A Preliminary Investigation of the New and Serious Malady of *Schinus molle* Canopy Thinning. Part 2.

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In a preliminary paper in these pages, Hodel et al. (2024) discussed and illustrated the malady of *Schinus molle* canopy thinning and identified the leafhopper *Empoasca sativa* as a possible causal agent (although not identified so, that paper is Part 1 of this study). Now we are able to report several new findings associated with canopy thinning on *S. molle*: co-author Paul Santos, who first discovered the leafhopper on *S. molle*, recently found the mite *Brachytydeus formosus* (*Lorryia formosa*); we detected the typically pathogenic fungus *Botryosphaeria* sp. on new, young growth; and we estimated relative soil moisture and measured tree diameter at standard height and compared them to relative severity of canopy thinning, and found that wetter soils typically were associated with more severely affected trees. Here, we present and discuss these new findings and explore their possible effects on *S. molle* canopy thinning.

The Mite *Brachytydeus formosus*

Co-author Paul Santos discovered this microscopic mite in early March, 2024 on severely affected and symptomatic *Schinus molle* in the Talega neighborhood of San Clemente, California. He and co-author Hodel visited the site later in March, and Hodel was astonished to see how severe the canopy thinning was on trees in common public areas and along streets in the region. Many of the trees looked dead or nearly so with few or no green leaves in the canopy although bark scraping on twigs mostly revealed green tissue (**Figs. 1–2**).

Santos and Hodel made collections of the mites and sent them to the California Department of Food and Agriculture (CDFA) for identification via the entomology and plant pathology departments in the Los Angeles County Agriculture Commissioner office. Dr. Peter Kerr of the CDFA Plant Pest Diagnostic Center, identified the mite to the Tydeidae family but was unable to provide a more precise identification.

1. We collected mites from these severely affected, seemingly dead *Schinus molle* trees in the Talega neighborhood of San Clemente, California.

2. Here is another view of the severely affected *Schinus molle* trees in the Talega neighborhood in San Clemente, California from which we collected mites.

Co-author Gevork Arakelian suggested we contact the Tydeidae mite specialist Dr. Guilherme Liberato da Silva of the Universidade do Vale do Taquari – Univates, Lajeado, Brazil for identification. Dr. Guilherme Liberato said it is too difficult to send him mite specimens and suggested we photograph the mite, and with sufficient quality and detail, and he could provide identification from the images.

Co-author Chris Shogren approached Dr. Amy Murillo in the Entomology Department at the University of California, Riverside about photographing the mites for identification. She agreed and Hodel brought her mite samples from affected trees in Long Beach, California that co-author Ben Fisher had located.

Hodel forwarded Murillo's images to Dr. Guilherme Liberato in Brazil, who quickly identified the mite as *Brachytydeus formosus*, the yellow or citrus yellow mite. Our report might be the first record of this mite on *Schinus molle*.

History

Jean Cooreman (1911–1983), a Belgian acarologist, first named and described *Brachytydeus formosus* as *Lorryia formosa* (Cooreman 1958), basing it on material that M. W. Smirnoff had collected on citrus plants in the region of Rharb, Morocco. The holotype is in the Royal Belgian Institute of Natural Sciences, Belgium. Several nomenclatural changes with this mite have occurred since it was first named. André (1980), in a revision of the mite family Tydeidae, synonymized *Lorryia* into *Tydeus*, with Flechtmann (1987) later using the subsequent combination, *Tydeus formosus*. Kaźmierski (1998) later reestablished *Lorryia*. Finally, André (2005) suggested that the species Kaźmierski (1998, 2008) had listed for *Lorryia* should be moved to *Brachytydeus*, with Kaźmierski (2008) and Silva et al. (2016) later using the subsequent combination *Brachytydeus formosus*, now the most currently accepted name although many current internet sources still use *Lorryia formosa*.

Taxonomy and Nomenclature

The taxonomic hierarchy of *Brachytydeus formosus* is presented in **Fig. 3**.

Brachytydeus is in the family Tydeidae, which comprises 328 species in 30 genera of cosmopolitan, soft-bodies, striated or reticulated, microscopic mites (Silva et al. 2016). Although their ecology is largely unknown, they are often found on plants but also occur in other habitats, including caves, soils, lichens, mosses, and stored products (Walter et al. 2009). Some are plant feeders, pollen feeders, or predators but most are scavengers of organic matter or fungal feeders (English-Loeb et al. 1999; Gerson et al. 2003; Hernandes and Feres 2006; Silva et al. 2014a, b). Predators and fungal feeding mites have potential as biological control agents. Indeed, some of the fungal feeders suppress powdery and downy mildews on grapes (*Vitis* spp.) (Duso et al. 2005;

Fig. 3. Taxonomic Hierarchy of *Brachytydeus formosus* (Wikispecies 2024).

