Nantucket Leafminers, Gallmakers, and Other Herbivorous Insects

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Abstract: A focus on the evidence left by certain herbivorous insects, such as galls and leaf mines, can reveal otherwise overlooked biodiversity. In many cases these persistent signs on plants are sufficient to identify the species that caused them. We surveyed Nantucket and Tuckernuck for galls and leaf mines, collecting those that we could not identify to attempt to rear them. We found over 260 species not previously reported from the islands, not including dozens of reared parasitoid wasps that remain to be identified. In the process we documented new host associations and found species that are new to science. Future surveys should target galls and leaf mines that remain unidentified, as well as free-living herbivorous larvae of other poorly known insect groups, with the goal of rearing the larvae to adults.

INTRODUCTION

The galls and leaf mines produced by insect larvae (and mites, in the case of galls) are often distinctive enough to identify their makers. In fact, there are species of both gallmakers and leafminers that can only be reliably identified by the signs they leave on their host plants, in the absence of DNA analysis. Insects such as gall wasps (Cynipidae), gall midges (Cecidomyiidae), and small moths (microlepidoptera) are often underrepresented in biodiversity surveys because of their small size and the difficulty of identifying them without host material. Upon reviewing the species listed by Johnson (1930) and Jones & Kimball (1943), it was clear that a survey focused on galls and leaf mines would add many species to the known fauna of Nantucket and Tuckernuck.

METHODS AND STUDY SITES

In 2011 we conducted surveys on Nantucket from September 7–10 and Tuckernuck on September 10. In 2012, we conducted focused surveys May 17–20 and August 2–8, with additional opportunistic observations made between May 3 and September 2. In 2013, we conducted focused surveys June 9–13 and made additional opportunistic observations November 1–4. In 2014, we conducted a targeted search for one species on May 16 and general surveys July 25–27. We conducted additional focused surveys August 27–29, 2015, June 8–13, 2016, July 26–31, 2017, November 3–6, 2017, June 14–16, 2018, September 5–9, 2019, and September 23–25, 2020. During each of the first four main survey efforts, we visited each of three 10 ha biodiversity plots established by the Nantucket Biodiversity Initiative: Squam Swamp, Madequecham, and Coskata Woods. We recorded every species we detected at the three plots and on Tuckernuck. Additional observations were made in over 80 other locations, including five other 10 ha biodiversity plots (Linda Loring Nature Foundation, Pout Ponds, Smooth Hummocks Coastal Preserve, Sheep Pond, and Trott's Swamp). All survey sites are listed in Table 1, along with the dates visited and initials of observers, and are shown on the map in Figure 1.

Surveys entailed close examination of each plant species encountered at a given site. We photographed each type of gall and leaf mine we found. If we were not certain which species was responsible and the gall or leaf mine was still occupied, we collected it in a plastic vial or bag, which was checked regularly until larvae or adult insects emerged. Agromyzid fly larvae were allowed to pupariate, and then the puparia were transferred to a fresh vial into which a moistened, crumpled piece of tissue paper had been added to prevent desiccation. Wandering larvae of other insects were placed in small jars containing a moistened 1:1 mixture of sand and peat, into which they burrowed to pupate. Jars and vials that had not yet produced adult insects by late autumn were stored in a refrigerator at 1–3 °C from mid-December 2012 to 15 April 2013, 6 November 2013 to 25 February 2014, 1 November 2014 to 1 March 2015, 1 November 2015 to 1 March 2016, 1 November 2016 to 1 April 2017, 20 October 2017 to 1 April 2018, 20 October 2018 to 1 March 2019, and 1 October 2019 to 21 February 2020; the last batch has been

in refrigeration since 16 October 2020. After removal from refrigeration, lids were removed from the soil jars, which were placed in sealed plastic bags and were checked daily.

