**Thoughts on 2018 research on the Spotted lanternfly, *Lycorma delicatula*,in Berks County PA**

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**Observation of habitat**

 From field research I have been doing this year the Spotted lanternfly, *Lycorma delicatula*, is an insect of ecotones. Locally we have four distinct ecosystems: urban, suburban, rural and forest. Three of these ecosystems are primarily ecotones: urban, suburban and rural. To this point the three most common food plants in order of preference appear to be *Ailanthus altissima*, *Vitis sp.* and *Celastrus orbiculatus*. *Acer saccharinum*, an ornamental tree common near where I live, appears to be another food source when *A. altissima* and *Vitis sp*. are not available.

 Urban ecosystems tend to be fragmented with few if any forested areas more than 100 yards across. Mostly, they are a series of vacant lots, small hedgerows between properties, utility right-of-ways and similar disturbed areas where plants grow. Additionally, there are domesticated trees planted by municipal authorities and landowners. Manmade surfaces abound where SLF eggs can be deposited and vehicles to transport SLF across the landscape. The distances between parts of the ecotone appear to be easily traversed by SLF without human help since they are often short. Therefore, this appears to the most highly infested of the four local ecosystems.

 Suburban ecosystems are less fragmented than urban areas but have similar characteristics in having vacant lots, disturbed areas between properties and utility right-of-ways with few deeper forested areas. Landowners and local government bodies plant domesticated plants, like urban governments, but on larger tracts of land. The largest difference is that there tends to be more space between buildings and larger patches of land where plants can grow with fewer manmade surfaces and vehicles. Still the distance between parts of this ecotone are relatively short.

 Rural ecosystems have more open space and larger blocks of trees, yet with the same patchwork of hedgerows, abandoned tracts of land, utility right-of-ways and similar as urban and suburban ecosystems. The biggest differences are that the hedgerows can be deeper/longer, there are small forests scattered across the landscape with many fewer vehicles and manmade surfaces and the distances between parts of the ecotone are further.

 Forested ecosystems tend to be large areas of deep forests with longer and fewer edges even though roads, trails and utility right-of-ways run through them. This is critical because most of the plants that the SLF feeds on appear to be ecotone plants, not plants of the deep forest. I seldom find *A. altissima*, *Vitis sp*. and *C. orbiculatus* more than a few yards deep in forests, except where an ecotone was created by geological features, fallen trees or human disturbance. I have yet to find SLF on any of the forest trees beyond the edges of an ecotone. Therefore, this appears to be the least heavily infested of the local ecosystems I have investigated.

 Each of these ecotones has different challenges in SLF control. Urban areas have closely spaced ecotones separated by roads of varying width and utility acting as minor boundaries for SLF spread and more people which apparently enhance SLF spread. Suburban and rural areas have decreasing numbers of roads with decreasing traffic loads and fewer people making the spread of SLF slower. Forested areas are the slowest for the spread of SLF because there are fewer people to facilitate its spreading and food sources tend to be further apart.

**Hypotheses on food consumption**

 To determine which woody plants are susceptible to SLF predation, analysis of the nutritional content of their sap needs to be done. Use *Ailanthus altissima* as a baseline since from observation it is the plant with the heaviest infestation and the one it feeds on in its original home. First test qualitatively for overall sap components of *A. altissima*. Then test quantitively for total sugars, proteins, fats, specific sugars and micronutrients. Compare this data to data from either specific species SLF may be using as an energy source or members of their families. Using sugar content as the primary test of plant desirability it can be assumed plants with the highest sugar content are preferred food.

 Another part of this is to run the same quantitative tests on the waste SLF produces on *A. altissima* to determine the amount of sugar and/or other nutrients in the waste, comparing it to the same from other potential food sources. The higher the sugar content in the waste, potentially the higher the sugar content in the tree because apparently the excess sugar will be in the waste produced by the SLF.