Phyllum Arthropoda
- Subphyllum Chelicerata
  - Class Arachnida
    - Subclass Acari
      - Superorder Acariformes
        - Order Trombidiformes
          - Suborder Prostigmata
            - Cohort Eupodina
              - Superfamily Tydeoidea
                - Family Tydeidae
                  - Subfamily Tydeinae
                    - Genus *Brachytydeus*
                      - Species *formosus*

4. *Brachytydeus formosus* is a small mite with a reticulated idiosoma. © 2019 by Eric Erbe and Chris Pooley, United States Department of Agriculture.

English-Loeb et al. 1999, 2007; Hernandes and Feres 2006, Melidossian et al. 2005; Norton et al. 2000) and sooty mold on citrus (Gautam et al. 2017, 2018b, 2021).

With about 200 species, *Brachytydeus* is the largest genus in the Tydeidae. Most species in this genus were previously in *Lorryia* but André (2005) synonymized all species except one into *Brachytydeus*, only the anomalous *L. superba* remaining in *Lorryia* (Silva et al. 2016).

Description

Brachytydeus formosus is a small mite less than 250 um (0.01 inch) long (Proctor and Walter 1999) (**Figs. 4–5**). It is pale lemon-yellow but slightly darker dorsally (Smirnoff (1957). Like all Acariformes mites, the small head segment with piercing, sucking mouth parts is called the capitulum and is attached to the front of the much larger body segment called the idiosoma. The striated and reticulated idiosoma is divided into three sections: the propodosoma (anterior or front segment), metaprodosoma (middle segment), and opisthosoma (posterior or end segment). Mites of subfamily Tydeinae have a pair of eyes positioned laterally on the propodosoma, which also holds the first two pairs of legs. The remaining two pairs of legs are held farther back on the idiosoma (Proctor and Walter 1999). The smooth, lanceolate, dorsal, body setae and the reticulate pattern divided into discrete areas distinguish *B. formosus* from similar species (Baker 1968).

Life Cycle

The mean lifespan of *Brachytydeus formosus* is 37 days, 60% of which is an adult. Six discrete developmental stages are recognized: egg; larva; three nymphal stages, including protonymph, deutonymph, and tritonymph; and adult (Hernandes et al. 2006). Larvae and nymphs are whitish but the latter become yellow during molting. (Smirnoff 1957).

Reproduction occurs asexually through a form of parthenogenesis called thelytoky where females produce embryos without male fertilization (Hernandes et al. 2006). It is unknown whether *Wolbachia*, a genus of inherited bacteria known to alter gender ratios of offspring in arthropods, including mites (Werren et al. 2008), does so in *Brachytydeus formosus* (Hernandes et al. 2006). The host plant species can also greatly influence gender ratios in offspring (Hernandes et al. 2006, Badii et al. 2001, Ferla et al 2002, Feres et al. 2002).

Eggs, densely deposited in two to three layers, are oval, white, faintly translucent, and become very slightly yellow prior to hatching. Incubation takes about three to four days (Smirnoff (1957).

Gautam et al. (2018b) found that adults and immatures of *Brachytydeus formosus* were present year-round on citrus in California but increased from February through April and June through October, peaking in July.

5. A front view of a *Brachytydeus formosus* mite shows its mouth parts, legs, and reticulated idiosoma. © 2019 by Eric Erbe and Chris Pooley, United States Department of Agriculture.

Smirnoff (1957) observed that spring population increases of *Brachytydeus formosus* coincided with young female black scales (*Saissetia oleae*, an important pest of citrus and olives) secreting abundant honeydew. Colonies settled on the abaxial leaf surface where the larvae remained until the first molt; later they abandoned the leaf. He observed no sucking of leaf or other vegetative tissues and no predators of *B. formosus*, even those that typically prey on other citrus mites.

Distribution and Ecology

Brachytydeus formosus occurs nearly worldwide and on a variety of plants. For example, it has been found on chayote squash, pear, papaya, mango, and parana pine in Brazil (Flechtmann 1973; various stone fruits, apple, and bell pepper in Portugal (Carmona 1970); avocado in Ecuador (Baker 1968); and hibiscus in Guadeloupe, French Antilles (Flechtmann et al. 1999).

