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# Article VI.—LIFE HISTORIES OF AMERICAN CYNIPIDÆ[1]

By Alfred C. Kinsey

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## INTRODUCTION

It is generally known that the peculiar biological phenomena of gall production, agamic reproduction, and heterogeny occur among the Cynipidæ (Hymenoptera); and a study of the life histories of a larger number of the species may reveal still other peculiar biological characters or will certainly show modifications of phenomena as they are known today which will furnish especially interesting information. The amount of work involved in solving these life histories is rather considerable, and to study any number of the five hundred or more American species of gall-wasps will call for the help of many students. It is to furnish a ready equipment to those who care to undertake such work, as well as to make available for general use a body of data, that I shall gather in this and subsequent papers the available facts concerning the species of which the life histories are known. Some of these have not previously been known. The accounts of the life histories of most of the others bring together for the first time information that has been scattered through a wide range of literature, much of which has not been available to the general student. It is my aim to supply complete bibliographies, redescriptions of adults

[1]Contribution from the Entomological Laboratory of the Bussey Institution, Harvard University, No. 164.

and galls, detailed records of distribution, etc., and all the biological data available for each species.

The nomenclature adopted needs a word of explanation. Because of the poor distinction of several of the genera of the oak gall makers, it seems unwise to employ the generic titles *Cynips, Callirhytis, Philonix,* etc., until a careful revision of the genera of the family has been made. For that reason, I have used the name *Andricus,* the most meaningless of all these titles, with a number of the forms.

To distinguish the alternate generations of a species, I have had to adopt a new form of naming. It is highly unreasonable to continue to use the names given independently to each generation before the connections of the two forms were understood. It is very inconvenient to use a single binomial to cover the species and to designate the generation referred to by some phrase such as "agamic generation," etc. These are the methods at present in use in Europe in naming these insects. I have adopted trinomials. Trinomials have been used previously to distinguish the forms of species showing a seasonal dimorphism; and, as I am showing elsewhere, alternation of generations among the Cynipidæ is merely seasonal dimorphism developed to an extreme degree in certain instances. So we seem warranted in adopting the sort of nomenclature employed in other cases of seasonal dimorphism. Such a system has the important advantages of retaining the well-known names for each form of the insect, but the name is combined in a way to indicate the complete specific relationships.

I am indebted to many persons who have helped me in this work. Dr. Frank Lutz of The American Museum of Natural History, Charles W. Johnson of the Boston Society of Natural History, and Nathan Banks of the Museum of Comparative Zoology have been liberal in allowing me to examine cynipid material in the collections of which they are in charge. Dr. William M. Wheeler, Professor Charles T. Brues, and Professor Irving W. Bailey, of the Bussey Institution of Harvard Un iversity, have constantly encouraged my work, and to them I am especially indebted. To Professor Brues I am further indebted for the remarkable plates with which this paper is illustrated and which are very important aids in showing the characters of the alternate generations.

## METHODS

For those who will pursue further the study of life histories of Cynipidæ, much time may be saved by a description of the methods I have found to be the most satisfactory for this work. My methods have been similar to those used by Adler but involve some modifications.

Galls are best collected not too long before they reach maturity. Only experience with each species, involving continued observation of specimens of the galls, and obtaining of such information as may be supplied by the size of the gall, the degree of development shown by the insect within the gall, etc., can supply information of the approach of the emergence date for a particular species. Most of the solid, hard, woody, or dry-shelled galls may be kept successfully for many months, but the adults of soft, spongy, or hollow, succulent galls cannot be raised if the galls are gathered more than a week or even a few days before the insects are due to emerge.

Sufficient care is not usually exercised to keep separate the several species collected at any one time. Confusion as to the species of the host plant from which the gall was obtained and the hopeless confusion of any adults that may emerge from the galls before they are finally sorted are the results of putting galls of several species into a single receptacle. A large part of museum material is rendered worthless by such methods of collecting. Paper bags of several sizes are readily available means of separating the galls in the field but, if extensive collecting is to be undertaken, it is preferable to make cloth bags, which are much stronger, take up less room, and may be more securely tied at the top than paper bags.

Undoubtedly the most satisfactory means of rearing the adult wasps is to place the galls on an inch or more of moist sand in a low glass jar at least four or five inches in diameter. The moisture thus supplied keeps the galls from drying out and dying; but the galls should not be piled in too deeply or those on top will not mature and those on the bottom will rot. The glass may be covered with cloth fastened on by an elastic band (which does not wear out-of-doors), or tied with twine (which is less convenient if it is desirable to open the jars a number of times). The jars must be broad and low, and should be kept out-of-doors, under some shelter but where the normal temperature and an abundance of air and wind will prevent mold from developing. Indoors, mold is almost certain to prove a problem. The use of earthern flower pots prevents too much moisture accumulating in the sand, and such receptacles for that reason are preferable to glass jars, but in the pots the emergence of the insects is not so easily observed. Galls that are to be kept over winter or for a long time before the insect matures may be kept in earthen pots until the approach of the date of emergence.

The growth of the galls under controlled conditions should be effected on plants growing in cultivation and kept from possible attack

by wasps from other than the bred material, either by distance from any other plants of the sort (the Cynipidæ almost never fly and most likely never travel more than a very short distance), or by a shelter or covering. It is not desirable to have the plants indoors, for they do not develop at normal rates under these abnormal conditions and the insects will not attack the plants unless they are at the proper state of development. Wild roses and blackberries are easily transplanted, but it is profitable to secure nursery-grown oaks of several species, four or five years old, for the work. These should be growing thriftily before experiments are started, or else galls will probably not be obtained. To wait a year or so after the trees are transplanted is one of the almost necessary problems presented by the work.

If the alternate generation of a species which is being studied is to lay its eggs in the flowers or acorns of the oak, recourse must be had to older trees growing in the open, such additional precautions then being taken as will insure as far as possible the immunity of the part of the tree used from attack by any other gall-wasps than those under observation. Some species will oviposit in the roots of trees. These will be detected instantly, for they are positively geotropic and will start immediately to climb down the tree. These forms, while in the breeding jars, should be placed at the bases of trees having living roots near the surface and covered by only a very little loose earth or, better, leaf-mold, and which have the covering nets extending entirely to the ground, into which the cloth is pegged.

When the insects have emerged within the breeding jars, the trees should be covered with net bags. I employ large cylinders made of a closely-woven cheese-cloth, the cylinder open at the bottom and kept in shape by two heavy wire rings of the same diameter as the cylinder and sewed into place, one in the closed end of the bag and the other about a foot from the open end. These cylinders should be large enough to cover a large part of the tree or even the whole tree, for then the insects are given greater freedom in the choice of the spot for oviposition. Tapes sewed to the closed end of the bag will hold it to some beam or other support above the tree. A strip of sheet celluloid may be fastened into the cloth by a waterproof solution (a few drops of castor oil added to sheet celluloid dissolved in acetone) and the window thus supplied is a great convenience for observing the insects ovipositing. The breeding jars may be placed on wooden blocks or other supports on the ground at the base of the tree, the net drawn down to include the jars, the open end of the net brought together and securely fastened around the main

stem of the tree, and then the covers worked off of the breeding jars. The insects are thus placed on the tree and confined immediately upon emergence from the galls. The nets may be left on the trees for three or four weeks, thus insuring quite completely that no other gall-wasps may attack that tree, but to keep the tree covered for a longer period will usually affect the vigor of the plant and prevent the growth of the galls. Adler, in working out the life histories of European cynipids, employed only smaller coverings for the trees, but by the use of nets large enough to cover the entire tree it is possible to give a much wider range of activity to the insect; and by placing the breeding jars directly into the nets the danger of injuring these delicate insects by handling is entirely avoided.

The adults of most species of cynipids have very little vitality, and to effect oviposition they must usually reach the part of the plant in which the egg will be laid within a few hours after emerging from the gall. Insects kept a couple of days after emergence rarely have vitality enough left to lay eggs. The occurrence of a rainy or even foggy day at the time of emergence of a species (most of the adults of any particular species will emerge within a very few days of each other) will prevent immediate oviposition, and by the time the weather has cleared the insects have lost all vitality and will not attempt to climb over the trees. In spite of all care, to obtain galls experimentally is a difficult process, often proving unsuccessful. From about two thousand gall-wasps placed upon plants the first year of my work, when the trees were newly transplanted and not growing very vigorously, I secured only twenty galls. The factors influencing the growth of these deformations are hardly at all understood, but it is very likely that the trees on which they are to grow must be in very vigorous condition. An abundance of insects of any one species will usually be necessary to secure any amount of results.

## HISTORICAL

The alternation of two quite different forms in successive generations of an organism was discovered first in 1819 by Chamisso in a tunicate of the genus *Salpa*. "A *Salpa*-mother is not like its daughter or its own mother, but resembles its sister, its granddaughter, or its grandmother" was a remarkable statement to hear in a day when spontaneous generation theories had only recently been widely discarded and when the resemblance of all offspring to their parents seemed the foundation stone of biological science. Though plenty of other observations soon confirmed Chamisso's discovery, it was not until the time of the extensive observations of Lichtenstein with aphids and of Adler with Cynipi-

dæ that it was realized that alternation of generations is a wide-spread phenomenon. The very diverse forms of the alternate generations of many species of gall-wasps and the apparently regular succession of the agamic with the bisexual forms, which constitutes true heterogeny, are not known to be equaled in any other large group of highly developed animals and, consequently, unusually wide attention has been attracted to life histories of gall-wasps.

The discovery of heterogeny in the Cynipidæ dates from an observation reported in 1864 by Homer F. Bassett, librarian in the town of Waterbury, Connecticut, and a student whose long series of observations of gall-wasps were made with a degree of painstaking care unmatched by any other worker with the family. Bassett reported as follows (1864, Proc. Ent. Soc. Philadelphia, III, p. 198):

> The flies [of *C. q. operator* O. S.] have now nearly all appeared [from woolly galls on the buds and aments] and I have watched them carefully to learn if possible whether the females deposited any eggs, and if so, whether they are deposited in the young leaf-buds.
>
> I have reared thousands of the flies and have seen thousands more within a few days on the leaves of the shrub-oak, but have not been able to find any in the act of ovipositing until this afternoon.
>
> On visiting a shrub-oak (*Q. ilicifolia*) thicket this afternoon I found *hundreds* of *C. q. operator* with the *ovipositor*, (nearly twice the length of the body) *inserted the full length into the cups of the young acorns.* [Etc. in detail.]
>
> That you may see that I am not mistaken, I send you with this a few acorns with the fly still attached. They were killed by immersing in boiling water.

To find a gall-wasp depositing its eggs at a spot which could not possibly have produced a gall similar to that from which the insect had emerged would, at the date of Bassett's first observation, have been passed by as mere delusion by observers less careful. Three years earlier Osten Sacken (1861) had suggested that the species of cynipids known in the female sex only might have the male developed in other kinds of galls, but the theory was quite without proof and could not have been of much encouragement to Bassett, even had he known of Osten Sacken's obscure paper. Bassett made no prediction or theory concerning the curious fact he had discovered.

In 1873 Bassett wrote again: "I have, for the past three years, carefully examined the buds of *Q. ilicifolia*, hoping to find the producer of *C. q. operator* at work, but without success, till this week, when I found no less than thirty gall flies ovipositing in the buds of this oak." Bassett had then discovered the insect which oviposited to produce the woolly gall and the galls produced by the insects from that woolly gall. It only remained to prove that insects from the second form of the

gall, the acorn-gall, were identical with those which had been found ovipositing to produce the woolly gall. This connection was finally established when C. V. Riley, in the spring of the same year in which Bassett found the producer of *C. operator*, bred the adult from the acorn-gall. It was identical with the producer of *C. operator*. The fact of alternation of generations in the Cynipidæ was thus completely proved.[1]

Meanwhile, B. D. Walsh (1864) had reported in great detail the discovery of two very different forms of adults, one agamic and the other bisexual, emerging at different times of the year from very similar if not identical galls of *Amphibolips confluens*. The work was undoubtedly exact as far as it went and, if it covers the complete life cycle of the species, it furnishes the first completed record of alternation. But Walsh, though he attempted to control the insects by confining them in nets placed on the trees, was unable to discover oviposition and it is not yet satisfactorily shown that the complete life cycle of the species has been discovered. Osten Sacken (1865, p. 341), greatly impressed with Walsh's work, predicted that perhaps "in some cases, the galls producing the dimorphous females were somewhat, or perhaps even altogether, different from those producing the bisexual brood," thus anticipating a summary of the rule which was not to be proved satisfactorily for another twenty years.

European zoologists had long been impressed by Hartig's observation (1840) that among almost 10,000 females bred from one species of gall not a single male was discovered. Similar experience had been had by all the students of gall-wasps and Giraud is quoted (Lichtenstein, 1881, p. xi) as remarking "Il a y dans ces Cynipides agames un mystère dont la découverte fera la gloire d'un homme." To solve this mystery, Dr. Hermann Adler, a physician at Schleswig, undertook to raise under controlled conditions successive generations of species of cynipids. In 1877 he made the first report of his work and, when he made the more complete report, in 1881, the abundance of his observations with a number

[1]Riley's share in the discovery consisted, according to his own early statement (1873), in this breeding of the adult from one form of gall—nothing more. That this adult or the gall from which it came had any connection whatsoever with the other form of gall was realized only because of Bassett's observations made 1864 to 1873. Overlooking this situation, Lichtenstein (1881) and Howard (1882 and 1910), followed by later reviewers, gave Riley the whole credit and by 1895 Riley himself had come to believe he deserved it. He then writes: "The writer established, by breeding, the connection of the agamic *Callirhytis operator* O. S. and *C. operatola* Riley in 1872, the facts and specimens having been communicated to H. F. Bassett July 10th of that year, though not published till 1873." But *C. operator* is not agamic, *C. operatola* is not a Riley species (it was published by Bassett in 1900), and the dates in this statement are at utter variance with Riley's published statement of 1873, where he expressly gives the date of breeding the acorn gall-wasp as 1873. I possess the copy of the French translation of Adler's work presented by Lichtenstein to Riley. Among several notes made in Riley's own handwriting is this: "Wrote to Bassett May 7/72 in reference to black flies from *C. q. operatola* & again July 10/73 announcing breeding of large ♀ from it." Fifteen years later Riley's black flies (inquilines or parasites) of May 7, 1872, had become in his mind the large female (true gall maker) of July 10, 1873.

of different species showed alternation of generations in Cynipidæ to be a fact not to be questioned and presented the proof in a way which immediately attracted attention from biologists over the world. What Bassett and Walsh had proven for three American species was now proved for fourteen European species by direct observation of the complete life cycle and for five other species where the second form of the gall was obtained from the first, but the return experiments were not successful. Other facts of importance concerning the life histories of other species were reported at the same time. None of the later workers have equaled that number of life histories solved, nor can any amount of later work ever prove as important as was the convincing work done by Adler.

The life histories of other European species have been solved by Beyerinck, Schlechtendal, Kieffer, and others. In America, Bassett solved the life histories of four species, Walsh and Triggerson of one each, and now I can add information concerning three other species. This, including two cosmopolitan species which Adler studied, totals ten or eleven American species of which the life cycles have been determined.

## LIFE HISTORIES

### **Aylax glechomæ** (Linnæus)

Plate XXVIII, Figures 1 and 2

The following includes only the most important of the many references in European literature, with a more complete bibliography of American literature.

[No name] PANKOW, 1656, Herbar. Portat., p. 709.

*Cynips glechomæ* LINNÆUS, 1758, Syst. Nat., 10th Ed., p. 553.

*Diplolepis glechomæ* LATREILLE, 1805, Hist. Nat. Crust. & Ins., XIII, p. 207.

*Aylax glechomæ* HARTIG, 1841, Zeitschr. f. Ent., III, p. 342. BEUTENMÜLLER, 1910, Bull. Amer. Mus. Nat. Hist., XXVIII, p. 138, Pl. XIV, figs. 1–3. DALLA TORRE AND KIEFFER, 1910, Das Tierreich, XXIV, p. 667, figs. 347–348. FELT, 1918, N. Y. State Mus. Bull., CC, p. 183, figs. 198, 235 (1–3).

