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A preliminary study of the biology and control of the euonymus scale, Unaspis eunonymi (Comst.).

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A PRELIMINARY STUDY OF BIOLOGY AND CONTROL OF THE EUONYMUS SCALE, UNASPIS EUONYMI (COMST.)

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INTRODUCTION

The euonymus scale, Unaspis euonymi (Const.), has been known to be a serious pest of the Euonymus shrub for many years. However, very little work has been done on its life history and control. With the increase in abundance of this insect, and its subsequent damage affecting more and more ornamental shrubs, need for a study of this insect has been clearly shown. Consequently the summer of 1948 was spent, by the author, at the Waltham Field Station in carrying out experiments and gathering information concerning the life history and control of Unaspis euonymi.

In the control of insects by insecticides, the chemicals are always directed at those stages in the life cycle of the insect pest which are most vulnerable. This susceptible stage can be determined only by a study of the insect's life history. In the case of Unaspis euonymi, the first nymphal instar or "crawler" stage, as it is commonly called, is the most vulnerable stage. In all of the other stages of the insect's life cycle the vital tissues are surrounded with a protective covering. In order to penetrate this non-living outer layer to reach the living body of the

insect, the chemicals required are of necessity highly concentrated and if such materials were applied during the growing season, injury to the plant host would result. Insecticides can be applied that are concentrated enough to be lethal to the early instar, but not so concentrated as to cause plant injury. Thus the timing of the spray is seen to be of vital importance since only the first nymphal instar of the insect can be killed by materials that do not harm the host plant. This proper timing can be achieved only through a study of the insect's life cycle. Since very little information had been gathered on the life history of the euonymus scale it was necessary to collect such information before control measures could be tried and before spray recommendations could be determined.

The control measures that were practiced and recommended at the time this research was initiated were expensive and unsatisfactory, consequently it was evident that a more practical control was desirable.

Other Pests of Euonymus

The Euonymus shrub is subject to a number of diseases. These diseases, however, are of only minor importance when compared with the euonymus scale as pests of the Euonymus plant. Plants infected with the crown gall organism Pseudomonas tumefaciens (E F S.) were given

to the Field Station by a nursery. These plants were used in various tests throughout the summer without any apparent influence on the results.

Insects other than the euonymus scale have been found on Euonymus shrubs. Whitney (1927 intercepted Pseudococcus comstocki (Kuw.) and Ceroplastes rubens (Mash.), on Euonymus plants being imported into Hawaii from Japan. Britton (1933) listed the bean aphid, Aphis rumicis (L.) cottony maple scale, Pulvinaria vitis (L.) as other pests of the ornamental shrub. Nikolskii (1937) wrote that Lecanium corni (Bch.) was very harmful to Euonymus in the Soviet Union. On June 23, 1948 the soft brown scale, Coccus hesperidum (L.), was found on Euonymus fortunei radicans (Sieb.). There are also numerous unfavorable conditions of weather, moisture, and nutrition which naturally effect the Euonymus plant. One such condition was found at a home in Weston, Massachusetts. Here, although a few specimens of Unaspis euonymi (Comst.) were found, their numbers were not sufficient to produce the extremely unhealthy conditions of the shrub. Conditions was ascribed to a lack of moisture resulting in a sunburned condition. These supplementary insects, diseases, and adverse ecological conditions are rarely the primary cause of unhealthy Euonymus plants. They are, therefore, of very minor importance as a hindrance in the cultivation of this species.

Economic Importance

On periodic occasions in the summer of 1948, during my stay at the Waltham Field Station, the ravages of this scale insect were noted. An excellent example of the destructiveness of the scale was seen in Lexington. The library in this town was constructed with rough masonry providing an ideal location for the Euonymus vine. This ornamental eventually had covered the entire building and had become an attractive contribution to the beauty of the Lexington common. The vine was then attacked by the euonymus scale, and, as was pointed out by the tree warden of Lexington, the resulting destruction to the ornamental was so great that the vine died. Since the recommended control measures at this time were to cut out the infested parts, the entire vine had to be removed. Thus an important element was subtracted from the beauty of the Lexington common. The same conditions existed at many private homes and on many other public buildings in the Boston suburbs, during the summer of 1948. Many of the infestations that were seen during the same period were light, but upon viewing the same plants in the early fall after the second generation had developed, one could easily realize that the scale was just beginning to spread its destruction. One could not help from being convinced that the injury inflicted by this scale insect would

increase in the very near future. It also was easy to conceive that eventually Euonymus plants would be grown by a limited number of people who could afford the expensive services of professional pest control operators. The value of ornamental shrubs is difficult to determine in terms of dollars and cents. Hence it is very difficult to estimate the actual monetary value of the damage caused by Unaspis euonymi. However, when one considers that large amounts of money are spent each year in the control of this insect, its economic importance is readily appreciated. In 1936 Nikolskii reported that the euonymus scale infested and often killed Euonymus plants which were being cultivated as a source of rubber in the Soviet Union. In this instance the euonymus scale was of prime importance to those attempting to grow Euonymus plants on a commercial scale, and the monetary loss due to the scale could be easily determined.

History and Distribution

In 1880 Comstock received specimens of Euonymus latifolia (Scop.) from Norfolk, Virginia, that were infested with the scale with a report that the insect had destroyed nearly all of the shrubs of this species in that city. It was at this time that Comstock named and described the scale as Chionaspis euonymi.

MacGillivray, proposed the generic name Unaspis in 1921 in his text "The Coccidae". In 1937 Ferris was the first to assign the euonymus scale to this previously proposed generic name. This name did not attain much standing until recent years. In 1948 Morrison reported that additional studies of the family Coccoidae have shown that the name represented a legitimate segregation group of several species having a coordinated zoogeographic foundation. The American Association of Economic Entomologists has since accepted the name Unaspis euonymi in their lists of economic insect names.

It has been found that scale insects as a group are generally more destructive in urban than in rural areas. Houser (1918) gave the following reasons to explain this situation.

1. Scales thrive best upon plants which have been weakened. This condition is brought about by adverse growing conditions which are always present in the city.

2. There are many opportunities for the introduction and distribution through the transference of planting stock.

3. In urban areas, there is a wide host range available, consequently insects such as, scales, which have cosmopolitan feeding habits are not held in check by a lack of food.

Although Unaspis euonymi could not be classed as a general plant feeder, the first two reasons apply unquestionably. These facts partially explain the reason why the euonymus scale is more plentiful in the urban sections than in the rural areas.

In 1905 Felt classed Unaspis euonymi as a southern species, since most reports concerning it came from the warmer climates. At the time Comstock named the insect, he reported that Howard had intercepted similar specimens from Havana, Cuba. Benlloch (1936) reported the scale in Spain. Ripper (1917) wrote of its occurrence in Austria, and Bongini (1935) noted the injurious scale in Italy. In 1927 Whitney in his report of the plant inspection station at Hawaii, stated that Unaspis euonymi was intercepted on Euonymus from Japan. In 1905 Felt was of the opinion that the scale was imported into the United States from Cuba. However Ferris (1937) believes the insect to be Oriental in origin, and that the scale was probably imppрted into America from Japan on nursery stock.

Although Unaspis euonymi has been repeatedly noted in the warmer areas of the world, it is by no means confined to these areas. Balachowsky (1930) reported the scale from France. De Santi (1941) added Argentina to the list of countries in which the scale had been found. In 1915 the euonymus scale was reported from Transcaucasia by Weiss, and in the Caucasus of Russia, the scale was noted by Nikolskii in 1936. In 1903 Fernald reported the scale from England and also New Jersey, Virginia, Georgia, and Ohio. In 1905 Felt wrote of the scale's appearance in many sections of New York. Four years later Sanders added Massachusetts, Pennsylvania, Delaware, Maryland, North Carolina and South Carolina to the list of states in which Unaspis euonymi had been found. In 1923 Merrill wrote of the scales appearance in Florida, California and Texas. More recently Britton has frequently reported the scale in Connecticut.

The euonymus scale could not be found on the University campus, where several species of Euonymus were growing. However it was found at Amherst College and on various other Euonymus plants in the town of Amherst, Massachusetts. In 1935 Herrick stated that the scale was widely distributed throughout the United States.

Locally Unaspis euonymi may migrate over the

same plant or onto a nearby plant while in the crawling stage. However the insect could not have been able to accomplish its world wide distribution by this method, due to the very limited distance which these first instar nymphs travel. This distance is usually just a few inches, since the crawlers are very delicate creatures and lose their desire to wander after a very short time. The introduction of this scale insect from one section of the country to another or from one continent to another is probably effected by the transportation of infested nursery stock, grafting, or budding material. The importation of nursery stock from Japan is the method by which Unaspis euonymi is believed to have reached the American continent. Accordingly this method appears to be the most common means of spreading the scale, especially over great distances. The crawling stage of other scale insects has been noted by some observers on the feet and bodies of other insects and birds. This means of transportation seems quite possible and might be a means of distribution over several miles. In conversations with several owners of Euonymus shrubs, during the summer of 1948, it was found that their shrubs which had been planted several years ago had only recently become infested with Unaspis euonymi. The only conceivable means by which

these plants could have been infested is that the crawlers of the euonymus scale had been carried into the new location by other animals. However this last method of distribution was not observed, and it is quite possible that other dispersal means are used by Unaspis euonymi.