Adult insects were photographed, and in some cases photos were posted on www.BugGuide.net for preliminary identifications. Adult insect specimens were pinned (if moths) or preserved in alcohol and have been or will be sent to specialists for examination. To date, we have sent gall midges to Netta Dorchin at Tel Aviv University and Raymond J. Gagné at the Smithsonian (USNM); a phorid fly to Emily A. Hartop at the Natural History Museum of Los Angeles County; agromyzid flies to Owen Lonsdale at the Canadian National Collection (CNC); anthomyiid flies to Brad Sinclair at the CNC; braconid parasitoids of flies to Francisco Javier Peris Felipo in Switzerland; eulophid wasps to Christer Hansson at Lund University; cynipid and figitid wasps to Matt Buffington at the USNM; braconid wasps to José L. Fernández-Triana at the CNC, Joseph Fortier of Keller, Washington, and James Whitfield at the University of Illinois (UI); encyrtid wasps to Robert Zuparko at the Essig Museum of Entomology; a eupelmid wasp to Gary Gibson at the CNC; ichneumonid wasps to Andrew Bennett at the CNC; platygastrid wasps to Peter Neerup Buhl at the Zoological Museum of Copenhagen; perilampid wasps to Chris Darling at the Royal Ontario Museum; sawflies to Dave Smith at the USNM; nepticulid, heliozelid, and gracillariid moths to Erik J. van Nieukerken at Naturalis Biodiversity Center; gracillariid moths to Don Davis at the USNM; coleophorid and eriocraniid moths to Jean-François Landry at the CNC; gelechiid, momphid, and tischeriid moths to Terry Harrison of Charleston, Illinois; tortricid moths to Jason Dombroskie at Cornell University; chrysomelid beetles to Shawn M. Clark at Brigham Young University; buprestid beetles to Henry Hespenheide at UCLA and Norm Woodley of Hereford, AZ; aphids to Andrew Jensen of Eagle, ID; aphids and thrips to Eric Maw at the CNC; and psyllids to Chris Mallory of Long Beach, CA.

In July 2014, we surveyed stands of arrowwood (*Viburnum dentatum*) for mines of the new *Marmara* species (Gracillariidae) that we discovered during our previous surveys, which is initially a leafminer but then burrows down the stem and overwinters there. These searches were conducted along the Polpis bike path and at the State Forest, Squam Swamp, and Ice Pond Lot. We flagged each plant that had leaf mines and recorded its coordinates on a GPS unit, along with

the number of mines on each plant. We returned in December and dug up six of the mined plants. These plants were potted and kept in an unheated shed over the winter, inside large sleeves of fine-meshed cloth. On 3 March, 2015, the plants were brought indoors, and they were checked daily until June for emerging adults. In June 2016, having discovered that this species pupates under bark flaps on stems of the host plant, we spent several hours searching arrowwood stems for these bark flaps and collecting them into vials.

Throughout our surveys, we have photographed other herbivorous insects (and signs thereof) in addition to searching for galls and leaf mines. In 2016, we began to expand our collecting and rearing efforts to include free-living larvae of sawflies, beetles, and microlepidoptera.

RESULTS

The species of leafminers, gallmakers, and their parasitoids and inquilines that we found or reared are listed in Appendix 1, with columns indicating in which of the eight NBI plots they were observed and whether they were found on Tuckernuck. Lost Farm is also given its own column because observations there encompassed an unusually large area. Numbers in the "GPS" column refer to the additional locations listed in Table 1 and shown in Figure 1. The host plants, and host insects for parasitoids and inquilines, are also indicated. See Appendix 2 for an illustrated guide to all the galls and leaf mines we found, organized by host plant. Species reported by others but not found by us are included but not illustrated. In Appendix 3, we have revised and updated the sections of Johnson (1930) and Jones & Kimball (1943) covering Thysanoptera (thrips), Miridae (plant bugs), Auchenorrhyncha (Free-living Hemipterans, i.e. spittlebugs and "hoppers"), Sternorrhyncha (Plant-parasitic Hemipterans, e.g. aphids and psyllids), Buprestoidea (jewel beetles), Chrysomeloidea (long-horned and leaf beetles), Curculionoidea (weevils), Symphyta (sawflies), Chalcidoidea (small parasitic wasps), Gelechioidea (twirler moths etc.), Yponomeutoidea (ermine moths etc.), Tortricoidea (leafroller moths), and Tephritoidea (fruit flies and relatives). Our observations of miscellaneous herbivorous insects are reported there.