**Supporting concepts on food consumption**

 A more complex and accurate predictor of plant preference is the analysis of the utility a plant has for the SLF. Utility is the amount of benefit an organism derives from a specific resource. U = (pU-c)/T. Utility = (potential Utility-cost)/Time. Potential utility is the maximum utility which can be obtained with no cost. Costs can be related to the sugar concentration of the sap (either too low or too high to use without additional energy expenditure), a different primary sugar than *Ailanthus*, sap viscosity and potential toxins in the sap which need to be dealt with, hardness of the bark, thickness of the bark or noxious/toxic chemicals in the bark. Time can either be by life stage from egg to senescence, end of a (the) reproductive cycle or a discrete unit of time such as minutes, hours or days. Environmental factors such as air temperature, bark temperature, humidity, amount of direct/indirect sunlight on the food source, state of the food source – bud break, full growth, dormancy and the amount of rain – flood, drought and time from most recent rainfall may change the utility values. The higher the quality of the food and the greater ease of access, the more utility it has. Hence, the higher the U value, the more energy for growth and reproduction.

**Observation of gender ratio**

 This may have a gender component as it is generally accepted that in most species males have a much lower reproductive cost than females. Therefore, males may be able to use a resource of lower quality or less of a high-quality resource than females because of their lower breeding cost. If this is true, then it helps ensure his progeny and the reproductive viability of the species by reserving either higher quality resources or more of a higher quality resource for females to maximize their reproductive success.

**Observation of egg laying strategy**

 Egg laying is an aspect which is confounding me. There appear to be mixed strategies of single females laying eggs and covering them relatively far from other females such as different trees/surfaces and group egg laying either contiguous to or near each other. This becomes more complicated because it appears that one SLF female may lay eggs close to the eggs of another female with the second female covering both sets of eggs. Then there are the eggs which are not covered which adds another dimension to the puzzle. The large communal egg masses are much less common than egg masses randomly scattered on a single tree or across the landscape on a variety of plants and surfaces. So far, I have found eggs on grey birch, black birch, pignut, choke cherry, wild grape, silver maple, box elder, oak sp. and *Ailanthus*.

**Supporting concepts on egg laying strategy**

All the egg laying strategies can be reduced to game theory in the same way determining food sources is. The biggest mistake is to assume that what we see in this area is not reflective of where the SLF originated. Egg masses scattered around a landscape may ensure lower egg predation in the home habitat. Whereas, egg masses on a food source ensures that hatching nymphs have a readily available food source. Large masses of eggs in a small area may ensure that if egg predation occurs, some of the eggs will survive. The problem with assigning values to variables such as predation and proximity to food is that we do not know what the conditions are in the original habitat. When the SLF became established here the variables changed. What was a good strategy in Asia, may be a neutral or negative strategy here. Or, the strategy is good here for different reasons than in Asia. The scattering of the eggs across the landscape in Asia may have avoided predation, but here allows for the efficient movement of multiple generations of SLF across our landscape. The one constant is that the egg laying and other survival strategies are rapidly evolving to meet the new challenges offered by our ecology as it is different than the home ecology of the SLF.

Dec. 12

**Observation of egg masses and location**

 What I have been learning in the last week or so is that the apparent chaotic egg laying and the coating on top of the egg masses, with subsequent color changing and cracks developing may in part be the SLF camouflaging the egg masses from the egg predators which it experienced in Asia. When I looked at the local trees and the egg masses, there are a lot of similarities between the egg masses, lichen, cankers and similar on the bark of trees. However, this is not Asia, so I cannot say exactly what the Asian vegetation looks like.

 An issue I came across today was that gypsy moth habitat and SLF habitat overlap and their eggs may be laid on the same trees. The only difference I see is that SLF is confined to the edge of forests, hedgerows and other ecotone areas since this is where its primary foods are located. The gypsy moth lays eggs on trees wherever it finds them, including the deep forest, the edge of forests, hedgerows and trees in cities. Gypsy moth egg masses are light brown foam while SLF egg masses are smooth, sometimes going from dirty white to light tan after laying. I am not sure if there is an overlap or the extent of the possible overlap of food plant species that Gypsy moths and SLF feed on. The timing of the egg laying is different. Gypsy moths tend to lay eggs mid to late summer. SLF egg laying appears to be late summer to a killer freeze.

