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What’s the Catch? Collateral Mortality of Spotted Lanternfly Sticky Banding

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Abstract:

Spotted lanternfly (*Lycorma delicatula*) is a novel invasive pest in the mid-Atlantic region of the United States. While the insect does not yet seem to be particularly damaging to trees, its conspicuousness, nuisance, and notoriety have prompted homeowners to take defensive measures. A commonly recommended method of control is sticky banding, wherein a band with an adhesive outwards-facing surface is affixed to the tree in question, trapping insects that traverse the band. The approach is appealing as it is chemical-free and thus ostensibly environmentally friendly. However, the ability of sticky bands to catch adult SLF is suspect and the quantity and character of the bycatch has not been assessed. Before the practice can be represented as environmentally benign, these unknowns must be determined. In this study, I quantified and identified the SLF catch and non-target bycatch of sticky bands on two species of tree (*Ailanthus altissima* and *Tetradium daniellii*). Bands were deployed for 72 hours every week. The resultant dataset is incomplete as data collection was cut short, but some trends are still apparent. Fly species constituted an overwhelming proportion of total catch (86% of total individuals caught in August, though decreasing in proportion in later months). The average catch of SLF per band-foot from August 9th to September 6th was only 9.1. From these results, it is obvious that sticky banding provides miniscule control of adult SLF. It is possible, however, that the catch of juvenile SLF is greater than that of the adults, given the juveniles’ cyclic ascent-descent behavior, inability to fly, and lesser strengthIt is my recommendation that homeowners do not deploy sticky bands after adult emergence of SLF.

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INTRODUCTION

Spotted lanternfly (*Lycorma delicatula*, hereafter SLF), is an insect in the order Hemiptera (true bugs) and family Fulgoridae (lanternflies). It established itself as an invasive pest in the United States after being introduced to Berks County, PA in 2014 (Barringer, 2015). In the intervening years, its range has expanded considerably, with established infestations in 40 counties across Pennsylvania, New Jersey, Delaware, West Virginia, and Virginia at the time of writing (New York State Integrated Pest Management, 2020). SLF causes both direct and indirect damage. SLF's direct damage is a consequence of its feeding habit. SLF feeding reduces the infested plant's vigor as it intercepts and reduces the plant's phloem. While the degree of direct damage to trees is so far thought to be minimal, extensive SLF feeding in vineyards has already proven to be devastating (Urban, 2019). The indirect damage of SLF is also the result of its feeding habit, though on the other end of the digestive tract. As phloem is primarily composed of water and sugars, and thus is relatively nutrient-poor, an obligate phloem feeder like SLF must feed extensively to obtain sufficient nutrition. The resultant excess of water and sugar is expelled as a liquid waste called honeydew. This is true of all sap-feeders, but given SLF's large body size and gregarious feeding habit (feeding in groups of hundreds, surpassing even a thousand), one infestation will excrete a tremendous volume of honeydew. The volume of honeydew produced by SLF, singly or as a group, has yet to be measured, but a moderate infestation will produce a light, persistent rain of excreta. While this in itself poses a nuisance for humans given the stickiness and unsavory origin of the fluid, the sugars in the honeydew attract a host of other nuisance insects, such as yellowjackets and ants. Further, honeydew residue is quickly colonized by sooty molds. When a plant is coated in honeydew, such as those underneath the infested tree, the resultant mold growth hampers photosynthesis and further decreases plant health.

The current insecticides able to control SLF are unsatisfactory for homeowners. Multiple insecticide trials (Biddinger and Leach, 2020) have found that organic options offer mediocre and brief control, and while they found synthetic pesticides such as pyrethroids and neonicotinoids to be much more lethal, these are often reserved as a last resort due to ecological concerns. It is no surprise, then, that the process of sticky banding is frequently recommended to homeowners for control of SLF (as in Leach and Etters, 2019; "Management: Introduction and Sticky Bands," n.d.). In this process, a band with an adhesive surface is placed around the trunk of an infested tree, trapping SLF when they attempt to traverse the band. The affordability and simplicity of sticky banding, coupled with its appeal as a chemical-free means of control (and, of course, the satisfying visual feedback of a few dozen SLF stuck to the band) has made this practice a popular choice for homeowners.

Unfortunately, the sticky band method is not without its drawbacks. Its control is untargeted; any creature traversing the banded tree trunk will encounter the sticky band. If the creature is not able to free itself, it becomes ensnared and dies of starvation and exposure. A few well publicized occurrences of bycatch of large and charismatic taxa (e.g. squirrels and woodpeckers; see news articles by Winfrey, 2018, and Merlin, 2019) quickly rallied outrage and criticism of the sticky banding method for control of SLF. However, these vertebrates are easily protected by the construction of a cage over top of the sticky band, allowing large animals to pass over the cage while smaller creatures walk underneath, encountering the adhesive. At the time of writing, I am not aware of any cases where a large animal has become ensnared by a sticky band that is protected by a properly constructed cage.

