United States
Department of
Agriculture

Animal and
Plant Health
Inspection
Service

Plant Protection
and Quarantine

Cooperating State
Departments of
Agriculture

September 1985

ACTION PLAN

ARROWHEAD SCALE
Unaspis yanonensis (Kuwana)

This PPQ Action Plan or New Pest Response Guideline has not been updated since its publication date. The actions or guidelines recommended may not be appropriate now, new survey tools may be available, and chemical pesticides named may no longer be registered. This documents is posted until updated versions can be drafted and as such are only guidelines that represent the state of knowledge at the time they were written. Please consult PPQ and/or your State Plant Regulatory Official prior to implementing any recommendations listed herein.

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AUTHORIZATION

This Action Plan provides guidelines and actions for the eradication of an arrowhead scale infestation. This Action Plan supplements information contained in the Plant Protection and Quarantine (PPQ) Treatment, Emergency Programs, and Administrative Procedures Manuals.

It is to be used in conjunction with other manuals when conducting emergency program activities. The information and instructions contained in this Action Plan were developed with and approved by representatives of cooperating States, the U.S. Department of Agriculture's Agricultural Research and Cooperative State Research Services, and affected industry.

All program technology and methodology employed are determined through discussion, consultation, or agreement with the cooperating State officials.

NOTICE

Recommendations in this Action Plan, which involve the use of pesticides, concern products which are registered or exempted under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended. Precautions on the pesticide label and all instructions in this Action Plan must be carefully followed.

Federal and/or State personnel may not make any warranty or representation, expressed or implied, concerning the use of these products and shall not be responsible for any loss, damage, or injury sustained as a result of the use of any product as specified in this Action Plan.

The use of trade names in this Action Plan does not imply an endorsement of those products or of the manufacturers thereof by Federal-State pest control programs. Equivalent formulations under different trade names are acceptable.

H. V. Ford

Deputy Administrator
Plant Protection and Quarantine

8/21/85
Date

William Kinard

Chairman
National Plant Board

8/21/85
Date

I. GENERAL INFORMATION

A. Action Statement

The information contained in this document is intended for use when an arrowhead scale infestation is known to exist. This Action Plan is to be used for guidance in implementing eradication procedures and in preventing spread to other locations. It provides technical and general information needed to implement any phase of an arrowhead scale eradication program. Specific program action is to be based on information available at that time.

B. Background Statement

The arrowhead scale is native to China. It spread to Taiwan and Japan (including Ryukyu Islands) at the beginning of this century and, more recently, to France where it was discovered in 1963. It is now known to occur in Australia, Burma, Hong Kong, India, Indonesia, Korea, Malaysia, Okinawa, Pakistan, the Philippines, Thailand, and Vietnam. Arrowhead scale is recorded from 38 hosts (as identified by the Tanaka identification system for citrus), mostly Citrus spp. Oranges, lemons, Japanese daidai, and kumquat seem to be preferred. It is commonly intercepted on fruit, dried fruit, or leaves from Asia. Plant injury results from nymphal and adult female feeding on plant juices, which causes desiccation of aboveground parts of the host. In due course, a consistent, stable, and fairly high reproductive capacity results in severe damage to the host. In about a year or so after damage is noticed, trees may die without corrective action. There is no instance where population density remains naturally low when left alone. Good biological control agents are not available except for Aphytis lignanensis, which may have to be periodically released in some locations. Physcus fulvus and Aphytis yanonensis are two other parasites which are potentially effective, but this is yet to be proven. Insecticides are the only efficient control agent available. All this results in economic losses of three types: (1) The cost of mandatory application of insecticides (generally three times a year), (2) the depreciation of commercial value of damaged fruit including export losses, and (3) the loss of yield caused by infestation of foliage and twigs.

Development from egg to adult, in constant optimum temperatures of 80.6-82.4 ^{o}F (27-28 ^{o}C) takes approximately 43 (female scale) to 45 (male) days, at which point both sexes are sexually mature. One generation usually requires approximately 63 days under natural conditions when the first eggs are laid, after a maturation period of approximately 20 days. Oviposition is prolonged and lasts approximately 80 days as subsequent eggs mature in their turn.

C. Life Cycle Application

Insect development is temperature dependent. Egg, nymphal, and adult reproductive development are influenced by air temperatures. A minimum temperature exists below which no measurable development takes place. For arrowhead scale, this threshold is 49.8 ^{o}F (9.9 ^{o}C) in air, on an average, for first and second instar and embryonic development (preovipositional period), the third instar being the functional female adult. A temperature model that is designed to use modified air temperature data for all life stages can be used to predict the entire life cycle. The number of degrees accumulated above this developmental threshold for a life stage are referred to as day degrees. For the model depicted in the table below, 1,598 ^{o}F (870 ^{o}C) day degrees must be accumulated before one life cycle has been completed.

Formula:

Minimum Daily		Maximum Daily		Total		Average Daily		Threshold		Day Degrees
Temp ^{o}F	+	Temp ^{o}F	=	$\frac{\text{Temp } ^{o}\text{F}}{2}$	=	Temp ^{o}F	-	Temp ^{o}F	=	Temp ^{o}F

Example: (Air model using a 49.8 ^{o}F (9.9 ^{o}C) threshold limit.)

Minimum Daily		Maximum Daily		Total		Average Daily		Threshold		Day Degrees
59 ^{o}F	+	64.4 ^{o}F	=	$\frac{123.4\ ^{o}\text{F}}{2}$	=	61.7 ^{o}F	-	49.8 ^{o}F	=	11.9 ^{o}F

This model should assist in predicting the initial emergence of the first instar of the subsequent generation. (Note: With completion of the preovipositional period, eggs hatch in only 35 to 70 minutes with emergence of first instar nymphs. This brief period need not be factored in the model.)

In cooler areas where quiescence may occur, the initial emergence of the first instar from overwintering female scales can be predicted by the use of regression equations and the examination of eggs of specimen female scales held in the laboratory, following their development as given in Addendum D.3.

The following chart illustrates such a technique suitable for areas where the first instar may be expected to emerge in May-June. For warmer areas where much of the citrus in the United States is found, emergency may be several months sooner. In any event, the data below may be adjusted depending on the expected months of emergence; i.e., if in April-May then February 28 (29) may be substituted for March 31. Expected first emergence can be determined roughly through study of local weather conditions and past history of a given area. Extrapolation of this information with the day degree formula should permit a determination of the approximate date for emergence.

This procedure cannot be used in regions where year-round development can be expected.

Development of ovary (x)	Initial occurrence date of the first instar larvae (y) Regression equation
Embryonated eggs found in all ovaries of the mature females (Type A & B eggs)	y=x+4
More than 50% of eggs in the mature female ovary found embryonated (Type A & B eggs)	y=0.52x+8.2
Initial appearance of the fully developed egg (Type A egg)	y=0.71x-8.4

x: Number of days between March 31 and the date of development of ovary.
y: Number of days between April 30 and the initial nymphal occurrence date.

Egg development is divided into four stages and visible under a microscope, as given below:

Stage	Type	Development
D	Immature Egg	Yolk Formation
C	Immature Egg	Blastoderm Formation
B	Mature Egg	Embryonated--no eyespots
A	Mature Egg	Embryonated--eyespots

Examples:

1. Embryonated eggs of Types A & B are found in all ovaries on May 15.

   x=30 days April + 15 days May=45.
   y=x+4.
   y=49=31 days May + 18 days June.
   Initial occurrence date of first instar is June 18.

2. Over 50% eggs of Types A & B are found on June 17.

   x=30 days April + 31 days May + 17 days June=78.
   y=0.52x+8.2.
   y=0.52 (78) +8.2.
   y=48.76=31 days May + 18.76 days June.
   Initial occurrence date of first instar is June 18-19.

3. Initial appearance of Type A egg on June 20.

   x=30 days April + 31 days May + 20 days June=81.
   y=0.71x-8.4.
   y=0.71 (81) -8.4.
   y=49.11=31 days May + 18.11 days June.
   Initial occurrence date of first instar is June 18.

Where second instar males survive the winter, it is possible to hold these and observe their development. The chart below shows the steps to take, again in areas where the first instar is expected in May to June. As given above, adjustments may be made to the dates depending on expected first emergence.

Development of male (x)	Initial occurrence date of first instar nymph (y) Regression equation
Pupation of more than 10% of the male nymphs in quiescence.	y=x+2
Initial adult emergence	y=x-7

x: Number of days between March 31 and date of development of male.
y: Number of days between April 30 and the initial nymphal occurrence date:

Examples:

1. More than 10% of males pupate as of May 17.

   x=30 days April + 17 days May=47.
   y=x+2.
   y=47+2.
   y=49=31 days May + 18 days June.
   Initial occurrence date of first instar is June 18.

2. Initial adult emergence date is May 26.

   x=30 days April + 26 days May=56.
   y=x-7.
   y=56-7.
   y=49=31 days May + 18 days June.
   Initial occurrence date of first instar is June 18.

Predictions can thus be made weeks in advance. It has been suggested that the most reliable date is a combination of the date derived from "eggs in all ovaries" plus the date from "pupation of male scales."

As mature Type B eggs require temperatures of 15.3 ^{o}C (59.2 ^{o}F) to complete the last stage (Type A) of embryonic development, the use

of eggs and regression equations may be more accurate for overwintering generations than the day degree method unless the weather warms appreciable during the last period of embryonic development.

The facility where the scales are held must be secure to prevent any inadvertent release of first instar larvae or adult males. Security measures must be equal to those established for a quarantine insect-rearing facility. See Animal and Plant Health Inspection Service 81-61 for detailed information.

Program actions are guided in part by insect life cycle data. Duration and timing of eradication treatments, length and frequency of survey activities, and regulatory functions are affected primarily by the length of time it takes to complete each stage of life cycle. Temperature data are available from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, private, State, university, or industry sources, or can be generated by strategically placing thermometers to measure air temperatures at various levels above the ground, depending on the average height of hosts in the core area.

II. SURVEY PROCEDURES

A. Delimiting Survey

1. The delimiting survey will primarily rely on a visual survey for the female scale--the only stage which can be identified with certainty. The visual survey is guided by a trapping survey, which can be expanded on if it is determined that reliable identification of the first larval instar is possible under project or local conditions.

When arrowhead scale is collected in an area, a delimiting survey will be implemented immediately to determine the population distribution.

a. Using the site of the detection as the focal point (epicenter), located suitable hosts in each square kilometer (km^2) of the core area. Up to 100 hectares (ha) (approximately 250 acres (a)) of host, if available, are to be surveyed in the core. This will include 20 ha (50 a) in each km^2 and around the epicenter where the find was made or nearest suitable hosts.

At least five separate sites containing a maximum of 4 ha (9.8 a) each will be sampled within each km^2 to obtain the sample size needed.