However, *Brachytydeus formosus* is best known and most closely associated with citrus plants around the world, including in Algeria, Italy, Morocco, Libya, Portugal, and Spain and France in the Mediterranean region (Baker 1968, Vacante and Nuciflora 1984-1985, Vacante et al. 1988); Argentina, Brazil, Chile, and Uruguay in South America (Baker 1968); and Florida (Aguilar and Childress 2000) and California (Gautam et al. 2017, 2018b, 2021) in the U. S. A. However, none of these accounts attributes any host plant damage to *B. formosus* although Ueckermann and Grout (2007) noted it was the only species of Tydeinae thought to be a citrus pest, likely alluding to Smirnoff's original account (Smirnoff 1957).

Smirnoff (1957) is the first and only mention of *Brachytydeus formosus* as a possible citrus pest, primarily because it was present in such large quantities, suggesting it might have an economic impact although he reported little damage, and then mostly on fruit. He noted that by midsummer larvae were abundant under the perianth of young fruits, where they began to "prick and suck" the fruit, leaving a ring of dead, brown tissue as the fruit enlarged. He also noted sclerification of young, green twig and leaf tissue followed by shedding of the epidermis, damage that might be due to the black scale (Gautam et al. 2018b). Smirnoff (1957) concluded that *B. formosus* could be phytophagous on citrus under certain circumstances.

Nonetheless, other reports show that *Brachytydeus formosus* is strongly associated with sap-sucking, honeydew-producing insects like black scale and subsequent sooty mold and does not damage the host citrus plant. Aguilar-Piedra (2001), who found *B. formosus* on citrus in several U. S. states and eight countries, noted that it had a complex feeding behavior and concluded it was not responsible for any damage to the host plant because it fed on honeydew, sooty mold, and pollen only. Mendel and Gerson (1982) reported that *B. formosus* was detrivorous (detritus feeder) and was actually a sanitizing agent on citrus. Hernandes et al. (2006) found large quantities of *B. formosus* at the base of rubber tree leaves (*Hevea brasiliensis*) but it caused no damage. Smirnoff (1957) noted that *B. formosus* was always associated with the honeydew-

6. White patches at the twig and leaf axils of affected *Schinus molle* typically support abundant *Brachytydeus formosus* mite populations.

7. White patches at leaf and twig axils of affected *Schinus molle* are composed of immature *Brachytydeus formosus* mites, mite detritus, and/or plant exudate.

8. In these white patches in the twig axils of affected *Schinus molle*, one can barely make out the yellow of congregated *Brachytydeus formosus* mites.

9. Yellow *Brachytydeus formosus* mites congregate on the white patches in the leaf and twig axils of affected *Schinus molle*.

producing black scale insects on citrus leaves. Not only was it attracted to the honeydew but it also it was equally attracted to the sooty mold, which held sugary droplets on the tips of the mycelia.

In laboratory studies, Badii et al. (2001) reared large colonies of *Brachytydeus formosus* on orange leaves but reported no damage. Gautam et al. (2018b) found that *B. formosus* could not survive beyond seven days on leaves of mandarin citrus only, but if sugar water, honeydew, or the sap-sucking cottony cushion scale insects were present, it survived for the duration of the study (26 days) and produced additional generations.

