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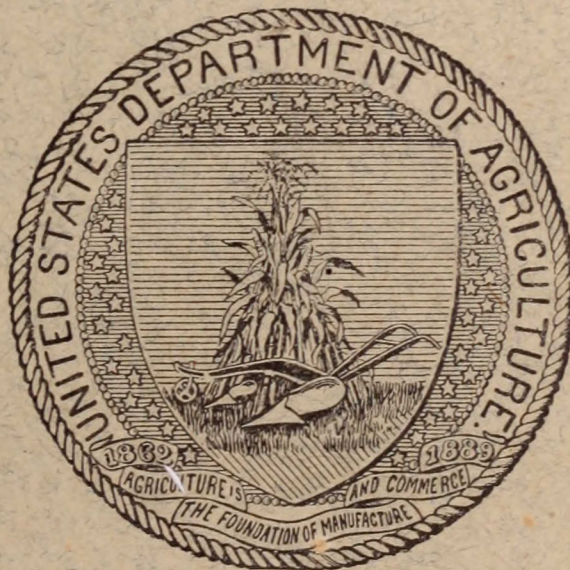
THE LIFE HISTORY
OF
TWO SPECIES OF PLANT-LICE

INHABITING BOTH THE WITCH-HAZEL
AND BIRCH.

BY

THEO. PERGANDE,
ASSISTANT ENTOMOLOGIST.

PREPARED UNDER THE DIRECTION OF THE ENTOMOLOGIST.



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GOVERNMENT PRINTING OFFICE.
1901.

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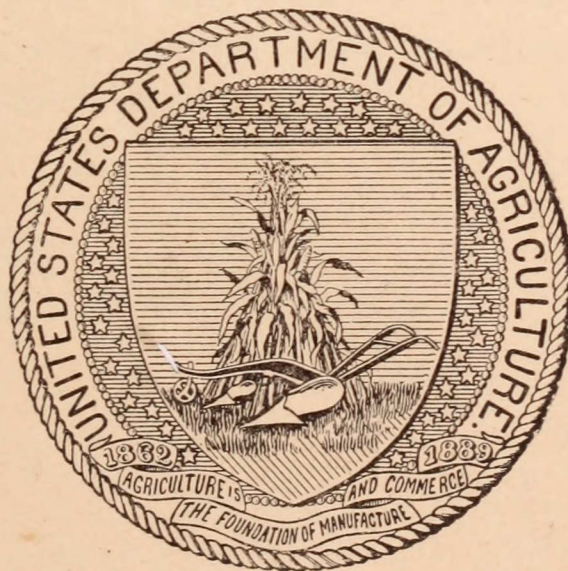
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LETTER OF TRANSMITTAL.

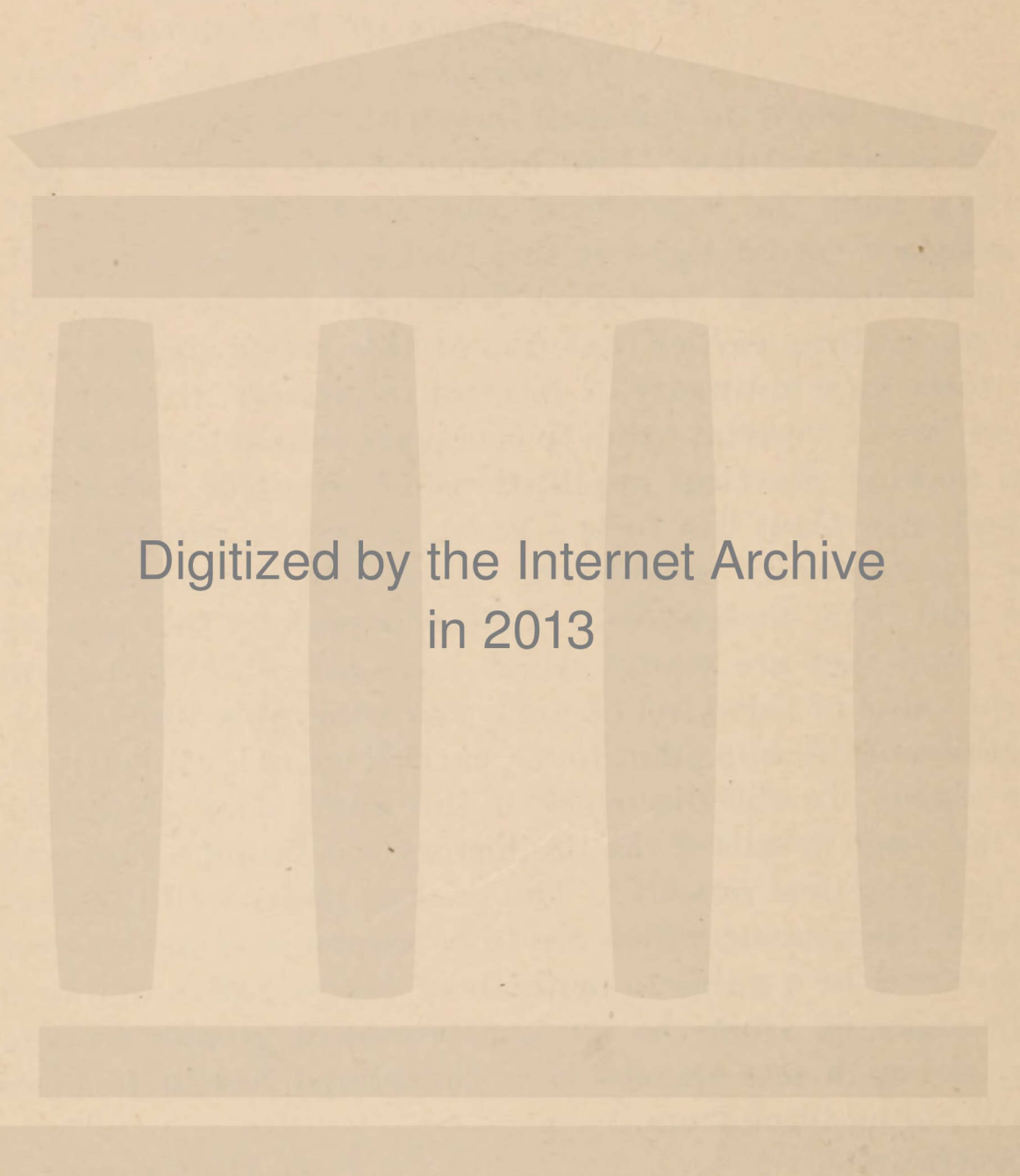
U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., July 16, 1901.

SIR: I have the honor to transmit herewith the manuscript of a short but full paper entitled "Life history of two species of plant-lice inhabiting both the witch-hazel and birch," by Theodore Pergande, an assistant entomologist in this Division. I recommend that this paper be published as Technical Series No. 9. As explained in the letters transmitting earlier bulletins of this series, papers of this character, while only indirectly of interest to farmers, fruit-growers, and foresters, are of especial value to economic entomologists who are engaged in making practical applications of scientific entomology. In the present case plant-lice form a group of insects which are very destructive, economically considered. Their life histories are very remarkable and little understood. This is especially the case with those forms (and they are many) which have alternate food plants. The practical value of this kind of work was admirably illustrated in the investigation of the hop plant-louse, carried on under this Division some years since. In the discovery of the alternation of the food plants and the exact details of the life history was found a suggestion for an easy and practical remedy. The present paper well illustrates the remarkable phenomena which are to be ascertained in this group of insects and will be a guide to methods of investigation and to the results to be expected from the study of forms of greater economic importance, although one species here considered has in fact been known to kill young birch trees.

Respectfully,

L. O. HOWARD,
Entomologist.

Hon. JAMES WILSON,
Secretary of Agriculture.



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CONTENTS.

	Page.
Introduction	7
Hormaphis hamamelidis Fitch	9
First generation	10
Second or migratory generation	13
Hamamelistes spinosus Shimer	25

ILLUSTRATIONS.

	Page.
Fig. 1. <i>Hormaphis hamamelidis</i> , galls	10
2. <i>Hormaphis hamamelidis</i> , young larvæ on bud, young stem-mother, antenna, etc	11
3. <i>Hormaphis hamamelidis</i> , second stage of stem-mother	12
4. <i>Hormaphis hamamelidis</i> , adult stem-mother	13
5. <i>Hormaphis hamamelidis</i> , second generation, young larva, pupa, migrant	14
6. <i>Hormaphis hamamelidis</i> , third generation, young larva	17
7. <i>Hormaphis hamamelidis</i> , third generation, third stage	18
8. <i>Hormaphis hamamelidis</i> , third generation, fourth or final stage	19
9. <i>Hormaphis hamamelidis</i> , sixth generation, second stage	21
10. <i>Hormaphis hamamelidis</i> , sixth generation, return migrant	22
11. <i>Hormaphis hamamelidis</i> , sexual generation	22
12. <i>Hamamelistes spinosus</i> , winter eggs, eggs in position on flower buds	27
13. <i>Hamamelistes spinosus</i> , twig of witch-hazel with young galls	28
14. <i>Hamamelistes spinosus</i> , mature gall	29
15. <i>Hamamelistes spinosus</i> , mature stem-mother	30
16. <i>Hamamelistes spinosus</i> , spring migrant	32
17. <i>Hamamelistes spinosus</i> , hibernating larva, antenna, etc	34
18. <i>Hamamelistes spinosus</i> , adult female, third generation	35
19. <i>Hamamelistes spinosus</i> , pseudo galls or corrugations on leaves of birch	36
20. <i>Hamamelistes spinosus</i> , young larva, fourth generation	37
21. <i>Hamamelistes spinosus</i> , young larva, first stage, fifth generation	39
22. <i>Hamamelistes spinosus</i> , young larva, sixth or sexual generation	42
23. <i>Hamamelistes spinosus</i> , male and female antennæ	43

THE LIFE HISTORY OF TWO SPECIES OF PLANT-LICE, INHABITING BOTH THE WITCH-HAZEL AND BIRCH.

INTRODUCTION.

The study of the life history of the Aphididæ or plant-lice, in connection with their peculiar and frequently destructive habits as well as the remarkable traits of many of the species, has offered a most fascinating field for research and study to many naturalists, and their labors have brought to light numerous interesting facts regarding the habits and economy of various species. Much is still to be learned concerning the annual migrations and the intermediate habits and changes of the majority of our *Pemphigini*, the architects of galls or excrescences on the leaves and other portions of certain trees and shrubs, which they desert, at the opportune time, to vanish completely from sight. These migrations and sudden disappearances of the gall-makers leave the observer in doubt as to the whereabouts of the connecting links of the fleeting migrants, of which very few have thus far been discovered. During autumn and early winter the return migrants make their appearance, as suddenly and mysteriously as the spring migrants disappear, without bearing a clue as to their former habitations. This is for the purpose of restocking their original host plants with their eggs, to enable the species to commence a new cycle of existence the following spring.

Interesting as the life history of all these insects is, there are few or none among them which have a more remarkable or a more diversified cycle of existence than two species belonging to the genera *Hormaphis* and *Hamamelistes*, both of which, alternately, inhabit the witch-hazel, *Hamamelis virginica*, and the birch, *Betula nigra*. The study of the life history of these, after numerous failures and disappointments, covering a space of nearly twenty-two years of patient labor, the writer has been fortunate to bring to a successful conclusion.

The drawings were all made by Miss L. Sullivan under the writer's supervision.

HORMAPHIS HAMAMELIDIS Fitch.

The synonymy of the oldest of the two species, as it will now stand, is:

Hormaphis hamamelidis Fitch.

Byrsocrypta hamamelidis Fitch, N. Y. Cat. of Hom. Insects, 1851, p. 69.

Hormaphis hamamelidis Osten Sacken, Stett. Ent. Zeitung, 1861, p. 422.

Hormaphis hamamelidis Walsh, Proc. Ent. Soc. Philad., VI, 1866-67, p. 281.

Hamamelistes cornu Shimer, Trans. Am. Ent. Soc., I, 1867, p. 283.

Hormaphis hamamelidis Thomas, Trans. Ill. State Hort. Soc., 1876-77, p. 199.

The earliest, a rather brief record and description of this interesting Aphid, was published by Dr. Asa Fitch in 1851, in his "Catalogue of the Homopterous Insects of the State of New York," under the name of *Byrsocrypta hamamelidis*. Ten years later it was redescribed by Baron von Osten Sacken in the *Stettiner Entomologische Zeitung* (p. 422, 1861), under the generic name of *Hormaphis*, using the identical specific name adopted by Fitch, though not being aware of its having been described by Fitch under the same name, and erecting for it a new genus. A translation of this description, by B. D. Walsh, will be found in the *Proceedings of the Entomological Society of Philadelphia*, 1866-67 (p. 281). In 1867 it was again described by Dr. Henry Shimer, in the *Transactions of the American Entomological Society of Philadelphia* (vol. 1, p. 283), under the name of *Hamamelistes cornu*, with a rather full description of the gall and its architects. Excepting a short description of the gall and the winged insect, by Prof. Cyrus Thomas, in the *Transactions of the Illinois State Horticultural Society* for 1876, published in 1877 (p. 199), nothing additional regarding the history of this interesting species has been published.

The writer's observations regarding this species were begun at Washington, D. C., in the spring of 1878, and were continued with varying success until the end of 1899, when they reached a successful termination.

As with other gall-producing plant-lice, the study of the galls and their architects is comparatively easy, but, with the departure of the winged migrants, continuous observations are suddenly interrupted and the track lost, leaving no trace as to the whereabouts of the intermediate generations. Migration from the host plant takes place generally during spring or summer, the return migrants making their reappearance from early in September till late in the fall, to restock their host with eggs.

What becomes of this particular species during the intervening time after leaving its gall remained a profound mystery to the writer for many years, notwithstanding continuous efforts to solve the problem.

Accidentally, while on a collecting trip near Tacoma, D. C., in September, 1890, the writer observed a peculiar Aphid inhabiting the under side of the leaves of a small shrub of *Betula nigra*, but failed at that time to recognize it as the missing link of *Hormaphis*. During the following seven years nothing additional was discovered to cause me to continue observations, this being due in a great measure to the destruction of large numbers of witch-hazel bushes and young birches, and the consequent scarcity of galls in the woods surrounding the city of Washington. Fortunately, however, I discovered in September, 1897, a number of witch-hazel trees and bushes, as well as young birches, in a narrow and protected valley near the edge of a small creek at Cabin John Bridge, Md., where I found numerous old and

dry galls on the leaves of the witch-hazel. Here I began again my search for the evading generations of this species, and in examining the leaves of birches rediscovered on many of them the same peculiar Aphid which had previously been found at Tacoma. It was in various stages of development, including the winged migrants, which proved, after a thorough examination and comparison with the spring migrants of the witch-hazel, to be identical with *Hormaphis hamamelidis*. To be sure of no mistake an examination was made of the leaves of witch-hazels near the birches with the result that the underside of numerous leaves was found to be almost completely covered with larvæ of various stages, and among them numerous specimens of the migrants from birch, actively engaged depositing their progeny, which later on proved to be the sexual generation. This settled the previously obscure question as to the secondary host of the intermediate generations, and enabled me to continue and to complete my protracted observations of the life history of this remarkable little species and the strange transformations it undergoes on the birches, which will be recorded in the following pages.

HORMAPHIS HAMAMELIDIS Fitch.

Gall (Fig. 1).—The more or less rapid development of the galls produced by this species on the leaves of the witch-hazel depends entirely on the advancement or retardation of the season. In the latitude of Washington, D. C., they usually start about the middle of April, attaining their full growth and development toward the end of May. To be in time and ready for the duty assigned to them by nature, the young stem mothers hatch about a week or more in advance of the appearance of the young leaves, when they frequently congregate in considerable numbers on the still closed buds, patiently awaiting their bursting. During this critical period many of them perish, either for want of food or from the inclemency of the weather. The survivors settle at once on the underside of the tender and unfolding leaves, generally along the midrib or the lateral veins, and insert at once their sucking bristles into the tender substance of the young leaf. The presence of the young gall-maker soon becomes apparent on the upper side of the leaf by a pale yellowish-green discoloration, and within a few days the first symptoms of the growth of the new gall are observable in a small, blister-like swelling on the upper side and a corresponding depression beneath. From now on the development of the new gall is quite rapid, in order to keep pace with the growth of the leaf, so that at the beginning of May they have become quite convex or slightly conical above with the underside almost closed and protected by numbers of rather stiff, white, and radiating hairs to prevent the entrance of enemies. The color of these young galls, above and below, is of a greenish yellow, with the most elevated portion of a more or less pronounced vinous shade and surrounded

at base with a purplish or vinous ring, which is also more or less distinct on the underside. By the middle of May the galls are about two-thirds grown, showing the peculiar conical formation clearly and reaching full development toward the end of May, when they measure from 10 to 12^{mm} in length by 4 or 5^{mm} in diameter at base. They are obliquely conical, or of the shape of a dog's tooth, and somewhat constricted at base, the underside forming an elevated and rather stout rim around the more or less circular opening which is densely covered with a pale pubescence. The opening has by this time become large enough to allow the migrants to escape. They are now of a firm, leather-like consistency and of a uniform pale yellowish-green or greenish-yellow color.

