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**What are the socioeconomic and environmental consequences of the invasive spotted lanternfly and what are potential solutions to the problem?**

**Introduction**

Dubbed a “national disaster” by the New York Times, the spotted lanternfly (*Lycorma delicatula*) has erupted in huge numbers in the northeastern United States (Montague, 2018). Originating from northern China, this invasive pest first appeared in Pennsylvania in 2014 (Dara, 2015). Its “voracious appetite” and “remarkable reproductive talents” have enabled it to cause serious damage to grape, orchard, and logging industries of commercial value; furthermore, the spotted lanternfly has created a significant burden to farmers that suffer from harmful crop loss due to their rampant destruction and warrants substantial costs and burdens for its management and control (Montague, 2018).

**Background**

*Morphological Characteristics*

The spotted lanternfly earned its name from the black spots that adorn its grey forewings (Dara, 2015). Its forewings also have reticulated tips, while its hindwings display contrasting red and black bands with a white wedge in between them (Dara, 2015). It has a black head and body with a yellow abdomen that also contains black bands (Dara, 2015). The planthopper is 17–25 mm long and belongs to the family Fulgoridae (Dara, 2015). Fulgoridae are moderately large in size and often known as lanternflies because of their inflated heads that are appear ‘luminous’.

*Origin and Distribution*

In 2004, the species, native to northern China, was detected in South Korea and has spread throughout the country as well as to Taiwan, Vietnam, and reportedly India (Dara, 2015). Recently, the exotic species was also found in Japan (Dara, 2015). There is limited knowledge of how the spotted lanternfly was accidentally introduced to the United States, however the lanternfly was first discovered in Berks County, Pennsylvania in September 2014 because of bees that were drawn to the honeydew (“Tree-of-heaven,” 2018).The native Chinese pest has now been found in 13 southeastern Pennsylvania counties (“Tree-of-heaven,” 2018). Pennsylvania officials state that populations are now well-established in Montgomery and Chester Counties in addition to Berks County (“Spotted Lanternfly,” n.d.). Quarantine zones have been established that limit certain industrial activities and the movement of articles that could facilitate the spread of the spotted lanternfly. As of 2017, the quarantine zone extends over 6,900 square miles (“Spotted Lanternfly on Grapes,”2017). The lanternfly has also been observed in New Jersey, Delaware, Virginia, and New York and has the alarming potential for reaching national pest status (Montague, 2018).

*Host Range*

At least forty agricultural crops or landscape plants in North America have been identified as hosts of the spotted lanternfly (Dara, 2015). The lanternfly’s prefered host plant is the tree-of-heaven (*Ailanthus altissima*), an aggressively invasive smooth-bark tree native to China that was intentionally introduced to the U.S. in 1784 (“Tree-of-heaven,” 2018). Other host plants include fruit trees such as apple, cherry, grape and stone fruit trees, ornamental trees, over 70 species of woody trees such as maple and poplar trees, and vines (Dara, 2015).

*Species Adaptations*

Studies have shown that certain adaptations have enabled the rampant survival and underdetection of the species, allowing populations to grow unchecked. Kang et al. (2011) found that theobscure color of the species’ forewings are an adaptation that allows it to remain undetected by predators, while its bright hindwings immediately open in response to a touch such as a bird peck. It is a sensory reflex that has an “aposematic function, warning of unpalatability” (Kang et al., 2011).

**Ecological Impact**

The feeding habits of adolescent and adult spotted lanternflies cause extreme damage to host plants. They feed on sap from stems, leaves and tree trunks and pierce the host plants, sucking the sap, and excreting copious amounts of a sticky, sugary liquid referred to as honeydew. These ‘weeping wounds’ that seep out of the tree promote sooty mold growth, which emits a fermented odor and blocks photosynthesis, stunting the growth of the host plant and leading to death. Just two years after their introduction to Pennsylvania, the spotted lanternflies wreaked havoc on vineyards, leaving behind viscous remnants of honeydew and sooty mold damage (“Spotted Lanternfly on Grapes,” 2017). The sugary excretions of the lanternflies also attract unwanted insects such as bees, wasps, hornets, and ants to the host plants (Dara, 2015).

The spotted lanternfly has also been found to be a mechanical carrier of diseases such as fire blight, a contagious disease that affects apples. The lanternflies are responsible for an overall decline in tree and small fruit populations that they feed on. The deterioration of these host plants is manifested as “loss of vigor”, or “systemic feeding shock”, that is comparable to the detrimental effects of large populations of pear psylla on pear trees, which is often termed ‘psylla shock’ (“Spotted Lanternfly on Grapes,” 2017).