Hosts

The genus Euonymus includes both deciduous and evergreen forms. The evergreen forms have been imported from Asia. These plants are shrubs climbing vines, or small trees, extensively planted for ornamental purposes. Some species are planted because of the attractive fruit. Plants of this genus belong to the family Celastraceae, commonly called the Staff Tree family.

Unaspis euonymi (Comst.) was first recorded on Euonymus latifolia (Scop.) by Comstock in 1880. In his paper in which he first described the species, Comstock wrote that Howard had observed the scale on the Orange tree in Louisiana. However in 1937 Ferris disputed this observation and stated that records of the scales' occurrence on Orange were probably wrong. This, he pointed out, was because of the confusion with Unaspis citri (Comst.), which is the only other species of this genus found in the United States and which is very similar in outward appearance

to Unaspis euonymi. The difference between the two species can be seen only upon a miscroscopic study of their pygidia. In 1905 Felt reported the euonymus scale on Syringa vulgaris (L.) on Celastrus scandens (L.) and on Prunus pissardi (Koehne). In 1914 the euonymus scale was reported on Jasminum in Italy. In 1943 Underhill reported the scale on Lonicera periclymenum (L.), Prunus cerasifera atropurpurea (Jaeg.) and Buxus. In 1923 Britton recorded the scale on Pachysandra terminalis (Sieb. & Zuec.). An infestation on this plant was studied at the Field Station in 1948. Three cuttings were potted and infested with the scale on August 31. These scales thrived and developed in the normal way, showing that Pachysandra was a favorable host plant. In 1935 Herrick recorded the scale of Hibiscus, commonly known as the Rose of Sharon. Ferris, in 1937, noted its presence exceedingly common on Euonymus japonicus (L.). In my experience with the scale, it was found most abundant on varieties of Euonymus europaea (L.). Several varieties of Euonymus europaea (L.) were observed at the Arnold Arboretum in Jamaica Plain, Massachusetts and at the Perkins Institution for the Blind in Watertown, Massachusetts and these were among the most heavily infested plants seen during the summer of 1948.

There are 120 species of Euonymus in North and Central America, Europe, Asia and Australia. 36 species

and varieties were found at the Arnold Arboretum. Of these 29 were infested with the euonymus scale. The following list includes these 29 species and varieties of Euonymus upon which the scale was found.

Euonymus americana (L.)
Euonymus bulgarica (Velen. Bots.)
Euonymus Bungeana (Maxim.)
Euonymus europaea (L.)
Euonymus europaea aldenhamensis (Gibbs)
Euonymus europaea atrorubens (Rehd.)
Euonymus europaea chrysophylla (Chen.)
Euonymus europaea coccinea (Hill.)
Euonymus europaea intermedia (Gaud.)
Euonymus europaea nana (Lodd.)
Euonymus fimbriata (Wall.)
Euonymus fortunei (Turcz.)
Euonymus fortunei colorata (Rehd.)
Euonymus fortunei gracilis (Reg.)
Euonymus fortunei minima (Simon-Louis)
Euonymus fortunei radicans (Sieb.)
Euonymus fortunei reticulata (Reg.)
Euonymus fortunei vegeta (Rehd.)
Euonymus hians (Koehne)
Euonymus latifolia (Scop.)

Euonymus Maachii (Rupr.)

Euonymus macroptera (Rupr.)

Euonymus niroensis (Nahai)

Euonymus obovata (Nutt)

Euonymus phellomana (Loes.)

Euonymus semi-exserta (Koehne)

Euonymus verrucosa (Scop.)

Euonymus yedoensis (Koehne.)

In 1948 Euonymus europaea chrysophylla (Chen.), Euonymus europaea intermedia (Gaud.) and Euonymus europaea nana (Lodd.) were listed as the most heavily infested varieties in the Arnold Arboretum by Robert Williams, superintendent.

No scales were found on the following species and varieties of Euonymus.

Euonymus sp. no. 94-33-B

Euonymus alata aperta (Loes.)

Euonymus alata compacta (Adams)

Euonymus kiautschovica (Loes.)

Euonymus sacchalinensis (Maxim.)

Euonymus sanguinea (Loes.)

The three plants at the Arnold Arboretum listed as most heavily infested and the seven plants that were

found free from the scale were all located in the hillside plot set aside for the Euonymus shrubs. A Euonymus alata (Maxim.) plant found at the Perkins Institute was entirely free from the scale, and it also was situated close to many heavily infested Euonymus europaea (L.) shrubs. Since these two cases were observed in which Euonymus alata (Maxim.) plants had been found free from scale infestations and at the same time had been exposed to the attacks of the scale with the same intensity as other species of Euonymus, a definite degree of resistance to the scale was believed to occur in these species. As a check on this resistance an experiment was set up on June 18.

Two Euonymus alatus (Maxim.) plants and two Euonymus alatus compacta (Adams) plants at the Waltham Field Station were potted and brought into the screened insectary. On the following day about thirty euonymus scale crawlers were transferred onto these potted plants by means of a camel hair brush. These individuals wandered about on the new twigs and branches in the normal way and by the next day had settled down. However the scales ceased to be normal from then on, since the only change that was seen in later observations was a gradual decrease in size. By the second day of August it was evident that all had died, and on that day many of the young scales had dropped from the plants.

On the thirtieth of August twigs infested with the crawlers of the second generation were attached to the same four potted Euonymus alata (Maxim.) plants that had been used in June but which were free of any traces of Unaspis euonymi (Comst.) at this time. The infested twigs were attached to the plant stems by means of paper-covered wires, commonly used in horticultural work. The results of this second attempt to propagate the scale on these two varieties of Euonymus alata (Maxim.) were similar to the first, and by September 20 no scales could be found on these plants.

From these experiments together with the fact that the Euonymus alata (Maxim.) varieties at the Arnold Arboretum and on the grounds of the Perkins Institute in Watertown were free from the euonymus scale, it was concluded that the varieties of Euonymus alata (Maxim.) grown in eastern Massachusetts, possess the amount of resistance needed to completely suppress the development of Unaspis euonymi (Comst.) on them.

Experiments were not conducted with Euonymus Kiantschovica (Loes.), Euonymus sachalinensis (Maxim), Euonymus sanguinea, (Loes.), and Euonymus sp. No. 94-33-B, the four other species which were found free from the scale at the Arnold Arboretum, because these species were unobtainable. However it appears possible or even quite certain that these

plants also possess some positive degree of resistance to the scale insect being discussed, since these plants were located in the same plot and were exposed to the attacks of the scale as much as were the other heavily infested plants.

Appearance and Injury

Evidence of Unaspis euonymi (Comst.) on the Euonymus plant is indicated by abnormal unthrifty appearance of the shrub. In severe infestations there may be dead branches or limbs or the entire plant may be killed. If the scale is responsible for the injury upon a close examination the insert will be seen on the branches, twigs and foliage. The snowy white, slender, three ridged male scales are more obvious. Upon closer inspection the dirty brown, oyster-shell-shaped female scale can be found. When the scale is present in sufficient numbers to cause injury, the originally brown twigs and green leaves of the host will appear gray.

The heaviest infestation of this scale is always to be found on the older growth of its host. The scale was also noted to be more severe, other factors being equal, on that portion of the host that was shaded by other taller vegetation. As a general rule the females are found in greater numbers on the twigs than on the foliage. The males

are more abundant on the leaves. On plants that are lightly to moderately infested, the females prefer the twig buds, where they congregate in small groups. Consequently the area around the new buds on the older branches is the first place to look for the females when hunting for them on plants suspected to be infested. The males prefer to settle on the underside of the leaves (See Table 1). Therefore this area is the first place to observe the male when checking for infestations. The males are much more numerous than the females, and are more easily seen because of their white covering which stands out on the green background of the leaves.

As the euonymus scale increases in numbers on the host plant involved, more and more nourishment is sapped from the shrub until finally the green leaves become mottled and then turn yellow.

If conditions remain favorable for the scale and control measures are not used, the host shrubs will become defoliated. This results in the death of the branches involved, and eventually the death of the plant.

