

Contribution to the Knowledge of Cecidia of Singapore

by

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This report is based on the author's thesis for the "Diplome d'Etudes Approfondies" presented before the Faculty of Science, University of Paris, in July 1970. The work was done partly at the Department of Botany of the Singapore University in 1968-69, which is under the direction of Professor A. N. Rao, and partly in Paris in the Laboratory of Tropical Botany in 1969-70 under the direction of Professor R. Schnell.

I should like to acknowledge with gratitude the help from many taxonomists who assisted me constantly throughout my research. In particular, I am indebted to Dr. H. Keng and Mr. D. H. Murphy of Singapore University who spent so much time in the determination of plants and gall-makers respectively and for their advice; to Dr. G. Gusset of Paris University for his help in the naming of plants and on morphological questions; to Dr. W. L. Chew then Botanist at Singapore Botanic Gardens and Dr. M. A. Rifai, Director of the Herbarium of Bogor Botanic Gardens, for their help in taxonomy.

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INTRODUCTION

I began my study in cecidology in Singapore where material was collected during the academic year 1968-69, and where subsequently I have had the opportunity to enrich my collection and to make new observations during two study trips in January and April 1970.

Singapore is a small island in the Malesian Region, situated at a latitude of 1° 21' North. It is exposed, at the same time, to an equatorial climate and a monsoon climate, uniformly hot and humid, nonetheless temperate because of the presence of the sea (Bib. 23; fig. 1a); the average annual precipitation is over 2.41 m. with seasonal maximums staggered from November to January.

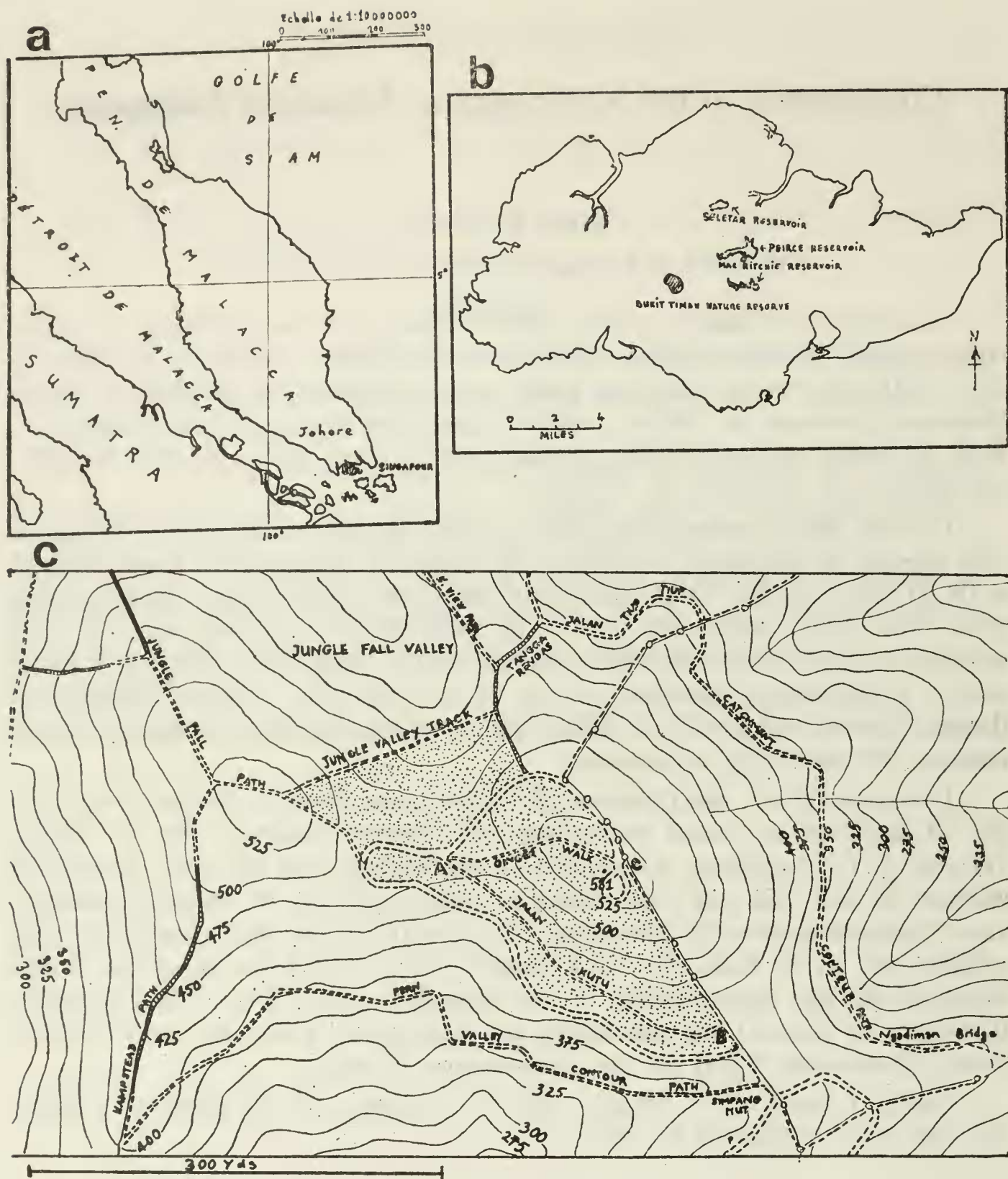


Fig. 1. a, location of Singapore adapted after the "Nouvel Atlas Général" (Bordas ed.); b, map of Singapore adapted after "Modern Singapore" (1969. Ooi Jin-Bee, Chiang Hai Ding ed., 285 pp.); c, part of the Bukit Timah Nature Reserve, adapted after an unnumbered plan. The stippled area represents my field of study. Contour numbers are in ft.

Meanwhile, in the course of "winter" 1968–69 rains were unusually low. This climatic anomaly certainly influenced the flora and its pathology, and therefore must have affected my results. I unfortunately cannot assess the importance, having made my observations over such a short period. Material was collected leisurely during walks in private gardens and along the wayside. A limited area in the Bukit Timah Nature Reserve was chosen for systematic collecting and study (fig. 1, b & c). This Reserve is according to H. M. Burkill*, a block of 184

* H. M. Burkill: A Survey of Nature Conservation on Singapore Island. The Proceedings of the Ninth Pacific Science Congress, 1957. Vol. 7, 1959.—pp. 34-37, 1 map.

acres of lowland forest clothing Bukit Timah (Malay for "Hill of Tin"). It is granite and without any tin deposits. With its two peaks both slightly over 525 ft the Reserve is the highest ground on Singapore Island. It is one of the first Forest Reserves made after Cantley's report* and has never been exploited for timber.

One should note that a large number of *Shorea curtisii* King** saplings which compose the undergrowth in my field area, is the result of the germination of anemochorous and heliophilic seeds. This testifies to a recent thinning of the forest.

Under "Material and Technique" is a description of the method I have used and perfected for my study. The cecidia that I have collected are listed with notes. This list follows the style of those of Houard (Bib. 28), and of W. and J. Docters van Leeuwen-Reijnvaan (hereafter D. v. L. R.) (Bib. 22), and consists of a succinct morphological description of my specimens, illustrated with line drawings and plates. As far as possible, a few morphological and physiological interpretations relative to the process of the cecidiogenesis are given. They are based on the recent works of Strasbourg Laboratory (Bib. 39). Adopting the ideas of Kloft (Bib. 34), Maresquelle and Meyer (Bib. 38), I have included in my list all developmental anomalies of parasitic origin, where the anomaly has bearing on the positive or negative growth, or also on the cellular differentiation.

HISTORICAL REVIEW

The only works of importance concerning cecidia in the Malesian Region are those of D. v. L. R. (Bib. 6 to 22), and of Houard (Bib. 28). There are also several previous Indonesian studies generally relevant to the pathology of economic and agricultural plants, unfortunately disseminated in journals of local interest and unavailable even in Singapore. The multiple studies of D. v. L. R. on Indonesian cecidia, complemented by the works of Nalepa (Bib. 40 to 44), on Acarina, and of Karny (Bib. 30 to 32) on the Thysanoptera are of fundamental interest. The systematic list of Houard relevant to the zoocecidia of the whole Malesian Region are of invaluable interest. Nonetheless one must know that the galls of this immense Region fractioned in a pleiad of islands and islets, are far from being well known. No previous cecidological study in Singapore has been published.

MATERIAL AND TECHNIQUE

GALL COLLECTING AND ITS PROBLEMS

The complete study of each cecidium necessitates much material; several duplicates are required for fixing, making of herbarium specimens, and separately for extricating gall-makers for the purposes of culture and despatch to various specialists for the determination of the host plants and gall-makers.

In the list, gall specimens are numbered in Arabic, identically as the host plant. Where different types of galls are found on the same host, each cecidium is labelled with an additional proper number in Roman.

*N. Cantley: Report on the Forests of the Straits Settlements. 1883, fide H.M. Burkill.

**All host-plants here published under this name are recently determined, thanks to Dr. K. M. Kochummen, Forest Botanist at the Forest Research Institute in Kepong. They appear under the erroneous name of *Shorea pauciflora* in earlier publications.

In order to make a complete study of a gall, various stages of its development are needed. With some species, these could be found during a single collecting trip, e.g. the mite-galls on *Litsea elliptica* (Bl.) Boerl. and *Actinodaphne* sp. Often, repeated collecting was necessary as is the case of the psyllid-gall on the leaf of *Notaphoebe kingiana* var. *malvescens* Gamble where juvenile stages were found in December-January and late stages only in April. Similarly were the coccid-galls on *Shorea curtisii* King (gall 23I and gall 23IVa) and the wasp-gall (gall 23IVb) on the same host: in December only a few juvenile stages of gall 23I whereas in April a considerable number of young stages were available. On the other hand, in the same interval, juvenile stages of 23IVa and 23IVb were totally absent. The wasp-gall (gall 120) on *Lithocarpus conocarpus* (Oudem.) Rehd. was first collected end March 1969 when it detached itself from the leaf, taking with it the larva in the fall. Despite methodic collecting March-September 1969, and in January 1970, that type of gall was not seen again. Finally in April 1970, I found leaves that bore marks of recent drop of galls. These observations lead me to conclude that galls 120 have a rapid development in February and March.

The observations above seem to confirm those made in temperate climates (Mani — Bib. 36. p. 197) to the effect that the majority of cecidia would develop strictly during a definite moment of vegetative growth of the host plant. Previous publications on the development cycle of galls refer to work in temperate climates (ibid. Chap. X, pp. 196-212) where the seasonal alternation fundamentally influences the vegetative rhythm of the host plant. No study has yet been made in the humid tropics where in spite of the absence of prominent seasons certain galls seem to have their own rhythm of development.

These observations suggest that a statistical correlative study in the tropics would be interesting. It would perhaps be possible to establish a calendar of gall development in Singapore in relation to the climate cycles, the internal rhythm of growth of the host plant and the cycle of the development of the gall-makers.

PRESERVATION OF THE COLLECTION

The most complete botanical specimen, carrying flowers and fruit if available, and the one with the least parasites are reserved for determination. Several parts of which the galls are well formed, ripe or already opened, are kept for the herbarium. One important part is put aside for obtaining or rearing the gall-makers. Juvenile or intermediate stages are fixed with F.A.A. for a morphological and anatomical study of the development.

Herbarium. For each type of gall two sets of herbarium sheets were made. One set is now at the Laboratory of Tropical Botany of Paris, the other at the University of Singapore, Botany Department.

The conventional techniques including the drying under pressure used for preservation in the herbarium are not to be recommended in many cases. Certain galls have a characteristic relief and a disposition which are useful to preserve. One can, for this reason, dry out the plant-part carrying the galls in a crystal powder of CuSO_4 dehydrated by heat before use. However this method presents the inconvenience of crowding and material prepared this way is very fragile.

Fixing in F.A.A. After drying, the fleshy galls shrink and become unrecognisable. It is better to fix them with F.A.A. I intend to make more precise anatomical and morphological study of the development of the galls subsequently. In this study

a series of permanent hand-sections were made by using a method taken from Johansen (Bib. 29): (a) technique of fixation, sectioning, staining (p. 102); (b) schedule of dehydration by T.B.A. (pp. 110–113). From these sections it was possible to make anatomical observations on certain cecidia which are listed.

Using the methods described above, more than one hundred galls were collected and preserved. This collection represents only a fragment of the galls in Singapore. Based on the 1536 numbers of galls of Indonesia, as given by D. v. L. R. (Bib. 22, p. 31), it is anticipated that the present collection will grow considerably in the years to come.

OBTAINING AND NAMING GALL-MAKERS AND INIQUILINES

This study necessitates much time and patience and can only be achieved by a resident worker in the area. Adult gall-makers are difficult to obtain in sufficient numbers to permit a determination. Thus my conclusions are very fragmentary and incomplete. There is no general method for obtaining parasites: the technique to be employed depends largely on the type of the gall-maker.

MITES

With the help of Mr. D. H. Murphy, I have tried out and perfected several methods to obtain mites: —

(a) *Showing the gall-mites in situ.* The numerous morphological convergences between mycocecidia and acaroccecidia (yellowish or orange swelling of the lamina, hypertrophy of the epidermic cells into hairs, parenchymatous, fleshy growths) had caused some confusion to early cecidiologists. (Mani-Bib. 36, p. 157). A method which can distinguish the presence of acaroccecidia from mycocecidia and which stains both mites and fungal mycelium alike (if present) is adapted here from one in use for research on nematodes. So far, fungi are absent in the galls examined. The process is: —

— Section the fresh and dry galls.

— Place them in a test tube and cover with a mixture composed of 5 parts of H₂ O₂ (20 vol.) and 1 part of ammonia (880) for 24 hours. This is for decolourization of plant tissues.

— The mixture is discarded and replaced with a solution of Aman's lactophenol mixed with 0.05 gm cotton blue stain.

— After boiling the test tube in a double boiler for 1 hour, leave galls in stain for at least 24 hours.

— The liquid is discarded, specimens are washed with pure lactophenol which is also used as a liquid for preservation.

— Mount specimen in drop of lactophenol.

The cuticle of mites absorb the blue stain but its opacity renders the method unsuitable for specific identifications of acaroccecidia. For this the most classic method is one which is perfected by Nalepa (Bib. 40; vol. V; p. 49).

(b) *Collecting mites by Nalepa's method.* After driving out the mites from the galls by gradual drying, they should be fixed with heated chloropicric acid. The 70% alcohol stage used by Nalepa is here bypassed because according to Keifer's work

cited by Owen Evans, Sheals and Mac Farlane (Bib. 45), alcohol is a bad medium for preserving mites, and these authors preferred to preserve them in the liquid of fixation. With this method a large number of mites can be obtained, but it necessitates much gall-material. On the other hand, I have noticed as did D. v. L. R. (Bib. 22; p. 17), that the success of this experiment depends on the humidity of the air: if the atmosphere is too humid, the gall goes mouldy, and the mites are killed inside.

(c) *Collecting mites by soaking methods.* Another technique of obtaining mites, more economical in material and independent of atmospheric conditions, was developed by Keifer as cited by Owen Evans, Sheals and Mac Farlane (Bib. 45; pp. 67–70). Their method of soaking in a solution made of resorcinol (50 g.), diglycolic acid (20 g.), glycerol (25 ml.), iodine water (about 10 c.c.), has been tried without success as I have not been able to needle the mites out of this solution which turned black and thick. That led me to investigate other methods of soaking based on the destruction of cellulose in the plant cell:—

Method I: Soaking in a solution of enzymatic extracts of digestive tubes of a snail; the snail is the only multiple-celled animal capable of digesting cellulose directly.

Method II: Soaking in Schweitzer's solution that dissolves cellulose and not chitin.

INSECTS

I set out to culture gall-midges and wasps, and inquilines but, cecidological moths and beetles being rarer, did not provide sufficient material for applying the methods described below to culture their larvae:—

(a) *Method of D. v. L. R.* (Bib. 22, m. 17). Galls are collected, opened up, and placed with their pupated parasites in a closed tube with a piece of gauze. Many wasps have been obtained by this method. The rearing of Diptera was much more difficult: the pupae of midges were very weak, they dried out and became mouldy. These unpredictable results led me to develop another technique described here.

(b) *Placing cages on the gall-bearing plant.* For descriptions and usage of various types of cages see Leach*.

It is necessary to have an opening covered over by a piece of gauze, thereby permitting aeration of the attacked part contained in the cage, and avoiding excess condensation which may cause (1) galls to mould before the opening or (2) the parasites to drown and to decompose rapidly after their exit. This method seems perfectly adapted to the rearing of winged gall-producers. It permits the observer to follow the development of the gall-makers and their cecidea in situ under quasi-natural conditions. The disadvantages are subsequent re-location of cages in the Nature Reserve and risk of destruction of those deposited in public areas. Also, leaves may succumb under the heavy weight of the cage and insects such as wasps and ants tend to cut out the gauze for making nests or to colonise the cages.

Frequently, several different sorts of animals are obtained, e.g. Diptera and Hymenoptera; it is at first sight difficult to discern as to which is the gall-maker, the parasite or the inquiline.

* J. G. Leach: Insect transmission of plant diseases. McGraw-Hill Book Co., Inc. New York and London. 615 pp. 238 figs. 1940.

