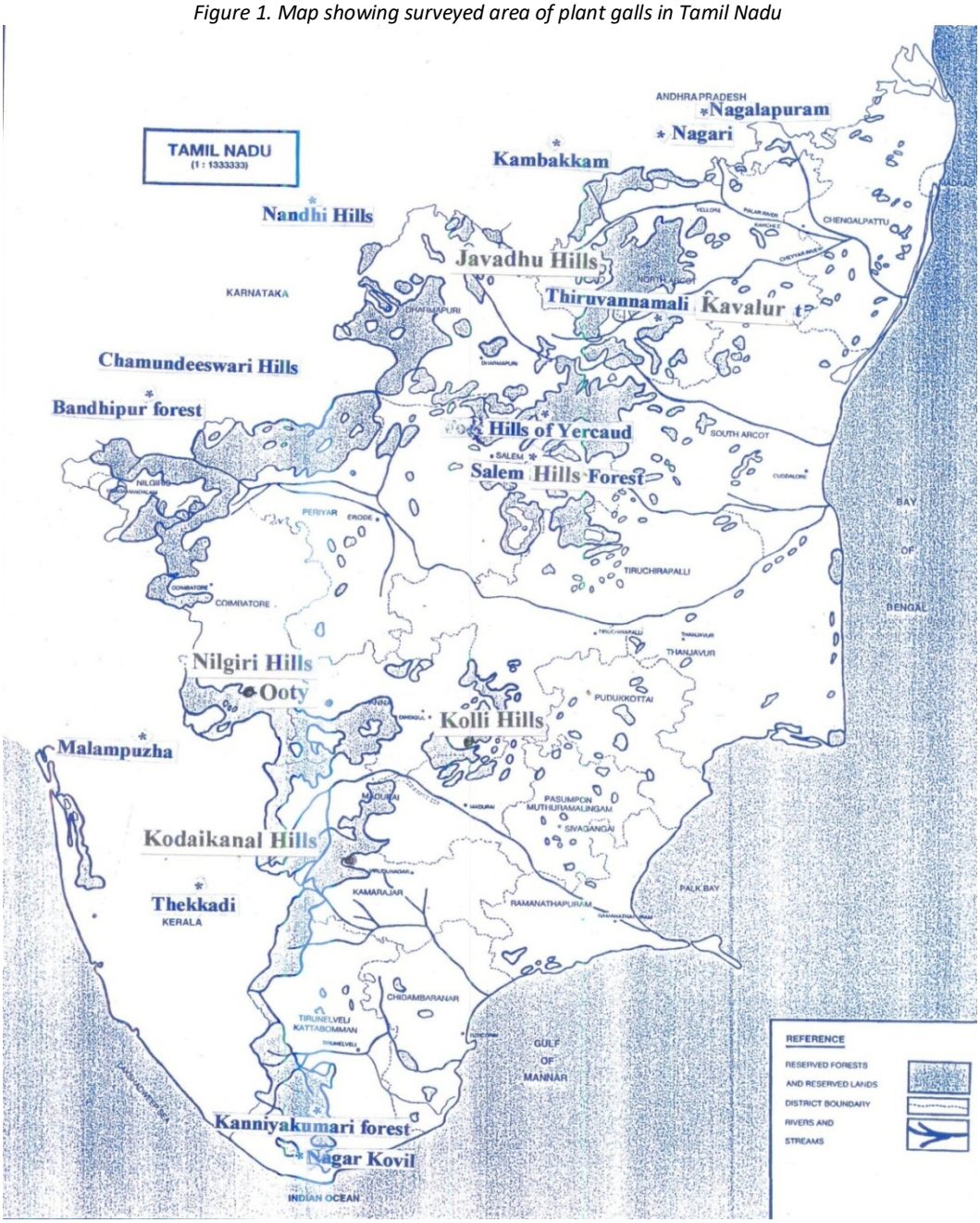
Figure 1. Map showing surveyed area of plant galls in Tamil Nadu



3. Observations

1. Acacia caesia W. & A. (Mimosoideae)

A straggling, thorny shrub, growing mostly near the streams and waterfalls. Five types of gall were recorded on the plant which is simultaneous in occurrence.

Gall Type – I (Figure 2): Blister leaf gall (Cecidomyiidae) – Greenish yellow, blister gall, smooth and shining, one or more galls per leaflet, located anywhere on the leaflet, lenticular gall, equally projecting on both sides of the leaflet, solitary or agglomerate. The gall in cross sectional view is lenticular with central vertically oblong larval chamber. Bulk of the gall consists of thin walled, less compact parenchymatous tissue.