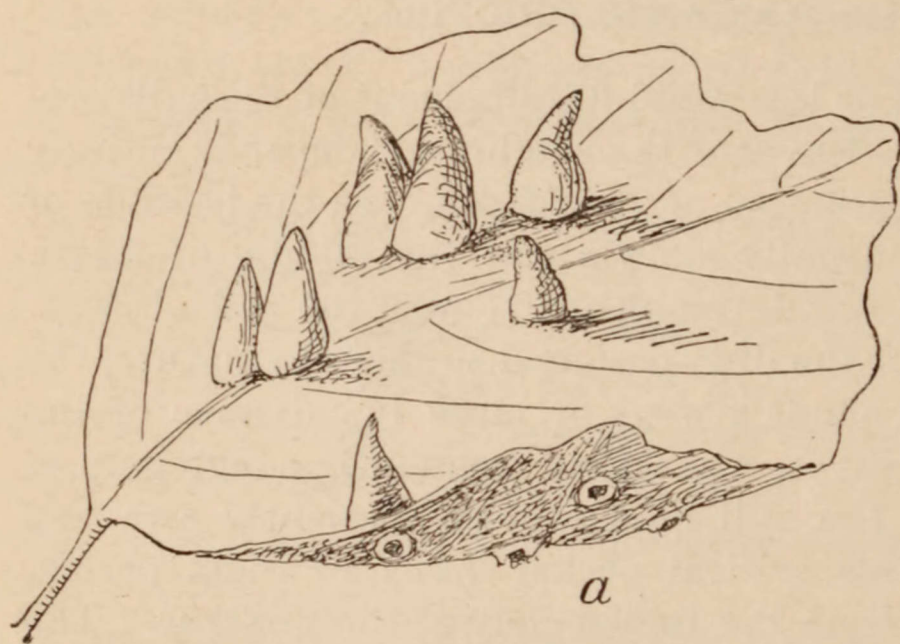
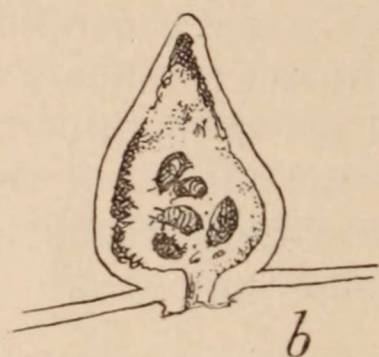


FIG. 1.—*Hormaphis hamamelidis*: a, galls, natural size; b, section of gall—much enlarged (original).

If not numerous, as in some years, there is generally but one or at most two galls on a leaf, whereas in favorable years there may be from two to eight or more galls on a single leaf, which then becomes more or less dwarfed and much distorted. These galls, even after their architects have departed, remain fresh and succulent for a considerable length of time, but gradually turn brown and dry up.

Winter egg.—The winter eggs of this Aphid, as in some other

species of plant-lice inhabiting trees and shrubs, are deposited on the branches and twigs, especially those bearing the leaves, and generally around or near the base of the buds or near the scars left after the dropping of the leaves in October, or as late as any of the leaves bearing the sexed generation remain on the shrubs. The eggs resemble greatly those of *Aphis mali*, though they are considerably smaller, and measure about 0.2^{mm} in length. They are of a slightly pyriform shape, bluntly pointed at the posterior end and highly polished, being at first yellowish or orange but changing gradually to a deep black.

FIRST GENERATION.

Stem-mother, first stage (Fig. 2).—The young stem-mother on hatching is but slightly larger than the egg, and makes her appearance

about the middle of April, generally about a week or so in advance of the appearance of the young leaves, during which time they congregate on the buds, on some of which I observed as many as 24 larvæ. Many of them doubtless perish before the leaves burst forth. They are of a dull black color, covered with a delicate film of a slightly bluish secretion. The eyes are dark purplish and the antennæ and legs blackish. They are provided with short, stout, and truncate dorsal and lateral secretory tubercles or pores, of which there are about 18 to 20 on the upper surface of the head, 2 medio-dorsal groups of 6 to 8 on the prothorax, a group of 4 to 6 pores or tubercles each side of the median line of the meso- and metathorax, and 1 or 2 pores each side of the median line on the abdominal segments. There are also about 8 pairs of tubercles along the front margin of the head, half of them ventro-lateral, 5 or 6 each side of the thoracic, and 2 each side of the abdominal segments, with an equal number on the ventral side near the lateral margin which, when the insect is living, can not be seen from above. From each of these pores or tubercles issues a rather stout and straight, or slightly curved, transparent and iridescent white and truncated waxy rod, which gives to the insect a rather bristly, though pretty, appearance.

The dorsum is but slightly convex and surrounded with a groove-like depression near the margin. The antennæ are three-jointed, with the third joint much

the longest, which is rather more than twice the length of the two basal joints combined and about as long as the hind tibiæ. It grows slightly stoutest toward the end and is indistinctly and irregularly annulated, bearing one or two short and colorless, movable, sensorial thumbs near the apex, and two or three short, stiff bristles at the tip. The legs are rather stout and long, and all the tarsi provided with four long and capitate digitules, of which the upper pair are longest. There are also two long and stout backward-curved bristles near the apex of the posterior tibiæ, one or two such bristles about the middle, externally, of the second joint of the hind tarsi, and a finer and straight bristle at the apical angle of the first joint. The rostrum is long and reaches beyond the base of the abdomen, the third joint being very

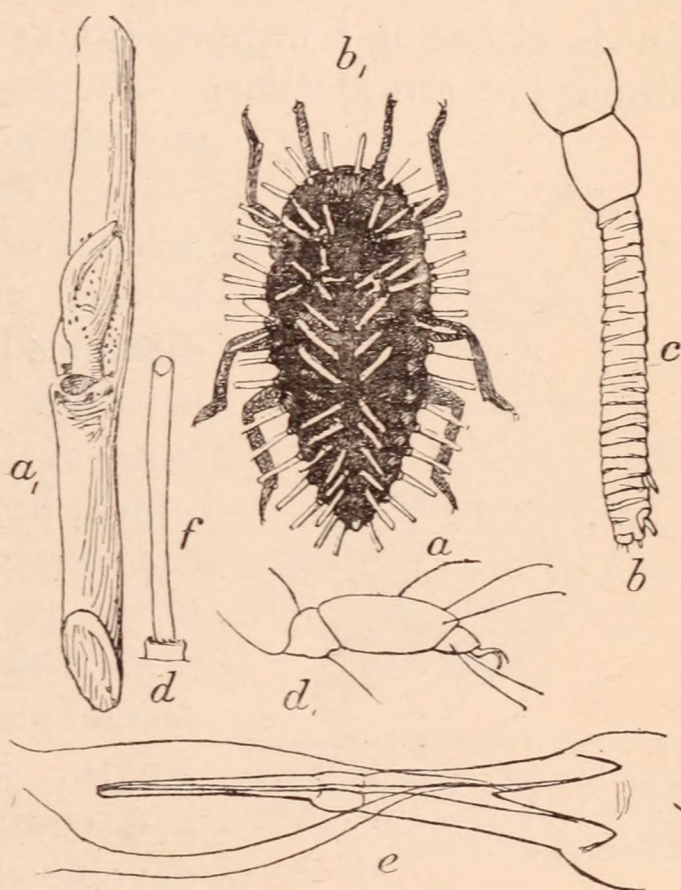


FIG. 2.—*Hormaphis hamamelidis*: a, twig and bud with young larvæ in position; b, young stem-mother; c, antenna; d, tarsus; e, rostrum; f, waxy rod—much enlarged (original).

long and slender, with its basal section bulbous. Before attaining maturity the young stem-mothers cast three skins, which are usually crowded into the opening of the gall, each stage lasting about a week, the last skin being cast between the 15th and 20th of May.

Stem-mother, second stage (Fig. 3).—The young stem-mother, after having cast her first skin, measures between 0.4 and 0.6^{mm} in length, and has become much stouter and of a broadly oval shape. She is dark purplish or almost black, with antennæ and legs paler; she is slightly pruinose and provided each side of the abdomen with a brush of white and glistening secretion, which grows gradually longer as she advances in age, though lacking entirely the characteristic glassy rods on the back and sides of the young larvæ. The antennæ are still of about the same length as in the first stage, though the third joint is either of a uniform thickness or slightly stoutest at base and without any annulations. The rostrum has become much shorter and

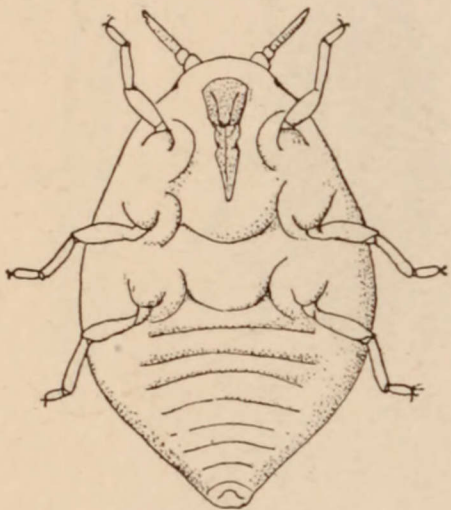


FIG. 3.—*Hormaphis hamamelidis*: Second stage of stem-mother, ventral view—much enlarged (original).

stouter and reaches barely to the median coxæ. The digitules of the tarsi and the bristles of the posterior tibiæ and tarsi have become much shorter and finer, while the digitules have become simple. All secretory tubercles or pores have disappeared, except three or four at each side of the abdomen, which, however, are less prominent than in the young larva, and become entirely obsolete in the cast skin.

Stem-mother, third stage.—After casting a second skin she measures from 0.7 to 1^{mm} in length. She is again stouter than before and contains already a number of partly developed embryos. She is dark purplish or brownish and is covered with a mealy secretion, giving her a pruinous appearance. There are now also apparently six or seven rows of more or less confluent tufts of a white and glistening, straight, and evenly shorn secretion each side of the dorsum, directed toward the median line. The antennæ and legs are very similar to those of the previous stage, except that the third antennal joint has become stouter at base and more distinctly tapering. The digitules, especially those of the posterior tarsi, are longer and stouter, though apparently simple, and the bristles of the posterior tibiæ and tarsi more prominent. Otherwise they are very similar to the larvæ of the second stage.

Adult stem-mother, fourth stage (Fig. 4).—About the middle of May the young stem-mother casts her third or last skin, and soon after having matured proceeds to produce her progeny and continues to do so during the following three or four weeks, or till about the middle of June, until her stock of larvæ is exhausted, depositing from

4 to 6 or more each day until, by the commencement of June, each gall may contain from 100 to 120 of her progeny in various stages of development, which, after casting several skins, acquire wings and gradually depart in quest of their appropriate food plant provided by nature for their offspring. The adult stem-mother, after having cast her last skin, measures from 1.2 to 1.4^{mm} in length, and is at first of a broadly oval or pyriform shape, being broadest near the end of the abdomen and slightly tapering toward the head, increasing gradually in diameter during the increase of and development of her ova until she becomes almost globular. She is of a dark purplish color, with the eyes black and the antennæ and legs dusky. At first she is dusted with a white, powdery secretion, which is soon followed by a rather long, white, and shaggy secretion, covering almost the entire abdomen. This secretion is, however, gradually more or less completely lost as the oc-

cupants of the gall increase in numbers, being rubbed off by the movements of the inhabitants as well as by coming in contact with the walls of the gall and the globules of ejected liquids which gradually accumulate. The antennæ and legs are very similar to those of the third stage, although the digitules appear to be slightly capitate. Those of the claws are very fine and about the length of the claws. The rostrum is short and stout and reaches only between the anterior and median coxæ. There is now a distinct, though rather short and broad, almost semicircular tail, bearing two fine bristles, while the last abdominal segment, which is more or less completely covered by the tail, has become distinctly bilobed, each lobe being provided with two stout bristles arising from small tubercles, the edge of both sides being also lined with small spines. After being completely exhausted and empty of ova the stem-mother shrivels up and dies.

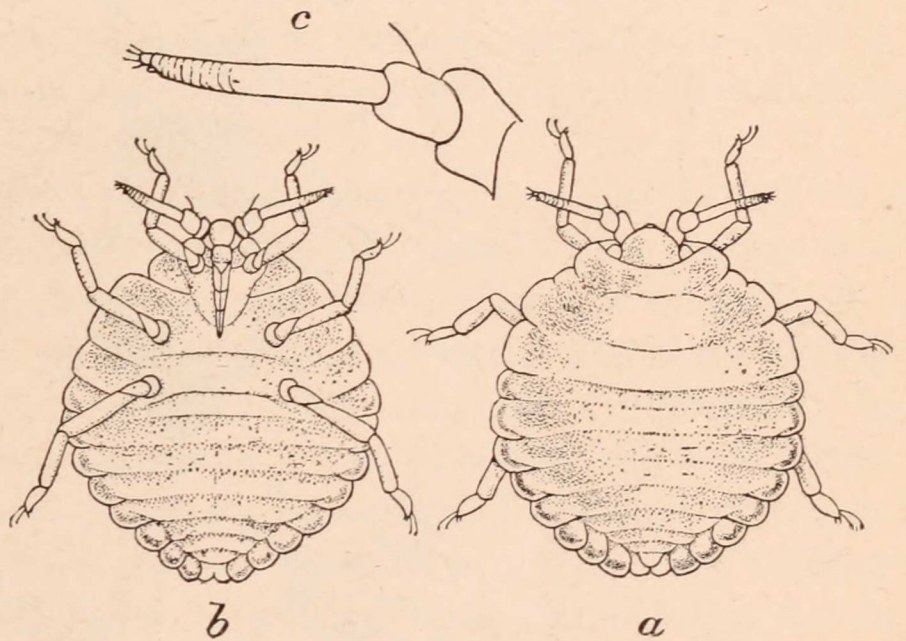


FIG. 4.—*Hormaphis hamamelidis*: a, adult stem-mother, dorsal view; b, ventral view; c, antenna—much enlarged (original).

cupants of the gall increase in numbers, being rubbed off by the movements of the inhabitants as well as by coming in contact with the walls of the gall and the globules of ejected liquids which gradually accumulate. The antennæ and legs are very similar to those of the third stage, although the digitules appear to be slightly capitate. Those of the claws are very fine and about the length of the claws. The rostrum is short and stout and reaches only between the anterior and median coxæ. There is now a distinct, though rather short and broad, almost semicircular tail, bearing two fine bristles, while the last abdominal segment, which is more or less completely covered by the tail, has become distinctly bilobed, each lobe being provided with two stout bristles arising from small tubercles, the edge of both sides being also lined with small spines. After being completely exhausted and empty of ova the stem-mother shrivels up and dies.

SECOND OR MIGRATORY GENERATION.

The development of the second generation, or progeny of the stem-mother or gall-maker, is more rapid, and is completed within sixteen to twenty days, all of which prove to belong to the migratory form. The earliest of these migrants make their appearance toward the end

of May or early in June; the remainder leaving the galls gradually till the end of June or early in July, by which time the last ones have disappeared. Frequently, however, a few stragglers may be met with as late as the end of July issuing from belated galls, the product of a few stem-mothers, hatching from eggs deposited very late in fall during an exceptionally favorable season.

There is but a single migratory generation in each gall, all of which, after casting four skins, become winged and leave the gall after having fully matured and migrate to birches, where they deposit their larvæ on the underside of the leaves, which, in favorable years, become frequently covered with migrants. So keen and unerring must be the instinct of these migrants to discover their secondary

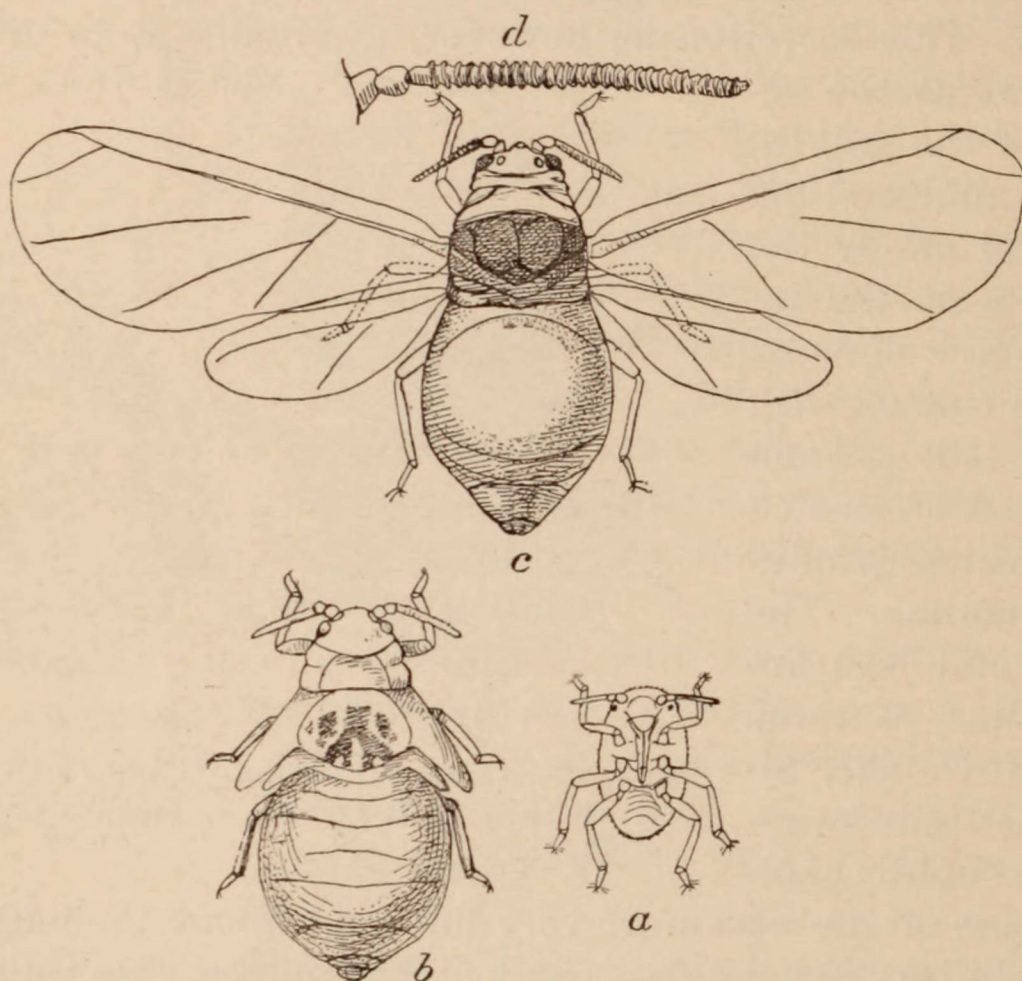


FIG. 5.—*Hormaphis hamamelidis*: Second generation; *a*, young larva; *b*, pupa; *c*, spring migrant; *d*, antenna.—Much enlarged (original).

host that they frequently fly great distances in search for birches, which may not be growing in the immediate neighborhood of witch-hazels, as is the case in some localities along the shore of the Potomac River, which they are compelled to cross in order to reach young birches on the opposite shore.