DISCUSSION

The bulk of this discussion is a review of the relevant species listed in Johnson (1930) and Jones & Kimball (1943). We update their taxonomy, correct a few errors, and note which of the species we failed to find in our survey. (Species listed by them that we did find are mostly not named here but are indicated in Appendix 2.) We conclude with a summary of what our survey has added to knowledge of the fauna of Nantucket and Tuckernuck, highlighting some species that are new to science, and noting some galls and leaf mines that require further study.

Johnson (1930)

Psyllids, Aphids, and Adelgids (Hemiptera)

Johnson listed five hemipteran inducers of galls and pseudogalls, of which we found *Adelges abietis* (Adelgidae; listed by Johnson under Phylloxeridae), which forms galls on spruce twigs, and *Livia bifasciata* (Liviidae; listed by Johnson as *Livia maculipennis* under Chermidae), which causes galls in rush inflorescences. *Trioza tripunctata* (Triozidae; also listed under Chermidae) curls and distorts terminal leaves of blackberry. *Eriosoma americanum* (Aphididae) rolls the edges of elm leaves, and *Pemphigus populicaulis* forms galls on poplar leaves.

Beetles (Coleoptera)

Johnson listed several species of beetles whose larvae are known to be leafminers, as well as a single gall-making beetle. *Eugnamptus angustatus* (Attelabidae; listed as *E. collaris*) mines dead leaves of sassafras and other trees in the leaf litter. *Brachys aerosus* and *B. aeruginosus* (Buprestidae) both mine in oak leaves; we found both species. *Phyllotreta* species (Chrysomelidae) make short linear mines in mustard leaves; we reared *P. chalybeipennis* from sea rocket, and the other species listed by Johnson is discussed under Brassicaceae. Another flea beetle, *Mantura floridana*, mines leaves of docks and other members of the buckwheat family. Two other chrysomelids, *Sumitrosis inaequalis* (listed as *Anoplitis inaequalis*) and *Microrhopala*

vittata, mine in leaves of Asteraceae. Although both species are common in mainland Massachusetts, we did not encounter either on Nantucket until 2017, when we found *S. inaequalis* at Stump Pond and *M. vittata* at Sanford Farm. *Orchestes pallicornis* (Curculionidae) mines leaves of rosaceous trees; we reared several adults from black cherry. Another weevil, *Bagous americanus*, mines leaves of waterlilies. *Agrilus ruficollis* (Buprestidae) causes swellings in raspberry stems.

Gall Wasps (Cynipidae)

Johnson listed twelve species of gall wasps (Cynipidae). Of these, *Callaspidia provancheri* and *Xyalosema* sp. (now *Neralsia*) are now placed in the family Figitidae and are fly parasitoids rather than gallmakers. *Synergus* sp. is an inquiline in galls of other cynipids; we reared at least two species of this genus. *Solenozopheria vaccinii* (now *Loxaulus vaccinii*) was once incorrectly associated with the blueberry galls that are now known to be caused by *Hemadas nubilipennis* (Pteromalidae); *L. vaccinii* actually produces stem galls in oaks and is only recorded from Florida. Of the eight remaining, legitimate, gall-producing cynipids listed by Johnson, we found at least five. *Disholcaspis perniciosa* is a southwestern species, so this was a misidentification; the dwarf chinquapin oak gall in Johnson's collection bearing this label looks like that of *Trigonaspis quercusforticorne.* The scrub oak gall of *Callirhytis tuberosa* appears in June and is said to be rare; Johnson's specimens may or may not be correctly identified. The final species, *Diplolepis dichlocera* (listed by Johnson as *Rhodites dichlocerus*), causes elongated swellings in rose stems; we found galls on swamp rose that may have been caused by this species, but only managed to rear parasitoids.

Sawflies (Tenthredinidae)

Among the sawflies (Tenthredinidae) listed by Johnson, there is one leafminer and one gallmaker. We found the mines of *Metallus rohweri* (listed by Johnson as *M. rubi*) in *Rubus* leaves, and we found willow leaf galls of one or more *Pontania* species, possibly including *P. salicispomum* (listed by Johnson as *P. pomum*).

