

# A BIOLOGICAL AND SYSTEMATIC STUDY OF PHILIPPINE PLANT GALLS<sup>1</sup>

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FIFTEEN PLATES

## INTRODUCTION

Galls are abnormal growths on the stems, leaves, roots, or other parts of plants, caused by the action of insects, arachnids, or fungi, or by unknown agencies. Just how these peculiar structural developments are brought about is still open to discussion and speculation, experimental proofs being, up to the present, too deficient to warrant our drawing any definite conclusion. These malformations have been ascribed to various causes, the more commonly accepted, in the absence of more reasonable, explanations being the following:<sup>2</sup> 1, a severe mechanical injury to certain parts of the plant; 2, a continuous mechanical irritation; 3, secretion of chemical stimulus by the causal animal or fungus. One, or a combination of two or all, of these causes may give rise to the production of galls. In the formation of zoöcecidia, the third factor—that is, the action of the virus secreted at the time of oviposition or during the development of the parasite—is probably the most important, the first two being of minor or absolutely no use whatever. This fact was shown by Molliard in connection with his experiments on *Aulax papaveris* Perris, a cynipid gall maker on the pistil of *Papaver rhoeas* Pall.<sup>3</sup> From time to time he removed a small quantity of the virus secreted by the developing *Aulax* larva, and injected the fluid into the growing pistils of *Papaver*. This artificial treatment resulted in the formation of galls which resembled in all respects those formed in the presence of the larva itself. He was thus enabled to draw the conclusion that the virus alone, without the influence of mechanical irritation from the presence of the animal within, is sufficient to produce the characteristic *Papaver* gall. The importance of chemical stimuli, as related to gall formation, was recognized as early as 1686 by Malpighi,

<sup>1</sup> Thesis presented in partial fulfillment of the requirements for the degree of Master of Science, University of the Philippines, 1918.

<sup>2</sup> Cook, M. T., Insect Galls of Indiana. Dept. Geol. and Nat. Resources, Indiana, 29th Ann. Rep. (1904) 801.

<sup>3</sup> Compt. Rend. Acad. Sci. 165 (1917) 160.

a physician to Innocent XII, and professor of medicine at Bologna and, later, at Messina. In his *De Gallis*, which is the earliest systematic treatise on galls, he maintained that, at least in the case of *Cynips*, the galls formed on the plant were caused by a certain acid secreted by the insects.<sup>4</sup> A more recent paper by A. Cosens has the following to say in connection with these chemical secretions:<sup>5</sup>

The larva secretes an enzyme capable of changing starch to sugar [and] which acts on the starchy constituents of the nutritive zone [of the gall] and accelerates the rate of their change to sugar. The material thus prepared supplies nourishment to both the larva and the gall.

Galls can be produced only "when the tissue of the plant is interfered with during, or prior to, the actual development of the tissue."<sup>6</sup> After the plant tissue has become fully matured, no amount of stimulus, whether physical or chemical, will lead to the formation of galls.

In the present work only galls caused by the action of animals, known as zoöcecidia, are taken into consideration. A zoöcecidium may be caused by the action of a member of either of two zoölogical classes—Insecta and Arachnida. Galls caused by the former vary in structure from a simple convolution in the leaf lamina or a swelling in the stem to a more or less complex formation on different parts of the plant. Insects that have the power of producing plant galls are confined to the following orders and families:

Order.	Families.
1. Rhynchota, or Hemiptera.	Psyllidæ, Aphididæ, and Coccidæ.
2. Diptera.	Itionididæ, or Cecidomyiidæ, and Trypetidæ.
3. Hymenoptera.	Cynipidæ and Tenthredinidæ.
4. Lepidoptera.	Gelechidæ.
5. Coleoptera.	Buprestidæ. <sup>7</sup>
6. Thysanoptera.	

Arachnid gall-makers are all mites, which are members of the family Eriophyidæ (formerly called Phytoptidæ). Galls caused by this family are called erineæ<sup>8</sup> and are generally simple convolutions in the leaf lamina, with hairy outgrowth on the concave surfaces. When the gall is young, the gall-making eriophyids are found among these hair tufts.

<sup>4</sup> Cook, M. T., op. cit. 802.

<sup>5</sup> Trans. Canad. Inst. 9 (1912) 297-387; [Ent. News 24 (1913) 187-189.]

<sup>6</sup> Butler, F. H., Galls. Encycl. Brit. 11 (1910) 425.

<sup>7</sup> Cook, M. T., op. cit. 802.

<sup>8</sup> Banks, Nathan, Acarina or Mites, Rep. U. S. Dept. Agr. 108 (1915) 135.

## OBJECT AND METHODS

Very little is known about Oriental galls, the only noteworthy treatise on the subject being the series of articles on Javanese, Sumatran, and Celebes galls by W. and J. Docters van Leeuwen-Reijnvaan. These publications are almost purely botanical in their nature, the causal animal being merely mentioned in passing in practically all cases. On account of the very close resemblance existing between the fauna and the flora of the Philippines and those of the Dutch East Indies, I found in the works of the authors just mentioned much valuable assistance in the preparation of the present paper.

In the Philippines the subject of plant galls is one which covers an absolutely virgin field, practically no attention having been paid to these curious abnormalities in this country. Although including many new and interesting species, the results of the present investigation do not pretend to be anything more than a mere breaking of ground for a future more thorough and comprehensive series of investigations along this line. This branch of research bids fair to be highly productive of results in the way of elucidating obscure facts relative to these interesting formations.

In gathering the materials for the study of galls, excursions were made to points in the vicinity of Los Baños, Laguna Province, Luzon, and especially to the thickets adjoining the college farm, the forests of Mount Maquiling, Balong Bulo Hill (near the college farm), the adjoining lowlands and valleys, and along the banks of Molauin Creek. The forests around Los Baños Falls and the thickets at the outskirts and in the barrios of Bay, Los Baños, Calamba, Cabuyao, Santa Rosa, and Biñan were visited several times and search made for galls. The materials were brought fresh into the laboratory and, as soon as possible, before the galls wrinkled up or otherwise became discolored or distorted, photographs were taken (to show the natural appearance of the galls on the parts of the plant attacked), preliminary descriptions made, and specimens saved in a medium of which the following is the formula:

	Parts.
Water	48
95 per cent alcohol	48
40 per cent formaldehyde (formalin)	4

Large-sized homeopathic vials or wide-mouthed dispensing bottles of convenient dimensions and with tight-fitting corks served as preserving vessels. Each bottle or vial had the accession number written on the cork and on the labels that accompa-

nied the specimens in the preserving fluid, the galls and insects being given the same number in the accession record.

Longitudinal and cross sections were made of the mature galls, and these were drawn to show the details in structure and the mechanism peculiar to each case.