**Supporting concepts on egg laying location**

The timing may be based on the preferred foods of each. Gypsy moth larvae feed mostly on the leaves of deciduous hardwoods, which come into leaf late winter to mid-spring. This is much earlier in the year than *Ailanthus*, which comes into leaf in the late spring, one of the last trees to do so. Emergence of the immature stage for both may also be related to their food sources and feeding method. Gypsy moth larvae feed by chewing and digesting leaves. This is very different than the SLF nymphs and adults drilling into a plant and sucking the sap. I am not sure how much ahead of bud break and leafing out sap runs in *Ailanthus* or how much after leaf drop it continues. This will affect the timing of SLF egg hatching since *Ailanthus* still appears to be the primary food of SLF.

**Observation of egg laying location**

 One last observation I made today is that I found SLF eggs only on grey birch trees in and surrounding the stand of *Ailanthus* trees. No egg masses were found on *Ailanthus* trees where I had seen SLF earlier in the fall. Reviewing the photos from earlier today, there were generally one to three egg masses on each grey birch where the eggs masses were found. As usual there was no apparent order in the scattering of the egg masses within the grey birch stand. This needs more time walking to see if this is generally true in other areas.

 A general ongoing observation is that I have seldom seen SLF egg masses much higher than 4 or 5 feet off the ground. The one obvious exception is on domesticated silver maple.

**Supporting concepts on genetic traits**

 *Ailanthus* has been isolated from the SLF since the mid-1700’s when seeds were brought from China to Paris. Next the tree went to London before coming to Philadelphia after the end of the American Revolutionary War in 1784. As often happens, when a defense is no longer needed it will either cease to exist or exist at a very low level. It will be exciting to watch the changes in *Ailanthus* over time with the reintroduction of this threat to it and the possibility that the tree by itself will control the SLF by bringing back or reinventing defense mechanisms to this specific threat. \*

 A final point is that the SLF was introduced in this country only a few generations ago, perhaps four generations, but most probably several more. What will happen in the next several years is hard enough to guess. What may happen beyond that is beyond our ability to comprehend at the present time. That the SLF we are seeing are derived from one to a few females is important. The fewer parents the more limited the gene pool. This means that the SLF does not have the full genetic toolbox of where it came from to deal with multiple new challenges such as predators, disease and foods (which may be toxic) in its new home. There lays our greatest hope – that the SLF will encounter a challenge which will either control it or hopefully eradicate it.

Dec. 20

**Supporting concepts on travel**

 If my observations about grasshoppers are correct, in general hoppers, especially big ones, need long open areas to move in because they do not have the ability to control their flight the way flyers such as moths and black flies do. This is what edge habitats/ecotones are usually like, wooded areas next to open fields.

 To make the jumps between feeding and egg deposition areas may mean long straight leaps along the edge of a forest, across a field or down a hedgerow. Shorter jumps in the edges of wooded areas of 2 to 10 feet from one food source to another or to an egg laying site are not a problem in a wooded area. However, the longer travelling jumps during the apparent explosion of adults across the landscape during the fall are only possible in open areas and along the outside edges of hedgerows and wooded areas. This further reinforces the idea that SLF is not a forest pest, but can be one of rural, suburban and urban areas which are composed of a mixture of hedgerows, small forests and large open areas. This is one area I intend to research this fall.

 Dec. 21

**Observation of habitat as compared to gypsy moth**

 The gypsy moth, *Lymantria dispar*, is a far more destructive pest of forests than the SLF. A few years ago, I saw hardwood trees completely stripped of their leaves and covered with Gypsy moth egg masses in the forest just east of Port Clinton. In areas of similar size, I may see perhaps a dozen SLF egg masses compared to hundreds of gypsy moth egg masses. SLF primarily feeds on *Ailanthus*. Gypsy moths feed on most hardwood and coniferous trees. The difference is that SLF lives where we do, in the cities and suburbs. To see the gypsy moth requires going to a forest. Hence, SLF is much more visible than the more destructive gypsy moth.

Dec. 31

 An important observation in the comparative damage between Gypsy moth and SLF is that the range of the SLF is a subset of the range of the Gypsy moth in the same way the SLF foods are at best a subset of Gypsy moth. (I am not sure if Gypsy moths feed on the same foods as SLF, but SLF does not feed on the same range of foods as Gypsy moths.) Throughout my life I have seen Gypsy moth egg masses in urban, rural and forested areas. I have yet to see SLF egg masses more than 50 feet into a forest with the egg masses deposited in reference to nearby *Ailanthus* trees or wild grape.