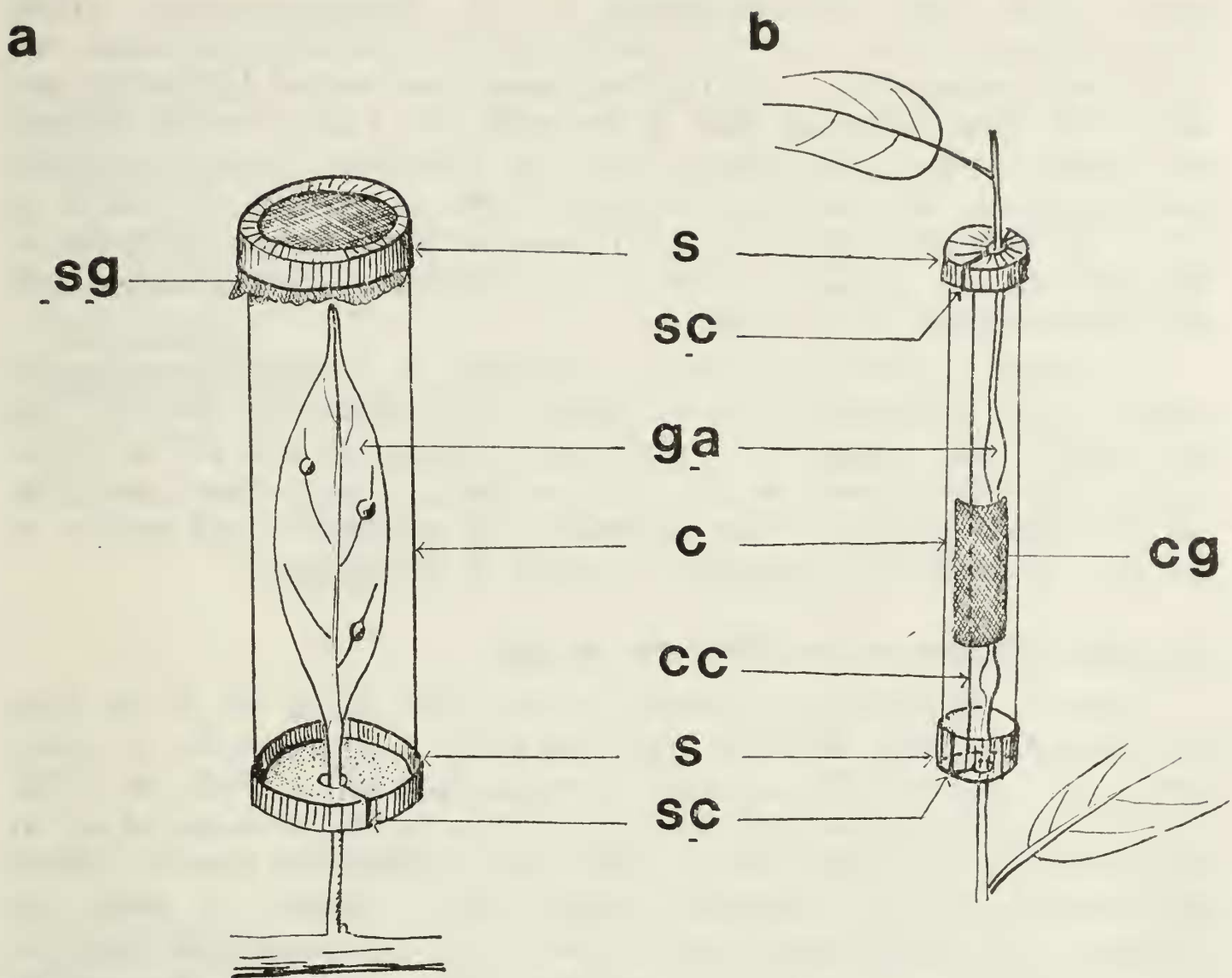


Fig. 2. Cages for rearing gall-makers; **a**, for foliar galls and acrocecidia; **b**, for pleurocecidia. **c**: transparent plastic cylinder; **cc**: cylinder cut; **cg**: gauze glued with chloroform to the cylinder; **ga**: gall bearing organ; **s**: perforated plastic stopper; **sc**: stopper cut; **sg**: gauze held in position by the stopper.

PROBLEMS ON DISTRIBUTION OF GALLS AND GALL-MAKERS

Range of geographical distribution

Of the hundred galls that are in my collection, only ten have been reported by workers in other parts of Malesia. This applies proportionately also to gall-producers: none of the animal species submitted to specialists for determination has been hitherto described. Thus the list contains many unidentified species. A new genus of Diptera was found on *Calophyllum ferrugineum* Ridl. (gall 68). Another, new genus of Coccidae is *Gallacoccus* with species *G. secundus* (Gall 23 I) and *G. anthonyae* (Gall 23 V) both on *Shorea pauciflora* King described by J. W. Beardsley*.

* J. W. Beardsley: A New Genus of Gall-Inhabiting Eriococcidae from Singapore (Homoptera: Coccoidea). The Proceedings of the Hawaiian Entomological Society, (1971) Vol. 21 (1) 31-39. N.B. See footnote on p. 19.

As many as seven different coccid-galls were collected; three occurred on *Shorea curtisii* King (Dipterocarpaceae), one on *Hypserpa cuspidata* (Wall.) Miers (Menispermaceae), one on *Calophyllum inophylloide* King (Guttiferae), one on *Xylopia malayana* Hk. f. and Th. (Annonaceae), and one on *Lithocarpus sundaicus* (Bl.) Rehd. (Fagaceae). Now, all the works that I have consulted indicate that coccids occupy a minor place among the gall-makers, except in Australia where they attain their maximum development. (Bib. 28, Vol. I, p. 11, Vol. II, p. 590. — Bib. 36, p. 27. — Bib. 22, p. 13). It seems so far that the galls on the flora in Singapore are very special and original; this endemism is certainly linked with the insular character of the region.

On Mount Kinabalu in Borneo, a coccid-gall on a young *Dipterocarpus? gracilis* Bl. was collected by E. J. H. Corner in 1963 (Bib. 2, pp. 339–341). This gall presents many analogies with *Gallacoccus secundus* i.e. gall 23I on *Shorea curtisii* King. The discovery of gall-coccids in Singapore with related representations in Borneo suggests a wider distribution and cecidiologists will perhaps be brought to reconsider the importance of coccids as gall-producers.

Ecological Problems on the distribution of galls

Plants of *Actinodaphne* sp. seemed to me equally spread out on the slope ABC limited by Ginger Walk and Jalan Kutu (fig. 1, c). *Actinodaphne* sp. carries several galls, two of which are caused by midges (gall 24II & 99III, see p. 38). One can find gall II everywhere in this location. In contrast the occurrence of gall III seems strictly limited around point C. Why is the distribution of these two midge-galls not homogeneous? Although a statistic study is necessary to confirm my findings, I can nonetheless, beginning with these observations, show up the problems on the distribution of the gall-makers and their ability to propagate. An ecological study of the habit of these two kinds of Diptera in relation to the variations of the microclimatic factors such as humidity, temperature, sun and others should be also interesting.

Distribution of galls and gall-makers in the different plant families (table 1)

The table here follows the style of D.v.L.R. (Bib. 22, pp. 28–31). It does not claim to embody exhaustive data but the following are noteworthy:

— The plant families of my list carrying the greatest number of different galls are the Dipterocarpaceae, Guttiferae, Myrtaceae, Lauraceae and Euphorbiaceae; the last three correspond to the collections of D.v.L.R. (ibid p. 28).

— Concerning the gall-makers, there are many obscure points. However midges are preponderant among gall-producers and occur in nearly all the regions of the world (Bib. 36, p. 30).

— In Bukit Timah 25 dipterocecidia and 7 acarocecidia were collected. The ratio is comparable to that of 4:1 as given by D.v.L.R. (Bib. 22, p. 26) w.r.t. humid forests in S. E. Asia. Future collections will perhaps modify my current results though the present data confirm the assessments of those authors and correspond with data related to forest and climatic types as given by them i.e. to the particularly high humidity of the undergrowth of Bukit Timah forest despite the relative dryness of the November 1968 — January 1969 period.

TABLE 1

Gall-maker	Mite		Midge		Wasp		Moth		Thrips		Psyll		Cocc.		Aphid		Insect		Fungus		?		Total	
	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b
Plant-families																								
Anacardiaceae			2								1													3
Annonaceae		1		2							2		1											6
Apocynaceae																					1			1
Asclepiadiaceae															1									1
Burseraceae		1		1					1												1			4
Combretaceae	1																							1
Celastraceae																	1							1
Dipterocarpaceae				2		3							3				2							10
Euphorbiaceae				2		1				1		1					1			1	1	1		8
Fagaceae				1		1		2						1										5
Guttiferae				4				2			1	1	1											9
Lauraceae		3		4					1		2						2							12
Leguminosae				2						1											1			4
Loganiaceae				1					1															2
Menispermaceae														1										1
Moraceae	1					1			1															3
Myristicaceae										1							1				1			3
Myrsinaceae																	1							1
Myrtaceae						1	1			2	2	4					2			1				13
Rhizophoraceae				1																				1
Rubiaceae				2																	1			3
Sapotaceae				1													1							2
Tiliaceae				1																				1
Verbenaceae		2		1											2			1						6
Vitaceae												1												1
Oleandroideae	1																							1
Total b		7		25																				
Total a+b	10		27		7		5		9		15		7		2		12		1		8		103	

b: galls from Bukit Timah Nature Reserve
a: galls from other localities

CONCLUSION

My results show that the gall flora of Singapore is special when compared with those in Malesia hitherto published.

(i) About ten only of the cecidia of my list have been mentioned in previous studies, the other galls appear, for the most part, on host-plants not mentioned in the works of Houard or D.v.L.R.

(ii) Moreover, my coccid-galls appear in the present stage of knowledge as pathological forms particular on the island of Singapore. Also my discoveries of coccids, added to that of Corner in Borneo, commit me to question the dogma generally accepted, i.e. that these Homoptera are hardly important as gall-producers except in Australia.

The list shows that, despite their particularities, my cecidia present certain typical characters of humid tropical regions: abundance in some families such as Lauraceae, Myrtaceae, Euphorbiaceae, and also abundance of gall-midges and thrips.

Certain types of galls, provoked by the same animal genus on the same plant genus are extremely widespread in the tropical world, for example the psyllid-galls on the *Eugenia* genus "distributed from East Africa to the Gambier islands" (Bib. 28, p. 592) are numerous in the Malesian Region (Bib. 28, pp. 593-598; Bib. 22, pp. 407-417), and in particular in Singapore (see list). This poses a phytogeographical problem of distribution and dispersion of the flora with the associated fauna.

Finally, it is noted that, though the action of gall-makers belongs to the same zoological group, galls of identical aspect and structure appear on taxonomically distant plant species. Examples are the ball-shaped, parenchymatous, fleshy midge-galls of my list: gall 168I on *Shorea* sp. (Dipterocarpaceae), gall, 13II on *Grewia blattaefolia* Corner (Tiliaceae), gall 107II on *Calophyllum pulcherrimum* Wall. (Guttiferae). In the formation of a gall two fundamental factors are distinguished: first, the role of the animal and second that of the host-plant. In the cases mentioned above, it would seem that under the influence of certain gall-makers, the same genetic factor of localisation would intervene in the gall morphogenesis.

ANNOTATED LIST OF GALLS

ANACARDIACEAE

Mangifera indica Linn. Gall. 140. Pepis Road (garden).

Midge-gall affecting the two faces of the lamina. Adaxially the cylindrical gall is 1.5 mm to 2.5 mm in diam., and 1 to 1.5 mm in height, often around the gall the lamina is elevated. The distal region of the cylinder has a small lid. Abaxially the gall is cone-shaped: 1.5 to 2 mm high, the diam. of the base 1.5 to 2 mm. Inside is a very small circular larval cavity. The galls on the specimens in Singapore were mostly located along the midrib and side veins.

Distribution: Singapore-Java, Rhio Archipelago, Sebesy Island, Celebes, Malacca. See Bib. 7, p. 107. No. 66, fig. 36-9, p. 187, No. 189.-11, p. 92, No. 12.-15, p. 36, No. 41.-20, p. 303, No. 43.-21, p. 137, No. 53, fig. 28.-22, p. 325, No. 803, fig. 579.-28, p. 467, No. 1719 & ? 1721.

Idem. Gall 82; Singapore, Changi Road, 11½ m.s.

Midge-gall looking like the preceding one but smaller. Adaxially, the cylinder is 1 mm high, and 0.5 mm in diam.; the apex of the cylinder is rounded. That is where the dehiscence by a pore is located. The gall is not surrounded by an elevation of the lamina as in the preceding case. Abaxially, cone of 1 mm high on 1 mm in diam. of base. It seems to correspond to the description of Houard (Bib. 28, p. 467, No. 1721).

Semecarpus sp. Gall 59 & 46. B.T.N.R.

Psyllid-gall. Disc-shaped thickening of the lamina 4 mm in diam. on 1 mm thickness, visible on both faces of the leaf. The exit pore of the gall-maker is abaxial and the tissue around it is slightly elevated.

ANNONACEAE

Artabotrys suaveolens (Bl.) Bl. Gall 22 I, 26 & 127. B.T.N.R. (Pl. 1).*

Midge-gall, attached to one or the other face of the lamina and sometimes to the twig by a large circular base 5 mm in diam. If the leaf is very infected it becomes atrophic. The young gall is horn-shaped, more or less curved, up to 2.5 cm long. In the course of its development, its inferior third part becomes hypertrophic and is 5 mm across; the superior part keeps its conical shape. In the centre of the swollen part is the larval chamber, surrounded by a hard and fibrous shell that digitates into the white parenchyma surrounding it (Pl. 1, e). The gall is covered with a green and glabrous epidermis. In the gall-chamber is only one midge-larva. On maturity the gall cavity is much widened; its wall becomes blackish. The midge makes its way out by piercing a large canal through the wall of the swollen part of the gall (Pl. 1, d, f), and leaves its pupal integument partly inserted in the gall (Pl. 1, b). Very often the gall contains a parasitic moth. There is then deviation of the cecidiogenesis: the swollen part becomes preponderant, reaching 1.4 mm in diam. The superior conical part is reduced to 2 mm in height. The moth larva eats the internal part of the gall and, after metamorphosis leaves the gall through a large circular pore (Pl. 1, c). When the parasite or gall-maker has left, the gall detaches itself easily from the leaf, therefore inducing the formation of an alveole on the lamina (Pl. 1, a, d).

Distribution: Singapore-Java (Bib. 22, p. 185, fig. 285).

Idem. Gall 22 II. B.T.N.R. (Pl. 1, g).

Psyllid-gall, very wide-spread in the Nature Reserve. The lamina is marked by conical elevations, 0.5 mm high, on a base 1 mm in diam., caused by the young psyllids attached abaxially.

Cyathocalyx ramuliflorus (Hk. f. and Th.) Scheff. Gall 100. B.T.N.R. (fig. 15, a).

Mite-gall. Mamillated pockets that pouch out from the adaxial leaf-surface between the side-veins, 3 to 5 mm high. The interior of the cavity is covered with an erineum that is brown when the gall is adult.

Popovia tomentosa Maingay Gall 70 & 151. B.T.N.R., Jalan Kutu and Jungle Valley. (fig. 13, c; Pl. 11, d).

*Figures 3 to 18 and all plates follow bibliography.

Midge-gall often attacked by wasps. On the stem or leaf-stalk, the gall is ovoid, 2 mm in height and 1 mm at the widest part, fixed by a large base. The opening is apical. On the leaf (Pl. 11, d), the galls are attached laterally along the midrib, usually packed closely in a more or less coalescent row. The isolated gall presents itself adaxially as a protuberance 2 mm in height and 1 mm wide at the base, and abaxially is a less distinct swelling, less than 1 mm in height. The large gall-chamber, containing only one midge-larva, is located at the level of the lamina; around it one finds the nutritive tissue (nt), a protective shell (s), and a tanniferous parenchyma. Finally the gall is covered with a hairy epidermis (fig. 13, c). The opening is apical and adaxial. After the exit of the gall-maker, one notices that the gall-chamber is plastered with a hard and blackish covering.

Xylopiya malayana Hk. f. and Th. Gall 154. B.T.N.R., between Ginger Walk and Jalan Kutu. (fig. 12, c).

Pleurocecidium caused by a coccid belonging to the family Lecaniodiaspididae, *Lecaniodiaspis* sp. On the scale-mother periphery, a fusiform wad develops in the direction of the axis of the stem, 1 cm long and up to 6 mm wide. The large opening of the gall cavity is covered by a waxy and resinous scale, 5 mm across, secreted by the mother. The female deposits its eggs beneath this scale. Under the growth of cortical tissues that actively participate in gall morphogenesis, the bark is fissured.

Undetermined ANNONACEAE. Gall 164. B.T.N.R., Jungle Valley.

Psyllid-gall. Conical elevation of the lamina, less than 1 mm in height, provoked by psyllids attached abaxially.

APOCYNACEAE.

Willughbeia coriacea Wall. Gall 28. B.T.N.R.

Cause not determined. Fusiform swelling 1 to 1.5 cm wide, affecting the stem for several cm in length. Under the effect of the growth of internal tissues (xylem, phloem, cortical parenchyma), the bark cracks and breaks up into fragments.

ASCLEPIADIACEAE.

Hoya diversifolia Bl. Gall 90. Dalvey Road.

Insect-gall. Leaf-gall affecting only the upper surface of the lamina. It presents itself as a slight purple protuberance of 5 mm in maximum diam, yellow in its centre.

BURSERACEAE.

Canarium pilosum A. W. Benn. Gall 69 I, 83 & 109. B.T.N.R. (Pl. 5, c).

Gall caused by a mite, *Eriophyes* sp. close to *E. reijnvannae* Nal. fide Dr. Keifer in litt. Hairy clavate finger-gall in 1 cm height by 5 mm width at the maximum, projecting out from the adaxial side of the leaflet, has a small abaxial opening and is covered inside with straight hairs. This type of gall occurs frequently on the genus *Canarium*. For example: *Canarium hispidum* (Bib. 28, P. 422, no 1550.—22, p. 262, no 627, fig. 436.—16, p. 28, no 531, fig. 531); *Canarium* sp. (Bib. 22, no 627 & 629, p. 263, fig. 438).

Idem. Gall 165 II. B.T.N.R.

Thrips-gall. The leaflets become involute.

Idem. Gall 121 III. B.T.N.R., between Jalan Kutu and Main Road.

Midge-gall (Pl. 5, a, b). Ovoid cecidium, 2 mm long, less than 1 mm wide, attached to the veins by a large base and opening by a round apical pore, when mature. Inside is a large gall-chamber containing a midge-larva. The internal wall of the gall is grey or blackish.

Idem. Gall 121 IV. B.T.N.R., between Jalan Kutu and Main Road.

Cause not determined (Pl. 5, d). Under the influence of the parasite, there is inhibition of the vein-growth, which creates the pleating of the lamina of leaflets the edges of which, moreover, tend to become involute.

COMBRETACEAE.

Terminalia catappa L. Gall 145. Campus of the University of Singapore and Angullia Park.

Mite-gall. On the adaxial face of the leaf this yellow, green or red pouch-gall forms a rounded protuberance less than 1 mm high; the ostiole of the gall is abaxially opened and leads to a small chamber.

Distribution: Singapore — Java, Krakatau Island, Sumatra, Salajar Group. (Bib. 15, p. 43, no 64, fig. 64.—16, p. 68; no 674.—17, p. 78, no 18, fig. 18.—28, p. 582, no 2104.—22, p. 404, no 1048, 20, fig. 752). This gall has a large distribution area, following the pantropical character of the host-plant.

CELASTRACEAE.

Salacia korthalsiana Miq. Gall 169. B.T.N.R.

Insect-gall. Fusiform swelling of the midrib, abaxially visible. The main vein can be affected locally and/or along its entire length. In the second case the lamina is contorted towards its abaxial side. The side-veins can also become hypertrophic at their junction with the midrib. The gall manifests itself adaxially by the unusual width of the affected veins. The exit of the gall-makers is abaxial.

DIPTEROCARPACEAE.

Shorea curtisii Dyer ex King Gall 23 I. B.T.N.R.

Gallacoccus secundus Beardsley, new genus and species.

— Description of an adult gall (Pl. 2, a, b, e): purplish-green pear-shaped gall, 3.5 cm long, 2 cm wide at its maximum. Its irregular surface is covered with bumps each of which has an apical tuft of hairs. It is formed of foliaceous appendages overlapping at their apex, with more or less thickened and fused bases. The two median appendages, larger than the others, separate between them a large ovoid gall-chamber containing many coccids.

— Location on the host (figs. 3, 4; Pl. 2): it is found in the axil of the leaf or on a leaf vein. Therefore this gall is hard to interpret without precise ontogenical study. The study of the young stages shows that this gall occurs either on one of the internal stipules (fig. 3, a, b; fig. 4, b), or on one of the young leaves of the

bud (fig. 4, c, d; Pl. 2, f). Normally the stipules are deciduous but if one of them has parasites, it participates in its totality to the cecidiogenesis without affecting the growth of the rest of the bud (fig. 3, a, b). That is why at the adult stage this gall gives the impression of being in the axil of a leaf: in fact it is in a lateral position since it is a stipule transformed by the cecidiogenesis. An anatomical study would be necessary to pinpoint to what degree the axillary bud of the leaf is affected. At the beginning of the development of the gall, a wad is always formed (fig. 3; 4), then there is the outgrowth of the foliaceous appendages. That leads me to think that after the installation of the gall-maker, there occurs, dedifferentiation, formation of a callus, then of an abnormal bud. One can note the resemblance of the gall 23 I with those figuring in the bibliography: 2, pp. 339–341, fig. 1–2.—22, p. 391, fig. 721.