*Aulax glechomæ* HARTIG, 1843, Zeitschr. f. Ent., IV, p. 412. DALLA TORRE, 1893, Cat. Hymen., II, p. 120. JOHANNSEN, 1911, Me. Agric. Exp. Sta. Bull., CLXXXVII, p. 8. FAGAN, 1918, Amer. Nat., LII, p. 168.

*Diastrophus glechomæ* SCHENCK, 1862–1863, Jahrb. v. Natur. Nassau, XVII–XVIII, pp. 211, 212, 248. ADLER, 1881, Alternating Generations (Straton Edit.), p. 274.

*Aulax glechomatis* MARSHALL, 1868, Ent. Month. Mag., IV, p. 274.

*Liposthenes glechomæ* FÖRSTER, 1869, Verh. zool.-bot. Gesell. Wien, XIX, p. 336. THOMPSON, 1915, Cat. Amer. Ins. Galls, pp. 25, 44.

*Liposthenes glechomatis* MARSHAL, 1874, Ent. Ann., p. 117.

*Diastrophus similis* BASSETT, 1881, Can. Ent., XIII, p. 95. ASHMEAD, 1885, Trans. Amer. Ent. Soc., XII, pp. 294, 304; 1887, idem, XIV, p. 134. DALLA TORRE, 1893, Cat. Hymen., II, p. 109. MAYR, 1902, Verh. zool.-bot. Gesell. Wien, LII, p. 287. COOK, 1903, Ohio Nat., III, p. 428, figs. 66–69; 1904, idem, IV, pp. 119, 120, 126, figs. 86, 106. VIERECK, 1916, Hymen. Conn., p. 436.

*Aulax similis* DALLA TORRE AND KIEFFER, 1902, Gen. Ins., Hymen., Cynip., p. 75.

*Diastrophus siminis* Cook, 1904, Ohio Nat., IV, p. 135.
*Aulax* (*Diastrophus*) *similis* Smith, 1910, Ins. N. J., p. 603.

Female.—Mostly piceous black; pronotum dark rufous anteriorly, with patches of long, yellowish hairs at the sides; second abdominal segment produced dorsally to almost two-thirds the length of the abdomen; areolet small or lacking. Head: piceous black or black, reddish on the face, mouth-parts yellowish rufous; slightly broadened behind the eyes; a broad, median facial elevation; microscopically rugose, more rugose on the face, striate, somewhat radiantly around the mouth; somewhat hairy; antennæ yellowish or light brownish rufous, 13-jointed, finely pubescent. Thorax: almost entirely black, mesonotum superficially appearing smooth and shining, but actually finely coriaceous or shagreened; parapsidal grooves distinct, continuous to the pronotum where they are divergent; anterior parallel lines rather faint, half the length of the mesonotum; median groove absent or barely indicated by a slight rugosity at the scutellum; lateral lines distinct but not deep, extending half the length of the mesonotum; scutellum very rugose, with two, rather large, round, mostly smooth and shining foveæ at the base separated by a rather fine ridge; pronotum black or piceous laterally, dark rufous anteriorly, rugose, hairy, with patches of long, yellowish hairs at the sides; mesopleuræ piceous or black, shining, rugoso-striate. Abdomen: rufo-piceous to black, mostly smooth and shining, with patches of dense, yellowish hairs at the base, laterally; the second segment produced dorsally, extending dorsally almost two-thirds of the length of the abdomen. Legs: entirely yellowish or light brownish rufous, finely hairy; the tarsal claws darker in color, and simple. Wings: yellowish-tinged, the veins yellowish brown, darkest on the basal half of the wing; areolet small or lacking, radial cell entirely open; the cubitus fine and very faint where it meets the basal vein considerably below the midpoint; the first abscissa of the radius entirely arcuate or sometimes subangulate. Length: 2.5–3.2 mm.

Galls.—Rounded galls (Figs. 1 and 2) on the leaves, petioles, or stems of *Nepeta* (*Glechoma*) *hederacea*, the ground-ivy (gill-over-the-ground). Monothalamous, or several galls fused. Each gall is 6–12 mm., more or less, in diameter, rounded, covered with a rather dense, stiff pubescence, reddish and green when young; when old becoming dry, brown, smooth, with a thin, papery covering separating more or less or entirely lost from the gall during the winter. The larval cell is central, held in place by rather abundant, very irregular, coarse fibers.

Types.—Types of *glechomæ* in the Linnæan collections and most likely lost. Cotypes of *similis* in The American Museum of Natural History, the Academy of Natural Sciences of Philadelphia, and the Museum of Comparative Zoology.

Range.—Europe. Maine: Orono (Johannsen). Massachusetts: Boston (Clarke); Sharon. Connecticut: Waterbury (Bassett). New York: Long Island (Bassett). New Jersey: Alpine (Beutenmüller). Ohio (Cook). Indiana (Cook). Illinois (Beutenmüller.)

Mayr first pointed out the synonomy of the European *glechomæ* and Bassett's *similis*. I made the above redescriptions from European material from Mayr and also from Bassett's types, and the identity of the two is quite certain. The species was undoubtedly introduced into America from Europe, for its host, the ground-ivy, is of European origin. It is likely that galls were brought to America on plants which had be-

come entangled in nursery material or used as packing. It is very interesting to find insects of so little vitality living through such a journey, and upon emergence from the galls to be able to endure the new conditions and to find the hosts necessary for the continuance of the species. There are only three other instances of the sort. The introduction of *Rhodites rosæ* and *R. mayri*, of roses, is easily understood, but the successful introduction of *Aylax glechomæ* and of *A. taraxaci* (not yet re-recorded from Europe, but since the dandelion is of European origin it is probable that the gall-wasp is also introduced) upon herbaceous plants is more surprising.

This species is, in many respects, very distinct from and more specialized than other members of the genus *Aylax*. The striations of the face resemble those of *Diastrophus*, the second abdominal segment is remarkably developed, the monothalamous and separable gall is (as I am showing elsewhere) a good indicator of advanced evolution, and the undoubtedly completely agamic reproduction is not found elsewhere, as far as is known, in the genus. These and other considerations suggest that *glechomæ* must be considered a high development in *Aylax* or possibly as belonging to a distinct genus.

The galls appear in late May or early June. In this young condition they are eaten in France. The galls mature in late July and, as the plants begin dying off in September, the dried galls drop to the ground where they overwinter, being in large part decayed by springtime. The galls are heavily parasitized. The insects mature in the fall and overwinter as adults, not emerging, however, until the following April or May. Adler proved, by experimentally raising successive generations, that there is no alternation of generations with the species and, since the male is unknown, it is likely that reproduction is regularly agamic, the eggs never being fertilized. This pure agamy is a remarkable condition not easily comprehended as a fit method of maintaining the vitality of an organism.

**Rhodites rosæ** (Linnæus)

Plate XXVIII, Figures 3 and 4

[No name] MALPIGHI, 1679, Anat. Plant., II, pp. 28, 41.
*Cynips rosæ* LINNÆUS, 1758, Syst. Nat., 10th Ed., p. 553.
*Diplolepis bedeguaris* GEOFFREY, 1762, Hist. Ins., II, p. 310.
*Diplolepis rosæ* FOURCROY, 1785, Ent. Paris, p. 392.
*Diplolepis bedeguaris fungosæ* LAMARCK, 1817, Hist. Anim., IV, p. 163.
*Rhodites rosæ* HARTIG, 1840, Zeit. Ent. Germ., II, p. 194. FÖRSTER, 1869, Verh. zool.-

bot. Ges. Wien, p. 332 [*rosæ* fixed as type of *Rhodites*]. ADLER, 1877, Deut. Ent. Zeit., XXI, p. 209 [Biology]. PASZLAVSZKY, 1882, Természetrajzi Füzetek [Budapest], V, pp. 192, 277 [Biology]. And many other references in European literature.

Detailed descriptions or illustrations are to be found in the following more available American publications:

COMSTOCK, 1895, Man. Study Ins., p. 621, fig. 747. BEUTENMÜLLER, 1904, Amer. Mus. Nat. Hist. Guide Leaf. 16, p. 7, fig.; 1907, Bull. Amer. Mus. Nat. Hist., XXIII, p. 632, figs. 1–4, Pl. XLIII, figs. 5–6. THOMPSON, 1915, Cat. Amer. Ins. Galls, pp. 22, 45, Pl. v, fig. 92. VIERECK, 1916, Hymen. Conn., p. 441, Pl. VI, fig. 5. LUTZ, 1918, Field Book Ins., p. 468, Pl. C, fig. 5. FELT, 1918, N. Y. State Mus. Bull., CC, p. 144, fig. 149, Nos. 5–6.

FEMALE.—Head, antennæ and thorax entirely black; abdomen red, piceous black posteriorly; wings with a large brown cloud covering the radial cell and extending beyond it. HEAD: entirely black or piceous black, mouth-parts reddish brown, tips of the mandibles black; front finely coriaceous, face rugoso-punctate with scattered hairs; antennæ entirely black, pubescent, 14-jointed, the third joint about twice as long as the fourth. THORAX: entirely black, mesonotum coriaceous; anterior parallel lines and lateral lines smooth; parapsidal grooves and median groove more apparent in some specimens than in others; parapsidal grooves sometimes traceable to the pronotum; scutellum black, finely rugose, the foveæ at the base similarly rugose and hardly distinct from the rest of the scutellum; pronotum rugose; mesopleuræ almost wholly smooth and shining, with a narrow, rugose area dividing the shining area unequally. ABDOMEN: bright red, lightest basally, the posterior segments piceous black, the hypopygium reddish brown and with a few, short hairs, abdomen otherwise smooth; second segment produced dorsally, there equalling almost two-thirds the total length of the abdomen; the hypopygium prominent, broad, acutely-pointed, "plow-shaped." LEGS: coxæ rufo-piceous to light reddish brown, tibiæ and tarsi light reddish brown; legs entirely hairy; tarsal claws simple. WINGS: yellowish-tinged, a large brownish area entirely covering the radial cell and extending considerably beyond it; wing-veins clear brown, darkest on the first abscissa of the radius; areolet moderately large; cubitus extending to the basal vein; radial cell entirely closed, first abscissa of the radius arcuate on the inner side, but with a considerable thickening on the other side, which makes it angulate into the radial cell. LENGTH: 2.7–3.5 mm.

MALE.—Similar to the female, differing as follows: third antennal joint almost three times as long as the fourth; abdomen small, black, piceous or reddish basally; wings without the radial cloud; length, 2.0–2.5 mm.

[The above descriptions made from large series of specimens from localities over Massachusetts.]

GALLS.—A large mass (Figs. 3 and 4) of moss-like filaments surrounding a cluster of hard, bud-like cells. The filaments are pale green or reddish or purplish-tinged when young, becoming brown or black during the winter; they are sometimes simple, forming a tangled mass, or may be broad, branched, or leaf-like; the whole gall is spherical or oval, about 50 mm. or less in diameter. Each cell of the central core is a modified bud, monothalamous, thick-walled, with a distinct but inseparable larval cell; the cell is more or less covered with irregular projections; and often several cells fuse. Terminal on the stems of roses, especially of the sweet briar; it has been recorded from eighteen species of rose, and is likely to be found on almost any of the species.

TYPES.—In the Linnæan collections and most likely lost.

RANGE.—Europe: throughout. Asia: western. North America: Canada (Toronto, Quebec) and New England to Georgia, west to Michigan, Kansas, and Colorado.

The gall of this species is one of the best known of the cynipid productions, being large and attractive and occurring most often on cultivated plants or on bushes escaped from cultivation. The species is evidently of European origin, probably having been imported into North America and other parts of the world on the sweet-briar. This is one of the four known instances of the importation of a cynipid species from one continent into another.

The gall is a curious modification of the young leaves. It is among the most specialized of the *Rhodites* galls. But what has been gained by the specializaton is not altogether apparent, for the amount of parasitism of this species is great (at least 15%), and evidently the peculiar devices which complicate the gall are of no avail in keeping out parasitic insects.

The galls of *rosæ* appear as early as June 5 (Adler, 1877), about three weeks after the eggs are laid; these galls are well grown in late July and mature by September. The insects overwinter as larvæ and pupate only a few days before their emergence from the gall. The adults emerge from April 27 to July 9. This is a wider range of dates of emergence than is commonly found among the Cynipidæ and, unlike practically all of the other gall-wasps, adults of this species will sometimes emerge from a single gall at two or more dates separated by a month or more, indicating a considerable range of differences between the eggs from a single parent. The adults oviposit within a few hours after emergence, but may live for four or five days before dying.

Males and females are sometimes produced in about equal abundance. From my first lot of material I bred six females and seven males, and Cameron reported (1889) a similar experience. But other galls will give no males at all, indicating a great variation in the eggs laid by different individuals. The final average gives between one and two per cent males, and the observations of several workers (Adler, 1888; Cameron, 1889; *et al.*) confirm my experience in this respect. It is to be expected that under such conditions the females are often not fecundated but, nevertheless, the eggs of such individuals will grow parthenogenetically. This was very positively proved by Adler (1877), who secured galls from eggs he had observed to be laid in the plant. He conducted extensive experiments with this species; in four different years he obtained similar results, rearing three generations in direct succession, obtaining galls

and adults in each case exactly like those of the parent generation. This was conclusive proof that there is no alternation of generations with this species, and nothing known of its life history would suggest that an alternation ever occurs. By strictly isolating the females from the males at emergence and before oviposition, and by anatomical examination of the receptaculum, Adler proved the parthenogenetic development of eggs.

### **Rhodites ignotus** Osten Sacken

Plate XXVIII, Figures 5 to 7

*Rhodites ignota* Osten Sacken, 1863, Proc. Ent. Soc. Phila., II, pp. 44, 45, 49. Gillette, 1892, Ent. News, III, p. 246. Beutenmüller, 1892, Bull. Amer. Mus. Nat. Hist., IV, p. 246, Pl. ix, fig. 2; 1904, Amer. Mus. Journ., IV, p. 94, fig. 7; 1904, idem, XX, p. 27; 1904, Amer. Mus. Nat. Hist. Guide Leaf. 16, p. 8, fig. Felt, 1906, Ins. Aff. Pk. & Woodl. Trees, II, pp. 621, 647. Stebbins, 1910, Springfield (Mass.) Mus. Bull., II, p. 37, fig. 73. Thompson, 1915, Cat. Amer. Ins. Galls, pp. 23, 45, Pl. v, fig. 100. Lutz, 1918, Field Book Ins., p. 468, Pl. c, fig. 8.

[*R. ignota* of Ashmead papers is *R. globuloides* Beutenmüller.]

*Rhodites carolina* Ashmead, 1887, Trans. Amer. Ent. Soc., XIV, pp. 133, 148. Dalla Torre and Kieffer, 1902, Gen. Ins., Hymen., Cynip., p. 78. Dalla Torre and Kieffer, 1910, Das Tierreich, XXIV, p. 718. Thompson, 1915, Cat. Amer. Ins. Galls, pp. 23, 45.

*Rhodites carolinus* Dalla Torre, 1893, Cat. Hymen., II, p. 126.

*Rhodites ignotus* Dalla Torre, 1893, Cat. Hymen., II, p. 127. Dalla Torre and Kieffer, 1902, Gen. Ins., Hymen., Cynip., p. 78. Beutenmüller, 1907, Bull. Amer. Mus. Nat. Hist., XXIII, p. 634, Pl. xliii, figs. 7–10. Dalla Torre and Kieffer, 1910, Das Tierreich, XXIV, p. 718, fig. 402. Smith, 1910, Ins. N. J., p. 604. Cosens, 1912, Trans. Can. Inst., IX, p. 350. Viereck, 1916, Hymen. Conn., p. 441, Pl. vi, fig. 3. Felt, 1918, N. Y. State Mus. Bull., CC, p. 146, fig. 149 (7–10).