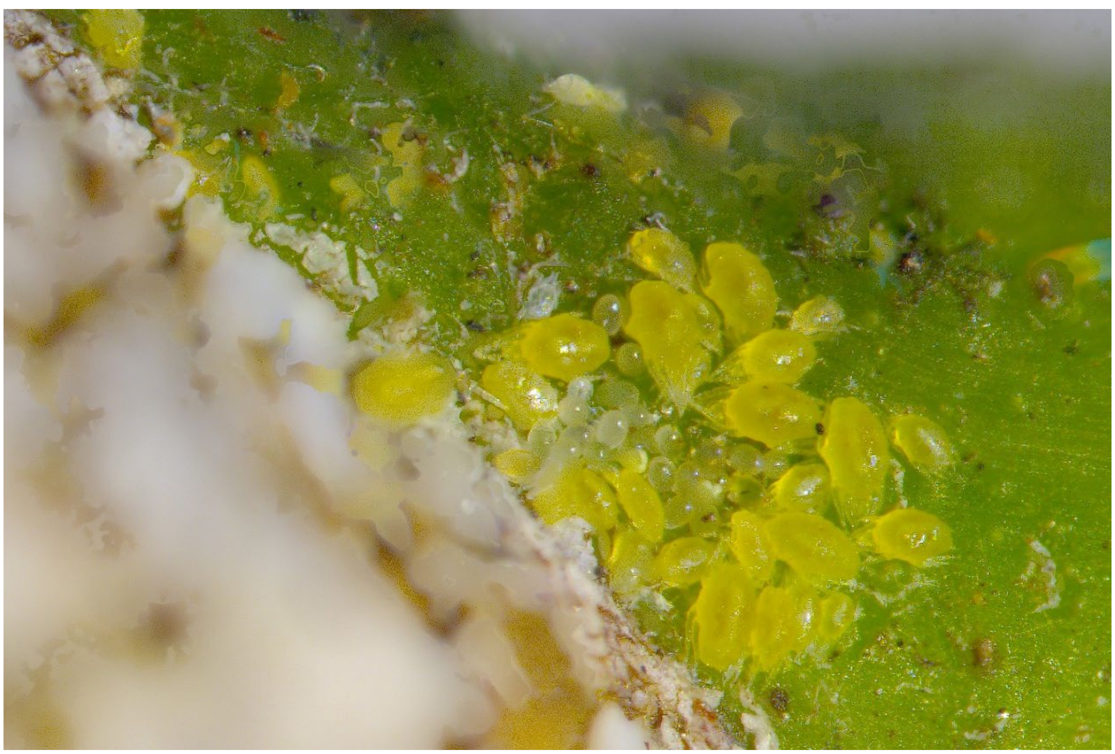
Gautam et al. (2017, 2018b) and Gautam and Grafton-Cardwell (2021) documented that *Brachytydeus formosus* mites are not citrus pests, do not damage leaves, need honeydew and/or sooty mold to grow and reproduce, and cannot survive and sustain their populations on leaf tissue alone.

In his original account of *Brachytydeus formosus* on citrus, Smirnoff (1957) provided a detailed and interesting summary that parallels several of our observations of this mite on *Schinus molle*. He noted that the mites swarm around honeydew-producing female black scales and are particularly visible at the base of twigs, petioles, and rough areas of branches. There, white patches 2 to 3 cm in diameter made by the larvae and their shed exoskeletons and yellow patches from the congregated adults, are unusually conspicuous. A white patch illustrated in his account (Smirnoff 1957, Fig. 1) is nearly identical in appearance and location to what we observed on *Schinus molle*.

Our observations show that while also roaming leaves and green twigs, *Brachytydeus formosus* tended to congregate on or near conspicuous white patches typically in leaf and twig axils, swarming on top of one another like a rugby scrum (**Figs. 6–11**). When doing so, they impart a yellowish tinge on or adjacent to the white patch and just barely visible to the unaided eye. These white patches, 0.5 to 1.5 cm in diameter, are likely composed of immature mites, mite detritus, and/or plant exudate, the latter of which might have occurred in response to plant stress and/or infections by the plant pathogenic fungus *Botryosphaeria* sp. (see below). Or perhaps the mites are feeding on the *Botryosphaeria* sp. itself. We often observed eggs just underneath the clusters of congregated mites. We did not observe black scale or sooty mold on the *S. molle*. Dark brown, platy, sclerified tissues might be from mite feeding activity as Smirnoff (1957) theorized for citrus or damage from the pathogen *Botryosphaeria* sp. (see below) (**Fig. 12**).

Thus, while we feel that *Brachytydeus formosus* is an unlikely pest of *Schinus molle* and might be feeding on stress- and/or disease-induced host exudate (**Fig. 13**) and/or host detritus and non-pathogenic fungi, it is possible that it is an opportunistic, facultative feeder and, under the right circumstances, might attack *S. molle*.

10. Yellow *Brachytydeus formosus* mites on and to the side of the white patch at twig axils of affected *Schinus molle*. © 2024 by G. Arakelian.



11. Yellow *Brachytydeus formosus* mites congregate like a rugby scrum adjacent to a white patch in a twig axil of affected *Schinus molle*. Note the rounded, clear-colored eggs under the mites. © 2024 by G. Arakelian.

12. Dark brown, sclerotized, platy tissues might be due to *Brachytydeus formosus* mites or the disease *Botryosphaeria* sp.

13. *Brachytydeus formosus* mites might be feeding on this abiotic stress- and/or *Botryosphaeria*-induced white exudate, which might be a component of the white patches in leaf and twig axils.