No hard and fast rule can be laid down as to the methods to be followed in breeding the insects from their galls. Conditions were different in each case, and laboratory methods had to be modified accordingly. In general, battery jars with fine muslin held on by elastic bands at the top proved to be the best form of breeding receptacle, a decided advantage in favor of these being that the green parts of the plants were kept adequately exposed to the light and that inspection and cleaning were easy. During dry months the materials had to be moistened at least once a day by spraying them with water from a small hand atomizer. Care was taken not to wet the plants too much, for then decay would set in, or the adult insects on emergence would be entrapped by the film of water on the plant surface or the inner wall of the jar and spoiled. The jars were inspected every morning and the adults caught by means of a short test tube. The removal of the adults as soon as they emerged was a necessary measure, because when allowed to stay in the vessel for a longer time many of them would be lost or badly mutilated among the moist plant materials.

Throughout the progress of the work precautions were taken against certain small spiders which, when accidentally introduced into the jar with the plant materials, would prey upon the gall insects as fast as the latter emerged. As a measure against this pest, the pieces of plants were thoroughly shaken, one by one, before being placed into the jars, and a constant watch was kept for the appearance of any of the spiders that might have hatched from eggs accidentally introduced.

Another piece of apparatus used consisted of a light-tight cardboard box with the mouth ends of test tubes or vials inserted into one side. This device was supposed to work on the principle that most insects are attracted to the light; and the interior of the box being dark, except at the insertion of the glass tubes, the insects on emerging were supposed to enter the latter. The apparatus had been used with good results and had been indorsed by the California Board of Horticulture and by the cotton-boll weevil investigators.<sup>9</sup> The results with this device in

<sup>9</sup> Banks, Nathan, Directions for Collecting and Preserving Insects, *Bull. U. S. Nat. Mus.* 67 (1909) 115, with figure.

the present experiments were most disappointing; in almost all trials the adult insects would not readily enter the test tubes, barely 5 per cent of those that emerged in the box having been captured in this manner.

With certain plants artificial breeding in the laboratory was found to be impracticable. The leaves of many species of *Ficus*, for example, dry up in less than an hour after being removed from the tree and placed under ordinary laboratory conditions; when confined in a vessel with a supersaturated atmosphere, decay readily sets in, or the material soon becomes moldy. The same is true with *Astronia* and certain other plants that grow at high altitudes. When the plant was conveniently near the laboratory, the galls were encased in muslin on the tree, so as to prevent the escape of the adults when they emerged; and daily inspection was made of these. However, in the case of the psyllid galls on the leaves of *Ficus ulmifolia* Lam., a badly infested plant of which happened to grow in close proximity to the entomological laboratory, the specimen was left without any cover. On examining the plant, it was found on January 25, 1917, after about two months' daily visits, that some of the galls were newly opened. On that day the plant was visited at frequent intervals, and it was discovered that the newly emerged adults, on growing stronger, had crawled over to the younger and softer tips of the branchlets, where they were easily caught in test tubes. For several days in succession captures were made in this manner.

The thysanopterous gall makers were easily secured from their galls. Provided the galls were not too old, the insects could always be found within in all stages of growth. They were scared out of the galls by gently tapping the latter, and could then be brushed off into a vial of 70 per cent alcohol. The eriophyids were not so easy to secure on account of their habit of clinging fast to the hair tufts of the galls and also because of their exceedingly minute size. Several methods were tried, but the simplest process was to brush the animals onto the surface of a mirror by means of a small camel's-hair brush, and then remove and mount them.

In the attempts to breed the gall insects from their galls, some other specimens—that is, parasites, inquilines, etc.—were often found. At times two or more species of a gall-making family were bred out, and in this case it was not easy to decide which was the gall maker and which the inquiline. There occurred a number of other instances where it was exceedingly

difficult to arrive at a definite conclusion as to the real gall maker.

The adult gall insects were kept alive for from six to twelve hours in a cotton-plugged vial in order to give them time to dry and assume their normal color before they were killed. With the exception of the thrips and the eriophyids, two series of preserved specimens were prepared, one on small pins and the other on microscopical slides in Canada balsam or turpentine solution of colophony. If the specimens were scarce, only the former series was made of the adults. The thrips in all instars were always mounted on slides. When plenty of specimens of fresh insect galls could be secured, a number of these were carefully dissected, and the insects in their earlier stages removed and mounted on slides. In the case of transparent specimens, such as the earlier instars of psyllid nymphs and the larvæ of Itonididæ, which would be almost invisible when mounted on slides, resort was had to a previous staining in 0.5 per cent aqueous solution of magenta red for about twenty-four hours.

Drawings of anatomical parts of the gall insects were made with the aid of a camera lucida. Whenever practicable corresponding parts of different species of the same family were drawn to the same scale and in the same position, in order to facilitate comparison. Most of the gall sections were too large to be drawn conveniently by the aid of the microscope and camera lucida, so that practically all the drawings of these materials were made freehand.

#### RESULTS

Fifty-seven species of galls have been worked with. These are distributed among twenty-six plant families, as follows:

Apocynaceæ, 1.	Lecythidaceæ, 1.
Araceæ, 1.	Leguminosæ, 2.
Araliaceæ, 2.	Loganiaceæ, 1.
Boraginaceæ, 1.	Melastomataceæ, 2.
Celastraceæ, 1.	Menispermaceæ, 3.
Combretaceæ, 2.	Moraceæ, 7.
Compositæ, 1.	Piperaceæ, 1.
Dilleniaceæ, 1.	Rubiaceæ, 1.
Dipterocarpaceæ, 4.	Sapindaceæ, 1.
Euphorbiaceæ, 10.	Tiliaceæ, 2.
Guttiferæ, 2.	Urticaceæ, 1.
Hernandiaceæ, 1.	Verbenaceæ, 3.
Lauraceæ, 2.	Vitaceæ, 3.

The present work has not been comprehensive enough to warrant our drawing very definite conclusions; but an examination of the above list tends to show that the Euphorbiaceæ have the greatest number of gall-making species, with the Moraceæ ranking second.

Classified as to causes, the following numbers of galls were obtained:

	Species of insects.
Itonidid galls	19
Psyllid galls	7
Thysanopterous galls	7
Eriophyid galls	7
Gelechid galls	1
Miscellaneous galls <sup>a</sup>	16

<sup>a</sup> "Miscellaneous galls" includes all the galls of which the causative agent is not definitely known.

Galls of the insects mentioned in the introductory paragraphs of this paper, other than those of the families enumerated above, have not been met with in the present investigation. Species of Cynipidæ <sup>10</sup> and Tenthredinidæ <sup>11</sup> have been reported from the Philippines, and the chances are that further work will lead to the discovery of the galls of the former, at least. The latter, *Selandria* (*Paraselandria*) *imitatrix* Ashm., according to Prof. C. S. Banks, the collector of the type, is an exophagous species and not a gall maker.

The Aphididæ and the Coccidæ are well represented in the Philippine fauna; but none of their galls have been found in connection with my work. It is not unlikely that their galls can be found here; for in Australia, a country that has many insects closely allied to Philippine species, among the largest and most remarkable galls are produced by some members of these families.<sup>12</sup>

The families Trypetidæ (Diptera) and Buprestidæ (Coleoptera) include many important pests of Philippine economic plants. Their work, however, has not been known to result here in the formation of galls.