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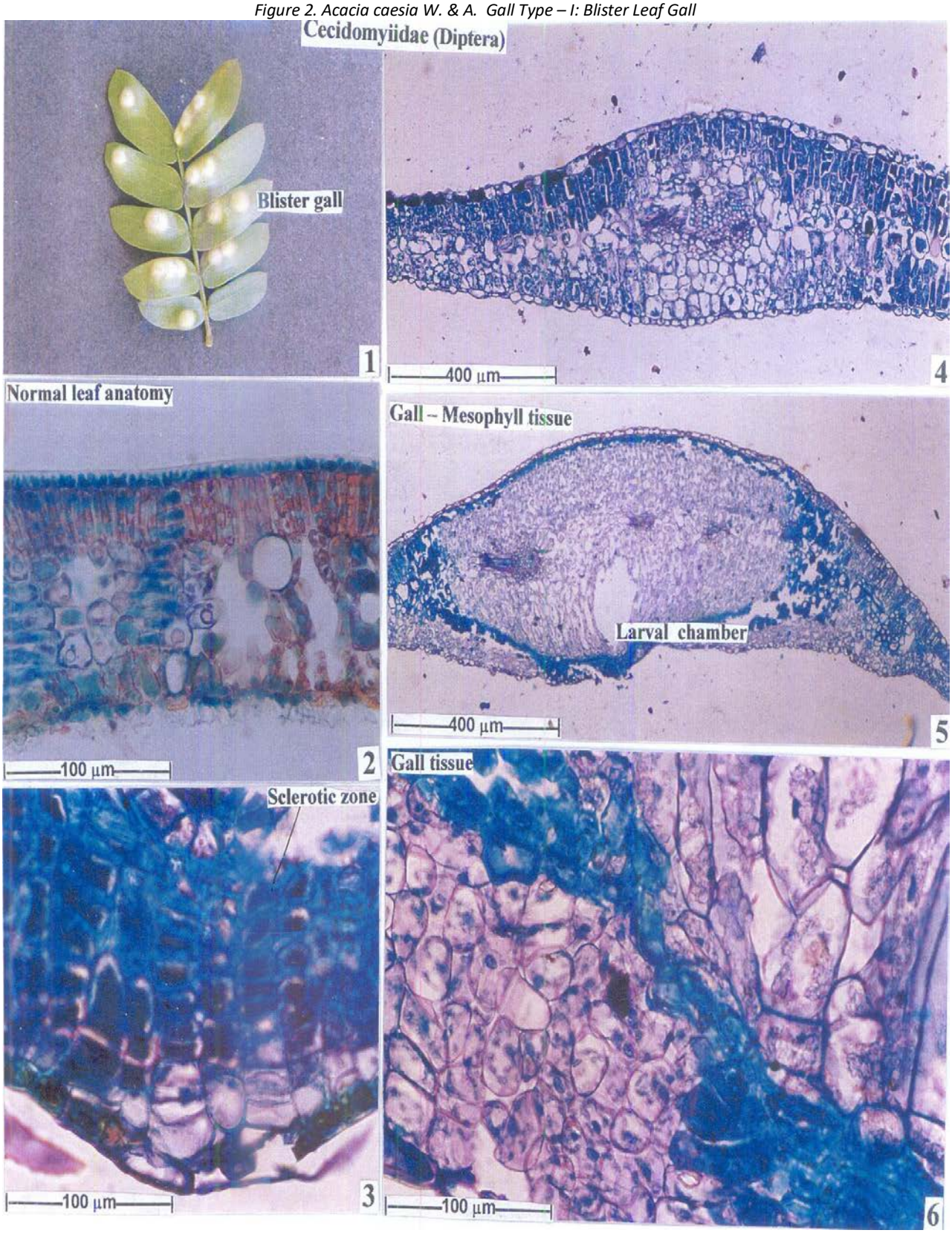
Figure 2. Acacia caesia W. & A. Gall Type – I: Blister Leaf Gall



Gall Type – II (Figure 3): *Lenticular purple leaf gall* (Cecidomyiidae) – Leaf let gall, brightly coloured, lenticular purple, circular, biconvex, solitary or occasionally agglomerate, smooth, shining, distribution on random on the leaflet.