At each site a total of 60 trees will be sampled. Generally, selections will be from every alternate tree (up to 10 per row) and from every other row (up to 6 rows). Where hosts are scattered it may be more practical to sample every other tree. Bias will be placed on unhealthy appearing trees, limbs, fruit, and leaves.

At a given selected tree, visual examination will be carried out by closely examining a minimum of 10 leaves. 10 twigs and branches, and 10 fruit. Fallen leaves, fruit, and branches will also be examined. A bias will be placed on those hosts showing any signs of characteristic damage such as leaves with yellow necrotic spots; drooping leaves; dropped, small, deformed, split, or encrusted fruit; short branches; encrusted, broken, or dead twigs; and white masses on leaves and twigs. Samples of suspect material that include leaves, twigs, and fruit will be bagged in durable, disposable, plastic bags for laboratory examination.

The visual survey will be repeated once every 2 weeks and rotated to other available host groves or to where hosts may be available. This will eventually allow coverage of the entire core area. The survey will be maintained for at least three arrowhead scale

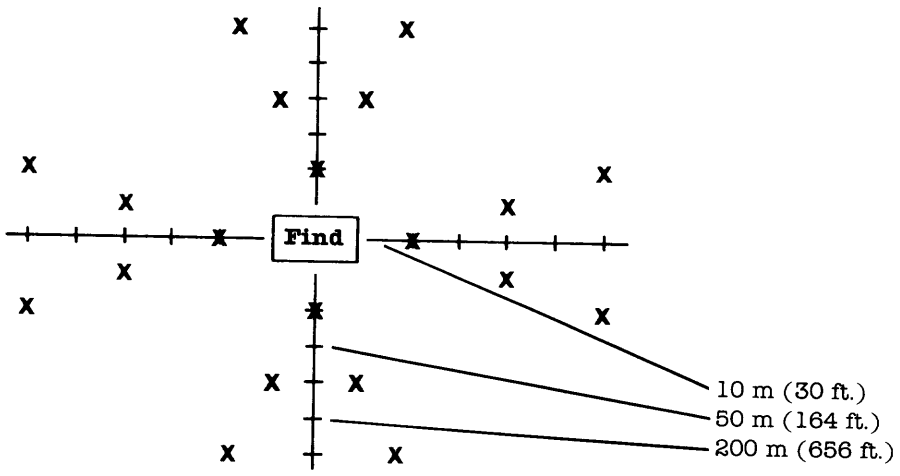
generations after the last find. Surveys in the core area will follow regulatory procedures given in III, F1 and 2 on "washing" and "clothing disposal" to avoid possible accidental spread of the arrowhead scale.

b. Using the site of the detection as the focal point (epicenter), four dispersal tower traps will be arranged around the focal point at a distance of approximately 10 meters (m) (30 feet (ft)) in each direction of the compass with a bias for placement near host trees.

At distances of approximately 50 m (164 ft) and 200 m (656 ft) from the focal point, another 16 traps will be erected with two towers at each distance in each direction of the compass with a bias for placement near host trees.

The area covered by the above trapping pattern will be approximately 16 ha (39.5 a). This arrangement will be used to determine the feasibility of tracking first instar dispersal in that area. If tracking of first instar dispersal is not feasible, as may be indicated by the inability to distinguish first instar scale from other scale species such as the citrus snow scale found in Florida and Louisiana, then dispersal trapping will be discontinued.

Dispersal Trapping



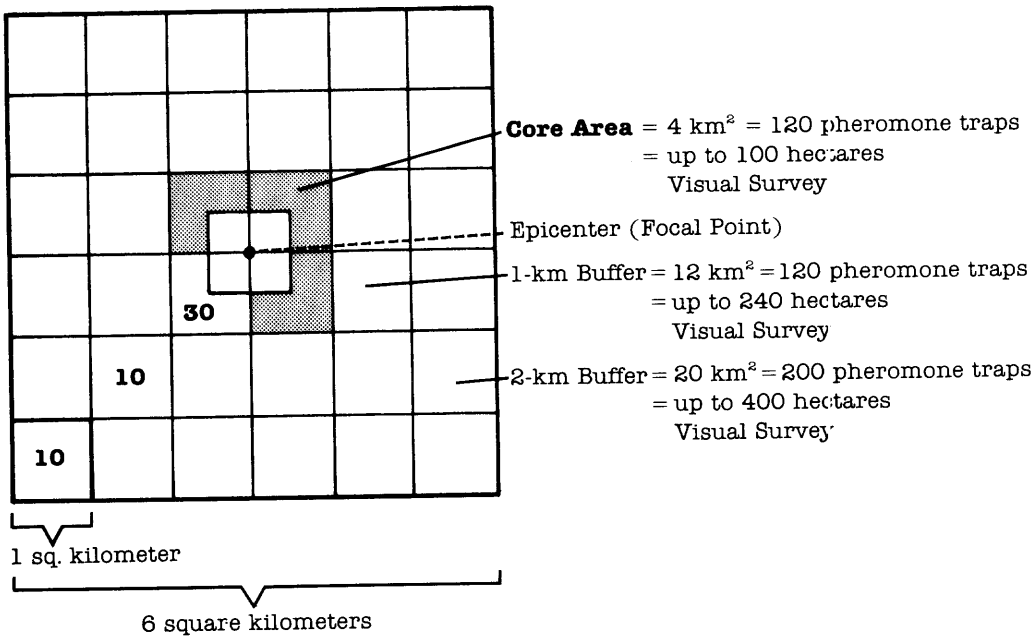
x = Location of each trap, which may vary.
Note: Not to Scale.

If dispersal trapping is successful, as may be indicated by the ability to distinguish arrowhead scale from related species, the program is in an area or on a host where related indistinguishable species do not occur, or the mature female arrowhead scale is found in the traps, thus permitting identification, then traps will be serviced every 2 weeks. They will be maintained during periods or estimated periods of first instar and mature male and/or female dispersal.

c. Using the site of the detection as the focal point (epicenter), pheromone traps with or without pheromone/female scales will be placed in the upper third of the canopy of every host within 200 m (216 yards (yd)) of each find. The traps are to be serviced weekly.

Within the core area, 10 pheromone traps per grove will be placed in three selected groves in each of the 4 km^2 (1.5 square miles (mi^2)) outside the epicenter. Five traps will be placed in hosts at least six trees apart on the site of he grove nearest the focal point. The others will be spaced at least six rows in and six trees apart and staggered with respect to the first traps. If only scattered plantings or individual trees are available, traps may be spaced 30 to 45 m (100 to 150 ft) apart, maintaining as far as possible the pattern.

Survey Per Square Kilometer



2. Since significant dispersal can take place by wind dispersal of first instar nymphs and perhaps mature female scales, the following steps must be taken to contain the probable spread of an infestation.

a. Under zero or little wind conditions, if only one insect, one colony, or a limited infestation on a property is detected, the delimiting survey is limited to the 4-km^2 (1.54-mi^2) core area.

b. Under zero or little wind conditions, if two or more colony detections are made within a 4-km^2 (1.54-mi^2) area, the delimiting survey will be conducted over 36 km^2 (about 14 mi^2). Pheromone traps will be deployed in the core areas at the rate of 30 per km^2 and at the rate of 10 per km^2 in the 1- and 2-km buffers. The visual survey will be carried out at the rate of 20 ha (50 a) in both core and buffer areas.

c. Under zero or little wind conditions, if six or more detections are made in an area involving 16 km^2 (6 mi^2) or more, the delimiting survey will be extended to cover all of the area between the buffer areas of each detection. Traps and survey efforts will continue at the same rates as in the buffer areas.

d. If one or more colonies are present and the average daily prevailing windspeeds during a period of first instar dispersal or estimated dispersal are moderate, then the core areas will extend linearly 2 additional km downwind along that side. The buffer area will also be extended on that side and will consist of another 36 km^2 (14 mi^2), but without a core area.

Should there be countervailing winds for a significant period during first instar dispersal or estimated dispersal, the core and buffer areas may be extended linearly in that direction as given above.

e. If average daily prevailing windspeed during a period of first instar dispersal or estimated dispersal is strong, then the core areas will also be extended on that side and will consist of two 36 km^2 (two 14 mi^2), including a 6 km^2 (mi^2) extension of the core.

f. If during first instar dispersal there is significant wind movement due to low pressure areas (storms, depressions), nymphs from an infested area could be drawn toward such a system, locally increasing their density up to the level of inversion close to the cloud base. A downdraft could deposit these nymphs over a relatively small area a considerable distance from the infested area. They could also be deposited when winds die away in the evening.

Provided that such a system was observed during first instar dispersal and noted to rain or disperse elsewhere by evening, exposed downwind localities with hosts could be surveyed. This should be done in 3 to 4 weeks time, allowing any presumed nymphs time to settle and develop to the point where they can be most readily observed by visual survey but prior to the production of another generation. Any effort expended on such a survey shall not be at the expense of regular program needs.

B. Monitoring/Evaluation Survey

A monitoring/evaluation survey will be conducted in that area where eradication treatments are applied. The traps and visual survey systems are maintained at the delimiting rate. The presence of any scales will indicate overall efficiency of the program against scales in host material.

C. Detection Survey

If two or more reproductive colonies of scales are found, host areas beyond the last buffer zone will be trapped at a minimum rate of 10 pheromone traps per 8 km^2 (one grove per mi^2) for two life cycles up to 10 km (6.2 mi) from the epicenter. A visual survey of at least one 4-ha (10-a) grove per 3 km^2 (one grove per mi^2) will also be continued in this area for two life cycles after the last find. In addition, area, regional, and State program officials will be asked to look for arrowhead scale in the course of regular survey work, particularly within 80 km (49.7 mi) of the infested area, especially if storms or other atmospheric disturbances were recently in the area during first instar dispersal.

D. Orientation of Survey Personnel

New personnel will be trained, on the job, by experienced personnel. It will be necessary to have 3 working days to teach the many facets of the arrowhead scale survey.

E. Survey Records

Records noting the areas surveyed, sites trapped, dates, locations, and hosts in which detections were made will be maintained (see Addendum G).

III. REGULATORY PROCEDURES

A. Instructions to Officers

Regulatory actions will be required until the pest is eradicated. At present, only treated nursery stock and processed articles can be moved. Officers must follow instructions for regulatory treatments or other procedures when authorizing the movement of regulated articles. Understanding the instructions and procedures will serve as a basis for explaining such procedures to persons interested in moving articles affected by the quarantine and regulations. Only authorized treatment procedures may be used.

General instructions that are to be followed in regulatory treatments are found in the PPQ Treatment Manual.

Officers should advise nursery shippers to apply treatment to small quantities of nursery stock prior to treating larger quantities to determine the reaction or effects of the treatment procedure.