In the various excursions made, it was noted that altitude influences the number of species of plant galls to a considerable

<sup>10</sup> See Kieffer, Nouveaux cynipides des Philippines, *Philip. Journ. Sci.* § D 9 (1914) 183; Neuer Beitrag zur Kenntniss der philippinischen Cynipiden, *Philip. Journ. Sci.* § D 11 (1916) 279.

<sup>11</sup> See Ashmead, Proc. U. S. Nat. Mus. 28 (1905) 971.

<sup>12</sup> Froggatt, Australian Insects (1907) 369, 370, and 380-383.

extent—the galls occurring most abundantly within a belt extending from sea level to an altitude of about 600 meters. Beyond that limit the galls are either very scarce or entirely absent. It was further noted that from sea level to an altitude of about 600 meters the greatest number of species occurred nearer sea level, their abundance diminishing with each 100-meter zone upward. This fact may be ascribed to at least two causes; namely, the prevalence or scarcity of the plant hosts in a given altitudinal zone; and the influence of temperature, moisture, pressure, absence or presence of natural enemies, and possibly other factors on the distribution of gall-making insects in different altitudinal zones. The following is the distribution of gall species, found by me, with respect to altitudes:

	Species.
Sea level to 100 meters	36
100 meters to 200 meters	31
200 meters to 300 meters	25
300 meters to 400 meters	23
400 meters to 500 meters	15
500 meters to 600 meters	9
600 meters to 900 meters	1
Above 900 meters	0

In the following pages the galls are divided into groups, according to their causative agents, which are indicated by the center heads; and each species is treated separately, with the specific name of the plant host as a side heading. Accounts of the causal insects, including descriptions of new species, will be given in later publications.

All of the specimen numbers cited in this paper refer to the collection of the department of entomology, College of Agriculture, Los Baños, Laguna, Philippine Islands.

#### GALLS CAUSED BY ITONIDIDÆ (CECIDOMYIIDÆ)

*Acalypha stipulacea* Klotz. Euphorbiaceæ.

Leaf galls caused by *Schizomyia acalyphæ* Felt.

Monothalamous; subcylindrical; red; basally yellowish or concolorous with leaf; covered all over with long, stiff, bristle-like hairs. Walls thin, fleshy; interior smooth. Opening apical; covered with a circular flap with edges confluent with the rest of the gall's surface, not visible until a few minutes previous to emergence of midges. Pupal exuviae often found projecting half way out of opening.

Length of galls, 3.5 to 5.5 millimeters; diameter at base, 1.5 to 2.



On the nether surface of leaf, along principal veins or at points where two small nervules meet.

LUZON, Laguna, College of Agriculture, near lower nursery, Los Baños; at an altitude of about 45 meters. March 15, 1917. Type gall No. 18313, College of Agriculture collection.

Numerous specimens of these galls were found on several young leaves of a small *Acalypha* plant. A part of these materials was confined in Petri dishes. The day following, March 16, 1917, most of the adults emerged. An idea may be had of the habits of the insect during and after emergence from the following notes:

1.40 p. m.—A circular flap gradually separated from the apex of one of the galls, leaving a small part at the circumference attached to the gall. An adult midge, exposed from the pupal exuviae to about the metathorax, wriggled its way out through the opening until about one-third the length of the exuviae was exposed. The midge continued to wriggle, this time gradually withdrawing itself from the exuviae.

1.57 p. m.—Legs completely exposed. With the legs anchored against the outer wall of the gall, the midge continued to struggle with a forward and backward motion, carrying the pupal exuviae until about two-thirds the total length of the latter were exposed. Finally, with a sudden jerk, the insect completed its emergence.

1.58 p. m.—Wings fully expanded.

2.17 p. m.—Midge able to fly.

*Summary.*—The midge emerged seventeen minutes after the separation of the lid from the gall was first noted; the wings were fully expanded after another minute; and the insect was able to fly nineteen minutes later.

The galls are apparently scarce, as subsequent excursions resulted in the finding of only one or two isolated specimens.

*Antidesma leptocladum* Tul. Euphorbiaceæ.

Leaf galls caused by *Ctenodactylomyia antidesmæ* Felt.

Monothalamous; very acutely subconical; red; sometimes basally or wholly concolorous with the leaf; thickly but very briefly pubescent. Apex slightly curved toward one side; very acute. Wall thin; inner layer woody, faintly greenish white; outer, suffrutescent. Chamber following the general shape of the gall. Opening basal; situated at opposite surface of leaf; subcircular, with a close-fitting flap, detachable through the force of the emerging midge.

Length, 8.5 to 10.5 millimeters; diameter at base, 1.5 to 1.75.

## GALLS CAUSED BY PSYLLIDÆ

*Alstonia scholaris* R. Br. Apocynaceæ.

Leaf galls<sup>14</sup> caused by *Pauropsylla tuberculata* Crawford.

Monothalamous; subcylindrical; concolorous with leaf, except at apex, yellowish; nonpubescent. Apex somewhat deeply cleft. Wall thick; succulent. Chamber subcuneate, with the sharp edge pointing distad; direction the same as the median depression at cleft of apex. Opening apical; subcircular; without process; not visible until the adult psyllids are ready to emerge. On the opposite surface of the leaf, a short, conical protuberance with apex broadly rounded.

Average length, 4 millimeters; broader diameter at apex, 3; narrower, 2.5; broader diameter at base, 3.75; narrower, 3.

On either surface of the leaf; more commonly on nether surface.

LUZON, Laguna, College of Agriculture, Los Baños, at an altitude of about 50 meters. May, 1917. Gall No. 18322, College of Agriculture collection.

These galls are abundant but the adult insects are somewhat difficult to rear on account of the tendency of the leaves to dry in a couple of days after removal from the tree. The causal psyllid was first described from Pusa, Bengal, and reported as captured on *Alstonia* and also on "pumpkin."<sup>15</sup> The insect has never been recorded from the Philippines before.

*Calophyllum inophyllum* L. Guttiferæ.

Leaf galls. Adult psyllids collected but not identified.

One or both margins of leaf, except at apex and base, narrowly doubled up inferiorly, the fold forming the chamber wherein the insect passes its preimaginal stages. Older leaves more deeply concave longitudinally; a slight yellowing at different places on the folds.

Average diameter of fold, 2.5 millimeters.

LUZON, Laguna, School of Forestry, Los Baños, at an altitude of about 100 meters. March, 1918. Type gall No. 18348, College of Agriculture collection.

<sup>14</sup> Previously described by Rübsaamen from Bismarek Archipelago in Marcellia 4 (1905) 7. Also described and figured by Leeuwen-Reijnvaan from Java in Marcellia 9 (1910) 38. Figured by Leeuwen-Reijnvaan in Bull. Jard. Bot. Buitenzorg, II 3 (1912) 4. Described by Leeuwen-Reijnvaan from Celebes, Bull. Jard. Bot. Buitenzorg II 21 (1916) 24.

<sup>15</sup> Crawford, Indian Psyllidæ, *Rec. Ind. Mus.* 7 (1912) 430.

Galls common in the place cited; not found on the same plant elsewhere in Los Baños. Adults found only on March 11, 1918, after about one year's occasional observation on the nymphs within the galls.

*Ficus nervosa* Heyne. Moraceæ.

Leaf galls caused by *Dinopsylla cornuta* Crawford.

