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Browntail Moth Research at the University of Maine: A Report of Activities and Findings 2016-2020

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Browntail Moth Research

at

THE UNIVERSITY OF MAINE

A Report of Activities and Findings

2016-2020

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Browntail Moth Research at the University of Maine

FIGURE 1*. Browntail moth late stage caterpillars*

The browntail moth (Fig 1) has become a very serious problem for many communities in southern, midcoast and central Maine over the past several years as this insect has reached populations levels that we have not seen in 80 to 100 years. Researchers at the University of Maine have teamed up with entomologists in the Maine State Department of Agriculture, Conservation, and Forestry Maine Forest Service (MDACF) to track the spread and investigate the causes of the outbreak and evaluate management strategies for this daunting pest. As most homeowners in the infestation areas* know, in addition to the damage to the trees that they feed on, the larger caterpillars of browntail moth have urticating or "irritating" hairs that can cause severe skin rashes for those people unfortunate enough to encounter them**. And, at outbreak densities, it is hard not to encounter them if they are infesting trees around your home, because the caterpillars feeding in the trees drop microscopic toxic hairs with their cast skins every time that they molt. We have found that the caterpillars molt 3-4 times from the time that they emerge from their winter webs in late April/early May to when they pupate in late June.

*MDACF Risk Map provides current data on areas impacted by browntail moth. See: https://www.maine.gov/dacf/mfs/forest_health/documents/Browntail%20Moth%20Exposure%20Risk%202020.pdf

**For more on the health effects of browntail moth, see: https://www.maine.gov/dhhs/mecdc/infectious-disease/epi/vector-borne/browntail-moth/browntail-moth-faq.shtml

FIGURE 2. *Browntail moth winter webs collected for the public bounty. Photo from 1910 USDA Bulletin: "Report on the Field Work Against the Gipsy Moth and the Brown-Tail Moth"[4]*

***A Brief History**:* Browntail moth is an invasive forest pest that was accidentally introduced in 1897 from Europe into Cambridge, Massachusetts. After its initial establishment, the insect rapidly spread through the northeast, encompassing an area of 150,000 km^2 from Long Island, NY to New Brunswick, Canada[1]. During this period, the U. S. Department of Agriculture launched a massive biological control effort to introduce natural enemies from the native range of this insect into these areas[2]. After this rapid expansion, browntail moth populations declined in the 1920's and 1930's, likely due to a combination of insecticide spraying, biological control, public action initiatives (Fig 2), and changes in the landscape[1]. There were some small outbreaks in the historic range in the 1960's. Since the time of its range retraction, browntail moth populations have remained in small isolated areas of the Casco Bay Region, Maine and on Cape Cod, Massachusetts. Since the early 1990's, small, localized outbreaks of browntail moth (100 to 10,000 acres) have occurred infrequently in communities along the coast from Freeport to Georgetown and surrounding Merrymeeting Bay[3]. However, from 2016 to 2019, Maine has experienced a dramatic increase in the infestation area such that as of winter 2020, traces of populations were found as far north as Calais, Maine, as far inland as Cambridge, Maine, and as far south as Scarborough, Maine (See MDACF Risk Map).

***FIGURE 3**. An adult browntail moth female. Photo: K. Boyd*

Life Cycle**:**_Browntail moth (Fig 3) have a unique life cycle (Fig 4) when compared to similar insects. The females lay their eggs on leaves at the tops of host trees in the later part of July. Eggs hatch in August and the young caterpillars feed gregariously into the early fall, constructing their winter webs (hibernacula) in which they spend the following eight months. The overwintered caterpillars emerge in late April and feed and grow until pupating in the latter half of June. Adult moths emerge from their pupal nests in July, mate, and start the cycle again. The life stages encountered by most people are the late-stage caterpillars (larvae) and pupation nests which are