Female.—Antennæ, head, and thorax black; basal joints of antennæ rufous; abdomen and legs rufous red; radial area of wings clouded but with a large clear spot in the center. Head: broad; black or piceous black, shallowly rugoso-punctate, more finely punctate on the vertex, with a long pubescence on the face; antennæ short, 14-jointed, black or piceous black, joints one and two light rufous to rufo-piceous. Thorax: black, coarsely rugose, hairy; parapsidal grooves similarly rugose, widely divergent from the scutellum, extending a little more than half the way to the pronotum; median groove lost in the rugosities of the mesonotum; anterior parallel lines fine, smooth, slightly raised, not extending half-way to the scutellum; lateral lines broader, smooth, about as long as the parapsidal grooves; scutellum long, elevated, depressed at the base but without distinct foveæ, entirely coarsely rugose; mesopleuræ rather smooth and shining, in part coriaceous, a narrow rugose band extending across the middle. Abdomen: bright rufous red, the tip of the hypopygium rufo-piceous; smooth and shining, the lower edge of the hypopygium hairy; abdomen long and slender; the second segment produced dorsally almost to the tip of the abdomen; hypopygium "plow-shaped." Legs: bright rufo-piceous including the coxæ, the last joints of the tarsi rufo-piceous; densely hairy; tarsal claws simple. Wings:

yellowish-tinged, hairy, the veins clear brown, those bounding the radial area darker; radial area closed, covered with a large, brown patch with a large, clear spot in the center; areolet moderately large, cubitus not quite reaching the basal vein below its midpoint; first abscissa of the radius distinctly angulate but without a distinct projection into the radial area. LENGTH: 2.0–3.5 mm.

MALE.—Similar to female but differing as follows: basal joints of antennæ piceous brown; abdomen piceous, shorter, more compressed, and more slender basally; wings with only traces of the clouds on the radial areas, with a slight projection from the first abscissa of the radius into the radial cell; length, 1.5–3.0 mm.

[Redescription made from New England and New York material compared with cotypes.]

GALLS.—Irregularly globose leaf-galls (Figs. 5 to 7), covered with a white, mealy powder. Each gall is about globose, monothalamous, but often several galls coalesce to form large, elongate, more or less entire masses sometimes 20 mm. long. On the terminal twigs, petioles, and stems of the leaflets of *Rosa blanda*, *R. carolina*, *R. humilis*, *R. nitida*, *R. virginiana*, and most likely other roses.

COTYPES.—Cotype females and galls in the Museum of Comparative Zoology, and "cotype" galls in The American Museum of Natural History.

RANGE.—Ontario: Toronto (Cosens). Massachusetts: Magnolia, Boston (Clarke); Westboro (Frost); Springfield (Stebbins). Rhode Island: Providence (Thompson). Connecticut: New Haven, Woodbridge (Britton); Waterbury (Bassett). New York: Albany (Felt); Nyack (Zabriskie); New York City (Beutenmüller); Staten Island (W. T. Davis). New Jersey: Fort Lee (Beutenmüller); Patterson, Bradley Beach (in Coll. Amer. Mus.). Pennsylvania (Beutenmüller). Maryland: Fareman (Osten Sacken). District of Columbia: Washington (Beutenmüller). North Carolina: Black Mts. (Beutenmüller); Asheville (Ashmead). Florida (Ashmead). Iowa (Beutenmüller). Colorado: Fort Collins (Gillette).

The galls of *Rhodites ignotus* are first noticeable about the middle of August, somewhat deforming the leaves of the roses on which they are formed. The galls overwinter, sometimes on the bush, but often on the ground, to which they readily fall when the leaves bearing them wither in the autumn. The mature wasps are known to emerge the following spring from May to August, most of the adults appearing about the last of May or the first of June. As with *R. rosæ*, this extended period of emergence is an unusual thing to find among the gall-wasps. Of thirty-seven of the wasps which I have bred, thirteen, i. e., 35% of them were males, which is a higher percentage than that known from other species of the genus. However, incomplete observations on other breedings I have made would indicate a much lower percentage of males to be more nearly normal. The number of parasites obtained from these galls is extremely high; I have found them to constitute about 90% of all the insects bred—another instance of the ineffacacy of highly developed "protective" devices. Most of these parasites are figitids, Synerginæ, etc., the so-called "inquilines," but many other parasitic Hymenoptera also attack the galls.

The adults of *ignotus* live for only a few days at the most, oviposition often occurring only a few hours after emergence. The females will refuse to oviposit unless they find a bush in the right condition for receiving the eggs. A lot of the insects which I placed on a cultivated rose which was somewhat retarded in development refused to climb over the bush at all to examine the buds, though the same insects became active enough when placed on a plant in a more advanced state of development. They carefully examined the young leaves, hardly yet out of the buds, and in these leaves the eggs were laid. The quantities of parasites which emerged, mostly a couple of weeks after the cynipids, were very active in examining the leaves of the same plant and many of them were observed to oviposit, but whether into the eggs and very young galls of the gall-wasps I am not certain.

The points at which oviposition was made by the *ignotus* females were carefully marked and kept covered by gauze bags for almost a month and a half. The galls produced were first seen about the first of September, i. e., over a month and a half after the eggs were laid, but the degree of development of the galls indicated that they had appeared possibly two weeks earlier. The galls thus obtained were typical *ignotus* galls, in every way resembling the galls of the parent generation. Nothing else known of the life history of the species would suggest that it possesses an alternation of generations. Ants attacked the cynipids when they died after oviposition and only a single whole specimen, a male, was rescued for the collection. This, with galls of the two successive generations, are in my collections, distinctively labelled. I cannot say positively whether the reproduction is wholly or at any time parthenogenetic, though it is very likely that it is parthenogenetic at least part of the time. The one male in my net may have fertilized the females, though I did not observe copulation.

### **Neuroterus batatus** (Fitch)

In most of the following references the two generations have not been separately described.

*Cynips Quercus-batatus* Fitch, 1859, Report Nox. Ins. N. Y., p. 810.

*Cynips quercus batatus* Osten Sacken, 1861, Proc. Ent. Soc. Phila., I, p. 71. Thomess, 1879, Trans. Ill. Hort. Soc. for 1878, p. 198. Packard, 1881, U. S. Ent. Comm. Bull., VII, p. 39; 1890, 5th Report U. S. Ent. Comm., p. 111.

*Cynips q.-batatus* Osten Sacken, 1861, Ent. Zeit. Stett., XXII, pp. 410, 414. Bassett, 1864, Proc. Ent. Soc. Phila., III, p. 684; 1877, Can. Ent., IX, p. 121. Packard, 1890, 5th Report U. S. Ent. Comm., p. 113.

*Cynips batatus* Osten Sacken, 1865, Proc. Ent. Soc. Phila., IV, pp. 340, 344, 350, 354. Packard, 1881, U. S. Ent. Comm. Bull., VII, p. 56.

*Neuroterus batata* MAYR, 1881, Gen. Gallenbew. Cynip., p. 37. ASHMEAD, 1885, Trans. Amer. Ent. Soc., XII, p. 296. PACKARD, 1890, 5th Report U. S. Ent. Comm., p. 107.

*Neuroterus batatus* BASSETT, 1882, Amer. Nat., XVI, p. 246. ASHMEAD, 1887, Trans. Amer. Ent. Soc., XIV, p. 132; 1890, Colo. Biol. Assoc. Bull., I, p. 38. PACKARD, 1890, 5th Report U. S. Ent. Comm., p. 109. BEUTENMÜLLER, 1892, Bull. Amer. Mus. Nat. Hist., IV, p. 262, Pl. XIII, fig. 1; 1904, Amer. Mus. Journ., IV, p. 107, fig. 41; 1904, Bull. Amer. Mus. Nat. Hist., XX, p. 26; 1904, Amer. Mus. Nat. Hist. Guide Leaf. 16, p. 21, fig.; 1910, Bull. Amer. Mus. Nat. Hist., XXVIII, p. 117, Pl. VIII, figs. 1–8. DALLA TORRE, 1893, Cat. Hymen., II, p. 40. BRODIE, 1896, Ann. Report Forest. Ont., p. 117, fig. 3. DALLA TORRE AND KIEFFER, 1902, Gen. Ins., Hymen., Cynip., p. 50. FELT, 1906, Ins. Aff. Pk. & Woodl. Trees, II, pp. 618, 624; 1918, N. Y. State Mus. Bull., CC, pp. 56, 58, fig. 54. STEBBINS, 1910, Springfield (Mass.) Mus. Bull., II, p. 29. SMITH, 1910, Ins. N. J., p. 598. COOK, 1910, Mich. Geol. and Biol. Surv. Publ. 1, p. 31. THOMPSON, 1915, Cat. Amer. Ins. Galls, pp. 6, 40, Pl. I, fig. 76. VIERECK, 1916, Hymen. Conn., p. 384. LUTZ, 1918, Field Book Ins., p. 464, Pl. XCVIII, fig. 4.

*Neuroterus quercus-batatus* DALLA TORRE AND KIEFFER, 1910, Das Tierreich, XXIV, p. 334, fig. 55.

[*Neuroterus batatus* FULLAWAY, 1911 = *N. pacificus* Beutenmüller.]

RANGE.—Canada (Brodie). New Hampshire: Wolfeboro. Massachusetts: Auburn, Boston, Blue Hills, Marthas Vineyard. Rhode Island: Providence (Thompson). Connecticut: New Haven (Champlain, Walden); Waterbury (Bassett). New York: Neperan, Long Island, Staten Island (Beutenmüller). New Jersey: throughout (Smith). Virginia (Riley). Ohio (Beutenmüller). Illinois (Beutenmüller). Michigan (Cook). Colorado (Ashmead).

### **Neuroterus batatus** form **bisexualis**, new name

Plate XXIX, Figures 8 and 9

FEMALE.—Almost entirely black except the legs and antennæ which are yellowish and brown; areolet large; length about 2.0 mm. HEAD: black; mouth-parts reddish; shagreened; sparsely hairy; antennæ 13-jointed, first three joints yellowish, the remaining joints brownish; hairy. THORAX: piceous black, shining, very finely shagreened, shrivelling on drying; parapsidal grooves, anterior parallel lines, etc., not present or sometimes very faintly traceable; scutellum black, broadly oval, finely shagreened, sparsely hairy; a distinct, arcuate depression separates the scutellum from the thorax; pronotum and mesopleuræ reddish piceous. ABDOMEN: reddish piceous to black, smooth, shining, shrivelling on drying, angular in outline, as deep as long, the second segment extending not much more than one-third the total length. LEGS: dark brown, hairy, yellowish at the joints, and on all the tarsi and on the tibiæ of the first and second pairs of legs. WINGS: large, much longer than the body, clear; veins clear brown; areolet large; cubitus reaches the basal vein; radial area completely open on the margin; first abscissa of the radius angulate, the angle little more than a right angle but the apex high upon the vein. LENGTH: 1.2–2.0 mm.

MALE.—Differs from the female as follows: head, thorax, and abdomen reddish to light piceous, the antennæ and legs entirely yellow; antennæ 14-jointed, the third joint curved; abdomen petiolate; wings yellowish, the veins yellowish brown, areolet of moderate size; length, 1.2–2.0 mm.

[Redescribed from New England specimens compared with Bassett's morphotypes.]

GALLS.—Moderate-sized swellings (Figs. 8 and 9) of young stems and petioles, essentially the same as the galls of the agamic generation (q. v.), but differing in being often much smaller, often having tufts of short, woolly pubescence. On stems, petioles, or midveins of *Quercus alba*.

TYPES.—Bassett's morphotype females, males, and galls in the collections of The American Museum of Natural History, of the Academy of Natural Sciences of Philadelphia, and of the Museum of Comparative Zoology.

In 1864 Bassett reported that he had observed for a number of years the alternation of two crops of galls on a small tree near his house. The abundance of each crop in turn suggested the relationships of the two. Moreover, the insects proved indistinguishable except through a slight difference in size and in the then unexpected condition of having only females in the winter galls, with both males and females in about equal numbers from the spring galls. Neither Bassett nor later workers have actually seen the oviposition of the species, nor obtained under controlled conditions the gall of one generation from an egg deposited by a female of the previous generation, but Bassett's field experience is regularly confirmed by later collectors of gall-wasps. I have examined material from the Bassett collection which shows this, also photographs of material collected by Miss Cora Clarke, and a quantity of material collected and bred by Millett T. Thompson. This latter material shows the two generations often close together on successive parts of the same branch. The descriptions here given are made from a study of many specimens which I have compared with the Bassett types. No previous separation has been made of descriptions of the two forms of adults, and the gall of the bisexual generation has never been described in detail, nor have Latin names been applied to distinguish the forms.

The galls of the bisexual generations appear about the middle of May and the adults emerge, in about equal numbers of the sexes, by the middle of June. These oviposit in the new wood of the stem on which the better-known gall of the agamic generation develops.

### **Neuroterus batatus** form **batatus** (Fitch)

Plate XXIX, Figures 10 to 13

FEMALE.—Almost identical with the female of the bisexual generation, but with the thorax usually less wrinkled and, in consequence, the anterior parallel lines more evident. The insect averages slightly larger than the female of the other generation, the abdomen being somewhat less angulate in outline. LENGTH: 1.7–2.2 mm.

GALLS.—Large, woody, stem swellings (Figs. 10 to 12). Polythalamous. Averaging 40×10 mm., often larger; tuber-like, irregular, but usually roughly cylindrical, elongate, involving stems and bases of petioles on terminal twigs; inseparable

from the rest of the plant. Bark-colored, reddish, purplish brown, or with a glaucous bloom. Internally the galls are solid, woody, the larval cells scattered irregularly, the cell walls hardly distinct and not at all separable from the surrounding tissues. On terminal stems of *Quercus alba* (not known definitely from any other species of oak).

TYPES.—Bassett morphotype females and galls in the collections of The American Museum of Natural History, the Museum of Comparative Zoology, and of the Academy of Natural Sciences of Philadelphia, and Fitch cotype galls in the Museum of Comparative Zoology.

The galls of this generation, because they remain upon the tree for the longer time and often reach the larger size, are the better-known of the two forms of this species. The insects live in the galls over winter, emerging late the following April or early in May.

The very great similarity of the adults of the two generations of this species (except for the agamy in the winter generation) and the essentially identical plan of the galls of the two forms, is a matter of great interest. In this species, as in *Neuroterus noxiosus*, we find as simple a case of alternation of generations as has yet been recognized. The differences in the galls are very evidently due to seasonal differences of the conditions in the part of the host affected.

**Neuroterus noxiosus** (Bassett)

In most of the following references both generations, at least of the gall, are described separately.

[No name] BASSETT, 1873, Can. Ent., V, p. 92; Trans. Ent. Soc. Lond., p. xv.

*Cynips noxiosa* BASSETT, 1881, Can. Ent., XIII, p. 108. PACKARD, 1881, U. S. Ent. Comm. Bull., VII, p. 57.

*Neuroterus noxiosus* MAYR, 1881, Gen. Gallenbew. Cynip., p. 37. BASSETT, 1882, Amer. Nat., XVI, p. 246. ASHMEAD, 1885, Trans. Amer. Ent. Soc., XII, pp. 296, 303. GILLETTE, 1888, 27th Report Agric. Mich., p. 471; 1889, Psyche, V, p. 187. PACKARD, 1890, 5th Report, U. S. Ent. Comm., pp. 107, 109. BEUTENMÜLLER, 1892, Bull. Amer. Mus. Nat. Hist., IV, p. 262; 1904, Amer. Mus. Journ., IV, p. 107, fig. 42; 1904, Bull. Amer. Mus. Nat. Hist., XX, p. 27; 1904, Amer. Mus. Nat. Hist. Guide Leaf. 16, p. 21, fig.; 1910, Bull. Amer. Mus. Nat. Hist., XXVIII, p. 118, Pl. IX. DALLA TORRE, 1893, Cat. Hymen., II, p. 44. DALLA TORRE AND KIEFFER, 1902, Gen. Ins., Hymen., Cynip., p. 51; 1910, Das Tierreich, XXIV, p. 330. FELT, 1906, Ins. Aff. Pk. & Woodl. Trees, II, pp. 618, 624, 711; 1918, N. Y. State Mus. Bull., CC, pp. 58, 84, fig. 55. NASON, 1906, Ent. News, XVII, p. 8. STEBBINS, 1910, Springfield (Mass.) Mus. Bull., II, p. 30. SMITH, 1910, Ins. N. J., p. 598. COOK, 1910, Mich. Geol. & Biol. Surv. Publ. 1, p. 30. THOMPSON, 1915, Cat. Amer. Ins. Galls, pp. 6, 13, 41, Pl. IV, fig. 118 [not Pl. I, fig. 16]. VIERECK, 1916, Hymen. Conn., p. 391. LUTZ, 1918, Field Book Ins., p. 464, Pl. XCVIII, fig. 11.

*Neuroterus noxiosa* ASHMEAD, 1887, Trans. Amer. Ent. Soc., XIV, p. 132.