B. Regulated Articles

1. Any aboveground part of the following hosts:

Common Name	Scientific Name
Citrus, all	Citrus spp.
Damnacanthus, all	Damnacanthus spp.
Kumquat, all	Fortunella spp.
Trifoliate-orange	Poncirus trifoliata

2. Any other product, article, or means of conveyance, of any character whatsoever, when it is determined by an inspector that it presents a hazard of spread of arrowhead scale and the person in possession thereof has been so notified.

C. Quarantine Actions

When detections are made, the following steps should be implemented in sequence:

1. With the detection site considered the epicenter, all growers and establishments that grow, handle, move, or process regulated articles within a minimum of 3 linear (lin) km (1.86 mi) will be issued emergency action notifications requiring treatment or other approved handling procedures. Emergency Action Notification (PPQ Form 523) and/or comparable State notifications are issued by field personnel to the property owners or managers of all establishments who grow, handle, move, or process articles capable of spreading the arrowhead scale. A notification will be issued pending authoritative confirmation and/or further instruction from the Deputy Administrator.

2. If necessary, the Deputy Administrator will issue a letter directing PPQ field offices to initiate specific emergency action under the Federal Plant Pest Act (7 U.S.C. 150dd) until interim regulations announcing emergency action can be published in the Federal Register.

The Federal Plant Pest Act of 1957 provides for authority for emergency regulatory action. This provision is for interstate regulatory action only; intrastate regulatory action is provided under State authority. However, if the Secretary of Agriculture determines that an extraordinary emergency exists and that the measures taken by the State are inadequate, USDA can take intrastate regulatory action provided that the Governor of the State has been consulted and a notice has been published in the Federal Register.

The Organic Act of 1944, as amended, provides the Federal Government, either independently or in cooperation with States or political subdivisions thereof, farmers' associations and similar organizations, and individuals the authority to carry out operations or measures to detect, eradicate, suppress, control, or to prevent or retard the spread of plant pests. This Act does not provide for trespassing on private property, but relies upon State authority and willingness to use State right-of-entry authority.

All program technology and methodology employed are determined through discussion, consultation, or agreement with the cooperating State officials.

3. The Deputy Administrator, through the National Regional Directors, will notify State cooperators of the arrowhead scale detection, actions taken, and actions contemplated.

A narrative description of the regulated area with support documents will be developed by USDA and cooperators and provided to the Regulatory Services Staff, National Program Planning Staff (NPPS). The regulated area will also be defined by the Universal Transverse Mercator Grid Marking System for use by the Project Manager.

4. APHIS Regulatory Coordination Staff will publish interim regulations, which are effective on publication, under the Federal Plant Pest Act in the Federal Register to announce an emergency action. Written comments will be solicited (for

approximately 60 days) on the rule from the public. If a quarantine is warranted after consideration of submitted comments, a final rule under the Plant Quarantine Act will be published in the Federal Register.

D. Regulated Establishments Inspection

Efforts to detect the pest within the regulated area will be made at all establishments where regulated articles are grown, handled, moved, or processed. Establishments that might be involved are: Airports, landfill sites, processing plants, farmers markets, produce markets, nurseries, flea markets, and any other establishment that handle regulated articles. At these premises, a visual examination of host material and containers will be necessary to detect the presence of scales, particularly where fruits are handled. Suspect fruit that appear to have scales or otherwise to be in poor shape will be examined as will any other host material such as leaves or twigs. If there is a large amount of suspect material, it may be necessary to take a large sample of 50 to 100 specimens from stockpiles for examination. A minimum of 20 samples of five selections each may be examined at each establishment.

E. Use of Authorized Pesticides

This Action Plan contains the authorized chemicals, methods and rates of application, and any special application instructions. Concurrence by PPQ's Survey and Emergency Response Staff (SERS) is necessary for the use of any chemical or procedures for regulatory purposes.

F. Approved Regulatory Treatments

1. Washing. The use of water to hose down vehicles and other suitable articles before leaving infested groves or premises during periods of first instar dispersal or estimated dispersal.

2. Clothing Disposal. Personnel working in infested groves or premises are required to wear disposable paper coveralls and plastic shoe covers during periods of first instar or estimated dispersal. These are to be placed securely in a plastic bag before leaving the premises or grove and disposed of by burning or in a landfill as soon as possible without opening.

3. Nursery Stock Dip. Exposure of nursery stock to a dip treatment in which all parts of the plant except roots are immersed in an oil-based solution.

4. Sanitation. The removal and destruction of leaves, branches, twigs, infected or fallen fruit, and other host material found during operations from premises, establishments, and vehicles handling regulated articles.

IV. ERADICATION PROCEDURES

The SERS, in consultation with methods and research agencies, outlines treatments to be used and must be notified of all treatment plans. If treatments selected or proposed are not in conformance with current pesticide labels, an emergency exemption may be obtained under Section 18 of the FIFRA, as amended. For further instructions, see Emergency Programs Manual, Section V, B.

Eradication of an arrowhead scale infestation is essential. Local conditions will determine the most acceptable procedures to achieve eradication.

A. Recommended Pesticides

1. Diazinon
2. Dichlorvos
3. Ethion
4. Ethion and Oil
5. Flowable Sulfur
6. Lime Sulfur
7. Malathion
8. Petroleum Oil

B. Approved Eradication Treatments

1. Thorough Coverage Ground Spray

Ground application of insecticide will be initiated immediately. All host plants which provide for reproduction of the arrowhead scale will be sprayed at the prescribed intervals 2 km (1.24 mi) beyond any known infestation. Care will be taken to apply spray to runoff to limbs, branches, and fruit as well as foliage. Ground spraying may be discontinued after an estimated two generations of negative survey.

2. Aerial Spray

Aerial application of insecticide is at best a supplement and extension to ground treatment. It should only be employed to

limit dispersal of the first nymphal instar in large outbreak situations. Aerial sprays will be applied at the prescribed intervals only during first instar dispersal or estimated dispersal over a minimum period equal to two life cycles of negative survey. The area to be sprayed will extend a minimum of 2 lin km (1.24 mi) beyond any known infestation under zero or little wind conditions and to all extended buffer areas under prevailing/countervailing wind conditions. Weather conditions may dictate changes in spray schedule. After an estimated two generations of negative survey, spray operations may be discontinued. Nonhost areas or areas with very little host material are not to be sprayed and will be handled by ground treatments.

The decision to apply insecticide applications will be based on the best weather information available. In the event rain washes an application from the foliage, plans will be implemented to retreat the area. During the dormant period in winter, only oil or oil-based sprays will be used against the overwintering, mostly mature female scales.

Retreatment should not be considered if weather reports indicate a 50 percent or greater chance of precipitation in the 48-hour period following washoff.

The objectives are to eradicate the pest and minimize environmental contamination. Any treatment or retreatment recommendations must consider these objectives.

3. Supplemental Methods

Sanitation in nurseries, groves, and other establishments or premises where hosts are present will be carried out within the core and buffer areas.

General pruning in groves and of other hosts in the core area will assist in reducing scale populations as well as maintain host vigor and resistance. If practical, all infested or otherwise dead or dying branches should be pruned. All pruned host material must be destroyed.

In situations were hosts are heavily infested or are dying, consideration will be given to cutting and burning. All host material must be completely destroyed. Due to the likelihood of first instar dispersal as a result of these disruptive

activities, a light application of flowable sulfur may be laid down first to dampen the host.

C. Eradication/ Control Methods Selection

The following parameters or criteria will determine the minimum treatments to be used in achieving eradication. Expanded or additional treatment actions can be applied if mutually agreed upon by cooperating agencies.

Eradication measures will continue for at least two generations and survey will continue for at least three generations following the last detection.

1. If one scale of any stage is detected in an urban/residential or commercial area, no eradication treatments will be initiated.

2. When one reproductive colony is detected in any urban/residential or commercial production area, sanitation in the core and buffer areas and thorough coverage ground applied sprays in the epicenter will be applied.

3. When two reproductive colonies are detected in an urban/residential or commercial production area of less than 16 km^2 (6 mi^2), pruning in the core, and sanitation plus ground applied sprays extended 2 kilometers (km) (1.24 miles (mi)) beyond the core will be employed.

4. When more than six reproductive colonies are detected in an urban/residential area greater then 16 km^2 (6 mi^2), host destruction, thorough coverage ground applied sprays extended 2 km (1.24 mi) beyond the core, pruning in the core, and sanitation will be employed. Similar detection in a commercial area will require all of the above plus treatment by air to cover all buffer areas during first instar dispersal.

D. Orientation of Eradication/Control Personnel

Only trained and experienced personnel will be utilized initially. Replacement personnel will be trained by the individual being replaced. A period of 3 working days is necessary for the orderly transfer of these functions.

E. Eradication/ Control Records

Records noting the location of detections, dates, number and type of treatments, and materials and formulations used will be maintained for all areas treated (see Addendum G).

F. Monitoring

An effective monitoring program will be implemented to aid in the evaluation of program efforts and environmental impact. The

application and use of insecticides and other controlled substances will be assessed through the use of appropriate monitoring program criteria. The evaluation must effectively address Agency, cooperator, and public concerns.

The monitoring program will include at least the following elements:

1. Determine efficacy of pesticide against the target pest.

    a. Iodine-starch test--monitor efficacy.

    b. Monitoring survey--the presence of scales, including male scales, will indicate overall program efficiency against scales in host material.

2. Evaluation of dye cards to monitor aerial application.

    a. Droplet size information.

    b. Droplet distribution information.

    c. Identification of wind drift components.

    d. Verification of spray block boundaries.

    e. Identification of skips.

3. Sampling to evaluate effect on environmental components.

    a. Water sampling to detect insecticide levels through direct application, leaching, and runoff.

    b. Soil sampling to determine insecticide levels and residues.

    c. Foliage sampling to identify residues.

    d. Biological organism sampling during application and posttreatments to determine impact of insecticides.

    e. Air sampling to determine presence of pesticides in respirable air.

The monitoring program is to be a combined effort between the State in which the emergency program in being conducted and PPQ. If specific plans need to be developed for monitoring activities, SERS will request assistance and guidelines from other NPPS staffs.