DESCRIPTION OF STAGES

Egg

Early references stated that Unaspis euonymi passed the winter in the egg stage. In 1922 Britton examined female scales during the winter months in Connecticut and found no eggs. Attempts by the author to find eggs during the first five months of 1948 were also unsuccessful. Although Britton reported that eggs were found in the bodies of the adult scales on May 5, such eggs were not found in 1948 until June 4. By June 10, six to twelve eggs were found beneath the scale and behind the body of the adult female. These eggs were honey yellow in color. This color was determined from Ridgway's Color Standards and Color Nomenclature (1912). The eggs were shiny, surrounded by a thin shell and contained a watery fluid. The eggs were 2 mm. in length and .1 mm. in width, with rounded extremities, giving an oval appearance. These measurements and those of other stages of the euonymus scale were made by means of a stage micrometer. The object to be measured was placed on a gradated slide and numbers of gradations covered by the specimen was read through a microscope. A correction figure was calculated for the magnification used, which was one line equaled.014 mm.

Hence the number of lines covered by the object being measured, multiplied by .014 gave the dimensions in millimeters of the specimen.

More than twelve eggs were never found under the female scale at any one time. Thus it was concluded that the female did not lay all of her eggs at once, but rather spread the egg laying period over about a month, since eggs were found beneath the female scale from June 10 to July 13. This fact explains why all stages of the developing nymphs can be found on an infested plant at any time during the year.

First Nymphal Instar

Observations of the immature stages of Unaspis euonymi were made using a hand lens and a binocular microscope of low magnification. With these instruments the developing scale covering could be seen, however changes in the insect itself were not noted. Since a study of the morphology of Unaspis euonymi was not attempted it was difficult to determine the exact number of nymphal instars.

The beginning of the first nymphal instar of Unaspis euonymi is represented by the crawler stage. This is true of both the male and the female which can not be differentiated in this stadium. This is the only period

in the life cycle of the euonymus scale that it is able to migrate from one place to another. The winged adult males are naturally able to move, but this movement is in no way responsible for the migration of the insect onto new hosts or into new locations. The crawlers are of the same honey yellow color as the eggs, designated as 19" YO - Y by Ridgway. These young nymphs have two prominent black eye spots, one on each side of the head near the base of the six segmented antennae. They have three pairs of short legs. The crawlers are plump and rounded at both ends which gives them an oblong appearance. They were measured to be .35 mm. in length and .19 mm. in width. After the crawlers emerge from the eggs, they remain under the female scale covering among the unhatched eggs for a short time before they start to wander about the host plant. This migration lasts for just a few hours to a day before they settle down on the host plant.

At this time crawlers in the first nymphal instar lose their legs and antennae and insert their long mouth parts into the host tissue and begin to draw nourishment. The long thread-like mouth parts are not seen on the crawlers. The mouth parts are often inserted into the plant host at some distance from the body of the insect. The mouth parts were about seven times the length of the body of the insect at this stage of development. It is for this reason that

the euonymus scales are able to form encrusted layers over the host tissue. Thus the insect is able to obtain sufficient food and develop normally under crowded conditions. With the loss of movement, these young nymphs become somewhat depressed. The oblong body has nine abdominal segments. An average of twenty-three days was needed to complete the first instar. At this time the first nymphal exuvium was not cast off by the developing scale, but remained as part of the scale covering protecting the developing insect beneath.

Second Nymphal Instar

At the beginning of the second nymphal instar the female can be distinguished from the male. This instar is first noted when the males begin to form their white tricarinate excretion. Six days later the females developed the covering of the second nymphal instar, which is dirty brown and more broadly rounded than the first exuvium. This growth takes place at the posterior end of the young scale. The female scale completed the second nymphal stage in about thirteen days. The broadly rounded covering of the second nymphal stage was .72 mm. in width. At this time the insect was .76 mm. in length which showed that the insect had increased more in width than in length during this second nymphal instar. At this time the first exuvium is

colorless, and still covered the anterior end of the developing scale.

The white secretion in the caudal region of the young male scales continued to increase for thirty-one days. During this time, the insect produced the three long, white, slender ridges so typical of its appearance. The snowy white folds were added to the posterior end of the first exuvium, The first nymphal exuvium remained over the anterior portion of the insect as an added protective covering, similar to the female. When development had been completed the over all length was 1.23 mm. The width of the three folds was .35 mm. The length of the first nymphal exuvium was .27 mm. or about one fifth of the total length of the male scale covering.

On a Euonymus plant which has been weakened through the attack of Unaspis euonymi, the males are most readily noted. Herrick (1935) described this condition, by stating that, "The infested shrubs appear white as though dusted with flour." This is partly due to the white excretion which covers the males and partly due to the greater abundance of males than females. Their first choice on the plant is the underside of the leaves. However, when the infestation is very heavy the males may be found any where on the host plant.

Third Nymphal Instar

In the case of the female, the great increase in size of the secreted scale covering is the most obvious change from the end of the second to the end of the third nymphal instar. During this stadium the female scale covering increases in length from .76 mm. to 1.5 mm. As during the second nymphal stadium, the scale covering is enlarged posteriorly. When this last nymphal instar is completed the scale was .76 mm. in width. Twenty-five days were needed by the female to complete this enlargement process.

During the second nymphal instar of the male, a long, white waxy secretion was produced which hid the later immature stages. Consequently the remaining nymphal instars can not be distinguished from the second inster from its outward appearance. Morphological studies of closely related genera have shown that the males usually pass through more nymphal stadia than the female. For this reason it is probable that an additional unobserved nymphal instar is present in the development of the male Unaspis euonymi (Const.). If the white covering is removed the pupa-like stage can be observed. It is enclosed in an oblong cuticular sac, .61 mm. long and .2 mm. wide. The various external appendages of the developing adult male

can be seen through the enclosing membrane upon a close examination.

Adult

The adult female Unaspis euonymi (Const.) is covered by a pear-shaped, dirty-brown scale. According to Ridgway's color plates the scale covering is seal brown (5"00-R). The margins of this scale are often colored a light gray. The oyster-shell-shaped female scale was 1.5 mm. long and .76 mm. wide. The three nymphal exuviae remain over the body of the adult and form the scale covering. The first exuvium is pale yellow, the second is brown, however, never as dark as the third nymphal exuvium. The scale is narrowest at the anterior end, and broadens slowly to the posterior end. There is a ventral scale covering which attaches itself to the outer margins of the dorsal scale covering, with the exception of the posterior margin. This ventral covering is a very thin membrane and is pitted from the surface of the plant tissue, showing that it adheres tightly to the surface of the plant. Within this almost complete shell, the body of the adult female is confined. It's shape conforms with that of the general outer appearance of the scale. Of necessity it's dimensions are smaller than those of the outer protective

layer. The soft body was 1.3 mm. long and .52 mm. wide. The adult female body is of the bright honey yellow color typical of the bodies of the younger stages of the insect. The fifth abdominal segment, just anterior to the pygidium is the widest point across the body. Like the external appearance of the scale, the inner soft body of the female tapers slowly to the anterior and end abruptly to the posterior end. The nine segmented abdomen is divided into two regions, the five segmented preabdomen and the pygidium which is composed of the fuseing together of the remaining four segments of the caudal region. It is within this region that the great majority of structures used in classifying the various species of the sub-family Diaspidinae are located. The posterior lobes on the pygidium are small and finely serrated. The median lobes diverge posteriorly. The second and third loves on each side are deeply incised and each is divided into unequal parts, the larger portion is located toward the center.

The female is not as easily seen as the male. This fact is readily accounted for by the dark unattractive brown color. The females are more abundant on the woody stems and small branches than on the green leaves. This makes them less conspicuous than the snowy white males on the dark evergreen leaves. The females are also greatly outnumbered by the males. A few counts that were made will help to prove these two facts.

Table 1. Scales per square centimeter of leaf surface

Leaf Number		Males	Females
1	Ventral side	76	0
	Dorsal side	65	0
2	Ventral side	52	6
	Dorsal side	24	3
3	Ventral side	107	0
	Dorsal side	51	2
4	Ventral side	52	8
	Dorsal side	32	4
	Total	456	23

These counts gave a ratio of twenty to one, males over females on the leaves.

Table II. Scales on surface of stems one centimeter long and one quarter inch in diameter

Stem Number	Males	Females
1	25	12
2	15	4
3	58	1
4	30	25
Total	128	42

These counts resulted in a ratio of three to one more males than females. By adding together all of these

counted scales, a general ratio of 8.9 males per female was determined.

Male

The adult male of Unaspis euonymi (Comst.) is probably never seen by the casual observer, for they are very short lived, a few hours to possibly one or two days at the most. Their small size also makes them inconspicuous.

These individuals were isolated only after several unsuccessful attempts, due to unsatisfactory cages from which they may have escaped. On August 10, 34 out of the 40 male scale coverings were found to be empty. However at t this time the delicate insects had not been found. It was not until August 16 that the adult males were isolated. Leaves covered with the white scales were placed in a quart battery jar, and covered with two layers of cheese cloth which was held in place over the opening at the top by means of a rubber band. In two days about 35 of these Dipterous like adults were seen within the jar. These had emerged during the first night and by the second day they were inactive and could be picked off the side of the jar easily with a camel hair brush. At this time they were mounted in balsam on slides. The adult male has distinct constrictions separating the body segments and has six simple eyes, four are located on the dorsal side of the head

and two on the ventral. The antennae have ten segments and the nine segmented abdomen bears a long and pointed stylus. These individuals have one pair of delicate wings. As is true of Dipterous insects halteres are present representing the other pair of wings.