The overwintering habits of the spotted lanternfly exacerbate their spread. From August until early November, they deposit their eggs on the trunks of host plants. They widely prefer the tree-of-heaven, but periodically move to other sources. Spotted lanternflies also deposit eggs on non-living, hard objects such as stones, fence posts, outdoor equipment, as well as vehicles, rail cars, and shipping palettes (Dara, 2015; “Spotted Lanternfly on Grapes,” 2017). In Korea, targeted trees were observed to have up to 3.4 egg masses (Dara, 2015). However, in Pennsylvania, a significantly larger amount of egg masses per tree is usually found. One observer reportedly found 197 egg masses on one tree-of-heaven (Dara, 2015). The large-scale deposition of these egg masses contributes to the invasive spread of the species, as egg fragments can remain on the trees for over a year (Dara, 2015). During late spring, the eggs hatch into nymphs and begin feeding on the host plant. These nymphs stay put on one host plant as they feed, moving up and downthe trunk, which could serve as potential for capturing them with traps. The egg-laying behaviors of the spotted lanternfly create a huge nuisance as the process of removal or mitigation can be arduous and inefficient. For example, reducing the amount of egg masses on woody debris requires laborious effort from individuals with expertise in handling wood such as landscapers and roadside workers. The accumulation of these masses is highly indicative of the wide-scale spread of the problem and its severity.

**Economic Impact**

In 2015, the Pennsylvania Department of Agriculture removed more than 175,000 insects and eradication efforts are expected to increase (Dara, 2015). The grape industry is a major commodity in the United States and the invasive species puts the country’s $5.5 billion grape industry at risk (“Spotted Lanternfly,” n.d.). According to the The Pennsylvania Department of Agriculture, the spotted lanternfly poses a threat on over $20.5 million grape, almost $134 million apple, and over $24 million stone fruit industries in the state of Pennsylvania alone (“Spotted Lanternfly,” n.d.). Pine and hardwood logging in the state of Pennsylvania also generates $12 billion, which is also at risk due to the invasive pest (“Spotted Lanternfly,” n.d.). The damage of these crops directly impacts the livelihood of farmers and agricultural workers.

**Social Impact**

Farmers will increasingly bear the burden of growing spotted lanternfly populations since they feed are known to feed heavily on orchards and vineyards. These fruit growers depend on their vineyards for their livelihoods. Pennsylvanian grapegrowers have found massive declines in their yields as well as reduced fruit quality due to the spotted lanternfly invasion. In 2017, they reported a “90% loss of grape tonnage” (“Spotted Lanternfly on Grapes,” 2017). One farm estimated that the total value of the corresponding loss of fruit quality was $400,000, despite the use of pesticides (“Spotted Lanternfly on Grapes,” 2017). Applying pesticide sprays to control the populations in costly and many grape and fruit growers have noticed significant increases in their spray bills (“Spotted Lanternfly on Grapes,” 2017). Another potential problem for these farmers is the effect of increased pesticide use on secondary pests. There could be a “flare-up” of secondary pests such as mites and aphids, which would require additional treatment sprays (“Spotted Lanternfly on Grapes,” 2017). The use of pesticides that could also cause harm to natural pollinators (“Spotted Lanternfly on Grapes,” 2017).

The spotted lanternfly can also leave impacts on individuals and communities. For example, the spotted lanternfly can enter buildings where humans live. In Asia, there have been reports of the insect found in peoples’ homes. The spotted lanternfly also leave their sticky excretions behind on outdoor patios and furniture. Studies have shown that the spotted lanternfly are more likely to engage with hosts that contain toxic secondary metabolites. For example, their much prefered host, the tree-of-heaven, contains high levels of cytotoxic alkaloids (Dara, 2015). Therefore, the spotted lanternfly could potentially be poisonous and harmful to humans, pets, or livestock, though more research is still needed on the subject.

**Methods for Control**

Various methods exist for controlling the spread of the spotted lanternfly. Some methods were proven effective and successful in Asia and can potentially be used in the United States to achieve similar results. Spotted lanternflies have limited flight abilities. According to Douglas H. Fisher, the New Jersey Secretary of Agriculture, the spotted lanternfly “has the ability to travel on all types of vehicles as well as various landscaping, wood-based materials and agricultural produce” (Department, 2018). Therefore, when coming up with a viable control method, it is important to note that the primary mode of invasion is by humans, not by the pest itself.