V. CONTACTS

When an arrowhead scale eradication program has been implemented, its success will depend upon the voluntary cooperation, assistance, and understanding from other involved groups. The following is a list of groups which either are involved in or must be kept informed of all operational phases of an emergency program:

A. Other Federal, State, county, and municipal agricultural officials;

B. Grower groups;

C. Commercial interests;

D. Universities;

E. State and local law enforcement officials;

F. Public health agencies;

G. Foreign agricultural interests;

H. National, State, and local news media; and

I. General public.

VI. ADDENDA

Addendum A--Definitions

Aerial Treatment:	Applying an insecticide by aircraft over a treatment area.
Array:	The trapping pattern in a 16-ha (39.5-a) area around a find.
Buffer Area:	The area extending beyond the boundary of the core--1- and 2-km (0.6- and 1.2-mi) buffer.
Commercial Production Area:	An area where host material is grown for commerce.
Confirmed Detection:	A positive laboratory identification of a submitted life form (specimen) as arrowhead scale.
Core Area:	A minimum distance of 1 km (0.6 mi) beyond any confirmed arrowhead scale detection.
Day Degrees:	The accumulation of heat units above a specified developmental temperature threshold during a life stage.
Delimiting Survey:	Determining the extent of the infestation in an area where arrowhead scale has been detected.
Detection:	The collection of any life stage of arrowhead scale.
Detection Survey:	An activity conducted in a susceptible area not known to be infested with arrowhead scale.
Dispersal:	(1) The movement of first instar nymphs of arrowhead scale by wind, more rarely by man, animal or bird, or vehicle. (2) Dispersal of winged adult male to within 200 m (256 yd) of emergence location or transport by man, animal, or vehicle. (3) Dispersal of scale stages by transport of host by man, water (rarely), or windblown leaf.
Dispersal Tower Trap:	A post 5 meters (16.4 ft) high with crossrods from which sticky cylindrical traps are hung vertically to catch first instar nymphs carried by wind currents.

Epicenter/Focal Point:	The initial site of an infestation.
Epicenter Survey:	A survey conducted to determine the nature and extent of the infestation in the initial 16 ha or 200 m surrounding a detection.
Generation: (Life Cycle)	The period of time for the pest to complete all stages of development predicated on day degrees or on the basis of other biological information.
Ground Spray:	Using ground spray equipment to apply an insecticide to host vegetation in an arrowhead-scale-infested area.
Host:	A plant species that potentially provides for reproduction of arrowhead scale.
Infestation:	The collection of one or more reproductive colonies from an area.
Infested Area:	Three km distance from all detection sites unless biological factors indicate the need for more or less area.
Monitoring/Evaluation Survey:	Using interdependent visual surveys in an area where an insecticide treatment has been applied to evaluate the effectiveness of the applications.
PPQ-APHIS-USDA:	Plant Protection and Quarantine, Animal and Plant Health Inspection Service, U.S. Department of Agriculture.
Quiescence:	A state of hibernation during cold months somewhat resembling torpidity.
Regulated Area:	An area that extends at least 3 lin km (1.86 mi) in any direction from an infested property.
Regulated Inspection:	Visual examination of host material and containers conducted at establishments where regulated articles are grown, handled, processed, or moved.
Reproductive Colony:	An established population of arrowhead scales, consisting of at least one mature mated female or two or more scales of which one is female and one is male in any state of development within 200 m (256 yd) of each other. However, if the associated female scale, when

collected, demonstrates definite signs of attempts to attract a mate, this suggests that an arrowhead scale male is not near enough to respond. These signs are abnormal elongated scales, exertion of the pygidium from beneath the edge of the scale, bodily exposure by leaving the armor cover completely, and finally the production of an anomalous external mass of secretary filaments. Such signs will be taken to indicate that a reproductive colony does not exist at that location.

Trap Survey: A survey deploying dispersal and/or pheromone traps in a predetermined pattern and serviced on a given schedule.

Unaspis yanonensis (Kuwana): The scientific name of the arrowhead scale.

Urban/Residential Area: Noncommercial crop production area generally containing multiple- or single-family dwellings.

Visual Survey: A survey conducted by examining hosts for scales, either in the field or in regulated establishments or in monitoring the movement of regulated articles.

Addendum C--Hosts

The arrowhead scale host list is separated into preferred and other recorded hosts. The hosts are listed by common and scientific names. The common names are arranged in a manner that is indicative of their usage. In all instances, an attempt has been made to use the most widely recognized common name. Tanaka's system of citrus names is employed for the purpose of this list. There may be other species and only known hosts are listed.

PREFERRED

Common Name	Scientific Name
Japanese daidai	Citrus aurantium var. daidai
Lemon	Citrus limon
Navel orange	Citrus sinensis
Round kumquat	Fortunella japonica
Trifoliate orange	Poncirus trifoliata
Unshu orange	Citrus unshu

OTHER

The literature indicates that these hosts will permit arrowhead scale development, but does not disclose all the conditions under which the host/pest relationship occurs. In several cases, there is evidence that at least two strains of arrowhead scale exist, and that one strain is capable of normal reproduction on summer orange, previously thought to be resistant to this pest.

Common Name	Scientific Name
Asahikan	Citrus asahikan
Calamondin	Citrus madurensis
Calamondin orange	Citrofortunella japonica
Damnacanthus	Damnacanthus spp.
Fingered citron	Citrus medica var. sarcodactylus
Grapefruit	Citrus paradisi
Grapefruit, a	Citrus iwaikan
	Citrus medioglobosa
	Citrus yamabuki
Hassaku	Citrus hassaku
Hyuganatsu	Citrus tamurana
Ichange lemon	Citrus ichangensis
Iyo	Citrus iyo

Kaiseito	*Citrus wilsoni*
Kikudaidai	*Citrus tankan*
Kinukawa	*Citrus glaberrima*
Lime	*Citrus bergamia*
Maltese blood orange	*Citrus nobilis* var. *kunep*
Marmela	*Citrus tengu*
Mato buntan	*Citrus natsudaidai* x *C. unshu*
Mexican lime	*Citrus aurantifolia*
Oval kumquat	*Fortunella margarica*
Pummelo	*Citrus maxima* (= *C. grandis*)
Rusk citrange orange	*Citrus sinensis* f. *sanguinea*
Shikikitsu	*Citrus keraji*
Sour orange	*Citrus aurantium*
Sour orange, a	*Citrus canaliculata*
Summer grapefruit	*Citrus natsudaidai*
Tangerine (Mandarin)	*Citrus reticulata*
Tankan	*Citrus sinensis* x *Poncirus trifoliata*
Washington navel orange	*Citrus sulcata*
Yatsushiro	*Citrus yatsushiro*
Yuzu	*Citrus junos*

Addendum D--Life History

1. SYSTEMATIC POSITION

Arrowhead scale, Unaspis yanonensis (Kuwana) (Homoptera, Coccoidea, Diaspididae)

Class: Insecta

Order: Homoptera

Superfamily: Coccoidea

Family: Diaspididae

The genus has eight species. These are all Asian in origin, three having spread to other parts of the world. These three species (including arrowhead scale) are of economic importance, two of which are already in the United States. These are:

Citrus snow scale, U. citri (Comstock) Florida and Louisiana
Euonymus scale, U. euonymi (Comstock) 32 States and Washington, DC

2. IDENTIFICATION CHARACTERISTICS

Some preidentification and sorting needs can be met by personnel assigned to the program.

The arrowhead scale male armor can generally be described as an elongated white armor with parallel sides about 1 milimeter (mm) (0.39 inch (in)) long. It has three ridges, the center one prominent and straight. The female armor is broadly elongated toward the end only and otherwise straight with a distinct ridge in the center (two features separating it from U. euonymi and U. citri). Length 3 to 4 mm (0.12 to 0.16 in), width 2.5 to 3 mm (0.1 to 0.12 in), darkish brown with gray margin; brownish-yellow exuviae.

This species generally occurs on leaves, branches, and fruits with male scales clustered in distinctive white masses. Other Unaspis species are primarily found on the twigs, more rarely on the leaves, and without such clustering of the males.

The following descriptions are of life forms found under the armor covering except for the first instar and the adult male which are free moving.

Eggs: About 0.18 mm (0.007 in) long, 0.09 mm (0.004 in) wide, oval in shape, surface smooth, orange-yellow to orange in color.

Nymph: First instar very small, about 0.23 mm (0.09 in) long and 0.14 mm (0.006 in) wide, body flat, otherwise oval-shaped, yellow with the

posterior end darker. Antennae with five segments, last segment large and distinctly annulate (ring-like) and with six setae plus one terminal seta, other segments with only one seta. Mouthparts well formed with long stylet loop. Eyes prominent and purple, located behind antennae at the margins. A pair of large tubular ducts are present near the front. Three pairs of well developed legs are present, with the femur long and greatly curved on the outer side, the tibia less than half as long, and the claw large and slightly curved. Three pairs of small lobes, the median largest are found on the posterior end, each lobe has a small spine at its base. The male is slightly darker in color than the female.

Second Instar Female: About 0.31 mm (0.012 in) long and 0.21 mm (0.008 in) wide. The antennae are rudimentary with a single segment; the legs are entirely lost. The pygidium is round, indented in middle with three pairs of distinct lobes and spines on the posterior end, the median pair serratulate (tooth-like), the other pairs divided into two lobes. Four pairs of gland spines present, one between the median and second lobes, the next between second and third lobes, and two others beyond the third spine.

Second Instar Male: Elongated about 0.64 mm (0.025 in) long and 0.21 mm (0.008 in) wide. Body color yellowish-orange changing to orange. The pygidium is not indented, three pairs of lobes present, and six pairs of gland spines present. Two pairs of purple eyes present, one pair on lateral margin, another pair more dorsal and closer together.

After the second molt, the female reaches the adult stage. The male continues development.

Prepupa Male: Length--no change recorded. Color orange-yellow darkening to yellowish brown at posterior end. Eyes very dark purple brown. Dorsal eyes now just behind antennal sheaths, ventral eyes are larger, closer together, and further behind dorsal eyes. Sheaths of antennae, legs, and wings visible but rudimentary and appressed to body.

Male Pupa: About 0.80 mm (0.031 in) long, 0.30 mm (0.012 in) wide. No color change. Ventral eyes larger and almost touching, dorsal eyes wider apart and slightly closer to anterior margin of head. Sheaths of antennae, wings, and legs very evident and close to body along ventral margin; style of penial sheath now prominent, 0.15 mm (0.0059 in) long.

Adult Male: About 0.45 mm (0.018 in) long, style 0.36 mm (0.014 in), wing expanse 1.76 mm (0.069). General color orange yellow, eyes deep dark brownish-purple, antennae and legs yellow. Head rounded, somewhat pointed at apex, antennae of 10 segments, first two much shorter and thicker than others, length 0.54 mm (0.021 in), segments 3 to 10 with long fine hairs.

Wings extending beyond tip of style when at rest, halteres club shaped with slender hook arising from tip of club. Legs slender, similar in size, femur broader but a little longer than tibia, tarsus shorter than tibia with curved claw. Abdomen with very evident segmentation ending in sharp penial sheath.