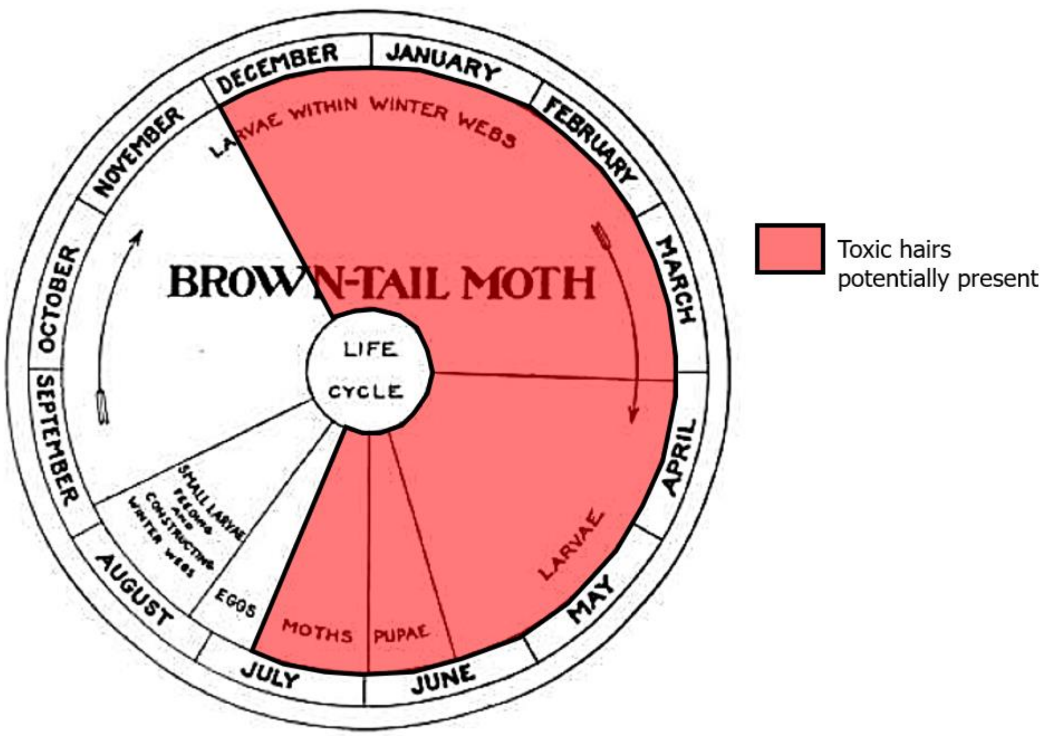


FIGURE 4. *Life cycle of the browntail moth adapted from Burgess and Crossman 1920 to show hazardous stages.*

present from May through July (For more information, see the MDACF webpage at https://www.maine.gov/dacf/mfs/forest_health/invasive_threats/browntail_moth_info.htm). Toxic hairs may be present in the winter webs stage, through the spring and summer caterpillar and pupal stages to the adults. Moths themselves do not seem to produce toxic hairs but the hairs may be present after they emerge from pupation nests.

Population Abundance and Survival throughout the State

Previous hypotheses have described "cold winter temperatures" as possible reasons for why the browntail population initially collapsed in the early part of the 20th century[1,5]. However, studies have shown that cold winter temperatures, sometimes below the threshold that browntail moth survive in laboratory studies, does not impact the survival of winter webs[5]. One of the few and perhaps most detailed study of browntail moth in the U.S. was conducted by Dr. Paul Schaefer when he was PhD student at the University of Maine in 1974. He suggests that there is likely a relationship between host tree, silk chemistry, web size and weight, and climatic conditions that all determine overwintering survival[1].

Dr. Eleanor Groden, Professor of Entomology, led the browntail moth research project at the UMaine from 2016 until her retirement in September 2019. Two graduate and 15 undergraduates assisted Dr. Groden in her efforts to study this pest and potential management strategies.

Dr. Groden and her students collected browntail moth at different life stages from 2016-2018 across the state. These included overwintering webs in March and April, late-stage larvae in early June, and pupation nests in late June and July. Overall, 770 winter webs, 1,275 larvae, and 1,526 pupation nests containing 4,810 pupae were sampled across 22 townships between over the three years. These individuals were reared and examined in the laboratory to assess their survival and natural enemies. In addition to these collections, abundance was also estimated in the field using winter web survey data from the MDACF and timed 10-minute density counts conducted by UMaine graduate students.

Chase Gagne was a field technician for the browntail moth project from 2016 - 2017, then went on to complete a M.S. in Entomology studying insect communities in rockpools along the Penobscot River. Chase now works with the USDA APHIS in Hermon, ME.

We found that abundance of winter webs differed across townships in Maine (Fig 5), but survival of larvae emerging from winter webs did not differ between sites or years. Densities on average across the infested sites decreased across sites between 2016 and 2018, at the same time that the infestation area increased. Overwintering survival of caterpillars across Maine was 45% and 73% in 2017 and 2018, respectively.

