Kansas Department of Agriculture—Plant Protection & Weed Control

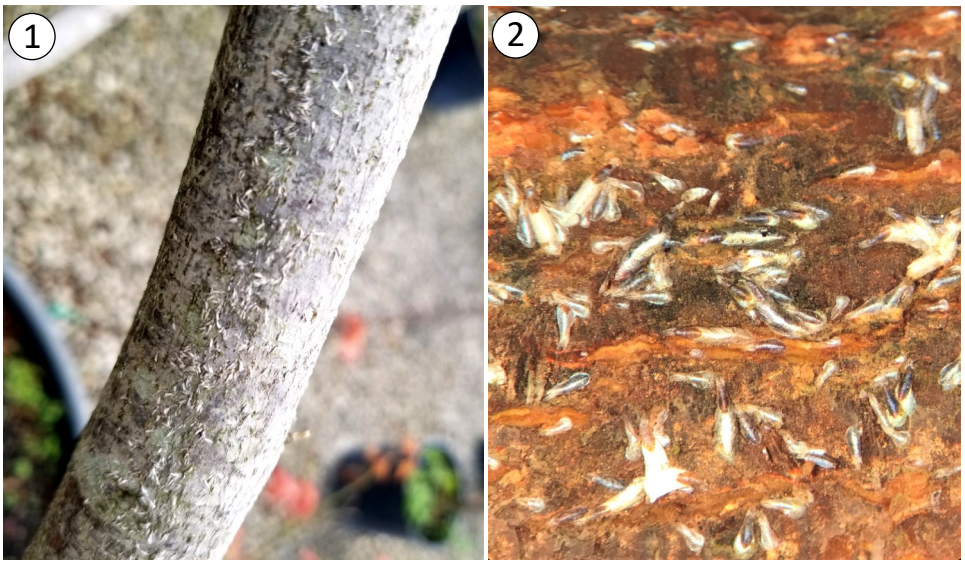
Fall 2019

Volume 66, Issue 3

Entomological News

INSECT SPOTLIGHT

Japanese maple scale (*Lopholeucaspis japonica*)



Figures 1–2. JMS detected at a KS nursery. Fig. 1 photo courtesy Jennifer Smith.

A new adventive invasive armored scale insect (Diaspididae), Japanese maple scale (*Lopholeucaspis japonica*), was detected at multiple Kansas nurseries for the first time on a Japanese maple (*Acer palmatum*) and zelkovas (*Zelkova* sp./spp.) this year (Figs. 1–4). Japanese maple scale (JMS) was initially detected in Connecticut in 1914 (Miller & Davidson 2005) and is now known from 19 states and District of Columbia (Alabama, Connecticut, Delaware, Georgia, Indiana, Kansas, Kentucky, Louisiana, Maryland, Missouri, Nebraska, North Carolina, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Tennessee, and Virginia) (Fig. 3).

As with all armored scales (Diaspididae), JMS does not feed on vascular tissue (i.e. phloem), rather they target individual mesophyll cells and empty their contents via mechanical cell lysis. Because armored scales do not feed on large quantities of phloem in order to obtain limited amino acids (they also harbor symbiotic bacteria that augment phloem nutritional deficiencies) (Douglas 2006), armored scales like JMS do not produce honeydew. Therefore, sooty mold is not a concern with JMS. Furthermore, armored scales including JMS are not prolific egg layers compared to other groups of scale insects, such as soft scales: armored scales typical lay fewer than 100 eggs versus 1,000 or more in soft scales.

Despite laying fewer eggs and not causing the growth of sooty mold, armored scales are of extreme economic importance. Scale insects have been estimated to annually cause as much as $5 billion in

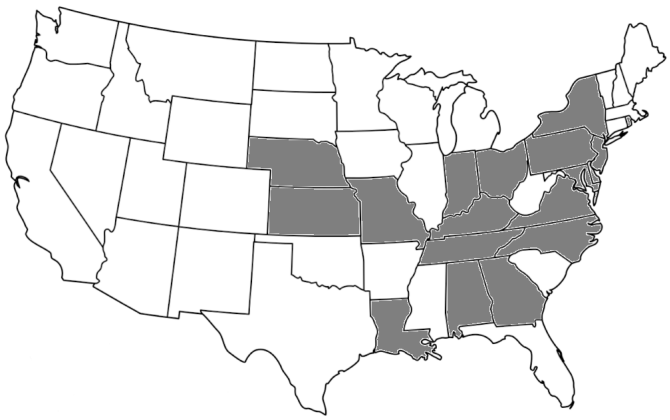


Figure 3. Distribution of JMS.