Second generation, first stage (Fig. 5).—The young larvæ of this generation are at first pale purplish and slightly covered with a white powder; they soon change to a dark purplish-brown, the eyes are black, and the antennæ and legs pale dusky. They measure about 0.3^{mm} in length, and are of a regularly oval shape; the front of the head is almost straight, and the surface of the body appears to be densely granulated. There are two rather long bristles on the front

of the head, two each side of the thoracic, one each side of the abdominal segments, and two at the end of the body, all of them arising from a small tubercle. The rostrum is stout and reaches nearly to the posterior coxæ. The antennæ are rather short and stout, barely reaching to the mesothorax; each of the two basal joints bears a long and stout bristle; the third joint is slightly curved inward and of almost equal thickness or slightly clavate with the apex, which bears two or three small bristles, bluntly rounded; its surface is faintly annulated or scaly; there are from one to three minute sensorial thumbs near its apex. The legs are stout and rather long; the digitules are simple, or faintly thickened toward the end, the lower pair of which is wanting.

Second generation, second stage.—The larvæ in the second stage are about twice as large as in the first and more elongated, with the antennæ longer and stouter; the third joint is slightly tapering and without any traces of annulation; the rostrum reaches only the median coxæ. In general appearance and coloration they are identical with the young larvæ.

Second generation, third stage.—In the third or semipupa stage they are 0.7 to 0.8^{mm} in length and considerably stouter than before and of a purplish-green, with the head and rudimentary wing pads of a dirty greenish-white, eyes brown, and the antennæ and legs whitish or faintly dusky. The future wing pads are now represented by rather prominent, rounded swellings. The antennæ are still longer and stouter than in the previous stage; the third joint is straight and somewhat tapering and the sensorial thumbs minute. The rostrum reaches nearly to the median coxæ. Front of head somewhat concave.

Second generation, pupa or fourth stage.—The fully developed pupa varies between 1 and 1.4^{mm} in length. They are of a dark purplish color, with the eyes dark brown and the antennæ, legs, and wing pads whitish. Front of head straight or slightly convex. The rostrum is short and stout, and reaches but slightly beyond the anterior coxæ, Antennæ and legs similar to those in previous stages, though proportionately longer. The third antennal joint is very long and stout, slightly tapering and slightly curved, and bears from one to three minute sensorial thumbs. All of the pupæ, if not rubbed, are furnished at each side of the abdomen with a dense brush of a white and hair-like secretion.

Second generation, migratory or fifth stage.—The mature migrants vary somewhat in coloration; they are generally of a dark purplish, purplish-brown, or black color, though frequently purplish-red or dark greenish-brown, with antennæ, thoracic lobes, and legs black. The wings are colorless or faintly dusky, the costal cell and stigma brownish, and the veins black. They measure from 1.2 to 1.6^{mm} in length and have an expanse of wings of 4 to 5^{mm}. The wings are carried flat in repose. Antennæ three-jointed, rather short and slender. The two

basal joints are very short and subequal in length; the first joint is cylindrical and obliquely truncate at the apex, while the second joint is almost globular. Joint three is very long in comparison to the two basal joints and five or six times as long as either of them. It is of uniform diameter and bluntly rounded at the apex, where it bears two or three short hairs, and deeply divided by thirty to thirty-six more or less regular or complete annulations, without a trace of divisions into separate joints. The legs are slender and almost destitute of hairs, which are somewhat more numerous and spine-like toward the end of the posterior tibiæ. There are four slender, subequal, and capitate digitules on each tarsus. Stigma long, narrow, lanceolate, and as broad as the costal cell, its basal angle almost obsolete. Veins simple; the second discoidal arises in front or beyond the middle of the first discoidal vein, though occasionally both start from the same point. The basal third or more of the third discoidal is obliterated. Stigmal vein short and almost straight. In the hind wings the second discoidal is generally wanting, frequently a stump of it or the entire vein may be observed arising from the first; sometimes both may start from the same point, though in rare cases both are normal, arising some distance from each other, and almost parallel to each other. The head is slightly convex in front. The rostrum is short, reaching but slightly beyond the anterior coxæ. Tail small, knob-like, bearing six to eight short hairs; last abdominal segment bilobed, each lobe provided with five or six hairs. There is also a small, blackish tubercle each side of the anterior four segments of the abdomen.

After feeding for some time on the juices of the gall, in order to become fully mature and strong enough for migration, and also to hasten the development of the embryonic larvæ, they abandon their old home in search for the appropriate food plant for their progeny, to insure the perpetuation of their race. Each of these migrants contains about fifty larvæ, which, after reaching the birches, are deposited on the under side of the leaves; on reaching the birches they deposit from six to eight larvæ each day until their stock of larvæ is exhausted, after which they shrivel up and die.

Third generation, first stage (Fig. 6).—Young larvæ of this generation were first observed during the first days of June and the first mature and apterous females on the 18th of the same month, the insects accomplishing all their changes within fourteen days. The young larvæ are at first of a pale yellowish color, but soon change to a brownish yellow; the eyes are dark purplish and the antennæ and legs colorless. The young larvæ are very small, barely 0.2^{mm} in length and broadly oval; the abdomen is comparatively small in proportion to the size of the larvæ and only about one-third the length of the entire insect. The entire margin of the body is studded with short and stout secretory tubercles; sixteen of which are along the

front edge of the head; about five or six each side of the thoracic segments, two each side of the abdominal segments, and seven or eight to ten on the last or eighth segment; from each of which issues a short, stout, truncated and cylindrical, glassy, transparent, and beautifully iridescent, waxy rod. There is also a series of similar though shorter rods along the middle of the back. The rostrum is stout and reaches to or between the posterior coxæ. The antennæ are rather long and slender, and about as long as the posterior tibiæ; they are faintly serrate or annulated and slightly clavate, with a notch near the apex, containing a small, movable thumb; the tip is bluntly rounded and bears two or three small hairs. Legs rather long and stout; the posterior tibiæ bear one or two rather long bristles and the tarsi a similar one on its external edge. The upper pair of digitules are long, slender, and capitate; the lower pair is wanting.

Third generation, second stage.—After having cast their first skin the larvæ measure about 0.4^{mm} in length and have become proportionally broader. The antennæ have become now very short, almost rudimentary, and composed of two, or sometimes three, more or less distinct joints, the last or last two joints, as the case may be, being about twice the length of the first, obliquely truncate at the apex, and bears a minute

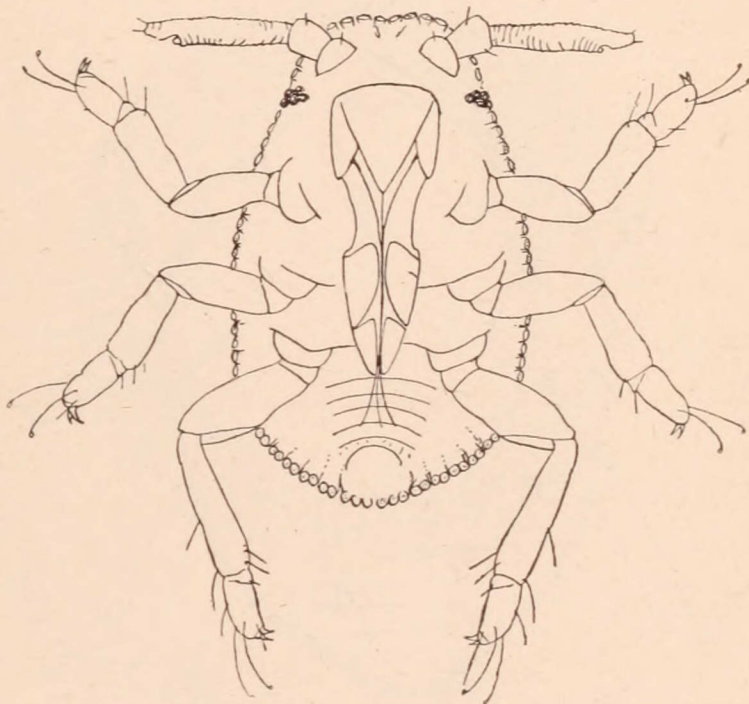


FIG. 6.—*Hormaphis hamamelidis*: Third generation; young larva, ventral view—much enlarged (original).

thumb at the inner apical angle. The tarsi of the anterior and median legs have been lost or they may sometimes be represented by a minute rounded stump. The tarsi of the posterior legs are deformed; their claws are lost or represented by a small spine-like process. The digitules are still present, though simple. The rostrum is stout and reaches to the meta-sternum. The number and arrangement of the secretory tubercles are about the same as in the first stage.

Third generation, third stage (Fig. 7).—In the third stage they are broadly oval; the antennæ have become still shorter, while the rostrum reaches only between the median coxæ. In other respects they are similar to the previous stage.

Third generation, fourth or Aleurodifform stage (Fig. 8).—Toward the middle or end of June the insects cast their third or final skin and assume a most remarkable mimicry; in fact, mimic now so closely

certain Aleurodids that for some time I was completely deceived as to their true nature, which only after close examination of numerous specimens, in connection with its earlier stages, was disclosed. When seen on the leaves they are to all appearance true Aleurodids, both in shape and size, resembling to some extent the scale-like form of *Aleurodes corni* or related species. At first they are pale brownish, but change gradually to a dusky or black color. They are almost circular, flat, and rather coarsely rugose above, with the ventral side quite convex, and measure, when fully mature, about 0.6^{mm} in length and are surrounded by a rather long fringe of cylindrical, waxy rods; the basal one-third or one-fourth of these rods is perfectly white, while the remaining two-thirds or more is glassy and iridescent. There is also a medio-dorsal group of rather long rods, identical with those of the lateral margin, which are curved in various ways; all of which,

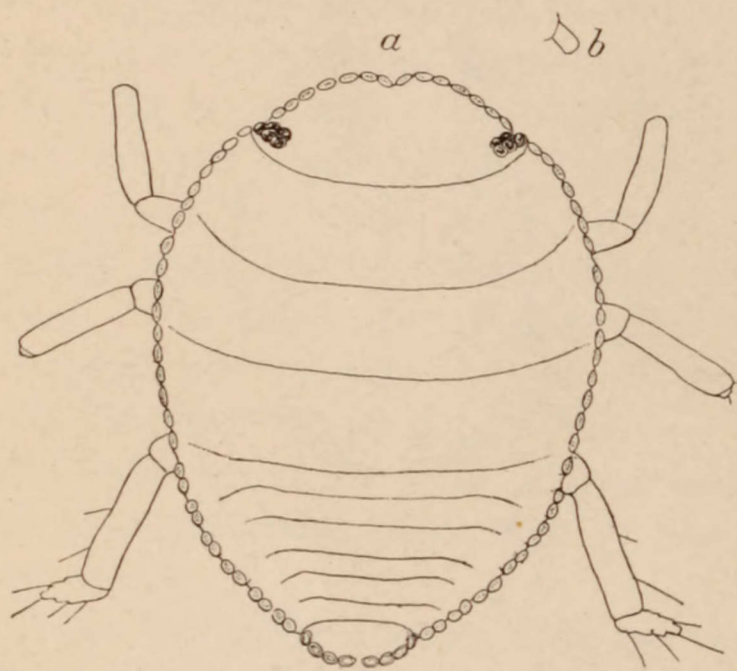


FIG. 7.—*Hormaphis hamamelidis*: Third generation, third stage; a, dorsal view; b, antenna—much enlarged (original).

combined, give to the insect a peculiarly pretty appearance. If denuded of the waxy rods there is seen a continuous double row of stout secretory tubercles surrounding the body excepting the free and movable terminal segment. The dorsal tubercles are irregularly arranged along the middle of the back and vary considerably in the number in each of the various groups.

Occasionally one or two tubercles or pores may be observed near the posterior margin of the head. There are

five to fifteen on the prothorax, six to twelve on the mesothorax, five to eight on the metathorax, three to five on the first abdominal segment, two or three on the second, and one or two on the third segment. The antennæ in this stage have become extremely minute and rudimentary, and are either one or two jointed. The rostrum is short and reaches but slightly beyond the anterior coxæ. The legs are as in the larval stages. The tail is very small and knob-like, and bears two short bristles. The last segment is bilobed and completely hidden by the semicircular, penultimate segment; each lobe of it bears five or six bristles, arising from a small tubercle. In this stage they are perfectly stationary, as in *Aleurodes*, and tightly cemented to the leaf, so that it is almost impossible to remove them without injury.

Fourth and fifth generation, or the second and third Aleurodiform generation.—The following two generations—the fourth and fifth—

are in every particular essentially identical with the third generation. Both of these generations are also Aleurodiform, differing but slightly either in coloration or size from the two preceding generations, obviating, therefore, the necessity of repeating their cycle of transformations. The fifth generation attains maturity about the middle of August or later, and gives birth to larvæ of the sixth generation. The number of larvæ deposited by individual females of the Aleurodiform

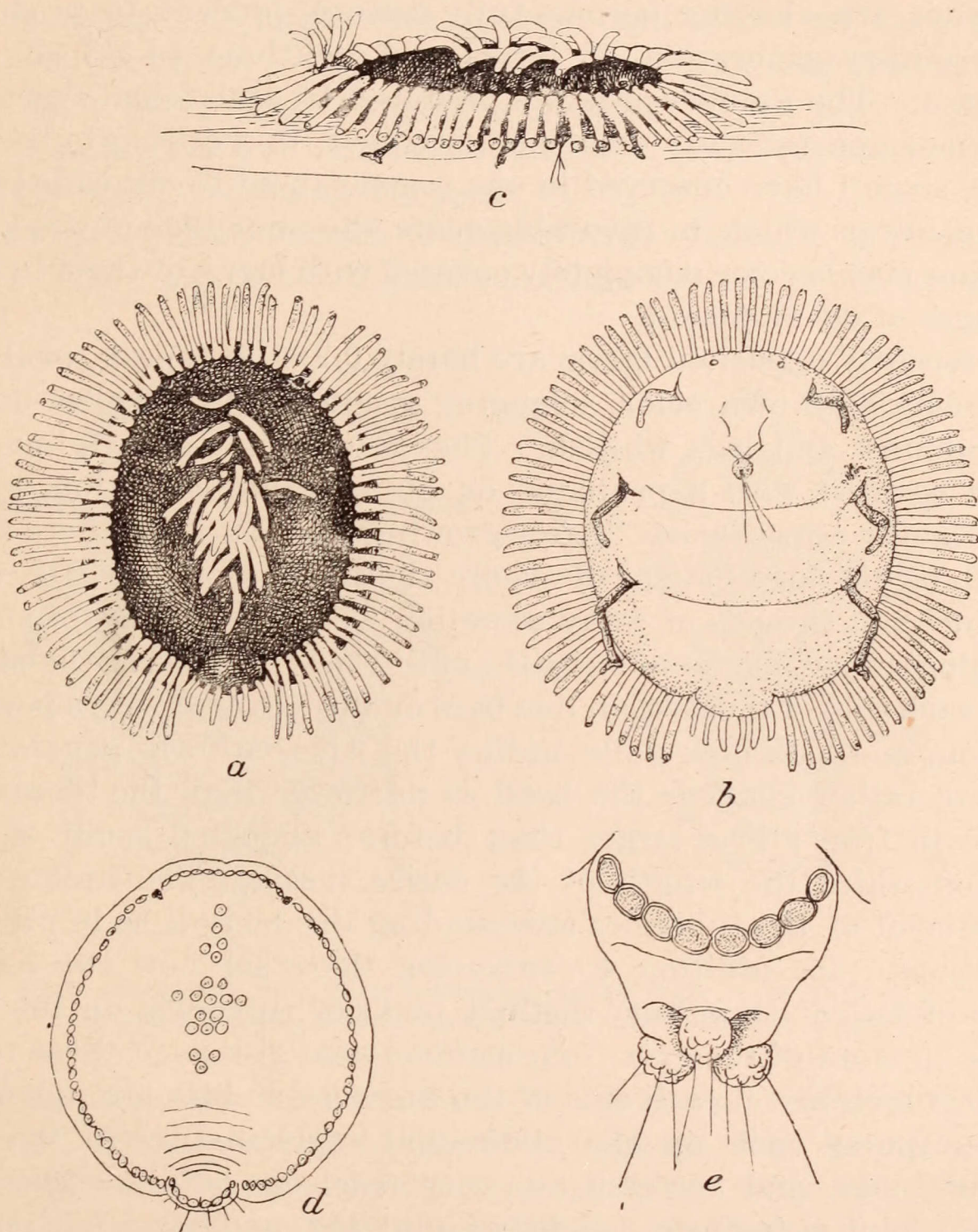


FIG. 8.—*Hormaphis hamamelidis*: Third generation, fourth or final stage; *a*, dorsal view; *b*, ventral view; *c*, lateral view; *d*, dorsal view, showing arrangement of pores; *e*, end of body—much enlarged (original).

generations is extremely variable. Many of these females are completely devoid of ova and die soon after attaining maturity; others may deposit one or a few larvæ, while the most prolific deposit from ten to fifteen or more.