Adult Female: Length about 2.5 mm (0.098 in), width 1.0 mm (0.039 in), elongated, constrictions of sutures distinct, anterior margin rounded. Antennae reduced to minute tubercles bearing one short seta. Mouthparts well formed with very long rostral loop, two prominent pairs of spiracles present, marked division present between thoracic segments, pygidium with numerous dorsal ducts, median lobes distinct but distance between lobes only about 1/2 average lobal width.

Female Armor: Length 2.84 to 3.56 mm (0.11 to 0.14 in), width at broadest point 1.40 to 1.92 mm (0.05 to 0.07 in), color dirty blackish to violet brown with gray margin, with elongated pale yellow to brownish-yellow exuviae in front of shield. A central ridge is present from which armored sides slope away like a roof in petal-like bands. Ventral side of armor grayish white and does not meet in middle.

Male Armor: Length 1.25 to 1.56 mm (0.49 to 0.61 in), width 0.48 to 0.75 mm (0.02 to 0.03 in), color white, straight, distinctly tricarinate, exuviae pale yellowish brown.

3. BIOLOGY

The eggs of the first generation of a given year are laid from May to July in Japan under the armor of the adult female. In citrus-producing areas of the United States, egg laying will most likely begin 2 to 3 months earlier in the year. Each female produces about 200 eggs. Eggs are rapidly produced until the ovary is full.

It takes normally about 20 days to complete embryonic development. This may be extended by cold weather, and the progress of egg development is one means by which the emergence of the spring generation of first instar nymph is calculated. This development is divided into four stages as follows:

Stage	Type	Development
D	Immature Egg	Yolk Formation
C	Immature Egg	Blastoderm Formation
B	Mature Egg	Embryonated--no eyespots
A	Mature Egg	Embryonated--eyespots

When embryonic development (preoviposition) is complete, the eggs are discharged at a maximum rate of 32 eggs a day. This happens every day for the first 10 days after starting, and intermittently afterwards for a maximum of approximately 80 days.

When the ovary is empty, a second period of egg production commences. This lasts until the ovary is full again. During this second period, each female produces about 200 eggs. The incubation period of the eggs is very short, ranging from 35 to 70 minutes. After about 1 day under the female armor, the first instar nymphs emerge and crawl about on the host for up to 3 hours before settling to feed. There are two peaks of emergence which appear to be related to the resting period the ovary gets when it is full of eggs. The first and main peak appears 10 to 15 days after the initial date of emergence; the second, smaller one about 30 days after the first. In the spring generation, the proportion of males is high, being about 2.5 to 3 times the number of females.

The first instar nymph, due to the activity of the nymphs before they settle, is the most dangerous stage in terms of natural spread. Wind is believed to be the chief dispersal agent and breezes above 0.42 km per hour (hr) (0.26 mi per hr) may suffice to carry this stage. No studies have been carried out on arrowhead scale movement by wind but studies on related scales suggest that dispersal, once a population is established, could be rapid. Since such nymphs tend to move up a given host to the growing points in response to light and gravity, they move higher into the turbulent planetary boundary layer which aids in vertical entrainment of the nymph. Such vertical, turbulent entrainment has sent nymphs as high as 50 m (164 ft), which can be very effective in dispersal. This is enhanced by the behavior of the nymphs, which arch their backs and extend their legs and antennae for more lift.

Horizontal movement depends on wind velocity. From available data, nymphal density in air at the source will expand with increasing windspeed up to 7.2 km per hr (4.4 mi per hr) before leveling off. The majority of wind-borne nymphs may (depending on wind) disperse up to 2.8 km (1.7 mi) away from a source when windspeed is approximately 5.4 km per hr (3.36 mi per hr), and (based only on theoretical projections) with a range of 80 km (49.7 mi) downwind. Arrowhead scale nymphs may last up to 2 days. Survival may reasonably be assumed to be shorter than 2 days under dry conditions. In spite of the above, spread of arrowhead scale may reasonably be expected to be slow and, even in the same grove, dispersal is primarily to adjacent trees.

Other kinds of dispersal include accidental carriage by birds, animals, insects, man, or vehicles. These are probably of minor importance in the case of arrowhead scale, since only the first instar nymph would normally be in contact with such carriers as a result of wind action. More direct contact could occur when animals, etc., come in contact with the host. Human, bird, or vehicle transport offers some chance for long-range dispersal if first instar nymphs are blown on them and then blown or brushed off again at a later time.

Direct transport of host by man (rarely by water) results in long-range dispersal, not only of nymphs but of any or all life stages. Viable propagative stock with but a single gravid female is capable of starting an infestation anywhere where the stock is planted or grafted.

On an individual tree, the population density is higher in the upper part and lowest in the inner or lower areas of the tree. Mortality, however, is higher in the crown or part way up and lower further down. As a rule the nymphs settle in less than 3 hours. The males generally settle near their mother scales in large masses of 30 to 40 and up to several hundred individuals per several square centimeter (cm^2) in the foliage and 1-year-old twigs of a host. The females generally settle on outer leaves and 1-year-old branches in the first generation. The second generation infests the fruit more commonly. Neither sex can attack large branches or the trunk of a host. Settling is accomplished by probing the host substrate with the stylets until a suitable spot is found. The nymph then pulls its legs under itself and affixes itself to the plant by piercing the surface with its stylets. Within 24 hours a wax secretion of cottony threads covers the dorsal surface of the body. After 2 to 3 days this secretion ends.

In the female, a waxy grayish secretion is produced medially and continues until it covers the posterior half of the body. The body itself undergoes a color change, becoming paler and then changing to deep orange in color. Just before the first molt, the dorsal carina and close wrinkles of the armor appear. The time interval of the first instar is 8 to 16 days.

In the male, the secretion consists of coarse cottony threads. There is no other secretion, but the length of time is about the same.

Under field conditions, local dispersal by crawling and settling of first instars has resulted in 35 percent mortality for females and 70 percent for males. There are no figures available for mortality during long-range dispersal.

In the second instar of the female, the cast skin is incorporated into the armor with the nymph beneath it. After several days the abdominal end projects outside the margin of the cast skin and produces a thin, grayish, waxy substance which is extended posteriorly behind the cast skin. The cast skin thus becomes an oval, yellowish plate at the anterior tip of the armor. The body changes color from orange to pale yellow and then to greenish yellow and nearly transparent a few days before the second molt. It becomes very flattened and changes back to orange just before the second molt. The dorsal carina and close wrinkles of the armor are now prominent. The duration of this stage is variable and depends on the time of year, taking 15 to 16 days in summer and up to 28 days in autumn.

The second instar of the male also exposes the abdominal end outside the posterior end of the cast skin, this occuring 3 to 4 days after the first molt. It is soon covered with a white cottony secretion in the form of three

lateral processes. With continued growth, this becomes a tricarinated mass of whitish secretion, elongated in form and characteristic of the male. The whitish overing is only produced in this stage. The body color remains orange and the entire stage lasts 15 to 17 days in summer and approximately 30 days in late autumn.

The third instar of the female is the adult stage, although it still appears morphologically to be a nymph. The second cast skin, which is much larger than the first, is also incorporated into the armor. The female is able to mate immediately after this molt and usually does so under field conditions.

The male prepupa or third stage is attained after the second molt. In this case, the second cast skin is pushed back beneath the armor covering and there is no change in external appearance. The duration of this stage is very short and lasts 17 to 36 hours.

The male pupa is attained on the third molt and molting is the same as the previous stage. The body is orange yellow in color and the stage lasts 1 1/2 to 4 1/2 days.

The female scale (adult) secretes the armor, which is attached to the posterior end of the second cast skin. Secretions are also produced from the ventral submargin of the body which produce a thin armor on the ventral side. This armor does not quite cover the ventral side as it does not meet in the middle. The color of the dorsal armor is pale at first, becoming dark gradually. The central ridge becomes well-marked and prominent with time. The body is yellow, gradually changing to orange-yellow, and to very deep orange just before oviposition. The adult female lives for about 55 to 65 days in the summer and the overwintering female lives for about 243 to 247 days. The adult female is normally sessile, but may be dislodged and carried or blown by wind. If this occurs, any accompanying first instar nymphs could, following transport, succeed in finding a host. This mechanism may effectively disperse the species.

The male (adult) casts the pupal skin beneath the armor. Then the wings are extended to their full length and folded over the back. For a while the male remains within the armor and then backs out and becomes active in late afternoon, immediately beginning the search for a female. Length of life is short, ranging from 16 to 104 hours--average 55 hours. The male may be dispersed by wind or even fly upwind if wind velocity is less than 1.6 km per hr (1 mi per hr). Flight is generally quite short if it is to a female on the same host. Long-range dispersal of arrowhead scale males has not been measured. Recent evidence indicates that some long-range dispersal may be possible, as demonstrated by marked California red scale males which have been recovered up to 189 m (620 ft) downwind and up to 92 m (302 ft) upwind when traps baited with female pheromone were set out. At present, no female pheromone has been demonstrated for arrowhead scale, although it is assumed that the location of receptive females by males is in response to such a pheromone.

During mating, males orient themselves on the edge of the armor, face toward the center, and place the aedeagus under the armor cover to the pygidium of the female. Length of time of mating is not known in arrowhead scale. Males and females may both have a number of mates but the female soon retracts its pygidium irreversibly and becomes unattractive (length of time to retraction not known).

Damage occurs due to nymphs and females feeding on plant juices. When numbers are high, this causes fruit and leaf necrosis, rapid desiccation of the leaves and branches, and deformation and splitting of fruit. When the population is low (up to one female scale per leaf), actual damage is almost nil to a lowering of fruit quality at worst. However, there is almost no instance of the density remaining low naturally with arrowhead scale. The population increases gradually to rapidly as a result of a fairly high, constant reproductive capacity and the ability to adapt to high population densities. This becomes readily evident when dead, collapsed leaves on branches; dropped fruit; encrusted, dead and broken twigs; and white masses of male scales on twigs and leaves appear. At this stage, there are about eight female scales per leaf. In a year or so the tree dies if such an attack is not contained. The exact mechanism of this desiccation is not known, but it is assumed that intense feeding due to high scale densities is responsible. It has also been suggested that a poisonous material is injected which kills plant tissues, but there is no proof, as yet, of this possibility. For lack of proper care, many trees and whole groves have been killed. It is considered the most serious citrus pest in Japan, where two to three generations per year will produce a very rapid increase in scale numbers.

The arrowhead scale may be expected to have two to three generations a year in citrus-growing areas. Nymphs of the second generation appear from July to September. In Japan, this may continue until November depending on the area. There is a 10-day period from first emergence to maximum emergence. The two peaks of emergence are not so evident as in the first generation. Females of this second generation produce, on average, fewer eggs (about 177 on average) and fewer males (about 1.6 times as many males as females).

The nymphs of the third generation emerge from September to November, but the population may be rather small in colder areas. Females produce even fewer eggs (133 on average) of which only 40 may hatch.