Fresh galls of these insects have never been obtained by me. A single infested leaf that had fallen from the tree was found; but the galls were too badly mutilated and shriveled up to furnish adequate material for description. Prof. C. F. Baker had previously bred this *Dinopsylla* from the same galls, and is my authority for the identity of the insect and its work. *Ficus nervosa* Hey. is fairly common in Mount Maquiling, at altitudes of 100 to 150 meters.

*Ficus ulmifolia* Lam. Moraceæ.

Leaf galls No. 1, caused by *Pauropsylla deflexa* sp. nov. (MS).

Monothalamous; very abruptly and irregularly subconical; lettuce green, lighter in color than leaf; pubescent, more thickly so than leaf. Apex usually obtuse; sometimes abruptly pointed. Bottom, at opposite side of leaf, subhemispherical; concolorous with and equally as pubescent as the rest of the gall. Chamber elongately subellipsoid; lining smooth. Wall thick; succulent. Opening apical; not visible until adults are ready to emerge; then wall splits open longitudinally from apex subbasad into several irregular lobes; each lobe deflected ectad.

Average length, 6 millimeters; diameter, 5; length of chamber, 3.5; diameter, 1.25.

Subconical portion on nether surface of leaf; subhemispherical, on upper surface. Usually aggregate and fused together, giving appearance of polythalamous galls.

LUZON, Laguna, College of Agriculture, Los Baños, at an altitude of about 42 meters. January, 1917. Type gall No. 18309, College of Agriculture collection.

These galls are very common, but the adults are very difficult to breed. The leaves dry in less than half a day after removal from the tree. Numerous adult psyllids emerged from galls on a small *Ficus* tree in the nursery of the college, and were collected from the young shoots, up which the insects had crawled to feed.

*Ficus ulmifolia* Lam. var. Moraceæ.

Leaf galls No. 2. Adult psyllids not found.

Monothalamous; subconical; slightly curved subapicad toward one side; orange to red. Surface scabrous; nonpubescent; somewhat shiny. Wall moderately thick; succulent. Chamber conforming with the general shape of the gall; a tiny raised tubercle centrad at bottom.

Average length, 7.5 millimeters; diameter at base, 4.

On the upper surface of the leaf; usually solitary; occasionally aggregate, but only partially fused together and the individual galls are distinguishable.

LUZON, Mount Maquiling, at an altitude of 150 meters. March 16, 1918. Type gall No. 18401, College of Agriculture collection.

Apparently rare.

*Ficus variegata* Blume. Moraceæ.

Leaf galls caused by *Pauropsylla montana* sp. nov. (MS).

Monothalamous; subspherical; paler green than leaf; covered all over with long, succulent, slightly pubescent spines. A tiny, abrupt, acutely subconical projection centrad at bottom of gall on opposite surface of leaf. Wall thin; succulent. Chamber subspherical; abruptly produced obconically at bottom. Opening apical; not visible until adult is ready to emerge; then wall splits from apex longitudinally subbasad into usually five irregular lobes; each lobe deflected ectad.

Average diameter, 5 millimeters.

On the upper surface of the leaf; numerous; sometimes connivent, but never fused.

LUZON, Laguna, Los Baños Falls, near Los Baños, at an altitude of about 50 meters; Mount Maquiling, at altitudes of 70 to 150 meters. January, 1917. Type gall No. 18310, College of Agriculture collection.

Galls fairly common; insects easy to breed.

*Mallotus philippensis* (Lam.) Muell.-Arg. Euphorbiaceæ.

Leaf galls caused by *Megatrioza pallida* sp. nov. (MS).

Shallow, concave depressions on nether surface of leaf, with the upper surface correspondingly convex. No abnormal growth of hair. Apex on concave surface yellowish to reddish brown; the rest unicolorous with leaf. Nymph fits in snugly on concave surface, the insect establishing itself there until ready to emerge.

Average diameter, 2 millimeters; average depth of concavity, 0.5.

LUZON, Laguna, College of Agriculture, Los Baños, at an altitude of about 45 meters. January, 1918. Type gall No. 18174, College of Agriculture collection.

Galls very common; insects observed in the adult stage only in January.

GALLS CAUSED BY THYSANOPTERA

*Dillenia reifferscheidia* F.-Vill. Dilleniaceæ.

Leaf galls. Causal thrips collected but not identified.

Leaf margins wholly or partially involute toward nether surface of leaf; when partially so, the involution usually extends from apex, leaving a basal fraction of the leaf unaffected. Minute, red, irregular, hard papules more prominent on upper surface or at the continuation of the latter in the roll than on nether surface. Thrips in different stages found within the rolls of younger leaves.

Average diameter of roll, 8 millimeters.

LUZON, Laguna, College of Agriculture, lower nursery, Los Baños, at an altitude of about 43 meters. October, 1917. Type gall No. 18158, College of Agriculture collection.

These galls are apparently confined to a single isolated tree at the bank of Molauin Creek in the place cited. None of these materials was found elsewhere.

*Ficus ulmifolia* Lam. Moraceæ.

Leaf galls caused by *Gigantothrips elegans* Zimmerman.<sup>16</sup>

Part of leaf margin involuted or deflected. Small, irregular, reddish dots, bounded by irregular, yellow areas, visible on both surfaces. Insects found on nether surface of leaf.

LUZON, Laguna, College of Agriculture, Los Baños, at altitudes of 45 to 100 meters. January, 1918. Gall No. 18403, College of Agriculture collection.

These galls are abundant during the greater part of the year.

*Garcinia venulosa* (Blanco) Choisy. Guttiferæ.

Leaf galls. Thrips collected but not identified.

Open; a carinate structure formed by the superior involution of a part of submarginal portion of leaf; paler green than leaf;

<sup>16</sup> The insect has been reported from Java as making similar galls on the leaves of various other species of *Ficus*. See Leeuwen-Reijnvaan, *Beitrage zur Kenntniss der Gallen von Java*, Pt. V, *Bull. Jard. Bot. Buitenzorg* II 10 (1913).

gall surface until shortly before emergence of adult. A thin, whitish, membranous secondary flap near base of neck. Opening subcircular; at one end of gall.

Length of gall, 11.5 millimeters; thickness, 5.75; breadth, 4.5; length of chamber, including neck, 9.25; diameter at broadest point, 2.5.

On upper surface of leaf; numerous.

LUZON, Laguna, Los Baños Falls, near Los Baños, at an altitude of about 50 meters (*Baker and Uichanco*); Mount Maquiling, at an altitude of about 150 meters. January, 1917. Type gall No. 18308, College of Agriculture collection.

Fairly common; but adults difficult to breed.

#### ERIOPHYID AND MISCELLANEOUS GALLS

The part of this treatise, involving galls caused by Eriophyidæ, is withdrawn for a later paper. Likewise, all other galls of which the insects have not been found are omitted here in the hope that further work on additional fresh materials, which are constantly coming in, may furnish some clue to the identity of the causative agents.