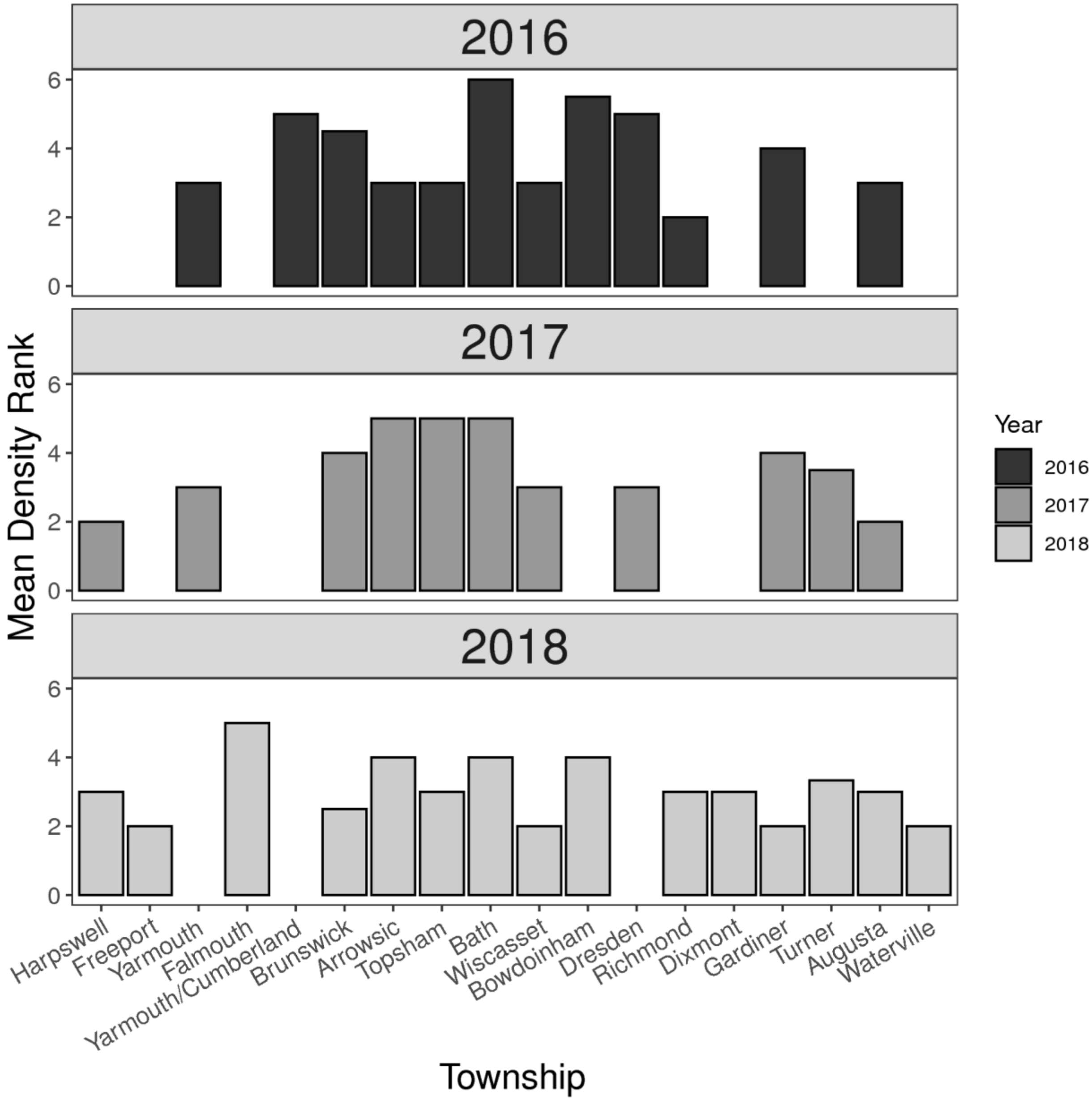


FIGURE 5. *Mean rank of browntail moth overwintering webs by township, from survey data provided by the Maine Department of Agriculture, Conservation, and Forestry. Note: Missing bars are those townships that did not have observed winter webs. Ranks are as follows: 0 = 0 webs, 1 = 1 - 9 webs, 2 = 10 - 99 webs, 3 = 100 - 499 webs, 4 = 500 - 999 webs, 5 = 1,000 to 4,999 webs, 6 = 5,000+ webs.*

Survival of the feeding, overwintered caterpillars through the month of May into early June varied between sites and differed between years of our study, but was generally very high, averaging 80% and 98% of the collected caterpillars surviving to maturity in 2017*** and 2018, respectively. A few natural enemies did emerge from collected caterpillars and were identified (See "Natural Enemies").

****A naturally occurring fungal disease that infects browntail moth caterpillars was observed at many sites around Merrymeeting Bay in 2017 and killed most of the caterpillars before they could be surveyed and collected.*

When the browntail moth caterpillars mature, they frequently wander as they look for a site to pupate. We have found that at high densities, they frequently congregate and create communal "nests" for pupating in trees using leaves and their silk, with upwards of 100+ pupae in a single nest. Throughout our study, we have been interested in and focused on this stage in the browntail moth's biology, because most natural enemies attacking browntail moth caterpillars emerge during this stage and their accumulated attack on the feeding caterpillars can be determined. Survival of our collected browntail moth pupae was 52%, 29% and 34%, in 2016, 2017, and 2018, respectively, with emergence of healthy adult moths differing both across sites and between years.

Karla Boyd, completed her M.S. in Entomology in May 2020, researching the natural enemies of the browntail moth. Karla helped manage the browntail moth lab since 2016 and continues to analyze and write about the research.

The Natural Enemies of Browntail Moth

Previous studies have reported several species of natural enemies attacking browntail moth in the northeast U.S.[1,6]. These include nine parasitoid insects (Fig 6), the fungal pathogen, *Entomophaga aulicae*, and the virus *Euproctis chrysorrhoea* Nucleopolyhedrosis Virus (EcNPV). Our lab assessed parasitism, fungi, and virus incidence between 2016 and 2019 in order to understand the natural mortality in the population during the current outbreak.

FIGURE 6. *Rearing containers of browntail moth pupae in 2018. Pupation nests were monitored for emergence of moths, parasitoids, and fungi.*

Pupation nests were reared in containers in the lab between 2016 and 2018 (Fig 6). The adult parasitoids (Fig 7) attacking browntail moth lay their eggs in the eggs, caterpillars, or pupae of the browntail moth. Their larvae feed on the developing browntail and the next generation adults emerge from the host, killing them in the process. Between 2016 and 2018 the most prevalent primary parasitoid reared from samples of browntail moth pupae was *Townsendiellomyia nidicola*, a parasitic fly that specializes on browntail moth. In the latter part of the study, several hyperparasitoid wasps also increased in their abundance in browntail moth pupae (Fig 8). This is concerning because hyperparasitoids typically feed on the primary parasitoids, and hence reduce the success of other parasitoids, like *T. nidicola*. Although parasitism may control some insect populations, we do not believe that parasitoids are causing enough mortality to naturally control populations, likely a result of many generalist parasitoids and high rates of hyperparasitism.