TAXONOMIC RELATIONSHIP

Scale insects belong to the order of insects known as Homoptera. Insects within this order are of many forms and many have no similarity in outward appearance. However, all insects in the order Homoptera have sucking mouthparts with their beaks arising from the posterior portion of the ventral side of the head which is not distinctly separated from the prothorax. When these insects have wings they are of uniform thickness. Many insects having ordinary forms can be found which possess these characters, however within this order are also found insects which have been greatly modified and changed in appearance. Scale insects are in this category and are classified in the superfamily Coccoidae. Unaspis euonymi (Comst.) belongs to a group of insects in which the body of the adult female is covered by an easily detached waxy scale consisting of molted skins which is flat and very tough. Adult females of this group have lost all traces of eyes, antennae, legs and wings. This group of insects is often referred to as armored scales and more correctly as the sub-family Diaspidinae.

The following is a key to the genus Unaspis, using such superficial characters as can be seen with the naked eye or with the aid of a hand lens.

A. Body of adult female small, flat, covered by an easily detached waxy scale; without legs or antennae - - - - sub-family Diaspidinae

B. Scale of female elongate, narrowed at cephalic end; exuviae terminal

C. Scale of female brown

CC. Scale of female white - - - - Chionaspis

D. Scale of female usually dark brown; scale of male similar to that of female but smaller - - - - Lepidosaphes

DD. Scale of female dark brown; scale of male, small, elongate, sides nearly parallel, white, felted usually carinated - - - - Unaspis

BB. Scale of female circular to oval, exuviae central to marginal. - - - - Aspidiotus

AS. Body of adult female sac-like, gall-like, not flat and covered by a detachable scale as are the Diaspidinae; sometimes enclosed in a sac or covered with waxy or powdery secreation

e.g. Orthezia
Pulvinaria
Lecanium

There are four known species of Unaspis in the world. Unaspis yanonensis (Kuw) found in Japan, Unaspis acuminata (Green) found in Ceylon and Unaspis euonymi (Comst.) and Unaspis citri (Comst.) in the United States. The following description of the genus Unaspis was made by Ferris in 1937. "A Diaspididae with 'two-barred' ducts. Body form is elongate sometimes fusiform. Dorsal ducts are numerous, scattered or at the most arranged in very indefinite rows, present to and including the seventh segment. The pygidium with a median furrow extending from the anus to the median lobes. Although close together at their bases, the median lobes are definitely non-zygotic. Second and third lobes are well developed and deeply bilobed. Perivulvar pores are present or absent." Such a description can only be made after a thorough microscopic study of representative insects. Separation of the two species of Unaspis found in the United States is based upon the last characteristic of Ferris' description. Unaspis euonymi (Comst.) possesses five small groups of perivulvar pores while these are lacking on Unaspis citri (Comst.).

LIFE HISTORY

Information concerning the life history of the euonymus scale was collected at the Waltham Field Station during the summer of 1948. Ten Euonymus plants were obtained from the nursery at the field station, potted, and placed in the screened insectary where they were infested with the scale insect. Six were Euonymus fortunei carrierei (Nichols) and four were Euonymus fortunei radicans (Sieb.). No differences were observed in the developing scales from the two varieties upon periodic observations during the ensuing summer. The development of the scales was noted throughout the summer.

The plants were cut back to keep the total infestation area to a minimum in anticipation that the young scales would be difficult to find. Five crawlers were transferred to each of these ten plants by means of a camel hair brush. The following day many were missing consequently more were added. It was found that by striking an infested twig a sharp blow with a pencil or some similar object, many crawlers could be shaken loose. A piece of paper was placed beneath the twig to catch the crawlers as they were shaken. In this way the crawlers could be concentrated, and, as a result, more could be picked up by one sweep of the camel hair brush, The time of the operation of transferring them

onto the new plant was by this means materially reduced. By the new technique eight to twelve more crawlers were transferred onto each of the plants.

By the seventeenth of June, the first nymphal instar crawlers had settled down. On that day four to seven individuals were found on each plant. These were identified by placing a number next to them on the plant in India ink.

At the end of seven days several of the nymphs had decreased in size. They continued to shrink in size until the first week of July at which time they were reduced to just a speck or had disappeared entirely. Two or three such cases were found on each of the ten experimental plants. The only explanation that could be offered was the possibility that these insects had been injured during their transferal. This mortality, was experienced in all tests carried out later in the summer where this method of infesting plants was employed.

On July 6, the first nymphal stage had been completed by some of the insects. This was about twenty days after the young insects had settled down on the host plants. The beginning of the second nymphal instar by the males was recognized when some of them began to build a white excretion. Consequently, it is at the beginning of

the second nymphal instar that one is able to differentiate between the sexes for the first time. The white excretion arose from three points on the scale. One fold arose from under the posterior end of the scale, and one fold developed from each side of the abdomen and extended posteriorly. The females were not distinguishable until July 12. At this time, the second nymphal instar covering, broader than the first, rounded, and light brown to reddish-brown in color became evident. The first nymphal instar of the female required about twenty-five days to complete its development after the insect had settled upon a host plant.

The first and second exuviae of the developing females were still evident on July 22. However, on this date, a grayish substance was seen to be building up from beneath and behind the other outer coverings. This was the beginning of the third nymphal instar which showed that the second instar required about thirteen days to develop. The posterior enlargement of the female was observed at periodic intervals and continued for about twenty-five days. The newly secreted margins were light gray in color. However as the development continued, the older areas darkened to a brown or reddish-brown. Upon further ageing the covering continued to darken until a dirty-brown color was seen. By August 16, no further enlargement of the posterior

secretion was seen.

During the month of July the males continued to secrete wax in the form of three posteriorly directed white folds. By August 9 this had ceased. Information relative to the number of remaining instars and the time needed to complete them was not obtained. This was due to the fact that the exuviae of these later instars were too indistinct to show through the heavy waxy covering secreted by the second instar. These later stages were observed, however, upon the removal of the white waxy covering. On August 10 it was discovered that many adult males had emerged from their scale coverings. These individuals were isolated after several unsuccessful attempts. Attempts to determine their life span were unsuccessful. However it was evident that the life span of these adults was a very short one. In all probability it lasted only a few hours to a maximum of one or two days.

The adult females live considerably longer than the males. The life span of the female is dependent on the time of year in which it matures. Females of the first generation survive until their egg laying process is completed. This period is about one month. Females of the second generation not able to lay their eggs before dormant conditions appear to survive the winter, making their life

span much longer.