— Deviation of the cecidiogenesis due to the presence of secondary hosts in the coccid-gall 23 I on *Shorea curtisii* King (Pl. 2, c, d). For an analogous problem see Bib. 39, Vol. 33, section 3, pp. 143–148, 2 Pl. The galls attacked by parasitic wasps appear almost normal except that they never reach their maximum size. They are more woody and dried out than normal galls. Moreover the parasitic wasps do not leave through the apical canal, but through apertures which they make in the gall-wall. The gall-cavity is very reduced and irregular; coccids are present but in very small numbers. On the other hand, the walls of the gall are hypertrophic and chambered. The parasitic wasps develop themselves in these oval gall-chambers which are 2 mm long and 1.5 mm wide. They protrude inward in the gall-cavity which explains its reduced size and its irregularity.

Idem. Gall 23 II. Wide-spread in B.T.N.R.

By means of cages, wasps and midges were obtained. Fide D.H. Murphy (personal communication), wasps are the gall-makers, and midges are inquilines (fig. 5, d, e; Pl. 4, e). Galls 23 II protrude onto the adaxial leaf-surface, mainly alongside the midrib and sideveins where they form continuous, non-coalescent alignments. At that level the lamina is deformed and has a tendency to roll up, thus partially covering them (Pl. 4, e). A fully developed gall is column-shaped, 2 mm high and less than 1 mm wide, reddish brown, covered with simple hairs. The gall can be divided into three superimposed parts: a pedicel, a median swollen zone and an apical zone (fig. 5, d). The pedicel is roughly cylindrical and perpendicular to the lamina. The gall swelling corresponds to the rounded larval chamber which appears lateral in position relative to the median gall-axis. The tapering apical zone is more or less curved. The position of the cavity and the apex of the gall distinguish morphologically a longitudinal plane of symmetry, perpendicular to the lamina. An anatomical study confirms this. The gall is covered with a piliferous epidermis. A longisection of the gall, perpendicular to the lamina shows that the epidermic gall-cells are longitudinally hypertrophic being 3.3 times longer than normal epidermic cells, and transversally only slightly higher. Under the gall epidermis one finds a cortical tanniferous parenchyma which reaches its maximum thickness in the apical gall part. Some or all cells of the outer cortical layers are differentiated into sclerenchymatous cells forming more or less a continuous shell. The gall axis consists of a tanniferous medullar parenchyma. Epidermis, cortical and medullar parenchyma are the only three tissues that constitute the apical gall-part. The cells of those tissues are much elongated in the direction of the longitudinal gall-axis. Level with the swollen part one finds the larval cavity surrounded by a spherical mass of nutritive parenchyma the cells of which are polygonal and characterised by a nuclear and nucleolar hypertrophy.

A section cut along the plane of symmetry shows that the nutritive tissue juts out over the gall pedicel and that its protruding part is covered uniquely by epidermic and shell layers; on the internal side the medullar parenchyma runs along the nutritive tissue. A vascular ring of tracheids and associated parenchyma runs the length of the pedicel in between cortical and medullar parenchyma. That vascular tissue in relation with the leaf-veins at the base reaches the nutritive tissue: the vascular bundles that come right up to the nutritive tissue spread and surround it on both sides of the gall plane of symmetry. Those bundles which are diverted from the nutritive tissue joins the latter by running obliquely round the medullar parenchyma. On maturity there is necrosis of the medullar parenchyma and formation of a dehiscing canal in the centre of the gall-pedicel. This canal opens through an abaxial pore.

Idem. Gall 23 III & 77. B.T.N.R. (fig. 5, a, b, c; Pl. 4, f, g).

By means of cages, Diptera and Hymenoptera have been obtained. Diptera: this species belongs to the subfamily Cecidomyiinae, supertribe Asphondyliidi. The genus seems to be underscribed fide Dr. Nijveldt in litt. Hymenoptera: Chalcidae of the family Eulophidae, genus near *Pediobius* fide Kerrich in litt. The midges are the gall-makers, the wasps are parasites. At the height of its development, the gall reaches 2 mm long by 1.5 mm wide. It is mushroom-shaped: pedicel topped by a cap. It stands more often on the abaxial surface of the leaf. The pedicel inserted on a small leaf-vein between the side-veins stands out adaxially as a small bright red protuberance; it is red at its base as well, becoming lighter and turning yellow towards the top. The cap is green-yellow. The gall turns brown and dries out when mature. The young gall is green-yellow, the red pigmentation does not appear until later. The gall-chamber containing one midge-larva is situated under the cap at the apex of the pedicel. This chamber remains open by a small ostiolar canal surrounded by hairs and located in the centre of the cap (fig. 5, c). The gall-cavity is surrounded by a sclerenchymatous shell made of an upper part and a lower part. The latter is covered by a thin nutritive epidermis. The epidermis of the gall is glabrous, level with the pedicel and hairy, level with the cap: on the external cap-side (*e*) these hairs are tufted and relatively short; on the internal side (*i*) they are very long and form a sleeve surrounding the apex of the pedicel. Under the epidermis lies a hypertrophic and tanniferous cortical parenchyma. The centre of the gall is occupied by a medullar parenchyma the cells of which are elongated vertically in the pedicel and radiate round the gall cavity, level with the cap. In the internal part of the parenchyma one finds about 24 vascular bundles disposed in a circle which run up the pedicel parallel to its axis. These bundles enter the cap and reach the ostiolar canal as shown on fig. 5, c. Ontogenically, the hairy cap forms first, the pedicel develops subsequently. The gall cavity, very small at the beginning, becomes enlarged due to the development of nutritive pillars that disjoint the lower and upper parts of the shell. After pupating the midge makes its way through the wall of the cap, leaving its pupal integument partly inserted in the gall. When the gall is attacked by parasitic wasps, its apical part is deformed by a lateral swelling, and the cap of the cecidium is rejected on the side (fig. 5, a).

Idem. Gall 23 IVa. B.T.N.R. (Pl. 3, a, b, c).

Cause: Coccidae, genus *Beesonia*, undescribed species, fide Beardsley in litt. These coccids are very unusual according to this specialist. They provoke a fusiform hypertrophy affecting the stem on a variable length, sometimes for more than

10 cm. The placement of the coccids is marked by a small depression, in the centre of which with the binocular magnifying glass one notices the brown cuticle of the posterior part of the scale mother. When mature the latter has a distended body in the shape of a flat bag, reaching 1 cm long by 8 mm wide, lying between the central cylinder and the cortical parenchyma. Dr. Beardsley comments as follows: "the posterior end of the bag forms a constricted neck which extends through the bark of the twig, and the young coccids probably leave the mother's body and the gall by way of an opening at the tip of this constricted portion". Under the influence of the parasitic coccids, the plant tissues necrotize, become brown, and the whole twig on which the gall occurs dries out (Pl. 3, a). The gall is often attacked by parasitic wasps that make their ovoid larval cavities in the hypertrophic cortical gall-tissue. They leave the gall by piercing the gall-tissues (Pl. 3, b, c).

Idem. Gall 23 IVb, 77, 75, 106. B.T.N.R. (Pl. 3, d, e).

Wasp-gall. The attacked part of the stem becomes hypertrophic, fusiform and covered with hemispheric swellings of approximately 3 mm in diam. Each of these growths contains several wasp-larvae, lodged in a rounded gall-cavity. The exit of the gall-makers is central and at the distal extremity of the vertical axis.

Idem. Gall 23 V. B.T.N.R., between Jalan Kutu and Main Road. (Pl. 4, a, b, c, d).

Gallacoccus anthonyae Beardsley. Same genus as the gall forming coccid 23 I. (for reference see foot-note on p. 23). The gall, abaxially attached on the basal half of the midrib or the petiole, has the form of a bud, constitutes overlapping foliaceous appendages, the base of which are on two generating lines (distichous disposition). It can reach 6 cm long and 2 cm at the widest part. Light-green and whitish when young, yellowing at maturity, it turns brown and dries out like the leaf that carries it. The young coccids are found in a translucent bag. They are surrounded by their waxy whitish secretion and hold themselves in the axil of the seventh leaf counting from the base.

Idem. Gall 23 VI. B.T.N.R., Ginger Walk.

Insect-gall. Ball-shaped, 1 to 2 mm in diam., yellow, becoming red-brown at maturity. The cecidia located on the veins are visible only on that face of the lamina on which they find themselves. They detach themselves easily.

Idem. Gall 23 VII. B.T.N.R., Ginger Walk.

Wasp-gall. Disc-shaped gall, less than 1 mm in thickness, 4 mm in diam., affecting symmetrically both faces of the lamina. The exit of the gall-makers is abaxial.

Idem. Gall 23 VIII. B.T.N.R., Ginger Walk.

Insect-gall. Adaxially, it is a conical protuberance 1 mm in height, on a base 1 mm in diam., to which corresponds abaxially a similar protuberance. The galls are located along the length of the side-veins, and on the side of the petiole. When they are close together, they fuse at the base, forming alignments that look like cockscombs.

Shorea sp. Gall 168 I. B.T.N.R., Jungle Valley.

Midge-gall. Bright-yellow spheroid gall 3 or 4 mm in diam., attached by a short pedicel to the under-side of the leaf. The point of attachment is marked on

the upper-surface of the leaf by a little protuberance surrounded by a depigmented area. This gall resembles the gall 21437 no. 1007 on *Shorea belangeran* Burck. (Bib. 22, p. 391).

EUPHORBIACEAE.

Acalypha wilkesiana Muell. Arg. Gall 161. Coronation Road (garden) Singapore, and Botanic Gardens of Tjibodas, Java.

Cause not determined. It appears as a globulous mass of witches' broom about 6 cm in diam., sprouting from the twigs. This gall is made up of a tangle of filaments radicular in nature, and of twigs carrying reduced leaves.

Aporosa benthamiana Hook. f. and Thom. Gall 98 I. B.T.N.R., Jalan Kutu. (fig. 6; Pl. 11, b).

Thrips-gall. The leaf becomes involute; the leaf-tip is not involved in the cecidiogenous morphogenesis. Abaxially the lamina is punctuated between the side-veins by little pustules 1 mm in diam., with a black point in their centre.

Idem. Gall 98 III. B.T.N.R. Jalan Kutu. (Pl. 11, b, c).

Insect-gall. Petiole or midrib develops roundish or fusiform swellings, 4 to 10 mm long and about 4 mm wide, visible on both faces of the lamina. The ovoid gall-cavity is located in the hypertrophic medullar pith. Exit of the gall-maker is by a large pore.

Idem. Gall 98 IV. B.T.N.R., Jalan Kutu. (Pl. 11, c).

Wasp-gall. Yellowish fleshy mamillated swelling affecting laterally the stem along a few cm. A longisection of the gall shows that the cortical parenchyma is the only stem-tissue to be hyper-developed under the influence of the numerous wasp-larvae that it contains; pith and vascular bundles are not modified by the gall-makers. That explains why the stem-growth is not affected by the gall. On maturity the wasps leave the gall through a large pore.

Baccaurea ? griffithii. Gall 130. B.T.N.R., Ginger Walk.

Cause undetermined. Globular or more or less elongated deformation of the stem or of the petiole for about 1 cm.

Coelodepus glanduligerum Pax. Hoffm. Gall 71. B.T.N.R., Jungle Valley track. (Pl. 11, a).

Midge-gall. Abaxial disc-shaped gall, 5 mm in diam., by 1 mm in height, depressed in its centre. The rim formed in this way is irregular and has a brownish-red tint. The central depression is cylindrical, 1 mm in diam., 0.5 mm in height. In it a fine epidermic pellicle forms the roof of the gall-cavity where one midge-larva is found. At maturity the parasite leaves the gall through a semi-circular orifice formed by piercing the membrane. On the adaxial side, the gall presents itself as a yellowish rounded spot which has a very slight central brownish point.

Macaranga triloba Muell. Arg. Gall 124. B.T.N.R., North View Path.

Midge-gall. Ovoid, attached to the abaxial face of the lamina, 4 mm long by 1 mm wide; its surface is green and covered with long white hairs. Its attachment is marked on the adaxial face of the lamina by a slight protuberance covered with white hairs. The exit of the gall-maker is adaxial.

Distribution: Singapore — Java, Sumatra, Malacca (Bib. 10, p. 80, no. 232.–12, p. 32, no. 304, fig. 131.–14, no. 31.–22, p. 313, no. 771.–28, p. 455, no. 1675 & 1676, fig. 983).

Mallotus penangensis Muell. Arg. Gall 111. B.T.N.R., North View Path.

Psyllid-gall? All the galls found were already open and devoid of gall-makers. Adaxially this leaf-gall is in shape of a hemispheric hollow dome 6 mm in diam., covered with long hairs. Abaxially the walls of the gall are divided into several reflexed lobes.

FAGACEAE

Castanopsis wallichii King Gall 25. B.T.N.R., on the corner of Main Road and Jalan Kutu. (Pl. 6, d, e).

Midge-gall. Gall of the stem and the leaves affecting the axillary and terminal buds, the petiole and the veins. The parasitic midges provoke hypertrophy and inhibit growth of the attacked organ.

— Petiole: fusiform swelling, 3 mm wide.

— Veins: the gall, especially visible abaxially, presents itself as a fusiform swelling 3 mm in width on the midrib, and 1 mm in width on the side-veins. Moreover, the lamina is deformed and curved around the attacked zone, caused by inhibition in growth.

— Terminal bud: hypertrophy of its axis transforms the bud into an irregular sphere 8 or 9 mm in diam. From this sphere contorted leaf-shoots project. Inside are many midge-larvae.

Lithocarpus conocarpus (Oudem.) Rehd. Gall 120 I. B.T.N.R., between Main Road and Jalan Kutu. (fig. 7, c, d; Pl. 6, c).

Wasp-gall (probably a cynipid). Brown ovoid cylindrical gall protruding more or less equally on both faces of the lamina, reaching 2 mm in total height and 1 mm in width. The apex of the gall on the adaxial face is equipped with a flat lid that has a small central erect prickle. The gall is sessile, detaches itself before maturity from the orange wasp-larva contained in its large cavity and leaves an alveole in the lamina (Pl. 6, c). This gall has a rapid development from January to March (see p. 20).

Idem. Gall 135 II. B.T.N.R., between Ginger Walk and Jalan Kutu. (fig. 7, b).

Moth-gall. Fusiform swelling of the midrib, 1.5 cm long, 0.6 cm wide at its centre, visible on both faces of the lamina, and is of woody consistence. The interior is a long gall-chamber.

Idem. Gall 135 III. B.T.N.R. (fig. 7, a; Pl. 6, a, b).

Moth-gall developed on stem and petiole.

— Stem: fusiform swelling of the stem. One moth-larva makes a central long gall-chamber. It induces the fragmentation of the cambium into four parts; after departure of the gall-maker, this divided cambium keeps on functioning and leads to the formation of four stem units (pl. 6, b). Due to the proliferation of these internal stem-tissues, the gall-cavity disappears and the bark is fragmented into four longitudinal strips. At the end of its development this gall reaches 2.5 cm in length and 8 mm in width (Pl. 6, a; fig. 7, a).

— Petiole: level with the insertion of the petiole on the stem, adaxial side, the internal hypertrophic tissues become a small irregular growth about 3 mm diam. (fig. 7, a).

Lithocarpus sundaicus (Bl.) Rehd. Gall 153 IV. B.T.N.R., very close to the summit. (fig. 8; 9).

Gall caused by a coccid that belongs to the family Diaspididae fide Beardsley in litt. The young Homoptera are localised at the axil of young leaves of lateral buds (fig. 8, a). They create:

— Shortening of the internodes; the leaves are tufted in a rosette (fig. 8, d). Their bases become hypertrophic (fig. 8, c, d).

— Cessation of growth of the principal axis.

— Formation of secondary and tertiary shoots by axillary buds (fig. 8, a, b). The young leaves are modified in rhabdodes.

One notices the development of vigorous shoots under the gall-zone which appear to be the strongest shoots in the plant (fig. 9, d); this poses the problem of causal determination. According to Dr. Cusset in litt. it might only be due to an inherent phenomenon in the considered species if the normal growth of the plant is either monopodial with flush (fig. 9, a) or sympodial and more or less acrotonic (fig. 9, b). But if the normal growth of the plant is monopodial and without rhythm (fig. 9, c), it might be a phenomenon linked to the remote action of the cecidiogenous agent. One could then take in consideration the possible interaction between the distal zone with axillary buds *abundantly* developed (BA), and the subjacent zone with axillary buds *strongly* developed (BS), fig. 8, d.

GUTTIFERAE

Calophyllum ferrugineum Ridl. Gall 68 I, 101, 136, 141. Widespread in B.T.N.R. (fig. 13, d; Pl. 5, e)

Midge-gall. This species belongs to the subfamily Cecidomyiinae, supertribe Cecidomyiidi, but the genus seems to be undescribed fide Nijveldt in litt. Parasites or inquilines: thrips and wasps. The latter are chalcids of the family Eulophidae, belonging to the genus *Tetrastichus* fide Kerrich in litt. The gall is formed by the edges of the lamina which fold downwards thus resulting in a cylinder 1.5 mm. in diam. One can, parallel to the midrib, distinguish three parts in each half lamina, the behaviour of which is different in the morphogenetic movement: proximal, median and distal zones, with respect to the midrib. The median zone only of each half lamina participates in the formation of the wall of the cylinder. This region of the lamina is considerably thickened and its surface is irregular. The proximal and distal zones are clung together, lower epidermis against lower epidermis (fig. 13, d). In the long cavity thus delimited, one finds many midge-larvae which at maturity protrude from the channel of the cylinder by sliding between the distal and proximal zones, where they leave their empty pupal integument. However the parasitic wasps work their way out by piercing the wall of the cylinder.

Idem. Gall 68 II, 101, 136, 141. Rather wide-spread in B.T.N.R. (Pl. 5 f).

Midge-gall, affecting the stem, petiole and midrib. On the midrib the isolated gall looks like a hemispheroid swelling of 5 mm in maximum diam., more often abaxial, visible only on one side of the leaf. Frequently the swellings are fused

and the whole vein looks hypertrophic. The attacked petiole is considerably larger (5 mm versus 2 mm). There are hemispheroid swellings laterally disposed on the stem.

Idem. Gall 141 III. Very rare in B.T.N.R., localised between Main Road and Jalan Kutu. (fig. 11, a).

Moth-gall. (See also description of gall 107 IV on *Calophyllum pulcherrimum* Wall. on p. 38). Swelling of both faces of the lamina, elongating parallel to the midrib, 25 mm in length, 8 mm in maximum width, and a few mm in thickness. The larvae eat the interior of the leaf except the epidermis. However it is a gall and not a mine: there is formation of a very definite growth due no doubt to a parenchymatous nutritive proliferation. The gall i.e. 141 III looks like that described on *Calophyllum inophyllum* L. (Bib. 22, p. 386, no. 989, 1st, fig. 705).

