INSECT GALLS AND GALL INSECTS.

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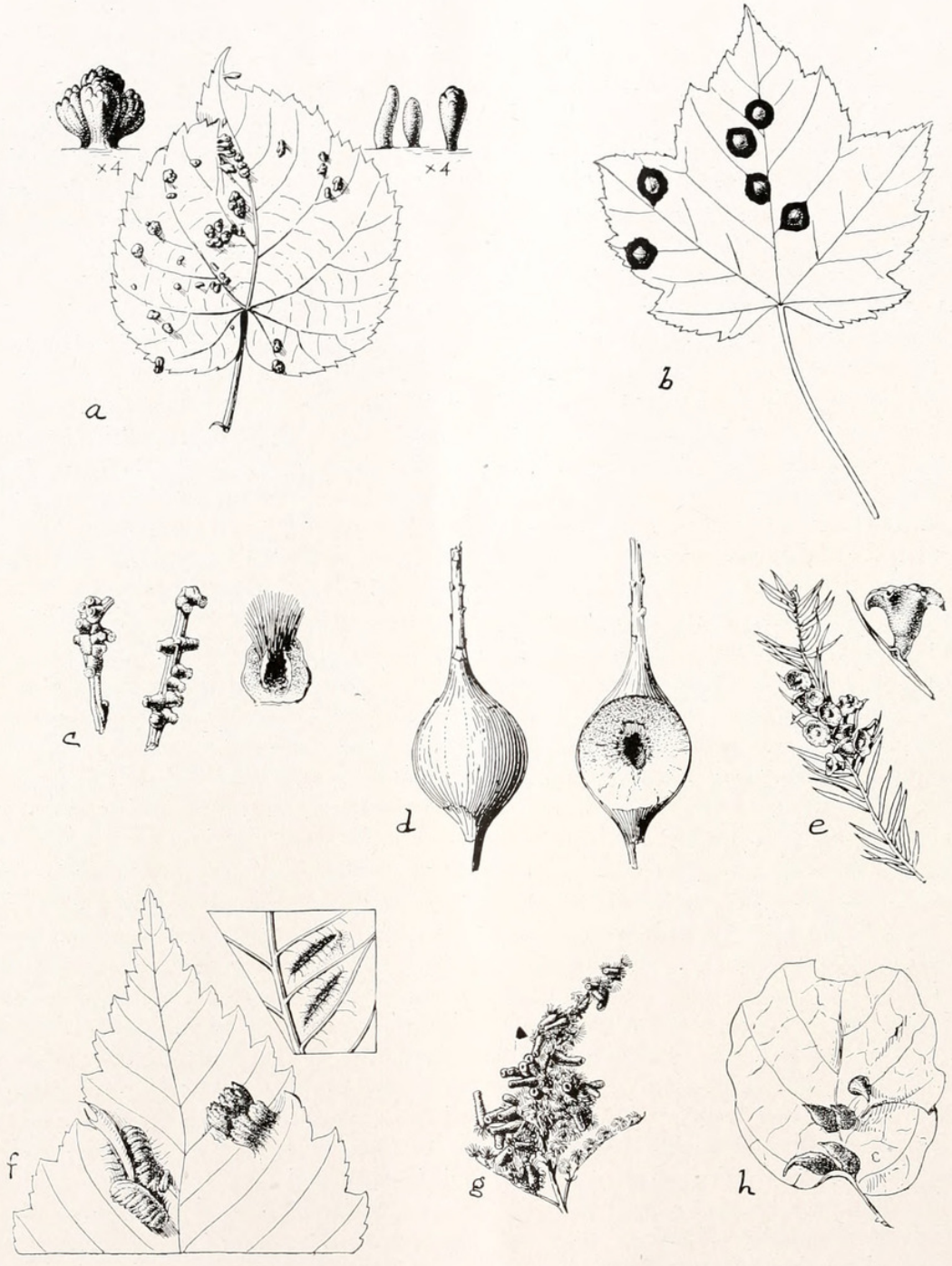
Insect or plant galls are the obvious and manifold deformities found upon all parts of a great variety of plants and usually given only a passing thought. Gall insects are the inhabitants of these insect or plant galls and, like the deformities themselves, are myriad in number, variety and structure. Insect galls are easily studied, since they are to be found at all seasons of the year and are readily located and preserved. Conversely, while gall insects exist throughout the year and in various stages, practically, it is difficult to obtain them except after some knowledge of their habits and the conditions which are necessary to complete their changes or transformations. Many issue direct from their galls and are easily reared, others enter the soil for the final transformations and are difficult to rear.