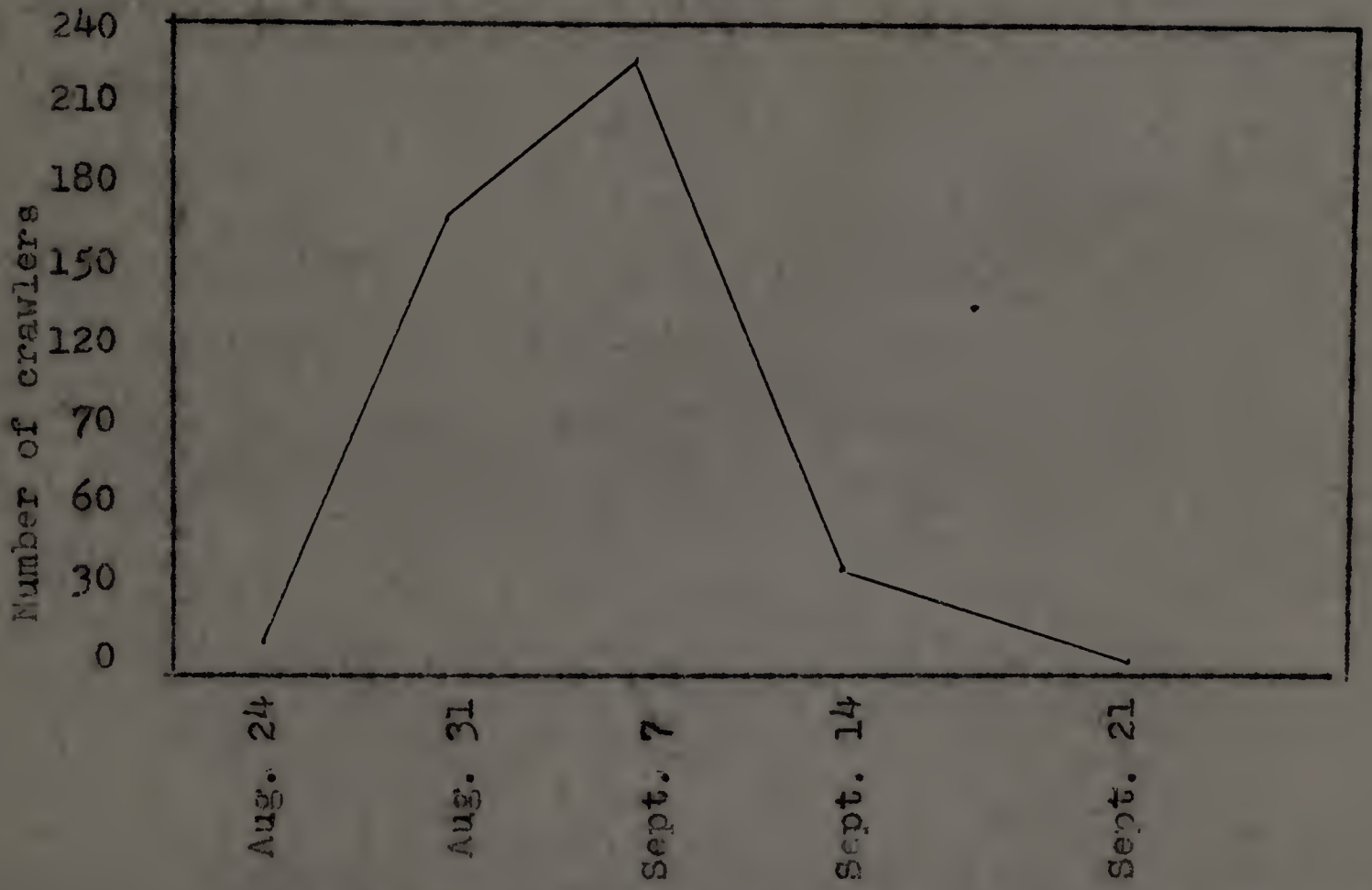
On June 16, four of the first generation adults were examined and 67, 56, 81 and 42 unlaid eggs were counted. This gave an average of 61.5 eggs per female. Unlaid eggs were found in the adult females on August 16. In eight of these gravid females 54, 47, 44, 52, 20, 51, 40 and 38 eggs were found. This gave an average of 43 eggs per female. The average number of eggs in the twelve gravid females was found to be 49.3. The total number of new insects of the second generation on the experimental plants was found to be 634. On these same plants thirteen adult females were known to be present. With this information, it was calculated that each female developed 50.3 offspring. These two figures are close enough to show that about fifty young are produced by each adult female.

SEASONAL HISTORY

The first activity of this insect in the spring is the development of eggs within the body of the adult females. This was first recorded on June 4. By June 10 eggs were found beneath the scale coverings. The egg deposition period continued until July 13. The young crawlers of the first nymphal instar were first found on June 14. These were seen until July 16. The second generation crawlers were found on plants from August 24 to September 20. The crawler population was at its height in the last week of June and again in the first week of September. Information gathered at the Waltham Station indicated that this peak of crawler activity was at least ten days later than it had been in other years.

A total of 66 crawlers were transferred onto the ten experimental plants on June 15 and 16. Of these thirteen developed into adult females. From August 24 until September 21 crawlers and newly settled nymphs of this second generation were counted each week. The resulting information, when plotted, shows clearly the trend and amount of activity of the second generation.

Chart I. Crawler activity of the second generation during 1948.



In both generations the egg laying period and the resulting period of crawler activity, extended for approximately one month. It is this long period of egg laying that differentiates Unaspis euonymi (Comst.) from the great majority of similar scale insect pests, which deposit all of their eggs at once. This same fact explains why scale coverings of all of the nymphal stages of Unaspis euonymi can be found throughout the year. Eggs laid in the latter part of August develop to scales that are in the adult or possibly the third nymphal instar when dormant conditions begin. Also eggs hatching during the end of

September would develop only into first or second nymphal instars at the time when their growth is halted due to the approaching winter season. The immature stages do not survive the winter since observations during the month of April showed that only the adult females were alive. However all stages remain attached to the host plant until worn off by various weather conditions.

During the summer of 1948 two complete generations of Unaspis euonymi were observed in eastern Massachusetts. Young nymphs of the first generation were first seen June 15. Their greatest abundance was noted on June 29. Ten weeks later on August 24 the first crawlers of the second generation were found. This generation attained its greatest numbers of crawlers on September 7. According to these figures a third generation could be expected, weather permitting, during the first week of November. Undoubtedly the temperature is the limiting factor which determines the number of generations and the extent to which the third generation will develop. In 1931 Felt reported three generations that the euonymus scale in New York, and in 1933 he reported the same from Connecticut. As has been previously pointed out the appearance of the crawlers during 1948 was about ten days later than in previous years. If the season had permitted the scale to

begin its activity ten days earlier in 1948, the third generation could have been anticipated in the middle of October. It is quite possible that the temperature in this instance would have not prohibited the scale from developing part of the third generation. Hence the variation of the seasonal temperature influences the scale's initial activity. This seasonal variation is also the controlling factor which determines the extent to which the third generation can develop. The climatic zone in which the scale is located will also effect the number of generations. Consequently during certain years the euonymus scale will be able to develop part of a third generation in Massachusetts. Farther south the probability of the third generation and the extent to which it will develop will therefore be greater.

BIOLOGICAL CONTROL

The work of parasites and predators on the euonymus scale has been observed since 1918. The obvious evidence of such activity as seen by the author in 1948 was seen as small holes in the adult scale covering. The body within such scales was destroyed to the extent that it could not be recognized. Attempts to isolate such parasites were unsuccessful. However other workers have successfully reared parasites from Unaspis euonymi. Houser (1918) reported that the small Hymenopterous parasite Aphelinus fuscipennis (How.) had been reared from the euonymus scale. Poutiers (1928) and DeSantis (1941) wrote that Aspidiotophague citrinus (How.) had been reared from Unaspis euonymi. In 1930 Balachowsky listed Chalcidoid parasites that had been obtained from Coccoidae. The list included the Encyrtid, Aenasioidea hispanica (Mercet.) as having been found on the euonymus scale. On March 29, 1948 numerous small mites were found among the scales on infested twigs. The extent of their damage to the scales, if any, could not be determined. Although parasites have been recorded on the euonymus scale, their effectiveness in reducing the population of the scale has not been determined. At the present time with the scale increasing in abundance, it appears that such natural enemies offer very little hindrance to the reproduction of the euonymus scale.

DORMANT CONTROL

Since a much stronger insecticide may be used on plants in the dormant conditions, dormant oil sprays have been used in an effort to control scale insects for many years. Felt (1905) was the first to recommend dormant oils for the control of the euonymus scale. In control experiments carried out in 1909 and 1910 by Metcalf, it was found that a 60 per cent kerosene emulsion was needed for effective control in the dormant season. A miscible oil, scalecide, was found effective against the scale when mixed 1 part oil to 10 parts water. The same investigator also used lime sulfur and weaker solutions of Scalecide with less success. In 1930 Chapman used a 1 to 10 solution of Scalecide, in Virginia, on Euonymus japonica (L.) on February 25, and he reported good control of the euonymus scale. However, it was also found that the leaves were injured and shortly after the treatment a considerable number of short twigs dropped. In 1931 Felt recommended a Sun Oil at 1 to 15, to be applied in the dormant season. He observed leaf injury but called it of no material importance since the old Euonymus leaves drops shortly after the new foliage appears. In 1935 Herrick reported that a miscible oil spray, diluted 1 part oil to 15 parts water was most effective against Unaspis euonymi. A water

soluable dinitro compound, sodium dinitro-cresylate, known as Elgetol was first used against the euonymus scale in April 1940 by Pyenson. He reported no plant injury and almost complete mortality of the scale. At this time, a 1 per cent Elgetol spray gave 98.5 per cent kill. A 1 per cent Elgetol and .5 per cent NNO (Technical mannitan monolaurate) gave 100 per cent kill. A Sunoco miscible oil spray was also tried at this time which resulted in a 45 per cent kill. From this brief account of the literature concerning dormant sprays used in the control of Unaspis euonymi, it is seen that Pyenson was the first to report a definite percentage kill and that the results with Elgetol were the most successful to date. Accordingly Elgetol and an oil emulsion known as Spra Cream were used on infested Euonymus plants in April 1948.

Six heavily infested Euonymus plants in scattered localities about the Waltham Field Station were used in the dormant control experiment. These included: Euonymus fortunei colorata (Rehd.), Euonymus fortunei vegeta (Rehd.), and Euonymus fortunei radicans (Sieb). The shrubs were pruned considerably so that thorough coverage of the spray was possible. The treatments were applied on April 30 at a temperature of 55°F. The day was clear and there was a light wind blowing. A two gallon hand pumped air pressure sprayer

was used to apply the dormant sprays. Spra Cream and Elgetol were the insecticides used in these tests. Spra Cream is a commercial name for a paste type oil emulsion containing 83 per cent actual oil. This oil was used at 2 per cent, 3 per cent and 4 per cent strength of actual oil present. Elgetol is the common name for a salt of DNOC, chemically known as dinitro-ortho-cresylate. This insecticide was used at 1 per cent and 1½ per cent strengths. Just previous to applying the sprays, counts were made of the number of female scales dead and of the number alive. Representative twigs were selected from each of the six plants, and the counts were made on one inch of these twigs. Similar counts were repeated on the 14th of June as shown in Table III. These counts showed a definite increase in the number of dead females and serve to indicate what may be expected from these dormant applications.