Figures 3–4. JMS slide mounts showing distinctive pygidium anatomy x1,000. **(3)** Dorsal. **(4)** Ventral.

economic losses in the U.S. as of 1990, and $2 billion (40%) is thought to be attributable to armored scales alone (Kosztarab 1990; Miller & Davidson 2005). A major reason for this is the large number of adventive invasive armored scales. Of the 1,019 species of scale insects in North America, 225 are adventive, 75% of which are pests compared to 8% of native scales being pestiferous. Most adventive species are from the Palearctic and polyphagous, feeding on many different plants. Interestingly, scale insects have an unexplained propensity to invade North America, representing 13% of the ~2,000 species of adventive insects, despite representing <1% of the total insect fauna of the U.S. (Miller *et al.* 2005; Wheeler & Hoebeke 2009).

Relatively speaking JMS is a minor pest (Miller & Davidson 1990), however they can locally become a very problematic pest, especially in nursery settings. JMS is extremely polyphagous and has been reported from >83 species/hybrid cultivars across 49 genera and 27 families. JMS is known to feed on many popular nursery and landscape woody perennial ornamentals including apples, ash, basswood, dogwoods, elms, hollies, honey locust, lilacs, maples, pears, privet, *Prunus*, redbuds, willows, and zelcovas, with a preference for smooth-barked trees (Addesso *et al.* 2016) (see the following publication by U. of Maryland Extension for a comprehensive list: https://extension.umd.edu/sites/extension.umd.edu/files/_docs/articles/EBR-18%20Japanese%20Maple%20Scale.pdf)[1]. While JMS has been in the U.S. for over 100 years, it has been within the last ten years or so that nursery crop producers and landscape managers in the eastern U.S. have become increasingly concerned. Furthermore, new state records have been cropping up more frequently in recent years, likely due to the transportation of infested material, and was first detected in neighboring Missouri in 2013. A stakeholder focus group has identified JMS as an emerging pest of concern alongside white peach

[1] Generally, armored scales, like JMS, are most frequently associated with and pestiferous on perennial woody plants, typical of ornamentals and shade trees (Miller & Davidson 2005).

scale (*Pseudaulacaspis pentagona*) (also see below under Identification) in the Southeastern U.S. (Fulcher *et al.* 2012).

Additionally, JMS is established across Eurasia, including non-EU European nations, and is considered a pest throughout their invasive distribution. Although formerly present in Australia, it is no longer thought to be established. Due to its pestiferous nature, its quarantine status is under review in the EU (Jeger *et al*. 2018).

Biology

Despite its name, JMS is widely native to East Asia, occurring in countries including China and South Korea. Like other armored scales, JMS develops via incomplete metamorphosis with females developing through three instars and males five. Adult females are neotenic (i.e. retain an immature form at sexual maturity) while males develop wings for mating dispersal and do not feed. Females are not prolific layers, typically laying about 25 eggs in a lifetime.

Like other scale insects, the first instars that hatch from eggs are termed crawlers, capable of dispersing from under the waxy covers that enclose females dorsally and underneath of which she lays her eggs. Crawler dispersal can be quite extensive, and in India, a single infested pomegranate tree generated enough crawlers to disperse to 58 neighboring trees over a period of nine months (Harsur *et al*. 2018). Crawlers will settle soon after dispersing, tucking in their legs and antennae to begin feeding. They will quickly begin secreting sheets of wax as they rotate along the axis of their piercing sucking stylate mouthparts inserted in the plant's tissue, creating a hard cover that envelops their body by cementing the wax with additional secretions (Miller & Davidson 2005). While adult males will fly away to find a mate, females become sessile after they disperse as crawlers, never to move again. As JMS develops through successive molts, additional wax is secreted, gradually enlarging the cover. At sexually maturity, mated females will lay eggs and gradually become spent and die.

A single annual generation has been observed in Pennsylvania; two generations occur in more southern states such as Maryland and Tennessee (Jeger *et al*. 2018, Miller & Davidson 2005). One of the challenges in management of JMS is extended crawler emergence, which can last weeks (e.g. Maryland: generation 1 = 8 weeks; generation 2 = 7 weeks. Tennessee: generations 1 + 2 = 24 weeks total). According to degree day (DD) research conducted in Maryland and Tennessee (Table 1), it is predicted that JMS will experience two annual generations once established in Kansas: First generation crawlers active early June; second generation early to mid-August (Table 2). In Maryland, JMS first crawler emergence has been observed to coincide with peak bloom of smokebush (*Cotinus coggygarias*) and Chinese lilac (*Syringa chinensis*); in Tennessee with oakleaf hydrangea (*Hydrangea quercifolia*) and Japanese lilac var. "Ivory Silk" (*Syringa reticulata*).