The oak apples are moderately common plant galls, occasionally being so numerous as to occur by the hundreds upon favoured trees. They are spherical, an inch or so in diameter, depend from leaves or twigs and are easily crushed. These curious developments are comparatively well known, though the little four-winged gall wasps issuing therefrom are very rarely seen by other than the professional entomologist. It is not so generally realized that there are over 350 different galls produced by various gall wasps upon our oaks and moreover that considerable series of these insects exist in two very different forms, namely, a perfect or complete generation, represented by males and females and usually appearing in midsummer or when warm weather is very favourable to insect activities, and the imperfect or incomplete generation, represented only by females, which issues from a very different gall, usually in early spring at a time when cool, inclement weather seriously restricts insect activities. This remarkable difference between parent and offspring is known as alternation of generations and may be summarized by the statement that it means dissimilar children and similar grandchildren. The great difference obtaining between the two generations is illustrated by a British oak apple which develops on the tips of the twigs and produces four-winged gall flies, whereas the alternate generation issues from masses of somewhat fig-shaped root galls and is wingless. In other words, the wingless insects issuing from root galls climb the trees to the tips of the twigs and those developing in galls at the tips of the twigs, although provided with wings, descend to the ground and make their way to rootlets before they deposit eggs. It is an interesting migration from one extremity of the tree to the other. The peculiar relationship existing between many of the oak galls has been worked out for the European gall wasps, though as yet little is known concerning our very numerous American forms. It is not so very difficult to ascertain this, since it is only necessary to collect the mature galls, keep them under approximately normal conditions in a jar or other cage and when the flies appear give them a chance to follow their instincts under as nearly natural conditions as possible, or better still, if small oaks be in the vicinity, watch the behaviour of the gall wasps as they issue in the open, using those in the cage to indicate the time when observations can be made to the best advantage. Naturalists with nearby scrub oaks have an almost ideal outdoor laboratory for such work.

There appear to be more special adaptations among gall making insects than are found in most other groups, though it should be remembered that the gall makers are by no means a natural group, since representatives of several dissimilar orders of insects have acquired this habit. The alternation of generations in the gall wasps is closely paralleled by what is found in certain plant lice, except that with these we have an alternation of indeterminate series of generations, their extent being determined largely by seasonal conditions and the vitality of the food plant. Moreover, in this group, the alternate series of generations are very likely to develop upon such dissimilar plants as birch and witch hazel. Certain species of gall midges have a very similar development except that there is an indeterminate series of generations remarkable in that maggots continue to produce maggots (that is pupæ and adults are eliminated) and then eventually a generation continues its development to the perfect flies and these latter behave as other insects. The reason for this remarkable deviation from the normal appears to be due to the fact that these maggots subsist upon decaying wood and develop in places where neither flies nor parasites can penetrate readily, consequently a series of maggot generations gives an advantage which would not obtain if the insects were compelled to transform to flies and emerge in the open from generation to generation.

Insect galls, as intimated above, are simply abnormal developments of plant tissues. A little study of these deformities reveals surprising modifications. There is the comparatively simple swelling of catkin, leaf, leaf stalk, twig or root containing



DIFFERENT TYPES OF GALLS: A. Linden mite gall, sometimes very abundant on basswood leaves, note the varied forms. The interior is inhabited by microscopic plant mites. B. Maple spot gall, a yellowish-red margined gall, very common on soft maple; at the centre there is an almost transparent maggot. C. Bud gall on the western rayless goldenrod, note the protecting brush of plant hairs shown in the enlarged section. D. Goldenrod ball gall, very common, each inhabited by a large stout yellowish-white maggot. E. Cypress flower gall, a peculiar whitish flower-shaped growth sometimes very abundant on the twigs. F. Cockscomb elm gall, a deformity produced by a plant louse and occasionally very abundant on small trees, the slit-like entrance on the under surface of the leaf is shown in the upper right-hand figure. G. Downy flower gall, sometimes very abundant on goldenrod. H. Witch hazel cone gall, a greenish or reddish gall, sometimes very abundant and produced by a plant louse.—(Author's illustrations, Scientific Monthly.)