On July 7, newly settled crawlers were counted on four leaves and three inches of twig, which were selected as representative from each of six plants. This count gave a definite indication of the effectiveness of the different insecticides and of the different concentrations. It was evident from this count that the strength of the oil emulsion dormant spray must be at least 4 per cent actual oil. The Elgetol tests resulted in higher percentages of reduction than did the oil emulsion tests. It appeared that 1½ per cent

Table III. Comparative effect of dormant insecticides against Unaspis euonymi (Const.) applied April 30.

Plant No.	Variety	Insecticide	Adult Females April 30 Alive	Adult Females April 30 Dead	Adult Females June 14 Alive	Adult Females June 14 Dead	July 7 Number 1st Instar Nymphs	Per Cent Reduction Based on Number of Nymphs on Cheek
1	E. f. colorata	Check	34	75	33	48	619	--
2	E. f. vegeta	2% Spra Cream	47	59	8	4	251	59%
3	E. f. vegeta	3% Spra Cream	56	60	13	14	213	65%
4	E. f. vegeta	4% Spra Cream	2	20	2	61	81	87%
5	E. f. radicans	1% Elgetol	22	26	30	25	8	98%
6	E. f. vegeta	1½% Elgetol	24	29	30	27	0	100%
		Total	175	169	116	179		

Elgetol was sufficiently strong to be lethan to all overwintering adult female scales present. Higher strengths of the solution would therefore not be necessary. However 4 per cent Spra Cream was not completely successful. Injury to the foliage was not observed in these tests. It is conceivable that higher concentrations of the oil emulsion would be more effective but their use might result in injury to the plant. The results of this test are summerized in Table III.

The excellent results obtained with the use of Elgetol substantiate the finding of Pyenson (1941), and it seems likely that an application in the dormant season two years in succession should come close to completely eradicating the euonymus scale from infested plants. Elgetol is made from materials with staining qualities. Since no one would want white woodwork stained yellow, caution must be exercised when applying Elgetol to direct all of the spray onto the plants. When the plants stand away from buildings, naturally no trouble should be expected. Rough masonry such as brick will not be affected by the stain. Luckily the Euonymus host is not able to climb on woodwork. Hence the only woodwork that will be encountered will be window frames and areas next to the ground where non-climbing varieties of Euonymus are planted close to a wooden building. Consequently it appears quite likely that Elgetol can be widely accepted and used to control the scale on Euonymus plants.

SUMMER CONTROL

Since one application of Elgetol has been found to materially reduce the population of the euonymus scale. This dormant spray appears to be the simplest treatment; but the small home owner and amateur gardener often overlooks the treatment in caring for his ornamental plants. This is due perhaps to the inconspicuousness of the scale on very lush plants. It is also very difficult to cover the vines with spray with the thoroughness needed for good control. For these reasons experiments were conducted with sprays of concentrations that could be used during the summer months. In all stages of development after the first nymphal instar, scale insects of the family Diaspididae are covered with cast skins and secretory substances, which serve as very effective protective coverings for the soft bodied insect beneath. During the growing season the plant is injured by dormant oil sprays of sufficient concentration to kill the scale. Consequently one can readily understand the necessity of using summer sprays to control the first nymphal instar, which is the only nymphal stage in the life history of armored scales that does not possess the protective covering.

First Generation

Since Unaspis euonymi was found to be in the first nymphal instar on June 16, work was started immediately on the problem of summer control. On that day nine Euonymus plants were potted. Euonymus fortunei radicans (Sieb.) and Euonymus fortunei carrierei (Nichols.) were the varieties used. These were brought into the insectary where they could be more easily observed. The first test was to determine the effectiveness of the residual qualities of DDT upon the young scales. Deenate, a 50 per cent DDT wettable powder, was used. Three different concentrations were used namely; one pound of material to 100 gallons of water, two pounds to 100 gallons; and three pounds to 100 gallons. Each of these concentrations was sprayed onto three plants with the air pressure operated sprayer which was installed in the entomological laboratory at the station. Since a small amount of spray was needed, dilutions were prepared with 4.4 grams, 9.0 grams and 13.4 grams per gallon respectively for the different concentrations. The DDT spray was applied to all of the experimental plants on June 17. One day later about twenty-five crawlers were transferred onto each of three plants which had been sprayed. Five days later twenty-five more crawlers were transferred onto three more plants which had previously been sprayed with the different concentrations of DDT. Ten days later on June 28,

the remaining three plants were infested with a similar amount of crawlers. The plants were observed at weekly intervals throughout the summer, and although the young scales did not drop from the treated plants at once, none developed, and, by July 2 it was clear that all were dead. By the end of August, no trace of the scale could be found on any of the nine potted plants. From this test it appeared that the residue of DDT was effective in the control of the crawlers for ten or more days after the DDT was applied. This experiment was repeated on July 1 and nine more Euonymus plants were potted and sprayed with the same strengths of DDT. The crawlers w ere transferred on July 2, July 6 and July 12. In this second experiment all of the plants, upon which the crawlers were placed eleven days after DDT had been sprayed, showed a few scales matured. Under the conditions of the experiment the effectiveness of DDT is lost after eleven days. The second tests were carried out toward the end of the period of crawler activity and this might have affected the results. Further experiments are needed to prove conclusively the exact length of the residual effectiveness of DDT; however from these tests it appears that one should not expect DDT to remain effective more than ten days after it has been applied. In this second residual test a

few scales matured on the plants that had been sprayed with Deenate used at the rate of one pound to 100 gallons of water. Hence it was assumed that the 50 per cent DDT wettable powder must be used at the rate of at least two pounds to 100 gallons of water to be effective in controlling the young euonymus scales.

Table IV. Toxicity of DDT residues to Unaspis euonymi (Const.)*

Crawlers Transfered After Spraying**	Number of Scales Alive		
	Concentration of Deenate		
	1 lb/100	2 lb/100	3 lb/100
1 day (July 2)	1	0	0
5 days (July 6)	2	0	0
11 days (July 12)	6	6	3

* Plants sprayed July 1.

** Twenty-five crawlers transferred onto each plant.

On June 16 nine Euonymus plants were potted and brought into the insectary. These were to be used in an experiment to determine the maximum age at which the young crawlers were no longer effected by the DDT spray. On that

day twenty crawlers were transferred onto each of the nine potted plants. DDT was used in the same form and strength as it was in the residue tests and was applied with the air pressure sprayer installed in the laboratory. Three plants were sprayed at 5 day intervals: three on June 18, three on June 23 and three on June 29. None of the euonymus scales survived the treatment and on July 1 nine more Euonymus plants were potted. These plants were infested on that date with thirty crawlers by means of a camel hair brush. The same concentrations of DDT were applied to the plants in a similar manner as had been used in the first test. Three plants were treated with each of the three concentrations of DDT, 1, 5 and 11 days after the crawlers were transfered. It was discovered by this time that after having transferred a given number of crawlers onto a test plant the same number of scales could never be found at a later date. The number found was always less than the number transferred and no definite correlation could be found between the number transferred and the number to expect to find upon a later examination of the plant. As a result no two plants used in a test ever had the same number of scales on them. Since the number of nymphs upon the test plant could not be kept constant, it was felt that the tests would be more valid if a greater number of individuals was present. This was done by attaching heavily infested twigs to the test

plants by means of paper covered wires. Consequently on July 2 infested twigs were attached to the remaining six plants which had not been treated, to assure that these plants would have more young scales on them than did the treated plants of the previous test. (See Table V)

From this summary it is evident that DDT in a 50 per cent wettable powder and applied as a spray cannot be relied upon to be lethal to the euonymus scale after the crawlers have settled on the host plant for eleven days or longer. This test did not indicate any difference with the various concentrations used. However since DDT used at the rate of 1 lb to 100 gallons of water was found to be insufficient in the residual test conducted earlier, it is assumed that 2 lb. of 50 per cent DDT to 100 gallons of water is needed to kill all of the young scales. Throughout the summer undeveloping first instar nymphs were seen remaining attached for many weeks to plants which had been sprayed. The first instar nymphs that still remained on the first and second plants treated with Deenate at 3 lb. DDT per 100 gallons of water concentration four weeks later are examples. (See Table V)

Since a complete kill of all of the young scales was obtained in the tests started on June 16, it appears that the scales are susceptible to DDT over a longer period

Table V. Toxicity of DDT residues to Unaspis euonymi (Const.)