While large vertebrate bycatch can be avoided, the catch of non-target arthropods is inevitable. A chicken wire or hardware cloth cage cannot both permit SLF entrance and prevent beneficial insects from becoming trapped. The severity of the collateral mortality of sticky banding has so far evaded scrutiny. Before sticky banding can truly be recommended as an eco-friendly method of control, its efficacy must be weighed against its costs. Of course, some amount of collateral damage must be tolerated; the question is not one of the presence or absence of bycatch, but of its scale and its kind. In brief, what are the species being caught and how many are being caught?

The following research project addresses this issue by analyzing the catch and bycatch of sticky bands over time. My hope is not to condemn all use of sticky bands, but to facilitate effective, efficient, and responsible practices.

METHODS

Banding

Catchmaster Pro Series Giant Fly Trap sticky bands were cut in thirds, yielding sticky bands with a width of approximately three and one third inches. A cage was constructed of hardware cloth with ½” mesh to prevent avian and mammalian bycatch. The hardware cloth was cut to a length allowing approximately two inches of overlap when wrapped around the target tree and a width of seven-inches to ensure that the sticky band was entirely covered. One-inch wooden cubes were used as standoffs so that the cage would stand proud of the sticky band, allowing for ingress of spotted lanternfly but prohibiting bycatch of larger animals.

Example of deployed sticky band on *A. altissima*. Note that the depicted cage setup uses black zip-ties; these were later replaced by metal wires to reduce waste and decrease deployment time.

Bands were wrapped tightly around the tree approximately at breast height. On the top left corner of each band was placed a piece of masking tape bearing the tree identification number and date of deployment. The height at which the bands were placed was not identical as the shape and branching of each tree varied considerably. By tightly wrapping the bands, enough friction was produced to secure the band in place for the duration of the banding period. If a band required extra support, push-pins were used to affix the band more securely. The cage was placed over the sticky band, with the wooden standoffs just above the band, and the ends were drawn tightly together with metal wire, producing enough friction to support the cage for the duration of banding.

Bands were deployed weekly on a Friday evening and collected the next Monday evening at the same time of day, resulting in a 72-hour banding period. Upon collection, bands were rolled adhesive-inwards, collected in quart sized Ziploc bags, and frozen until analysis. The banding timeframe corresponded closely with adult emergence of SLF, with the earliest adults emerging in the area roughly two weeks prior. The first set of bands was deployed on August 9th, 2019, and the final set was deployed on November 8th, 2019.

Band Number	**Circumference (inches)**	**Tree Species**	**Location**
801	29	*Tetradium daniellii*	Morris Arboretum
802	35	*Tetradium daniellii*	Morris Arboretum
803	15	*Ailanthus altissima*	Crossways Preserve
804	16	*Ailanthus altissima*	Crossways Preserve
805	19	*Ailanthus altissima*	Crossways Preserve
806	17	*Ailanthus altissima*	Crossways Preserve
807	25	*Ailanthus altissima*	Crossways Preserve

Table 1. Bands and the characteristics of the banded trees.

Two species of tree were selected for use in this study. The first, *Ailanthus altissima*, is the preferred host of SLF (Han, 2008). The second, *Tetradium daniellii* was selected as a relatively large population of adult SLF were observed feeding on two specimens at the Arboretum.

Counting

Upon counting, sticky bands were withdrawn from the freezer and deposited into wide-mouth plastic bottles. Mineral oil was found to effectively dissolve the adhesive of the sticky bands while preserving most of the characters needed for accurate arthropod identification. Roughly 100 mL of mineral oil was added to each bottle. Each bottle was marked with the tree identification number and band deployment date. The bottles were then laid on their sides and periodically agitated to aid in uniform penetration of the mineral oil. As the bands had been rolled for storage, mineral oil often could not penetrate the entire band. Thus, after 24 hours the cap of each bottle was opened and the bands within were uncoiled using large forceps. The lids were replaced, and each bottle was again laid on its side and periodically agitated. After another 24 hours, the adhesive had dissolved entirely, and the bands were removed for recovery of the specimens.