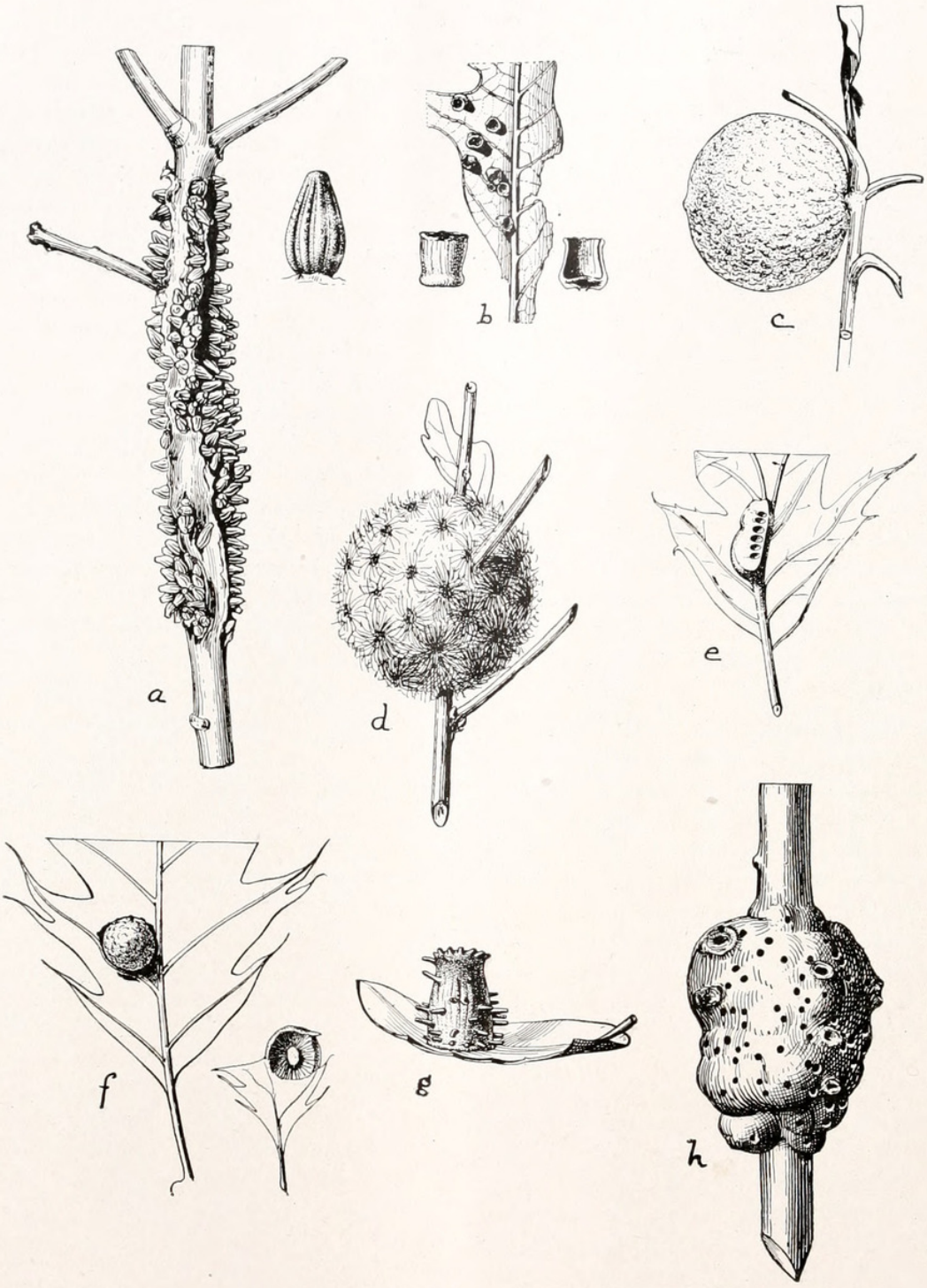
one or more maggots, each in a small oval cavity or cell. Many of these deformities have the surface clothed with wool-like hairs, really modified and greatly developed plant hairs. This is carried to an extreme in the spherical masses of delicate, creamy-white hairs with pink spots caused by the wool sower. This mass, beautiful because of its wonderfully delicate tints and deceptively heavy, is really nothing but many deformed buds, each cell containing a maggot and united to those around by the greatly developed plant hairs. Some of the leaf galls, aside from the distinctly wooly ones, present extremely interesting modifications in that the plant hairs are modified to form more or less well developed spines, as for example in the yellow sea urchin and some of its allies, with their peculiar ornamentations and often striking coloration. A few galls show this development to an even more striking degree and are variously and sometimes grotesquely angled or spined. There is an apparently uninteresting succulent oak gall which is very deceptive since it is hollow and most remarkable of all the cavity contains a free rolling oval cell in which the gall maker is securely ensconced. It is literally a "high roller".