#### ACKNOWLEDGMENTS

I wish to express my hearty appreciation of the valuable assistance given me by Prof. Charles Fuller Baker, acting dean of the College of Agriculture, and Prof. Charles S. Banks, chief of the department of entomology, under whose joint direction the work was conducted. The work was begun under Professor Baker while Professor Banks was in America. I am also under great obligation to Prof. F. W. Foxworthy and Messrs. Calixto Mabesa and Nemesio Catalan, of the department of dendrology (forest botany), School of Forestry, for identification of most of the botanical material and for their kindly coöperation; to Prof. E. D. Merrill, botanist of the Bureau of Science, for identification of some botanical specimens; to Dr. E. P. Felt, state entomologist, Albany, New York, U. S. A., for determination of gall midges collected from my galls; and to Dr. W. Docters van Leeuwen-Reijvaan of Bandoeng, Java, for having very kindly furnished me with an almost complete set of his important papers on Dutch East Indian galls.

## ILLUSTRATIONS

### PLATE I

- FIG. 1. *Acalypha stipulacea* Klotz. Leaf gall caused by *Schizomyia acalyphæ*. Longitudinal median section.  $\times 5$ .  
 2. *Barringtonia luzonensis* Rolfe. Leaf gall caused by *Kronodiplosis wichancoi* Felt. Longitudinal median section.  $\times 8$ .  
 3. *Antidesma leptocladum* Tul. Leaf gall caused by *Ctenodactylomyia antidesmæ* Felt. Longitudinal median section.  $\times 5$ .  
 4. *Callicarpa erioclona* Schauer. Leaf gall caused by *Asphondylia callicarpæ* Felt. Longitudinal median section.  $\times 2.5$ .  
 5. *Cissus trifolia* (L.) K. Sch. Stem gall caused by *Asphondylia vitea* Felt. Longitudinal median section.  $\times 2$ .  
 6. *Cissus adnata* Wall. var. Leaf gall caused by *Hyperdiplosis banksi* Felt. Longitudinal median section.  $\times 5$ .  
 7. The gall shown in fig. 6. Cross section near the base.  $\times 5$ .

### PLATE II

- FIG. 1. *Pæderia tomentosa* Blume. Leaf gall caused by *Itonida pæderiæ* Felt. Cross section.  $\times 7.5$ .  
 2. *Parashorea plicata* Brandis. Leaf gall probably caused by *Tricontarinia luzonensis* Felt. Longitudinal median section.  $\times 7.5$ .  
 3. *Leca manillensis* Walp. Leaf gall caused by *Lasioptera manillensis* Felt. Longitudinal median section.  $\times 6$ .  
 4. *Diplodiscus paniculatus* Turcz. Terminal stem gall caused by *Schizomyia diplodisci* Felt. Longitudinal median section.  $\times 2$ .  
 5. The gall shown in fig. 4. Cross section.  $\times 2$ .  
 6. The gall shown in fig. 1. Longitudinal median section.  $\times 3$ .

### PLATE III

- FIG. 1. *Symphorema luzonicum* F.-Vill. Leaf gall caused by *Luzonomyia symphoremæ* Felt. Distal aspect, with lid removed to show opening.  $\times 22.5$ .  
 2. The gall shown in fig. 1. Longitudinal median section.  $\times 22.5$ .  
 3. The gall shown in fig. 1. Lid, ectal aspect.  $\times 22.5$ .  
 4. The gall shown in fig. 1. Lid, ental aspect.  $\times 22.5$ .

### PLATE IV

- FIG. 1. *Spatholobus gyrocarpus* (Wall.) Benth. Leaf gall caused by *Helioidiplosis spatholobi* Felt. Longitudinal median section.  $\times 20$ .  
 2. *Glochidion album* (Blanco) Boerl. Leaf gall. Longitudinal median section.  $\times 5$ .  
 3. The gall shown in Plate VI, fig. 3. Cross section.  $\times 20$ .  
 4. *Vernonia lancifolia* Merr. Leaf gall caused by *Diceromyia vernoniæ* Felt. Longitudinal median section.  $\times 2$ .  
 5. *Mallotus moluccana* (L.) Muell.-Arg. Leaf gall. Longitudinal median section.  $\times 5$ .  
 6. *Siphonodon celastrineus* Griff. Leaf gall caused by *Kamptodiplosis reducta* Felt. Longitudinal median section.  $\times 20$ .

## PLATE V

- FIG. 1. *Alstonia scholaris* R. Br. Leaf gall caused by *Pauropsylla tuberculata* Crawford. Longitudinal median section in the direction of the apical cleft.  $\times 20$ .
2. The gall shown in fig. 1. Section across the apical cleft.  $\times 20$ .
3. *Mallotus philippensis* (Lam.) Muell.-Arg. Leaf gall caused by *Megatrioza pallida* sp. nov. (MS). Longitudinal median section.  $\times 20$ .

## PLATE VI

- FIG. 1. *Ficus ulmifolia* Lam. Leaf gall caused by *Pauropsylla deflexa* sp. nov. (MS). Longitudinal median section.  $\times 5$ .
2. *Ficus variegata* Blume. Leaf gall caused by *Pauropsylla montana* sp. nov. (MS). Open, after emergence of adult. Distal aspect.  $\times 5$ .
3. *Schefflera odorata* (Blanco) Merr. and Rolfe. Leaf gall caused by *Gynaikothrips chavicae* var. *heptapleuri* Karny. Longitudinal median section.  $\times 5$ .
4. The gall shown in fig. 2. Spine from exterior wall.  $\times 130$ .
5. The gall shown in fig. 2. Longitudinal median section.  $\times 7.5$ .
6. *Dillenia reifferscheidia* F.-Vill. Leaf gall. Section across leaf.  $\times 7.5$ .

## PLATE VII

- FIG. 1. Old galls of the species illustrated in fig. 3, showing openings through which the adults escaped. View from nether surface of leaf.  $\times 1.5$ .
2. *Grewia stylocarpa* Warb. Leaf galls caused by *Asphondylia greviae* Felt. View from upper surface of the leaf.  $\times 1$ .
3. *Barringtonia luzonensis* Rolfe. Young or nearly mature, unopened leaf galls, caused by *Kronodiplosis uichancoi* Felt. View from nether surface of leaf.  $\times 1.5$ .
4. *Parashorea plicata* Brandis. Leaf galls, probably caused by *Tricontarinia luzonensis* Felt. View from nether surface of leaf.  $\times 1.5$ .

## PLATE VIII

- FIG. 1. *Diplodiscus paniculatus* Turcz. Terminal stem gall caused by *Schizomyia diplodisci* Felt. Nearly mature specimen, without crevice.  $\times 1.5$ .
2. The gall shown in fig. 1. Old specimen, showing crevice through which adults escaped.  $\times 1.5$ .
3. *Acalypha stipulacea* Klotz. Leaf galls caused by *Schizomyia acalyphae* Felt. View from nether surface of leaf.  $\times 1.5$ .
4. *Cissus trifolia* (L.) K. Sch. Stem gall caused by *Asphondylia vitea* Felt. Type 1.  $\times 1.5$ .
5. *Pæderia tomentosa* Blume. Leaf gall caused by *Itonida pæderiae* Felt. Lateral view.  $\times 1.5$ .
6. The gall shown in fig. 4. Type 2.  $\times 1.5$ .
7. *Cissus adnata* Wall. var. Leaf galls caused by *Hyperdiplosis banksi* Felt. View from nether surface of leaf.  $\times 1$ .