Moths (Lepidoptera)

Among moths, Johnson listed one leafminer and one gallmaker, both found on black locust. We found leaf mines of *Parectopa robiniella* (Gracillariidae), but not the twig galls caused by *Ecdytolopha insiticiana* (Tortricidae).

Agromyzid Flies (Agromyzidae)

Johnson listed nine species of agromyzid flies (commonly known as the "leafminer flies," but not all species are leafminers). Older literature (i.e., published prior to Spencer & Steyskal (1986)) on this family is full of misidentifications and other taxonomic problems, but it is possible to sort out the identities of most of those Johnson recorded, of which we encountered *Liriomyza brassicae* (listed by Johnson as *Agromyza pusilla*, the "serpentine leafminer") and *Phytoliriomyza melampyga*. *Agromyza aeneiventris* apparently refers to *Euhexomyza schineri*, which causes oval stem galls in aspen twigs; we found possible *Euhexomyza* galls on dwarf prairie willow. *Agromyza laterella*, which Johnson mentioned as forming galls on iris leaves, is now *Cerodontha thompsoni*; we found leaf mines of this species in 2017. *Agromyza maura* var. *simplex*, which Johnson mentioned as an asparagus miner, is now *Ophiomyia simplex*. *Agromyza platyptera* var. *jucunda* is now *Calycomyza platyptera*, a miner in various members of the aster family; we reared this species from marsh elder (a new host record) in 2017. *Agromyza parvicornis*, the only agromyzid listed by Johnson whose name remains intact, is known as the corn blotch leafminer, mining in leaves of corn and other grasses. *Agromyza coquilletti* and *Cerodontha femoralis* both seem to refer to species of *Cerodontha* (but not *C. femoralis*, which is not known to occur in North America) that mine in wheat and other grasses. We have found one *Agromyza* and at least four *Cerodontha* species mining leaves of grasses, sedges, and rushes.

Anthomyiid Flies (Anthomyiidae)

Johnson listed two names of anthomyiid flies that at that time (Needham et al. 1928) referred to miners of dock (*Rumex*) leaves, *Pegomya bicolor* and *P. winthemi*. Both are still valid names of

North American species, but identifications of the former from that time are questionable (Griffiths 1982), and the latter is now known to be a mushroom feeder (Griffiths 1983). We did find *Pegomya* sp. mines on bitter dock and sheep sorrel; rearing adults is necessary for a species level identification.

Gall Midges (Cecidomyiidae)

We found six of Johnson's seven gall midge (Cecidomyiidae) species. *Cecidomyia resinicola*, found on pine, forms resin masses rather than galls.

Fruit Flies (Tephritidae)

Johnson listed two species of fruit fly (Tephritidae) that cause galls on goldenrod. *Eurosta solidaginis* (listed by Johnson as *E. asteri*) forms spherical stem galls, which we did not find. *Procecidochares polita* causes small rosette galls (Felt 1940); we found galls of a member of this genus that may or may not have been *P. polita*.

Jones & Kimball (1943)

Leaf-mining Moths

Jones & Kimball (1943) reported several moths, in addition to *Parectopa robiniella*, that are leafminers throughout their larval lives. Included are three *Elachista* species (Elachistidae), all of uncertain identification, which are likely to be miners of graminoids. We found larvae of three different grass-mining *Elachista* species, but we were only able to rear one of them and it has not yet been identified. We found mines of *Exoteleia pinifoliella* (Gelechiidae) in pitch pine needles, *Tischeria* (now *Coptotriche*) *citrinipennella* (Tischeriidae) on oak, and mines of *Lithocolletis* (now *Cameraria*) *picturatella* (Gracillariidae) on bayberry.