RANGE.—Massachusetts: Everett (Clarke); Boston; Amherst (Thompson); Springfield (Stebbins); Marthas Vineyard. Rhode Island: Providence (Thompson).

Connecticut: New Haven (Champlain, Walden); Waterbury (Bassett). New York: New York City (Beutenmüller); Staten Island (W. T. Davis). New Jersey: Fort Lee (Beutenmüller); New Brunswick (J. B. Smith). Illinois: Algonquin (Nason). Iowa (Beutenmüller). Michigan: Lansing (Gillette).

### **Neuroterus noxiosus** form **vernalis**, new name

Plate XXIX, Figures 14 to 16

FEMALE.—Head, thorax, and abdomen mostly black; antennæ yellowish, shading into brown toward the tip; areolet rather small; length about 1.5 mm. HEAD: black, shading into rufous brown on the lower half of the face and on the mouthparts; finely coriaceous to punctate; antennæ 13-(14-)jointed, yellowish, shading into brownish toward the tips. THORAX: black, or piceous black, finely coriaceous; without more than very faint traces of anterior parallel lines, parapsidal grooves, etc.; scutellum black, finely coriaceous, separated from the mesonotum by a deep, distinct, arcuate groove. ABDOMEN: black or piceous, smooth and shining, shrivelling on drying, angulate in outline; the second segment about only one-third as long as the whole of the abdomen. LEGS: light golden yellowish, the middles of the femora, the hind coxæ and tibiæ, and the tips of the tarsi dark brown; hairy. WINGS: long, clear, the veins light brown in color, areolet moderately small; cubitus reaching the midpoint of the basal vein; radial cell long and narrow, open (rarely in small part closed on the margin); the first abscissa of the radius angulate, the apex of the angle above the middle of the vein and without a very distinct projection into the radial cell. LENGTH: 1.2–1.7 mm.

MALE.—Similar to the female, but with legs and antennæ entirely yellowish; antennæ 14-jointed, the third joint curved; the first abscissa of the radius showing a slight projection into the radial cell; abdomen small, petiolate; length, 1.0–1.4 mm.

[Redescription made from a large amount of New England material which was compared with the types.]

GALLS.—Irregular clusters of woody swellings (Figs. 14 to 16) of the stems, petioles, and leaves. Polythalamous. The whole mass roughly about 20×40 mm. in diameter or less, inseparable from the plant; fist-like, the separate parts woody, indicating the separate leaves or parts of leaves involved, and bearing a small portion of deformed leaves; these parts are united by the deformed petiole, or by a fused mass of petioles or young twigs. The gall is bark-colored, or tinged with a glaucous bloom. Internally the larval cells are crowded closely together, the cells very distinct but not separable from the surrounding woody tissue. On the young growth of *Quercus Prinus* and *Q. bicolor*.

COTYPES.—Cotype females, males, and galls in The American Museum of Natural History, the Academy of Natural Sciences of Philadelphia, and the Museum of Comparative Zoology.

When Bassett first described this species he gave detailed descriptions of the galls of the two generations and noted differences in sizes of the adults. The specific relations of the two generations had been arrived at through the field observation of the alternate abundance of the two forms of galls and the close similarity of the adults of the successive generations. The tremendous abundance of this species locally often gives abundance opportunity for observations. Gillette, Beutenmüller,

Miss Clarke, Thompson, and other students of the family have made observations confirming Bassett's statements, and there can be no doubt of the regular alternation of these forms, even though the data has not been checked by experimental work. This was the fourth and last instance of heterogeny discovered by Bassett.

The galls of this form appear when the young leaves first unfold in May and, like most of the spring galls of dimorphic species, grow very rapidly to maturity. The adults are known to emerge from June 12 to July 5. They occur in about equal numbers of the sexes: I counted 276 females and 233 males in one lot bred by Millett T. Thompson. After fertilization the females oviposit in the new wood of the twigs, usually not far from the galls in which they have developed.

**Neuroterus noxiosus** form **noxiosus** (Bassett)

Plate XXIX, Figures 17 to 19

FEMALE.—Almost identical with the female *vernalis*, with the thorax and abdomen more piceous, especially at the base of the abdomen; the anterior parallel lines on the mesonotum more distinct, the abdomen relatively larger and more angulate; the wing veins slightly darker brown; the whole length 1.6–2.0 mm.

GALLS.—Irregular, elongate, woody swellings (Figs. 17 to 19) of young stems and sometimes petioles. Polythalamous. About 60×10 mm., roughly cylindrical, but often very irregularly twisted, etc. Inseparable from the plant. Bark-colored, usually with a glaucous bloom. Internally the gall is closely packed with larval cells which are distinct but not separable from the surrounding woody tissue. On the newer growth of *Quercus bicolor*, *Q. Prinus*, and possibly other oaks.

COTYPES.—Cotype females, males, and galls in The American Museum of Natural History, the Academy of Natural Sciences of Philadelphia, and the Museum of Comparative Zoology.

This gall is the better-known form of the species, due apparently to its longer persistence on the tree. The gall very closely resembles that of *Neuroterus batatus batatus*, from specimens of which it is often difficult to distinguish this species. The more highly distinct larval cells of *noxiosus* is often a good basis for making the distinction. The most certain test, however, is the species of the host plant, *noxiosus* being confined as far as known to *Quercus bicolor* and *Q. Prinus*, while *batatus* occurs on *Q. alba*. It would prove interesting to try to induce one of these species to oviposit on the "wrong" species of oak, and to observe if galls and what galls were produced.

The larvæ of *noxiosus* overwinter in the galls, emerging the following spring from March 24 through April to early May.

**Neuroterus tectus** Bassett

*Neuroterus tectus* BASSETT, 1900, Trans. Amer. Ent. Soc., XXVI, p. 331. DALLA TORRE AND KIEFFER, 1902, Gen. Ins., Hymen., Cynip., p. 51; 1910, Das Tier-

reich, XXIV, p. 337. BEUTENMÜLLER, 1904, Bull. Amer. Mus. Nat. Hist., XX, p. 26; 1910, idem, XXVIII, p. 126, Pl. XII, figs. 1–2. SMITH, 1910, Ins. N. J., p. 599. THOMPSON, 1915, Cat. Amer. Ins. Galls, pp. 5, 13, 41. VIERECK, 1916, Hymen. Conn., p. 389. FELT, 1918, N. Y. State Mus. Bull., CC, p. 56, fig. 53, 1–2.

RANGE.—Massachusetts (Thompson). Rhode Island: Providence (Thompson). Connecticut (Bassett). New York (Beutenmüller). New Jersey (Beutenmüller). Pennsylvania (Beutenmüller).

### **Neuroterus tectus** form **tectus** (Bassett)

Plate XXX, Figures 20 to 22

FEMALE.—Mostly piceous black, antennæ 13-jointed, wing-veins brownish, areolet only moderately large; length about 1.2 mm. HEAD: piceous or piceous black, mouth-parts reddish brown, microscopically coriaceous; a distinct median elevation on the face; antennæ 13-jointed, dark brown, lighter basally. THORAX: piceous or piceous black, shining; mesonotum almost entirely smooth, the parapsidal and other grooves lacking, scutellum rounded, the groove at the base broad and deeply arcuate; pronotum and mesopleuræ very microscopically coriaceous. ABDOMEN: Blackish, piceous basally, shining, triangular in outline. LEGS: brownish, straw-brown at the joints. WINGS: narrow, one-third again as long as the whole body; veins straw-brown, distinct but not heavy; areolet moderately large or not large; cubitus continuous to the basal vein which it meets slightly below the midpoint; radial area long and narrow, open, the first abscissa of the radius somewhat angulate high on the vein. LENGTH: 1.2–1.5 mm.

MALE.—Similar to the female, but with the antennæ lighter colored, the third joint slightly curved, the abdomen petiolate.

[Redescribed from Thompson material bred in successive generations, and from Bassett cotypes.]

GALLS.—Small swellings (Figs. 20 to 22) of the stems of flower clusters, of petioles, or of young stems of oak. Each swelling consists of closely-packed clusters of thin-walled, oval larval cells, each measuring about .7×1.2 mm. with a thin covering of distorted bark, there being little other hypertrophied tissue present. Usually covered with gray pubescence. On *Quercus prinoides* (and *Q. alba?*).

COTYPES.—Cotype females, males, and galls in The American Museum of Natural History, the Academy of Natural Sciences of Philadelphia, and the Museum of Comparative Zoology.

These galls are very inconspicuous productions, hardly to be observed until the tiny exit holes made by the insects may be found in the stems of the flower clusters. The insects emerge late in May and early in June, after only a month spent in the galls. Bassett found the adults mostly emerged by June 10.

### **Neuroterus tectus** form **abundans,** new name

FEMALE.—Closely resembles the female of the bisexual generation, but has the abdomen darker in color and decidedly larger and more oval rather than triangular. LENGTH: 1.2–1.5 mm.

GALLS.—Not certainly identified. Most likely swellings very similar to the galls of the bisexual generation, but on the midvein of the young leaves, somewhat distorting the whole leaf.

COTYPES.—Cotype females in The American Museum of Natural History, the Academy of Natural Sciences of Philadelphia, and the Museum of Comparative Zoology.

The eggs which produce this form of the species are laid early in June by the female of the bisexual generation. It is not certain what sort of galls are produced. Galls of the above description, in the Thompson Collection, belong, I believe, to the females of this generation, but the data was not distinctly affixed. From what is known of the life history of the species, it is evident that this generation lives in the galls for about ten and a half months, emerging and ovipositing April 29 (Bassett) to May 10 (Thompson). As far as known, the generation is agamic. The females very closely resemble the females of the bisexual generation but are readily distinguishable by the larger, more oval abdomen, a character to be expected in the agamic generation.

The material on which I base this data was obtained by the late Millett T. Thompson, whose collection of gall-insects is now in the Museum of the Boston Society of Natural History. The females marked "F" in the collection were found ovipositing May 10, 1907, in buds of *Quercus prinoides,* the points of oviposition were marked, the galls produced were bred and the females and males of the bisexual generation obtained. This material, distinctively labelled, is now in the Boston Society collections and in the author's collections.

These observations are in accord with those made by Bassett concerning the similarity of the two generations as he had found them, but Bassett did not mark the points of oviposition of the agamic form, nor did he note the differences in the two generations and keep them separate in his collections. The female "*tectus,*" as Bassett described it, was apparently the agamic female, but the description of the abdomen as "small, in outline an equilateral triangle," applies distinctly to the female of the bisexual generation; while among the Bassett cotypes are females of both generations. Inasmuch as the male and the distinctive gall of the bisexual generation were called *tectus,* I use that name to designate that generation, and *abundans,* describing the larger-bodied female, for the agamic generation.

I feel fortunate in being able to present the life history of this species, because it gives another instance of the very slight differences between the successive generations of the species of *Neuroterus* and, further, bears out my belief that alternation of generations is merely a development of seasonal dimorphism. It is very much to be desired that we closely observe other species of *Neuroterus* and try to discern still more prim-

itive instances of dimorphism, or of a double-brooded condition without an accompanying heterogeny, among the species of the group.

### **Andricus futilis** (Osten Sacken)

RANGE.—Ontario (Jarvis). New Hampshire: Wolfeboro. Massachusetts: Magnolia (Clarke); Boston, Blue Hills, Sharon, Marthas Vineyard; Springfield (Stebbins). Connecticut: Waterbury (Bassett). New York: New York City (Beutenmüller). New Jersey: throughout (Smith). Pennsylvania: Shawnee (Thompson). District of Columbia: Washington (Osten Sacken). Maryland: Plummer's Is. (Weld). Ohio: Sandusky (Sears). Indiana (Cook). Illinois: Fort Sheridan (Weld). Michigan: Ionia Co. (Gillette).

### **Andricus futilis** form **futilis** (Osten Sacken)

Plate XXX, Figures 28 and 29

*Cynips quercus futilis* OSTEN SACKEN, 1861, Proc. Ent. Soc. Phila., I, p. 64.

*Cynips quercus papillata* OSTEN SACKEN, 1861, idem, I, p. 64.

*Cynips q. futilis* BASSETT, 1863, Proc. Ent. Soc. Phila., II, p. 329; 1873, Can. Ent., V, p. 92; 1873, Proc. Ent. Soc. Lond., p. xv.

*Cynips futiilis* OSTEN SACKEN, 1865, Proc. Ent. Soc. Phila., IV, p. 339.

*Cynips futilis* OSTEN SACKEN, 1865, idem, IV, pp. 346, 349, 352, 355.

*Cynips papillata* OSTEN SACKEN, 1865, idem, IV, pp. 339, 346, 349, 352, 355.

*Andricus futilis* OSTEN SACKEN, 1865, idem, IV, p. 379. GILLETTE, 1889, Psyche, V, p. 185. DALLA TORRE, 1893, Cat. Hymen., II, p. 88. JARVIS, 1908, Report Ent. Soc. Ont., p. 86, Pl. B, fig. 4. BEUTENMÜLLER, 1904, Bull. Amer. Mus. Nat. Hist., XX, p. 27; 1904, Amer. Mus. Nat. Hist. Guide Leaf. 16, p. 13, fig. FELT, 1906, Ins. Aff. Pk. & Woodl. Trees, II, p. 710; 1918, N. Y. State Mus. Bull. CC, p. 88, fig. 83, Pl. II. fig. 3. COOK, 1910, Mich. Geol. & Biol. Surv. Publ. I, p. 27. SEARS, 1914, Ohio Nat., XV, p. 381, fig. 21.

*Andricus papillata* OSTEN SACKEN, 1865, Proc. Ent. Soc. Phila., IV, p. 379.

*Andricus (Callirhytis) futilis* MAYR, 1881, Gen. Gallenbew. Cynip., p. 28. BASSETT, 1882, Amer. Nat., XVI, p. 246. ASHMEAD, 1885, Trans. Amer. Ent. Soc., XII, pp. 294, 295. PACKARD, 1890, 5th Report. U. S. Ent. Comm., p. 105. BEUTENMÜLLER, 1892, Bull. Amer. Mus. Nat. Hist., IV, p. 254, Pl. II, fig. 1. VIERECK, 1916, Hymen. Conn., p. 433.

*Cynips (Andricus) papillata* PACKARD, 1881, U. S. Ent. Comm. Bull., VII, p. 56.

*Cynips (Andricus) futilis* PACKARD, 1881, U. S. Ent. Comm. Bull., VII, p. 56.

*Andricus (Callirhytis) papillatus* ASHMEAD, 1885, Trans. Amer. Ent. Soc., XII, p. 295. PACKARD, 1890, 5th Report U. S. Ent. Comm., p. 105. BEUTENMÜLLER, 1892, Bull. Amer. Mus. Nat. Hist., IV, p. 255.

*Callirhytis futilis* ASHMEAD, 1885, Trans. Amer. Ent. Soc., XII, p. 303; 1887, idem, XIV, p. 129. BASSETT, 1889, Psyche, V, pp. 235–237. PACKARD, 1890, 5th Report U. S. Ent. Comm., p. 109. RILEY, 1895, Sci., I, p. 461; 1895, Proc. Ent Soc. Wash., III, p. 261. DALLA TORRE AND KIEFFER, 1910, Gen. Ins., Hymen., Cynip., p. 66. SMITH, 1910, Ins. New Jersey, p. 601. STEBBINS, 1910, Springfield (Mass.) Mus. Bull., II, p. 27. THOMPSON, 1915, Cat. Amer. Ins. Galls, p. 13, Pl. v, fig. 49. LUTZ, 1918, Field Book Ins., p. 462, Pl. XCVI, fig. 4.

*Callirhytis papillatus* ASHMEAD, 1887, Trans. Amer. Ent. Soc., XIV, p. 129. COOK, 1902, Ohio Nat., II, p. 269, fig. 30; 1903, idem, III, p. 427, fig. 64; 1904, idem,

IV, pp. 119, 124, 126, 127, 133, 141, 143, figs. 81, 107. SMITH, 1910, Ins. N. J., p. 601. THOMPSON, 1915, Cat. Amer. Ins. Galls, p. 13, Pl. IV, fig. 57. LUTZ, 1918, Field Book Ins., p. 462, Pl. XCVI, fig. 7.