14. Dark, necrotic spotting and lesions on twigs are symptoms associated with *Botryosphaeria* sp. on *Schinus molle* with canopy thinning.

15. Dark, necrotic spotting and lesions on twigs are symptoms associated with *Botryosphaeria* sp. on *Schinus molle* with canopy thinning.

***Botryosphaeria* sp.**

Botryosphaeria is a genus of six (Phillips et al. 2013) to about ten species (Dissanayake et al. 2016, Wijayawardene et al. 2022) of mostly pathogenic fungi in the family Botryosphaeriaceae. The Botryosphaeriaceae are Ascomycetes or sac fungi; morphologically diverse pathogens, endophytes (living on a plant but not producing disease symptoms), and/or saprophytes (living on dead, decaying organic matter); occurring primarily on woody plants; distributed worldwide except the polar regions; and frequently associated with destructive vascular diseases of woody plants (Garcia et al. 2021, Luo et al. 2019, Phillips et al. 2103, Slippers and Wingfield 2007).

Botryosphaeriaceae is estimated to include about 25 genera and from 1,500 species (Kirk et al. 2008) to as few as 222 (Burgess et al. 2019). The advent of molecular data to sort out phylogenetic lineages and species has led to numerous changes in species interpretations, especially as they concern different sexual stages of the same fungus named or identified as different species.

Climate change and its attendant array of plant stressing impacts, including global warming, temperature extremes, drought, aridification, excessive rain, enhanced storm severity, natural wounds, and other existing pests and diseases, have ushered in the age of the opportunistic Botryosphaeriaceae. Furthermore, abiotic stresses related to cultivation, such as light exposure (too much or too little sun), nutrient deficiencies, adverse soil pH, saline conditions, soil compaction, too deep planting, above- or below-ground mechanical damage, insufficient growth space, extremes of soil moisture, lack of mulch or excessive mulch, and poor pruning and human-made wounds, can enhance Botryosphaeriaceae disease symptom severity (Lawrence et al. 2018, Mullen 1991, Old et al. 1990, Pusey 1989, Smith et al. 1994) and/or increase disease susceptibility, in some instances taking seemingly innocuous endophytic fungi and transforming them into pathogens (Desprez-Loustan et al. 2006, Downer et al. 2022, Flor et al. 2019, Luo et al. 2019, Slippers et al. 2007).

The Botryosphaeriaceae causes common diseases on a wide array of ornamental woody landscape plants. Symptoms include wilting, discolored foliage, dieback, and cankers. Botryosphaeriaceae pathogens can infect through wounds and natural openings, such as lenticels and stomata, and produce enzymes and/or toxins that damage and kill cells and tissues (Flor et al. 2019, Garcia et al. 2021). One of the more common *Botryosphaeria* diseases on landscape trees in southern California is *Ficus* branch dieback of *Ficus microcarpa* (Hodel 2009, Hodel et al. 2009, Mayorquin et al 2011, 2012).

Symptomatic tissue on *Schinus molle* from which we detected *Botryosphaeria* was on the spring flush of new, green, current year's growth. Symptoms included dark brown to black, sclerified, platy lesions (**Fig. 12**), dark, necrotic spotting and lesions on leaves and twigs (**Figs. 14–15**), shoot

16. Shoot tip dieback is a symptom associated with *Botryosphaeria* sp. on *Schinus molle* with canopy thinning.

17. A white exudate is a symptom associated with *Botryosphaeria* sp. on *Schinus molle* with canopy thinning.

18. A white exudate, typically at leaf and twig axils, is a symptom associated with *Botryosphaeria* sp. on *Schinus molle* with canopy thinning.

19. Leaf necrosis is a symptom associated with *Botryosphaeria* sp. on *Schinus molle* with canopy thinning.

20. Leaf necrosis and drop are symptoms associated with *Botryosphaeria* sp. on *Schinus molle* with canopy thinning.

21. Leaf necrosis and drop are symptoms associated with *Botryosphaeria* sp. on *Schinus molle* with canopy thinning.

tip blackening and dieback (**Fig. 16**), white exudate typically in leaf and twig axils (**Figs. 13, 17–18**), and perhaps some of the other symptoms described and illustrated in Hodel at al. (2024), including a general yellowing of distal pinnae accompanied by some leaf necrosis and drop (**Figs. 19–20**), leaving bare leaf rachises and dieback (**Fig. 21**), and canopy thinning. Other symptoms we observed (Hodel et al 2024), such as deformed or distorted and often epinastic, "bunchy" shoot growth, somewhat like witch's broom, are more difficult to associate with typical *Botryosphaeria* infections until we have stronger corroborating evidence.