The outer end of the band was gripped using long forceps and drawn slowly from the mouth of the bottle. While the band was being drawn from the bottle, specimens still adhering to the band were brushed back into the mineral oil in the bottle using a paint brush. Once the band was completely removed, it was checked for any remaining specimens. If found, the specimens were transferred back into the mineral oil in the bottle via paintbrush. The band was then discarded. Squares of hard roll paper towel were cut for use as filter paper. A filter was marked with the tree identification number and deployment date of the band for which it was to be used. Using a quarter fold, the filter was placed into a funnel and that funnel placed into a large Erlenmeyer flask. The contents of the corresponding bottle were decanted into it. Inevitably, small specimens clung to the side of the bottle due to the residual mineral oil. Thus, the bottle was rinsed with a small amount (approximately 10mL) of mineral oil and again decanted. If any specimens still remained, they were transferred by paint brush to the filter. The rate of filtration in some samples slowed to a near halt, possibly due to an accumulation of debris clogging the filter. In these cases, the mineral oil remaining in the funnel was decanted into another funnel with a fresh filter. The filters were marked as belonging to a pair (denoted as “a” on one and “b” on the other) to ensure that their contents were analyzed at the same time. Once filtration of a given batch of samples was complete, the filters were again folded, collected together, wrapped in paper towels to wick off further mineral oil, and stored in the freezer.

All of the catch of a given filter (or pair of filters) was sorted based on morphology. Identification was frequently assisted by use of a stereomicroscope. Specimens were grouped onto individual slips of cardstock, first coarsely by order, then revised until each group contained only one species (insofar as could be determined by the author). These groups were then identified to the finest taxonomic level reasonable given the constraints of time on the project. As a result, it will often appear in the data that two entries are identical (e.g. two counts of the genus *Camponotus*). However, in these cases, neither group could be identified to species level, but were determined to be distinct. Where species could not be identified, the group is referred to as an “inferred species.” I conceived of this approach in order to preserve some measure of biodiversity, rather than grouping all specimens together in coarser taxonomic ranks. However, it is possible that some species were erroneously considered to be identical and others erroneously considered distinct, so the measure of biodiversity is certainly not perfect. Counts were not made until all specimens had been grouped by species, in case one inferred species was recorded in two separate entries, falsely appearing to be two species.

Initially, bands were counted in chronological order; all the bands of Week 1 were counted, then those of Week 2, and so on. Quickly, however, it became apparent that the counting and identification process would be significantly lengthier than anticipated and that all samples could not be counted within the time constraints of the project. Thus, only samples from every other week were counted, sacrificing some temporal resolution but cutting total analysis time in half. Even still, counting was cut short by the social distancing policies resulting from the COVID-19 pandemic in March.

RESULTS AND DISCUSSION

Counts of all specimens on all bands were made for Weeks 1 and 3. Counts of only SLF were made for all bands on Week 5. As data analysis was proceeding more slowly than expected, the data collection approach was shifted from a week-by-week method to a band-by-band one. Thus, one band (803) has been counted for almost all of the target weeks, though even for this band, the final two weeks (11/1 and 11/8) were not able to be counted due to the social distancing circumstances. Thus, my ability to analyze temporal trends of SLF is severely limited.

Week	Deployment	Collection	801	802	803	804	805	806	807
1	8/9/2019	8/12/2019	🟩	🟩	🟩	🟩	🟩	🟩	🟩
2	8/16/2019	8/19/2019							
3	8/23/2019	8/26/2019	🟩	🟩	🟩	🟩	🟩	🟩	🟩
4	8/30/2019	9/2/2019	▨	▨	▨	▨	▨	▨	▨
5	9/6/2019	9/9/2019	🟩	🟧	🟩	🟩	🟧	🟧	🟧
6	9/13/2019	9/16/2019	🟩			🟩	🟩		
7	9/20/2019	9/23/2019			🟩	🟧			
8	9/27/2019	9/30/2019							
9	10/4/2019	10/7/2019			🟩	▨			
10	10/11/2019	10/14/2019							
11	10/18/2019	10/21/2019	▨		🟩				
12	10/25/2019	10/28/2019							
13	11/1/2019	11/4/2019							
14	11/8/2019	11/11/2019							

Key		🟩	🟧	▨
	No count	All counts made	Only SLF counted	Data not available

Table 2. Band counts. Counts for Week 5 were in progress when the study was cut short; however, counts of SLF were finished for all bands in this week. Band 803 was counted nearly

to the end of the study. No bands were deployed on Week 4 due to travel The sample for Band 804 on Week 9 cannot be located. On Week 11, Band 801 fell from the tree during the banding period.

As the approach to counting changed a few times during the study, three bands (801, 804, 805) were counted on Week 6, but no other counts were made on even numbered weeks.