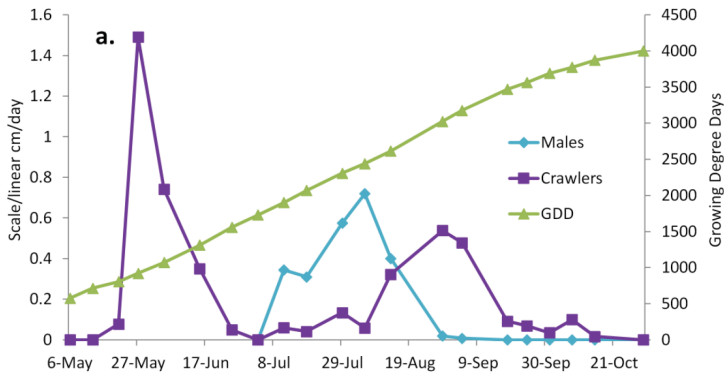


Figure 5. JMS crawler and male abundance/cm^2/day on Japanese cherry limb and cumulative growing DD in middle Tennessee in 2014. Source: Addesso *et al.* 2016.

Table 1. Degree day estimates using base 50 °F.

Generation	**1**		**2**	
Degree Days	Start	Peak	Start	Peak
Maryland Extension est.	816	1143	2508	3022
Tennessee Extension est.	801	927	2615	3024

Table 2. Crawler activity estimated for Kansas, 2019. Temperature thresholds (°F): lower = 50; upper = 95. Calculation type = simple average/growing DDs. Forecast type = after 7day use 10-year averages (default). Weather station = KFOE, Forbes Field, KS, 38.9414 -95.6506. (http://uspest.org/cgi-bin/ddmodel.us)

Generation	**1**		**2**	
Degree Days	Start	Peak	Start	Peak
Maryland Extension est.	June 4	June 19	Aug. 6	Aug. 23
Tennessee Extension est.	June 4	June 9	Aug. 9	Aug. 23

Identification

JMS is extremely small (1.5–2.0 mm) and difficult to detect in the field if infestation is minimal. JMS typically infest bark; leaves only when infestation is dense. Adult females have asymmetrically oyster shell-shaped covers that are a light grey in color, which blend in extremely well with the background bark. When scouting for JMS, according to U. of Tennessee Extension: "(o)n shrubs and multi-stem trees, focus initial scouting at the base of the plant from the soil like to approximately 8 inches above the soil line. On standard-form trees, look on the trunk and scaffold branches, in particular at the branch collar".

According to U. of Missouri Extension, JMS may be confused with several other species of scale insects that are sympatric with JMS in Missouri: Euonymus scale (*Unaspis euonymi*), oystershell scale (*Lepidosaphes ulmi*), pine needle scale (*Chionaspis pinifoliae*), pine scale (*C. heterophyllae*), and white peach scale (*Pseudoleucaspis pentagona*).

- Euonymus scale is similar in size to JMS but inhabit foliar surfaces and mature females have a dark brown cover. Additionally, male and female covers differ in form compared to JMS in which both sexes share cover form. Euonymus scale males have a white parallel-sided elongate cover with three ridges running down its *length*. Euonymus scale are predominantly known from *Euonymus* spp. (Miller & Davidson 2005), which is a host shared with JMS.
- Oystershell scale have brown and grey morphs, and the grey morphs may be confused with JMS. Oystershell scales are highly polyphagous and share numerous hosts with JMS. However, oystershell scale are typically larger (1.5–3.0 mm) and females, eggs, and crawlers are white.
- Pine needle- and pine scale are both specific to conifers and host ranges do not overlap with JMS. Furthermore, pine needle- and pine scale have a white cover and are significantly larger in size (~3.0 mm).
- White peach scale, unlike the others (above) and JMS have a white circular cover (all others discussed above are oyster shell-shaped) with a centrally located yellowish shed skin, the appearance often being compared to a "fried egg".

Adult females, eggs, and crawlers are a bright purple in color, making them extremely distinctive and diagnostic. In the field, suspect JMS may be readily identified by a combination of their cover shape (asymmetrical oyster shell-shape), small size, and color of live individuals: rubbing an edge (i.e. fingernail or spine of a knife) across an aggregation of JMS will reveal the purple hemolymph (i.e. blood) of the scales, revealing a purple discharge, the source of the purple color observed in adult females and eggs.