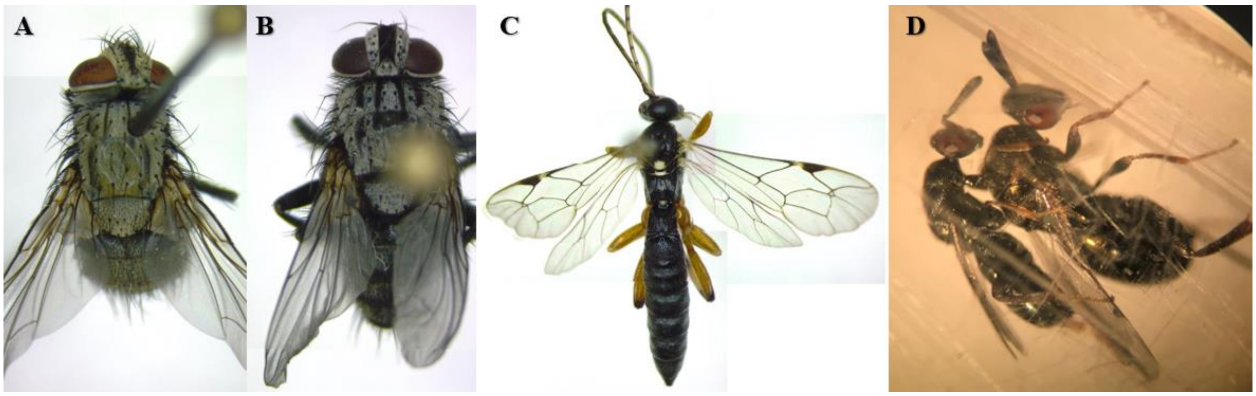


FIGURE 7. *A) Townsendiellomyia nidicola, a primary parasitoid that displayed the highest incidence of parasitism across all samples of primary parasitoids image via MDACF, B) Compsilura concinnata, a generalist primary parasitoid image via MDACF, C) Itoplectis conquistador, a generalist primary parasitoid native to the US image via MDACF and D) Monodontomerus aerus, a generalist hyperparasitoids that attacks many of the primary parasitoids in our study*. Photos: K. Boyd.

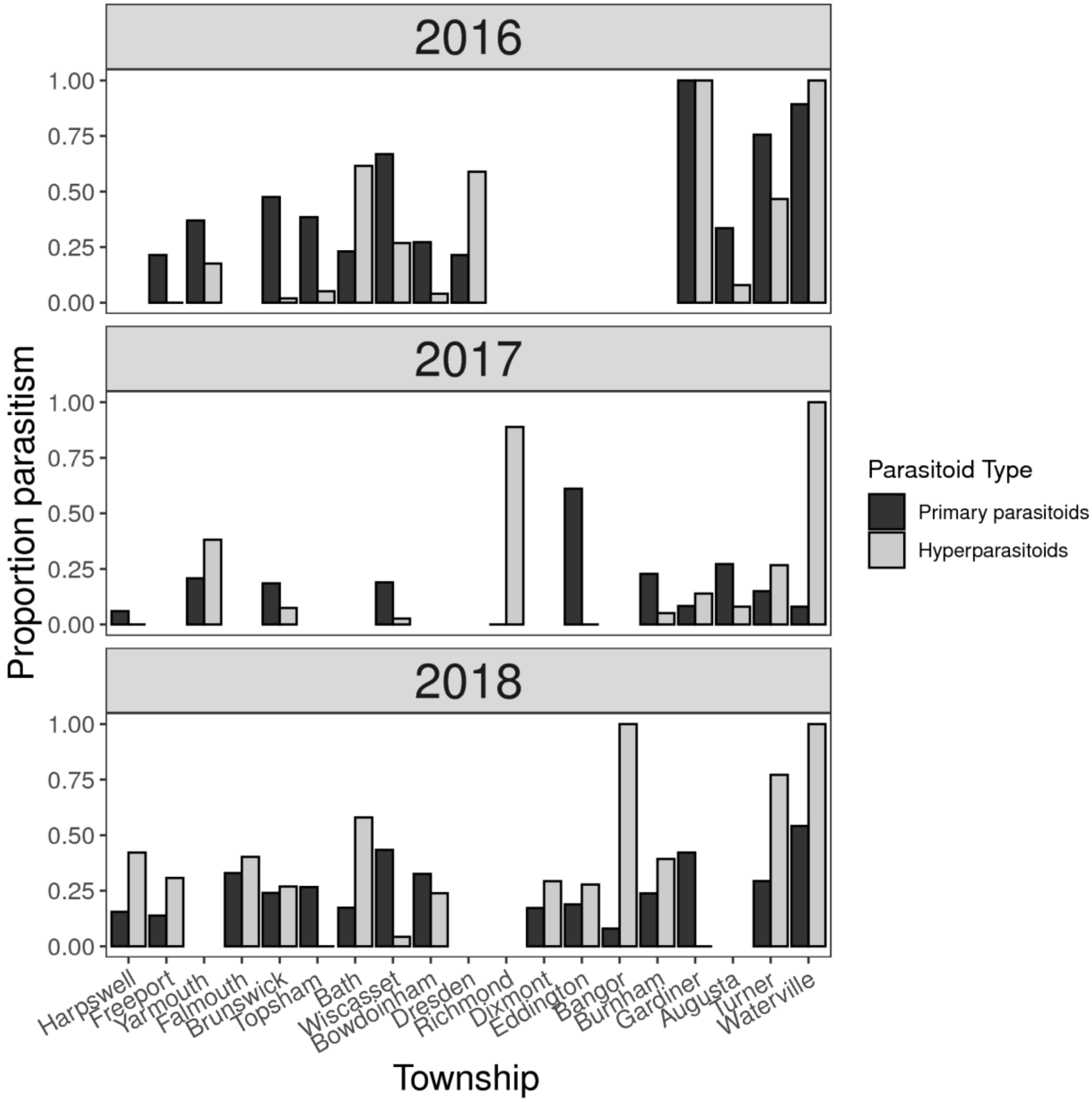


FIGURE 8. *Proportion of pupal nests with primary parasitoids and hyperparasitoids across townships in Maine. Note: Townships ordered left to right from nearest to coast to furthest from coast and pupal nests may contain more than 1 pupa.*