Casebearer Moths (Coleophoridae)

Jones & Kimball listed a few *Coleophora* species (Coleophoridae); *Coleophora* larvae are the "casebearers," which live in portable cases they construct of silk and plant material. Some, but not all, make characteristic frass-free blotch mines by chewing their way into leaves and excavating as much as they can while keeping the posterior end anchored in the case, which is typically attached to the underside of the leaf. Of the species Jones & Kimball listed for Nantucket, two are "pistol casebearers" that do not mine leaves: *C. atromarginata* (which we reared from a larva on white oak) and *C. malivorella* (which they listed as *C. atlantica*; "larval cases sometimes plentiful on beach plum"). We found larvae on black cherry and scrub oak at Madequecham that could have belonged to either or both of these species. *Coleophora coruscipennella* is a synonym of *C. mayrella*, which feeds among clover seeds. The remaining species, *C. limosipenella* ("larval cases abundant on planted elms, Town"), is in fact a leafminer, and we did find *Coleophora* mines on elm leaves. According to Jones & Kimball "numerous flown specimens, not surely identifiable, indicate the presence of additional species of this genus." We found at least five additional leaf-mining *Coleophora* species on Nantucket.

Moths that Mine Leaves Only in Early Instars

Other species listed by Jones and Kimball start out life as leafminers and then feed externally in later larval instars. They include four approximate identifications of *Bucculatrix* species (Bucculatricidae), which typically skeletonize small patches of the leaf underside after forming a short linear mine. We found mines of *B. pomifoliella* and unidentified oak-feeding species (and reared *B. trifasciella* from cocoons on white oak), which correspond with two of the species they tentatively listed, as well as of two other species that they did not list. Five species of *Gracillaria* (Gracillariidae) are listed; larvae of these moths typically start out by making a linear or blotch mine and then exit this to form a cone-shaped leaf roll in which they complete their development. Three of Jones and Kimball's species were not identified confidently; of the remaining two, *G. syringella* (which they indicated was rare) feeds on lilac and privet, and *G.* (now *Caloptilia*) *vacciniella* feeds on blueberry, but the details of its mine are not recorded (Ely

1915). We found mines of *G. syringella*, and some unidentified mines on highbush blueberry could have been made by *C. vacciniella*. "*Callisto nr. crataegifoliella*" (Gracillariidae) could refer to *Parornix crataegifoliella*, which is one of the species possibly responsible for underside tentiform mines we found on shadbush and black cherry. Most *Parornix* species exit their leaf mines to feed in a flap at the edge of a leaf. We reared *Scrobipalpa* nr. *atriplicella* (Gelechiidae) from larvae that initially fed as leafminers in orache leaves; this species was listed by Jones & Kimball as *Phthorimaea chenopodiella*. Jones & Kimball also listed *Plutella xylostella* (Plutellidae; as *P. maculipennis*), a Brassicaceae feeder that mines leaves only in its first instar, as well as two tortricid moths that initially mine in pine needles, later tying them together: *Argyrotaenia pinatubana* and *Taniva albolineana*.

Jones & Kimball reported finding larval cases of *Paraclemensia acerifoliella* (Incurvariidae) on huckleberry, on both Nantucket ("not common") and Martha's Vineyard ("locally abundant"). We were skeptical of this, since this species typically feeds on maple, and usually sugar maple, which is not recorded from either of the islands (Cullina et al. 2011). However, in 2014 we found larvae of this species feeding on highbush and lowbush blueberry as well as on scrub oak; in 2017 we found larvae (along with their abandoned leaf mines) on post oak, and in 2019 we found larvae on Chinese chestnut.

Gall-making Moths

Stagmatophora sexnotella (Cosmopterigidae) causes stem galls on bluecurls (Lamiaceae: *Trichostema*). We only encountered this plant once and did not observe galls. Finally, Jones & Kimball list two species of *Gnorimoschema* (Gelechiidae), a genus that includes many gallmakers and leafminers. *Gnorimoschema banksiella*, however, is recorded as a peach borer (Felt 1920, p. 67). Jones & Kimball reported that the galls of *G. salinaris* were fairly common in stems of seaside goldenrod (*Solidago sempervirens*), formed close to the sand. We did not find these but did find *Gnorimoschema* galls in Elliott's goldenrod (*S. latissimifolia*), which is apparently not a recorded host for any *Gnorimoschema* species.