With the appearance of the sixth generation a new cycle of forms begins to make its appearance, in which the aspect of the insects has changed completely, so much so that the casual observer would fail

to trace a connection between them and the Aleurodifform generations. Continued observations, both in the woods and on small, potted birches to which the insects were transferred, removed, however, all doubt as to the close relationship of these aberrant forms. This generation develops in time into the return migratory generation.

Sixth generation; return migrants; first stage.—By the end of August or early in September the females of the last Aleurodifform generation, after having become fully mature, proceed to produce a supplementary generation of larvæ, and continue to do so until exhausted. The number of larvæ produced by each female varies, as in previous generations. As a rule, however, they appear to be more prolific, since I have observed in one female about thirty embryos, in consequence of which, in favorable years, the underside of the leaves of birches may become completely covered with larvæ of them in various stages of development.

The recently deposited larvæ are barely 0.2^{mm} in length, oval, and of a yellowish-brown color, changing gradually to purplish-brown, with antennæ and legs whitish. They are at first naked, but soon become covered with a pruinous or bluish-white secretion, giving them a moldy appearance. After growing for some time, there forms a broad, medio-dorsal stripe of evenly shorn, dense and bristly, white and iridescent threads of waxy secretion. A dense fringe of similar glistening threads surrounds also the entire body, leaving the subdorsal region each side of the median line bare or only covered with a powdery secretion, and look now quite unlike the Aleurodifform generations. They are rather convex; the head is narrower than the thorax and arcuate in front; eyes larger than before; abdomen small or only about one-third the length of the entire insect. The number and arrangement of the tubercles surrounding the body is as in previous generations. In addition to tubercles, there are now two median groups of two or three very distinct pores or tubercles on the head slightly in front of the eyes, four medio-dorsal groups of three to five pores or tubercles on each side of the thoracic, and two groups of one to three pores each on the abdominal segments except the last. Antennæ, legs, and rostrum are very much as before. The third antennal joint is fusiform, slightly annulated, and bears from one to three minute thumbs near the apex. The upper digitules of the tarsi are slender and distinctly capitate. The lower digitules are wanting.

Sixth generation; second stage (Fig. 9).—Length of body, 0.4 to 0.6^{mm}. In coloration and general appearance they are similar to larvæ in the first stage, though they are considerably larger and stouter in proportion, with the sides of the pro- and mesothorax considerably swollen. They are now densely covered with a white and glistening, straight and evenly shorn, hair-like secretion, issuing from large, more or less confluent medio-dorsal and lateral compound glands or tubercles, which, on the abdomen, form broad, transverse

bands, giving them a peculiarly bristly or hairy appearance. The antennæ are very stout, much longer than before, and distinctly tapering. The rostrum is stout and reaches between the anterior and median coxæ. Legs as in previous stage, though longer and stouter.

Sixth generation; third or pre-pupa stage.—Length of body, 0.6 to 0.8^{mm}. In this stage they are also densely covered with hair-like secretion resembling still to a great extent the second larvæ, except that they are still larger and stouter, and that they have already acquired wing pads. The antennæ are now very long and stout, the third joint being longer than the posterior tibiæ, slightly tapering and without a trace of annulation, and with the usual movable thumb and three stiff bristles on the apex.

Sixth generation; fourth or pupa stage.—Length of body, 1 to 1.6^{mm}. They are in every particular like the pre-pupa, except that

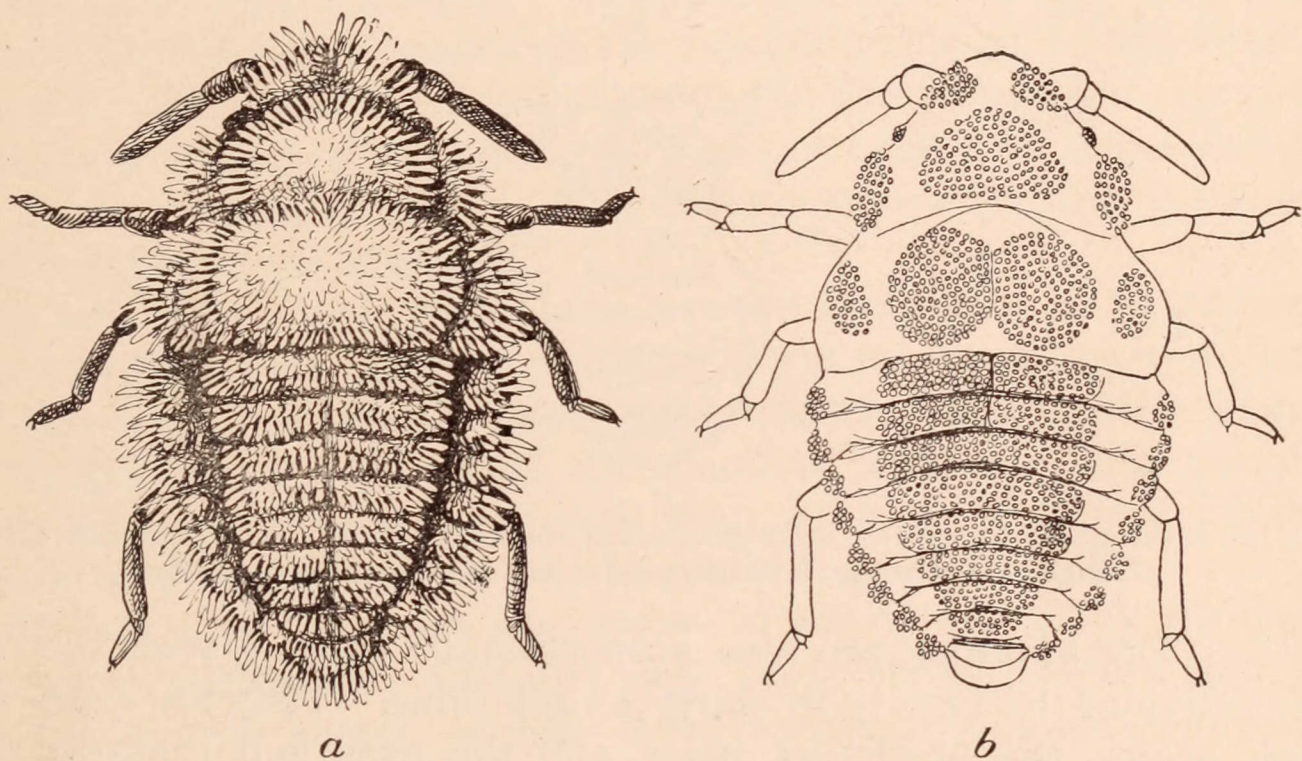


FIG. 9.—*Hormaphis hamamelidis*: Sixth generation, second stage; *a*, dorsal view; *b*, dorsal view denuded, showing arrangement of pores—much enlarged (original).

the wing pads and the antennæ are still longer, and that the annulation of the third joint of the future imago may be more or less distinctly seen through the transparent skin. They are of the same dark color as before, with the head and prothorax paler, and the eyes, thoracic lobes, and wing pads blackish. The digitules are apparently simple and bristle-like.

Sixth generation, fall migrant (Fig. 10).—Having cast their fourth or final skin, they acquire wings and, after feeding for some time to attain complete maturity, forsake the birch and migrates back to witch-hazel to deliver themselves of the ultimate or sexual generation. Each migrant, according to size, contains from seven to fifteen or perhaps more larvæ. Migration continues for about a month and a half, according to conditions of the season and other natural causes, and commences usually toward the end of August and terminates during the early part of October. In general appearance they are essentially

the same as those of the spring migrant from the witch-hazel, though they are uniformly smaller and measure from 0.8 to 1.4^{mm}, or rarely 1.6^{mm} in length, with an expanse of wings varying between 3 and

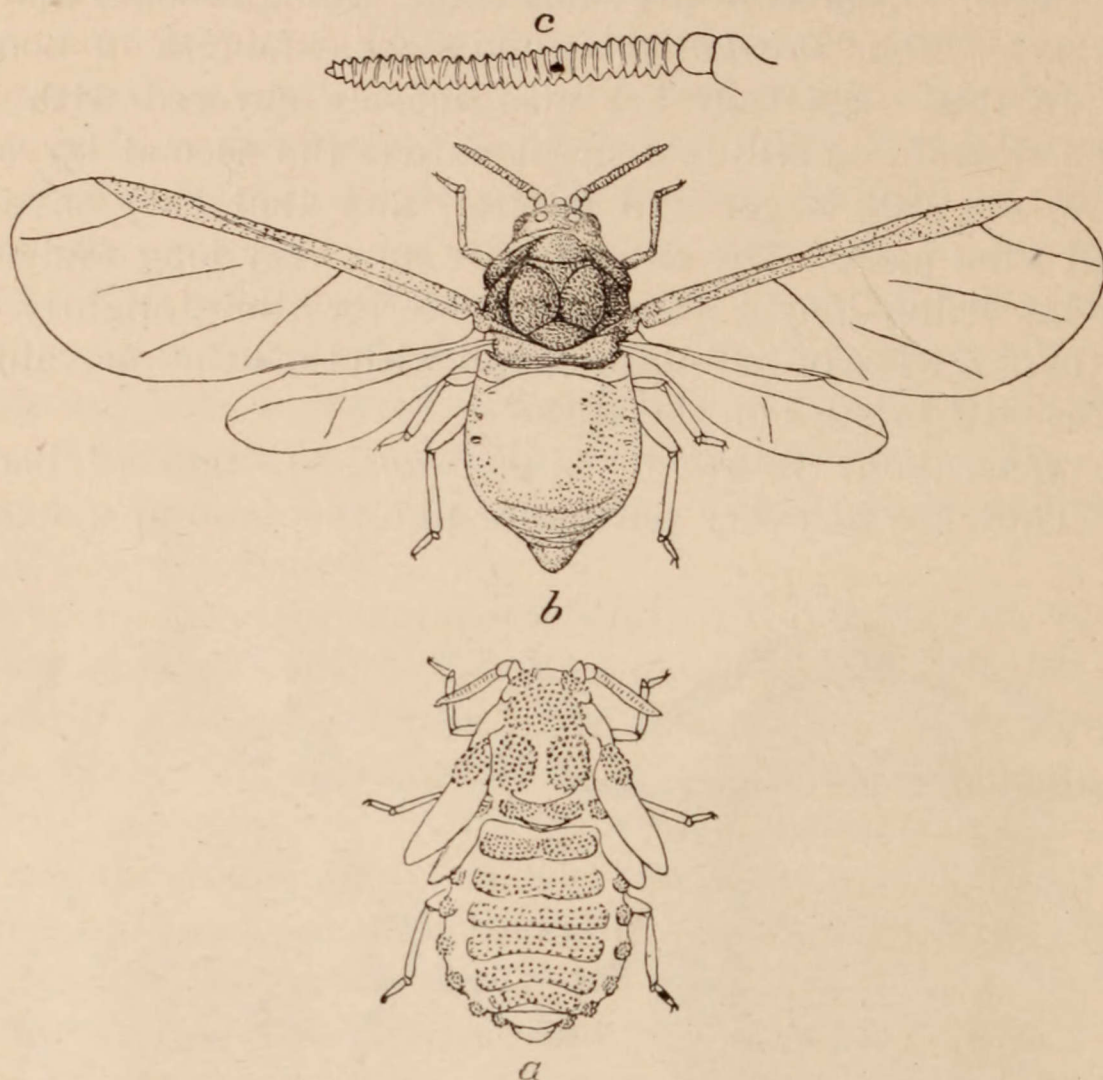


FIG. 10.—*Hormaphis hamamelidis*; sixth generation, return migrant: *a*, pupa, denuded, showing arrangement of pores; *b*, imago; *c*, antenna—much enlarged (original).

4.4^{mm}. The antennæ are also proportionally shorter, with the third joint divided by twenty to thirty annulations. They are dark purplish brown, the prothorax paler, and the eyes and thoracic lobes black, the legs yellowish brown.

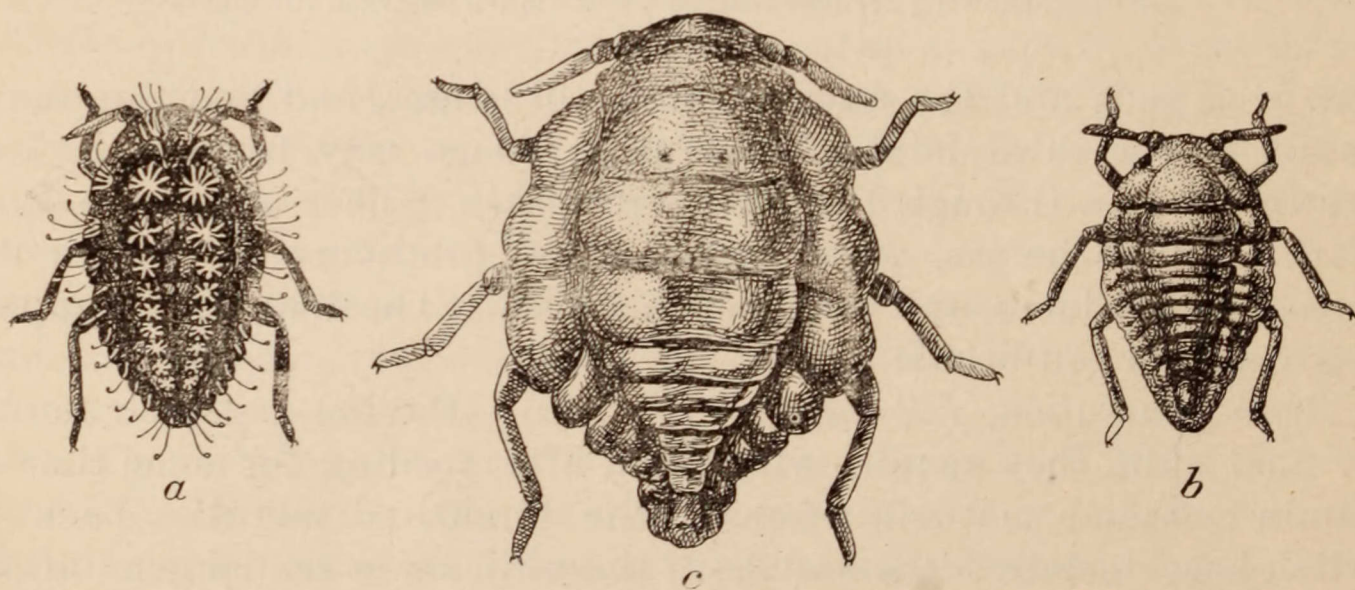


FIG. 11.—*Hormaphis hamamelidis*; sexual generation: *a*, young larva; *b*, male; *c*, female—much enlarged (original).

Seventh, or sexual generation. (Fig. 11.) *Female, first stage.*—The young larvæ of this generation are oval, with the median line slightly and the dorso-lateral line deeply impressed, and measure

0.2 to 0.4^{mm} in length. These, as well as the three following stages, are of a brown or purplish-brown color, the eyes deep purplish, and the antennæ and legs pale dusky. All are covered with a delicate, pruinous pubescence, intermixed with a short, glistening and hair-like secretion which gives to them a moldy or bluish appearance, all of which in the two following stages becomes gradually so dense as to cover the entire insect. There are also, as in former generations, two medio-dorsal and a marginal row of short, transparent, and iridescent waxy rods, issuing from short secretory tubercles. In this stage there are about twelve tubercles along the front edge of the head, two or three each side on the thoracic segments, one each side on the abdominal segments, and two at the end of the body. There are also two tubercles about the middle of the head, two medio-dorsal groups of two pores each on the thoracic segments, and two median tubercles on the abdominal segments. Antennæ and legs are stout and rather long, with two small bristles on the front of the head, a long bristle at the apex of the second antennal joint, and three short and spine-like bristles at the tip of the last; digitules and bristles of tibiæ and tarsi as in previous generations. The rostrum is stout, highly developed, and reaches to the abdomen.

In favorable years these larvæ become frequently so numerous as to cover the entire underside of some of the leaves of the witch-hazel, in consequence of which numerous predatory insects, such as larvæ of Syrphid flies, Chrysopids, Coccinellids, and various mites make their appearance and commence their work of destruction, so that within a few days they may be found with great difficulty.

Female, seventh generation, second to fourth stage.—In the following three stages they resemble each other closely, except that they gradually grow larger, become more convex and more pyriform in shape, and that the antennæ and legs grow longer and stouter. All are dark purplish, and densely covered with hair-like secretion. The secretory tubercles increase gradually in numbers and prominence, whereby the segmentation of the body is strongly brought out. In the fourth stage they measure about 1^{mm} in length. The legs and antennæ are considerably longer and stouter than in the other stages, though otherwise very similar, and the rostrum shorter, reaching only between the anterior and median coxæ. There are now two large groups of secretory tubercles at the front of the head; a group of 20 to 24 each side of the prothorax, 17 to 20 each side of the mesothorax, 11 to 16 or more each side of the metathorax, 8 to 10 each side of the first three segments of the abdomen, 3 to 6 each side of the other four segments, and about six on the terminal one. There are also two median groups of 7 to 10 tubercles on the head between the eyes; two medio-dorsal groups of 10 to 15 on each of the thoracic segments; 8 to 10 or more on the four anterior segments of the abdomen, and from three to six on the other three segments.