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Figure 3. Acacia Caesia W. & A. Gall Type – II: Lenticular Purple Leaf Gall

Figure 4. Acacia caesia W. & A. Gall Type – III: Sea Urchin Leaf Gall

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Gall Type – III (Figure 4): *Sea urchin leaf gall* (Cecidomyiidae) – 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, but not agglomerate, found adjacent to the midrib, green when young, pale yellow when old. The gall develops entirely from the mesophyll tissue which undergoes localized, proliferation forming abaxial invagination of spherical body with adaxialostiolar canal and central ovate larval chamber.

Figure 5.Acacia caesia W. & A. Gall Type – IV: Amorphous bunched leaflet gall

Gall Type – IV (Figure 5): *Amorphous bunched leaflet gall* (Eriophyes sp.) – irregular, buerculate, lobed, amorphous mass formed by deformed leaflets which fuse together forming an involuted, yellowish green body. The gall has highly loved, branched, irregular emergent ingrowths form crowded masses in the gall; the emergences are thick and fleshy. Vascular stands are seen in all lobed masses. The surface layer of cells lining the lobes, are darkly staining. Parasites are frequently seen in the crevices of the lobes.

Gall Type – V: *Blister gall* (Cecidomyiidae) – Elliptical, shallow, swelling of the leaflets, bright red with yellow margin, indehiscent, smooth, visible on both sides of the leaflets.

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2. *Acacia catechu* Willd. (Mimosoideae)

Thorny tree of scrub forests. '*Cup – saucer*' leaf gall (*Lobopteromyia bivalviae* (Rao) Mani (Diptera). Complex gall involving two or more consecutive leaflets of the same side. Reddish brown, conspicuously visible eye catching remarkable gall. The gall develops between anterior and posterior leaflets forms plano-convex, adaxially flat structure. The anterior cup and the posterior saucer shaped part fit accurately with each other forming a gall complex called '*cup-sacuer* gall'. The midge larva lies in between the cup and the saucer. Induced by the larva lying in between two consecutive leaflets the mesophyll tissues of the anterior and posterior leaflets undergo initial hypertrophy followed by cell divisions in periclinal plane. The anterior leaflet undergoes increased proliferation of the upper part of the tissue as shown in Figure 6.

Figure 6. Acacia Catechu W. & A. Cup and Saucer leaf gall

3. *Acacia ferruginea* DC (Mimosoideae) – Small thorny tree

Gall Type - I: Cylinder piston gall (*Lobopteromyia* sp.). Complex gall with remarkable profile and colour, formed by coordinated growth of two successive leaflets of the same side, appearing as complex of 'cylinder piston. The posterior leaflet produces a hypophyllous, hollow cylindrical out pocketing, and the anterior leaflet produces a solid, cylindrical rod shaped piston, the piston fits tightly into the hollow cylinder. The tip of the cylinder has a hollow beak in which the gall-larva lives. The gall is indehiscent, varies in colour from yellowish green to red or violet; the gall surface is smooth.

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The gall system consists of a solid cylinder penetrating into a hollow piston. The cylinder has compact, vertically stretched central parenchymtous tissue and outer sclerenchymatous zone. The cylinder is derived from downward growth of the mesophyll tissues. The piston has inner epidermis followed by parenchyma zone and outer sclerotic zone. The terminal portion of piston is prolonged into a beak which is partly sclerenchymatic. The larva is nurtured by the hollow cylindrical gall.

Gall Type – II: Hour glass gall (*Lobopteromyia ramachandrani* Mani) – A remarkable, barrel shaped or hour glass shaped gall involving two successive leaflets. Each gall consists of two units, one formed by abaxial growth of the anterior leaflet, another by adaxial growth of the posterior leaflet. On the upper side of the leaflet develops a hollow, barrel shaped, stout thick walled covering growth, from the lower side of the leaflet lying above the lower leaflet, gives rise to a short, stumpy, cylindrical pestle like gall which goes into the barrel and fits exactly with the cavity. These two units form a combined gall complex resembling the 'hour glasses. A curved beak is usually formed on the upper part of the barrel gall. The gall is unilocular, habrd, indehiscent, red or brown, 3 – 4 mm long and 2.5 mm thick. The gall harbours the larva in the chamber of the peg and barrel. Several galls occur in longitudinal series on either side of the leaf. The anterior cylinder consists of a broad expanded upper portion which becomes narrowed into a solid thick cylinder below. The cylinder consists of compact, vertically stretched parenchymatous cells with dense tannin contents. The lower portion is a wide hollow and deep cup. The lower part also consists of parenchymatous compact thin walled cells.