Effect of Root Zone Moisture and Trunk Diameter/Age on *Schinus molle* Canopy Thinning

Because *Schinus molle* naturally occurs in seasonally dry areas of South America and Mexico and is considered a Mediterranean-climate plant (Hodel et al. 2024), we wanted to determine what impact varying root zone moisture levels have on canopy thinning. We also wanted to check if plant size, and by extension age, played a role in canopy thinning. Thus, we assessed *S. molle* street trees in a several-block area of Long Beach.

Materials and Methods

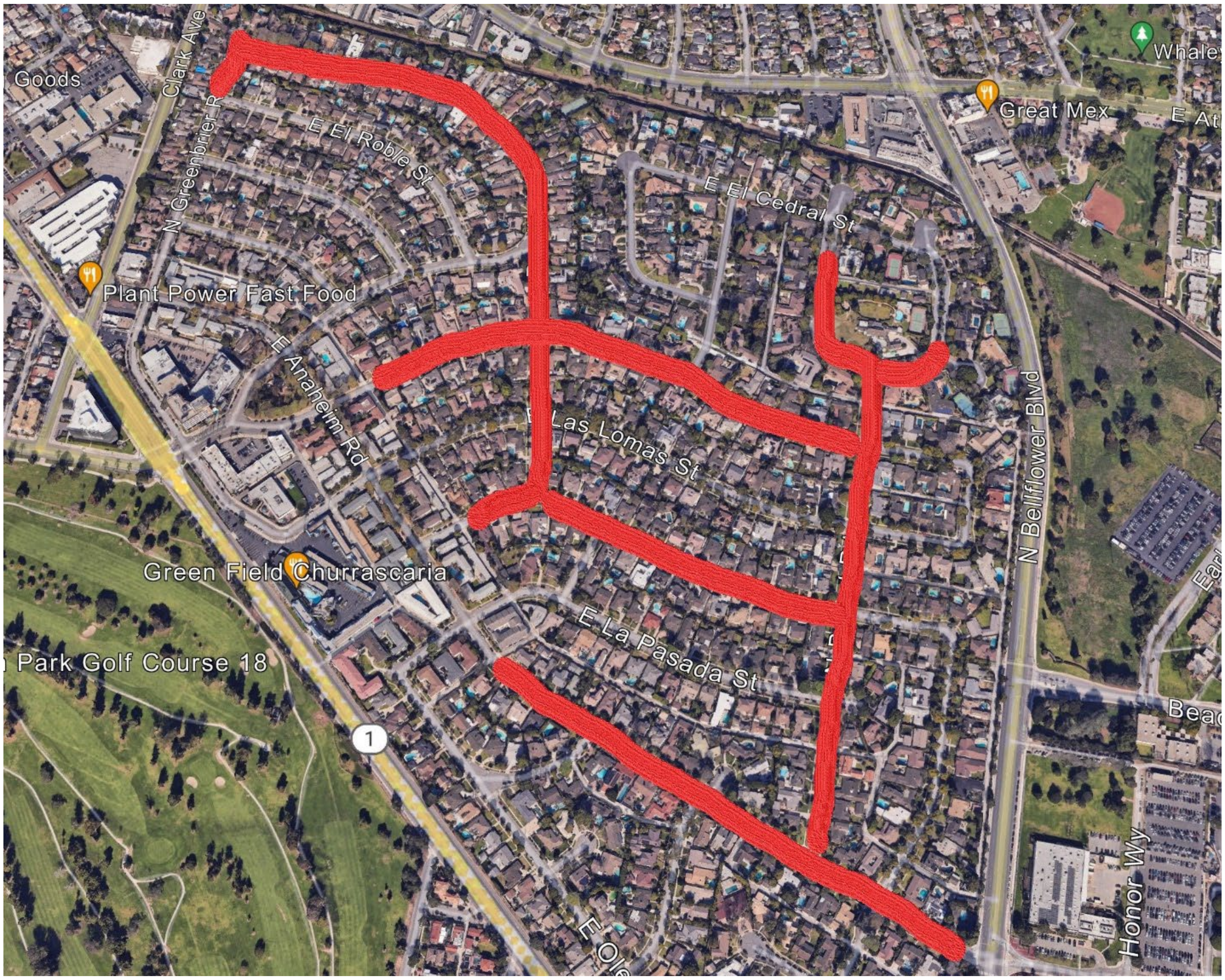
In May, 2024, in two samplings, we collected data on 310 street trees of *Schinus molle* in the Park Estates neighborhood of Long Beach, California. These trees were lining the streets of 5406–5654 E. Anaheim Rd.; 1151–1465 N. Bryant Rd.; 1410–1420 E. Bryant Dr.; 5350–5560 E. El Jardin St.; 5301–5542 E. El Parque St.; 1351–1591 Ramillo Ave.; 5107–5270 E. El Cedral St.; and 1561–1661 N. Greenbrier Rd (**Fig. 22**). The trees were in varying states of root zone moisture, were of various sizes/ages, and displayed a range of severity of canopy thinning.