Nature delights in camouflage or mimicry. The cypress flower gall is a striking instance of this tendency to simulate even in places where nothing of the kind would be expected. The pretty little gall with its delicate tints, suggests for all the world one of the smaller flowers, despite the fact that it occurs upon cypress, a tree which produces no such flowers as are found among the other plants. This deformity is produced by a little gall midge and occasionally is so very abundant as to fairly dot good sized limbs with its pleasing combination of colour and form.

The relation of the gall insect to the plant upon which it subsists is worthy of careful consideration. The gall insects are fragile, minute and in many cases with restricted powers of flight, some even being wingless. Nevertheless, hosts of species manage to exist in the face of these limitations and in some cases it is known that a colony may remain year after year for a considerable series of years upon one or two relatively isolated bushes. A very considerable proportion of these gall insects must attack some part of the plant when it is growing rapidly, and usually in early spring when the tender tissues are literally rolling out of the buds and are in a most plastic condition. It is very probable that a considerable series of globular or variously shaped galls on the surface of leaves originate when the foliage is still in the bud. The wide scattering of some of these growths is simply due to the expanding tissues after the young gall insect has established itself upon the developing leaf. But infestation is characteristic of a considerable series of gall midges, notably the peculiar forms producing variously shaped galls upon the surface of both hickory and oak leaves and as mentioned earlier, it is also true of a considerable series of the gall wasps. Were we to search carefully for an explanation of the peculiar alternation of generations mentioned above, we would probably decide that the appearance of this early spring, incomplete generation justified itself not only because all of the individuals were able to deposit eggs, but also on account of the fact that these eggs were deposited in the buds and therefore the young could develop under the best possible condition, due to the soft, plastic state of the leaves and catkins. In other words, alternation of generations is a modification which has enabled gall wasps to maintain themselves in large numbers, and an additional reason for believing this is seen in the fact that species presenting this marked deviation from what we usually find among gall insects are extremely abundant. It is one of the most striking of the numerous interrelationships occurring between insects and plants.

The mysterious and enchanting adaptations of gall insects are by no means completed with the above recital. Some of our plant lice exhibit equally interesting relationships. The galls of these insects are invariably recognized by the more or less distinct orifice and then there is usually a considerable cavity inhabited sometimes by one insect, frequently by more and occasionally the aphids are so numerous as to completely cover the entire interior so that a gall, when opened at this time, presents a striking resemblance in miniature to the geode. How is this strange modification brought about? Those who have studied louse galls state that in some cases at least, the parent insect simply establishes herself upon the leaf stalk, commences feeding and as a result of continued irritation, the plant appears to be compelled to develop an abnormal mass of cells which literally grows up and encloses its enemy. There is, of course, with this development of the plant, an increase in the number of the insects, so that eventually, conditions are as described above. Some of the jumping plant lice, rather closely related to the aphids just mentioned, are nearly as dependent upon hackberry as certain gall midges and gall wasps are upon oaks, and we find among these jumping plant lice not only a series of species upon a favored food plant but also an equally large series of galls, each with its peculiar structure, at least within certain limits.

These are not the only interesting relationships between insect galls and gall insects. There are also a number of species which take advantage of



CHARACTERISTIC OAK GALLS: A. Bud-like galls on oak twigs, sometimes very abundant and since they produce a sweetish fluid, hosts of bees, flies and other insects may be attracted in early summer. B. Oak spangles, produced by a gall midge, note the cup-like shape and the little oval cavity at the base, shown in the illustration of a sectioned gall. C. Large oak apple, one of the more common and striking galls produced by gall wasps. D. Gall of the wool sower, a delicate appearing white, pink-marked wooly growth containing seed-like cells, each inhabited by a white maggot. E. Mid-rib tumor gall sectioned to show the series of cells inhabited by the white maggots. F. Small oak apple, the one in section shows the characteristic central cell inhabited by a maggot and supported by numerous radiating fibres. G. A peculiar cylindrical-spined, rosy red, yellow-banded gall on a western oak. H. Gouty oak gall, a large swelling frequently forming bead-like enlargements on most of the smaller branches of various oaks, large trees sometimes being badly infested.—(Author's illustrations, Scientific Monthly.)