4. *Acacia leucophloea* (Roxb.) Willd. (Mimosoideae)

Predominant thorny tree of the semiarid forests. Many insects and mites infest the various parts of the plant and produce many remarkable galls of high complexity. Rinden gall (*Haphalophragmium ponderosum* – Fungus). Fungal gall on tender branches and fruits, huge, abundant, variously shaped, hard, woody, indehiscent, solid, reddish-brown, smooth or warty, rinden gall, the galls persists for several years, and almost entire tree bears galls of varying sizes and stages of development. The gall arises through extensive proliferation of the cortical as well as the vascular tissues. Since the fungus permeates freely and indefinitely, the gall tissues are rendered unlimited growth into huge amorphous body. The xylem tissue is thrown into twists and curls and also nodules due to hyperplasy and hypertrophy of the ground parenchyma. The fungal mycelium is intracellular and occupies the entire cell lumen.

5. *Eupatorium adenophorum* Spreng (Asteraceae)

Herbaceous weed [9, 10], *Utricularshoots axis gall* (*Procecidochares utilizes* Stone). Shoot axis gall, sometimes extending to petiole and veins. Fusiform or ovoid, solitary or agglomerate moniliform, solid, soft, smooth, yellow or purple, indehiscent, larval escape through circular exit holes. The normal stem has collenchymatous cortex, discrete, radially oblong collateral vascular bundles and wide pith. Gall cavity wide and medullary. Meristematic activity diffuses in the pith and cortex leading to widening and cleavage of the vascular cylinder. The inner boundary of the gall chamber provides the nutritive on which the insect bites and chews the cells. Broken vascular cylinder gets folded, twisted and nodulated due to the stress imposed on the tissues during growth of the gall.

6. Garugapinnata Roxb. (Burseraceae)

Large deciduous tree (*Phac opteron lentiginosum* Buckton). Leaf gall, a remarkably curious gall, alluring in size, shape and colour. Gall occurs mostly at the basal part of the leaflet, near the veins. Epiphyllous densely clustered or solitary, ovoid, or sub cylindrical, smooth, soft, and hollow and apically nipple like mucronate. The gall consists of a basal cuplike covering growth, from the basal cup arises the erect cylindrical part, which is constricted into neck at the place of insertion. Gall is yellow when young, turns reddish and finally brightly reddish brown. Wide gall contains Psyllid nymphs and adults; mature gall dehisces along the vertical cylinder. Mature galls are 2 cm high and I cm thick. The normal leaflet has prominently projecting veins, thick and broad epidermal layers and dorsiventral mesophyll tissues. The larval chamber is found deeply buried in the spongy mesophyll zone; a broad massive hemispherical gall develops on the adaxial side of the lamina above the region of the larval chamber.

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The mature gall has a wide circular thick copular covering growth in the center of which a long cylindrical, fleshy, mucranate pouch is situated. The vertical pouch has wide longitudinal axial passage where fungal mycelium and other predators and inquilines enter as the gall attains full growth. Both cup and pouch have soft, thin walled parenchymatous tissues. The larval chamber is seen at the base of the cylindrical pouch and the insect seems to escape through abaxial exit hole.

7. Morindapubescens J. E. Smith (Rubiaceae)

Medium sized tree with useful timber, *Agglomerate inflorescence gall* (*Asphondylia morindae* Mani). Flower gall, globose, fleshy, solid, soft, indehiscent greenish large masses of fused gall formed by many aggregate flowers. The gall is readily mistaken for the ordinary fruit; however, absence of seeds readily distinguishes the gall from the normal fruit. The gall consists of homogeneous, compact, thin walled parenchymatous tissue with scattered vascular bundles with thin ramifying branches.

8. Pistacia integerrima Stewart ex Brandis (Anacardiaceae)

Horn gall (*Dasia aedifactor* Buckton). The gall is foliar in origin, it is horn shaped, pod like, spirally twisted, curved or straight, hollow, leaflet roll call, green or pinkish when fresh, dark brown when dry, hard and brittle, the galls remain on the branches even after escape of the aphids. The galls are 1.3 – 4 cm long, 25 mm thick. In cross sectional view, the gall has wide circular, empty gall chamber. The outline of the gall chamber is smooth and even. The ground tissue of the gall is parenchymatous, densely tanniniferous and compact.