Seventh generation, mature female.—After having cast the last skin they measure but slightly over 1^{mm} in length. They are broadly pyriform, highly convex above and quite flat beneath, surrounded with a rather broad and deep dorso-lateral depression. They are polished, of a deep black or purplish black color, and without a trace of secretion of any kind, and, when seen on the leaves, remind one strongly of certain small Coccinellids, such as *Pentilia*, and also of some of the Oribatid mites. All of the secretory tubercles have now completely disappeared. The head is arcuate in front and bears two to four small hairs. Eyes small, each composed of three ocelli. The rostrum is highly developed and reaches almost to the median coxæ. The antennæ are much longer than in the last larva stage, and about as long as the posterior tibiæ and tarsi combined; the two basal joints, as usual, are stoutest, shortest, obconic, subequal in length, and provided with a short bristle near the inner apical angle; the third joint is very long and slender, of uniform diameter, rather densely and sharply serrated or annulated, provided with the usual sensorial thumb and two or three short hairs at the apex. The legs are long and stout, and bear the usual bristles on the tibiæ and tarsi; the digitules are well developed and capitate, the lower pair being much shorter and but slightly longer than the claws. The posterior tibiæ are stouter than the others, and are provided with a considerable number of sensorial pores or tubercles. The tail is small, transversely oval or knob-like, and bears six bristles; the terminal segment is bilobed, each lobe bearing three to four bristles. Each female contains from five to ten eggs, which, shortly after copulation, are deposited around the base of the leaf buds for next year's brood.

Seventh generation, male.—On account of the very small size of the male and its general similarity to female larvæ I failed to ascertain through how many transformations it passes, though they are evidently the same as those of the female. The mature male measures 0.4 to 0.6^{mm} in length, and about one-half or less the size of the female. It is of the same black or purplish-black color and of an elongated pyriform shape, being broadest about the middle of the thorax and gradually tapering toward the end of the body; the front of the head is rounded and bears two small hairs. Surface of body densely reticulated. Secretory tubercles are wanting. The antennæ are considerably longer and more slender than in the female; the two basal joints are subequal in length; the first joint is stoutest and about as long as broad, stoutest near the truncated apex; the second joint is clavate and more elongated; both bear bristles at the inner side near the apex. The third joint is very long, slender, and of equal diameter up to the terminal thumb, slightly curved inward, profusely serrate or scaly and bears along its external edge from ten to fifteen or more minute and colorless sensorial thumbs and three small hairs at the apex. Eyes composed of three ocelli. The rostrum is highly

developed and reaches beyond the median coxæ. The legs are long and more slender than in the female. The tail is small and knob-like, and bears two small bristles; the last segment is rounded and provided with four small bristles. The mature male is extremely active and restless and is continually running about in search of mature females. Copulation lasts but a short time.

HAMAMELISTES SPINOSUS Shimer.

Hamamelistes spinosus Shimer, Trans. Amer. Ent. Soc., vol. 1, p. 284, 1867.

Hormaphis spinosus, Bull. U. S. Geol. Geog. Surv. Terr., Vol. V, No. 1, p. 14, 1879.

Hormaphis papyraceæ Oestlund, Geol. and Nat. Hist. Surv. of Minn. Bull. 4, Synopsis of Aphidæ of Minn., p. 13, 1887.

The life history of the second species of gall-making Aphids, inhabiting both the witch-hazel and birch, is as remarkable and interesting as that of *Hormaphis hamamelidis*. Its earlier generations, as in the former species, subsist upon the witch-hazel, but instead of infesting the leaves select the young and dormant flower buds for their future operations, which gradually are changed into conspicuous, spiny galls, the architects of which, at the proper time, forsake also their old home and migrate to the birches to consign to them their progeny in order to complete the cycle of existence of the species, but, unlike *H. hamamelidis*, which completes its cycle within the space of one year, this species hibernates on the birch, on which, during the following spring, it produces two additional generations, the second one of which returns during June to the witch-hazel for the purpose of producing the sexed generation. These return migrants appear just about the time that the spring migrants of *H. hamamelidis* leave their galls, so that during this cross migration both species may frequently be found simultaneously upon both plants, which occurrence during my earlier observations caused considerable confusion and speculation whether these two forms were only variations of one or whether there were really two distinct species. Continued studies, however, have clearly demonstrated that these two forms, notwithstanding their great similarity in venation and general appearance, are good species, belonging to two distinct genera.

The genus *Hamamelistes* was described by Dr. H. Shimer, of Mount Carmel, Ill., in the Transactions of the American Entomological Society, vol. 1, page 284, 1867, to include two gall making species found on the witch-hazel, without, however, being aware that the first one of these two species, to which he gave the name of *Hamamelistes cornu*, had previously been described by Dr. A. Fitch under the name of *Byrsocrypta hamamelidis*, for which subsequently Baron Osten Sacken erected the genus *Hormaphis*. Since, however, the antennal characters of *spinosus* are markedly different from those of

hamamelidis, the generic name of *Hamamelistes* will have to be retained for this species.

In 1879 it was again partly described by Prof. C. V. Riley in the Bulletin No. 1 of Volume V of the U. S. Geol. and Geog. Survey, p. 14, who erroneously referred it to *Hormaphis*.

Mr. O. W. Oestlund, while studying the Aphides of Minnesota, described an insect, which he found to corrugate the leaves of birches, in Bulletin 4, of the Geological and Natural History Survey of Minnesota, page 17, 1887, under the name of *Hormaphis papyraceæ*, not being aware that he had discovered the return migrant of *Hamamelistes spinosus*. The complex history of these two remarkable species has remained a sealed book up to the present time, when, at last, it has been solved.

My own acquaintance with the birch-inhabiting form of this species dates back to May, 1887, when I discovered the younger stages of it on the young leaves of a small birch at Richfield Springs, N. Y., but failed, on account of the immature state of the insects, to recognize its generic position. It was again found by me in June, 1893, on leaves of young birches at Charlton Heights, Md., in various stages of development, including the migrant, but considered it to be a new species of *Hormaphis*, which I later found to have been described by Mr. Oestlund. My failure to recognize it at that time as the return migrant of *spinosus* was in a great measure due to the fact that at the date of finding these migrants on the birches I observed also young galls of *spinosus* on the witch-hazels.

The geographical distribution of this species depends in a great measure on the presence of both plants in the same locality. In favorable seasons it may become so numerous as to cause great injury to the foliage of birches, inducing the leaves to fall prematurely.

Winter egg (Fig. 12).—The winter eggs of this species, unlike those of *Hormaphis hamamelidis* and the majority of other Aphids, are deposited from about the middle of June to early in July, instead of during the fall of the year, and hatched by the end of May or early in June the following year, remaining dormant almost a whole year, whereas in the other species it takes only about one-half of that time. These eggs are commonly deposited between or near the crotches formed by the twigs and petioles of the flower buds, the scars left by previous flowers or seed capsules, and in crevices of the bark, or similar sheltered positions. That the instinct of the migrant is rather defective in selecting the proper shrubs of witch-hazel for the continuance of its race has been demonstrated by the fact that it will migrate indiscriminately to both the bearing and immature plants, on account of which the young stem-mother, hatching from eggs deposited on immature plants, is doomed to perish through absence of flower buds on which to settle. I have repeatedly found large numbers of the sexes and their winter eggs on immature

plants, though never a gall of this species on them, whereas the other species, inhabiting the leaves, thrives equally well on the smallest plants but a few inches high, as well as upon fully grown trees, and is therefore the more common and more numerous of the two.

The eggs of this species are rather peculiar, quite flat, about three times as long as broad, and about 0.2^{mm} long; they are regularly oval, and covered with a glistening, hair-like secretion, applied to them when deposited, from the hair-like secretion on the abdomen of the female, which gives to them a hoary appearance, corresponding quite well with the pubescence of the twigs, and rendering them very difficult of detection. They are at first of a pale yellowish color, but change gradually to a dark gray or blackish color, corresponding more or less closely with the color of the bark, which makes it still more difficult to detect them.

They are tightly glued to the twigs, and are so extremely delicate that it is almost impossible to remove them without breaking.

The gall (Fig. 13).—At the time of hatching of the eggs of this species, which takes place from the middle of May till early in June, the young flower buds measure about 1 to 1.4^{mm} in diameter. They are globular, with three shallow longitudinal grooves, situated on a short, rather stout, and succulent petiole, which is surrounded with four or more small and lanceolated leaflets. They are of a yellowish-green color and densely pubescent or hairy. The young stem-mother, after hatching, readily finds the buds and selects almost invariably that side of it directed toward the twig and settles down near the base in one of the grooves of the bud. The ensuing irritation, caused by the sucking of the insect, and probably also through injection of an irritating fluid, checks the longitudinal growth of the petiole, but hastens that of the bud, especially that side of it opposite the insect, which at once commences to lengthen, to broaden, and to curve over toward the gall-maker, and to acquire a beautiful rosy color. The formation of the young gall proceeds rapidly, so that within a few days the insect is completely inclosed, leaving but a transverse scar and small opening where the insect had settled, by which time the original structure and component parts of the buds have become com-

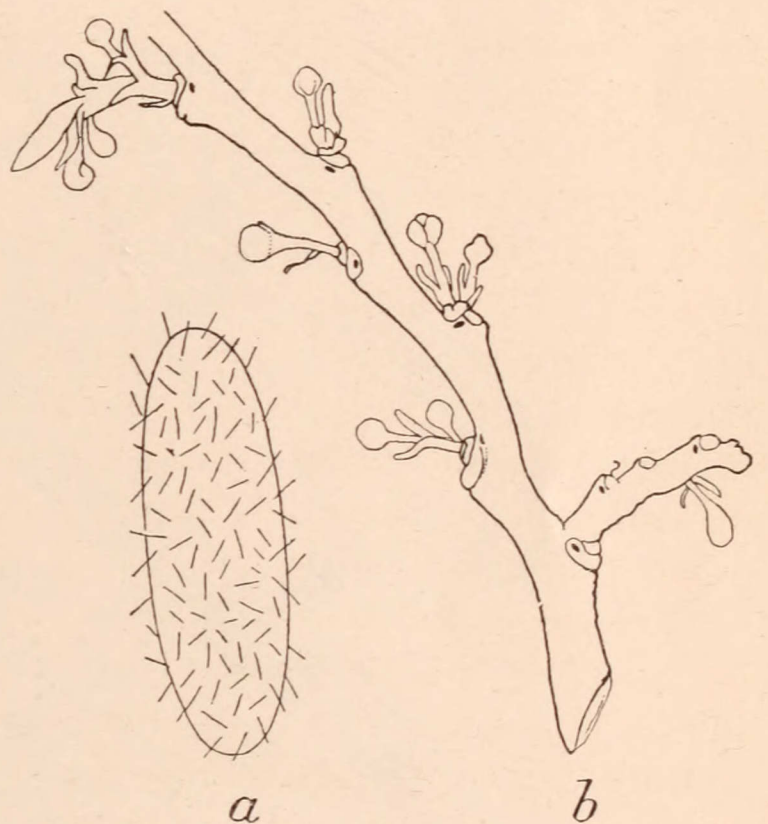


FIG. 12.—*Hamamelistes spinosus*: a, winter egg, much magnified; b, twig of witch-hazel with young flower buds and eggs in position—natural size (original).

pletely fused. The newly formed gall is also globular and but slightly larger than the original bud. They grow now rapidly, so that by about the middle of June the oldest or earliest formed galls are about half grown, have lost their beautiful rosy tint, and are now of the same pale, dingy green color of the buds. They are globular; the opening or mouth is closed and indicated by a fine whitish pubescence; while the leaflets surrounding the petiole have dropped. The surface of the gall has become densely tuberculate and in addition is covered with a greenish-white pubescence, while the tubercles are covered with

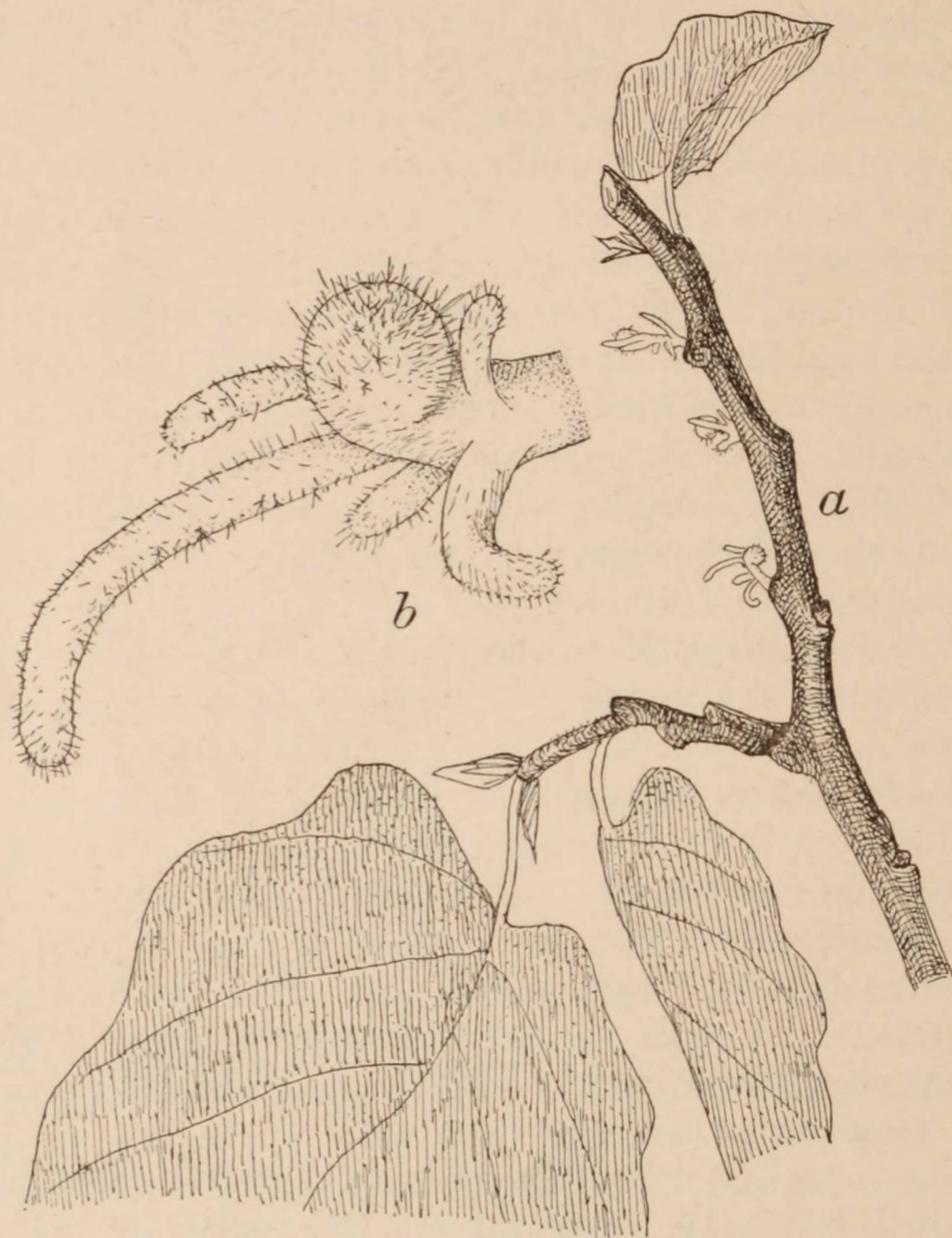


FIG. 13.—*Hamamelistes spinosus*: a, twig of witch-hazel with young galls, natural size; b, young gall—much magnified (original).

the peculiar brown and branching papillæ which are noticed on the buds. They are fully grown by the end of June or early in July, and have acquired the characteristic shape.