Results from Weeks 1 and 3

The following results are from Weeks 1 and 3, as these are the only two weeks in which all bands were fully counted. The sum of the specimens from Weeks 1 and 3 was 6,558, resulting in a total average catch of about 468 specimens per 72 hours. Of this total, only 260 (3.96%) were SLF. A single inferred species of drosophilid fly comprised a staggering 3,786 (58%) of the total count. It should be noted that this inferred species may well be a species complex of multiple drosophilid species that I could not distinguish morphologically. The species was present in every sample analyzed until September 23rd. Eleven orders of insect, arachnid, and millipede were represented in the fully counted bands. Their average number of species trapped on a band, total catch, and proportions of catch follow.

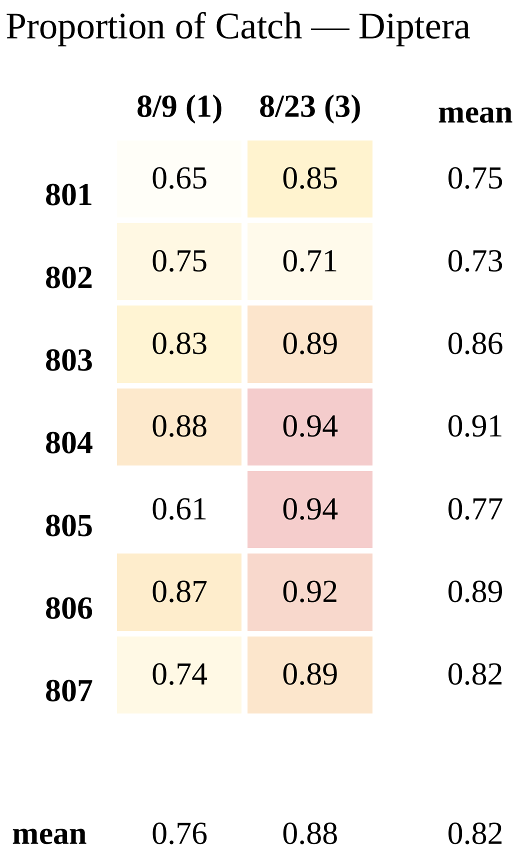
Common Name	Class	Order	Avg. Species per Band	Total Catch
Flies	Insecta	Diptera	10.71	5,644 (86.1%)
Ants, Bees, Wasps	Insecta	Hymenoptera	10.00	537 (8.2%)
Hemipterans	Insecta	Hemiptera	2.57	284 (4.3%)
Spiders	Arachnida	Araneae	2.43	51 (0.8%)
Beetles	Insecta	Coleoptera	1.50	21 (0.3%)
Harvestmen	Arachnida	Opiliones	0.29	8 (0.1%)
Moths, Butterflies	Insecta	Lepidoptera	0.36	6 (0.1%)
Millipedes	Diplopoda	Chordeumatida	0.14	3 (0%)
Grasshoppers, Crickets	Insecta	Orthoptera	0.14	2 (0%)
Silverfish	Insecta	Zygentoma	0.07	1 (0%)
Mites	Arachnida	Acari	0.07	1 (0%)
Total				6,558

Table 3. Composition of the catch of all fully counted bands.

The majority catch of every sticky band was fly (dipteran) species. In the first two weeks, the dipterans represented 86% of the total catch and, on average, 82% of the catch of a given band. However, while about ten times more dipterans were caught than the next most common order

(Hymenoptera), they represented nearly the same number of species per band on average (note that the proportion of dipteran species in the total catch is not known because, unless identified to species, it cannot be determined whether inferred species on different bands represent the same or different species). In other words, the species diversity of dipterans and hymenopterans was roughly equal on the bands, but dipteran species were ten times more populous on average. The large catch of a moderate number of dipteran species may indicate that the sticky bands employed in this study proved particularly attractive to certain species of fly, perhaps because of their yellow-green coloration. It may also be simply due to an abundance of these flies within our study areas.

Dipterans represented not less than 61% and as much as 94% of the catch of the bands in Weeks 1 and 3, becoming more prevalent in the third week in all bands but band 802.