The fungus, *Entomophaga aulicae*, caused considerable disease in the browntail moth populations in 2017 and 2019. Molecular analyses (Fig 9) confirmed this species in 2018. These fungi are highly contagious to caterpillars at high densities, which cause localized disease outbreaks throughout populations in the mid-coast areas. During 2017 and 2019 the spring season was unseasonably cool with high amounts of precipitation. A total of 20% and 4% of larvae collected in 2017 and 2018 died of *E. aulicae* infection, respectively. Although favorable, these conditions did not cause as much widespread disease in northern and inland sites. Without sufficient rainfall AND disease inoculum, the disease will be slow to spread. More molecular analyses are needed to develop tools to successfully track this phenomenon and characterize situations in which this fungus can reduce caterpillar populations.

FIGURE 9. *Graduate student Karla Boyd extracting DNA from browntail moth caterpillars to confirm if fungal DNA is present in asymptomatic populations.*

We tracked the spread of the *E. aulicae* (Fig 10) outbreak in caterpillars through Maine in 2019 and preliminary analyses indicate that the disease incidence was very high early in the season from Portland north through the southern portion of the midcoast and around Merrymeeting Bay, and reached areas as far east as Deer Isle by late June. Although parasitoids are not considered to be effective at browntail population control, the fungus seems to control populations at a localized level during years with favorable spring conditions (high precipitation, low temperatures).

FIGURE 10. *An E. aulicae infected browntail moth caterpillar, with increased magnification to highlight individual fungal hyphae on the surface of the integument*, Photo: *K. Boyd*.

We microscopically examined several caterpillars collected throughout the state and recovered the virus, EcNPV, at only one site during our study. This was in a caterpillar collected in 2016 at a site in Bowdoinham where the MDACF had released the virus in prior years.

MANAGEMENT

Field Trial and Bioassays Against Feeding Caterpillars

FIGURE 11. *UMaine research technician and certified master pesticide applicator, Judy Collins, using a backpack mist blower to apply materials to trial areas in Harpswell, Maine in 2018.*

Between 2016 and 2019, the Groden lab conducted multiple laboratory bioassays to assess the susceptibility of browntail moth caterpillars exposed to six registered biorational insecticide products. Throughout these assays, both caterpillars that were newly emerged from overwintering webs in the Spring and larvae that recently hatched from egg masses in August were assessed. Survival of both Spring and Fall caterpillars was reduced by many materials, and there was no difference in susceptibility between the two stages, suggesting that management in early spring and late summer can be useful.

In 2018, three biorational products were selected for a field trial against overwintered browntail moth caterpillars (Table 1). The trial was conducted at multiple sites in Dresden and Harpswell, Maine, where individual trees were sprayed

(Fig. 11) and the density of caterpillars and defoliation post spray were monitored. In addition, immediately after spraying, treated leaves were collected and fed to browntail moth caterpillars held at different temperatures in the laboratory to see whether any materials performed better at cooler versus warmer temperatures. Results revealed that the Foray 48B® (BtK) was more effective at colder temperatures than Mycotrol® (BtK was even effective at 54°F, the lowest temperature tested). In the field, although one application of BtK significantly reduced caterpillars compared to the control, enough caterpillars survived to be of concern. Two applications, however, were effective. This result leads us to recommend that if applying Foray 48B® in the early spring, two applications may be necessary to reduce browntail moth populations for that season. Future research by Dr. Angela Mech (see below) will explore whether other forms of BtK will more effectively manage browntail moth with a single application.

Table 1. Success of materials used for the 2018 field trial in Dresden and Harpswell, Maine. Number of asterisks relates to the relative effectiveness of the treatment: *moderate, many surviving caterpillars, **few surviving caterpillars. **NOTE**: These are results from a single research trial and should be replicated. Not all products tested have been approved for private or commercial control of browntail moth.

Product	**Active ingredient**	**Did product reduce caterpillars compared with control?**
Foray 48B® (Btk) - 1 application	***Bacillis thurengensis* var. *kurstaki***	Yes*
Foray 48B® (Btk) - 2 applications	***Bacillis thurengensis* var. *kurstaki***	Yes**
Mycotrol®	***Beaverua bassiana***	No
Azasol™	**6% Azadirachtin**	No
Foray 48B® (Btk) + Mycotrol®	***Bacillis thurengensis* var. *kurstaki* + *Beauveria bassiana* (equal parts)**	No

Silk Research and Bioassays and Trials Against Caterpillars in Winter Webs

The browntail moth spends the majority of its life (7-8 months) as a dormant caterpillar in its winter webs, typically from September to April. The caterpillars construct these winter webs by tightly weaving leaves of their host plant together with silk they produce. Currently, winter webs are targeted by arborists who clip individual webs in the tree canopy, which can be extremely time consuming and costly. However, if there were materials that could be used to effectively treat webs during this time of year when there are few non-target organisms active and exposure to toxic hairs is low for both arborists and private landowners, it may provide a more cost-effective management tactic.