The mature galls (Fig. 14) vary more or less in shape and size. Their shape varies from globular to ellipsoidal and their size from 10 to 30^{mm} in length by 10 to 12^{mm} in diameter. Their surface, when fully grown, is now covered with long and stout more or less curved spines or teeth, which frequently may attain a length of 8^{mm} or more, though as the galls grow older and become dry these spines become

shorter and blunter. The whole aspect of these galls when fresh is that of a miniature seed capsule of the common Jamestown weed (*Datura stramonium*). They are of about the same green color of the leaves and studded with reddish brown papillæ. The orifice or mouth, at the base of the gall, is circular and 1 to 2^{mm} in diameter, with its external prolongation more or less decidedly funnel-shaped, terminating in a rounded or bulging rim, to allow the departing migrants space to adjust their wings for flight. The inner wall of the gall is smooth and coated with a delicate layer of a white secretion, to prevent the watery fluids, or honeydew, expelled by the insects from adhering to the surface, as a preservative against premature decay or the drying up of the tissues of the galls. After attaining their full

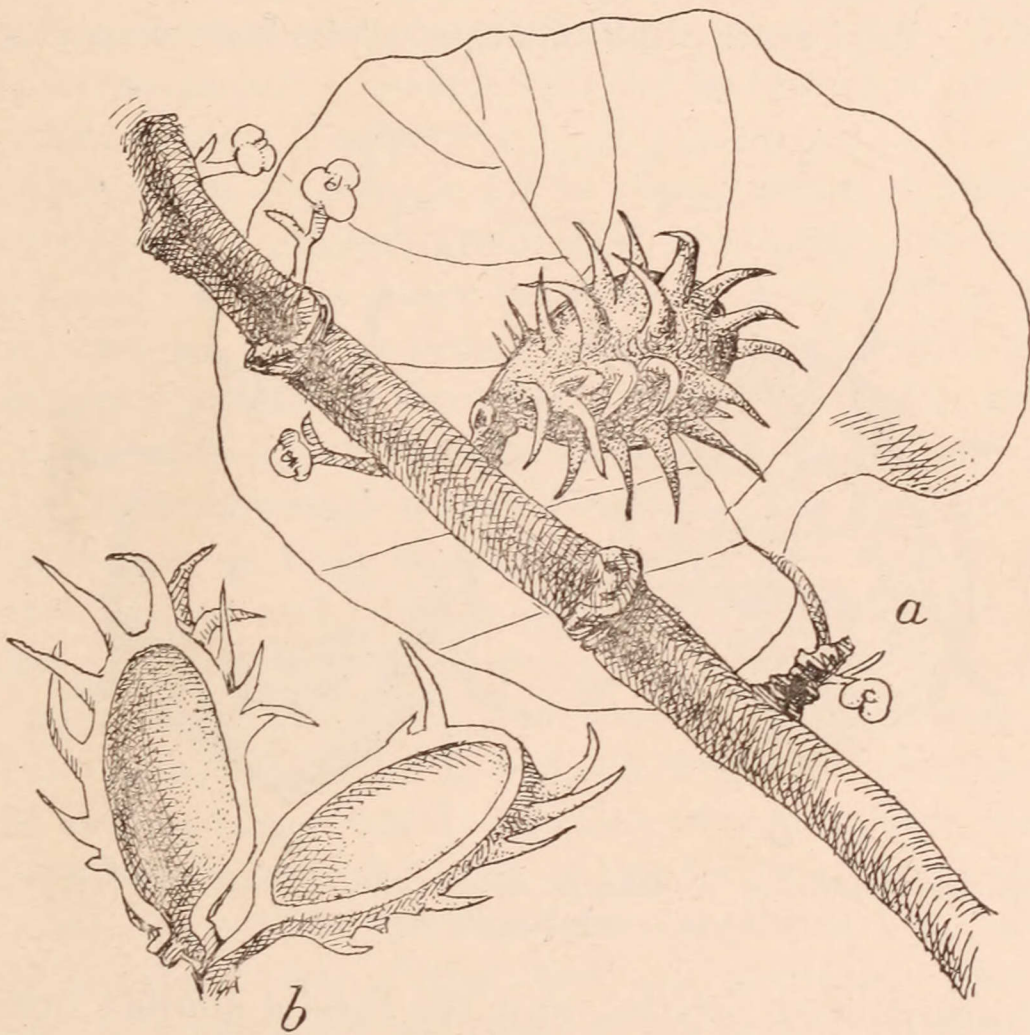


FIG. 14.—*Hamamelistes spinosus*: a, mature gall; b, section of gall—natural size (original).

growth, they remain fresh and succulent for a long time, so as to enable the latest additions to their inhabitants to acquire maturity. The majority of these galls become dry and brown by the end of summer, though occasionally fresh and green ones, containing the insects in various stages of development, may even be found as late as the end of November.

Stem-mother; first stage.—The young stem-mother, after hatching, is extremely small and measures only about 0.2^{mm} in length. She is broadly oval and of a dark purplish-brown color; the eyes, antennæ, and legs are blackish. The head is broadly rounded in front and bears two small bristles. There are three short and stout secretory tubercles each side of the prothorax, arranged in a triangle—two each

side on the other thoracic segments; one each side of abdominal segments one to seven and two, bearing two small bristles, on the last segment. There is also a semicircular row of four similar tubercles near the inner edge of the eyes and a transverse row of four between the eyes; two outward-curved medio-dorsal rows of four tubercles in each row on the prothorax; a transverse row of four tubercles on the meso- and metathorax; two median tubercles on the first three abdominal segments and one on segments four to seven. The antennæ are short, four-jointed, and inserted on the underside of the head. The two basal joints are short, stout, and subequal in length; the third is longest and slightly stoutest at the apex; the fourth is somewhat shorter, clavate, and terminates in a short, blunt spur; both are slightly annulated or serrate and bear a slender cylindrical thumb near the apex. Legs stout; the posterior tibiæ bear near the end two

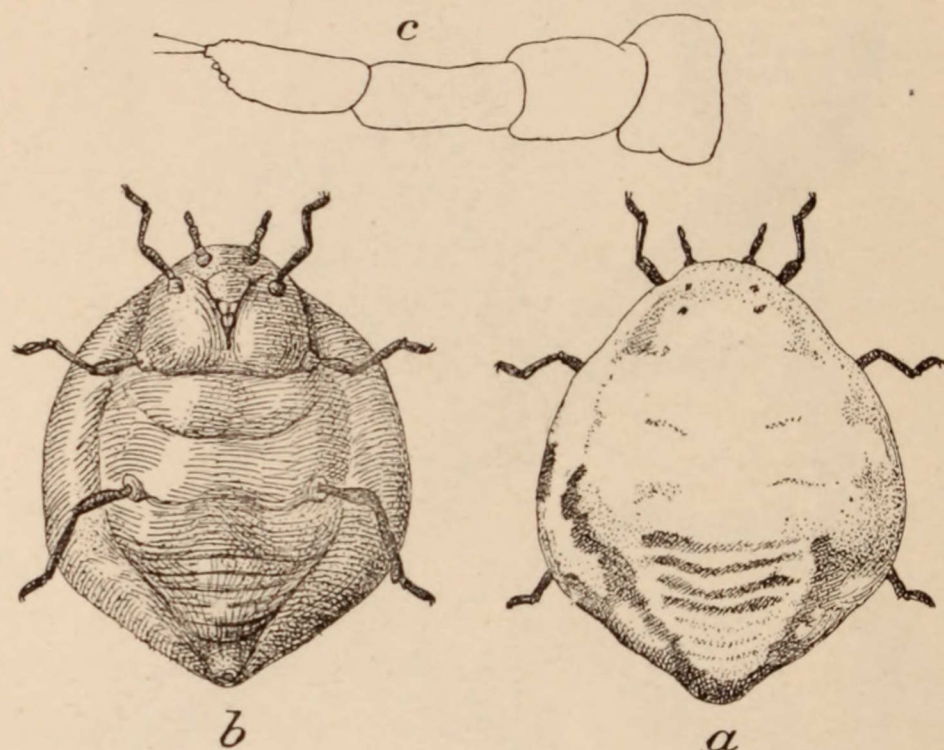


FIG. 15.—*Hamamelistes spinosus*: a, mature stem-mother, dorsal view; b, ventral view; c, antenna—much magnified (original).

long, backward-curved bristles, and the tarsi a similar one on their external edge. The digitules of all the tarsi are long and capitate, the lower pair being much the finest. The rostrum is long and tapering and reaches beyond the posterior coxæ.

In the following two stages the larvæ have lost all of the secretory tubercles, which are to some extent replaced by hairs. In other respects they are very similar to the first stage.

Adult stem-mother; fourth stage (Fig. 15).—The full-grown stem-mother is almost globular or broadly pyriform, about 2^{mm} long, and of a dark purplish-brown color, covered with a mealy secretion; antennæ, legs, and rostrum blackish. Eyes small and composed of three ocelli. There are apparently two bristles on the front of the head, two each side of the thoracic, and one each side of the abdominal segments. The tail is small, broad, knob-like, and bears two bristles; the last segment is broadly bilobed, and each lobe is furnished with about

eight bristles. Antennæ short, stout, and four-jointed; the two basal joints are shortest and stoutest, each bearing a bristle near the apex; joints 3 and 4 are longer and subequal in length, the third is clavate, and the fourth elongated oval; each bears a small thumb near the apex, and the fourth three small capitate hairs and a small spine at the tip. The rostrum is stout and reaches beyond the anterior coxæ. Legs short and stout; the digitules of the claws apparently wanting.

That the stem-mother of this species is extremely prolific was proved by the fact that one mature gall, found July 9, contained, besides the stem-mother, 220 of her progeny, in various stages of development, from the recently deposited larvæ to the winged migrants, the old mother being at the same time still very plump and almost globular, containing yet a large number of embryos, which, after all have been deposited, may increase her descendants to about 300. The galls are sometimes so completely crowded with the insects as to allow but little room for them to move about.

Second generation, first stage.—The young larvæ of this generation are brownish-red or grayish-green and gradually develop into the migratory form. They measure between 0.4 and 0.8^{mm} in length, and are about twice as long as broad, with almost parallel sides. The head is nearly straight or broadly rounded in front, and bears a rounded, fleshy tubercle. The abdomen is about one-half the length of the body; its segmentation very distinct. The head and prothorax are confluent and as long as the combined meso- and metathorax. The rostrum is stout and reaches almost to the hind coxæ. Antennæ four-jointed, curved inward, short and stout; the two basal joints are stout and short, the third and fourth are subequal in length; the third is clavate and the fourth slightly tapering; each bears a cylindrical and movable thumb. Legs stout and rather long; there is a rather long bristle near the apex of the femora; two, externally, on the tibiæ and one or two on the tarsi; digitules long, slender, and apparently simple; those of the claw are wanting. There are also four or more bristles along the front of the head, two each side of the thoracic, one each side of the abdominal segments, and four at the end of the body.

Second generation, second stage.—In this stage they are still very similar to the young larvæ, though they are much stouter and about 1.2^{mm} in length. The antennæ are now distinctly five-jointed, rather stout, and still more curved inward; the two basal joints, as usual, are short, the first stoutest; the other three grow gradually somewhat longer, the fifth being somewhat the longest and thinnest; joints two and four are clavate, the third cylindrical, and the last one conical, its tip rounded; the last two joints, as usual, bear each a small thumb. The rostrum reaches to the median coxæ.

Second generation, third stage.—In this stage they are still larger and stouter, and measure about 1.4 to 1.6^{mm} in length. The future

wing pads are now indicated by a rounded swelling each side of the pro- and mesothorax. The antennæ are about twice as long as before, and reach, if laid backward, to the median coxæ. Joint three is longest, the two last ones somewhat shorter and subequal in length; joints one, three, and four are cylindrical; the second, which is slightly the shortest, is stoutest at the apex; the fifth is curved and tapering; the last two bear the usual thumb. In other respects they are very much like before.

Second generation, fourth or pupa stage.—In this stage they are still larger and stouter than before, and measure 2.4 to 2.6^{mm} in length and have now fully developed wing pads. They are reddish-brown to purplish-brown, the disc of the thorax more yellowish; eyes brown, the antennæ, legs, and wing pads whitish, the external margin of the latter blackish. The front of the head is now concave and the frontal tubercle minute. The antennæ are again much longer than before, or almost twice as long, with the division between joints three and five almost obliterated. The eyes are large and well developed.

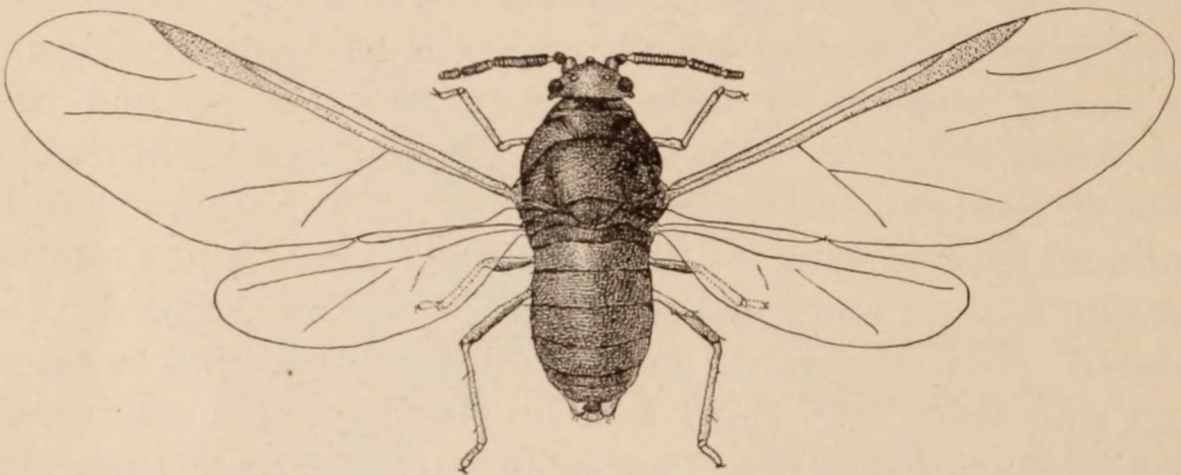


FIG. 16.—*Hamamelistes spinosus*: Spring migrant—much enlarged (original).

Second generation, migrant or fifth stage (Fig. 16).—Early in July, or about a month and a half after hatching of the stem-mother, the earliest migrants are fully developed and commence leaving the galls and continue to issue till late in the fall. Having adjusted themselves, they start on their migratorial trip, during which they may frequently alight on the leaves of various plants, not alone for rest, but evidently for the purpose of determining the nature of the plant on which they may happen to be, though they will rarely deposit any larvæ until their unerring instinct finds the birches, the only plant suitable for the welfare of their progeny. Each of these migrants contains from thirty to forty or more larvæ, or only about one-seventh as many as the stem-mother. These migrants are rather larger than those of *Hormaphis hamamelidis* and measure between 1.8 and 2.4^{mm} in length, with an expanse of the wings of 4 to 6^{mm}. They are stoutly built and of a dark, purplish-brown color; the head, eyes, antennæ a dorso-lateral spot on the prothorax, thoracic lobes and sternal plate, black, and the legs dusky; apex of abdomen more

or less distinctly reddish; the wings are clear or faintly brownish, with the costal cell and stigma dusky and the veins blackish. They are slightly covered with a white and powdery secretion and, when not rubbed, have also two small tufts of a dense and white secretion on the scutellum, a similar tuft or patch each side on the thorax, and some fibers or flakes of secretion on the abdomen. Antennæ five-jointed, reaching only to the base of the wings; the two basal joints are short, with joint two almost globular; the third joint is longest, and as long as the remaining two combined; the last two are subequal in length, all three are densely and deeply annulated. There are between twenty-seven and thirty-two annulations on the third joint, twelve to fourteen on the fourth, and eleven to thirteen on the fifth joint. The head is broader than long and distinctly conical in front; eyes large. The legs are rather short and slender, the digitules highly developed. Tail small, transversely oval and knob-like, tuberculated, and hairy; the last segment is bilobed, and each of its lobes furnished with numerous, rather long hairs. The wings are large and broad and are carried flat on the back when at rest; the stigma is broadly lanceolate and somewhat broadest at the base of the stigmal vein. The venation is similar to that of *Hormaphis hamamelidis*, though the second discoidal vein joins the first much nearer its base than in the other species. The first discoidal of the posterior wings is rarely entire, and is usually represented by a small stump; sometimes it is wanting.

Third, or Coccidiform, generation.—After having fully matured the winged form leaves the witch-hazel galls and migrates to the leaves of birches to deposit their larvæ, which after a short time of feeding move to the twigs and branches and settle down close to a bud for their future transformation and for hibernation. Their growth appears to be very slow, and many of them perish before the approach of spring, so that usually but very few adult females will be found.

Third generation, first stage (Fig. 17).—The young larvæ of the migrant from witch-hazel are very peculiar, and resemble more closely, when seen on the twigs, the larvæ of a Lecaniid than those of an Aphid. They are about 0.4^{mm} in length, about twice as long as broad, oblong-ovate, and rather flat above. A slightly elevated rounded carina runs from the head to the end of the body, which is traversed by fine impressed lines, indicating the divisions of the body but failing to reach the lateral margin. There is also a rather deep fovea each side of the carina on the prothorax and a puncture each side of the carina on the other two segments of the thorax. The abdomen in comparison with the rest of the body is very small, or only about one-third or less of its length. The dorsum is densely granulated and more or less polished. The lateral edges are studded with about 30, and the front of the head with 16 to 18, short, truncated, and cylindrical secretory

tubercles, from each of which issues a transparent and colorless straight or slightly curved cylindrical waxy rod.

When first deposited these larvæ are of a reddish-brown color, the antennæ and legs paler, and the eyes dark purplish, which soon changes, however, excepting the under side of the body, to a beautiful, brilliant dark metallic blue or green, while others change to bluish-green, purplish, or to a brassy or coppery reflection. The antennæ are short, four-jointed, and inserted on the under side of the head. The first joint is shortest, stoutest, and slightly conical; joint two is somewhat longer and slightly clavate; the third is longest, cylindrical and about one-third longer than the second, while the last is a little shorter than the third and bears the usual sensorial thumb near the apex, the tip being surrounded with a few short hairs. The rostrum is stout and

reaches beyond the median coxæ. Legs stout; the tarsal digitules are long, capitate and curved; those of the claws are much finer, straight, and only about half as long as the others. There are also two or three long and stout, backward curved bristles near the end of the hind tibiæ, and two similar ones on the hind tarsi.