*Andricus papillatus* PACKARD, 1890, 5th Report U. S. Ent. Comm., p. 109. DALLA TORRE, 1893, Cat. Hymen., II, p. 93. BEUTENMÜLLER, 1904, Bull. Amer. Mus. Nat. Hist., XX, p. 28; 1904, Amer. Mus. Nat. Hist. Guide Leaf. 16, p. 14, fig. COOK, 1905, 29th Report Geol. & Nat. Res. Ind., p. 827, fig. 20. FELT, 1906, Ins. Aff. Pk. & Woodl. Trees, II, p. 712; 1918, N. Y. State Mus. Bull., CC, p. 88, Pl. II, fig. 6.

*Callirhytis papillata* DALLA TORRE AND KIEFFER, 1910, Gen. Ins., Hymen., Cynip., p. 66. STEBBINS, 1910, Springfield (Mass.) Mus. Bull., II, p. 31.

*Callirhytis quercus-futilis* DALLA TORRE AND KIEFFER, 1910, Das Tierreich, XXIV, p. 584, fig. 325.

*Callirhytis quercus-papillata* DALLA TORRE AND KIEFFER, 1910, Das Tierreich, XXIV, p. 584.

*Dryophanta papula* [error] THOMPSON, 1915, Cat. Amer. Ins. Galls, p. 13, Pl. IV, fig. 270.

*? Neuroterus sp.* [error] THOMPSON, 1915, idem, p. 59, Pl. XV, fig. 15.

[*Andricus papillatus* JARVIS, 1908, Report Ent. Soc. Ont., p. 91; 1909, idem, p. 87, Pl. C, fig. 5 = wrong determination.]

FEMALE.—Generally reddish brown or piceous, antennæ yellow, darker apically; mesopleuræ in part smooth and shining; wing-veins light brown, areolet small; length about 1.5 mm. HEAD: golden to dark, reddish brown, brightest on the face, darker toward the mouth, mouth-parts golden; coriaceous; antennæ 14-jointed, golden yellow, darker apically, hairy. THORAX: dark reddish- or piceous-brown; mesonotum regularly coriaceous; parapsidal grooves continuous to the pronotum, convergent at the scutellum; median groove indistinct beyond the middle of the mesothorax, anterior parallel lines indistinct, extending half the length of the mesothorax; lateral grooves shallow, indistinct; scutellum rugose, two shallow foveæ at base finely rugose; pronotum and mesopleuræ finely rugose, the latter in part smooth and shining. ABDOMEN: golden, rufous, or rufo-piceous, brighter basally, smooth and shining, the second segment covering only about half the abdomen. LEGS: reddish brown, hairy, the tarsal claws simple. WINGS: narrow, veins brownish yellow, not heavy; areolet small; cubitus faint, hardly reaching the basal vein, radial cell long and narrow, open; the first abscissa of the radius slightly angulate. LENGTH: 1.5–2.0 mm.

MALE.—Differs from the female in being darker, the antennæ 15-jointed, the second abdominal segment larger.

[Redescribed from bred Massachusetts material, galls and males compared with types.]

GALLS.—Blister-like swellings (Figs. 28 and 29) of the leaf-blades, more or less globular, projecting only slightly on the upper surfaces, projecting in about half a hemisphere on the lower surfaces. Leaf-color, sometimes surrounded by a reddish ring on the surface of the leaf; about 3–7 mm. in diameter. Thin-shelled, hollow, with usually 2 or 3 small larval cells, distinct, central, connected with the outer wall of the gall by fine, silky, radiating fibers. On leaves of *Quercus alba*, *Q. bicolor*, *Q. prinoides*, *Q. Prinus*, and *Q. stellata*.

COTYPES.—Cotype males and galls of both *futilis* and *papillatus* in the Museum of Comparative Zoology, and "type" galls in The American Museum of Natural History.

Osten Sacken did not feel certain of the specific differences of *futilis* and of *papillatus;* the main reason for which the two have been kept distinct is the reddish ring sometimes found around the galls called *papillatus*, and the different host plants of the two. I have compared the types of the two species and believe them to be identical. At the most, *papillatus* may be a host variety of *futilis*. As far as I can discover, the female of this species has not been previously described. It is quite variable as to shade of coloring.

The galls of *futilis* are first discernible about the middle of May, and are then to be found often very abundantly, on the white oak especially, sometimes occurring in numbers on a single leaf. The galls are at first so succulent that they are not easily bred; they should be gathered late in June and be placed directly on moist sand. The adults emerge from the last of June to the middle of July, leaving the empty galls now dry, hard, and brittle. The insects are positively geotropic and, after copulation, oviposit in the bark of the roots or the bases of the trunks of the white oaks.

### **Andricus futilis** form **radicicola** (Dalla Torre)

Plate XXX, Figure 27

*Callirhytis radicis* (*non* Fabricius, 1798) Bassett, 1889, Psyche, V, p. 237. Dalla Torre and Kieffer, 1902, Gen. Ins., Hymen., Cynip., p. 66. Smith, 1910, Ins. N. J., p. 601. Dalla Torre and Kieffer, 1910, Das Tierreich, XXIV, p. 571. Felt, 1908, N. Y. State Mus. Bull., CC, p. 54.

*Andricus radicicola* Dalla Torre, 1893, Cat. Hymen., II, p. 95.

*Andricus* (*Callirhytis*) *radicis* Viereck, 1916, Hymen. Conn., p. 426.

Female.—Bright rufous and darker rufo-piceous; mesopleuræ mostly aciculate with some smooth and shining areas; abdomen with a ring of dense, whitish hairs at the base; areolet of moderate size. Head: bright rufous to dark piceous, slightly darker on the vertex; tips of mandibles piceous; very finely rugose, the face from the bases of the mandibles to the tips of the jaws densely hairy, rest of the head finely pubescent; antennæ 14-jointed, remarkably short, uniformly yellowish rufous or rufous, or somewhat darker distally, densely hairy. Thorax: bright reddish to reddish brown or dark piceous, variable; mesonotum brightest in the center toward the scutellum, densely rugoso-punctate, somewhat striate toward the sides; parapsidal grooves continuous to the pronotum, convergent toward the scutellum, deep, hardly smooth; median groove deep at the scutellum, traceable beyond the middle of the mesothorax to the pronotum; anterior parallel lines close together, smooth, extending half-way to the scutellum; lateral lines smooth, two-thirds the length of the mesothorax, approaching the parapsidal grooves anteriorly. Scutellum almost circular, brighter rufo-piceous, irregularly rugose, the two distinct foveæ at the base smooth; pronotum piceous, rufous anteriorly, rugose, hairy; mesopleuræ piceous black, mostly aciculate, smooth and shining along the posterior and the ventral edges; bright rufous at the bases of the wings. Abdomen: bright rufo-piceous, brighter basally; smooth and shining, two lateral patches and a ring of dense, whitish hairs at

the base of the second segment; this segment covering two-thirds of the abdomen, and somewhat produced dorsally. LEGS: rufous, the coxæ piceous basally, the hind coxæ almost entirely piceous; hairy, hairs densest on the tarsi; tarsal claws simple. WINGS: slightly tinged with yellowish, the veins light yellowish or almost colorless, except the subcostal and basal veins and the first abscissa of the radius which are light brownish yellow; areolet of moderate size or moderately large; cubitus very faint, not reaching the basal vein; radial cell open, broad; first abscissa of the radius angulate, not sharply so, without a projection into the radial cell. LENGTH: 2.7–3.7 mm.

[Redescribed from Bassett material bred from root-galls, and taken ovipositing in white oakbuds.]

GALLS.—Larval cells (Fig. 27) in the scurfy bark of the roots or the basal portions of the trunks of oaks. The cell-wall is distinct but inseparable from the surrounding bark-tissue which does not seem to have much new tissue developed, but is distorted to cover the larval cell, forming pustules about 3–4 mm. in diameter. On the same species of oak, most likely, on which *futilis* occurs.

In 1873 Bassett reported finding a number of wasps of an unknown species ovipositing in the buds of white oaks, which trees bore, at a later date, quantities of the galls of *futilis*. This alone was not sufficient evidence to warrant conclusions, for *futilis* is often exceedingly abundant on the majority of *Q. alba* trees in a region. But by 1889 he was able to report a more complete life history of the species. He had found hundreds of females which agreed with those he had bred from root-galls ovipositing in the buds of trees which later bore *futilis*-galls in abundance and only those galls. This evidence for the relation of the root-gall to the *futilis*-gall does not invite much doubt. The agamic form which had come from the root-galls was described as *radicis*.

The eggs which produce this form were laid in the bark during July. Because of the difficulty of finding these inconspicuous, subterranean galls, little is known of the form until it emerges as an adult the following spring, from April 22 to Arpil 25 and likely later. At such times they are often found ovipositing in the buds of the white oaks, on the new leaves of which the *futilis*-galls will appear.

In 1895 (Proc. Ent. Soc. Washington, III, p. 261) Riley reported the rearing of *futilis* galls by Pergande from buds which he had observed being pricked by several females of a cynipid which Ashmead identified as *Callirhytis clavula*. Riley suggested, therefore, that Bassett's observations were in error because of misidentification. On the other hand, it is to be noted that the value of Riley's record depends on the correctness of Ashmead's identification. I have carefully examined numbers of the very specimens on which Bassett based his report, and they are available to others who wish to study them. I cannot see any specific differences between the individuals bred from root-galls and those marked as "ovi-

positing in *Q. alba* buds, April 22, 1889." Moreover, my own experience with *C. clavula* leads me to doubt the correctness of Riley's report. I know of no published dates of the emergence of that species but, having collected many hundreds of the galls, examining them for enclosed larvæ or adults regularly for a couple of years, I have found nothing to suggest that the imago emerges before the middle or last of July, at which time (July 27) I have been successful in obtaining several adults. Mr. Lewis H. Weld and Wm. Beutenmüller have kindly confirmed my experience by similar records from their own observations, July 12 to July 30 being the emergence dates from their breedings. It is not likely that Riley's insects, found ovipositing three months earlier than *clavula* emerges, could be that species. I have no doubt that there is an error in Riley's report and that Bassett's observations of this species are correct.

**Andricus operator** (Osten Sacken)

RANGE.—Canada: Ottawa (Beutenmüller). Massachusetts: Boston (Clarke); Blue Hills, Sharon; Springfield (Stebbins). Rhode Island: Providence (Thompson). Connecticut: Waterbury (Bassett). New York: Sullivan Co. (Beutenmüller); Staten Island (W. T. Davis). New Jersey: Plainfield, New Brunswick, Milltown, Davis, Hornerstown (in Coll. Amer. Mus. Nat. Hist.). Pennsylvania (Beutenmüller). District of Columbia (Osten Sacken). Illinois (Walsh).

**Andricus operator** form **operator** (Osten Sacken)

Plate XXXI, Figure 32

*Cynips quercus operator* OSTEN SACKEN, 1862, Proc. Ent. Soc. Phila., I, p. 256.

*Cynips q. operator* BASSETT, 1863, Proc. Ent. Soc. Phila., II, p. 332; 1864, idem, III, pp. 197, 198. WALSH, 1864, Proc. Ent. Soc. Phila., II, p. 494. BASSETT, 1873, Can. Ent., V., pp. 91, 93, 94; 1877, Can. Ent., IX, p. 121. RILEY, 1873, Amer. Nat., VII, p. 519. HOWARD, 1882, Psyche, III, p. 329. PACKARD, 1890, 5th Report U. S. Ent. Comm., p. 11.

*Cynips operator* OSTEN SACKEN, 1865, Proc. Ent. Soc. Phila., IV, pp. 341, 346, 350, 357.

[No name] BASSETT, 1880, Can. Ent., XII, p. 170.

*Andricus (Callirhytis) operator* MAYR, 1881, Gen. Gallenbew. Cynip., p. 28. BASSETT, 1882, Amer. Nat., XVI, p. 246. ASHMEAD, 1885, Trans. Amer. Ent. Soc., XII, p. 294. PACKARD, 1890, 5th Report U. S. Ent. Comm., p. 105. VIERECK, 1916, Hymen. Conn., p. 429.

*Callirhytis operator* ASHMEAD, 1885, Trans. Amer. Ent. Soc., XII, p. 304; 1887, idem, XIV, p. 131. PACKARD, 1890, 5th Report U. S. Ent. Comm., p. 110. RILEY, 1895, Sci., I, p. 463. DALLA TORRE AND KIEFFER, 1902, Gen. Ins., Hymen., Cynip., p. 66. STEBBINS, 1910, Springfield (Mass.) Mus. Bull., II, p. 25, fig. 47. SMITH, 1910, Ins. N. J., p. 601. THOMPSON, 1915, Cat. Amer. Ins. Galls, pp. 11, 30, Pl. II, fig. 169. FELT, 1918, N. Y. State Mus. Bull., CC, p. 72.

*Andricus operator* DALLA TORRE, 1893, Cat. Hymen., II, p. 92. BASSETT, 1900, Trans. Amer. Ent. Soc., XXVI, p. 315. FELT, 1906, Ins. Aff. Pk. and Woodl. Trees, II, pp. 618, 622, 713.

*Callirhytis quercus-operator* DALLA TORRE AND KIEFFER, 1910, Das Tierreich, XXIV, p. 582.

FEMALE.—Generally bright brownish, rufous, median groove essentially lacking; several of the wing-veins very faint, the terminal portion of the subcosta almost lacking, areolet closed. HEAD: bright brownish rufous, darker toward the cheeks and vertex, tips of mandibles piceous; finely shagreened, a broad median elevation on the face; antennæ 12–13-jointed, the last division sometimes obscure, uniformly light brownish rufous, glabrous, the first joint obconical, the second ovate, the third elongate and the longest segment. THORAX: bright brownish rufous, irregularly darker in places; glabrous; the mesonotum finely, shallowly shagreened; parapsidal grooves punctate, widely separated, hardly at all convergent at the scutellum, divergent at the pronotum; median groove faint or lacking; anterior parallel lines fine, not very distinct, extending half-way to the scutellum; lateral grooves almost parallel to the parapsides, extending over half the way to the pronotum. Scutellum rather circular, rugose, the two foveæ broad, deep, shining but sparsely rugose, separated by only a fine ridge; pronotum finely punctate-shagreened, the mesopleuræ finely shagreened to striate ventrally. ABDOMEN: rich rufous, brighter basally, darker apically and dorsally, essentially smooth and shining, very microscopically punctate; the second segment covering two-thirds of the abdomen; the sheaths of the ovipositor pointing almost vertically. LEGS: rather uniformly rufous brown; the tarsal claws darker, simple. WINGS: clear, the wing-veins, especially on the basal half of the wings, light brown, terminal portion of the subcosta very faint or lacking; areolet closed; cubitus not reaching the basal vein; the radial cell open; the first abscissa of the radius angulate, the angle about 120°, without a projection into the radial cell. LENGTH: 2.2–2.5 mm.

MALE.—Similar to the female, but more generally yellowish rufous, the antennæ light yellowish rufous, 14-jointed, the third joint incised beneath; the abdomen bright yellowish rufous basally, almost black posteriorly, smaller and more slender, the second segment covering most of the abdomen; length, 1.7–2.2 mm.

[Redescribed from Massachusetts material bred in a series of over 600 individuals.]

GALLS.—Large, compact masses (Fig. 32) of wool containing seed-like larval cells. The clusters are irregular in shape, often oval, 4×5.5 cm., more or less, in dimensions, the hairs at first crisp, succulent, greenish, white, or rose-tinged, sometimes deep red, becoming yellowish brown with age, finally weathering bluish gray or black and drying into a shrivelled mass. Within the wool, scattered or in small clusters, are the larval cells, hard and rather thick-walled, oval, about 1.5×3 mm., distributed mostly but not entirely toward the center of the gall. On and involving the young terminal stems, new clusters of leaves, and especially the flower clusters of *Quercus coccinea, Q. ilicifolia, Q. marylandica, Q. palustris, Q. rubra, Q. velutina,* and likely related oaks.

COTYPES.—Cotype females and galls in the Museum of Comparative Zoology.