We estimated relative root zone moisture by species and condition or appearance of tree companion plants, which were mostly turfgrass but also occasionally included groundcovers and shrubs. We rated estimated relative root zone moisture on a scale of 1 to 3, where 1 = low, 2 = medium, and 3 = high (**Figs. 23–25)**. For condition of companion plants, we assessed leaf color and plant density and dieback. We also considered the presence of weeds, lichens, and mosses.

We measured trunk diameter at standard height, ca. 1.4 m above the ground, with an arborist's D-tape.

We estimated relative tree canopy appearance or condition on a scale of 1 to 5, where 1 = dead or nearly so and 5 = optimal (**Figs. 26–27**). For tree appearance we considered leaf color, canopy density and dieback (thinning), and presence of epicormic growth.

We conducted an analysis of variance using a model that included the effects of sampling date, estimated root zone moisture and tree diameter using R base package (R Core Team 2021) to



22. Residential streets marked in red where we assessed 310 street trees of *Schinus molle* for relative severity of canopy thinning, rated for estimated relative soil moisture, and measured for DSH, Estate Park neighborhood, between Pacific Coast Highway (Highway 1) and Bellflower Blvd., Long Beach, California, May 2024. Image adapted from Google Earth.

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analyze the data and determine if treatments differed significantly. Means for significant effects were estimated and significance levels presented.

Results

Date of sampling and trunk diameter/age had no effect on tree canopy appearance. However, a significant effect existed between estimated relative root zone moisture and estimated relative tree canopy appearance. (**Table 1**).

When considering the natural habitat of *Schinus molle* in seasonally dry areas and its designation as a Mediterranean-climate plant, it is no surprise that trees in lush, heavily irrigated landscapes (high water) had more severe canopy thinning than trees in low-water situations. Mediterranean-

Table 1. Effect of estimated relative root zone moisture on *Schinus molle* tree canopy relative appearance, Park Estates, Long Beach, California, May 2024.

Estimated Soil Moisture[z]	Mean Tree Canopy Appearance[y]
1 (low)	3.3c
2 (medium)	2.7b
3 (high)	2.4a

[z]Root zone moisture rated on a scale of 1 to 3, where 1 = low, 2 = medium, and 3 = high.
[y] Tree canopy appearance rated on a scale of 1 to 5, where 1 = dead or nearly so and 5 = optimal. Different letters following means indicate that the value was significantly different, $P < .001$.

climate plants typically perform poorly in year-round, lush well irrigated landscapes, suffering root damage and subsequent canopy thinning and dieback. Also, trees stressed from inappropriate irrigation are more susceptible to secondary problems, like pests and diseases. Thus, we suspect that if a primary cause of *S. molle* canopy thinning exists, excessive, inappropriate irrigation is likely exacerbating it if not causing it. Conversely, and somewhat surprisingly considering *S. molle* is a drought tolerant species, insufficient water, like the several years of consecutive drought from 2013 to 2017 and 2020 to 2022, could also stress trees, predisposing them to a myriad of problems, including abiotic and biotic, such as pests and diseases.

Conclusions and Management

The mite *Brachytydeus formosus*, the disease *Botryosphaeria* sp., and the abiotic stress of improper irrigation (excessively moist soil and/or perhaps even prolonged drought) can now be added to the leafhopper *Empoasca sativa* as possible causal agents of *Schinus molle* canopy thinning. It seems probable that any one of these factors is not acting alone but that two or more are acting in combination. A likely scenario is that excessively wet soil or prolonged, consecutive years of drought could not only stress trees and lead to canopy thinning on its own but could initiate or predispose trees to disease (*Botryosphaeria* sp.) and pests (*E. sativa* and *B. formosus*). Also, improper soil moisture could enhance pest and disease damage, making them more severe than they would be on a healthy, stress-free tree.