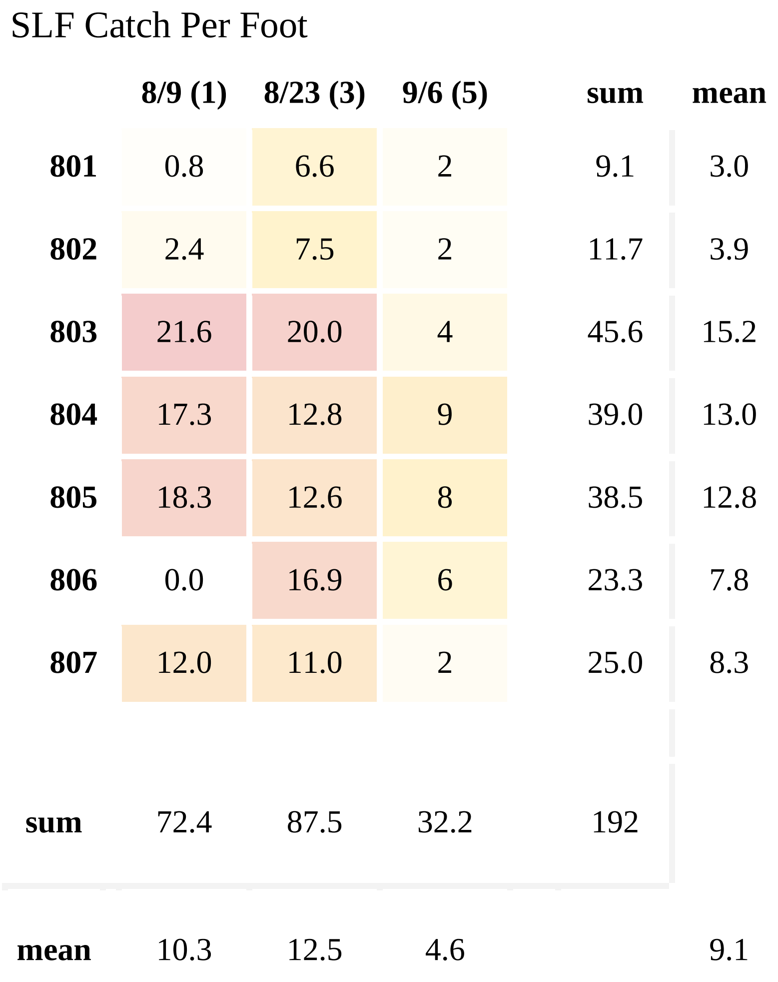
Proportion of Catch — Diptera

	8/9 (1)	**8/23 (3)**	**mean**
801	0.65	0.85	0.75
802	0.75	0.71	0.73
803	0.83	0.89	0.86
804	0.88	0.94	0.91
805	0.61	0.94	0.77
806	0.87	0.92	0.89
807	0.74	0.89	0.82
mean	0.76	0.88	0.82

Table 4. Dipteran catch in Weeks 1 and 3. Color scale runs from white at 0th percentile to yellow at median to red at 100th percentile.

SLF Catch in Weeks 1, 3, and 5

The following charts show SLF catch only on the first three odd numbered weeks (Week 1, deployed 8/9; Week 3, deployed 8/23; Week 5, deployed 9/6) as these are the only weeks for which all SLF counts have been completed.



SLF Catch Per Foot

	8/9 (1)	8/23 (3)	9/6 (5)	sum	mean
801	0.8	6.6	2	9.1	3.0
802	2.4	7.5	2	11.7	3.9
803	21.6	20.0	4	45.6	15.2
804	17.3	12.8	9	39.0	13.0
805	18.3	12.6	8	38.5	12.8
806	0.0	16.9	6	23.3	7.8
807	12.0	11.0	2	25.0	8.3
sum	72.4	87.5	32.2	192	
mean	10.3	12.5	4.6		9.1

Table 5. SLF catch per foot for all completed weeks. As the circumference of the trapped trees varies, these results have been normalized by dividing the total catch by the length of the sticky band in feet. Color scale runs from white at 0th percentile to yellow at median to red at 100th percentile.

With an average SLF catch of 11.4, the bands on *A. altissima* (803-807) seem to show much greater catch than those on *T. daniellii* (801 and 802), which had an average of 3.5 SLF per banding period. This is reasonable given the strong preference of SLF for *A. altissima*. However, further investigation is needed as the two species of tree were in different locations. The causative factor could be location, rather than tree type.

All bands also showed a distinct drop in SLF catch from Week 3 to Week 5.

Catch Over Entire Season

As data collection was cut short, trends regarding catch over time must be inferred from a single sticky band (803). This offers limited insight into catch trends in the late season as there is no replication.

Total catch began at around 400 specimens per banding period in the first half of August, but rose sharply in September to just under 1,000. Catch then diminished to less than 100 in October.