the activity and enterprise of gall insects and depend like the cuckoo among birds upon others to provide sutiable conditions for their young or even go farther and actually prey upon the true gall producers. The former is carried to a very high degree of perfection in the case of the gall wasps, since the gall "cuckoos", if we might coin a word, resemble the rightful owners of the gall so closely that it is very difficult to distinguish one from the other. Apparently the same thing exists, though to a more limited extent, among some of the gall midges and there are cases where it appears quite probable that a plant deformity of a given character may be produced by more than one gall midge, each performing its fair share of labour in the development of a common shelter. The enemies of the gall insects, generally termed parasites, are occasionally so numerous that comparatively few of the gall producers attain maturity. They are natural checks and when it comes to discussing the ethics of life, it is a little difficult to draw any satisfactory line between the gall insects, real parasites upon plants, the associates or cuckoo-like species which subsist at the expense of these plant parasites or the parasites of the gall insects, since they are all engaged in wresting life from other forms of life.

The above gives a little idea of the extraordinary interest attaching to insect galls and gall insects. There are in America, something like 1,400 different species and a considerable number await discovery in practically all parts of the country. Man has an innate love for nature and anything which will bring the individual into closer touch with the verities of life is a distinct gain for the human race. The hunting of animals, the study of birds, the collection of plants, are all manifestations of our love of nature. These are excellent recreations and comparatively well known. Insect galls and gall insects offer a large, accessible and relatively unknown field for the student of natural history, which can be entered to advantage by a very large proportion of amateur and professional naturalists.

BOOK NOTICES AND REVIEWS.

INTERESTING SEASONAL DATA.—In the Migrational Bulletin issued by E. H. Forbush, Ornithologist to the Commonwealth of Massachusetts, No. XI, dated Nov. 15, occurs the following:

"The autumn has been remarkable. Although there were many rains in September, most of the storms were warm and the season has been so mild and open that not only have fall flowers escaped the frost, but spring flowers and fruits have developed. Wild strawberries, raspberries and blackberries were ripening late in October. Many lawns, mowing fields and pastures still retain their green verdure. From the Berkshire hills to the Atlantic coast the trailing arbutus bloomed late in October, and the common dandelion blossomed again in many localities, besides the fall species, and in some cases it seeded for the second time this year. Both spring and fall dandelions were blooming the first week in November. Willow catkins are now (Nov. 15) open in eastern Massachusetts, and a few flowers still bloom in some gardens.

The effect produced upon the birds by such spring-like weather was what might have been expected. Not only did many of them sing in the usual subdued autumn tones, but some apparently gave their full spring songs. Even the flight songs of several species have been reported, and the singing of robins, song sparrows and some other species continued well into November. The mild weather seemed to delay the departure of some individuals of several species, and to bring about dilatory movements of the waterfowl."

Though the above writer may be mistaken in ascribing this late floral and fruiting activity to unseasonably mild weather, the facts of the case are interesting, especially the ornithological ones and it would be well for us to see just how widely these conditions and phenomena extended during the past autumn.

Late fall blooming of spring plants is not a very uncommon occurrence,* almost every season a few violets can be found here and there in the woods. Bloom on such plants occurs only immediately after awakening from a period of dormant quiescence such as is effected normally by the cold winter season, but a prolonged drought in summer will produce a similar effect and it can be artificially produced by florists by the use of narcotics, anesthetics or other more simple means of inducing unseasonable rest which will be followed by the production of bloom. Without doubt, the unusual amount of fall blossoming here reported was induced by a previous dry spell followed by wet that deceived the roots into the belief that a new spring had come. It will probably be found that in every such case it is the future that has been drawn upon, that next spring's flowers have been expended and the coming season will be one without floration and sterile for the misguided individuals that bloomed at the wrong time.

*See Cephas Guillet, On Autumn-flowering of Various Wild Plants in 1900; Ottawa Naturalist, XV, August, 1901, pp. 123-126, in which a number of such cases are noted, though ascribed as above to unusually mild weather.