## PLATE IX

- FIG. 1. *Leca manillensis* Walp. Leaf galls caused by *Lasioptera manillensis* Felt. Superior lobes on upper surface of leaf.  $\times 1.5$ .
2. The gall shown in fig. 1. Inferior lobes on nether surface of leaf.  $\times 1.5$ .
3. The gall shown in Plate X, fig. 1. View from nether surface of leaf.  $\times 1.5$ .
4. *Antidesma leptocladum* Tul. Leaf galls caused by *Ctenodactylomyia antidesmæ* Felt. View from upper surface of leaf.  $\times 1.5$ .
5. *Symphorema luzonicum* F.-Vill. Leaf galls caused by *Luzonomyia symphoremæ* Felt. Young or nearly mature, unopened specimens. View from nether surface of leaf.  $\times 1.5$ .
6. The gall shown in fig. 5. View from upper surface of leaf, showing depressions formed by galls at opposite surface.  $\times 1.5$ .
7. The gall shown in fig. 5. Old specimens, showing circular openings distad, through which the adults escaped. View from nether surface of leaf.  $\times 1.5$ .

## PLATE X

- FIG. 1. *Spatholobus gyrocarpus* (Wall.) Benth. Leaf galls caused by *Heliodiplosis spatholobi* Felt. View from upper surface of leaf.  $\times 1.5$ .
2. *Callicarpa erioclona* Schauer. Leaf gall caused by *Asphondylia callicarpæ* Felt. Superior aspect.  $\times 1.5$ .
3. *Vernonia lancifolia* Merr. Leaf galls caused by *Dicromyia vernoniæ* Felt.  $\times 1.5$ .
4. The gall shown in fig. 3. Longitudinal median section, showing larval chambers.  $\times 1$ .

## PLATE XI

- FIG. 1. *Mallotus moluccana* (L.) Muell.-Arg. Leaf galls. Type 1, with acute apices. View from nether surface of leaf.  $\times 1$ .
2. The gall shown in fig. 1. Type 2, with obtuse apices.  $\times 1.5$ .
3. The gall shown in fig. 1. View from upper surface of leaf, showing long, slender projections at bottom of galls.  $\times 1.5$ .
4. *Siphonodon celastrineus* Griff. Leaf galls caused by *Kamptodiplosis reducta* Felt. View from upper surface of leaf.  $\times 1.5$ .

## PLATE XII

- FIG. 1. *Ficus ulmifolia* Lam. Leaf galls, No. 1, caused by *Pauropsylla deflexa* sp. nov. (MS). Old specimens, showing openings through which the adults escaped. View from nether surface of leaf.  $\times 1.5$ .
2. *Alstonia scholaris* R. Br. Leaf galls caused by *Pauropsylla tuberculata* Crawford. View from upper surface of leaf, showing bottoms of galls.  $\times 1.5$ .
3. The galls shown in fig. 2. View from nether surface of leaf.  $\times 1.5$ .
4. *Ficus ulmifolia* Lam. Leaf galls No. 2. Young or nearly mature galls. View from upper surface of leaf.  $\times 1.5$ .

5. The galls shown in fig. 1. Superior lobes on upper surface of leaf.  $\times 1.5$ .
6. The galls shown in fig. 1. Inferior lobes on nether surface of leaf.  $\times 1.5$ .

## PLATE XIII

- FIG. 1. *Ficus variegata* Blume. Leaf galls caused by *Pauropsylla montana* sp. nov. (MS). Closed, before emergence of adults; open, after emergence. View from upper surface of leaf.  $\times 1$ .
2. *Mallotus philippensis* (Lam.) Muell.-Arg. Leaf galls caused by *Megatrioza pallida* sp. nov. (MS). View from upper surface of leaf.  $\times 1.5$ .
  3. The galls shown in fig. 2. View from nether surface of leaf.  $\times 1.5$ .
  4. *Calophyllum inophyllum* Linn. Marginal leaf gall. View from nether surface of leaf.  $\times 1.5$ .

## PLATE XIV

- FIG. 1. *Dillenia reifferscheidia* F.-Vill. Leaf galls. View from nether surface of leaf. The seven subhemispherical, white bodies along the midrib of the leaf are coccids, which have been accidentally introduced in the picture. They have absolutely nothing to do with the formation of the galls.  $\times 1.5$ .
2. *Mallotus philippensis* (Lam.) Muell.-Arg. Leaf galls caused by *Neoheegeria mendax* Karny.  $\times 1.5$ .
  3. *Ficus ulnifolia* Lam. Leaf galls caused by *Gigantothrips elegans* Zimmerman. Lateral view.  $\times 1.5$ .
  4. *Garcinia venulosa* Lam. Leaf galls. View from upper surface of leaf.  $\times 1.5$ .

## PLATE XV

- FIG. 1. *Glochidion album* (Blanco) Merr. Leaf galls caused by Gelechiidæ. View from nether surface of leaf.  $\times 1$ .
2. The gall shown in fig. 1. View from upper surface of leaf.  $\times 1$ .
  3. *Raphidophora perkinsæ* Engl. Leaf galls. Proximal portion of leaf.  $\times 1.5$ .
  4. The gall shown in fig. 3. Distal portion of leaf.  $\times 1.5$ .
  5. *Schefflera odorata* (Blanco) Merr. and Rolfe. Leaf galls caused by *Gynaikothrips chavicæ* var. *heptapleuri* Karny. View from upper surface of leaf.  $\times 1.5$ .
  6. The galls shown in fig. 5. View from nether surface of leaf, showing openings of the galls.  $\times 1.5$ .
  7. *Piper loheri* C. DC. Leaf galls caused by *Gynaikothrips chavicæ* Zimmerman. View from upper surface of leaf; nether surface of leaf exposed at rolled-up margin.  $\times 1.5$ .