We, Dr. Groden, and now Dr. Mech in the School of Biology, and Drs. Barbara Cole and Ray Fort in the Department of Chemistry, and our students, Hye Weon Hwang, Phoebe Abrahamson, Eva Nazim, and Maggie Bradbury, have embarked on studies of the physical and chemical structure of

FIGURE 12. *Graduate student Karla Boyd and Maine Forest Service Entomologist Tom Schmeelk apply treatments to winter webs at field site in Harpswell, ME, December 2018.*

the silk that the caterpillars produce in order to explore whether there may be opportunities to disrupt this essential component of the browntail moth's biology. We also investigated whether a number of currently available products could: 1) disrupt the integrity of the silk, exposing the caterpillars more to harsh winter conditions, and/or 2) kill the caterpillars directly in the webs.

Ten different commercial products were tested in five bioassays conducted during 2019 and 2020 to determine if they had potential to reduce emergence of caterpillar from their winter webs (Table 2). Webs were sprayed with materials at recommended rates, but at high volume to assure maximum coverage (Fig 12). Sprayed webs were held either in the laboratory or outside with exposure to harsh winter conditions (Fig 13). We identified several products that when applied to the outside of the webs, killed the larvae inside the web, thereby reducing caterpillar emergence (See Table 2). However, caterpillars exposed to these materials died in equal numbers when held inside the laboratory after treatment compared with those being held outside. This indicates that the materials tested did not kill larvae by impacting the integrity of the silk and web and increasing their exposure to harsh winter conditions, but directly impacted the caterpillars through the web.

A final bioassay was conducted with the materials that killed caterpillars to evaluate whether their effectiveness would hold up at reduced volumes more realistic for arborists' applications. Two of the ten materials tested to date provided good efficacy at lower application volumes.

FIGURE 13. *Dr. Groden sampling treated browntail moth winter webs in Harpswell, Maine for a field trial of products on overwintering caterpillars.*

TABLE 2. Effectiveness of products applied to winter webs in reducing emergence of caterpillars from the webs. **NOTE**: These are results from research trials with direct treatment of webs. Studies should be replicated in larger scale field trials. Not all products tested have been approved for private or commercial control of browntail moth.

Product	**Active ingredient**	**Did product reduce caterpillar emergence compared with control?**
Safer® Soap	**Potassium Salts of Fatty Acids 49.52%**	No
Turbo Spreader Sticker	**Alcohol ethoxylate, alkylphenol ethoxylate 80%**	No
Orange Guard®	**d-Limonene 5.8%**	Yes*
All Seasons® Horticultural & Dormant Spray Oil	**Mineral oil (CAS No. 801209501) 98%**	No
AzaSol®	**Azadirachtin 6 %**	No
Entrust®	**Spinosad (Mixture of A and D) 80%**	Yes
PyGanic®	**Pyrethrins 5%**	Yes**
OxiDate® 2.0	**Hydrogen Peroxide 27.1%, Peroxyacetic Acid 2%**	No
Essentria® IC-3	**Rosemary Oil 10%, Geraniol 5%, Peppermint 2%**	Yes**
Mycotrol® ESO	***Beauveria bassiana* Strain GHA 11.3%**	No***

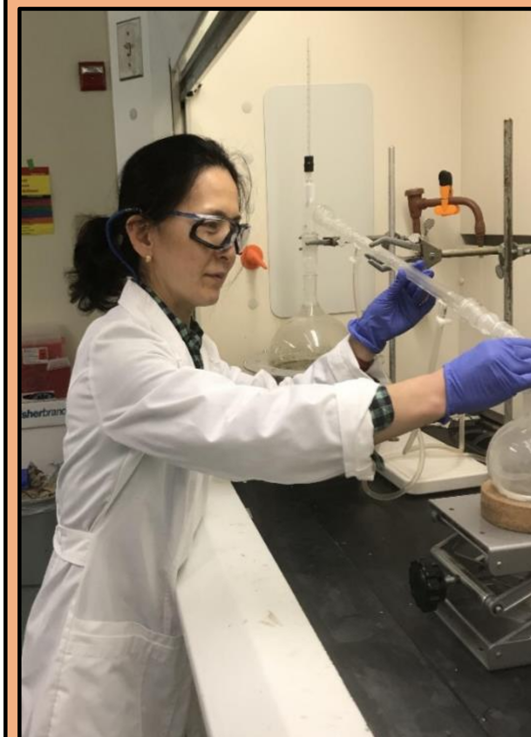
*Effective in initial assessments at recommended dose and high volume
**Effective in initial assessments and at recommended dose and medium volume
***Did not reduce the number of emerging caterpillars, but caterpillars became infected on emergence from the web and most died within 10 days

FIGURE 14. *An entomopathogenic nematode.*

With the help of undergraduate student, Katie Trebilcock, an additional study was conducted in the summer of 2019 to determine whether commercially available entomopathogenic (insect-killing) nematodes (Fig 14) could penetrate the webs and kill the caterpillars. Three different species of commercially available nematodes were evaluated in the laboratory. All three species killed browntail moths when sprayed directly on the caterpillars, with *Steinernema feltia* more effective than *S. carpocapse* and *Heterorhabitus bacteriophora*. However, when sprayed on the winter webs, *H. bacteriophora* was more effective than either of the *Steinernema* species. Currently available commercial entomopathogenic nematodes likely do not possess enough cold tolerance to be an effective management option in the early spring treatment of browntail moth. There is on-going research and development in the USDA and private companies on the development of commercially viable cold tolerant strains of nematodes. This development could make nematodes a viable option for late summer-early fall treatment of newly formed webs. Further studies will be needed to determine whether nematodes can be effective under conditions experienced in the field.