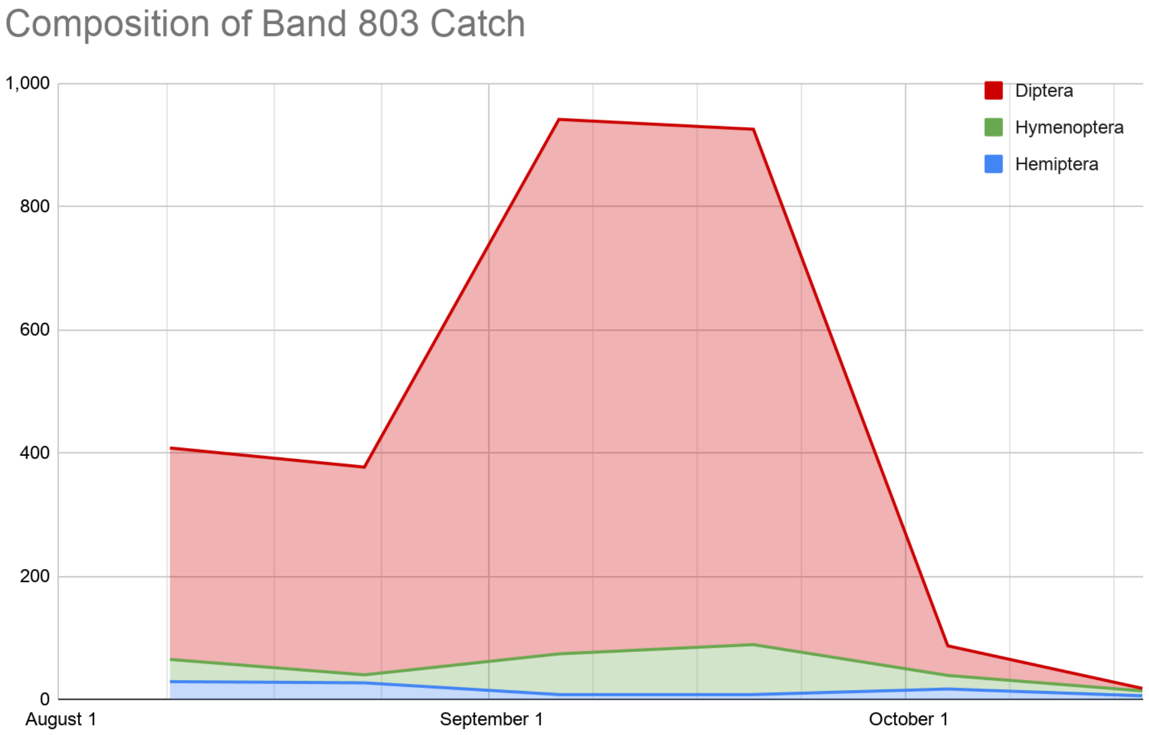


Chart 1. Catch of the three most caught orders of Band 803.

The total catch showed an increase from around 400 to just under 1,000 for the month of September, then decreased sharply in the beginning of October to levels under 100 specimens of total catch. However, these trends in total catch were dominated by changes in dipteran catch, which overwhelmed the other orders. Hymenopteran catch showed a small increase in September and decrease in October, but the trend of hemipteran catch was inverse, being lowest during September—though just as total catch trends were dominated by dipteran catch trends, the trends of hemipteran catch are dominated by the trends in SLF catch. While dipteran catch was the majority of catch for most of the season, it decreased more rapidly than other orders after Week 9 (10/4), with only 4 specimens (21% of total) caught in Week 11 (10/18).

Band 803 Primary Catch Composition

	8/9	**8/23**	**9/6**	**9/20**	**10/4**	**10/18**
Diptera	343 (83.1%)	337 (88.9%)	867 (91.8%)	836 (90.1%)	48 (52.2%)	4 (21.1%)
Hymenoptera	36 (8.7%)	13 (3.4%)	66 (7%)	81 (8.7%)	22 (23.9%)	8 (42.1%)
Hemiptera	29 (7%)	27 (7.1%)	8 (0.8%)	8 (0.9%)	17 (18.5%)	6 (31.6%)

Table 6. Catch of the three most caught orders of Band 803.

SLF catch and proportion was low on Band 803 throughout most of the study, starting a little above 20 in the first two weeks and dropping to 5 in the next two—this sharp decrease on Week 5 was reflected in all other bands in this study. However, while late-season catch was low (at 16 and 4 in Weeks 9 and 11 respectively), it constituted a much greater proportion of the overall catch in the late season than in the early and mid season.