Management

Unlike other groups of scale insects, armored scales including JMS, feed directly on individual storage cells and not on "sap", or phloem. Due to this unique feeding behavior, although feeding causes mechanical cellular lysis and collapse, damage to plants is typically less relative to other groups of scale insects. Therefore, while JMS will rarely kill plants, heavy enough infestations can cause branch dieback. Generally, loss of saleable plants and rejected live plant material appears to be the primary concern for the U.S. nursery industry (Miller & Davidson 2005).

Compared to other groups of scale insects, armored scales tend to become a densely abundant and dominant pest in monocultures and urban landscapes. It is thought that lack of plant diversity decreases abundance of natural enemies (e.g. lacewings (Chrysopidae), lady beetles (Coccinelidae), parasitoid wasps) that keep scale populations in check. While this relationship is true for all plant pests, among scales, armored scales show a particular propensity to demonstrate this association. Therefore, an integrated pest management (IPM) approach is thought to be the most effective in controlling armored scales such as JMS (Miller & Davidson 2005).

The goal of IPM is to minimize the use of insecticides to a safe and economically justifiable level by combining: (1) identifying target pest levels; (2) preventative cultural practices; (3) monitoring; (4) mechanical control; (5) biological control; (6) responsible insecticide use (https://www.epa.gov/safepestcontrol).

While best IPM practices for JMS have not been developed for this newly introduced pest in KS, the following may serve a useful starting point for JMS IPM:

(1) For live plant dealers operating in Kansas, scale insects have a zero-tolerance threshold, and "target pest levels" should comply accordingly.

(2) All purchased stock should be carefully examined for the presence of JMS upon arrival. Even a few individuals may quickly multiple into a difficult problem. If JMS is identified, removing infested material and proper disposal will minimize unintended spread. Even pruned material should be properly removed from the premise and disposed. First instar crawlers can travel long distances with the aid of wind and by attaching themselves to other insects (phoresy) (Addesso *et al.* 2016, Magsig-Castillo *et al.* 2010).

(3) Monitoring for the presence of JMS is foremost, and identifying crawler activity is paramount for effective insecticide application. While degree days (DD) are a useful approximation (see above under Biology), DD calculations should be supplemented with physical on-site monitoring. Crawler activity can be simply and effectively monitored by wrapping double-sided around branches of infested plants (https://edis.ifas.ufl.edu/pdffiles/IN/IN110300.pdf).

(4) Upon identifying JMS on plants, the first step should be mechanical control. Due to the sessile nature of most armored scale life stages, bark can be gently scrubbed with a fine brush to kill and dislodge any scales.

(5) Biological control involves the use of natural enemies for pest management. Avoiding wide spread application of broad-spectrum insecticides, avoiding extensive monoculture, and generally promoting a more diverse and insect-friendly landscape in grow operations will promote the establishment of natural enemies. While natural enemies will not eliminate scale populations, they will minimize densities and have a positive economic and environmental impact in relation to insecticide use. In the mid-Atlantic region, at least four parasitoid wasps are known to attack JMS (Gill *et al.* 2013), and a similar diversity can be expected in KS.

(6) Armored scales (i.e. San Jose scale [*Quadraspidiotus perniciosus*]) were some of the first insect pests to show signs of insecticide resistance in North America. Insecticides should be used minimally and rotated in order to prevent resistance development. Additionally, alternatives such as horticultural oils, which act mechanically

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		% Live scale			
		Days after treatment			
Year	Treatments	30	60	90	120
2014	Control	33.1 ± 5.4a	49.3 ±10.5a	50.5 ± 10.2a	46.8 ± 12.4a
	Imidacloprid	22.5 ± 8.0a	22.9 ± 5.2ab	6.4 ± 2.8b	9.4 ± 6.4b
	Dinotefuran	13.0 ± 4.7a	12.1 ± 2.7bc	55.1 ± 5.8a	50.7 ± 6.2a
2015	Control	2.7 ± 1.1a	1.4 ± 0.5a	3.2 ± 1.9a	8.8 ± 4.2a
	Imidacloprid	6.5 ± 2.7a	0.3 ± 0.3a	1.2 ± 0.9a	3.9 ± 1.5a
	Dinotefuran	6.0 ± 0.7a	1.2 ± 0.5a	1.0 ± 0.7a	0.5 ± 0.5a