No. of Days Spray Applied After Crawlers Transferred*	1 lb/100		2 lb/100		3 lb/100		
	No. found before sprayed	Per Cent alive Aug. 9	No. found before sprayed	Per Cent alive Aug. 9	No. found before sprayed	Per Cent alive Aug. 9	
1 (July 2)	5	0	4	0	5	0	3**
5 (July 6)	16	0	58	0	57	0	15**
11 (July 12)	46	45.6	185	44.4	46	34.8	

* Crawlers transferred July 1

** First nymphal instars found August 9

during the time when crawler activity is just beginning than later in the development of the insects. The residue of DDT appears to be more effective for a longer period during the early season of crawler activity. From these four experiments it may be concluded a 50 per cent DDT wettable powder, applied as a spray, and used at the rate of two pounds in one hundred gallons of water is 100 per cent lethal to first instar nymphs of Unaspis euonymi (Comst.). - This is true when the spray is applied either a week before the young have hatched or a week after they have settled. It appears that this period can be extended to ten days in the early season of the new generation.

During the summer of 1947, thirty shrubs of Euonymus fortunei carrierei (Nichols.) were secured by the Waltham Field Station and were set out in a small plot next to the insectary. On June 21, 1948, ten of these Euonymus plants were infested with the euonymus scale in the crawler stage by means of attaching a twig, heavily populated with the crawlers, to a branch of these plants. This was done with the idea of conducting tests to determine the effects of other insecticides upon the young euonymus scales. Volck, a highly refined oil emulsion containing 83 per cent actual oil; Black leaf-40, a 40 per cent nicotine sulfate solution; and Resitox, a 25 per cent DDT emulsion, were the

materials to be used in this test. Volck was used at 2 per cent dilution which was obtained by mixing it 1 part to 50 parts water. The concentration of Black leaf-40 was 1/8 per cent, or a 1 to 800 solution of the nicotine sulfate and water. Resitox was mixed 1 part Resitox to 400 parts water giving a spray solution containing 1/16 per cent DDT. The Volck and Black leaf-40 were used together forming one spray solution. Resitox was used alone and in combination with Black Leaf-40. These insecticides were applied with a one quart hand sprayer. These three insecticidal solutions were applied to the nine Euonymus plants in the following order. Three were sprayed one day after the crawlers had been transferred, three six days later, and three plants were sprayed ten days later.

Thirteen scales developed on the plant sprayed with Resitox and Black leaf-40, the day after the plant was infested. A few scales were found on the two plants sprayed with Resitox and with Resitox and Black leaf-40 ten days after the crawlers had been transferred. The solution of 2 per cent Volck and 1/8 per cent Black leaf-40 therefore gave the best results. (See Table VI) It appears that this last solution can be relied upon to be effective against the first nymphal instar of this scale for a period of ten days after the young have settled on

Table VI. Effect of Volck, Nicotine Sulfate and Resitox on Unaspis euonymi (Comst.)*

Insecticide	Sprayed June 22		Sprayed June 28		Sprayed July 2	
	No. found before sprayed	No. alive July 20	No. found before sprayed	No. alive July 20	No. found before sprayed	No. alive July 20
Volck (2%) and Black leaf-40 (1/8%)	125	0	125	0	75	0
Resitox (1/4%)	100	0	175	0	50	9
Resitox (1/4%) and Black leaf-40 (1/8%)	150	13	85	0	45	6
Check	15	14				

* Crawlers transferred on July 21.

the host plant. No injury to the plants from spray materials was seen in this test.

On July 14 fifteen cuttings from heavily infested Euonymus shrubs were potted. Two inches of loam was placed in the bottom of the pots and then covered with three inches of sand. The pots in turn were placed in a tray of sand three inches deep. The tray was placed in a shaded area in the insectary and covered with cheese cloth. The sand and cloth were kept moist to help the cuttings take root. It was hoped that the twigs would live long enough so that the effects on the partially grown scales of the insecticides applied could be noted. The following insecticides were used: Parathion, 25 per cent wettable powder, used at the rate of 1 pound to 100 gallons of water; Oreseco, 30 per cent DDT and carbon tetrachloride, used at the rate of 1 part to 400 parts water; 50 per cent Vapotone, hexaethyl tetraphosphate, used at the rate of 1 part to 800 parts water; 2 per cent Volck and Black leaf-40, 1-800; Deenate used at the rate of 3 pounds to 100 gallons of water; and 40 per cent Dowklor, a chlorodane compound used at the rate of 3 pounds to 100 gallons. The twigs however failed to survive, and the anticipated information could not be obtained.

Second Generation

On August 23 control experiments were begun on the crawlers of the second generation of the euonymus scale. A clump of infested Euonymus fortunei vegeta (Rehd.) and Euonymus fortunei radicans (Sieb.) plants located at the Waltham Field Station were used for this purpose. The branches were numbered by means of tags. On each branch a representative leaf was marked in India ink and all counts of the scale were made on these marked leaves. The insecticides were applied with a one quart hand-operated sprayer. In applying the spray, one branch was isolated from the others by means of a cotton cloth. The only additional insecticide that had not been used in previous tests was Parathion, a 25 per cent wettable powder, which was used at the rate of 1/2 pound per 100 gallons of water and 1 pound per 100 gallons of water. The name of this insecticide is 0,0-diethylo, p-nitrophenyl. Thiophos 3422 is a common brand name. (See Tables VII - X.)

From these tests it is seen that the mature scales are not affected by the summer sprays, since many more young scales were found after the sprays were applied. The eggs were also not injured by the treatments. This is readily understood since eggs were never found outside of the female scale covering, and since the insecticides were not to

Table VII. Comparative effects of various insecticides against Unaspis euonymi (Comst.)*

Insecticide	Aug. 23		Sept. 14	Sept. 28	Dec. 7	
	No. ♀	No. crawlers	No. 1st instar nymphs	No. in 2nd stadium	No. in 3rd. stadium	No. matured
Deenate (2 lb/100)	4	1	30	4	0	0
Deenate (3 lb/100)	14	4	53	0	0	0
Volck (2%)	28	1	3	0	0	0
Check	6	1	41	26	18	8
Black leaf-40 (1/8%)	2	1	3	0	0	0
Resitox (1/4%)	1	16	6	0	0	0
Parathion (½ lb/100)	3	2	5	0	0	0
Parathion (1 lb/100)	3	2	2	0	0	0

* Sprayed August 23.

Table VIII. Comparative effects of various insecticides against Unaspis euonymi (Comst.)*

Insecticide	Aug. 24		Sept.14	Sept.28	Dec. 7	
	No. ♀ +	No. crawlers	No. 1st instar nymphs	No. in 2nd stadium	No. in 3rd. stadium	No. matured
Deenate (2 lb/100)& Volck(2%)	9	3	0	0	0	0
Deenate (2 lb/100)& Black leaf-40(1/8%)	13	9	6	0	0	0
Volck (2%) & Black Leaf-40 (1/8%)	10	3	6	8	0	0
Volck (2%) & Resitox (¼%)	9	2	8	0	0	0
Check	9	3	16	4	0	1
Resitox (¼%) & Black leaf-40 (1/8%)	12	9	5	6		6
Parathion (1 lb/100) & DDT (2 lbs/100)	8	2	2	0	0	0
Parathion (1 lb/100) & Black leaf-40 (1/8%)	5	2	2	1	0	0
Parathion (1 lb/100) & Volck (2%)	22	3	3	0	0	0
Parathion (1 lb/100) Resitox (¼%)	4	2	0	0	0	0

* Sprayed August 24

Table IX. Comparative effects of various insecticides against Unaspis euonymi (Comst.)*

Insecticide	Aug. 23		Sept. 14	Sept. 28	Dec. 7	
	No. ♀	No. crawlers	No. 1st instar nymphs	No. in 2nd stadium	No. in 3rd stadium	No. matured
Deenate (2 lbs/100)	3	2	15	4	0	3
Deenate (3 lbs/100)	16	2	38	2	2	0
Volck (2%)	2	5	0	0	0	0
Black leaf-40 (1/8%)	9	1	1	0	0	0
Resitox (1/4%)	9	1	29	3	0	2
Parathion (½ lb/100)	4	3	0	0	0	0
Parathion (1 lb/100)	17	2	2	0	0	0

* Sprayed August 23 and August 30.