Calophyllum inophylloide King var. *singaporense* Henderson & Wyatt-Smith. Gall 43 I. MacRitchie Reservoir. (fig. 12, b).

Gall caused by a coccid: *Amorphococcus* sp. (Lecanodiaspididae), fide Dr. Beardsley in litt. The gall develops abaxially on the midrib. Each gall is made up in the same way as bivalve molluscs, of two shells contacting one another by the edge, limiting between them a large rounded gall-cavity containing the young coccids that form an orange mass surrounded by the product of their whitish waxy secretion. When the coccids settle on a young leaf they inhibit the development of the lamina and the internodes are shortened: the apex of the stem is crowned by a globular bunch of more or less spherical galls each 1 cm in diameter.

Idem. Gall 43 II. MacRitchie Reservoir. (fig. 12, a).

Psyllid-gall. The leaf becomes revolute. Each leaf-half can be affected separately, forming a cylinder, 1 mm in diam. Mr. D. H. Murphy notes that leaf roll galls of this type on *C. inophyllum* are well known and are caused by *Leptynoptera sulphurea*.

Calophyllum pulcherrimum Wall. Gall 107 I. Wide-spread in B.T.N.R. (fig. 10, a).

Psyllid-gall. The leaf is conduplicate and tends to become revolute. Its edges are undulated and crisped. The midrib is curved in a hook towards the abaxial leaf-side. The petiole is sometimes twisted, bringing the abaxial side of the leaf in adaxial position.

Idem. Gall 107 II. B.T.N.R. (fig. 10, c,d).

Midge-gall. The midge belongs to the genus *Bruggmanniella* but the species seems to be undescribed fide Nijveldt in litt. Fleshy spheroid gall 3 mm in diameter. pale-green or light-yellow, more often abaxially attached to the midrib by a little pedicel. In aging, it becomes yellow, orange, then brown and dries out. Inside the gall-cavity, one midge-larva is found. The gall is often attacked by parasitic wasps: its consistence is then firmer, and its color changes to dark green, marbled with brown. This gall i.e. 107 II looks like that described on *Calophyllum javanicum* Miq. (Bib. 22, p. 386, no 991, 1st, fig. 760).

Idem. Gall 107 III. Quite rare in B.T.N.R. (fig. 10, b).

Midge-gall. Swelling of the stem, petiole and midrib. The stem-gall is spheroid, about 1 cm across; it is due to a considerable hypertrophy of the central cylinder,

and contains several cortical gall-chambers. When the stem is strongly attacked, the galls are more or less fused, linked by hypertrophic stem-tissue, i.e. without larval cavity.

Idem. Gall 167 IV and 107 IV. Rare in B.T.N.R. (fig. 11, b).

Moth-gall. See also description of gall 141 III on *C. ferrugineum* Ridl. on p. 37. Swelling visible on each face of the lamina; it is 4 cm long, 0.4 cm wide, 0.2 cm in height abaxially and about 1 mm in height adaxially. It is elongated parallel to midrib, in form of a "S", of which the basal extremity (petiole side), pushes away from the vein, while the distal extremity converges towards it. The adaxial dehiscence is caused by the wall of the gall collapsing inward.

LAURACEAE.

Actinodaphne sp. Gall 24 I, 67, 73, 93, 99, 138, 143. Wide-spread in B.T.N.R. (Pl. 7, a).

Gall caused by a mite "*Eriophyes* sp., very similar to Nalepa's *gyrographus* (on *Litsea*) and also close to Corti's *Linderæ*, but the host species is different and Corti's mite makes conical galls." fide Dr. Keifer in litt. Pockets 1 cm high which appear like blisters on the adaxial leaf-surface. They are abaxially covered with a whitish erineum becoming brown on maturity.

Idem. Gall 24 II, 67, 73, 93, 99, 138, 143. Widespread in B.T.N.R., alongside Jalan Kutu; the trees are sometimes entirely covered with galls. (fig. 13, b; Pl. 7, b).

The gall-maker is a midge belonging to the subfamily Cecidomyiinae, supertribe Cecidomyiidi, fide Nijveldt in litt. Gall of the leaf, stem and petiole. On the stem it is a lateral spheroid outgrowth, attached by a large base. On the leaf (case of an isolated gall), it is a sphere 5 mm in diam., having the lamina as diametrical plane. The glabrous green galls are located principally on the midrib; they are very often fused, and the whole leaf can be affected. The dehiscence is abaxial (fig. 13, b). In the centre of the abaxial hemisphere one finds a small depression that eventually becomes the exit pore for the gall-maker. There is a cellular degeneration along a central axis, more or less perpendicular to the lamina. Often the galls are attacked by parasitic wasps belonging to the superfamily Proctotrupoidea, family Scelionidae, *Platygaster* sp. fide Nixon in litt. Then the galls are dark green, marbled with brown.

Idem. Gall 99 III. B.T.N.R., at the extremity of Jalan Kutu, around point C on fig. 1, c. (Pl. 7, c, d).

Midge-gall. Spheroid acrocecidium reaching 3 cm in diam. with a greenish surface, marbled with brown spots more or less suberized. It contains a number of gall-cavities distributed in a median horizontal plane. The young galls carry modified leaves in the shape of spines, with lamina absent or very reduced. These appendages are adaxially plane, and abaxially rounded: there is therefore bilaterisation. The exact nature of these foliar appendages poses a morphological problem. One can admit that, under the influence of gall-makers, there is an inhibition of the foliarisation phenomenon depending on the stem-apex, and formation of rhabdodes. For experiments of microsurgery of the apex see Wardlaw, Bib. 51.

Idem. Gall 143 IV. B.T.N.R., at the corner of Main Road and Jalan Kutu, near a thinning of the forest. This gall is not widespread. (fig. 13, a).

Midge-gall. Spherical cecidium of 5 mm in diameter, more often attached abaxially to the midrib by a large base, and visible only on the side on which it finds itself. It is fleshy, chlorophyllous, covered with a brown suberized layer. The interior is a large rounded gall-chamber containing one midge-larva. The animal pierces the wall at maturity.

Cryptocarya sp. Gall 128. B.T.N.R.

Cause undetermined, but the presence of numerous ants at the interior of the rolled leaf suggests that it might be caused by Homoptera. Edges of lamina revolute. The leaf curves downwards forming a hook.

Endiandra sp. Gall 156 I. B.T.N.R., Main Road. (fig. 14).

Thrips-gall. Edges of lamina involute and crisp. The leaf is contorted, swollen, depigmented, yellow, marbled with brown.

Idem. Gall 156 III. B.T.N.R., Main Road near the summit. (fig. 14, b).

Cause undetermined. Cylindrical conical adaxial expansion on the midrib, 3 mm in height and less than 1 mm in diam. at the base. This gall is not very widespread.

Litsea elliptica (Bl.) Boerl. Gall 86. MacRitchie Reservoir. (Pl. 8, f).

Gall caused by a mite: *Eriophyes gyrographus* Nal. fide Keifer in litt. Pockets varying in size and height from a few mm to a few cm pouch out from the adaxial leaf-surface. They are covered abaxially with a bright erineum which browns on maturity. It is formed by unicellular clavate hairs.

Litsea grandis Hook. f. Gall 144. B.T.N.R.

Homoptera-gall. Spots, visible on both sides of the lamina; roundish, 1 cm in diam. approximately, often confluent and forming large depigmented patches. The gall-makers, fixed abaxially to the centre of the depigmented area, induce a very slight elevation of the lamina. They are surrounded by their whitish waxy secretion and are covered with an hemispheric shield (skin of the first larval instar) which lifts at maturity like a lid.

Nothaphoebe kingiana var. *malvescens* Gamble. Gall 92 I, 79, 94, 133. Wide-spread in B.T.N.R. (Pl. 8, d).

Psyllid-gall. The young psyllids fixed abaxially create adaxial laminal elevations 2 mm in diam. at base, and 1 mm in height.

Idem. Gall 94 II, 79, 92, 133. B.T.N.R. (fig. 15, d, e).

Midge-gall, visible on both faces of the lamina, forming a circular swelling 3 mm in diam. approximately, slightly thicker than the lamina, affecting especially the adaxial face. The midge-larva fills completely the small central gall-cavity. On the adaxial face the gall is dark green, almost black and lighter in its centre. At dehiscence the centre becomes white-grey adaxially and red-brown abaxially. The gall opens adaxially by a central ostiole.

Idem. Gall 133 III, 79, 94. Wide-spread in B.T.N.R. (fig. 15, b, c.; Pl. 8, e).

Mite-gall. Pouch-gall affecting both faces of the lamina, generally isolated, sometimes two or three are fused. Abaxially, the isolated gall is in the shape of a mushroom, 1.5 mm high, the cap is 2.5 mm in diameter. To the insertion point of the gall corresponds adaxially a depression 0.5 mm in depth, and 2 mm in diameter. The gall is formed abaxially by development of lips enclosing a space in which the parasites are lodged. This gall-cavity is crowded with fleshy parietal projections directed inward. The gall stays open by an ostiole situated in the centre of the slight apical depression of the cap; this orifice is surrounded by hairs.

LEGUMINOSEAE.

Dalbergia rostrata Grah. Gall 134, 162. Wide-spread in B.T.N.R. (Pl. 9, d, e).

Midge-gall. Leaflets conduplicate. The two leaflet-halves thicken and are more or less fused. The place of each gall-cavity is marked by peg-like pustules on the abaxial surface. The leaflets can be affected partially or entirely. In the latter case, they take the appearance of a pod.

Dialium maingayi Baker Gall 147. B.T.N.R., between Jalan Kutu and Main Road.

Thrips-gall. Leaflets revolute and retrorse. The distal extremity of the leaflet is not involved in the cecidiogenous morphogenesis. The gall surface is yellow-green, spotted with red.

Pithecellobium clypearia Benth. Gall 115 I. Quite wide-spread in B.T.N.R. (fig. 16, b, c; Pl. 9, a, b, c).

Gall caused by a midge belonging to the supertribe Asphondyliidi fide Nijveldt in litt. Gall occurs on the main leaf-stalk, on the midrib and veins of the leaflets. On the lamina, the galls on the veins are isolated, ovoid, 2.5 mm in length and 1.5 mm in maximum width. They are attached by a large base to the main vein, abaxially and sometimes adaxially. At the interior one finds a very large larval chamber. The circular emergence-hole is made on the gall-top. On the main leaf-stalk, the galls are less definite since they are often fused. The main leaf-stalk can be infected, starting from its distal extremity along a varied length; it is then hypertrophic and contorted.

Idem Gall 115 II. Very rare in B.T.N.R., located between Jalan Kutu and Main Road. (fig. 16, a).

Homoptera-gall? The leaflets tend to be conduplicate. Their lamina is entirely undulate. The distal end of the leaflets becomes retrorse.

LOGANIACEAE.

Fagraea fragrans Roxb. Gall 45, 87. MacRitchie Rerservoir. (Pl. 10, e).

Thrips-gall. The affected leaf becomes revolute. The surface of the gall is more or less granulate.

Strychnos sp. Gall 27, 74. B.T.N.R. (Pl. 11, e).

Gall caused by a midge the species of which belongs to the genus *Bruggmanniella* and seems to be undescribed fide Nijveldt in litt. Brownish or greyish fusiform swelling, 5 to 10 mm long, laterally affecting the stem, petiole or midrib. The galls are sometimes fused. At the interior one finds a larval cavity elongated in the direction of the axis of the organ.

MENISPERMACEAE.

Hypserpa cuspidata (Wall.) Miers Gall 123, 108. Wide-spread in B.T.N.R. (Pl. 13, a).

Coccid-gall; the gall-maker "appears to belong to the family Eriococcidae, . . . It probably represents an undescribed genus and species, . . . It is *not* closely related to the new Eriococcids from *Shorea pauciflora* King."* fide Beardsley in litt. Gall of the stem and leaf (lamina, petiole, veins). Under the effect of the gall-makers, there is an inhibition of growth and hypertrophy occurs. The young coccids are contained in large numbers in fine-walled bags 0.1 mm in diam. These bags fill completely the gall-cavity that opens out by a circular ostiole. They fit in the cavity and the short exit canal so that they have the form of a bottle with a large body and a very short neck. On the adaxial face of the lamina, the placement of the coccids is made visible by the local depigmentation which they cause: the leaf is punctuated by little yellow spots 0.5 mm across, with central ostioles, where a tuft of white filaments (waxy secretion of the coccids) comes out. During the development of the lamina-gall, one notices a slight augmentation in thickness of the lamina, located at the placement of the gall-makers, then necrosis and darkening of the gall-tissues. The coccids installed in the veins inhibit their growth and create a distortion of the leaves. The parasites localised in the stem create a general hypertrophy of this part which when thus affected can reach 8 mm across, and cause some inhibitions of growth: shortening of the internodes, contortion of the stem, inhibition of leaf-development.

MORACEAE.

Ficus pumila Linn. Gall 48, 150. B.T.N.R., Jalan Kutu and Main Road. (fig. 18).

Gall caused by a wasp belonging to the superfamily Chalcidoidea. Gall of terminal or axillary bud. This cecidium is fleshy, globulous, 1 cm in diam. approximately, often slightly elongated in the direction of the axis. It is light yellow when juvenile, becoming brown and drying out on maturity. At the interior of a young gall one finds three or four larval cavities, each containing a wasp-larva. Those chambers become united into one large irregular cavity as the larvae feed on the nutritive gall-parenchyma. The gall is situated in the leaf axil or at the apex of the stem: it is a bud gall. In fact the gall is largely constituted of the petiole of the first leaf fused with the axis of the bud, both enlarged. The lamina of the first leaf does not participate in the formation of the gall; it emerges from the globulous mass and is sessile or subsessile. The fusion between the lower part of the bud-axis and the petiole of the first leaf is proved by the presence of the stipules of the latter on the gall, and by the presence of the apex of the bud at the apex of the gall. There is a resemblance between the gall i.e. 48 and 150 and the wasp-gall on *Ficus recurva* Bl. of other authors (Bib. 22, p. 136, no 20145, fig. 172.-28, pp. 186-187, no. 679-680, fig. 385).

Ficus retusa L. Gall 33. Mangrove, West Coast Road.

Thrips-gall. Leaf conduplicate, with a brown surface, marked with red. It is one of the first thrips-galls that has been described and studied. Distribution: this gall is spread throughout tropical Asia (Singapore — Siam, CochinChina, Hongkong, Malacca, Java, Sumatra, Celebes), and also in Africa. (Bib. 1, p. 250.-5, p. 154.-15, p. 30.-17, p. 54, no 18.-19, p. 272.-21, p. 128, no 31.-22, p. 140, no 269, 8th, fig. 14, Pl. IV.-25, pp. 56-58, no 108, fig. 103-108.-26, p. 95.-27, pp. 248-250.-28, p. 188, no 685, fig. 372-377.-30, pp. 131, 150, 152, 160.-31, pp. 302, 309, 314.-37, pp. 251-253.-46 pp. 423-424.-52, p. 117, Pl. XVI, fig. 16-18.)

*See footnote p. 19.

Ficus sinuata Thunb. ssp. *sinuata* Gall 146. Tyersal Road and 44 Nassim Road. (Pl. 8, a, b, c).

Gall caused by a mite, "*Eriophyes* sp. which does not closely resemble any of Nalepa's *Ficus* spp. either as to mite description or gall . . ." fide Keifer in litt. Irregular adaxial outgrowth, nodulous or more or less conical, 5 mm in maximum height. To this corresponds a conical protuberance abaxially, 6 mm in maximum height, the apical extremity is perforated by an orifice leading to the gall-cavity. This cavity is crowded by parietal out-growths.

MYRISTICACEAE.

Knema communis J. Sinclair Gall 129 I. B.T.N.R., between Jalan Kutu and Main Road. (Pl. 13, d).

Insect-gall. Symmetrical gall in relation to the leaf surface. On the adaxial and abaxial faces, the gall presents itself as a conical growth 1 mm in height and 2 mm in diam. at the base. At dehiscence the outer wall of the gall divides into brown woody lobes which become reflexed, leaving a central erect column. This column forms a stopper that detaches itself at maturity, allowing therefore the exit of the gall-makers.

Idem. Gall 129 II. B.T.N.R., between Jalan Kutu and Main Road.

Thrips-gall? The edges of the leaf tend to become involute. Between the side-veins, the lamina is more or less crisped.

Gymnacranthera eugeniifolia (A. DC.) Sinclair var. *eugeniifolia* Gall 118. B.T.N.R., Jalan Kutu.

Cause non determined. Local inhibition of growth of the stem and the midrib, provoking contortion. Moreover the edges of the affected leaves tend to become revolute. The lamina is contorted and crisped.

MYRTACEAE.

General comments concerning the galls on genus *Eugenia*: the galls found in Singapore on the genus are of classic types, already described by many authors on different species of *Eugenia*. One can distinguish four types of galls:

- (1) Stem-galls: spherical or fusiform swellings formed by hypertrophy and hyperplasy, caused by insects.
- (2) Leaf-galls:
 - (a) Edges of the leaf involute or revolute, caused by thrips.
 - (b) Adaxially hemispheric, abaxially conical equipped with an ostiole, caused by psyllids.
 - (c) Conical elevation of the lamina due to the psyllids installed on the leaf.

Eugenia cumingiana Vidal Gall 155 I. B.T.N.R.

Wasp-gall. Fusiform swelling of the stem, containing a number of gall-cavities.

Idem. Gall 139 II. B.T.N.R.

Psyllid-gall. Conical depression of the lamina less than 1 mm in depth from base less than 1 mm in diameter.

Idem. Gall 157 III. B.T.N.R., Jungle Valley.

Thrips-gall? The edges of the leaf tend to become involute.

Eugenia malaccensis Linn. Gall 81. Singapore Botanic Gardens.

Psyllid-gall caused without doubt by *Megatrioza vitiensis*, the biology of which was studied by Zehnter but not consulted. Adaxially, it is a red hemisphere 5 to 8 mm in diam. containing a large gall-cavity. Abaxially, the young gall has the form of a conical hollow swelling 5 mm in height, the wall of which splits and curls at maturity. This gall is very wide-spread: Singapore-Java, Ceylon, Singapore, Malacca, Amboina, Sumatra, Salajar Island and Fiji Island (Bib. 3, p. 266.-4, p. 195.-5, p. 172, fig. 175.-12, p. 6, no 37.-13, p. 6, no 8.-14, p. 6, no 10.-15, p. 29, no 19.-21, p. 126, no 26.-22, p. 411, 1st, no 1074.-28, p. 594, No 2142, fig. 1235 & 1236.-33, p. 103, fig. 3, 4, 5.-49, p. 150.-52, p. 3, fig. 1 to 5.).

Eugenia rugosa (Korth.) Merr. Gall 158 I. B.T.N.R., Jungle Valley track. (fig. 17, c).

Psyllid-gall. Adaxially, hemispherical or conical protuberance, reaching 3 mm in height on a base 6 mm in diam. Abaxially, conical outgrowth 4 mm high, opening at the apex by a large circular ostiole. Galls are often fused. of a lighter green than the leaves, turning yellow or orange on maturity.

Idem. Gall 158 II. B.T.N.R., Jungle Valley track. (fig. 17, a, b).