Silk Structure & Composition

Insect silk is often studied for its strength and composition, particular pertaining to the cosmetic industry. Other than the silk moth, *Bombus mori*, which produces commercial silk during its preparation for pupation, few insects have had their silk analyzed. Spider silk has also studied for its strength and elasticity and potential chemical and engineering applications in industries. Browntail moths use silk to construct dense webs in which they overwinter in as caterpillars. The overwintering webs have recently been the focus of study for projects at the University of Maine, because they are in this state for seven to eight months of the year, they are easily visible in the winter, and they are safer to handle than large caterpillars. Also controlling them at this stage would prevent toxic hairs from entering the environment and there would be fewer non-target insects affected by treatments at during this timeframe.



Dr. Hye Weon Hwang helped with BTM silk analysis. She completed her PhD in Chemistry in May 2020, researching phenolic phytochemicals in Maine-grown plums.

In collaboration with the Department of Chemistry, browntail moth overwintering silk was compared to the silk moth, *B. mori*, cocoon silk using Scanning Electron Microscopy (SEM). We found two remarkable differences between BTM overwintering silk and *B. mori* cocoon silk. The diameter of BTM silk was much smaller than that of *B. mori* silk, about 2 μm and 12 μm, respectively. BTM silk also did not contain sericin, a "glue-like" protein coating that encases the two strands of silk, fibroins, produced by *B. mori*. Due to the presence of the sericin coating, *B. mori* silk appeared to have a rough surface in the SEM image (Figure 15A), whereas BTM silk showed a smooth surface (Figure 16A). When cross sections of silk sheets were compared, the BTM silk sheet had uniform layers of air between thin layers of silk, forming a highly organized layered sheet (Figure 16B). In contrast, the silk sheet from *B. mori* was far less ordered and did not have distinct layers (Figure 15B). We hypothesize that this alternating silk and air multilayered structure in the BTM silk sheet provides excellent insulation, allowing the caterpillars to survive harsh winter conditions. We also observed that the BTM silk sheet changed physically when it was treated with water and subsequently dried, forming a hydrogel-like material in water and a stiff paper-like structure upon drying. This physical change with water may contribute to its ability to maintain mechanical strength despite frequent precipitation during the winter.

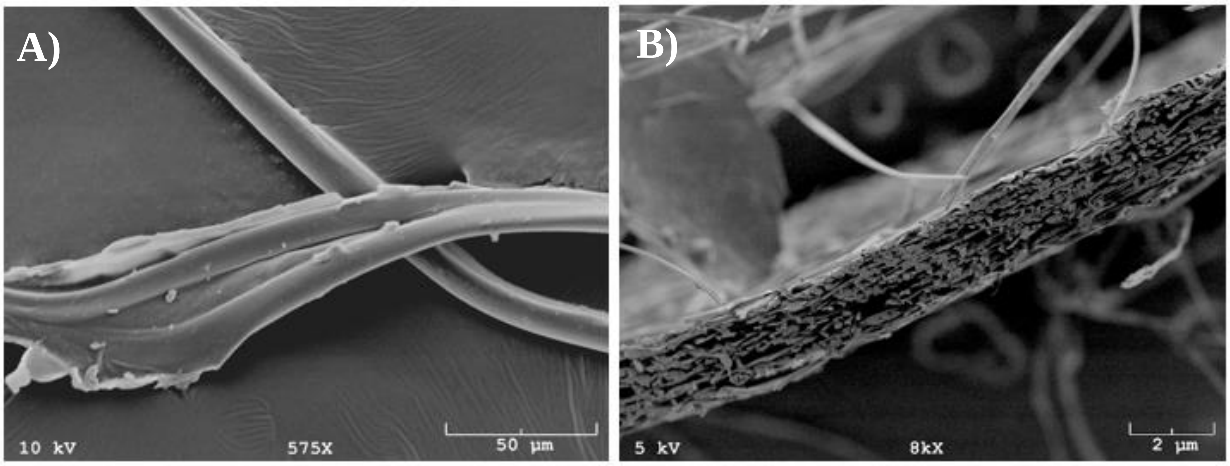


FIGURE 15. *Scanning electron microscopy of A) Individual strands of commercial silkworm (Bombus mori) silk with a rough, sericin coating B) A cross-section of several strands of B. mori silk.*