With colder weather, the fertilized female of the arrowhead scale enters quiescence. Immature females will also enter quiescence. These constitute 20 percent of overwintering scales. In warmer regions, second instars (males and females) can also enter quiescence, but their numbers are low. Quiescence is falculative and easily broken by high temperatures.

The life cycle of arrowhead scale from egg to egg is 63 days under optimum conditions or 65 days if only males from that particular stock are available.

Under minimal conditions, egg to egg development will take 245 days or 247 days if only males from the same mother scale are available.

Immature eggs may develop at 8 ^{o}C (46.4 ^{o}F), but require temperatures over 9 ^{o}C (48.2 ^{o}F) to develop into mature eggs. A temperature greater than 9.9 ^{o}C (49.8 ^{o}F) is necessary for embryonic development of the first generation up to the mature egg stage. The mature egg requires 15.3 ^{o}C (59.2 ^{o}F) temperatures to complete development. Otherwise, normal development requires over 15 ^{o}C (59 ^{o}F). Development is retarded when temperatures exceed 27 ^{o}C (80.6 ^{o}F).

Addendum E--Identification of Specimens

As many specimens as possible of the pest are to be collected for identification. Suspect scales should be forwarded dry in a small cardboard box inside a pillbox or inside a folded piece of blotting paper placed in an envelope. First instar nymphs and females will be mounted on slides for ease of identification and adult males will be immersed in small vials of alcohol. Specimens will be sent for confirmation to 1/ below. These specimens must be accompanied by PPQ Form 391 marked "Urgent" (see PPQ Manual M390.500).

INFORMATION FLOW FOR THE IDENTIFICATION OF INSECTS

SPECIMEN COLLECTED

SCREENING/IDENTIFICATION BY STATE OR PPQ

SPECIMEN SUBMITTED TO USDA 1/
for Confirmation

CONFIRMATION NOTIFICATION 2/
to Other USDA Agencies

RESULTS SENT TO APHIS AND IF EXOTIC
Information Relayed to 2/ 3/

APHIS/ARS 1/ All States 2/ NAPPO 3/

Insect Identification
and Beneficial Insect
Introduction Institute
Agricultural Research Service
U.S. Department of Agriculture
Building 003, BARC-WEST
Beltsville, Maryland 20705

1/	ARS	
	APHIS	Plant Protection and Quarantine
2/	All States	State and Territory Agricultural Regulatory Officials
3/	NAPPO	North American Plant Protection Organization

Addendum F--Technical Application Data

1. HORIZONTAL SLIDE DISPERSAL TRAP

The trap is essentially a glass or plastic plate formed by placing 10 glass or plastic microscope slides 76 by 25 mm (3 by 1 in) in a retaining rectangle on a Masonite sheet. Such slides are easier to examine under the microscope than a single sheet. All slides are coated on both sides with tanglefoot or glycerine jelly (1 gram (g) gelatine, 7 g glycerine, phenol 1 percent, and water 6 centimeters (cm)). The exposed sticky surface will serve to trap wind-borne nymphs, male and mature female scales, and other stages or parts of scales. The other side will help hold the slides in the trap.

2. TRAP DISPERSAL TOWER

The dispersal tower is a 2- by 4- or 4- by 4-in wooden pole 5 m (16.4 ft) high or equivalent above the ground. There are four crossrods on the tower, each at a different height. One crossrod is at 1.15 m (4 ft), one at 2.4 m (8 ft), another at 3.66 m (12 ft), and the last at about 4.6 to 4.9 m (15 to 16 ft). Each crossrod must be fastened to a different side of the tower. A notch of sufficient size to secure a trap cord should be cut in the top of the crossrod no less than 15 cm (6 in) away from the tower. The tower is placed downwind from the targeted host trees and about 10 to 20 feet away from the nearest such host. One trap is then hung vertically from each crossbar by means of the trap cord. The cord should be of such length that the trap, when hung, will be approximately 1, 2, 3, and 4 m (3.3, 6.7, 10, and 13 ft) off the ground.

3. DISPERSAL TRAP SERVICING

The traps are lifted off of the crossrods by hand or with the aid of a pole with a hook to catch the trap cord. They are replaced the same way. To service the trap, the slides are lifted off the Masonite sheet and placed in a slide box on which all collection details are noted for transport to the laboratory. New, greased slides are placed in the trap and the trap replaced on the tower.

Once in the laboratory, the slides are examined for first instar nymphs with the aid of a microscope.

4. PHEROMONE TRAP

The pheromone trap is the commercial tent trap, cut down in size from 7.6 by 25 to 7.6 by 12.5 cm (3 by 9 to 3 by 4 1/2 in) for high catch efficiency, easy maintenance, and reduced counting time. These are folded at 90° angles with the catching surface on the underside. A rubber septum containing pheromone or container with virgin, sterile female scales goes underneath the trap. The rubber septum is suspended by a thin wire running through the trap and inside the

overhang. To keep the septum from touching the trap sides, the wire may be run through pieces of untreated cut rubber septa on each side of the trap paper and pressed together to prevent movement. If the female scales are on fruit, the fruit is placed in a covered 0.47-liter (L) (1-pint) styrofoam cup covered with 160 mesh nylon screening over a 15-by 30-mm (0.6- by 1.2-in) opening in the top of the cup. If the female scales are on twigs, the twigs may be wrapped in a plug of cotton and inserted in a plastic vial of water before placing in the cup. A minimum of 20 sterilized virgin females is required per trap.

Since male scales are in general weak fliers and tend to wander within or near the canopy, they are easily caught by the trap alone without any pheromone. They may be attracted by the yellow color of the underside of the trap. In hot, dry weather a rubber septa or cotton wick loaded with water may add to the attraction. As the traps are reasonably able to catch male scales without a pheromone or female scales, it is important to note that traps will be deployed as soon as possible with or without pheromone or female scales, and serviced on a regular basis. The pheromone or female scales will then be added when available.

5. VIRGIN FEMALES

Virgin females may be obtained by overseas arrangement. Prior treatment is necessary to avoid possible scale spread.

a. Treatment with Dichlorvos

The dichlorvos method requires dipping infested fruit or twigs in a suspension of prepared by mixing the technical ingredients first then adding water. This results in a stable suspension, which will remain stable for at least 1 month when stored in the dark. The fruit or twigs should contain females on artificially infested fruit or twigs predominately in the second instar (roughly 20 days old) and be dipped for at least several seconds. Drying for a minimum of 12 hours is necessary and may be done in lots as long as fruit or twigs remain covered by 160 mesh screening to prevent entry of males. Subsequently, females should be held for a minimum of 1 week before deployment to allow maturation and pheromone production.

b. Treatment by Hand

Male scales may be cleaned from fruit or twigs by hand removal. This method is labor intensive.

c. Irradiation

Irradiation dosages have not been worked out for arrowhead scale.

A small number of females may be gravid in spite of treatment and produce first instar nymphs which can escape the traps. Treated fruit and/or twigs must be removed and destroyed within 43 days after such fruit or twigs were originally infested.

6. PHEROMONE TRAP SERVICING

The trap is taken out of the host and replaced with a new trap, including attractant. If it is determined that under prevailing conditions the pheromone is still effective and/or female scales still effective and younger than 43 days, then the attractant may be retained until the following servicing period. In all cases, the trap proper is replaced. All collection details are noted on the trap and it is stored open in a box between layers of waxed paper for transport to the laboratory.

7. NURSERY STOCK DIP

a. Metric Measurement

Ethion and Petroleum Oil (Ethion 8 EC and Summer Oil)--177 milliliter (mL) of 81.9 percent ethion and 7.57 L of summer oil in 378.5 L of water. Use as a dip, submerging the whole plant except for the roots and allow to drain. Plants must be moved within 21 days of treatment or the procedure must be repeated and plants recertified.

b. U.S. Measurement

Ethion and Petroleum Oil (Ethion 8 EC and Summer Oil)--6 fluid ounces (fl oz) of 81.9 percent ethion and 2 gallons (gal) of summer oil in 100 gal of water. Use as a dip, submerging the whole plant except for the roots and allow to drain. Plants must be moved within 21 days of treatment or the procedure must be repeated and plants recertified.

8. DRENCH SPRAY

a. Metric Measurement

(Ethion 8 EC)--1.36 L of 81.9 percent ethion and 7.57 L of 60- to 90-second petroleum oil in 378.5 L of water. Soak twigs, branches, and leaves inside and outside of canopy of each host treated to runoff. Repeat every 90 days.

b. U.S. Measurement

(Ethion 8 EC)--46 fl oz of 81.9 percent ethion and 2 gal of 60- to 90-second petroleum oil in 100 gal of water. Soak twigs, branches, and leaves inside and outside of canopy of each host treated to runoff. Repeat every 90 days.

9. SANITATION

Sanitation will consist of the removal and disposal of host material. This includes all dropped or infested fruit on the ground or in the tree or grove, all obviously infested and drooping leaves and branches, where practical, and all rinds, etc., or other such parts as may be found as a result of human or animal activity.

10. GROUND APPLICATION

The following pesticides may not be registered for use on a given crop. Any application inconsistent with product labeling must have prior approval and the specific use covered under an emergency exemption.

a. Metric Measurement

Ethion (Ethion 8 EC)--177 mL (170 g actual ingredients (ai)) of 81.9 percent ethion in 378.5 L of water.

Apply as a thorough coverage spray of up to 7,550 L per a (18,700 L per ha) when detections are made, depending on type of equipment and crop/host being sprayed. Repeat at 90-day intervals. Do not apply within 21 days of a sulphur application.

Ethion and Petroleum Oil (Ethion 8 EC & Petroleum 60- to 90-Second Oil)--177 mL (170 g ai) of 81.9 percent ethion and 7.57 L or approximately 6.2 kilograms (kg) ai (depending on oil used) of summer oil in 378.5 L of water. Apply as a thorough coverage spray of up to 7,550 L per a (18,700 L per ha) when detections are made, depending on type of equipment and crop/host being sprayed. Repeat at 90-day intervals. Do not apply within 21 days of a sulphur application.

Malathion (Cythion®)--709 mL (425 g ai) of 57 percent Cythion® in 378.5 L ofwater. Apply as a thorough coverage spray of up to 13,248 L per a (32,735 L per ha) when detections are made, depending on type of equipment and crop/host being sprayed. Repeat at 7- to 10-day intervals.

Diazinon (Diazinon® 50 W)--0.9 kilograms (kg) (454 g ai) of 50 percent Diazinon® in 378.5 L of water. Apply as a thorough coverage spray of up to 3,785 L per acre (9,353 L per ha) when detections are made, depending on type of equipment and crop/host being sprayed. Repeat at 21-day intervals.