The gall of this form is a very abundant early-spring gall in scrub-oak country, appearing with the flowers of the oaks about the middle of May and growing rapidly. It should not be gathered for breeding until after the first of June, for it is succulent when first formed and dries and dies unless nearly mature when gathered. The woolly hairs, Bassett has

pointed out, are merely a much modified leaf pubescence. The galls, after the emergence of the adults, become much the worse for weathering and by autumn only fragments of the wool remain upon the trees. The galls often bring great numbers of the insects to maturity; from three galls I obtained 578 adults which emerged from June 9 to June 30. The sexes are produced in about equal numbers. The females, as Bassett discovered, deposit the eggs in the acorns of the scrub-oaks, inserting the ovipositor between the nut and the cup of the very small, young acorns. The gall produced is the form *operatola*.

**Andricus operator** form **operatola** (Bassett)

Plate XXXI, Figures 30 and 31

*Cynips q. operatola* RILEY, 1873, Amer. Nat., VII, p. 519 [Adult not described].

*Callirhytis operatola* RILEY, 1895, Sci., I, p. 463. THOMPSON, 1915, Cat. Amer. Ins. Galls, pp. 21, 30, Pl. II, fig. 169.

*Andricus operatola* BASSETT, 1900, Trans. Amer. Ent. Soc., XXVI, p. 315 [Adult first described]. DALLA TORRE AND KIEFFER, 1902, Gen. Ins., Hymen., Cynip., p. 62; 1910, Das Tierreich, XXIV, p. 550. BEUTENMÜLLER, 1913, Bull. Brooklyn Ent. Soc., VIII, p. 103, fig. 8. VIERECK, 1916, Hymen. Conn., p. 418.

*Andricus operator* form *operatola* FELT, 1906, Ins. Aff. Pk. and Woodl. Trees, II, p. 709.

*Callirhytis operator* STEBBINS, 1910, Springfield (Mass.) Mus. Bull., II, p. 26, fig. 48.

*Andricus operator* FELT, 1918, N. Y. State Mus. Bull., CC, p. 118, Pl. II, fig. 5.

FEMALE.—Generally rufous; median groove faint or lacking; mesopleuræ rather heavily aciculated; second abdominal segment hairy; several wing-veins faint, the terminal portion of the subcosta lacking. HEAD: rufous, the tips of the mandibles piceous; coriaceous or shagreened; face and cheeks finely hairy; antennæ rufous, irregularly marked brown, 12-13-jointed, third joint the longest, twelfth joint obscurely divided. THORAX: bright rufous, irregularly darker on the anterior parallel lines, at the edges of the thoracic plates, and elsewhere; mesonotum punctate to finely rugulose, with appressed hairs; parapsidal grooves punctate, widely separated and hardly convergent at the scutellum, divergent at the pronotum; median groove very faint or lacking; anterior parallel lines extending half-way to the scutellum; the lateral grooves sinuous, short and smooth; scutellum almost circular, rugose hairy, the foveæ at the base are shining but sparsely rugose, separated by a not broad ridge; pronotum coriaceous; the mesopleuræ rather heavily aciculated. ABDOMEN: bright rufous, brightest basally, darker dorsally and posteriorly, essentially smooth and shining, only microscopically punctate, the second segment with appressed hairs basally and largely over the sides; second segment covering three-quarters of the abdomen, considerably produced dorsally. LEGS: rufous, not uniformly so, hairy, the tarsal claws darker, simple. WINGS: veins reddish brown, the terminal part of the subcosta faint or lacking, the second abscissa of the radius, the cubitus, and the discoideus very faint; areolet rather small or lacking; the cubitus continuous to the basal vein but hardly apparent; the radial cell open; the first abscissa of the radius angulate, the angle about 120° without a projection into the radial cell. LENGTH: 3.2–3.5 mm.

[Redescribed from material Bassett found ovipositing May 4, 1873, to produce the woolly gall.]

GALL.—A small, seed-like gall (Figs. 30 and 31) at the base of the nut of the acorn, inside the cup. The gall suggests a development of the aborted ovule of the acorn, but sometimes five or six occur in a single acorn. It is a compressed, inverted cone in shape, about 5 mm. high by 4 mm. in diameter, larger or smaller, and is thin-walled, the larval cell occupying most of the gall. In the acorns of *Quercus ilicifolia* and of the other red oaks on which the bisexual form occurs.

COTYPES.—In the collections of The American Museum of Natural History and of the Academy of Natural Sciences of Philadelphia.

The agamic female is in many detailed respects quite similar to the female *operator*. It is similar in head and thoracic sculpture, peculiarities of coloration, wing venation, etc., and is to a certain extent merely an enlarged edition of *operator*, with, of course, enough "specific" differences. The most remarkable character of the heterogeny of this species really lies in the very great differences of the galls of the two generations, and even this does not appear so remarkable when one considers the totally different natures of the parts of the plant affected.

The gall of *operatola* usually escapes detection until the fall, when the growing gall projects beyond the rim of the acorn cup and often splits or otherwise deforms the nut of the acorn. These galls fall to the ground, sometimes fixed in place, more often broken out of the fruit, so that acorns bearing the scars of the galls may be found abundantly under scrub-oaks. The galls are highly parasitized and are often much damaged by wintering on the ground—another instance of the poor quality of the "protection" afforded a gall-wasp. Consequently, it is a difficult matter to rear the adults of this form. Bassett states that the insects may mature the following spring or may remain in the galls until the second or even third spring before they emerge. He found them emerging May 4 and ovipositing in the young buds of the oaks.

Bassett's observations of this species finally led to the first absolute proof that heterogeny occurred in the Cynipidæ. A detailed account of the discovery has been given on page 324. Adults have been bred from galls of both generations and each of these have been observed to oviposit to produce the galls of the other generation. Bassett's observations were apparently made in the open, but his definite statements would indicate that the pricked parts were definitely marked for later identification.

**Andricus palustris** (Osten Sacken)

RANGE.—Canada: Ottawa (Provancher); Toronto (Cosens). Maine (Patch). Massachusetts: Magnolia (Clarke); Boston; Springfield (Stebbins); Marthas Vineyard. Rhode Island: Providence (Thompson). Connecticut: New Haven (Walden); Waterbury (Bassett). New York: Cypress Hill, Nyack (Zabriskie); New York City (Beutenmüller). New Jersey (Smith); Fort Lee, Mattawan (Beutenmüller). Pennsylvania (Beutenmüller). District of Columbia: Washington (Osten Sacken).

Ohio (Beutenmüller). Indiana (Cook). Illinois (Walsh). Michigan (Beutenmüller). Iowa: Ames (Gillette).

### **Andricus palustris** form **palustris** (Osten Sacken)

Plate XXX, Figures 23 and 24

*Cynips q. palustris* Osten Sacken, 1861, Stett. Ent. Zeit., XXII, pp. 409, 412; 1865, Proc. Ent. Soc. Phila., IV, pp. 343, 346, 349. Bassett, 1863, Proc. Ent. Soc. Phila., II, p. 329. Walsh, 1864, Proc. Ent. Soc. Phila., II, p. 488.

*Cynips quercus palustris* Osten Sacken, 1861, Proc. Ent. Soc. Phila., I, pp. 51, 62; 1865, Proc. Ent. Soc. Phila., IV, p. 359; 1870, Trans. Amer. Ent. Soc., III, p. 54. Packard, 1890, 5th Report U. S. Ent. Comm., p. 113.

*Cynips (Trigonaspis ?) quercus palustris* Osten Sacken, 1861, Proc. Ent. Soc. Phila., I, p. 63.

*Cynips q. notha* Osten Sacken, 1870, Trans. Amer. Ent. Soc., III, p. 55. Thompson, 1915, Cat. Amer. Ins. Galls, p. 28.

*Andricus (Callirhytis) palustris* Mayr, 1881, Gen. Gallenbew. Cynip., p. 28. Bassett, 1882, Amer. Nat., XVI, p. 246. Ashmead, 1885, Trans. Amer. Ent. Soc., XII, p. 294. Provancher, 1886, Addit. Fauna Canad. Hymen., p. 54. Packard, 1890, 5th Report U. S. Ent. Comm., p. 105. Beutenmüller, 1892, Bull. Amer. Mus. Nat. Hist., IV, p. 256. Thompson, 1915, Cat. Amer. Ins. Galls, p. 30.

*Andricus (Callirhytis) notha* Ashmead, 1885, Trans. Amer. Ent. Soc., XII, p. 295. Packard, 1890, 5th Report U. S. Ent. Comm., p. 105.

*Callirhytis notha* Ashmead, 1885, Trans. Amer. Ent. Soc., XII, p. 304. Packard, 1890, 5th Report U. S. Ent. Comm., p. 110. Dalla Torre and Kieffer, 1902, Gen. Ins., Hymen., Cynip., p. 66.

*Callirhytis palustris* Ashmead, 1885, Trans. Amer. Ent. Soc., XII, p. 304. Packard, 1890, 5th Report U. S. Ent. Comm., p. 110. Dalla Torre and Kieffer, 1902, Gen. Ins., Hymen., Cynip., p. 66. Stebbins, 1910, Springfield (Mass.) Mus. Bull., II, pp. 21, 23, 26, fig. 37. Smith, 1910, Ins. N. J., p. 601. Thompson, 1915, Cat. Amer. Ins. Galls, p. 14. Lutz, 1918, Field Book Ins., p. 462, Pl. xcvi, fig. 11.

*Dryophanta notha* Ashmead, 1887, Trans. Amer. Ent. Soc., XIV, p. 129. Dalla Torre, 1893, Cat. Hymen., II, p. 53. Beutenmüller, 1911, Bull. Amer. Mus. Nat. Hist., XXX, p. 366, Pl. xvi, fig. 4. Thompson, 1915, Cat. Amer. Ins. Galls, p. 38. Felt, 1918, N. Y. State Mus. Bull., CC, p. 106, fig. 68, 4.

*Dryophanta palustris* Ashmead, 1887, Trans. Amer. Ent. Soc., XIV, p. 129. Cresson, 1887, idem, XIV, Suppl., p. 179. Bassett, 1890, idem, XVII, p. 74. Dalla Torre 1893, Cat. Hymen., II, p. 53. Cook, 1902, Ohio State Univ. Bull., Ser. 6, p. 268, fig. 29; 1903, idem, Ser. 7, p. 427, fig. 65; 1904, idem Ser. 8, figs. 82, 84, 84*b*, 94. Beutenmüller, 1911, Bull. Amer. Mus. Nat. Hist., XXX, p. 361, Pl. xv, figs. 1–4, Pl. xvii, figs. 1–2. Cosens, 1912, Trans. Can. Inst., IX, p. 344, figs. 49–52. Thompson, 1915, Cat. Amer. Ins. Galls, pp. 21, 38, Pl. i, fig. 167. Felt, 1918, N. Y. State Mus. Bull., CC, p. 90, figs. 86, 87 (1–4)

*Andricus palustris* Provancher, 1889, Add. et correct., p. 163. Beütenmuller, 1904, Amer. Mus. Journ., IV, p. 101, fig. 26; 1904, Amer. Mus. Nat. Hist. Guide Leaf. 16, p. 15, fig. Cook, 1905, 29th Report Dept. Geol. & Nat. Hist. Ind., p. 829, fig. 22. Jarvis, 1906, 37th Report Ent. Soc. Ont., p. 71. Felt, 1906, Ins. Aff. Pk. & Woodl. Trees, II, p. 714. Viereck, 1916, Hymen. Conn., p. 419.

*Andricus (Callirhytis) pusulatoides* BASSETT, 1890, Trans. Amer. Ent. Soc., XVII, p. 74.

*Andricus pusulatoides* DALLA TORRE, 1893, Cat. Hymen., II, p. 94. FELT, 1906, Ins. Aff. Pk. & Woodl. Trees, II, p. 712.

*Neuroterus notha* ASHMEAD, 1899, Proc. Ent. Soc. Wash., IV, p. 332.

*Callirhytis pustulatoides* DALLA TORRE AND KIEFFER, 1902, Gen. Ins. Hymen., Cynip., p. 66; 1910, Das Tierreich, XXIV, p. 570.

*Callirhytis quercus-palustris* DALLA TORRE AND KIEFFER, 1910, Das Tierreich, XXIV, p. 565.

*Callirhytis quercus-notha* DALLA TORRE AND KIEFFER, 1910, Das Tierreich, XXIV, p. 565.

*Callirhytis pusulatoides* STEBBINS, 1910, Springfield (Mass.) Mus. Bull., II, p. 23. THOMPSON, 1915, Cat. Amer. Ins. Galls, pp. 14, 30.

*Cynips notha* THOMPSON, 1915, Cat. Amer. Ins. Galls, p. 14.

*Andricus (Callirhytis) pustulatoides* VIERECK, 1916, Hymen. Conn., p. 433.

The following are very likely synonyms of *Andricus palustris palustris:*

*Cynips q. aquaticæ* ASHMEAD, 1881, Trans. Amer. Ent. Soc., IX, p. xvi [Florida].

*Spathegaster q. laurifoliæ* ASHMEAD, 1881, idem, IX, p. xvii [Florida].

*Andricus (Callirhytis) quercifoliæ* ASHMEAD, 1885, idem, XII, pp. 295, 299 [Florida].

*Dryophanta liberœcellulæ* GILLETTE, 1889, Iowa Agric. Exp. Sta. Bull., VII, p. 283, fig. 27 [Iowa, Michigan].

FEMALE.—Head, thorax, and abdomen black; antennæ brown, yellow basally; the legs a dull amber-brown; mesonotum shining, almost smooth, the parapsidal grooves distinct, other lines lacking; wing-veins heavy, the areolet of moderate or small size. HEAD: black, reddish on the mouth-parts, finely coriaceous, the face with a few scattered hairs; antennæ 14-jointed, dark brown, the first three or four joints dull amber-yellow. THORAX: black, mesonotum finely coriaceous but appearing almost smooth and shining; parapsidal grooves broad, deep, continuous to the pronotum; median groove very short or lacking; anterior parallel lines and lateral lines lacking; scutellum black, elongate, rugoso-punctate, the shallow foveal depression at the base coriaceous; pronotum almost smooth; mesopleuræ slightly rugose. ABDOMEN: black, smooth, shining, the second segment "tongue shaped," i. e., produced dorsally. LEGS: dull amber-yellow or brown, the tips of the tarsi almost black; hairy; the tarsal claws simple. WINGS: clear, the veins dark brown, areolet small, cubitus not quite reaching the basal vein; radial cell open; the first abscissa of the radius slightly angulate, without a projection into the radial cell. LENGTH: 1.8–2.3 mm.

MALE.—Similar to the female, but with the antennæ 15-jointed, the third joint somewhat thickened apically and appearing slightly curved; the abdomen small and petiolate.

[Redescribed from material bred in life-history experiments, and compared with types.]

GALLS.—Globular, entirely hollow, succulent galls (Figs. 23 and 24) the size of a cherry, containing a free larval cell. The galls average about 3-12 mm. in diameter, are green or rose-tinged, very succulent, quickly shrivelling or decaying, and are entirely glabrous or in other instances roughened or densely but finely pubescent, depending upon the nature of the host. The mature gall is thin-walled, entirely hollow, more or less filled with a liquid, and contains a single larval cell, whitish,

averaging 2.0 mm. in diameter, hard but thin-walled, entirely free, rolling about within the gall. Singly or in clusters, sometimes somewhat fused together, on the young buds, aments, petioles, and leaf-blades of oaks, sometimes only slightly attached, at other times inseparable from the leaf-tissue. On *Quercus coccinea, Q. falcata, Q. ilicifolia, Q. imbricaria, Q. marilandica, Q. palustris, Q. phellos, Q. rubra, Q. velutina,* and most likely other red oaks.

COTYPES.—Cotype females, males, and galls in the collection of the Museum of Comparative Zoology.

I have examined the types of *Andricus notha* (Osten Sacken) and the adults appear to be true *palustris*. The galls are somewhat more oval in shape, with the larval cell more elongate, but I have found that that character shows gradations in large series of *palustris* and there is little doubt that *notha* is, as Osten Sacken strongly suspicioned, not distinct. Beutenmüller makes *Andricus pusulatoides* Bassett a synonym of *notha*. Beutenmüller (1911, Bull. Amer. Mus. Nat. Hist., XXX) also says that he cannot find essential differences between true *palustris* and the types of *Dryophanta aquaticæ, D. laurifoliæ,* and *D. liberæ-cellulæ* but, because of lack of sufficient material, he prefers to consider them distinct. I can hardly see any justification for keeping those names out of the synonymy.