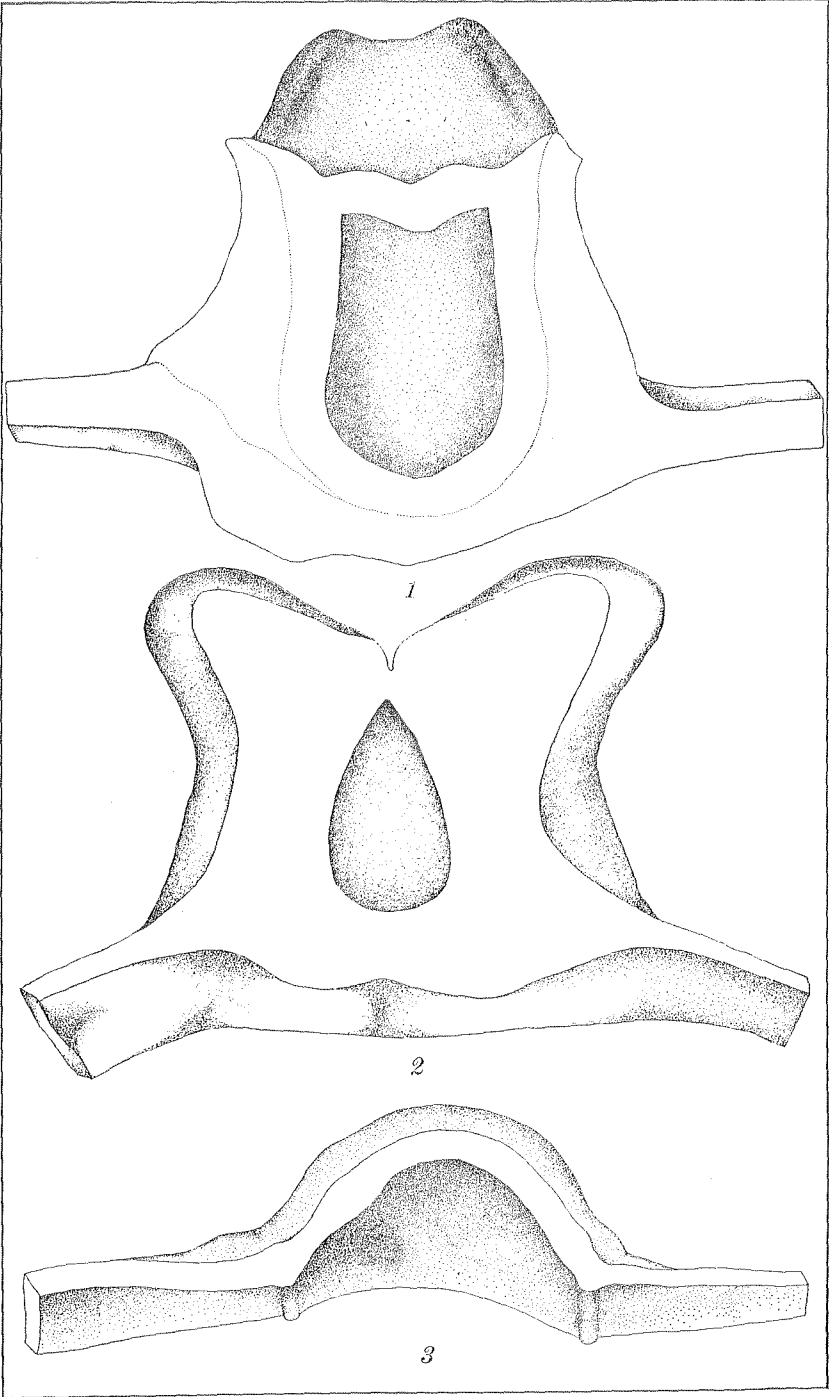


PLATE V. PLANT GALLS.

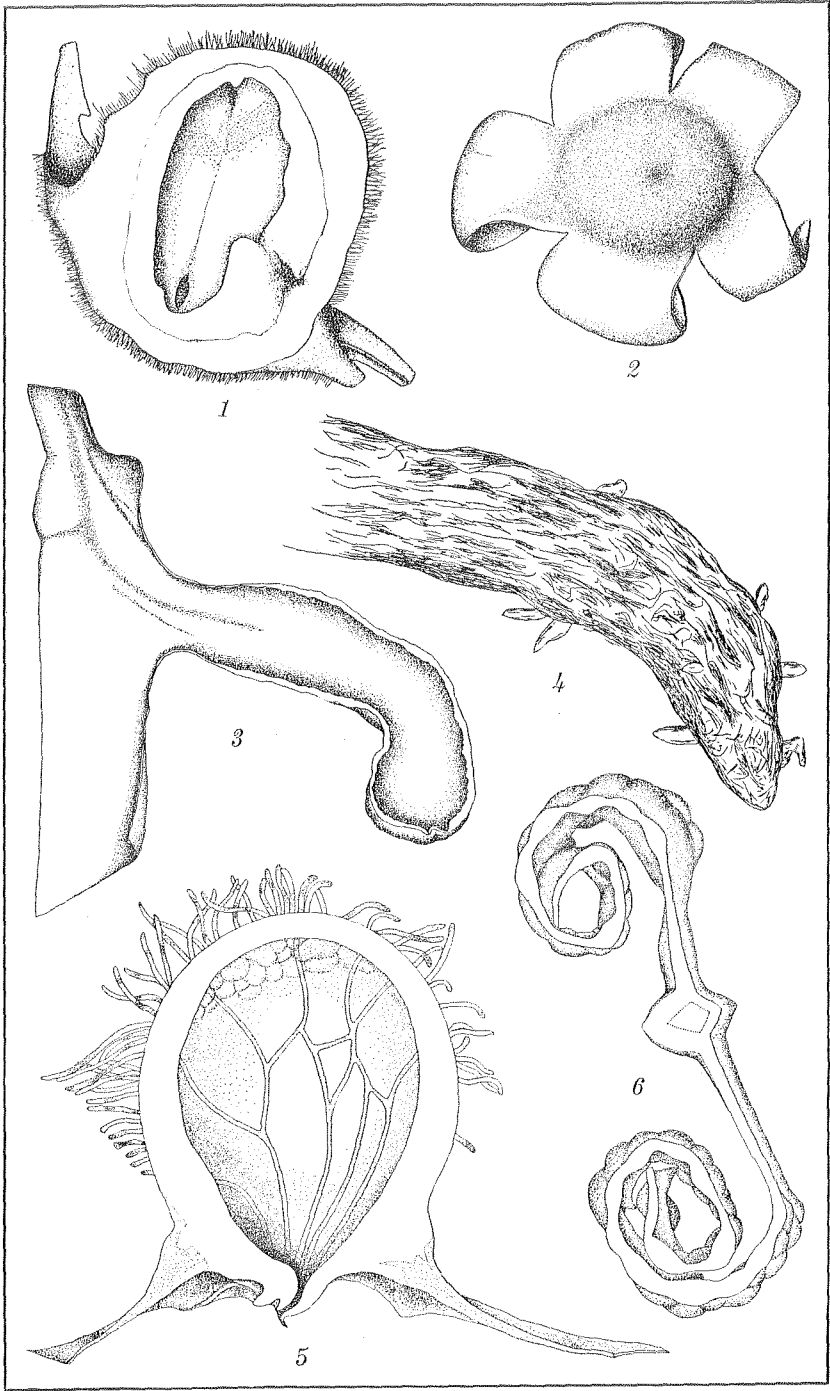


PLATE VI. PLANT GALLS.