Insect-gall. Spherical swelling of the stem, 1.5 cm in diam. All the tissues seem to participate in the cecidiogenous morphogenesis, in particular the vascular tissue, xylem and phloem, and the cortical parenchyma. The gall-cavity is irregularly surrounded by a red-brown parenchymatous nutritive tissue; at maturity the gall-makers pierce a cylindrical canal through the gall-tissues leading to a circular orifice.

Idem. Gall 158 III. B.T.N.R., Jungle Valley track.

Psyllid-gall. Conical depression of the lamina approximately 1 mm deep, caused by the psyllids fixed adaxially.

Idem. Gall 143 IV. B.T.N.R., Ginger Walk. (fig. 17, d).

Wasp-gall? Irregular fusiform swelling of the twig, containing a number of gall-cavities. The bark pushed by the internal tissues breaks into flakes.

Eugenia subdecussata Duthie Gall 148 I. B.T.N.R.

Psyllid-gall. Conical elevation of the lamina of 1 mm in height on a base 2 mm in diam.

Idem. Gall 166 II. B.T.N.R. (Pl. 10, d).

Thrips-gall? The leaf is involute. The surface of the gall is more or less marked with red spots.

Rhodamnia cinerea Jack (— *Rh. trinervia* Bl.). Gall 88 I. MacRitchie Reservoir. (Pl. 10, a, b).

Moth-gall. Woody fusiform swelling of the stem, reaching 6 cm in length and 1 cm in width. At the interior one finds a large gall-cavity containing only one larva.

Distribution: Singapore-Java, Sumatra (Bib. 21, p. 143, fig. 35.-22, p. 418 no 1098, 1st).

Idem. Gall 88 III. Mac Ritchie Reservoir.

Psyllid-gall. Adaxially it is a depression of the lamina 0.5 mm in depth on a base 0.5 mm in diam., caused by the psyllids installed adaxially.

Idem. Gall 72 IV. B.T.N.R. and Mac Ritchie Reservoir. (Pl. 10, c).

Homoptera-gall? Local inhibitions of growth of the veins, provoking the distortion of the leaf.

RHIZOPHORACEAE.

Anisophyllea disticha Baill. Gall 114. Everywhere in B.T.N.R. (Pl. 12, b).

Midge-gall. Gall pyriform with a long neck, 3 mm long and 1 mm wide, covered with long hairs, attached at the base of the leaf to the adaxial edge of the lamina, containing a large longitudinal gall-cavity, in which one finds a midge-larva. Galls are sometimes fused in twos or threes.

Distribution: Singapore–Bangka, Rhio–Archipelago (Bib. 22, p. 402, no 1040, fig. 746).

RUBIACEAE.

Lasianthus maingayi Hk. f. Gall 76. B.T.N.R.

Cause undetermined. Inhibition of growth of the veins, hence the contorted aspect of the leaf.

Psychotria ovoidea (Hook f.) Wall. Gall 110. B.T.N.R. (Pl. 12, d).

Midge-gall affecting the leaf. Abaxial roughly hemispherical outgrowth of the lamina, 5 mm in diam, corresponding adaxially to an umbonate outgrowth 2 mm in height. The gall develops by hypertrophy: spectacular elongating of the cells perpendicularly to the surface of the leaf, then division of the cells of the spongy mesophyll. In the centre of the gall one finds a large rounded gall-cavity. Exit of parasites abaxial.

Urophyllum hirsutum Hook. Gall 159. B.T.N.R., Jungle Valley track. (pl. 12, c).

Midge-gall. Fusiform swelling 6 mm in maximum width, affecting the stem, petiole and midrib. In the last case, the gall is mostly visible abaxially. The organ can be hypertrophic along a variable length. The gall-cavity is elongated in the direction of the spindle-axis.

SAPOTACEAE.

Palaquium obovatum (Griff.) Engl. var. *obovatum*. Gall 125. B.T.N.R.

Aphid-gall? Under the influence of the Homoptera fixed on them, the various organs of the host-plant (stem, veins), are submitted to inhibitions of growth that cause them to be twisted. The leaves are contorted, their edges become involute.

Palaquium semaram H. J. Lam. Gall 78, 116. B.T.N.R. (Pl. 12, a).

Midge-gall. Disc-shaped gall affecting both faces of the lamina, gall less than 1 mm thick, and diam. approximately 4 mm. Inside one finds a small larval cavity containing one midge larva. That larva leaves the gall through an adaxial emergence hole before pupating. The gall is yellowish, browning and drying out on maturity.

TILIACEAE.

Grewia blattaefolia Corner Gall 131. B.T.N.R., Jalan Kutu. (Pl. 12, e, f.).

Midge-gall. This light yellow spherical gall, less than 5 mm across is attached on the adaxial or abaxial side of the leaf, laterally to the veins. The pyriform gall-chamber stretches out perpendicular to the vein.

VERBENACEAE.

General comments concerning the galls occurring on the genus *Clerodendron*: Aphids are parasitic on a number of *Clerodendron* and provoke the formation of characteristic acrocecidia:

— Inhibition of the growth of the veins, hence the contorted aspect of the leaves.

— Inhibition of the growth of the internodes.

These galls were considered as pseudogalls by previous authors, on account of their inhibitory effect. See an illustration of this type of gall Pl. 13, b. This type of gall has been found on:

C. deflexum Wall. Gall 95. B.T.N.R.

C. laevifolium Bl. (= *C. disparifolium* Bl.). Gall 119 I; 122. B.T.N.R.

Clerodendron laevifolium Bl. (= *C. disparifolium* Bl.) Gall 119 II, 219. B.T.N.R. (fig. 5, f).

Midge-gall. The edges of the lamina are involute. The distal end of the leaf does not participate to the gall-morphogenesis. The external surface of the gall is covered with white spots. Distribution: Singapore-Java (Bib. 22, p. 488, no 1300, fig. 934).

Clerodendron sp. Gall 137, 151. Coronation Road (garden).

Mycocecidium. Rounded elevation of the lamina, a few mm in height, and 5 to 8 mm in diam., abaxially covered by small whitish vesicles (sori), disposed concentrically. The yellowish gall turns brown on maturity, therefore causing the whole leaf to dry out.

Vitex pubescens Vahl. Gall 64, 160. B.T.N.R. and Cherengi Road. (Pl. 13, f).

Mite-gall caused by *Eriophyes cryptotrichus* Nal. fide Keifer in litt. Globulous and wart-like pockets that project from the adaxial leaf-surface, 0.5 to 6 mm in diam., covered adaxially by short hairs, and abaxially by a dense erineum. Distribution: this gall is very widespread. Singapore-Java, Sumatra, Sebesy Island, Malacca, Siam (Bib. 12, p. 49, no 342, fig. 153.-14, p. 19, no 49.-18, p. 61, no 34.-20, p. 311, no 77.-21, p. 148, no 82, fig. 44.-22, p. 493, no 1317, fig. 943.-28, p. 766, no 2756.-42, p. 59).

Vitex vestita Wall. Gall 126. B.T.N.R.

Mite-gall. Whitish erineum browning at maturity, covering the lamina in rounded or reticular blotches abaxially but also adaxially.

VITACEAE.

Vitis gracilis Wall. Gall 80, 163, B.T.N.R. (Pl. 13 c).

Psyllid-gall. The psyllids fixed adaxially create a depression of the lamina, less than 0.5 mm in depth on a base 0.5 mm in diam.

PTERIDOPHYTES. OLEANDROIDEAE.

Nephrolepis biserrata (Sw.) Schott Gall 240 I. Catchment Area. (Pl. 13, e).

Gall caused by a mite, *Nothopoda paucopus* Nal. fide Keifer in litt. Small finger-galls that project out from the adaxial and more frequently the abaxial surface of the fronds. It is conical, 3 mm high, 1 mm wide at the base, having an apical ostiole surrounded by hairs. The internal wall of the gall-cavity is glabrous and longitudinally fluted. When galls develop at margin of pinnae they are sub-globular, about 2 mm high and 4 mm wide.

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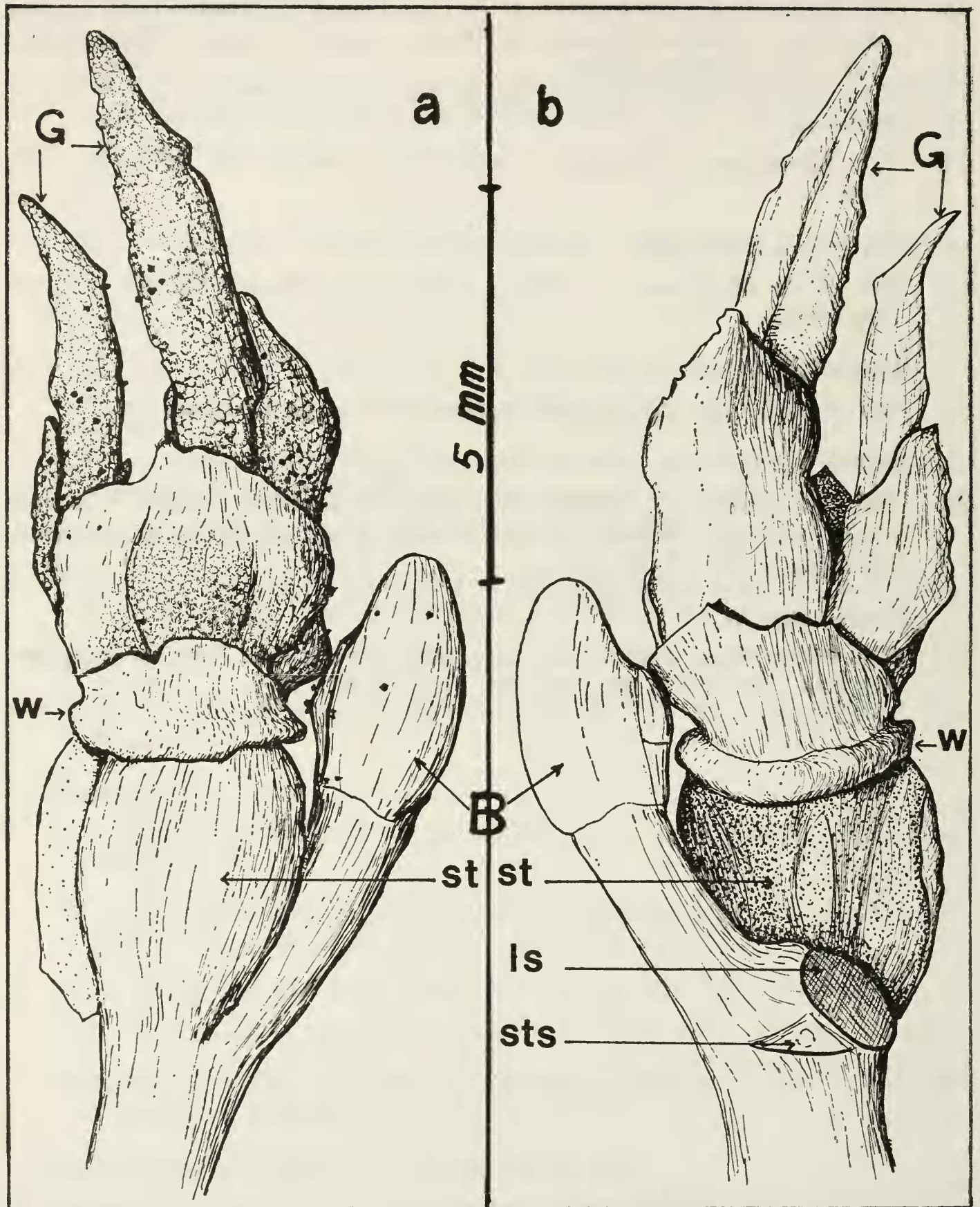


Fig. 3. a & b, two different views of two young coccid-galls 23 I developed on a stipule of *Shorea curtisii* King (on b tufts of hairs not drawn).

B: bud; G: gall; ls: foliar scar; st: stipule; sts: stipular scar; w: wad.

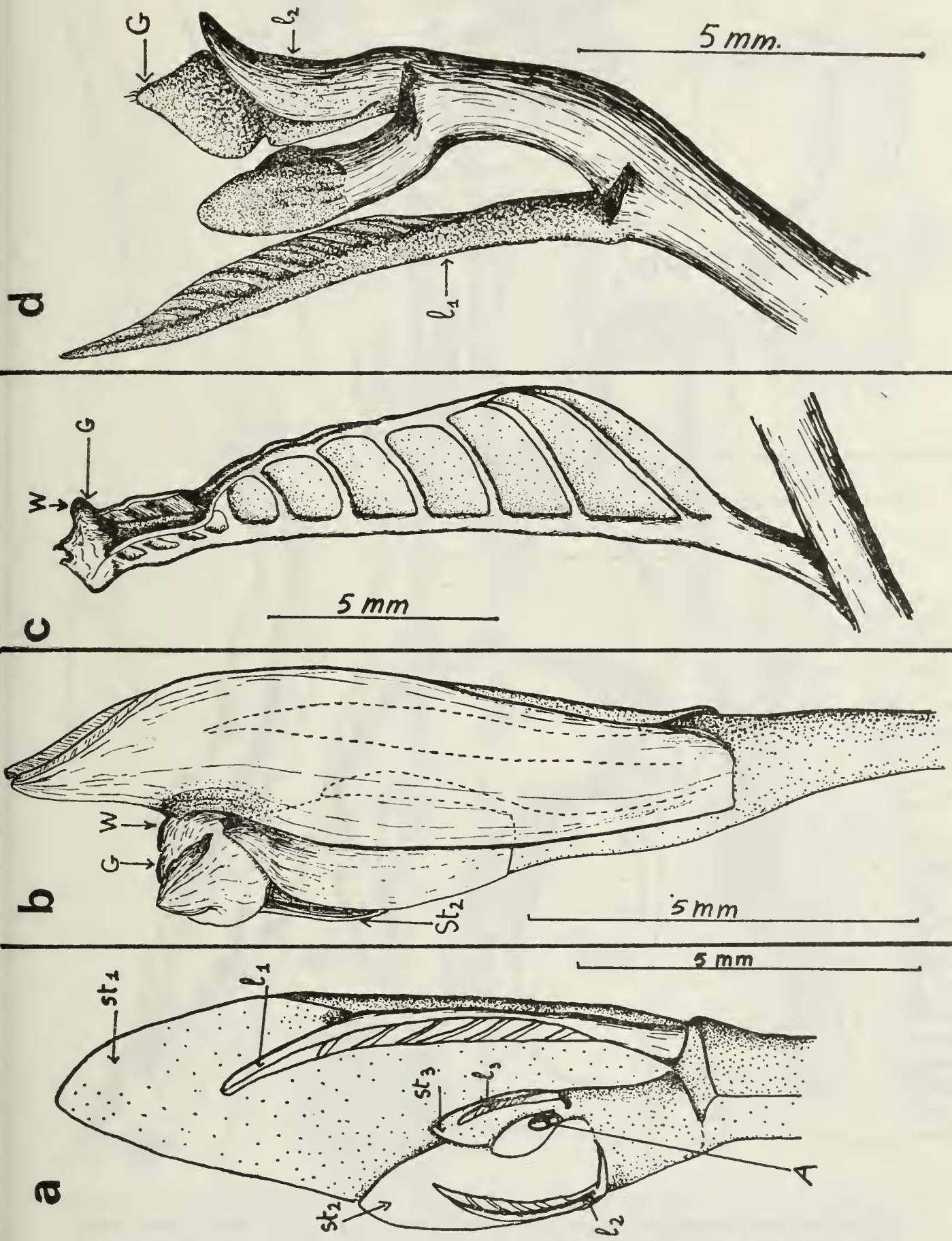


Fig 4. Some aspects of the young coccid-galls 23 I on *Shorea curtisii* King; a, normal bud. One stipule of each pair has been removed; b, early stage of a gall developed on one of the stipules of the second order; c, young gall developed at the tip of the midrib; next to the gall the lamina is very reduced, but the rest of the leaf is normal; d, young gall developed on a leaf that has become completely atrophic. It corresponds to an earlier stage of attack than case c.
 A: growing point; G: gall; l₁, l₂, l₃, each a leaf of the respective order: similarly st 1, st 2, st 3 for stipules; W: wad.

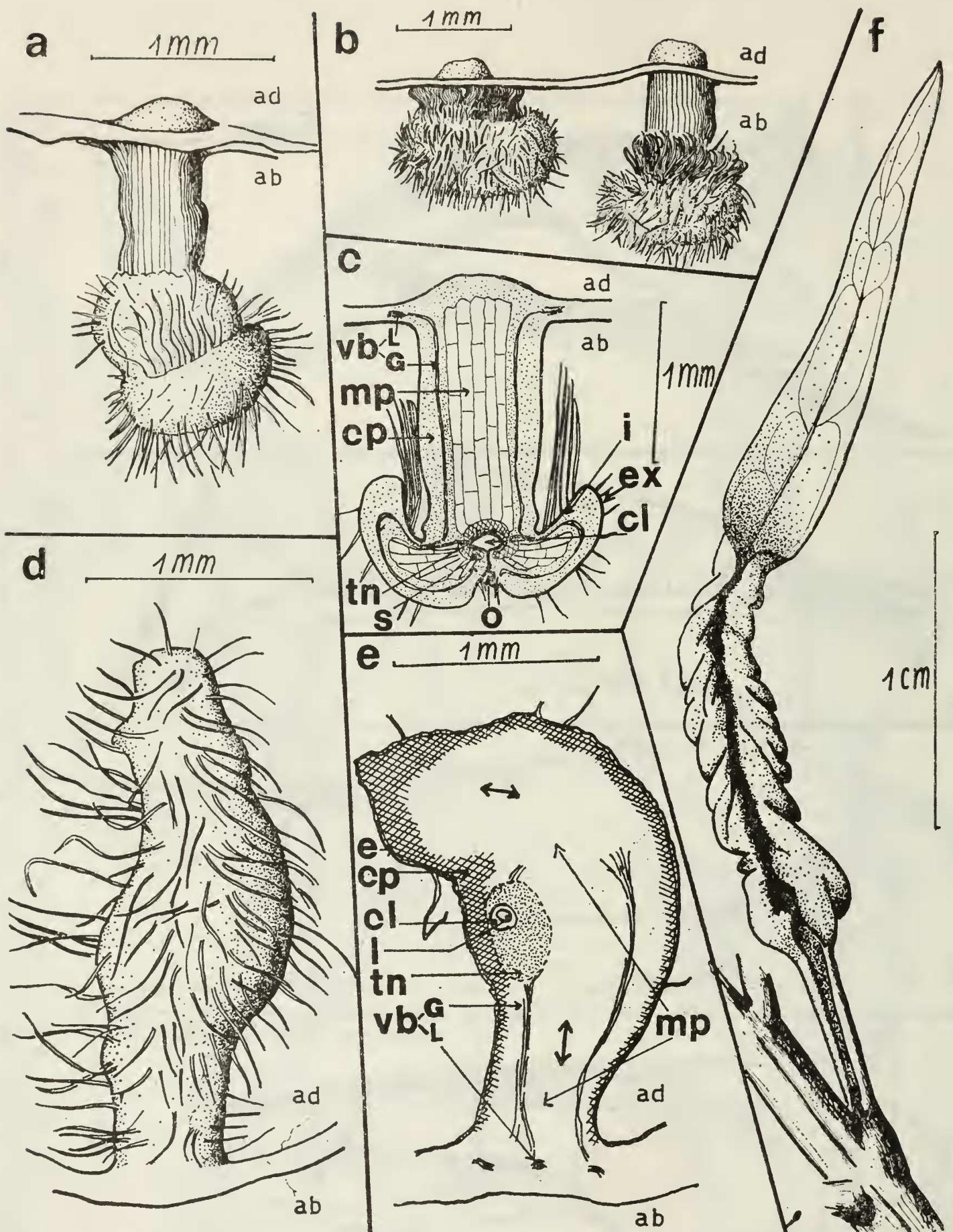


Fig. 5. a-e, galls on *Shorea curtisii* King; a, midge-gall 23 III attacked by a parasitic chalcid; b, two developing stages of the midge-gall 23 III (left: early stage; right: older stage.); c, longisection of the midge-gall 23 III; d, wasp-gall 23 II; e, longisection of the same; f, thrips gall 219 on *Clerodendron laevifolium* Bl. ab: abaxial leaf-surface; ad: adaxial leaf-surface; cl: larval cavity; cp: cortical parenchyma; e: epidermis; ex: external cap-side; i: internal cap-side; l: larva; mp: medullar parenchyma; o: ostiole; s: shell; tn: nutritive tissue; Vb-L/G: vascular bundles of the leaf/gall.