Thus, until we know more about the roles that each of these possible causal agents plays in *Schinus molle* canopy thinning, the best strategy for managing this malady is to provide proper cultivation, primarily appropriate water, mulch, and pruning, to ensure optimal tree health.

Ensure *Schinus molle* is an appropriate species for your area, site in full sun, and provide adequate space to accommodate future shoot and root growth to reduce wounds from pruning for size control.

23. Dryland plants, including groundcovers and succulents, suggested low relative soil moisture and was rated a "1."

24. Spotty, uneven turfgrass coverage suggested medium relative soil moisture and was rated a "2."

25. Lush, green turfgrass suggested high relative soil moisture and was rated a “3.”

Irrigate judiciously; if winter rains are average, perhaps only an occasional summer deep irrigation, for example once every four to eight weeks in cooler, more humid coastal areas and once every three to four weeks in hotter, more arid inland areas, might be beneficial. During consecutive years of drought, when winter rains are lacking, consider supplemental winter and spring irrigation. Keep irrigation water off trunks and foliage and maintain mulch to decrease soil evaporation.

To avoid wounds, prune judiciously, only when necessary and then mostly to achieve, preserve, and/or enhance proper structure; avoid pruning for size control. Employ proper pruning principles, practices, and tools.

Maintain five to seven cm of good quality mulch from the trunk out to at least two m, or ideally to the canopy dripline, if possible. The naturally shedding leaves of *Schinus molle* make a good mulch. Remove companion plants at least close to the trunk or out to the canopy dripline, if possible.

Also, for diseases, Downer et al. (2022) suggested removal and disposal of infected growth, pruning 10 to 15 cm proximal of visible infections. Clean pruning tools of plant debris and then

26. The severely thinned out canopy earned this tree a "1" rating. Note the lush, green turfgrass indicating relatively high soil moisture.

27. This tree was in good condition and we rated it a "4." Note the companion plants of *Ceanothus*, a California native, and other dryland plants, suggesting the relative soil moisture was low.

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sanitize them for 30 minutes in a solution of one part household bleach (5.25% sodium hypochlorite) and nine parts of water prior to making new cuts. A solution of 70% alcohol can also be used to sanitize pruning tools.

Monitor and control sap-sucking insects like aphids, scales, mealybugs, and leafhoppers; they can predispose plants to disease and aid in spreading disease.

As a last resort for diseases, consider phosphorous acid-based fungicides that induce a plant immune response to protect new growth. However, once the disease progresses deeper into the main branches and trunk it is typically best to consider removal.

At this time pesticide applications aimed specifically at *Empoasca sativa* and *Brachytydeus formosus* seem unwarranted. We are unsure what damage, if any, *E. sativa* is causing to *S. molle*. Also, because they are so mobile, leafhoppers like *E. sativa* are difficult to control with pesticides.

In the case of *Brachytydeus formosus*, because it is likely not a primary pest of *Schinus molle*, its control is not an urgent concern. Indeed, because it is likely beneficial and cleaning up or sanitizing non-pathogenic and pathogenic fungi, to suppress or eliminate it might be detrimental to the trees' health. However, if proven to be an important pest of *S. molle*, Gautam et al. (2018a) reported that it is rather easily controlled by several miticides.

Anecdotally, several landscape managers have reported improved tree appearance after applications of a combination of fertilizer, kelp extract, and dinotefuran. Unfortunately, we do not know which of these three ingredients, if any, are responsible for the positive outcome.

We observed that trees afflicted with *Schinus molle* canopy thinning tend to be somewhat cyclical in severity of symptom expression. If trees are not yet severely affected, they tend to look best in spring, benefitting from surges of fresh, new growth typical of Mediterranean climate plants, masking the previous damage. Yet, by the fall and winter, after a long warm summer of little new growth, they tend to look their worst. On the other hand, trees severely affected, such as those in the Talega neighborhood of San Clemente, might recover only slightly, if at all, in the spring, which after several years of poor growth might lead to their decline and eventual death.

We feel that future work on *Schinus molle* canopy thinning should focus on determining what role the three biotic causal agents play in this malady. Perhaps growth chamber studies with plants of *S. molle* with *Empoasca sativa*, *Brachytydeus formosus* and other sap-sucking insects, and *Botryosphaeria* sp., alone and in combination, could prove useful.

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