Table X. Comparative effects of various insecticides against Unaspis euonymi (Comst.)*

Insecticide	Aug. 24		Sept. 14	Sept. 28	Dec. 6	
	No. ♀ + ♂	No. crawlers	No. 1st instar nymphs	No. in 2nd stadium	No. in 3rd stadium	No. matured
Deenate (2 lb/100) & Volck (2%)	7	1	0	0	0	0
Check	6	5	150	40	3	31
Deenate (2 lb/100) & Black leaf-40(1/8%)	12	1	0	0	0	0
Volck (2%) & Black leaf-40 (1/8%)	8	2	5	0	0	0
Volck (2%) & Resitox (¼%)	8	1	0	0	0	0
Resitox (¼%) & Black leaf-40 (1/8%	14	2	25	2	0	2
Parathion (1 lb/100) & Black leaf-40 (1/8%)	12	2	0	0	0	0
Parathion (1 lb/100) & Deenate (2 lb/100)	16	1	0	0	0	0
Parathion (1 lb/100) & Volck(2%)	9	2	0	0	0	0
Parathion (1 lb/100) & Resitox (¼%)	5	4	9	0	0	0

* Sprayed August 24 and August 31.

penetrate this outer protective covering surrounding the female. Hence the treated scales continued to produce young over the normal four week period. However, even though the eggs were laid and the crawlers hatched, their development ceased at this point. Very little difference in the final results was obtained between the scales on the plants which received one treatment, and those on plants which received two treatments. This was not anticipated to be the case from the results of previous experiments. The only difference was that fewer scales were found as first stage nymphs on the plants that received two applications of the insecticides. This was perhaps due to the second treatment washing the recently killed scales from the test plants.

About one month after the treatments had been applied, on September 28, a few scales were found which had completed their first nymphal instar and had started to develop the distinctive features of the second stadium. These were found on branches treated with Deenate, 2 and 3 pounds per 100 gallons of water concentration, and with Resitox used alone and in combination with Black leaf-40. On these same plants, a few mature scales were seen on December 7, indicating that these were the least effective materials used. In previous tests with Resitox carried out on the young of the first generation, the same inferior results

were obtained. 2 per cent Volck, when used alone or in combination with Black leaf-40 resulted in excellent control as was indicated in earlier tests. The Parathion also gave excellent control in both concentrations used and in combinations with the other insecticides used. It would appear that a combination of Parathion and Deenate would give good control. Under experimental conditions such a combination did give excellent results as seen in the above summary. (See Table XI)

On September 14 the remaining seven plants invested on August 24 were sprayed with those insecticides which through previous tests had indicated were the most effective to control euonymus scale. The summarized results are in Table XII. Nearly perfect results were obtained with these materials. It appears from the results of the tests carried out in the summer of 1948 that if the infested plants are thoroughly covered by any of the above insecticides little difficulty will be encountered in controlling the euonymus scale. Solutions of; Parathion, rate of 1 pound per 100 gallons water, and Deenate, rate of 2 pounds per 100 gallons; Parathion and 2 per cent Volck; Black leaf-40, 1-800, and Volck, 2 per cent; and Deenate and Volck gave the best results. In all tests these four insecticides resulted in complete kill. Spray solutions

Table XI. Comparative effects of various insecticides against Unaspis euonymi (Comst.)*

Insecticide	No. 1st instar before spraying	Sept. 14 No. 2nd stadium	Sept.28 No. 3 stadium	Dec. 7 No. matured
Deenate (2 lb/100) & Volck (2%)	161	33	0	0
Deenate (2 lb/100) & Black leaf-40 (1/8%)	76	32	0	0
Volck (2%) ' Black leaf-40 (1/8%)	148	130	0	0
Volck (2%) & Resitox (¼%)	56	11	2	3
Black leaf-40 (1/8%) & Resitox (¼%)	127	125	0	0
Parathion (1 lb/100) & Deenate (2 lb/100)	76	7	0	0
Parathion (1 lb/100) & Black leaf-40 (1/8%)	18	3	0	2
Parathion (1 lb/100) & Volck (2%)	8	2	0	0
Parathion (1 lb/100) & Resitox (¼%)	61	21	0	0
Check	25	14	4	4

* Crawlers transferred August 24, sprayed August 31.

On August 24 the remaining small shrubs in the outside plot were infested with the crawlers of the euonymus scale. Seven days later nine were sprayed. The results are summarized as above.

Table XII. Comparative effects of various insecticides against Unaspis euonymi (Comst.)*

Insecticides	Sept. 14 : No. 1st instar before sprayed	Sept. 28 : No. 2nd instar	Dec. 7 : No. matured
Check	13	4	4
Deenate (2 lb/100) & Volck (2%)	17	0	0
Deenate (2 lb/100) & Black leaf-40 (1/8%)	40	2	2
Parathion (1 lb/100) & Deenate 2 lb/100)	44	0	0
Parathion 1 lb/100) & Volck (2%)	58	0	0
Black leaf-40 (1/8%) & Volck (2%)	27	0	0
Volck (2%) & Resitox (1/4%)	28	0	0
Parathion (1 lb/100) & Black leaf-40 (1/8%)	48	0	0

* Crawlers transferred August 24, sprayed September 14.

containing the DDT emulsion repeatedly gave inferior results. However these inferior results were not extremely poor, but rather did not give the same complete control that was obtained with the four solutions mentioned above.

On July 27 the author accompanied a representative of a commercial concern involved in controlling pests of trees and shrubs, on his trip inspecting the results of previous treatment on Euonymus shrubs. Three excellent cases of control were seen. The plants of all three clients had received one dormant oil emulsion treatment in the middle of March. One plant in Belmont had received another treatment in June with Black leaf-40, Volck and (DDT) Deenate (rate 2 lb/100 gal). No scales were found alive on this bush. Another Euonymus plant in Belmont had received, besides the dormant oil spray on March 16, a spray of Black leaf-40, Volck (1 per cent) and DDT(50 per cent Deenate 1 lb/100) on March 21 and a treatment of Black leaf-40, Double Styx and DDT (50 per cent Deenate 2 lb/100) on June 2. Two spots of young scales were observed developing on the shrubs so treated. From these two instances it appears that the additional treatment in the second case did not give additional control of the euonymus scales. This follows logically in that Volck, and DDT and Black leaf-40 could not be expected to be of any value in controlling the scale

in March. From studies of the seasonal history of Unaspis euonymi (Comst.) in 1948, June 2 was about two weeks early for the most effective time to apply the spray for the first generation. However since only two scattered infestations were found in the latter case, the treatment of Black leaf-40, Double Styx and DDT was almost as effective as the Black Leaf-40, Volck and DDT treatment used in the first instance. This slight infestation was probably due to a less thorough treatment since the living scales were found in protected places. These two practical examples of control support the experimental results reported in this paper. A fine Euonymus shrub was seen in Dover which had just received a second summer spray of Black leaf-40, Double Styx and DDT on July 27. Even though this was two weeks after the last crawlers of the first generation had been seen, no scales were found on this ornamental.

CONCLUSIONS

The euonymus scale, Unaspis euonymi (Comst.), was observed on numerous occasions during 1948 causing a great deal of damage to the Euonymus plants. The female of the scale insect is dirty brown, oyster-shell-shaped and inconspicuous. The scale covering of the males is white and appears to have three long ridges. The adult females pass through the winter and in 1948 the egg laying process was first observed on June 10. Each female lays approximately fifty eggs over a period of one month. When the first nymphal instar hatches, it has legs, eyes and antennae and is called the crawler stage. The peak of crawler activity in 1948 was on June 27 and on September 5. Fewer crawlers were found two weeks before and two weeks after these two dates.

From information gathered in 1948 it was concluded that Unaspis euonymi can be controlled with a 1½ per cent Elgetol dormant spray or a 4 per cent dormant oil emulsion spray. The Elgetol will give the best results.

One attempting to control the scale should familiarize himself with the crawler stage of this insect, because the true population of the scale can only be estimated by the numbers of these first nymphal instars present on the host plant. After treatments have been

applied, the old, dead scales will for the most part remain attached to the twigs and foliage for several months. However, if crawlers cannot be found in June there is less need to apply summer sprays. This is difficult for many to understand. However if one continues to observe his plants he will see a gradual decrease in the number of these scales due to the influence of weather factors which loosen them.

The first treatment on Euonymus shrubs heavily infested with the scales is the dormant Elgetol 1½ per cent spray applied in March or April. No other treatments are necessary until the young crawlers have been found. These should be anticipated in late May and early June and the search should be continued until the end of June unless they are found before this time, since each year there is a seasonal variation. As soon as these crawlers are found, one of the following sprays should be applied.

1.	Summer oil emulsion (Volck 83%)	2 gallons	3 tablespoonsfuls
	40% Nicotine Sulfate (Black leaf-40)	1 pint	2 teaspoonfuls
	Water	100 gallons	1 gallon

2. DDT wettable powder (50% Deenate)	2 pounds	2 tablespoonfuls
Summer oil emulsion (Volck 83%)	2 gallons	3 tablespoonfuls
Water	100 gallons	1 gallon
3. Parathion wettable powder (25%)	1 pound	1 tablespoonful
Summer oil emulsion (Volck 83%)	2 gallons	3 tablespoonfuls
Water	100 gallons	1 gallon
4. Parathion wettable powder (25%)	1 pound	1 tablespoonful
DDT wettable powder (50% Deenate)	2 pounds	2 tablespoonfuls
Water	100 gallons	1 gallon

The shrubs should be inspected again for signs of the young scales in August. If the crawlers are found, one of the above sprays should be applied thoroughly. It is believed that these three treatments are sufficient to control the euonymus scale.

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