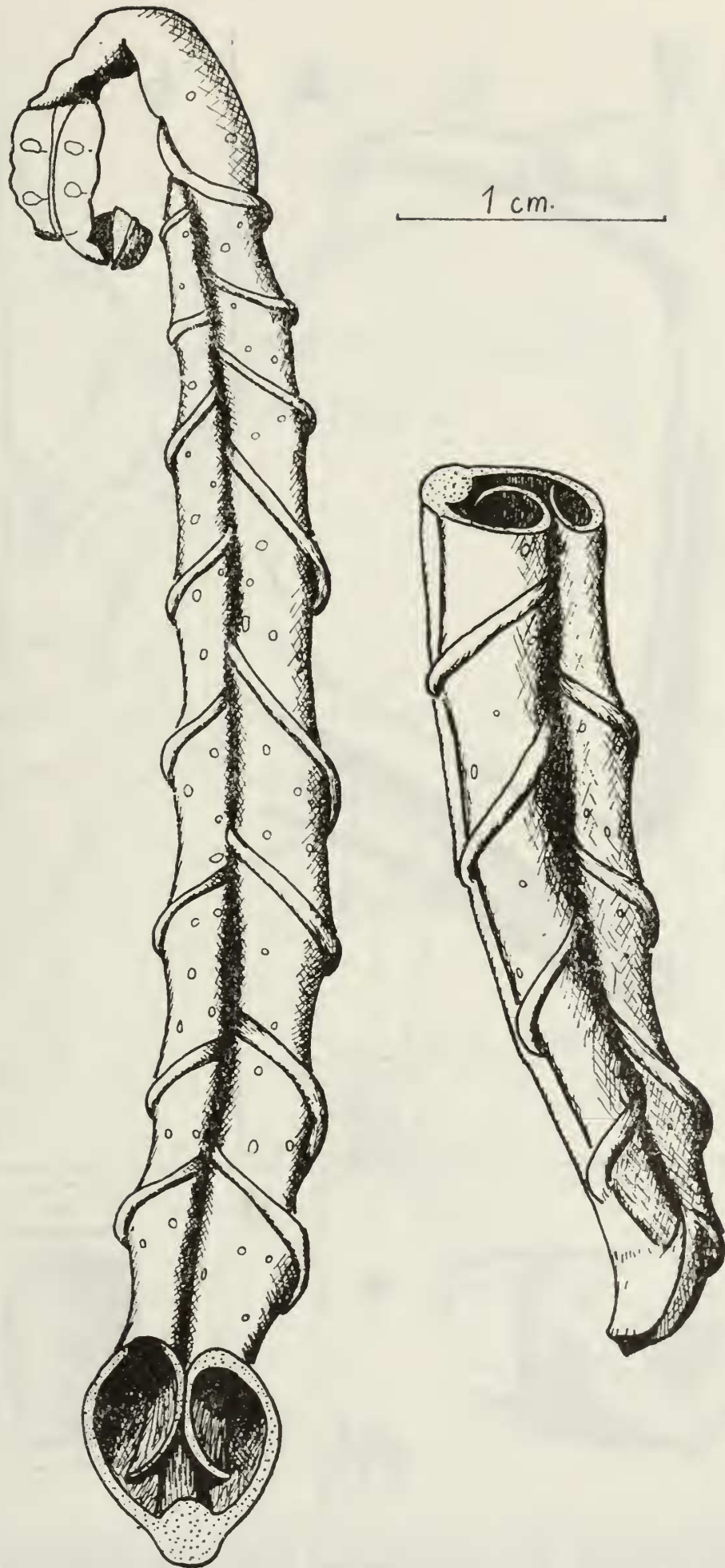


Fig. 6. Thrips-gall 98 I on *Aporosa benthamiana* Hk. f. & Th.

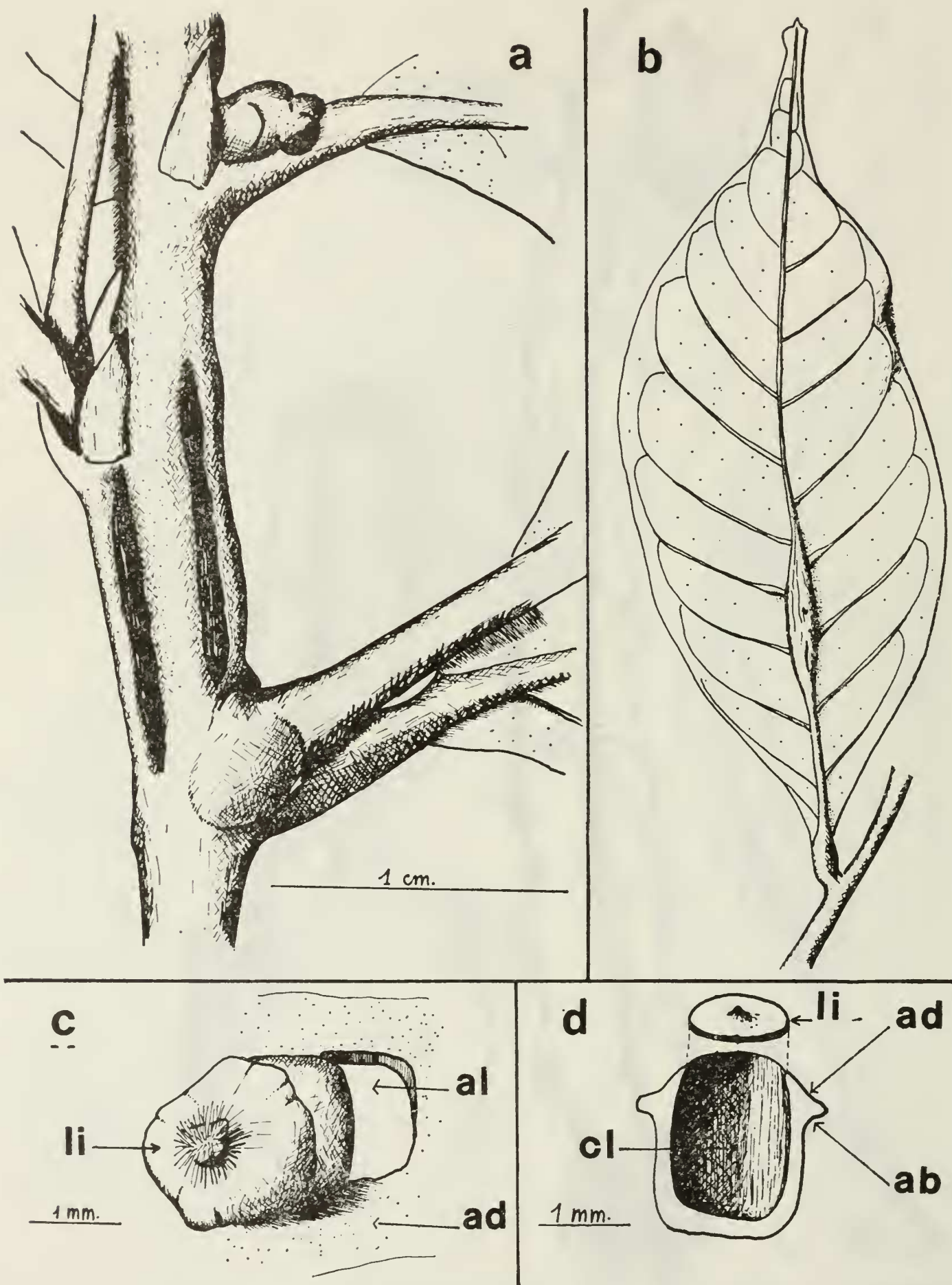


Fig. 7. Galls of *Lithocarpus conocarpus* (Oudem.) Rehd.; a, moth-gall 135 III on stem and petiole; b, moth-gall 135 II on midrib; c, sessile wasp-gall 120 I; d, longisection of the gall 120 I. On top, the detached lid of the gall.
 ab: abaxial leaf-surface; ad: adaxial leaf-surface;
 al: alveole; cl: larval cavity; li: gall-lid.

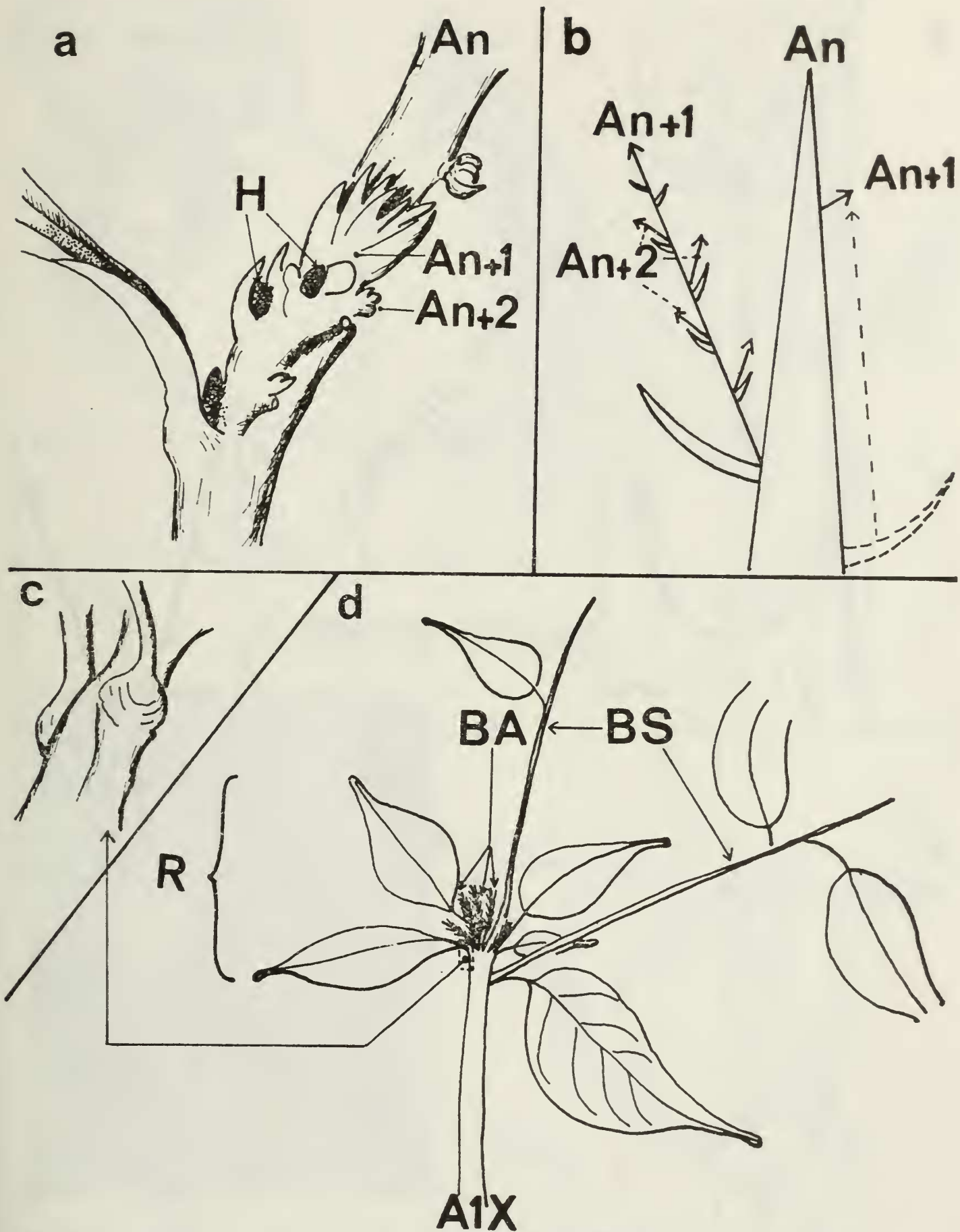


Fig. 8. Witches' broom 153 IV caused by coccids on *Lithocarpus sundaicus* (Bl.) Rehd. a, pathological development of an axillary bud: formation of secondary and tertiary shoots and reduction of leaves; b, sketch of the line drawing a, c, hypertrophic base of a leaf; d, sketch of the witches' broom. A1X: cessation of growth of the principal axis; An, An+1, An+2, each a shoot of the respective order; H: Homoptera; R: rosette of leaves due to the shortening of internodes; BA: axillary buds abundantly developed; BS: axillary buds strongly developed.

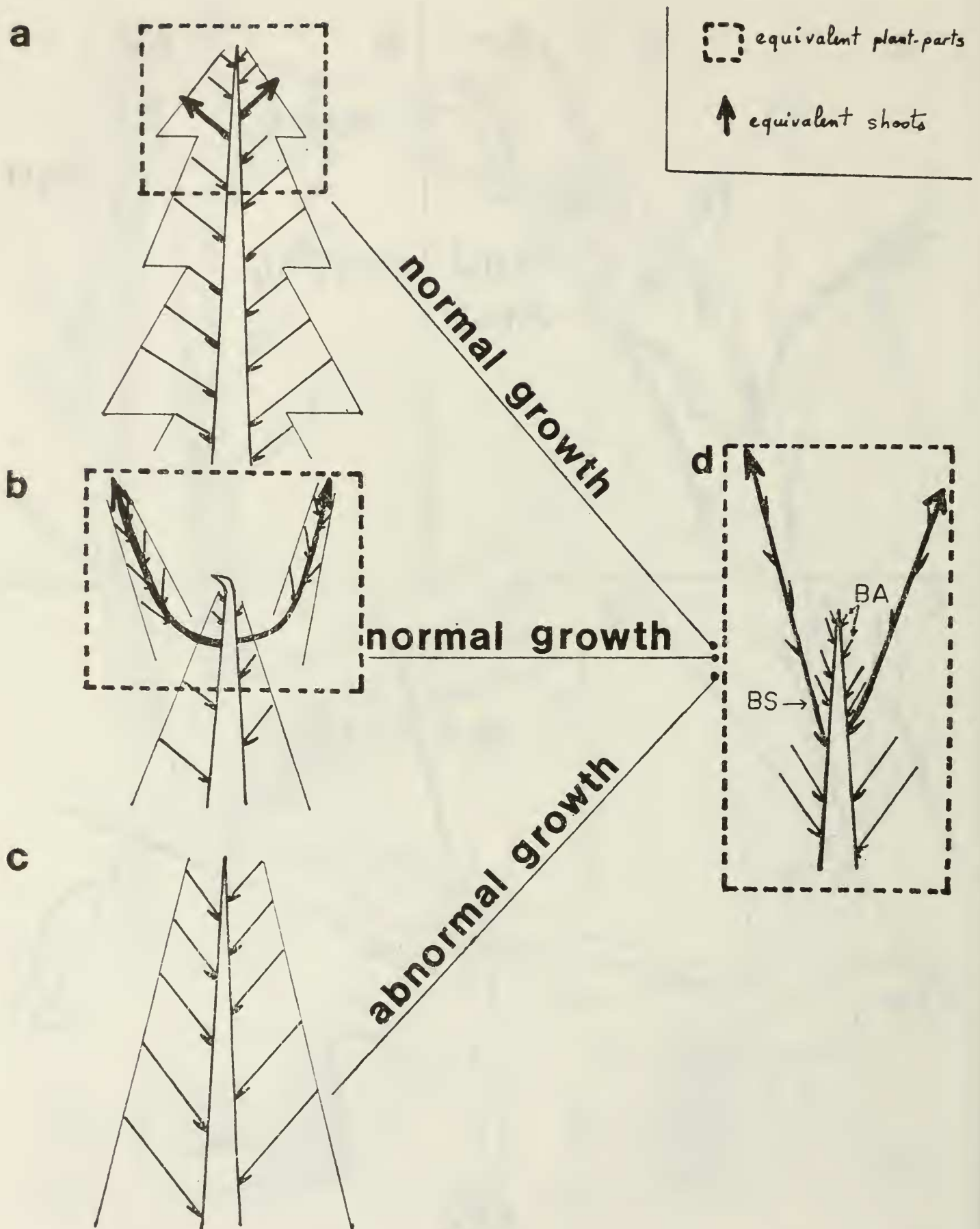


Fig. 9. Hypothesis on the growth vigor under the gall-zone, fide Dr. Cusset in litt. (see p. 36 in text); **a**, monopodial growth with flush; **b**, sympodial and more or less acrotonic growth; **c**, monopodial growth without rhythm; **d**, observed gall-growth. BA: axillary buds abundantly developed; BS: axillary buds strongly developed.