9. Terminalia chebula Retz. (Combretaceae)

Medium sized tree, known for its medicinal fruits. *Hypophyllous huge pouch gall* (*Dixothripsonerosus* Anan.). The gall is fairly huge, balloon like pouch produced on lower side of the leaves with wide abaxialostiolar opening. The gall is smooth, glabrous, fleshy and soft, mostly solitary and along the leaf margins. The gall is an invagination of the lamina. The mesophyll loses its differentiation becomes compact homogenous mass cell around the gall chamber are smaller and gradually increases in size towards the periphery. Vascular strands are scattered in the gall. The gall chamber is occupied by many predators and parasites.

10. Ziziphusmauritiana Lam. (Rhamnaceae)

Small tree yielding edible fruits. '*Tuberculate callus like gall*' (*Eriophyescernuus* Massee). The gall occurs mostly in the axillary buds or sometimes on the tender leaves and petiole. The gall is bright reddish callus like mass of tuberculate surface. The mites feed on the surface cells of the callus mass and punctured cells develop into a 'shoot apical cell' which produces lateral vegetation producing again new lateral primordial. Thus, several masses with individual apical organization are repeatedly produced forming mass of tissues.

4. Discussion

The plant tissues respond to the feeding stimulus of the gall insect to varying degrees depending upon their meristematic potentials. The tissues of the vascular cylinder have more tendencies to undergo meristematic activity under proper stimulatory factors. These tissues readily respond to the larval feeding and give drug, 'Karkatasingi' is said to be produced on the host plant *Rhus succedanea* according to some authors [11]. Others claim that the authentic source of the drug is the plant, *Pistacia integerrima*. In [12] in his plant galls of India gives a brief description of the external features of Karkatasingi and its causative insect. His descriptions accede with the features of the market sample studied. Some *Acacia* species having remarkable gall on leaves. Each and every species constitute specific gall morphology and caused by specific insects. The same gall structure never produces some other plants at any situation. These galls are very useful to identify the plant during lack of floral characters. Even though the galls are pathological in nature, these galls are very useful to eradicate the weeds from the vegetation especially *Eupatorium*. Some literatures as well as our present investigation prove that some galls are very useful for pharmacological importance. Based on the literature survey *Quercus infectoria* and *Pistacia integirrima* are used as a traditional medicine. Among the basic aspects of studies on galls, rarely some galls are used for making natural dyes. Many galls develop bright pigmentation of red, brown purple and yellow hues. Many trees bear huge and massive galls which are rich in tannin and pigmented with various colours.

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The galls of *Garuga pinnata*, *Morinda pubescens*, *Pistacea integirrima* [13] [14] and *Ziziphus mauritiana* are used for making natural dyes and it is reliable vegetable dyes certified by Kalamkari unit of Kalakshetra Foundations, Thiruvanmiyur, Chennai. Apart from these studies galls are vital role to study ontogeny, callus culture and plant and insect interaction in a natural conditions (Figure 7).

Figure 7. Different hues of cloth dyed with various plant gall extracts

The nutraceutical value of galls properly prepared would offer a good source of vitamin, minerals, carbohydrates etc. Suitable methods have to be worked out for the actual manufacture of the concentrate (Table 1).

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Table 1. Preliminary phytochemical analysis

No	Gall on	Saponin		Alkaloids		Steroids		Coumarin		Tannin		Quinones		Phenols	
		N	G	N	G	N	G	N	G	N	G	N	G	N	G
1.	*Garugapinnata*	-	+	-	+	-	-	-	-	+	+	-	-	+	+
2.	*Morindapubescens*				+				+		+				
3.	*Pistaceaintegirrima*		+		+		-		-		+		-		+
4.	*Ziziphusmauritana*		+		+		-		+		+		-		+

(G – Gall portion; N – Normal part; - = Absent; + = Present)

5. Conclusion

The plant galls were found to possess many biologically active compounds. Of these compounds, tannins, alkaloids and coumarin are invariably richer in the galls than in the normal leaves. Tannins are claimed to be potential compounds of high pharmaceutical values. A few tannin containing galls, such as the Nut gall, Karkatashringi and Ber have been used in the Indian system of Medicine as astringents both to the gastrointestinal tract and on skin abrasions. An axillary bud gall on *Ziziphus mauritiana* (Rhmnaceae) and foliar gall on *Garugapinnta* (Burseraceae) are available in abundance. These galls, after the exit of the insects, go as waste by decay and decomposition. The gall biomass can be subjected to phyto chemical evaluation and tapped for their pharmacological potentials.

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