Third generation, second stage.—The larvæ in this stage are about 0.6^{mm} in length, broadly oval and still rather flat; being but slightly convex on the thoracic segments and along the middle of the abdomen; the sutures dividing the various segments are quite plain, though they do not reach to the

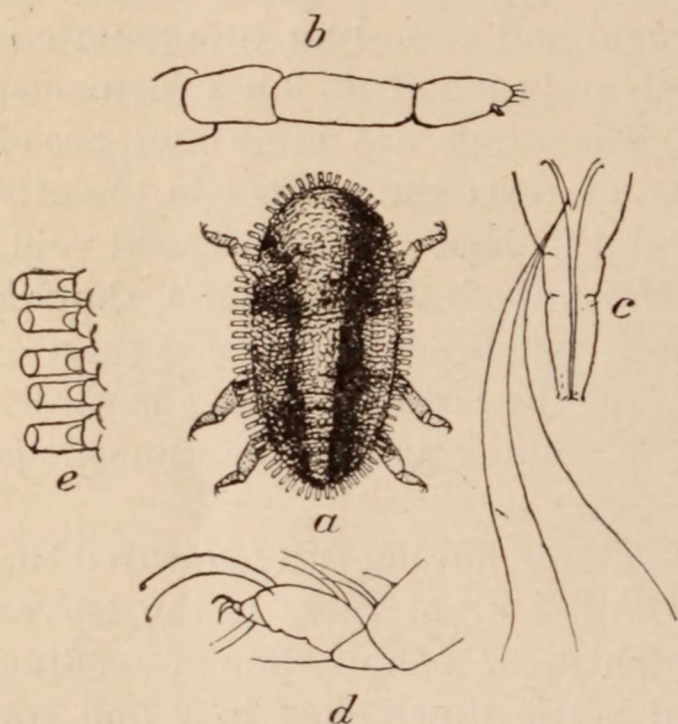


FIG. 17.—*Hamamelistes spinosus*: a, hibernating larva, third generation; b, antenna; c, rostrum; d, tarsus; e, lateral tubercles and waxy rods—much enlarged (original).

lateral margin. The surface of the body is now finely rugose and its lateral margin surrounded by a very short fringe of waxy secretion, issuing from closely set secretory tubercles. The antennæ are now much shorter than before and only three-jointed; the two basal joints are short and subequal in length, while the third is about as long as the two basal joints together, slightly tapering and truncate at the tip. The rostrum has become shorter and reaches only to the median coxæ. The legs are also shorter, while the anterior and median legs have lost their tarsi, which sometimes are indicated by a minute, knob-like swelling; the posterior pair of tarsi are still present, though rather short, irregular in outline and have lost the claws; the digitules are still present, though rather short and fine. The color of the insect is now of a dull black or dark brown.

Third generation, third stage.—In this stage they look very much

like before, except that they are much broader and about 0.8^{mm} in length; the surface of the body is now densely and finely rugose, and the sutures between the segments have become deep and broad; there is also a depressed subdorsal line around the body; the tail is broad, semicircular, more distinct than before, and furnished with 4 to 6 hairs. The antennæ are still three-jointed, the second joint being much the longest and cylindrical and the third joint minute or rudimentary. They are dark brown or black and greasy looking.

Third generation; adult female; fourth stage (Fig. 18).—The adult female of this generation is broadly oval and measures 1.2 to 1.4^{mm} in length and 1 to 1.2^{mm} in diameter. After casting the last skin they are deep black, convex, and densely and coarsely rugose, with three rather prominent, short, and rounded transverse ridges about the middle of the body, and irregular rows of pits and depressions each side of the median line. The edge of the body is closely lined with about 120 short, secretory tubercles and about 14 similar ones along the edge of the tail, producing a continuous, but very narrow, waxy fringe around the body. The dorsal surface is at first bare, but soon becomes covered with a whitish, powdery secretion, which gives to the insect a moldy appearance; this changes gradually into scattered, delicate, waxy flakes or scales, which, toward the approach of spring, form a solid and continuous waxy covering, most dense or solid along the sides and the end of the body, giving them a dark silvery-gray appearance, on account of which they assume a remarkable resemblance to certain species of the Lecaniid genus *Ctenochiton*. Advancing to maternity, the ventral side of the body becomes very much inflated and assumes a box-like appearance, as in some Aleurodids, and is covered with a powdery secretion. The antennæ are now very small and rudimentary and apparently but two jointed, though there may be three, which, however, could not be ascertained with certainty on account of the very dark color and the coarse rugosity of the body. The legs are as in the previous stage, except that the hind tarsi are only about half as long as before.

Pseudo-galls, or corrugations (Fig. 19).—About the middle of April, or just about the time of bursting of the leaf-buds of the

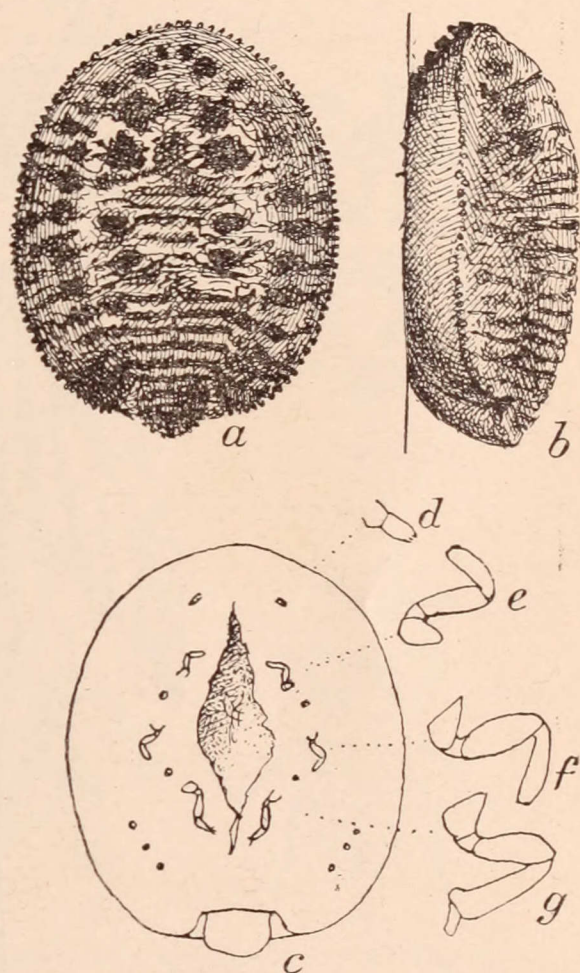


FIG. 18.—*Hamamelistes spinosus*: a, adult female, third generation, dorsal view; b, lateral view; c, ventral view; d, antenna; e, f, g, legs—much enlarged (original).

birches, the coccidiform, or hibernating females, have attained their full development and begin at once their duty of reproduction. The young larvæ soon after having been deposited are directed by their inherited instinct, to move at once to the young and tender leaflets which are just bursting forth, and settle on the under side in the folds or plications between the transverse veins. The continuous irritation produced by the sucking of the insects causes the edges of the young leaves to curve down, while at the same time the upper surface of the leaves between the veins commences to bulge out and gradually forms



FIG. 19.—*Hamamelistes spinosus*: Pseudo-galls, or corrugations, on leaves of birch—natural size (original).

rounded ridges, or corrugations, while the folds on the under side gradually close up. The thus formed pseudo-galls, offer ample room for the gall-makers and their progeny. These corrugations or folds acquire a reddish-brown shade which soon changes to a beautiful reddish or crimson color. The growth of the young insect is rapid, keeps pace with the growth of the infested leaves and reaches full development by the end of April or early in May, or about twenty days from the time they were born and commence at once to reproduce their kind, which frequently become so numerous as to fill these pocket-like folds to their utmost capacity. In favorable years the insects

are apt to become extremely numerous, so as to injure even large trees very seriously, causing the infested leaves to turn gradually brown and to drop after most of the insects have left. This injury to the foliage of badly infested trees or shrubs, as a rule, is very severe on the branches, many of which gradually dry up and die, which injury, if continued for a number of years, will kill the trees. The development of the second generation of the gall-inhabiting insects, which eventually become winged, is also rapid, to enable them to attain full development before the leaves commence to drop and to be ready for return migration to the witch-hazel early in June, to give birth to the final or sexed generation, to complete the cycle of existence of the species. This is the generation described by Mr. O. W. Oestlund in his "Synopsis of Aphidæ of Minnesota," under the name of *Hormaphis papyraceæ*.

Fourth generation, first stage, (Fig. 20).—The general appearance of the leaf-corrugating generation has so completely changed as to bear no resemblance whatever to the previous coccidiform generation; so much so as to render it impossible to detect their affinity or their close relationship except by continued and close observation; which I have been so fortunate as to trace without the shadow of a doubt.

The young larvæ when first deposited are of an orange color, but soon change to yellowish-brown; marked with two broad and faintly dusky stripes on the head, which extend to the prothorax. The eyes are purplish, with three colorless ocelli. Antennæ and legs dusky. They are elongate-oval, slightly convex, distinctly segmented, and 0.3 to 0.5^{mm} in length. The head is broader than long and semi-circular in front, where it bears four short bristles arising from small tubercles; two similar bristles are each side of the thoracic, one each side of the abdominal segments, and four along the edge of the broad and semicircular tail. There appears to be also a transverse row of four short bristles on the thoracic segments and two, medio-dorsally, on the abdominal segments. The antennæ are four-jointed; the two basal joints short and subequal in length; the two last joints long

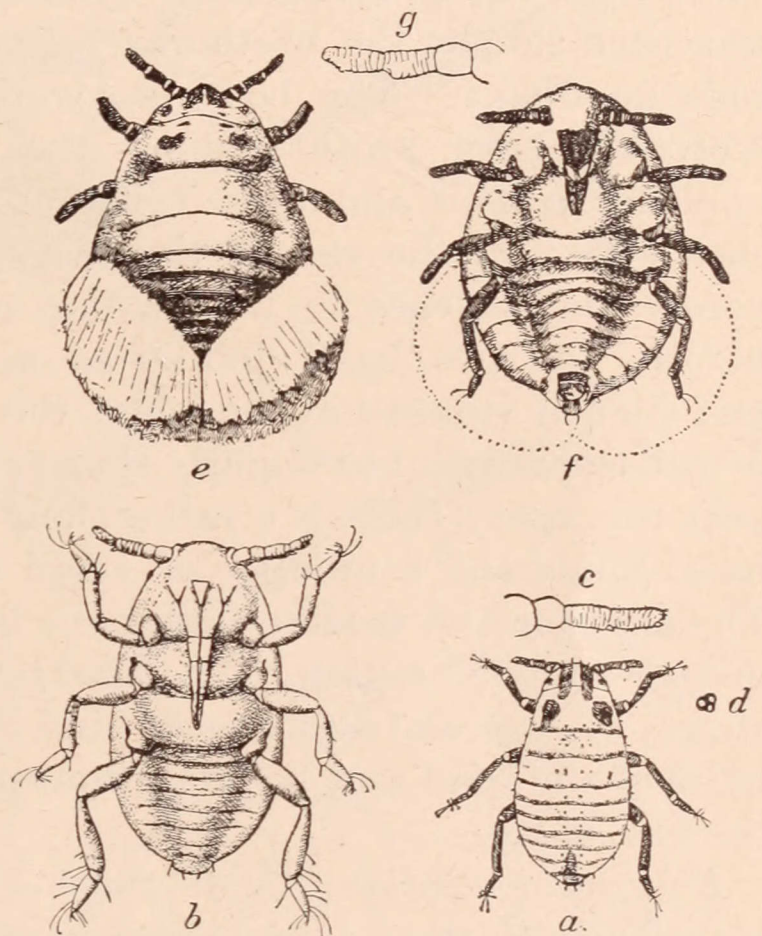


FIG. 20.—*Hamamelistes spinosus*: a, Young larva, fourth generation, dorsal view; b, ventral view; c, antenna; d, eye; e, adult female, dorsal view; f, ventral view; g, antenna—much enlarged (original).

and also subequal in length; joints one to three are cylindrical or slightly stoutest at the apex; the fourth being elongated oval. The third and fourth are slightly annulated, each bearing a small and movable thumb. The legs are long and stout, with the hairs and digitules very similar to those of previous generations. The rostrum is stout and reaches to the posterior coxæ.

Fourth generation; second stage.—In this stage they measure between 0.6 to 0.9^{mm} in length and are broadly ovoid, broadest across the thorax and gently tapering toward the end of the body. They are of a reddish color, marked with two large and triangular, dusky or black spots near the anterior margin of the head, two to four small dusky spots between the eyes and a dusky, depressed subdorsal spot each side on the prothorax. Eyes, antennæ and legs black, the rostrum dusky. The body is covered with a white and powdery secretion, most profuse along the middle. There has now also appeared a short and dense brush of a white and glistening secretion each side near the end of the body. The rostrum is shorter than before and reaches to the median coxæ; antennæ four-jointed as before; the two basal joints, as usual, short, subequal in length and slightly stoutest at the apex; the third joint is longest and cylindrical, the fourth but slightly shorter and both bearing a short thumb near the apex; there is a rather long bristle near the apex of the two basal joints and a number of small hairs at the apex of the fourth. The anterior and median tarsi have been lost or are represented by a minute rounded stump. The hind tarsi are present, but have lost the claws; bristles and digitules of hind tibiæ and tarsi are present. The hairs of the head and body are now much longer and stouter than in the first stage.

Fourth generation; third stage.—In this stage they are almost identical with those in the previous stage, though they are now almost globular, 1^{mm} in length and of a dark-greenish or brownish-green color, marked with two large dusky spots on the head, reaching beyond the eyes. The powdery secretion forms now a distinct white line along the middle of the back. The rostrum has grown still shorter than before; the tail is broad, provided with six hairs and densely covered with rows of minute and sharp spines.

Fourth generation; adult female, or fourth stage.—The adult female of this generation is very convex, almost globular, 1.2 to 1.6^{mm} long and 1 to 1.2^{mm} in diameter. They are at first dark brownish-red, changing gradually to dark yellowish-green, and finally to a purplish color; the front of the head, two small dots on the prothorax, a band at base of the tail, tip of tail and of the two lobes of the last segment, eyes, antennæ, legs, and rostrum, all black. They are slightly dusted with powdery secretion as before, and bear also a short brush of secretion along both sides of the abdomen. The segmentation of the body is quite distinct; there is also a rather deep dorso-lateral groove

or furrow around the entire body, which, with the lateral margin, forms a prominent, rounded ridge. The antennæ are identical with those of the previous stage, except that they are somewhat longer. The anterior and middle tarsi are either wanting or are sometimes represented by a minute, squarish stump, which occasionally bears at its external angle two rather stout, outward-curved hooklets, evidently the representatives of claws, while the hind tarsi, in the majority of cases, are again quite normal; some specimens have one or two perfect claws, indications of claws, or none whatever; the tarsal digitules of the posterior legs may be well developed, rudimentary, or wanting. The mature insect may, however, be always recognized by

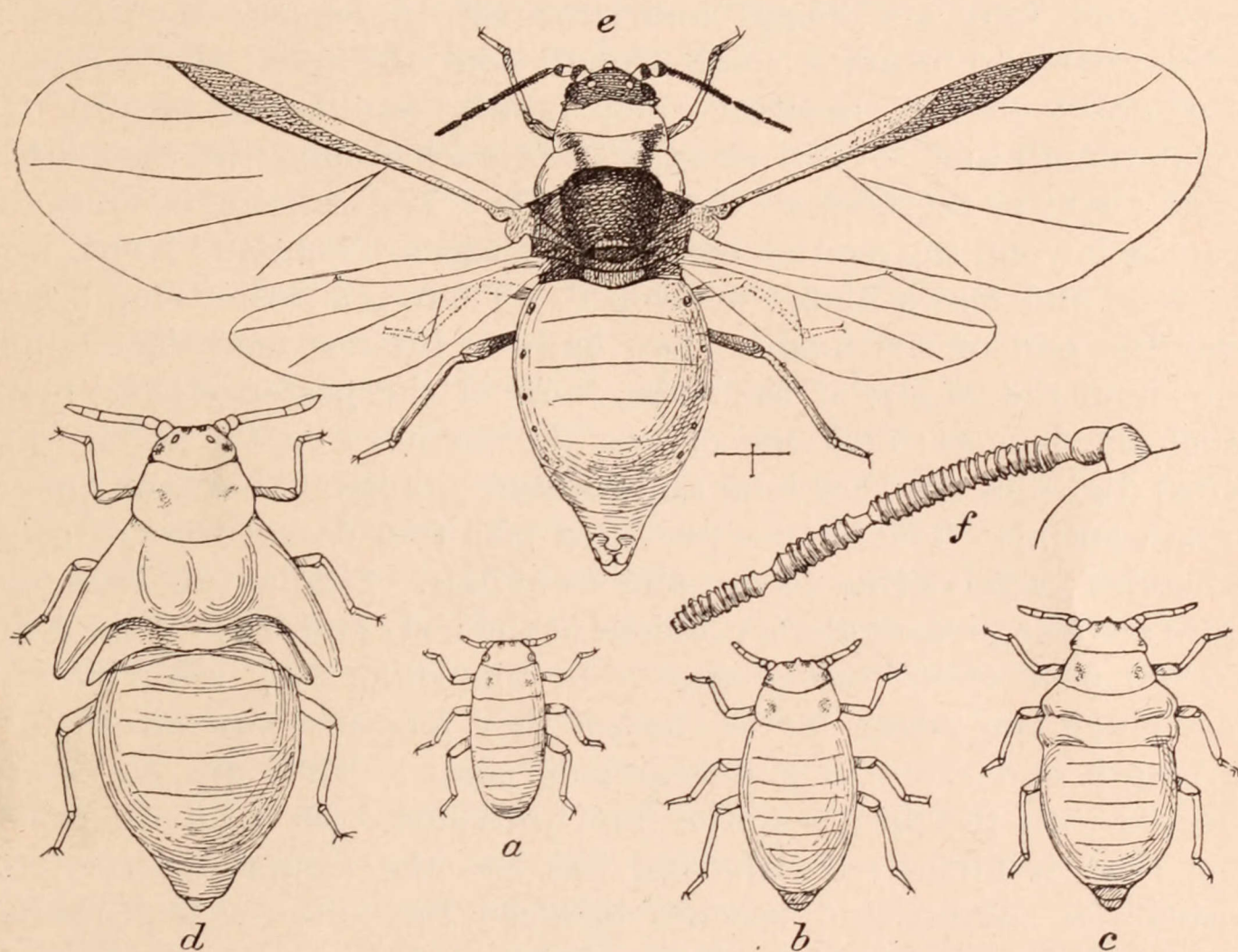


FIG. 21.—*Hamamelistes spinosus*: *a*, young larva, first stage, fifth generation; *b*, larva, second stage; *c*, prepupa, third stage; *d*, pupa; *e*, return migrant; *f*, antenna—much enlarged (original).

the formation of the last abdominal segment and the shape of the tail; in the immature specimens the tail is short, very broad, being either broadly arcuate or with an obtuse angle medially, while the last abdominal segment is semicircular and entire. In the adult female, however, the tail is small, transversely oval, knob-like, and bears two bristles, the last segment being strongly bilobed, each lobe bearing ten or more long hairs. The rostrum is short and reaches but slightly beyond the anterior coxæ. The hairs of the head and body are similar to those in previous stages, except that they are longer and stouter.