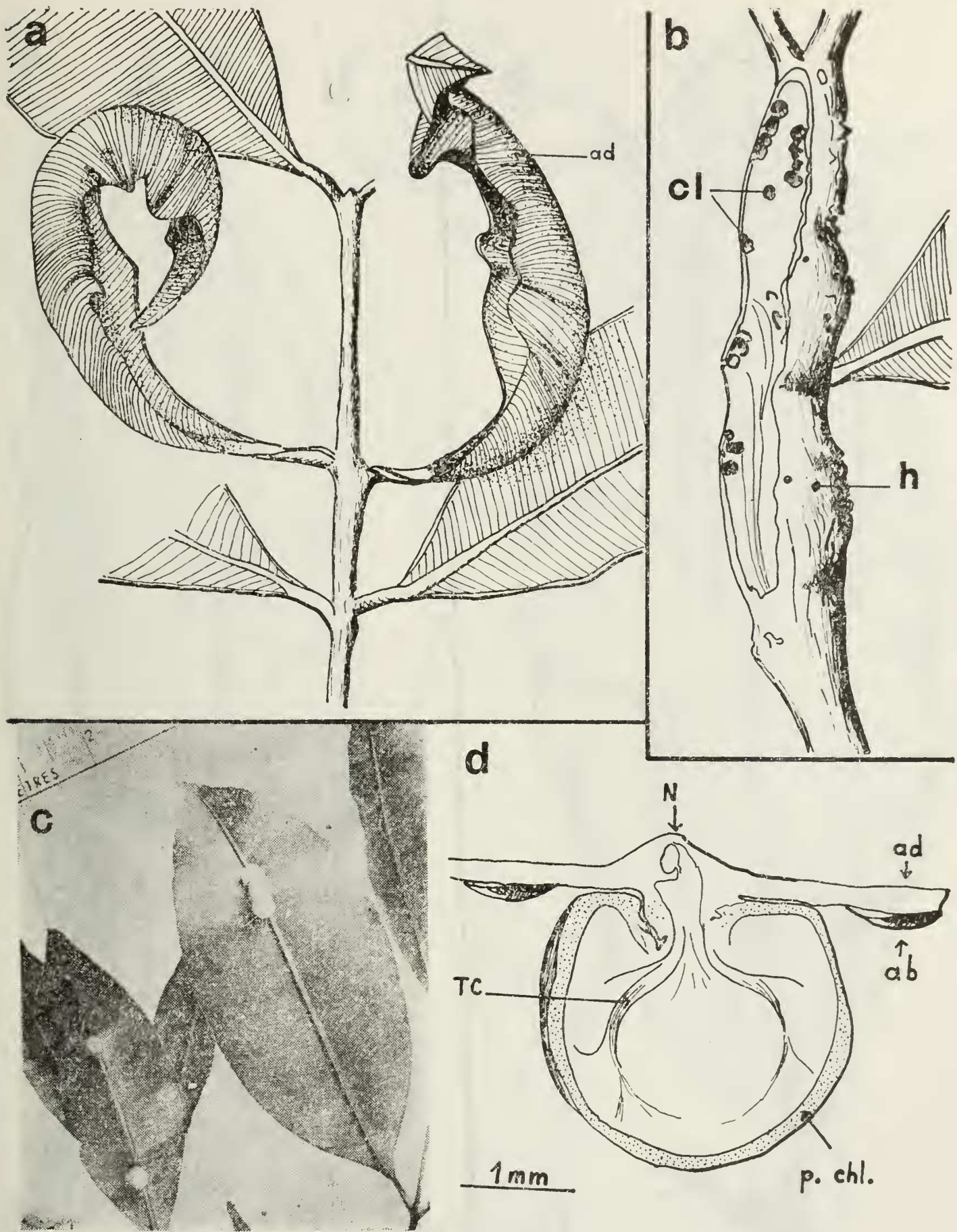


Fig. 10. Galls on *Calophyllum pulcherrimum* Wall.; a, psyllid-gall 107 I; note the twisted petioles; b, midge-gall 107 III on stem longitudinally cut on the left; c, midge-galls 107 II; d, longisection of gall 107 II.
 ab: abaxial leaf-surface; ad: adaxial leaf-surface cl: larval cavity; h: emergence hole; N: midrib; p. chl; parenchyma with chlorophyll; TC: vascular bundle.

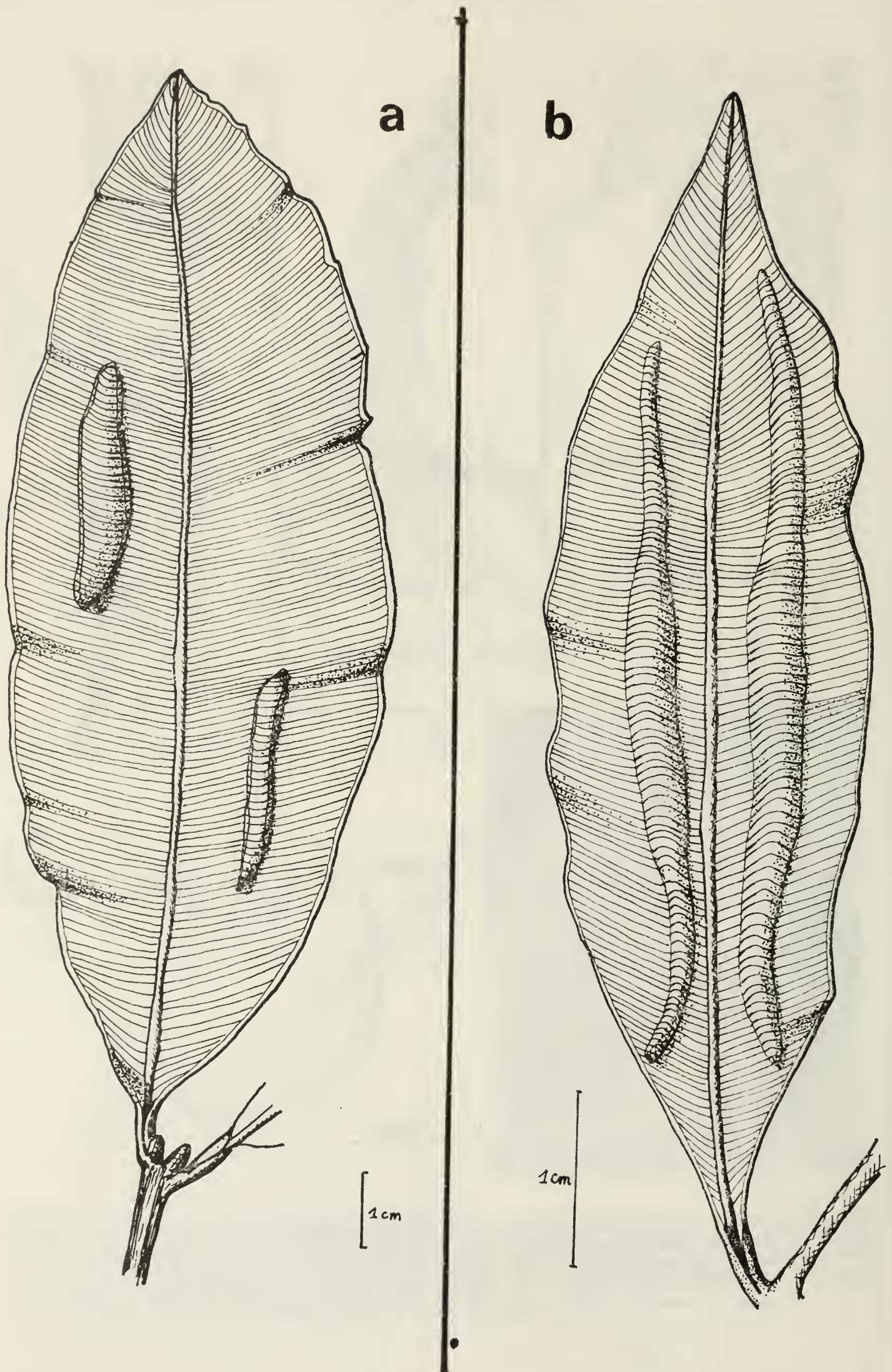


Fig. 11. Leaf-galls caused by moths; a, *Calophyllum ferrugineum* Ridl. gall 141 III; b, *Calophyllum pulcherrimum* Wall. gall 167 IV.

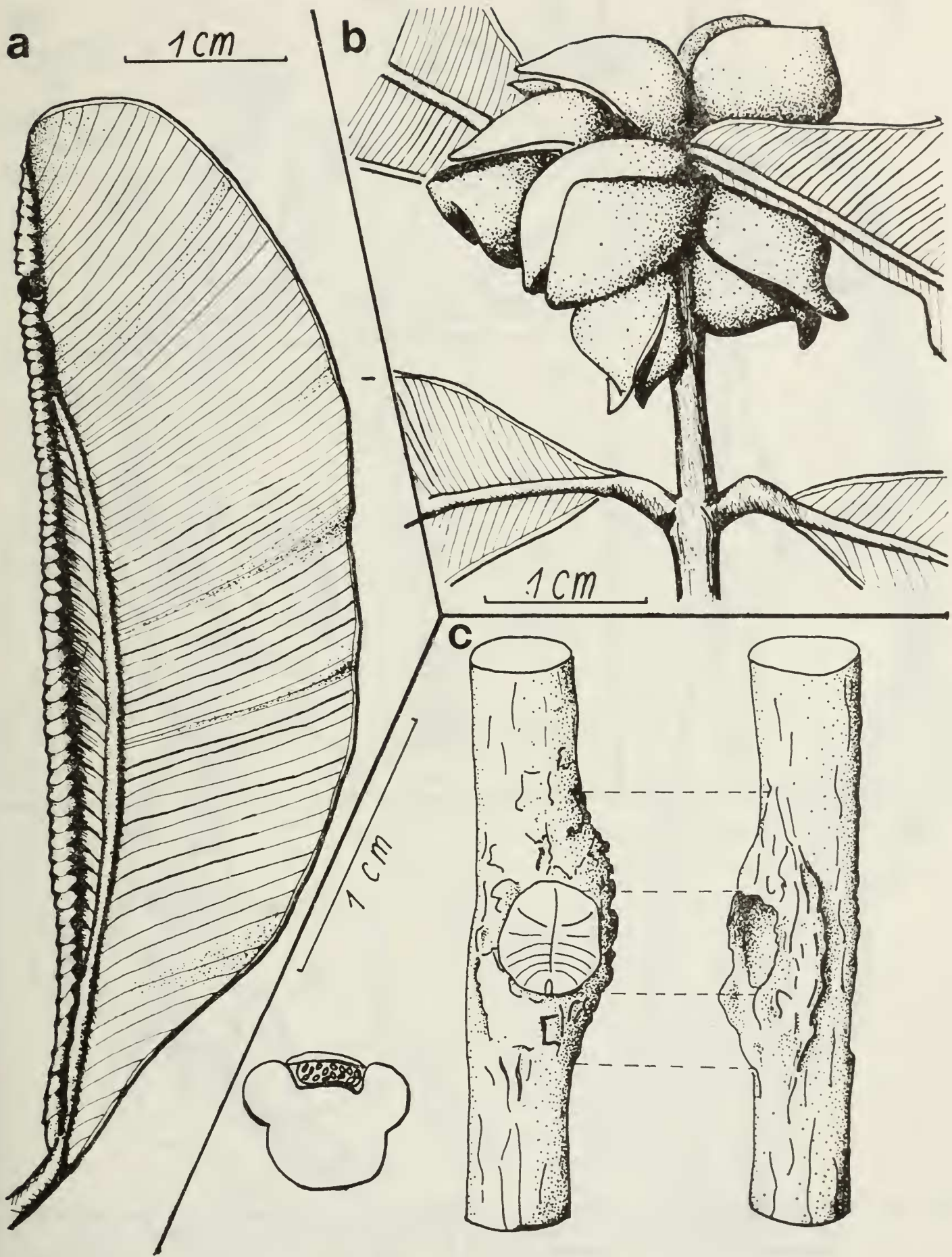


Fig. 12. a, psyllid-gall 43 II on *Calophyllum inophylloide* King; b, coccid-galls 43 I on same; c, coccid-gall 154 on stem of *Xylopia malayana* Hk. f. & Th.

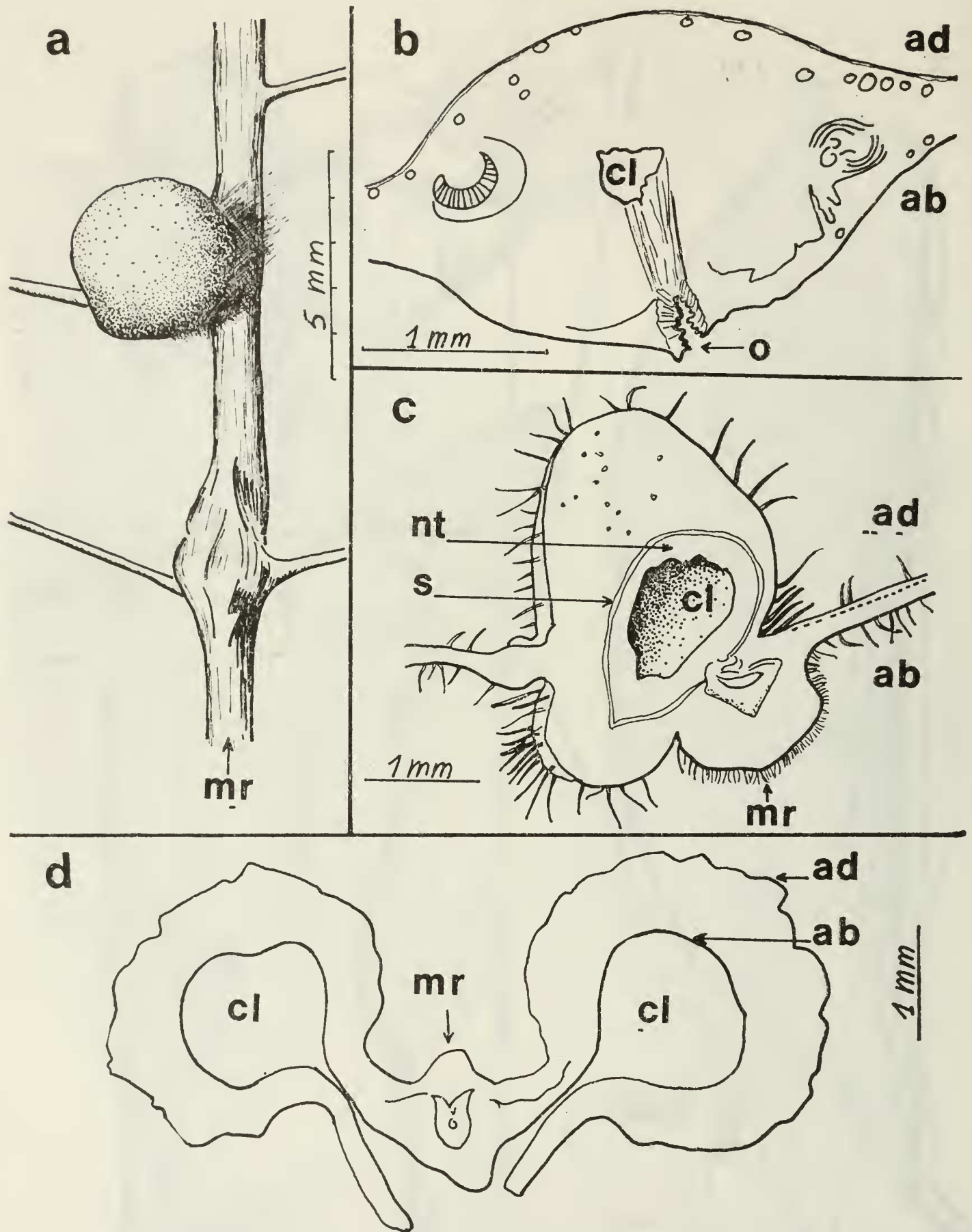


Fig. 13. **a**, midge-gall 143 IV on vein of *Actinodaphne* sp; **b**, longisection of the midge-gall 138 II on leaf of same; **c**, longisection of the midge-gall 151 on midrib of *Popowia tomentosa* Maingay; **d**, transection of the midge-gall 68 I on leaf of *Calophyllum ferrugineum* Ridl.

ab: abaxial leaf-surface; ad: adaxial leaf-surface;
 cl: larval cavity; mr: midrib; nt: nutritive tissue;
 o: ostiole; s: shell.

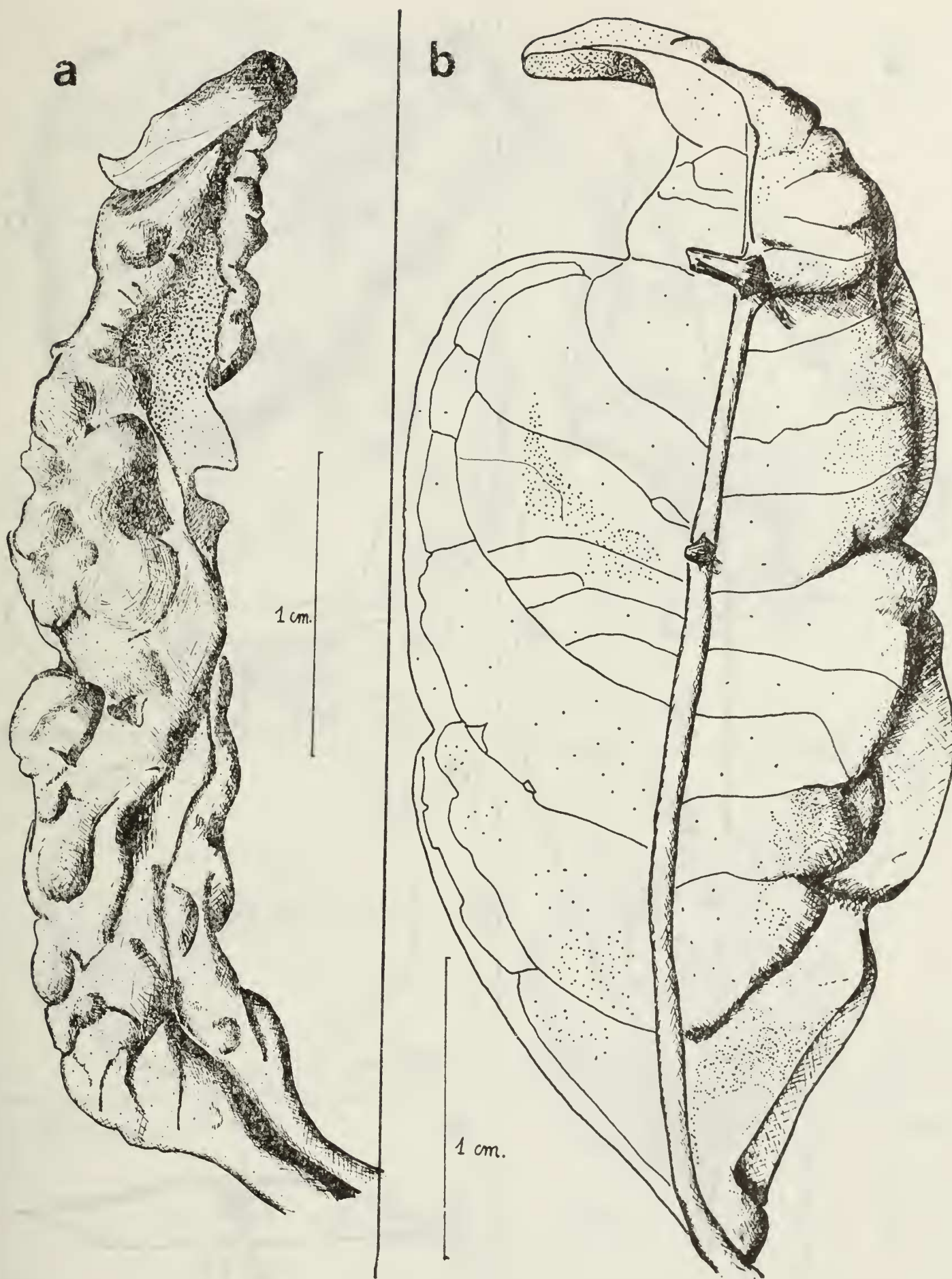


Fig. 14. *Endiandra* sp.; **a**, gall 156 I caused by a thrips; **b**, gall 156 III, gall of the midrib developed on the upper-surface of the leaf and gall 156 I caused by a thrips, on the right part of the leaf.