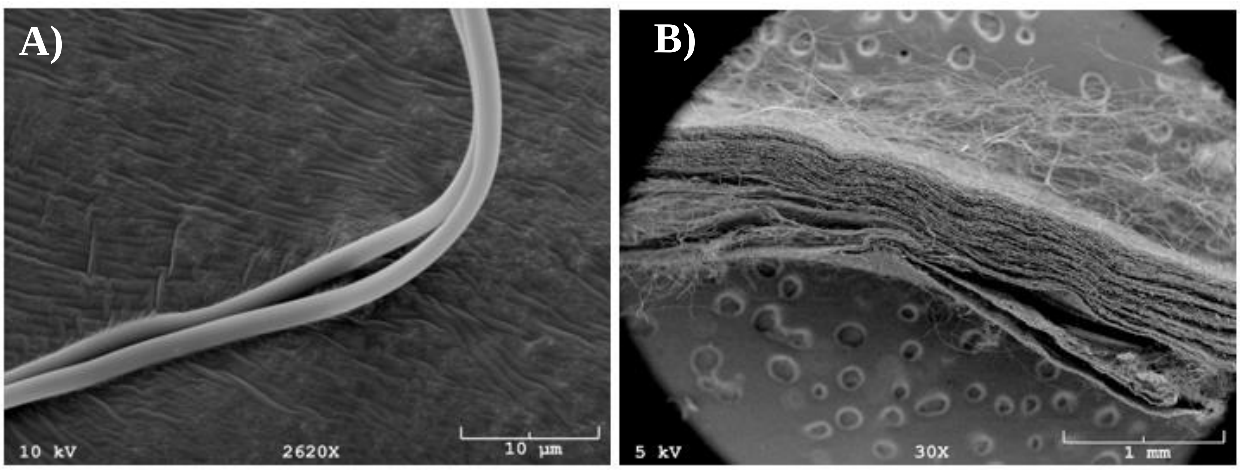


FIGURE 16. *Scanning electron microscopy of A) Individual strands of browntail moth (Euproctis chrysorrhoea) silk, B) A cross-section of several strands of browntail moth silk.*

The Big Picture

FIGURE 17. *A browntail moth winter web.*

The current outbreak of browntail moth has encompassed parts of its historical range in Maine, with detections of webs found in Novia Scotia, Canada in the winter of 2020. During the initial outbreak between 1897 and the 1930s and in subsequent years, several methods that would be considered irresponsible by today's standards were employed to reduce browntail moth populations. This included heavy pesticide use (lead arsenate then DDT, and other pesticides that are now banned), offering financial bounties for collection of winter webs, and release of unvetted imported parasitoids, among other methods[1]. It is unclear if these led to any success or if browntail populations eventually declined due to some other factors. It is important to note that it took decades for the initial early outbreak to subside. The goal of researchers at the University of Maine is to understand the biology, ecology, and biochemistry of browntail moth, in addition to finding current, environmentally ethical options for management of this pest. The Department of Agriculture, Conservation, and Forestry is monitoring for disease in the browntail population and attempting to move infected caterpillars between trees to facilitate localized epizootics throughout heavily affected areas. Private landowners may be able to control small populations using two applications of Foray 48B® *BtK*) in the early spring when caterpillars are emerging from winter webs (Foray 48B® is approved for use against browntail moth), but may need to be re-applied seasonally to maintain management. Web experiments are showing early signs of promise with some products successfully killing caterpillars within their winter webs, but further evaluations in the field are needed.

Dr. Barbara Cole, Professor of Chemistry, joined the browntail moth project in 2017 collaborating on investigations of the physical and chemical properties of the web silk and exploring means of degrading the overwintering webs.

This report will serve as the first of yearly updates on research and potential management options for browntail moth that could prove useful for landowners, managers, and the general public.

FUTURE WORK

Dr. Mech and her students will continue browntail moth research in the forest entomology lab at UMaine, which will include the following goals:

Dr. Angela Mech, Professor of Forest Entomology, joined University of Maine and browntail moth project in 2020.

1. Determine which *Bacillus thuringiensis* var. *kurstaki* (Btk) strain/product would be the best for large-scale treatments. This natural bacterium is one of the best options for targeted control of pest caterpillars, but the efficacy of commercially available products is currently unknown for browntail moth. If an effective product is found, aerial applications in infected areas could begin as soon as 2022.
2. Determine the host preference for browntail moth. It is known that browntail moth utilizes a number of hardwood tree species but it is unknown where its preferences lie. Understanding its preferences is essential for developing risk assessments in regards to its spread.
3. Determine the flight capabilities of browntail moth. In addition to host preference, the flight capabilities are necessary for developing an accurate risk assessment map. This information will also be useful for determining where monitoring efforts should be focused.
4. Determine whether exposure to winter conditions without the protection of the winter webs would cause browntail moth mortality. We know that this insect is a cold-tolerant species, but it is unknown whether the removal of the web would expose them to conditions, such as ice and UV, that could result in mortality over the lengthy Maine winters.
5. Continue to evaluate different browntail control methods and products.
6. Continue to learn about the biology of browntail moth and its natural enemies complex.

Dr. Cole and her students continue to work with Drs. Mech and Groden on development and testing of products that can potentially impact browntail moth in their winter webs and at other stages of development.

Challenges**:** Browntail moth is an extremely difficult insect to work with due to the adverse health effects the venom from the toxic hairs has on a large portion of the human population. These insects are also difficult to sample and treat as they are typically located high in the tree canopy and there is anecdotal evidence that moths do not always lay eggs in the same trees every year[3]. Research for this insect is also difficult to fund, as populations tend to fluctuate year to year and it is considered a "Maine" problem, where other insect pests affect multiple states and municipalities which make them a priority for research funding. However, as this insect becomes more widespread throughout its historical range, there have been many generous towns, groups, and individuals that have made this browntail moth research possible at the University of Maine.

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- Hannah Ward, *B.S. Environmental Horticulture 2019*
- Zachary Beneduci, *B.S. Wildlife Ecology 2019*
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- Charlene Donahue, Forest Entomologist (Retired)
- Tom Schmeelk, Entomologist II
- Allison Kanoti, State Entomologist

Contributions to support Browntail Research at the University of Maine are greatly appreciated.

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