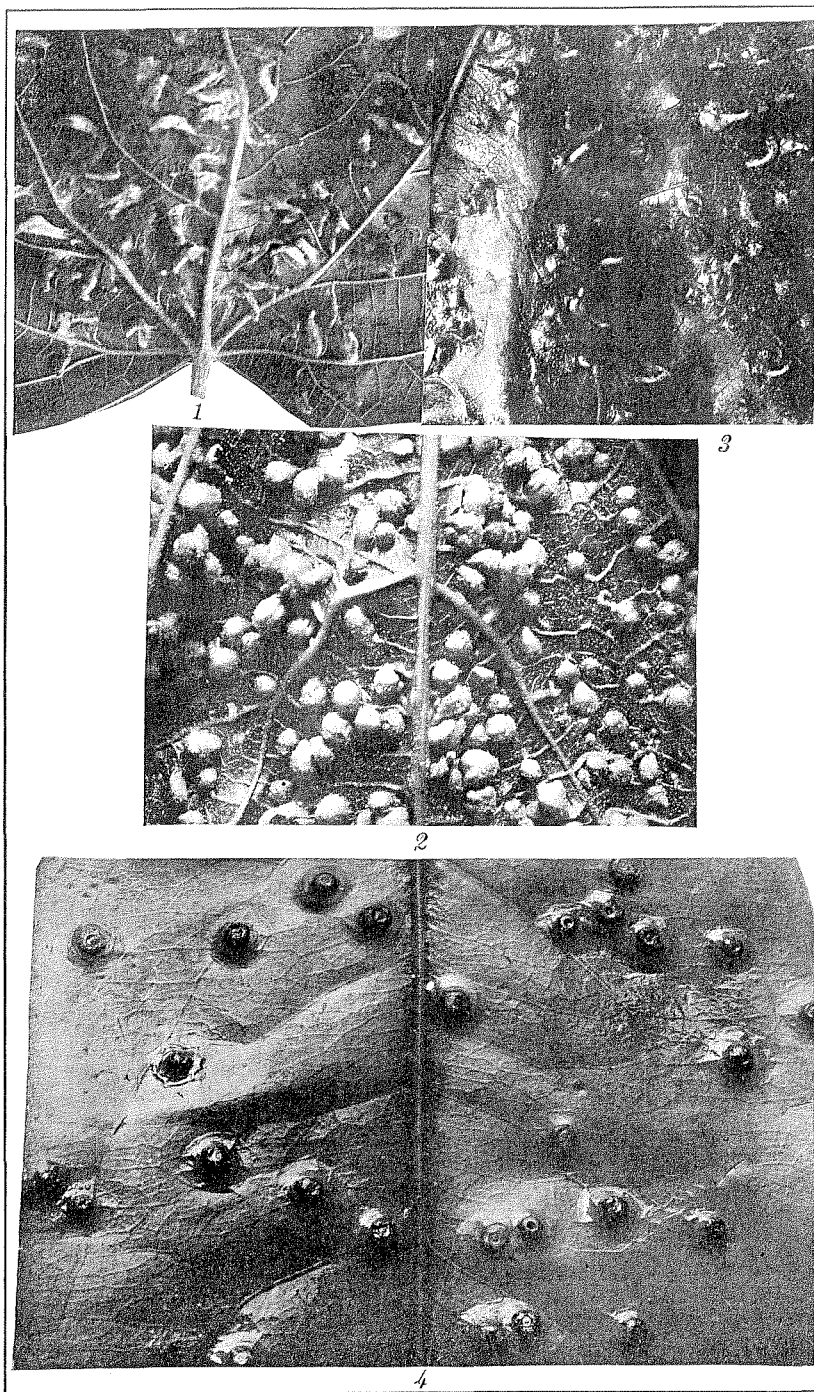


PLATE XI. PLANT GALLS.

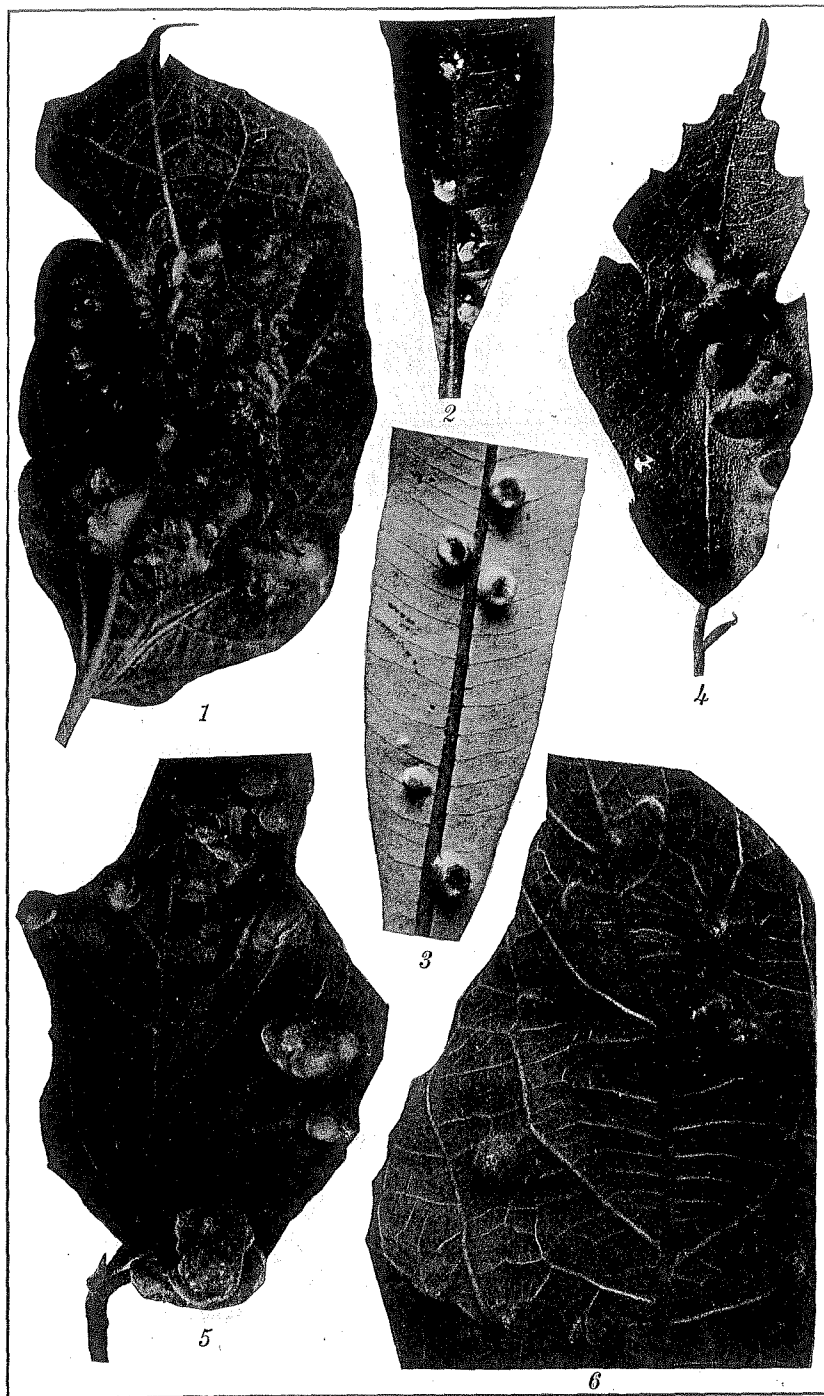


PLATE XII. PLANT GALLS.



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VOL. XIV, No. 5

MAY, 1919

# THE PHILIPPINE JOURNAL OF SCIENCE



MANILA  
BUREAU OF PRINTING  
1919



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The Philippine Journal of Science is issued twelve times a year. The sections were discontinued with the completion of Volume XIII (1918).

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