The gall of *Andricus palustris palustris* is one of the best-known of the galls of early spring, appearing abundantly on red oaks of many species, often before any leaves have appeared. They often crowd closely on the flowers of the oaks. When the galls first appear they are solid, with the larval cell distinct but entirely connected with the outer walls of the gall; but within a very few days or even hours the gall, growing very rapidly, becomes hollow, leaving the larval cell (which had gained its full size in the young gall) loose to roll about within the enlarged outer wall at every movement of the branches of the tree. How the nourishment is provided for the larval cell and the enclosed larva is a process yet to be studied. During damp weather the galls will be found to contain a more or less viscous liquid, and placed in a pan of water they become filled with this liquid. It is probable that food is carried by osmosis to the larval chamber. Galls taken from the tree will grow still larger if placed directly on very moist sand or in water, indicating how independent an organism these deformations may become.

Because the galls are so very succulent they should not be gathered for breeding until they are about mature, and should then be placed directly on very moist sand. The growth of these galls is very rapid after their first appearance upon the trees and they are mature within

ten days or two weeks. The pupation period of the insect is very short; within a few days the adult emerges and within another few days the galls are mostly completely withered away or have decayed.

The adults emerge from mid-May to June 4, depending on the latitude and the progress of the season. The insects are produced in about equal numbers of the sexes. They copulate almost immediately upon emergence and run rapidly up the branches to the young leaves, on the under sides of which they settle to oviposit, often remaining there for several days before they die. In all, only about a month has passed from the time of the first appearance of the young gall to the time of oviposition. Over ten months will be required for the alternate generation to reach full maturity.

The experiments by which I was fortunate enough to discover the relations of the two generations of this species were made under the strictly controlled conditions which I have described in the introduction. The tree on which the sexual adults were put was covered with a net for almost a month and there was no chance of other insects having reached it during that time, nor is there much likelihood of the galls having been produced by insects from any other source. Of the thirty small oaks in the greenhouse, none produced any galls that season (1918) except the one on which the *palustris* had been isolated. Several scores of the adults of that form were observed to oviposit on the under surface of the leaves on which eight galls of *Philonix compressa* were found the first of September. The small size of the galls had prevented their detection earlier, for it is likely that they appear by the first of August.

*P. compressa* was a "species" known definitely from only two stations, Westchester Co., N. Y., and Ames, Iowa, while *palustris* had been known for sixty years to be a very abundant species throughout eastern America. It was rather surprising to find an apparently rare, local species to be the alternate form of one of the commonest of widely distributed galls. Fortunately, I recalled definitely the location of the very trees on which I had found the *palustris* galls from which the experimental material had been bred. I made a trip to these trees and found the leaves bearing an abundance of the *compressa* galls. Then I found the galls in the Millett Thompson Collection, taken in Massachusetts or Rhode Island; these were figured in the Thompson Catalogue but the collection was not recorded in the text. After that, I collected *compressa* galls at Melrose Highlands, Forest Hills, and Blue Hills, which are in the neighborhood of Boston, and always found it abundant at that date. The small size of the galls and the fact that they are very quickly decidu-

ous is sufficient explanation of the failure of previous collectors to find the form.

### **Andricus palustris** form **compressus** (Gillette)

Plate XXX, Figures 25 and 26

*Acraspis compressus* GILLETTE, 1891, Bull. Ill. Lab. Nat. Hist., III, p. 197.

*Acraspis compressa* DALLA TORRE, 1893, Cat. Hymen., Cynip., II, p. 64. DALLA TORRE AND KIEFFER, 1902, Gen. Ins., Hymen., Cynip., p. 58. DALLA TORRE AND KIEFFER, 1910, Das Tierreich, XXIV, p. 409.

*Philonix compressa* BEUTENMÜLLER, 1909, Bull. Amer. Mus. Nat. Hist., XXVI, p. 253. FELT, 1918, N. Y. State Mus. Bull., CC, p. 94.

*Acraspis compressum* THOMPSON, 1915, Cat. Amer. Ins. Galls., pp. 15, 35, Pl. IV, fig. 78.

FEMALE.—Wingless, small, ant-like, the head nearly twice as broad as the thorax, the abdomen compressed and very large, circular. HEAD: rufous, darker dorsally, very finely reticulate or regularly coriaceous; antennæ 14-jointed, rufous basally, shading into dark brown apically. THORAX: entirely rufous, coriaceous, very small and narrow, about one-half as wide as the head, not twice as long as wide; parapsidal grooves continuous to the pronotum but not very evident because of the small size of the mesothorax; other furrows lacking; scutellum very narrow, elevated posteriorly, with two very tiny foveæ at the base. ABDOMEN: rufous or rufo-piceous, brightest basally and dorsally; smooth and shining; very large, circular, strongly compressed, the second segment about one-half the length of the abdomen. LEGS: rufous to reddish brown, the hind legs darker. WINGS: entirely wanting. LENGTH: 2.5 mm.

GALLS.—Small, globular galls, (Figs. 25 and 26), 2–3 mm. in diameter, very slightly attached to the under surfaces (rarely the upper surfaces) of the leaves by a slight projection on the gall. White or pinkish, wax-like, solid and succulent at first, quickly deciduous, after which the gall enlarges and becomes brown, thin-walled, and hollow, the cavity constituting the larval cell. On the same species of red oaks, most likely, as the *palustris* gall.

TYPES.—At the Illinois State Laboratory of Natural History (Urbana, Illinois).

These minute galls are very quickly deciduous, falling in October or early November, usually before the leaves, to the ground where they undergo further development. The larva does not pupate until the next spring, a little time before emerging in April or early May, just before the time of appearance of *palustris* galls.

### **Andricus fulvicollis** (Fitch)

RANGE.—Ontario: Toronto (Cosens). Massachusetts (Clarke). Connecticut: Waterbury (Bassett). New York: New York City (Beutenmüller); Staten Island (Davis). New Jersey: Fort Lee, Paterson, New Brunswick (in Coll. Amer. Mus. Nat. Hist.). Pennsylvania: Philadelphia (Bassett). Virginia (Beutenmüller). North Carolina (Beutenmüller). Florida (?Beutenmüller). Ohio (Bassett). Indiana (Cook). Illinois (Walsh). Michigan: Lansing (Gillette). Iowa (Gillette). Kansas, (Bridewell). Oklahoma: Ben's Farm, Arkansas River (in Coll. Amer. Mus. Nat. Hist.). Colorado (?Ashmead).

**Andricus fulvicollis** form **bicolens**, new name

Plate XXXI, Figure 33

*Dryophanta erinacei* TRIGGERSON, 1914, Ann. Amer. Ent. Soc., VII, pp. 4–7, Pl. I, fig. 4, Pl. II, figs. 7, 9, 10, Pl. III, figs. 21–29, Pl. IX, fig. 70.

*Cynips erinacei* FELT, 1918, N. Y. State Mus. Bull., CC, p. 75.

FEMALE.—Generally piceous black; the parapsidal grooves not reaching the pronotum, lateral grooves broad and shallow, mesonotum otherwise about smooth, first abdominal segment only one-third the length of the abdomen. HEAD: black, rough, face sparsely hairy, mouth-parts yellowish brown; head not broadened behind the eyes; cheeks not half as long as the eyes; antennæ brown, lighter basally, hairy, 14-jointed, the first two segments considerably stouter than the following. THORAX: piceous black to black, mesonotum almost smooth, slightly roughened, coriaceous to finely rugose anterior of the parapsidal grooves; parapsidal grooves distinct, continuous almost but not entirely to the pronotum; median groove and anterior parallel lines lacking; lateral grooves broad and shallow, two-thirds the length of the pronotum; scutellum black, somewhat angulate in outline, finely rugose and finely hairy, with two, small, shallow, not smooth, divergent foveæ at the base; pronotum and mesopleuræ almost but not entirely smooth. ABDOMEN: piceous or brownish black, lightest basally, almost smooth, the second segment only about one-third the length of the whole abdomen. LEGS: clear amber-brown, hairy, the coxæ darker brown, the tarsal claws simple, brownish black. WINGS: tinged with yellowish, the veins light brown; areolet rather large; cubitus fainter than other veins but continuous to the basal vein; the radial area open; first abscissa of the radius angulate, slightly and limitedly clouded, the angle about 135°. LENGTH: 1.7–2.0 mm.

MALE.—Similar to the female; generally more brownish piceous; antennæ 15-jointed; legs lighter yellowish brown; abdomen smaller, petiolate; length, 1.5–1.7 mm.

[Redescribed from Illinois material bred by Mr. Lewis H. Weld.]

GALLS.—Small, thin-walled, elongate egg-shaped galls (Fig. 33), within the bud-scales. The galls are about 2–3 mm. long, all but microscopically smooth, monothalamous, thin-walled, yellowish brown, without a separate or even distinct larval cell; sometimes two or three galls will develop in the same bud-scale and become fused. In the bud-scales or ("*bicolens*") on the terminal portions of leaf and flower buds of *Quercus alba*.

TYPES.—?

In 1914 C. J. Triggerson reported from the Entomological Laboratory of Cornell University an account of the life history of this species, together with a study of its parasites and inquilines, and questions concerning the stimulus for gall formation. The observations on the life history of this wasp are more complete, and the evidence concerning the alternate generations more definite than for any other species of American cynipid, to date. Branches with buds in which the agamic form had oviposited were brought into the laboratory, where the adults of the second generation were bred from the galls. Oviposition of this generation was observed both in the laboratory and in the field, and later

at these points galls of the agamic generation were obtained and the agamic female was again bred. Triggerson's account furnishes many details of the life history of the species, and no attempt need be made here to give much more than descriptions of the galls and adults of the two generations.

According to Triggerson, the galls of this form were first visible about May 12; the adults emerge from May 21 (indoors) or May 29 (out-of-doors) until June 5. They oviposit immediately to produce the agamic generation.

### **Andricus fulvicollis** form **erinacei** (Beutenmüller)

Plate XXXI, Figure 34

*Philonix fulvicollis* FITCH, 1859, 5th Report on Noxious. . . Ins. N. Y., p. 783. OSTEN SACKEN, 1865, Proc. Ent. Soc. Phila., IV, p. 353. ASHMEAD, 1903, Psyche, X, p. 148. FELT, 1906, Ins. Aff. Pk. & Woodl. Trees, II, p. 711. BEUTENMÜLLER, 1909, Bull. Amer. Mus. Nat. Hist., XXVI, p. 254; 1918, Ent. News, XXIX, p. 328. VIERECK, 1916, Hymen. Conn., p. 381.

*Cynips q. erinacei* WALSH, 1864, Proc. Ent. Soc. Phila., II, p. 483.

*Teras fulvicollis* OSTEN SACKEN, 1865, Proc. Ent. Soc. Phila., IV, p. 379.

*Cynips (Teras) fulvicollis* PACKARD, 1881, U. S. Ent. Comm. Bull., VII, p.56.

*Acraspis erinacei* MAYR, 1881, Gen. Gallenbew. Cynip., p. 30. ASHMEAD, 1885, Trans. Amer. Ent. Soc., XII, p. 295; 1887, Trans. Amer. Ent. Soc., XIV, p. 128; 1890, Colo. Biol. Assoc. Bull., I, p. 38. GILLETTE, 1888, 27th Report Agric. Mich., p. 470; 1889, Psyche, V, pp. 186, 221; 1892, Proc. Iowa. Acad. Sci., I, part 2, p. 112. PACKARD, 1890, 5th Report U. S. Ent. Comm., p. 106. BEUTENMÜLLER, 1892, Bull. Amer. Mus. Nat. Hist., IV, p. 259, Pl. XII, fig. 1; 1904, Amer. Mus. Nat. Hist. Guide Leaflet 16, p. 18; 1904, Amer. Mus. Journ., IV, p. 104, fig. 35. DALLA TORRE, 1893, Cat. Hyman., II, p. 64. BRIDEWELL, 1899, Trans. Kans. Acad. Sci., XVI, p. 203. DALLA TORRE AND KIEFFER, 1902, Gen. Ins., Hymen., Cynip., p. 58. COOK, 1905, 29th Report Dept. Geol & Nat. Res. Ind., p. 832, fig. 25; 1910, Mich. Geol. & Biol. Surv. Publ. 1, p. 28. JARVIS, 1906, 37th Report Ent. Soc. Ont., p. 70. FELT, 1906, Ins. Aff. Pk. & Woodl Trees, II, pp. 619, 627. THOMPSON, 1915, Cat. Amer. Ins. Galls, pp. 15, 35. FAGAN, 1918, Amer. Nat., LII, p. 157. LUTZ, 1918, Field Book Ins., p. 462, Pl. XCVII, fig. 4.

*Biorhiza fulvicollis* ASHMEAD, 1885, Trans. Amer Ent. Soc., XII, pp. 296, 304. PACKARD, 1890, 5th Report U. S. Ent. Comm., pp. 106, 110. DALLA TORRE AND KIEFFER, 1910, Das Tierreich, XXIV, p. 402.

*Biorrhiza fulvicollis* DALLA TORRE, 1893, Cat. Hymen., Cynip., II, p. 60. DALLA TORRE AND KIEFFER, 1902, Gen. Ins., Hymen., Cynip., p. 56.

*Philonix erinacei* BEUTENMÜLLER, 1909, Bull. Amer. Mus. Nat. Hist., XXVI, p. 247 [first description of adult named *erinacei*], Pl. XLIII, fig. 24. SMITH, 1910, Ins N. J., p. 598. Cosens, 1912, Trans. Canad. Inst., p. 341, fig. 64.

*Acraspis quercus-erinacei* DALLA TORRE AND KIEFFER, 1910, Das Tierreich. XXIV, p. 413, fig. 118.

*Philonyx fulvicollis* SMITH, 1910, Ins. N. J., p. 598.

FEMALE.—Almost wingless; antennæ black, basal joints rufous; parapsidal grooves not quite reaching the pronotum; thorax densely hairy anteriorly and on the mesopleuræ; abdomen large, considerably elongate. HEAD: black, with a more or less large amount of rufous around the compound eyes and on the mouth-parts; rather finely rugose, more rugose toward the vertex and toward the mouth-parts; hairy; antennæ 14-jointed, black, basal joints rufous. THORAX: mesonotum rufous, coriaceous or very finely rugose, very hairy anteriorly; parapsidal grooves indistinct, not quite extending to the pronotum, gradually convergent toward the scutellum; median groove very short but distinct; anterior parallel lines essentially absent; lateral grooves present, not deep; scutellum rufous, blackish basally, hairy, rugose, long and narrow, with a short, projecting spine terminally, the two, shallow, narrow foveæ at the base only finely separated; pronotum rugose, black, more or less rufous laterally, densely hairy; mesopleuræ black, aciculate to rugose, densely hairy. ABDOMEN: large, considerably elongate, piceous black, with more or less rufous, especially basally and terminally, hairy on the sides ventrally, densely hairy at the tip of the hypopygium and at the tip of the abdomen; second segment not quite one-half the total abdominal length. LEGS: rufous, hairy, irregularly darker in places; tarsal claws large, toothed. WINGS: rudimentary, not twice the length of the scutellum. LENGTH: 1.5–3.0 mm.

[Redescribed from Bassett material from Ohio and Connecticut.]

GALLS.—Oval leaf-galls (Fig. 34), densely covered with fine spines, reddish purple. The galls are globular or more often oval, 10×14 mm., more or less, the surface light yellowish, closely set with small, raised points, each tipped with a slender, thread like, flexuous spine 2 or 3 mm. long, yellowish, reddish purple, or blackish in color. Within, the tissue is compact-granular, the larval cells usually two or three (two to eight), each measuring about 1.5×2.0 mm., the cells distinct but inseparable. Attached by a single point to a main-vein, on the upper or under surfaces of leaves of *Quercus alba*.

TYPES.—Fitch's type "*fulvicollis*" is in the United States National Museum; the cotypes "*erinacei*," adults and galls, in The American Museum of Natural History, the Museum of Comparative Zoology, and in the collection of Mr. William Beutenmüller.

Beutenmüller is authority for the identity of *erinacei* and *fulvicollis*.

This gall appears in late June, becoming mature about the last of August, staying on the trees into October. The insects emerge from November 5 to 21, or even in early December, often when the weather is very cold, and snow is on the ground. The insect oviposits in the young buds of the oak trees. Fuller details of the habits of this species are given in Triggerson's paper.