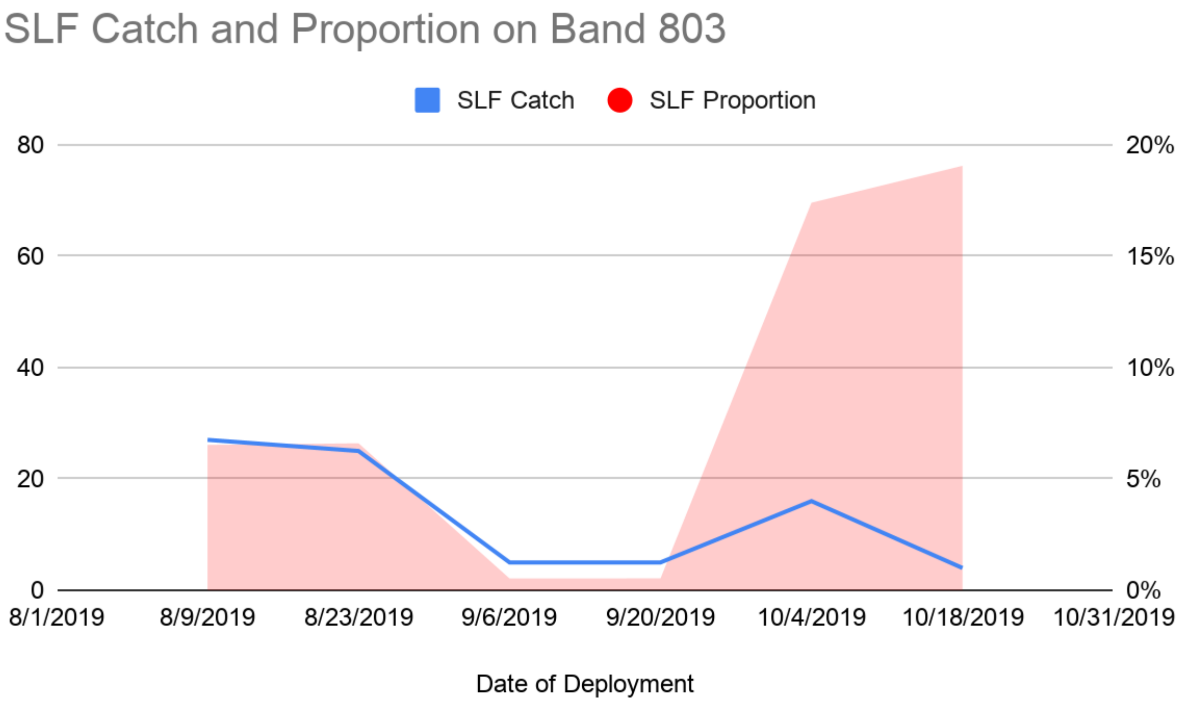


Chart 2. SLF catch and proportion of total catch in Band 803 from Weeks 1 to 11.

The increase in SLF catch in October could be the result of mating and oviposition activity. However, more data is needed to determine if this trend holds for all sticky bands or if it is merely an anomaly. From personal observation, there seemed to be an increase in SLF catch on sticky bands in the late season, but these bands were never quantified.

CONCLUSION

The control of adult SLF provided by this sticky banding method is unsatisfactory given the costs in time and money required to deploy the bands, as well as the potential collateral damage caused by bycatch. This does not mean, however, that the sticky banding procedure is entirely without merit.

Sticky banding may hold greater value as a measure of control for SLF nymphs than for adults. Nymphal capture is likely greater than that of adults. As was the case in the trapping study by Cooperband *et al.* (2019), I observed that congregations of adult SLF above and below the sticky bands were plentiful even when catch was low. I also repeatedly observed that an adult lanternfly, upon encountering the band with its forelegs, was able to remove itself from the adhesive with its yet untrapped hind legs. Twice it was observed that an adult lanternfly with all legs trapped by adhesive was able to escape the band by jumping. Not all SLF could produce enough force in a jump to free themselves, as many trapped individuals were seen and heard to be attempting to jump in futility. It is unlikely that early instar nymphs possess the strength to remove themselves from the band as frequently as older nymphs and adults. Though Cooperband *et al.* (2019) found capture of younger nymphs to be greater than older nymphs on brown sticky bands developed by Korea Beneficial Insects Lab Co., they did not quantify this difference, nor did they refer to which instars they considered young and which they considered old. Another reason to suspect greater capture in SLF nymphs is their cyclic ascent-descent behavior. As documented by Kim *et al.* (2011), SLF spends its nymphal stages ascending and falling from trees. The exact mechanism is unknown, perhaps from mechanical disturbance by wind, but it is possible that this is a dispersal adaptation. Consequently, SLF nymphs spend much of their time traversing tree trunks, making them particularly susceptible to the sticky banding method. Finally, as adult SLF are able to fly as much as 40 meters in a single bout of flight (Myrick and Baker, 2019), sticky banding a valuable tree is no guarantee of protection. However, nymphal SLF are constrained to travel afoot, and so in theory will be unable to infest a banded tree's canopy.