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		% Live scale		
		Days after treatment		
Year	Treatments	30	60	90
2014	Control	57.2 ± 6.9a	36.2 ± 12.9a	59.5 ± 12.1a
	Pyriproxifen	21.4 ± 6.4a	9.1 ± 5.8a	5.6 ± 5.4b
	Summer Oil	43.3 ±10.9a	51.1 ± 14.9a	61.9 ± 25.4a
2015	Control	6.0 ± 2.1a	2.9 ± 0.5b	8.8 ± 4.2a
	Pyriproxifen	7.5 ± 1.4a	1.0 ± 0.7b	0.5 ± 0.5a
	Summer Oil	7.3 ± 2.0a	9.1 ± 2.1a	9.7 ± 5.6a

[z]Treatments with different letters are significantly different by Tukey's pair-wise comparison test (P = 0.05).

Figures 6–7. Percentage of live JMS on Japanese cherry trees after 30, 60, and 90 days post treatment in 2014 and 2015 field trials in Tennessee. **(6)** Drench treatment. **(7)** Trunk spray treatment. Source: Addesso *et al.* 2016.

and therefore do not contribute to resistance should be incorporated into management programs.

According to a two-year study conducted in Tennessee (Figs. 6–7): While summer oil application in June was not found to be effective, dormant oil application in March was shown to decrease live scale population by 76%, 30 days post application (both treatments used Ultra-Pure® Oil). Although systemic application of imidacloprid (Discus® N/G) are generally considered less effective against bark-feeding armored scales, testing inspired by anecdotal grower observations showed that while it is slow-acting, imidacloprid was successful in suppressing JMS in the first year and eliminating visible infestation by early in the second year after a single application in April of the first year. Rapid uptake of dinotefuran (Safari® 2G) application in April was effective in reducing scale populations initially but was unable to prevent second generation resurgence. Supplementing dinotefuran with an insect growth regulator (IGR) (e.g. chlorpyrifos, pyriproxyfen) may be necessary to overcome second generation resurgence. Concerns over neonicotinoid use and their effect on pollinators may mean a combination of dinotefuran + IGR may be a better option. Both chlorpyrifos and pyriproxyfen were observed to be effective, but chlorpyrifos and other chemicals have been shown to have negative effects on non-target organisms and workers; pyriproxyfen may be preferable (Addesso *et al.* 2016).

Some of the challenges to consider in the management of JMS are: (1) wide host range that can promote rapid spread throughout a landscape; (2) extended and overlapping crawler activity that necessitates continued control measures; (3) small and cryptic form that makes them difficult to see until populations have reached high levels; (4) crawlers can settle and begin secreting a wax cover (lack of a protective cover is what makes the crawler stage the most vulnerable and most effective life stage to target for control) with several hours of emergence. Due to these factors, all tenants of IPM should be carefully considered in tackling JMS infestations.

NOTE: Licensed live plant distributors in the state of Kansas must comply with Pest Freedom Standards set forth by the Plant Pest and Agriculture Commodity Certification Act which mandates a zero tolerance policy for "scale insects" (https://agriculture.ks.gov/docs/default-source/statutes-ppwc/plantpestact.pdf?sfvrsn=55d8320f_14). Above management practices were aggregated from available literature and are not official recommendations by the Kansas Department of Agriculture. As with all pesticide applications, it is extremely important to read and follow label instructions and state regulations. Timing applications appropriately is important in protecting valuable pollinators. Questions concerning pest management should be directed to your local Cooperative Extension specialist(s).

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Further Reading

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- University of Missouri Cooperative Extension. (https://www.extension.umd.edu/sites/extension.umd.edu/files/_docs/programs/ipmnet/JapaneseMapleScale-UMD-1.pdf)
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Our mission:

- Exclude or control harmful insects, plant diseases and weeds.
- Ensure Kansas plants and plant products entering commerce are free from quarantined pests.
- Provide customers with inspection and certification services.

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Acknowledgments

We would like to thank Mengmeng Gu with Texas A&M and Gregory Evans with USDA-APHIS for their assistance in identifying *Acanthococcus lagerstroemiae*; Arkansas Department of Agriculture's Plant Industries Division for information on *A. lagerstroemiae* establishment in Arkansas; Kansas Forestry Service for their assistance with our walnut twig beetle survey work, especially with help in assembling walnut bolts; Brian Brunkow and Morgan Trible for their survey work as seasonal staff members for Kansas Department of Agriculture, Plant Protection & Weed Control.