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In addition to the above data, studies of *Amphibolips confluens* (Harris)[1] and of a couple of species of *Neuroterus* have been reported, but I feel that the information is not sufficiently complete to warrant reporting life histories of those species until further studies have been made.

[1]See Walsh, 1864, Proc. Ent. Soc. Phila., II, pp. 443-500.

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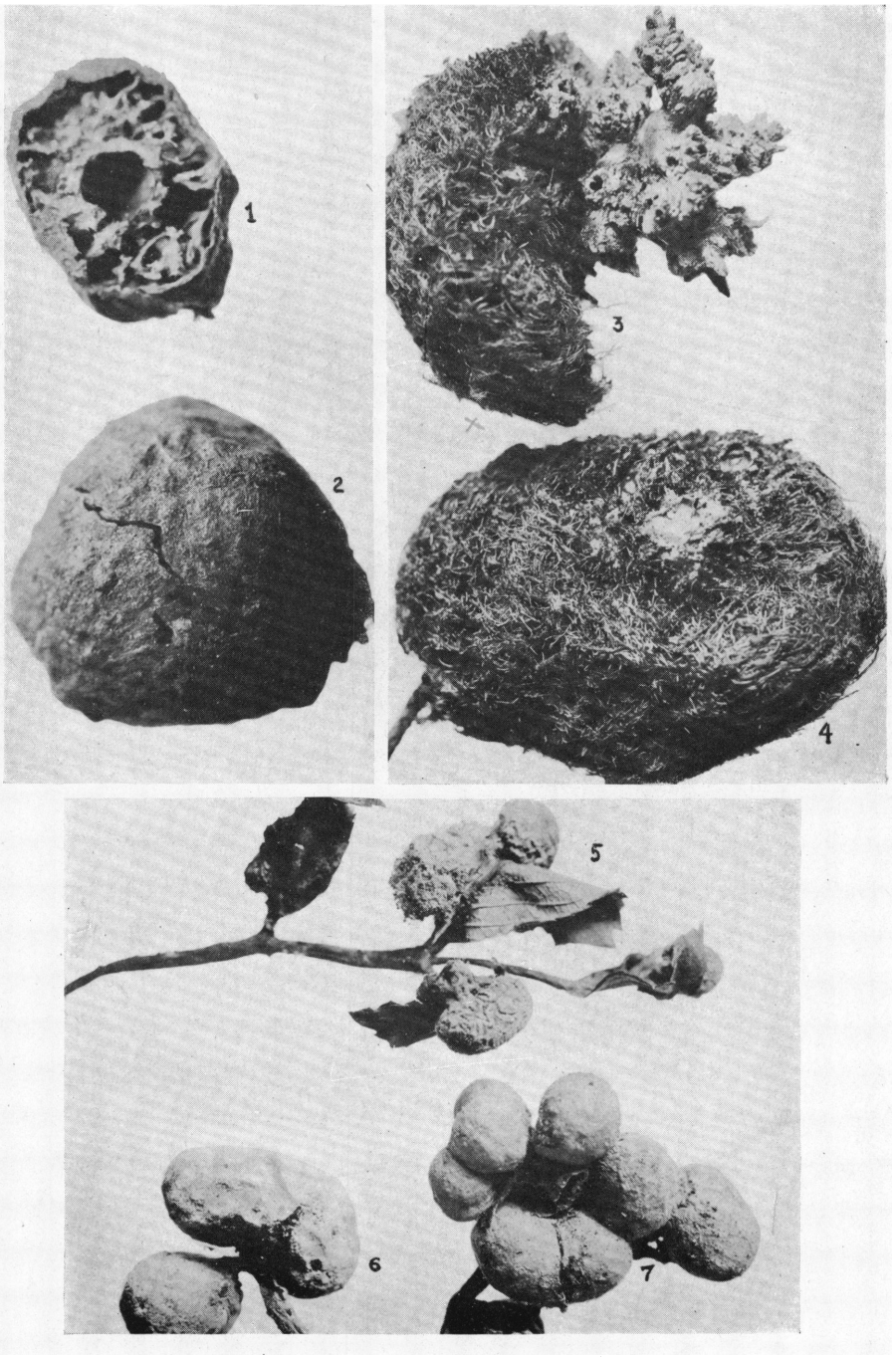
## Plate XXVIII

Figs. 1 and 2. *Aylax glechomæ* × 3.
Figs. 3 and 4. *Rhodites rosæ* × 1.5; filaments partly removed.
Figs. 5 to 7. *Rhodites ignotus* × 2.5; fig. 5, galls of second generation.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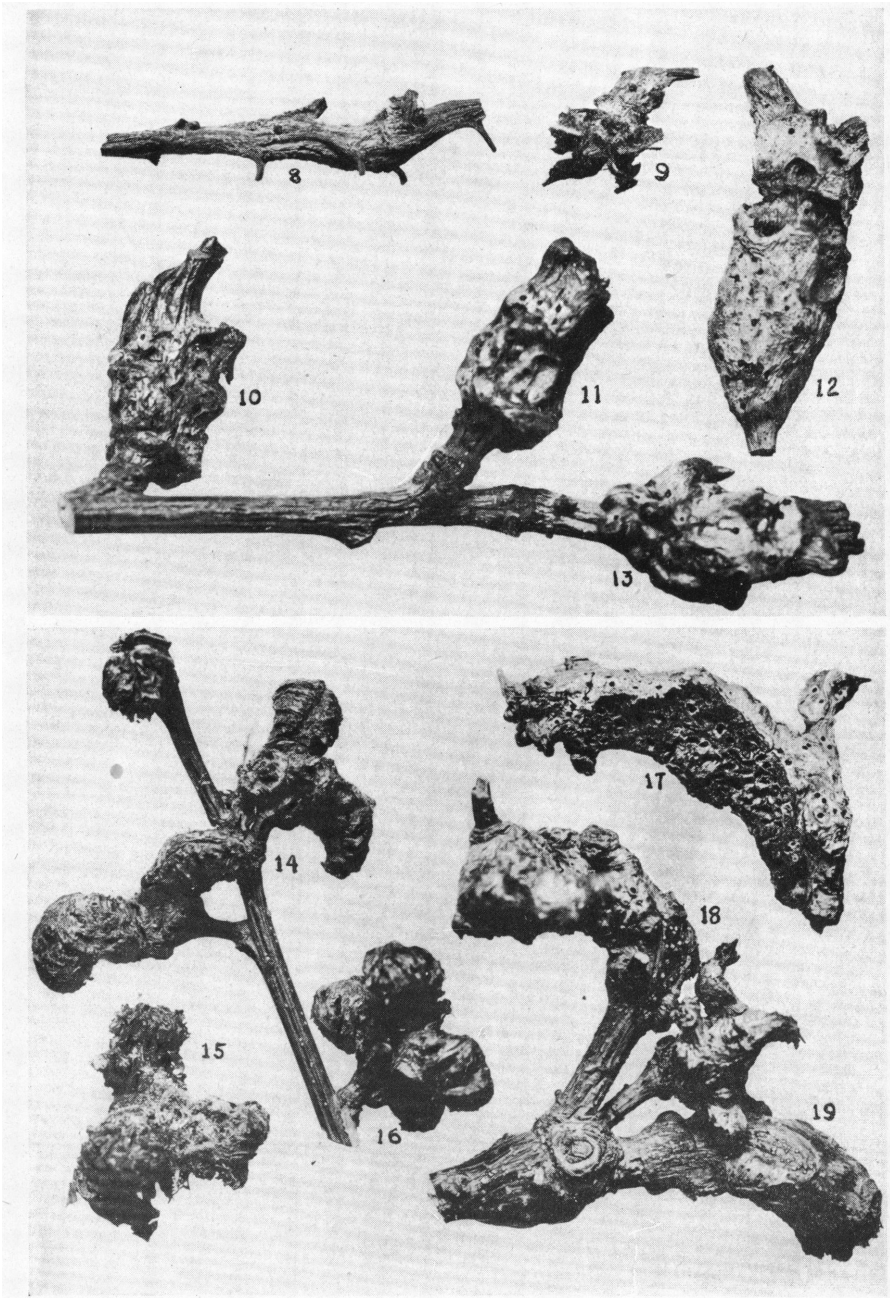
## Plate XXIX

Figs. 8 and 9. *Neuroterus batatus* form *bisexualis* × 1.
Figs. 10 to 13. *Neuroterus batatus* form *batatus* × 1.
Figs. 14 to 16. *Neuroterus noxiosus* form *vernalis* ×1.
Figs. 17 to 19. *Neuroterus noxiosus* form *noxiosus* ×1.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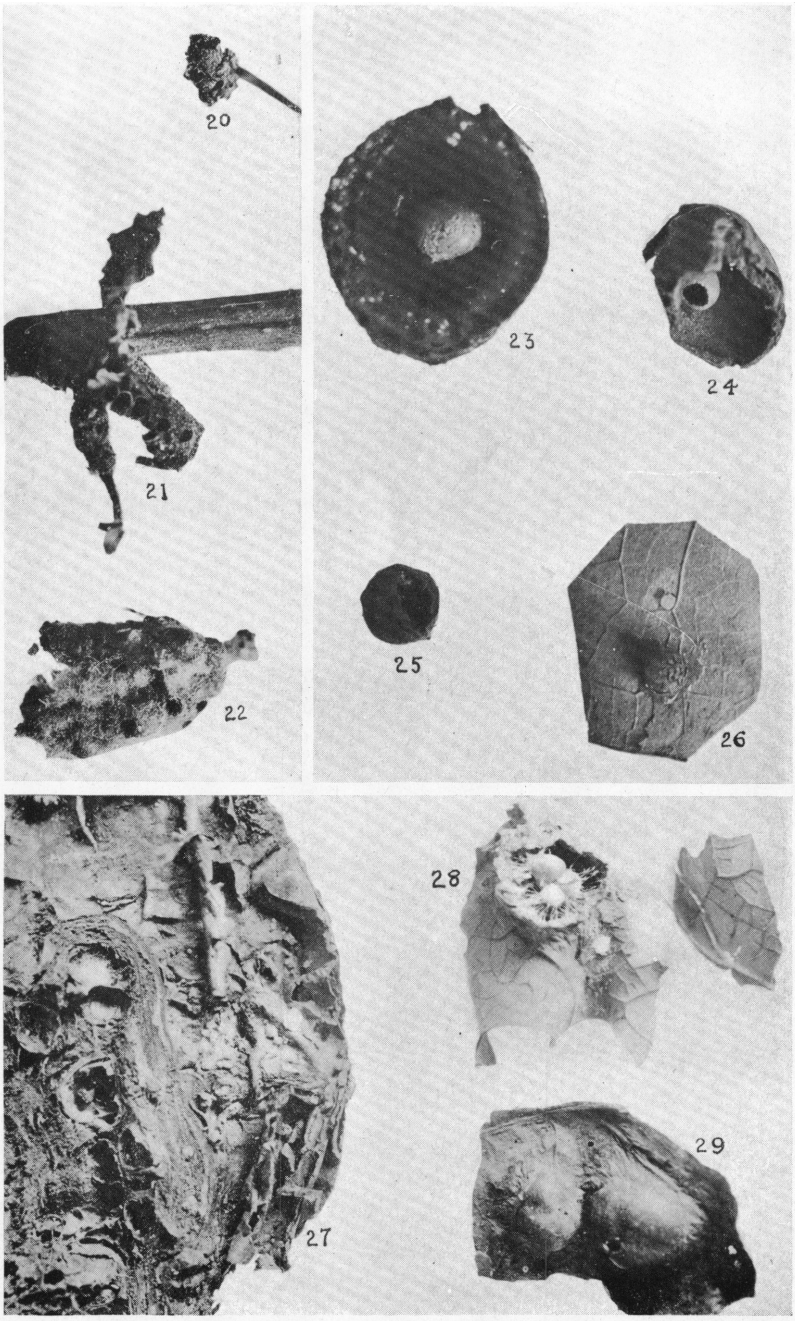
## Plate XXX

Figs. 20 to 22. *Neuroterus tectus* form *tectus* ×3.5.
Figs. 23 and 24. *Andricus palustris* form *palustris* ×2.5.
Figs. 25 and 26. *Andricus palustris* form *compressus* ×2.5.
Fig. 27. *Andricus futilis* form *radicicola* ×4.
Figs. 28 and 29. *Andricus futilis* form *futilis* ×4.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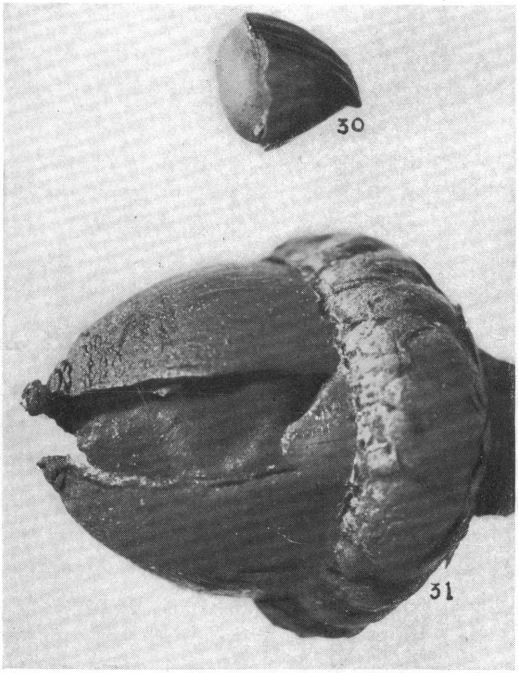
## Plate XXXI

Figs. 30 and 31. *Andricus operator* form *operatola* ×4.
Fig. 32. *Andricus operator* form *operator* ×2.
Fig. 33. *Andricus fulvicollis* form *bicolens* ×4.
Fig. 34. *Andricus fulvicollis* form *erinacei* ×4.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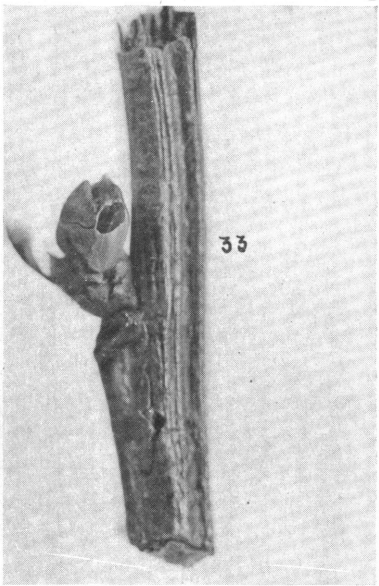
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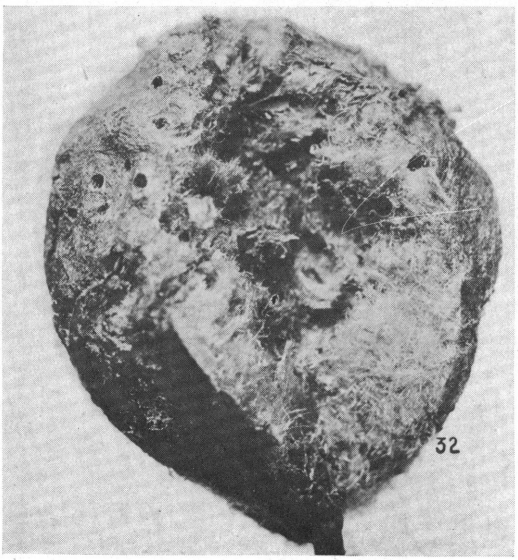
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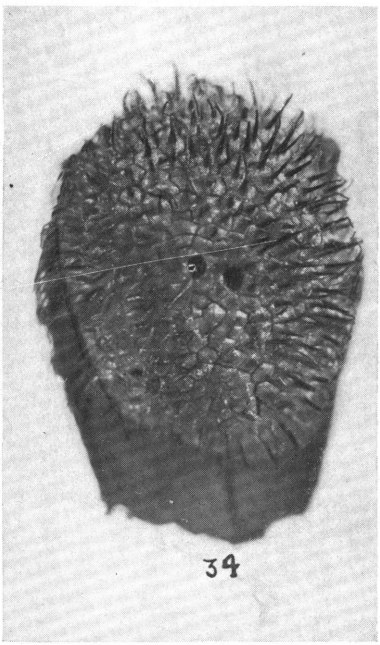
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