Additionally, there has been recent development in the use of lures for SLF. Methyl salicylate was shown to be particularly promising in a study by Cooperband *et al.* (2019) and was employed again by that lab in a later study (Francese *et al.*, 2020). Lures may be able to improve sticky band catch of SLF significantly. However, methyl salicylate, a volatile organic compound released by many plants in response to herbivory, is an attractant of many insect species, including a variety of beneficial insects (see James, 2003; James and Price, 2004, and other similar studies). Whether or not methyl salicylate lures increase the catch of beneficial arthropods is worthy of investigation.

Sticky banding in the early season may provide adequate control over SLF nymphs, but the procedure appears to be nearly worthless for controlling SLF adults. The adults are caught in low numbers and are not necessarily prevented from infesting the tree as they may travel to the canopy by flight, bypassing the sticky band. At the same time, the bands catch a startling number of nontarget arthropods, primarily flies. Sticky banding will not reverse the invasion of SLF and even its impact on local infestations is uncertain. I propose that, barring developments in lures or other innovations in the technique, sticky banding should desist as soon as SLF adults emerge.

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REFERENCES

Barringer, L. E., Donovall, L. R., Spichiger, S. E., Lynch, D., & Henry, D. 2015. The first new world record of Lycorma delicatula (Insecta: Hemiptera: Fulgoridae). *Entomological news 125*(1), 20-23.

Biddinger, D., Leach, H. L., & Heather L Leach Articles Spotted Lanternfly Management for Homeowners Articles Spotted Lanternfly Management. (2020, April 4). Updated Insecticide Recommendations for Spotted Lanternfly on Tree Fruit. Retrieved from https://extension.psu.edu/updated-insecticide-recommendations-for-spotted-lanternfly-on-tree-fruit

Cooperband, M. F., Wickham, J., Cleary, K., Spichiger, S. E., Zhang, L., Baker, J., ... & Carrillo, D. 2019. Discovery of three kairomones in relation to trap and lure development for spotted lanternfly (Hemiptera: Fulgoridae). *Journal of economic entomology 112*(2), 671-682.

Francese, J. A., Cooperband, M. F., Murman, K. M., Cannon, S. L., Booth, E. G., Devine, S. M., & Wallace, M. S. 2020. Developing Traps for the Spotted Lanternfly, Lycorma delicatula (Hemiptera: Fulgoridae). *Environmental Entomology*.

Han, J. M., Kim, H., Lim, E. J., Lee, S., Kwon, Y. J., & Cho, S. (2008). Lycorma delicatula (Hemiptera: Auchenorrhyncha: Fulgoridae: Aphaeninae) finally, but suddenly arrived in Korea. Entomological Research, 38(4), 281-286.

James, D. G. 2003. Synthetic herbivore-induced plant volatiles as field attractants for beneficial insects. *Environmental entomology 32*(5), 977-982.

James, D. G., & Price, T. S. 2004. Field-testing of methyl salicylate for recruitment and retention of beneficial insects in grapes and hops. *Journal of chemical ecology 30*(8), 1613-1628.

Kim, J. G., Lee, E. H., Seo, Y. M., & Kim, N. Y. 2011. Cyclic behavior of Lycorma delicatula (Insecta: Hemiptera: Fulgoridae) on host plants. *Journal of insect behavior 24*(6), 423.

Merlin, M. (2019, June 5). Sticky tape meant to snare lanternflies also catching birds and squirrels. Retrieved from https://www.mcall.com/news/breaking/mc-nws-spotted-lanternfly-banding-bycatch-20190605-knqyk3kogfb6djsmiheckmdboi-story.html

Myrick, A. J., & Baker, T. C. 2019. Analysis of anemotactic flight tendencies of the spotted lanternfly (Lycorma delicatula) during the 2017 mass dispersal flights in Pennsylvania. Journal of Insect Behavior, 32(1), 11-23.

New York State Integrated Pest Management. Management: Introduction and Sticky Bands. (n.d.). Retrieved from https://nysipm.cornell.edu/environment/invasive-species-exotic-pests/spotted-lanternfly/spotted-lanternfly-ipm/management-introduction-sticky-bands/

New York State Integrated Pest Management. Introduction, Native Range, and Current US Range. 2020. https://nysipm.cornell.edu/environment/invasive-species-exotic-pests/spotted-lanternfly/spotted-lanternfly-ipm/introduction-native-range-and-current-range-us/

Urban, J. M. 2020. Perspective: shedding light on spotted lanternfly impacts in the USA. *Pest management science 76*(1), 10-17.

Winfrey, K. (2018, October 10). Reports: Lanternfly 'sticky bands' catching birds, squirrels. Retrieved from https://www.wfmz.com/news/area/berks/reports-lanternfly-sticky-bands-catching-birds-squirrels/article_a7bf6abe-a093-5870-9eed-90bf905efbbe.html