Lime Sulfur (Security Lime Sulfur)--37.9 L (3.7 kg ai) of 5 percent Security Lime Sulfur in 378.5 L of water. Apply as a thorough coverage spray of up to 3,785 L per a (9,353 L per ha), depending on type of equipment and crop/host being sprayed in autumn, winter, and spring. Do not apply within 21 days of an oil-based spray application. Toxic during periods of temperatures above 32.2 ^{o}C.

Flowable Sulfur (Magnetic® 6)--1.7 L (1.2 kg ai) of 51.1 percent flowable sulfur in 378.5 L of water. Apply as a thorough coverage spray of up to 7,570 L per a (18,705 L per ha), depending on type of equipment and crop/host being sprayed. Apply from autumn through spring (November through May) at 30-day intervals. Do not apply within 60 days of an oil-based spray application. Toxic during periods of temperatures above 32.2 ^{o}C.

Petroleum Oil (Volck® Supreme Spray)--3.79 to 4.73 L (3.1 to 3.9 kg ai) of 98 percent Volck® Supreme Spray in 378.5 L of water. Apply as a thorough coverage spray of up to 13,248 L per a (32,727 L per ha) when detections are made, depending on type of equipment and crop/host being sprayed. Repeat once every 4 months as determined by program officials. May be used between applications of insecticides and during the dormant period of the scale in winter. May not be used within 21 days of a sulfur application, within 8 weeks of lemon harvest, or after September 1 of a given year on oranges. Toxic during periods of temperatures above 32.2 ^{o}C.

b. U.S. Measurement

Ethion (Ethion 8 EC)--(6 fl oz) of 6 avoirdupois ounces (avdp oz) ai of 81.9 percent ethion in 100 gal of water. Apply as a thorough coverage spray of up to 2,000 gal per a (4,940 gal per ha) when detections are made, depending on type of equipment and crop/host being sprayed. Repeat at 90-day intervals. Do not apply within 21 days of a sulphur application.

Ethion and Petroleum Oil (Ethion 8 EC & Petroleum 60- to 90-Second Oil)--6 fl oz (6 avdp oz ai) of 81.9 percent ethion and 2 gal or approximately 13.7 pounds (lb) ai (depending on oil used) of summer oil in 100 gal of water. Apply as a thorough coverage spray of up to 2,000 gal per a (940 gal per ha) when detections are made, depending on type of equipment and crop/host being sprayed. Repeat at 90-day intervals. Do not apply within 21 days of a sulphur application.

Malathion (Cythion®)--24 fl oz (15 avdp oz ai) of 57 percent Cythion® in 378.5 L(100 gal) of water. Apply as a thorough coverage spray of up to 3,500 gal per a (8,648 gal per ha) when detections are made, depending on type of equipment and crop/host being sprayed. Repeat at 7- to 10-day intervals.

Diazinon (Diazinon® 50 W)--2 lb (1 lb ai) of 50 percent Diazinon® in 100 gal of water. Apply as a thorough coverage spray of up to 1,000 gal per acre (2,471 gal per ha) when detections are made, depending on type of equipment and crop/host being sprayed. Repeat at 21-day intervals.

Lime Sulfur (Security Lime Sulfur)--10 gal (8.1 lb ai) of 5 percent Security Lime Sulfur in 100 gal of water. Apply as a thorough coverage spray of up to 1,000 gal per a (2,471 gal per ha) depending on type of equipment and crop/host being

sprayed in autumn, winter, and spring. Do not apply within 21 days of an oil-based spray application. Toxic during periods of temperatures above 32.2 °C.

Flowable Sulfur (Magnetic® 6)-- 56 fl oz (42 avdp oz ai) of 51.1 percent flowable sulfur in 100 gal of water. Apply as a thorough coverage spray of up to 2,000 gal per a (4,942 gal per ha), depending on type of equipment and crop/host being sprayed. Apply from autumn through spring (November through May) at 30-day intervals. Do not apply within 60 days of an oil-based spray application. Toxic during periods of temperatures above 32.2 °C.

Petroleum Oil (Volck® Supreme Spray)--1 to 1/4 gal (6.86 to 8.6 lb ai) of 98 percent Volck® Supreme Spray in 100 gal of water. Apply as a thorough coverage spray of up to 3,500 gal per a (8,649 gal per ha) when detections are made, depending on type of equipment and crop/host being sprayed. Repeat once every 4 months as determined by program officials. May be used between applications of insecticides and during the dormant period of the scale in winter. May not be used within 21 days of a sulfur application, within 8 weeks of lemon harvest, or after September 1 of a given year on oranges. Toxic during periods of temperatures above 32.2 °C.

11. AERIAL APPLICATION

The following pesticides may not be registered for this use on a given crop. Any application inconsistent with product labeling must have prior approval. Aerial application for arrowhead scale is intended to try to limit dispersal of the first instar nymph in large outbreaks. It is at best a supplement to ground application and cannot replace the latter.

a. Metric Measurement

Ethion (Ethion 8 EC)--177 mL (170 g ai) of 81.9 percent ethion in a minimum of 3.8 L of water per a, depending on type of equipment and crop/host being sprayed or 437 mL of ethion in a minimum of 9.5 L of water per ha. Apply as a spray when detections are made and repeat at 90-day intervals.

Ethion and Petroleum Oil (Ethion 8 EC and Petroleum 60- to 90-Second Oil)--177 mL (170 g ai) of 81.9 percent ethion and 7.57 L (approximately 6.2 kg ai) (depending on oil used) of summer oil in a minimum of 3.8 L of water per a depending on type of equipment and crop/host being sprayed or 431 mL of ethion plus 18.7 L of summer oil in a minimum of 9.5 L of water per ha. Apply as a spray when detections are made and repeat at 90-day intervals. Do not apply within 21 days of a sulfur application.

b. U.S. Measurement

Ethion (Ethion 8 EC)--6 fl oz (6 avdp oz ai) of 81.9 percent ethion in a minimum of 1 gal of water per a, depending on type of equipment and crop/host being sprayed or 14.8 fl oz of ethion in a minimum of 2.5 gal of water per ha. Apply as a spray when detections are made and repeat at 90-day intervals.

Ethion and Petroleum Oil (Ethion 8 EC and Petroleum 60- to 90-Second Oil)--6 fl oz (6 avdp oz ai) of 81.9 percent ethion and 2 gal (approximately 13.7 lb ai) (depending on oil used) of summer oil in a minimum of 1 gal of water per a depending on type of equipment and crop/host being sprayed or 14.8 fl oz of ethion plus 5 gal of summer oil in a minimum of 2.5 gal of water per ha. Apply as a spray when detections are made and repeat at 90-day intervals. Do not apply within 21 days of a sulfur application.

12. IODINE-STARCH TEST

To determine the mortality of arrowhead scales in a treatment area, the following applies:

Iodine-starch paper is prepared by coating one side of a regular white sheet of typing paper with 2 percent starch and 0.17 percent iodine. This is left to dry with the formation of a blue color on the coated side. If storage in the dark is possible for 2 weeks, a supply should be made up to suit program needs in that time frame.

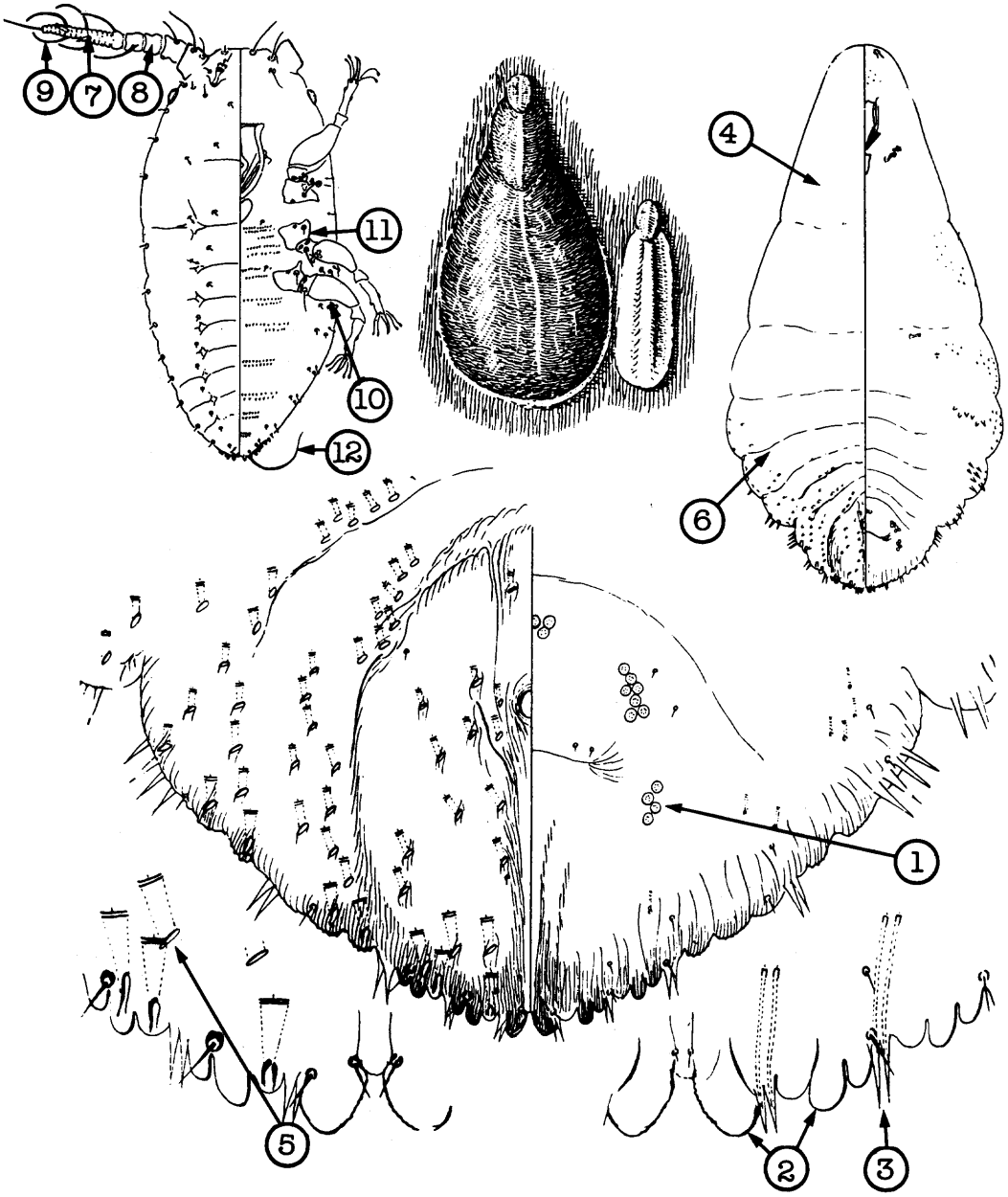
If mature scales are not available or the vitality of the first and second instars is desirable, a concentration of 1 percent starch plus 0.085 percent iodine will enable a determination of the mortality of these stages.