*Natural Enemies*

One potential control method is the use of natural enemies to keep spotted lanternflies in check. However, this method still requires additional research in the United States, as there are few known natural enemies. The species was introduction into the country relatively recently and more information is needed on species interactions and dynamics. However, there are two bugs in Pennsylvania, the predatory wheel bug (*Arilus cristatus*)and the stink bug (*Apoecilus cynicus*) that have been reported to feed on adult spotted lanternflies (Barringer, 2016). In China and South Korea, some egg parasitoids were found to be natural predators of the spotted lanternfly (Choi et al., 2014, Kim et al., 2011). In 2016, one source observed *Ooencyrtus kuvanae*, a nonnative egg parasitoid introduced to control the gypsy moth, preying on spotted lanternfly egg masses in Pennsylvania (Liu et al., 2017). These native and imported enemies represent possible options for biological control of the spotted lanternfly. Nevertheless, additional biological research must be done to decrease the gap in our understanding of the spotted lanternfly.

*Pesticides*

Reports show that the spotted lanternfly is highly vulnerable to broad-spectrum pyrethroids, organophosphate and neonicotinoid insecticides (Dara, 2015). When sprayed on the insects in the egg stage, they exhibited lower activity. Applying these agents that are low risk to humans and the environment can be a suitable method of control in “urban and environmentally sensitive areas” (Dara, 2015). Spotted lanternfly management may be integrated with the management of other insects, mite, and disease pests because of the overarching effects of the spraying on these secondary pests.

*Traps*

Traps are also a feasible method to control the spread of the species and reduce ecological damage. Sticky bands can be placed on the base of host trees. According to Choi et al. (2012), sticky bands are able to trap several hundred insects in a short window of time. In particular, the study found that the color brown was much more effective in attracting spotted lanternflies than blue or yellow (Choi, 2012). However, there are several barriers that make it difficult to set up these traps. Some trees such as sumacs and Chinese Mahogany look very similar to the tree-of-heaven, and thus could be confused as the host of the spotted lanternfly.

*Chemicals*

Certain chemicals or essential oils have been proven to attract or deter spotted lanternflies. The application of these chemicals as attractants and repellents can improve the effectiveness of traps. One laboratory study found that small amounts of spearmint oil can attract nymph and adult spotted lanternflies and boost the effectiveness of a trap (Moon et al., 2011). Another study found that methanol had similar effects in attracting spotted lanternflies to the tree-of-heaven.

*Host Removal*

Another potential management strategy involves controlling tree-of-heaven populations. Because the spotted lanternfly overwhelmingly prefers the tree-of-heaven as its host, the strong linkage between these two invasive species could serve useful in reducing the spread of the spotted lanternfly.

Erupting spotted lanternfly populations can be contained using a combination of physical removal host tree removal, and pesticide application techniques. Effective management requires the cooperation of homeowners and agricultural workers. For long-term, sustainable control, these agricultural and industrial workers must integrate pest management strategies into their work to reduce the likelihood of the pest finding its way into the produce they ship. Businesses are now required to obtain spotted lanternfly permits if they want to ship their items that could contain spotted lanternflies in quarantined regions.

**Conclusion**

The spotted lanternfly has caused serious ecological and economic damage regarding its introduction into the northeastern region of the United States. By observing methods of control used in regions of Asia such as South Korea, where the pest is nonnative as well, similar methods can be implemented in the United States; however, there are key differences between the regions that cannot be ignored. For example, spotted lanternfly eggs are highly susceptible to cold temperatures in Korea, but temperatures in the northeastern United States appear to be more suitable for the survival of the eggs. Also, some methods of control are more practical than others.

To better understand the mechanisms of the spotted lanternfly invasion, comparisons can be made with a similar pest invasion that occured in the mid-Atlantic region of the United States. In 2010, the brown marmorated stink bug invaded the area, including Pennsylvania, and caused $37 million of damage to the region’s fruit industry (“Spotted Lanternfly on Grapes,” 2017). Similar to the spotted lanternfly, the brown marmorated stink bug has a variety of hosts. Therefore, lessons can be learned from past invasions to provide insight for current spotted lanternfly management strategies. It is necessary to first fully understand the behavioral characteristics, migration patterns, and species interactions of the spotted lanternfly in order to determine which method of control is best.

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