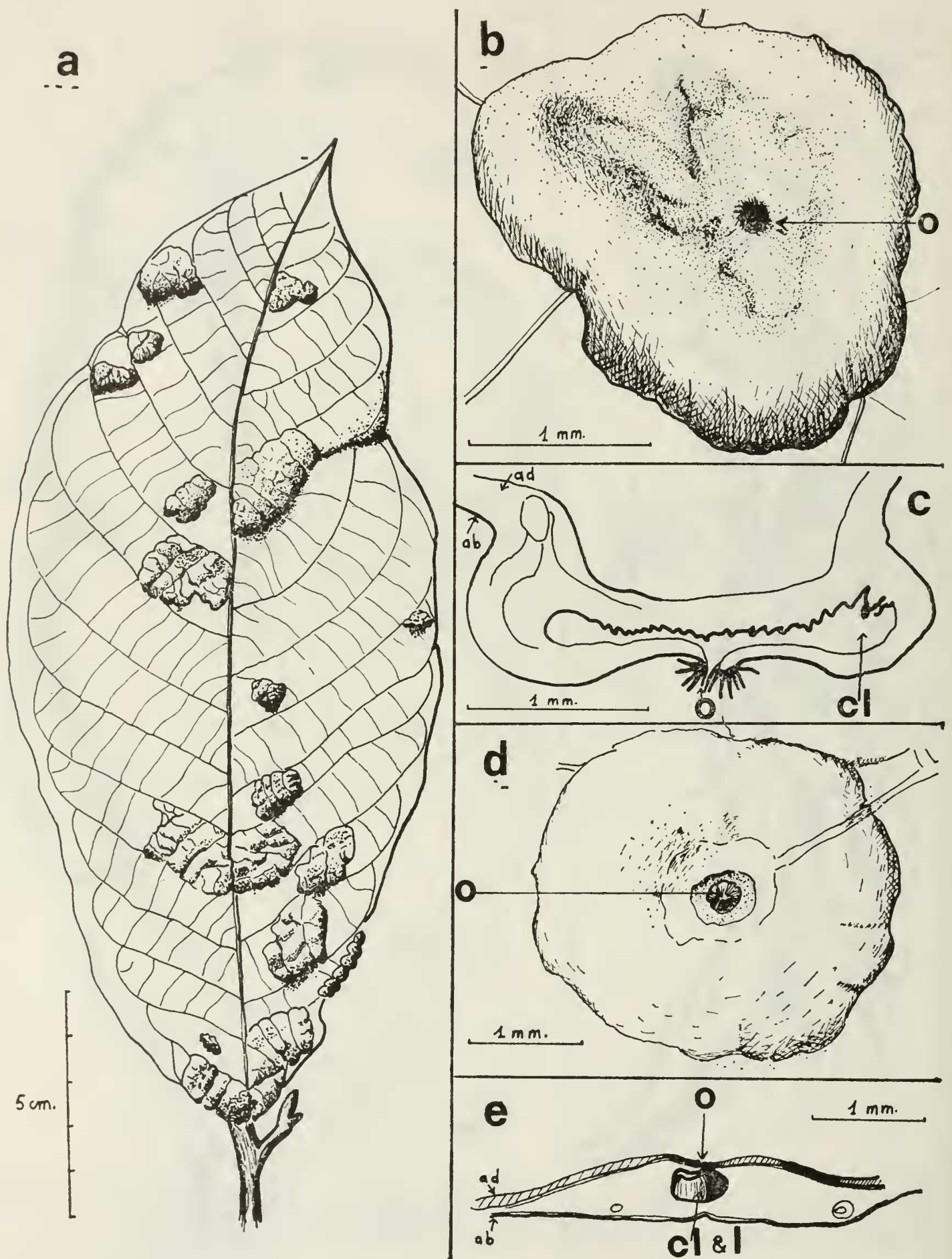


Fig. 15. a, mite-gall 100 on leaf of *Cyathocalyx ramuliflorus* (Hk. f. & Th.) Scheff.; b-e, galls on *Nothaphoebe kingiana* var. *malvescens* Gamble; b, abaxial view of the mite-gall 133 III; c, section of the same; d, adaxial view of the mite-gall 94 II; e, section of the same.
 ab: abaxial leaf-surface; ad: adaxial leaf-surface;
 cl: larval cavity 1; larva: o: ostiole.

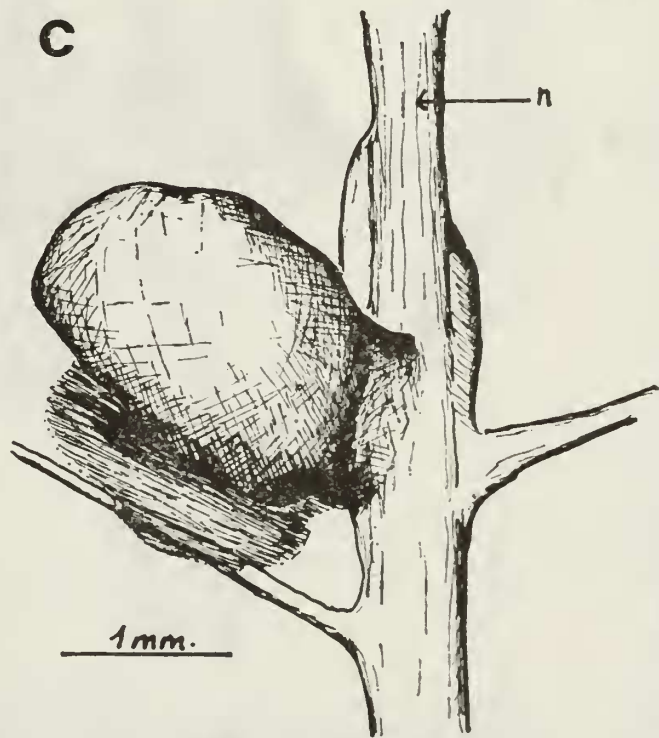
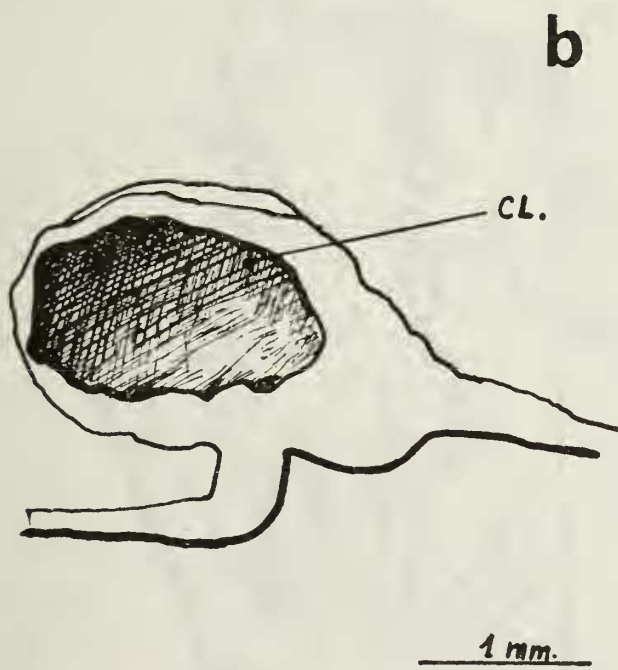
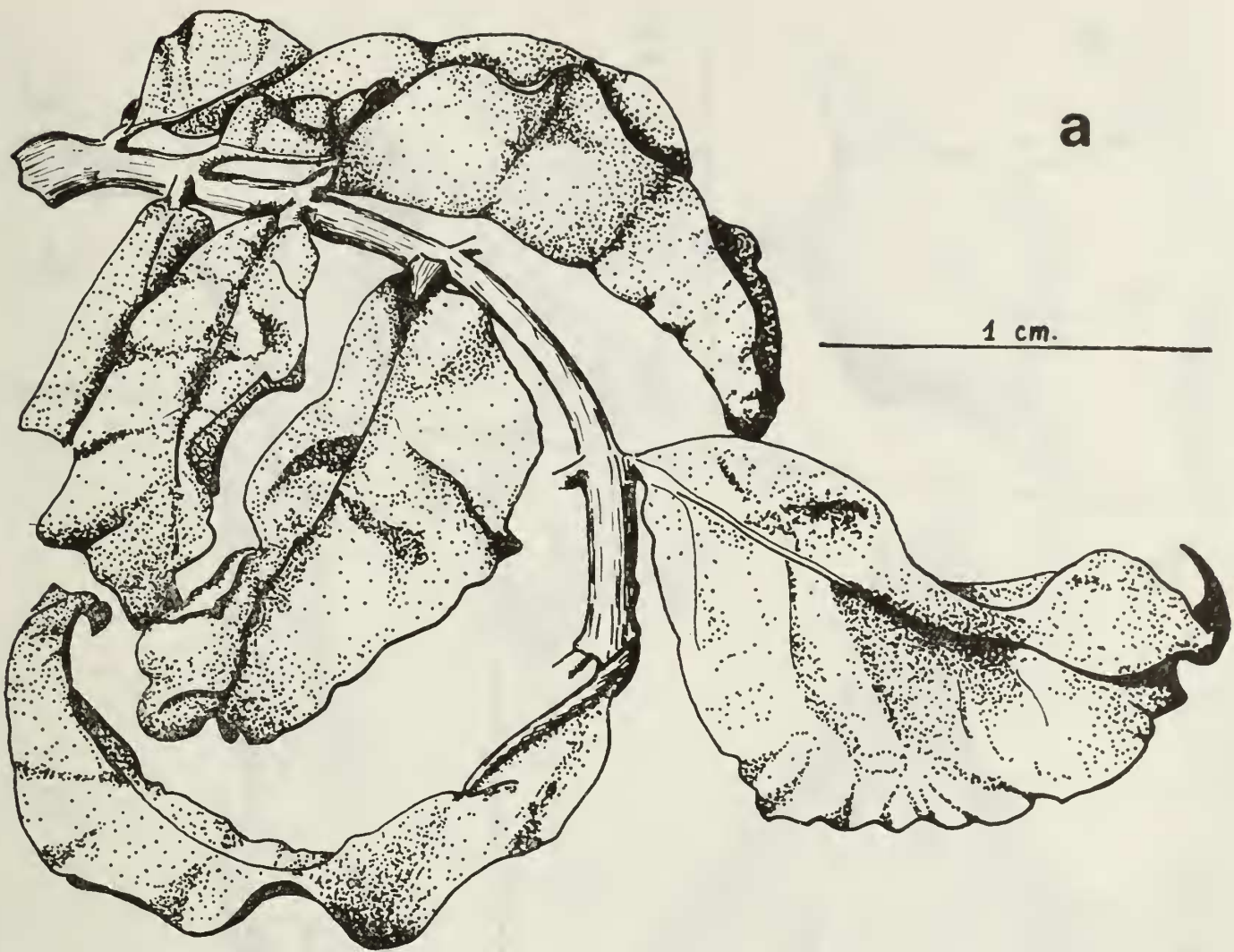


Fig. 16. *Pithecellobium clypearia* Benth.; a, gall 115 II, probably caused by Homoptera; b, gall 115 I, median longisecion of the midge-gall, showing the large larval chamber (CL); c, midge-gall 115 I abaxially attached to the midrib (n).

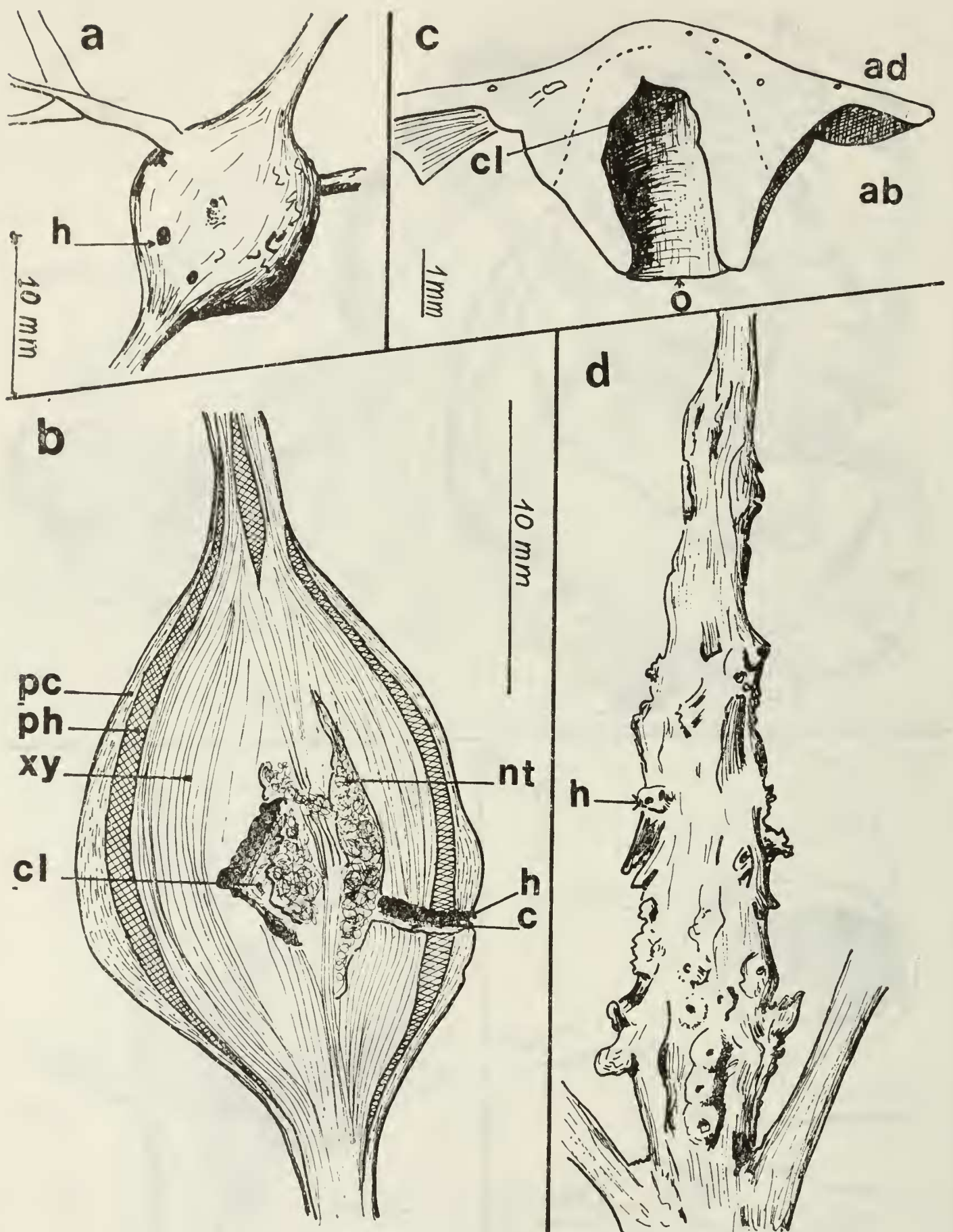


Fig. 17. Galls on *Eugenia rugosa* (Korth.) Merr.; **a**, stem-gall 158 II, caused by an unidentified insect; **b**, longisection of the same gall; **c**, longisection of the psyllid-gall 158 I; **d**, wasp-gall 142 IV, on stem; ab: abaxial leaf-surface; ad: adaxial leaf-surface; c: emergence canal; cl: larval cavity; h: emergence hole; nt: nutritive tissue; o: ostiole; pc: cortical parenchyma; ph: phloem; xy: xylem.

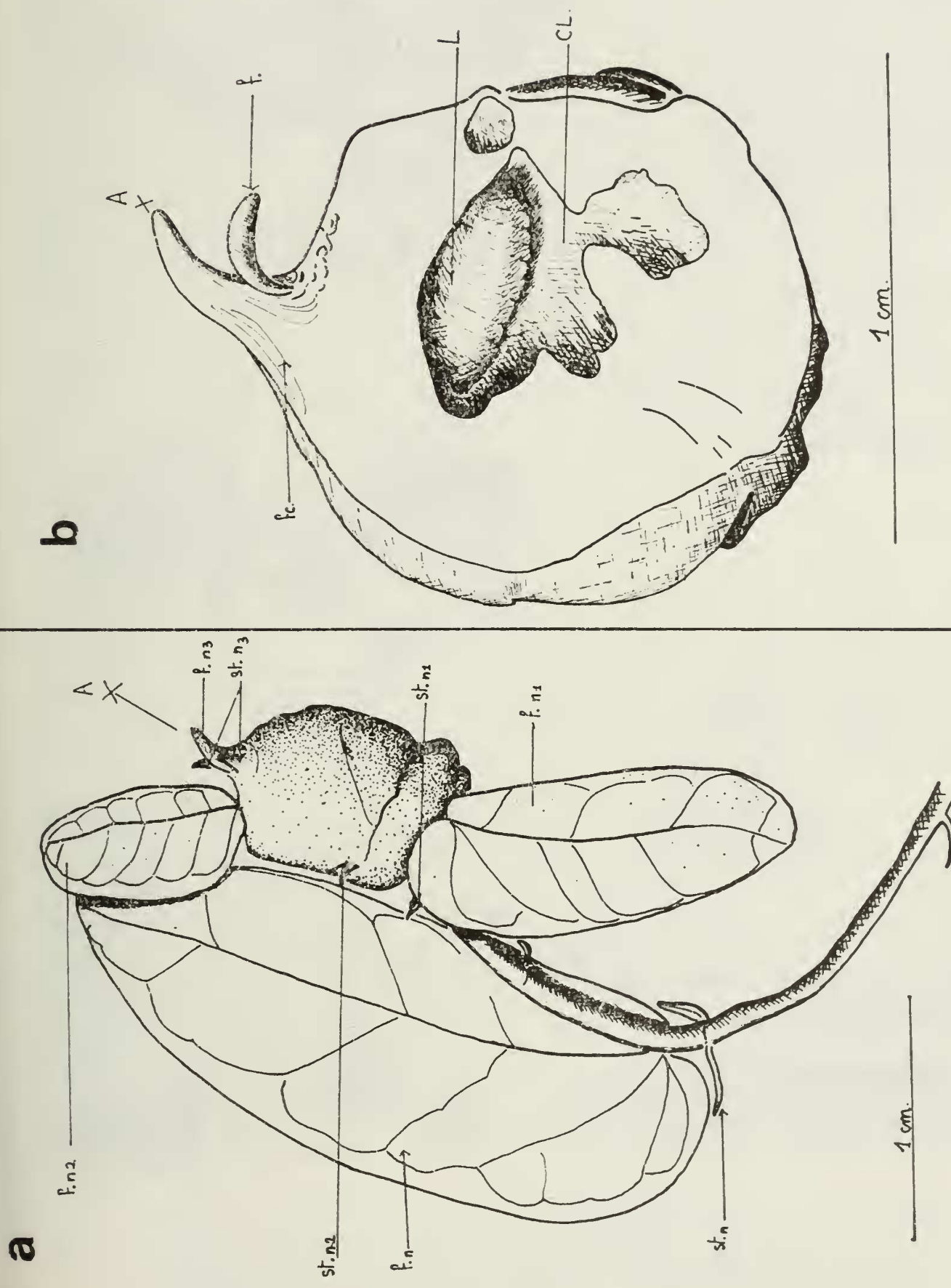


Fig. 18. Wasp-gall 150 on *Ficus pumila* Linn.; a, morphology of the gall (A: inhibited growing point of the stem; f.n.: leaf of nth order; st.n.: stipule of nth order.); b, longitudinal section of the gall showing the gall-chamber (CL) and one larva (L), (f.: leaf; fc: vascular bundle).