Fifth or migratory generation; first stage (Fig. 21).—Early in May the leaf-corrugating females or fourth generation of the series are fully matured and commence their reproductive functions. The

young larvæ of this generation are at first pale yellowish, but as they grow in size become much darker. The head is dusky; antennæ, legs, and rostrum darker, and the eyes black or purplish black. They are dusted with a mealy secretion, and soon acquire a short brush of white secretion along each side of the abdomen. They are about 0.6^{mm} in length, much elongated, and almost three times as long as broad, with the sides nearly parallel. The front of the head is almost straight and provided at the middle with a prominent, rounded tubercle. The posterior end of the body is rounded. The antennæ are four-jointed, rather stout, and slightly curved inward; joint two is slightly the shortest, the first stoutest; both bear a bristle near the apex; joints three and four are longer and subequal in length; the third is cylindrical and bears a small thumb near the apex; the last joint is slightly curved, tapering, and faintly annulated, bearing the usual thumb and several short, stiff bristles around the apex; they reach about as far back as the first coxæ. The rostrum is stout and reaches beyond the median coxæ. The legs are long and stout, with the tarsi and claws highly developed. There is a rather long bristle near the end of the femora; two hairs or bristles near the end and one about the middle of the tibiæ, those of the posterior tibiæ being much the longest; also one or two shorter ones on the tarsi. The tarsal digitules are very long and capitate; those of the claws appear to be wanting. The body is provided with four dorsal rows of small tubercles, each bearing a short and stout hair. Similar tubercles, and hairs are also present along the sides of the body and front of the head.

Fifth generation; second stage.—In this stage they resemble still very much the young larvæ, though they measure now already 1^{mm} in length and are of a more elongate shape. They are, as before, covered with powdery secretion and provided with a lateral brush. The head is almost straight and has lost the frontal tubercle; the rostrum is shorter and reaches between the anterior and median coxæ. The antennæ are now five-jointed, very stout and distinctly curved inward. The two basal joints are short, each bearing a bristle near the apex; the third and fourth are nearly subequal, with the third somewhat the longest; the fifth is longest of all, curved and tapering, bearing a number of spine-like hairs around the apex. The last two joints bear the usual thumbs. All the tarsi, claws, and digitules are present. The hairs of the body and head are now much longer and stouter than in the first stage.

Fifth generation; third stage.—In this stage they resemble still those of the second, though they are larger and measure about 1.2 to 1.4^{mm} in length. The future wing-pads are now indicated by rounded swellings at the sides of the meso- and metathoracic segments. Tarsi and claws present, as before. The antennæ are now about one-fourth longer than in the second stage, the third and fourth joints being subequal and longer than the others; in other respects they are as before.

Fifth generation; fourth or pupa stage.—The fully developed pupæ

vary to some extent in size, measuring from 1 to 1.6^{mm} in length. They are of a reddish or purplish-red color, with the prothorax somewhat the darkest, the head and rest of the thorax palest, the shoulders whitish or yellowish. Eyes brown and the ocelli red. Antennæ, legs, wing-pads, and rostrum pale dusky; the sutures between the antennal joints white and the external edge of the wing-pads blackish. All are covered with a dense, straight and hair-like, white and glistening secretion, which is most dense and brush-like along each side of the abdomen; this secretion is apt, however, to be easily detached by the movements of the insects within the folds. The antennæ are much longer than in the preceding stages, and if directed backward would reach to or beyond the base of the wing-pads. The third joint is much the longest and almost as long as the two last joints combined; the fourth and fifth are subequal in length; the sensorial thumb of each is minute; the third and fourth are cylindrical and the last one slightly tapering, with the usual hairs at the apex. In other respects they are similar to those of previous stages.

Fifth generation; migrant, or fifth stage.—The winged form or return migrant is much smaller than those leaving the witch-hazel galls, being only about one-half their size. Length of body, 1.6^{mm}, and expanse of wings about 5^{mm}. They are dark reddish, the abdomen frequently with a purplish tinge or sometimes greenish-brown. Head, antennæ, an oblique or triangular depression each side of the prothorax, thoracic lobes, sternal plate, and tarsi, black; the legs dusky. Wings faintly dusky, the subcosta and stigma dusky, the costal cell somewhat paler; veins black. Antennæ five-jointed; the second joint is almost globular; the third is much the longest; the other two subequal in length and together somewhat longer than the third; all three are strongly and deeply annulated, the number of annulations in each varying more or less; those of the third joint vary between 20 and 30; in the fourth between 10 to 13, and in the fifth between 14 and 15, though in some specimens there may be but a very few and widely separated annulations on the last joint. The legs are normal and the digitules of the tarsi, as well as the claws, well developed. The head, including the eyes, is about twice as broad as long and more or less distinctly conical in front. The tail is knob-like, densely covered with minute spines, and bears two long and about six smaller bristles. The last abdominal segment is deeply bilobed and densely spinous, and bears in addition a number of bristles.

Fifth generation; accessory, apterous female.—In the folds or corrugations, in company of the winged form, are frequently found apterous females, belonging to the fifth generation, which are destined to produce an additional or intermediate migratory generation. The economy of these apterous females and additional migratory generations remains rather obscure.

These accessory females are of a dirty brownish color, and densely

covered with a short, flocculent secretion, giving them the appearance of mealy bugs, and measure about 1.8^{mm} in length by about 1^{mm} in diameter. The front of the head is straight, the tail knob-like, the last segment deeply bilobed and provided with bristles and minute spines as in the migratory form. The antennæ are also five-jointed, though only about half as long as those of the migrant. The two basal joints, as usual, are short and stout, each bearing a bristle; the last is somewhat the longest; the third and fourth slightly shorter, subequal in length, and all three slightly annulated. In other respects they resemble the previous stages.

Sixth, or sexual generation.—From early in June till about the middle of the month the migratory generation, bred on the birches, attains its full development and migrates back to the witch-hazel to consign to it the final or sexed generation. Large numbers of these migrants may then frequently be seen on the under side of the leaves

of this shrub, in the neighborhood of the birches, and with them numerous larvæ, scattered over the surface of the leaves, particularly along the midrib and the veins. On one of the leaves examined 61 living and 20 dead larvæ were counted, and on another leaf 35 living and a considerable number of dead larvæ, which tends to in-

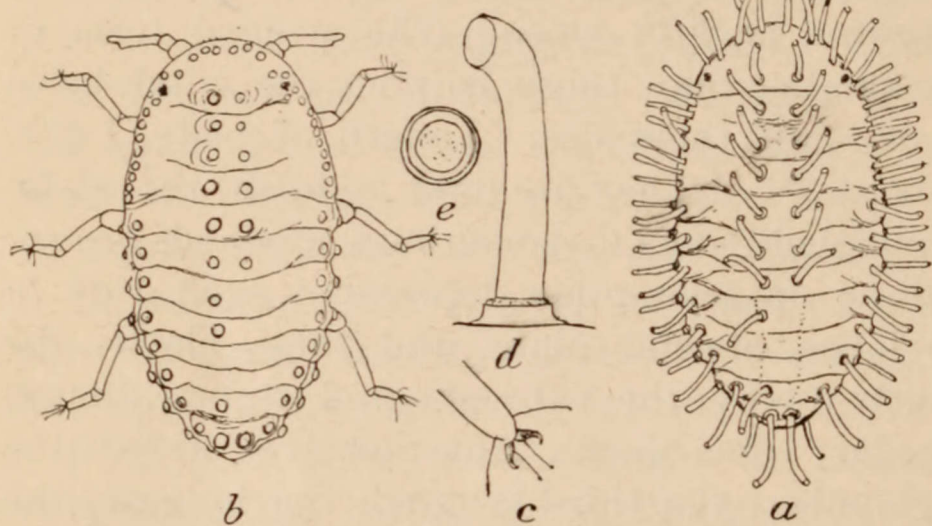


FIG. 22.—*Hamamelistes spinosus*: a, young larva, sixth or sexual generation, dorsal view; b, denuded, showing arrangement of pores; c, tarsus; d, lateral tubercle and waxy rod; e, apex of lateral tubercle—much enlarged (original).

dicate that only about one-third, or even a smaller percentage of all the larvæ, are able to reach maturity, and that even a much smaller number of the winter eggs may survive and hatch the following spring. The sexual generation develops also rather rapidly and reaches maturity within two or three weeks, when, toward the middle or end of June, after copulation has taken place, the females forsake the leaves and betake themselves to the twigs for the purpose of depositing their winter eggs in the immediate neighborhood of the dormant flower buds, which, in the spring following, start to develop just at the time that the eggs are hatching.

Sixth generation, first stage (Fig. 22).—The young larvæ of the sexual generation are of a very pale yellowish-white color, with the eyes black and minute. They are about 0.5^{mm} long, oval or slightly broadest across the thorax. There are generally about twelve short and stout secretory tubercles along the front of the head, two or three in front of the eyes, and two near the posterior margin between the

eyes; there are also four medio-dorsal tubercles placed in a square, and three to four along the lateral margin of the prothorax; two tubercles medio-dorsally and three to four each side of the meso- and metathorax; one or two median ones on the three or four basal segments of the abdomen and sometimes one on the remaining segments; there is also one dorso- and one ventro-lateral tubercle on each abdominal segment, the last segment bearing from four to six tubercles along its posterior margin, from each of which issues a white and iridescent, truncated, and curved waxy rod. The head is transversely and deeply concave in front of the eyes. Antennæ short and four-jointed. The two basal joints are short, each bearing a short bristle; the other two are longer and subequal in length; both are slightly annulated, and both bear a small, sensorial thumb; the spur of the

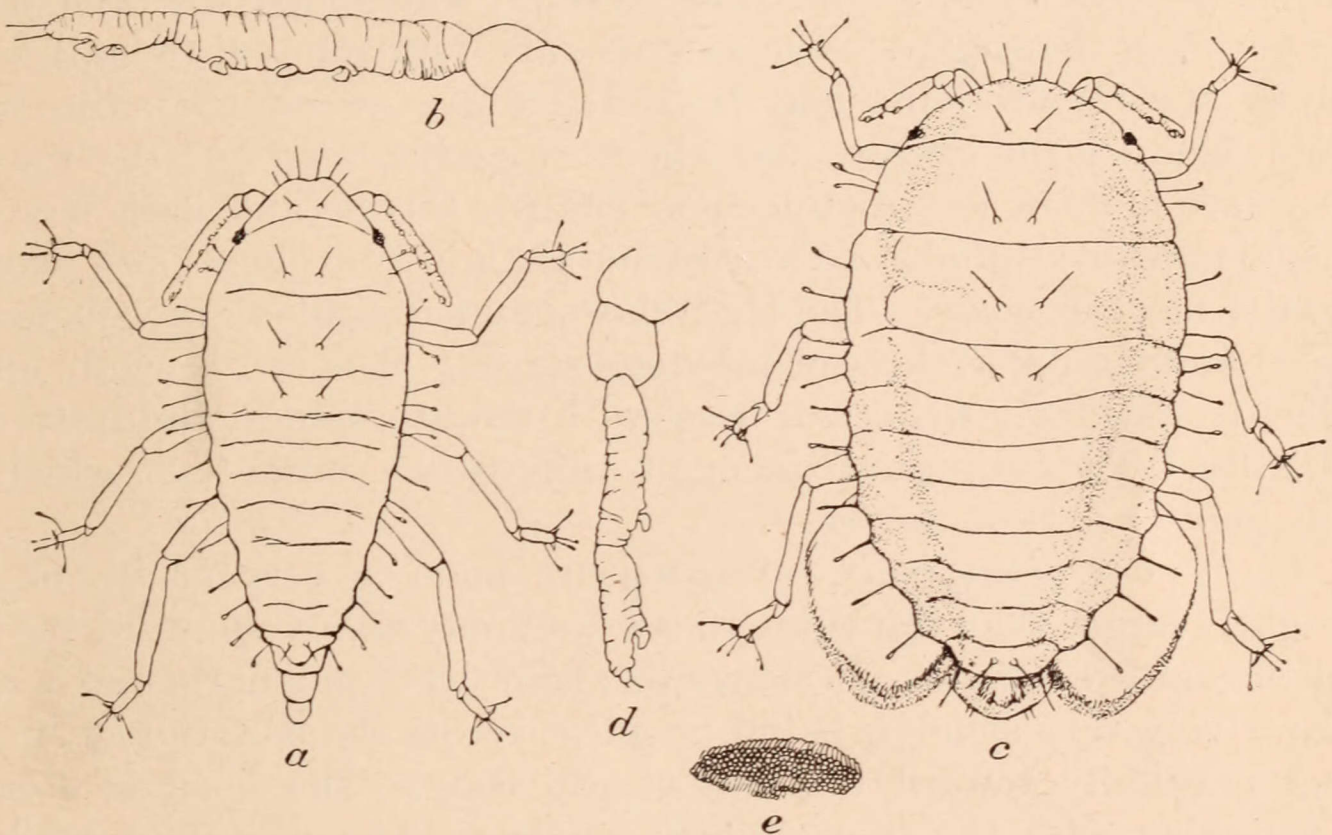


FIG. 23.—*Hamamelistes spinosus*: *a*, male, dorsal view; *b*, antenna; *c*, female, dorsal view; *d*, antenna; *e*, ventro-lateral secretory gland—much enlarged (original).

last joint is short and stout and bears two or three small hairs at the apex. The rostrum is stout and reaches beyond the posterior coxæ. The legs are long and stout, with their tarsi, claws, digitules, and bristles highly developed. Male and female larvæ are difficult to distinguish from each other.

Sixth generation, second to fourth stages.—In these stages they resemble still those of the first stage, except that they grow gradually larger, that the antennæ increase in length, and that the two last joints tend to become more or less distinctly fused, the division between them being, as a rule, indicated by a very minute knob.

Sixth generation, mature female (Fig. 23).—The mature females are of the same pale color as before and about 1^{mm} in length, they are broadly oval and have lost all traces of the secretory tubercles, but have acquired instead of them rather long and stout bristles, some of

which are slightly capitate; eight of these bristles may be observed along the front of the head; two between the eyes; two medio-dorsal ones on the thoracic segments and two in front of the tail; also two lateral bristles on the thoracic and one each side of the abdominal segments. There is now also a large ventro-lateral poriferous plate or gland each side on the ventral side of the abdomen, covering segments 4 to 6, from which a dense mass of fine white and glistening threads of waxy secretion issues, which curves up the sides of the body, so as to form a dense brush or rosette, the material of which is afterwards used by the female, while in the act of ovipositing, to cover the sticky eggs with the aid of its hind tarsi to disguise them so as to conform with the pubescence of the twigs and buds. This habit resembles in this respect that of the sexual females of *Phyllaphis fagi* and certain other species, which have the same habit of covering their eggs. The antennæ are four-jointed, though sometimes the fourth joint may be rudimentary or wanting; the third joint is much the longest and about twice the length of the fourth; both are more or less distinctly or sharply serrate and both bear the usual movable thumbs. The rostrum is highly developed and reaches to the median coxæ. The legs, claws, and digitules are well developed and similar to those of previous stages. The tail is small, knob-like, transversely wrinkled, beset with minute spines, and bears two bristles. They contain from one to five rather large eggs, which fill the greater part of the body.

Sixth generation, male.—The mature male is very small, or but slightly larger than the young larvæ and only about one-third the size of the mature female. It measures about 0.4^{mm} in length, and is comparatively very slender, being broadest across the mesothorax, tapering gradually toward the end of the body. The head is broadly triangular, with the apex slightly concave. The eyes are prominent and reddish-black. The rostrum is stout, highly developed, and reaches to the median coxæ. Antennæ slender, four-jointed, and reach when laid backward to the anterior femora. The third joint is much the longest and about twice the length of the fourth. Both are rather sharply and densely serrate. Joint 3 is cylindrical and bears from two to three movable, sensorial thumbs, and the fourth joint one or two at the base of the short spur and two or three small hairs at the apex. The legs are more slender and comparatively longer than those of the female; tail small and knob-like. All of the pores have disappeared. The hairs or bristles of the head and body are as in the female. The male is extremely active after attaining its full development and runs briskly about over the surface of the leaves. On account of its smallness and general resemblance to the larva, it is extremely difficult to distinguish it from female larva.

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