If arrowhead scale is not available in the program area, the test may be carried out on related armored scales or armored scale species of a similar size and habitat to determine estimated mortality.

To perform the test, remove 100 adult or immature scales and place on the appropriate iodine test paper. Place paper between two iron or other metal plates and these between two wooden boards. Press together with a carpentry clamp for 15 minutes. Remove clamp, boards, and plates and count the number (a hand lens may be necessary) of clear oblong discolored spots. Due to chemical reaction with the test paper, the spots represent those scales which were alive at the time of the press. The number of spots will represent the percentage of live scales and the converse representing the percentage of mortality or presumed percentage of mortality if substitute species are used.

The test should be carried out in all spray areas or zones where eradication treatments are ongoing to measure the effect of such treatment.

Figure 2—*Unaspis euonymi* (Comstock)



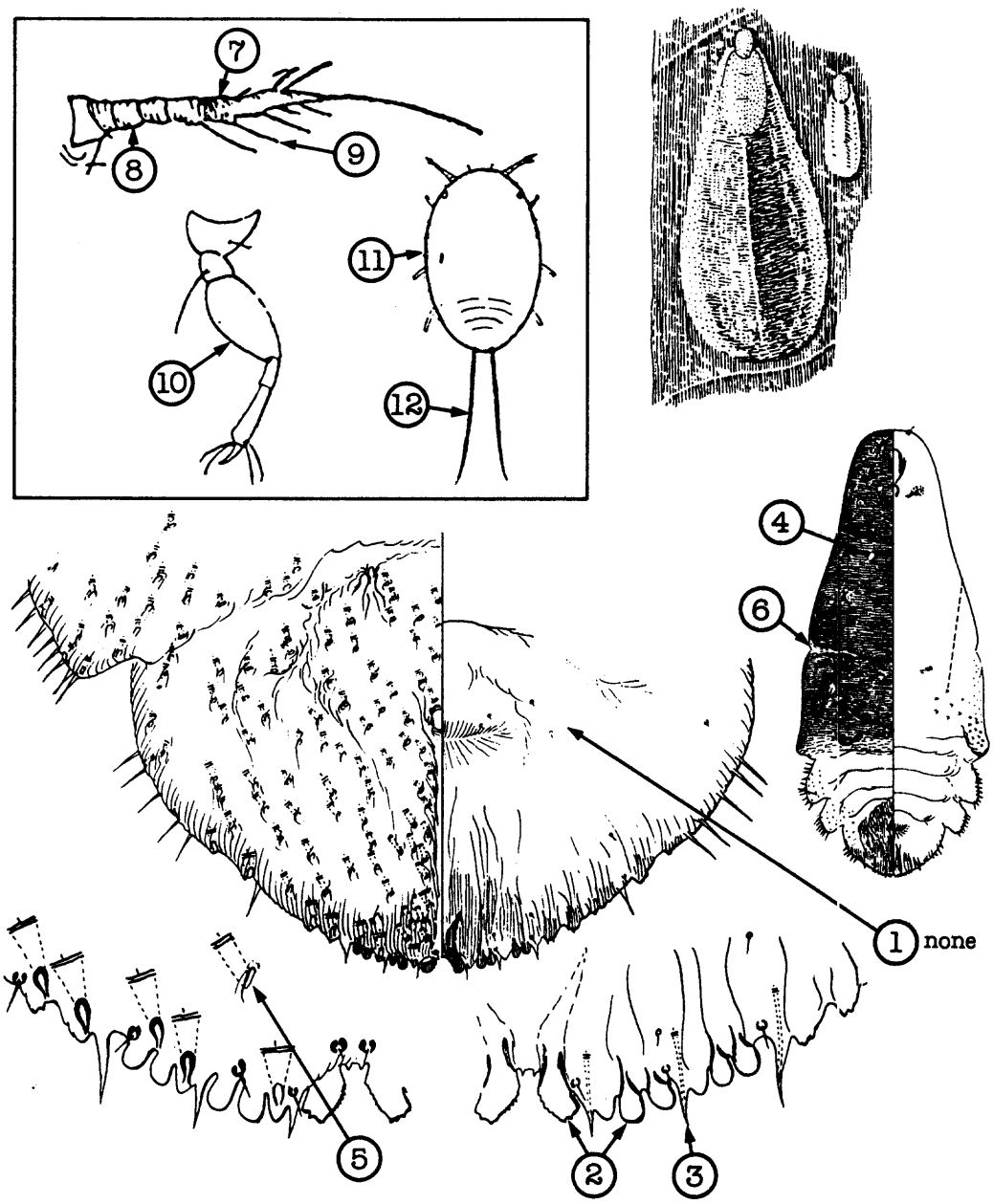
Adult Female

1. 9 to 15 perivulvar pores on each side of the body.
2. Median lobes protruding beyond the apex of the second lobes.
3. Two gland spines on each side of segments V through VIII.
4. Head, thorax, and anterior part of abdomen not sclerotized.
5. 25-36 dorsal macroducts on each side of pygidium.
6. Mesothoracic suture prominent.

First Instar

7. Antennal segment V elongate, length 6:1 to IV segment.
8. Antennal segment III no seta, antennal segment I has two setae.
9. Antennal segment V has five fleshy setae, one terminal seta.
10. Tibia concave on inside.
11. Body oval.
12. Anal setae of moderate length.

Figure 3—*Unaspis yanonensis* (Kuwana)



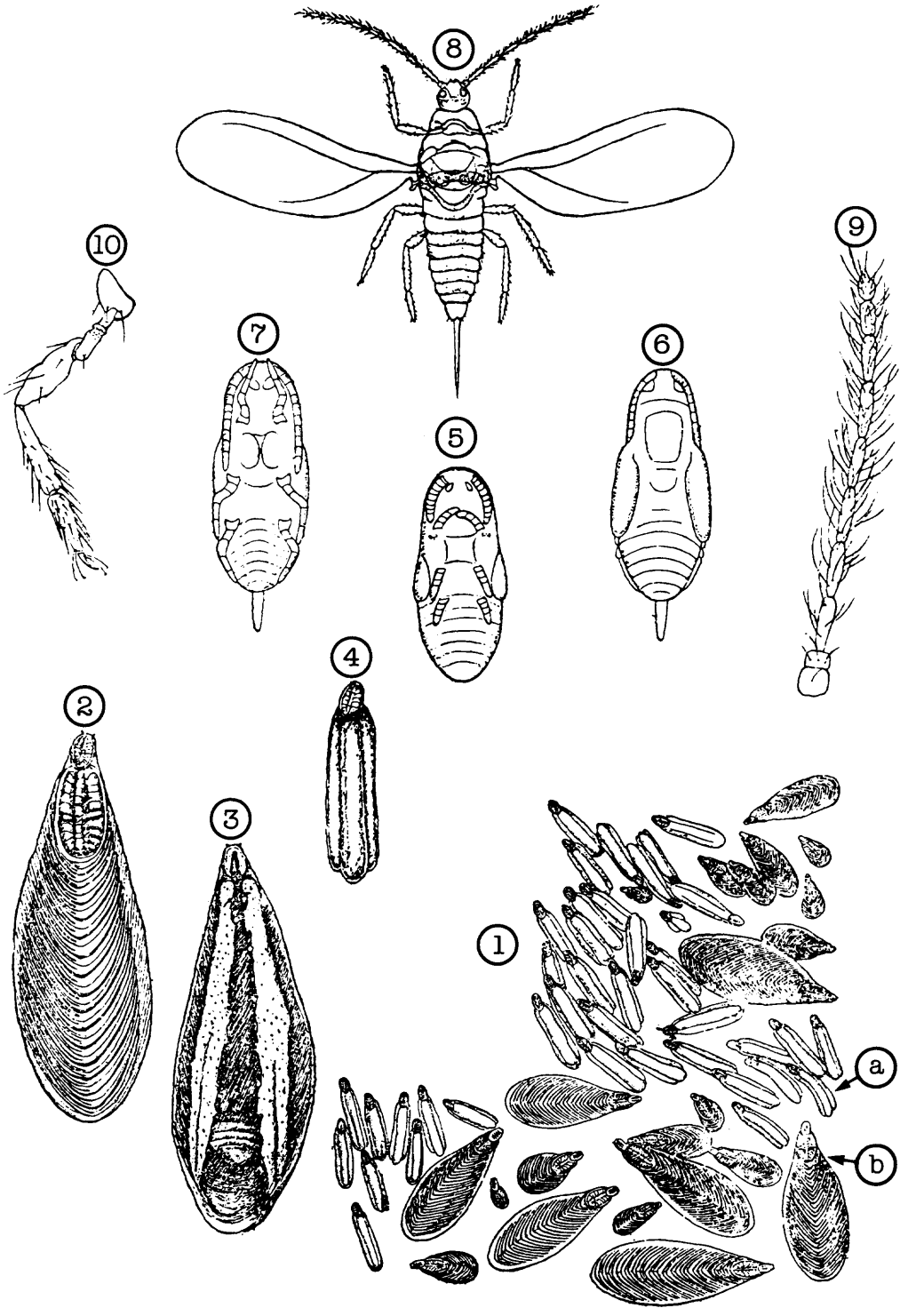
Adult Female

1. No perivulvar pores.
2. Median lobes do not attain apex of second lobes.
3. One gland spine on each side of segments V through VIII.
4. Head, thorax, and segment I sclerotized.
5. 48-64 dorsal macroducts on each side of pygidium.
6. Mesothoracic suture not evident in middle.

First Instar

7. Antennal segment V elongate, length 6:1 to IV segment.
8. Antennal segment III has seta, segments I through IV have one seta each.
9. Antennal segment V has six fleshy setae, one terminal.
10. Tibia convex on both sides.
11. Body broad and flat.
12. Anal setae elongate.

Figure 4—*Unaspis yanonensis* (Kuwana)



1. Group of scales: a. male; b. female.
2. Female scales, dorsal view.
3. Same, ventral view.
4. Male scale, dorsal view.
5. Prepupa, ventral view.
6. Pupa, dorsal view.
7. Same, ventral view.
8. Adult male, dorsal view.
9. Antenna of same.
10. Hind leg of same.

Addendum G--Forms

To be added later.

Addendum H--Contributors

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The aforementioned individuals were major contributors to the development, preparation, and review of the Action Plan. Other contributors and/or reviewers were research scientists of Agricultural Research Service and regional and staff personnel of Plant Protection and Quarantine.

Addendum I--References

The literature on arrowhead scale is moderate in extent. Articles relevant to this Action Plan are listed here.

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