**Hypotheses on gender ratio**

  One of the odd consequences of the Spotted Lanternfly is that it may move diseases between *Ailanthus* trees. If so, this will be at the point where the nymph stage becomes adults and explosively move across the ecology. Once the adults settle on an *Ailanthus* tree, I doubt they move except females to lay eggs on non-*Ailanthus*. I’m not sure, but doubtful, that females move afterwards to a different *Ailanthus* tree in a stand to feed until dying or to feed until producing a second brood. My observation is that there is an unexpectedly large skewed gender ratio in favor of males on *Ailanthus* trees instead of the expected one-to-one correspondence between the genders. Either I am unable to tell sexually immature females from males or more probably females die soon after egg deposition while males continue living until a hard freeze kills them.

**Observation of egg laying**

 On Dec. 24, we walked from the gate at the lower parking area in SGL110-10 to the top of the ridge on a dirt road built by the PA Game Commission. Very clearly, SLF hitched rides on vehicles from different parts of Berks County and dropped off on the way up the mountain to lay eggs no more than 30 feet from the dirt road. Also, once at the top we found many dead SLF still stuck to *Ailanthus* trees, but not one egg mass on any of the 30+ to *Ailanthus* trees.

**Hypotheses on fertility after feeding on wild grape, silver maple and *Ailanthus***

 If close association of SLF egg masses with wild grape vines (*Vitis sp.*) is a valid indicator of fertility, then feeding on *Ailanthus* is not required for egg production. To this point I have found this association weakly along the Appalachian Trail at Ft. Franklin Road, Lehigh County and strongly along the Appalachian Trail at Rt. 183, Bethel township, Berks County. At both locations I found SLF feeding on wild grape earlier in the fall without any *Ailanthus* trees nearby. Along Sterner Hill Road, Blue Marsh and SGL110-10 on the service road to the top of the ridge, headed towards the Auburn Overlook, there is a strong association between SLF egg masses and *Vitis sp.* without nearby *Ailanthus* trees. I will continue looking for similar associations to strengthen the argument and checking these egg masses for hatched SLF nymphs in the spring. For me the only definitive proof of viable reproduction is an F2 generation, grandchildren. The F1 generation, children, can be sterile, which means that even though the parents produced viable eggs they were still not successful in reproducing their parental line and the species.

 I will be also be checking domesticated silver maples (*Acer saccharinum*) in a friend’s yard to look at the egg masses for hatching in the spring.

 From observation at multiple sites such as the end of Peacock Road, Blue Marsh, SGL110 near the Auburn Overlook, Sterner Hill Road towards the lake, Blue Marsh and elsewhere, feeding on *Ailanthus* trees does not guarantee egg laying. This may be due to a chemical produced by *Ailanthus* either preventing SLF sexual maturation or a similar cause which in effect sterilizes SLF.

**Concluding thought**

 My biggest concern is that “researchers” are biasing their data and results by being intent on “solving” this apparent problem instead of observing and knowing SLF and its effects. It is vital at this point that scientists spend most of their time walking and observing instead of participating in the nonsensical and naïve panic which is infecting everyone from homeowners to farmers and politicians. The proposed strategy which I heard about of trying to remove all the *Ailanthus* trees from the infested area is one without practical application. It would require walking every square meter of land to locate possibly 10,000,000 *Ailanthus* trees. Then when it is discovered that SLF can reproduce after feeding on *Vitis sp.* will there also be attempts to remove that from the ecology? And, and, and?

**WALK MORE AND TINKER LESS**

\*The wild (European) parsnip *Pastinaca sativa* L. apparently decreased its defenses when introduced to the European North American colonies in the early 1600’s due to the lack of a principal herbivore - the parsnip webworm, Depressaria pastinacella. Defenses built back up with the accidental reintroduction of *D.* pastinacella in the late 1800’s. (Increase in toxicity of an invasive weed after reassociation with its coevolved herbivore, Arthur R. Zangerl and May R. Berenbaum, PNAS October 25, 2005 102 (43) 15529-15532.