Additions to the Known Fauna of Nantucket and Tuckernuck

Our initial four-day survey in September 2011 yielded over 80 leaf-mining and gall-making species not previously documented on Nantucket and Tuckernuck. Our 2012 surveys added at least another 50; we added about 20 more in 2013, at least another 20 in 2014, nearly 20 more in 2015, at least 10 more in 2016, about 20 more in 2017, at least 10 more in 2018, about 25 more in 2019, and at least 10 more in 2020. The actual number of species represented by the galls and leaf mines we encountered is substantially higher, but an exact count is not possible because the situation is complicated by the presence of numerous undescribed or not fully identified species. So far we have added about 50 additional (neither leaf-mining nor gall-making) new phytophagous species to the groups covered in Appendix 3. We also have reared well over 100 hymenopteran and dipteran parasitoids and inquilines to date, most of which will add new species to the islands' known fauna once they have been fully identified.

Our surveys and rearing efforts have resulted in new host and geographical records for some species. From leaf mines on yellow thistle (*Cirsium horridulum*), we reared *Oulema palustris* (Chrysomelidae), a member of a subfamily (Criocerinae) that was not previously known to include leaf-mining species in North America. We discovered that *Agromyza vockerothi* (Agromyzidae) is the species responsible for the linear mines common on blackberry (*Rubus*) leaves. From leaf mines in scrub oak (*Quercus ilicifolia*), we reared *Eriocraniella platyptera* (Eriocraniidae), which was previously known from just a few adults caught (not reared) in New York (Davis 1978; Eiseman 2016). Beach plum (*Prunus maritima*) and black cherry (*P. serotina*) both represent new larval host records for *Orchestes pallicornis* (Curculionidae), and American and beaked hazelnut (*Corylus americana*, *C. cornuta*) are new host records for *O. mixtus* (Anderson 1989). *Woodwardia* is a new host record for *Chirosia gleniensis* (Anthomyiidae), *Iva* is a new host record for *Calycomyza platyptera* (Agromyzidae), and *Baccharis* is a new host record for *Liriomyza eupatorii* (Eiseman & Lonsdale 2018). *Phytomyza mulitfidae* (Agromyzidae), which we reared from leaf mines in wood anemone (*Anemone quinquefolia*), was previously known only from Alberta (Eiseman et al. 2015), and *P. spondylii*, which we reared from leaf mines in cow parsnip (*Heracleum maximum*), was previously only

known in North America from Alaska and California (Eiseman & Lonsdale 2018). *Perittia herrichiella* (Elachistidae) is a European honeysuckle-mining moth for which the only published North American records are from eastern Canada (Pohl et al. 2018). The bayberry-mining *Stigmella myricafoliella* (Nepticulidae) was previously only known from Florida (Erik van Nieukerken, pers. comm.). In September 2019 we found the first New England examples of *Keiferia inconspicuella* (Gelechiidae) and *Telamoptilia hibiscivora* (Gracillariidae), two leaf-mining moths previously known only from more southern localities. Numerous other species have not been documented from Massachusetts previously, but gallmakers and leafminers are so poorly studied that this is not particularly surprising information. Similarly, many of the parasitoids we have reared will likely prove to represent previously undocumented parasitoid-host relationships.

More interestingly, our rearing efforts have produced several species that were unknown to science. A scuttle fly (Phoridae) that emerged from a midge gall on scrub oak proved to be a new species, which we have named *Megaselia nantucketensis* (Eiseman & Hartop 2015). A parasitoid wasp (Platygastridae) that emerged from a midge gall on grape was likewise a new species, which we have named *Platygaster vitisiellae* (Buhl & Eiseman 2016). It is named after its host, which is itself an undescribed species in the genus *Vitisiella* (Cecidomyiidae). *Platygaster tephrosiae* was described from two specimens we reared from an as yet unidentified gall midge on goat's rue (*Tephrosia virginiana*) (Buhl & Eiseman 2017). Eiseman et al. (2017) described *Marmara viburnella* (Gracillariidae), whose leaf mine on arrowwood (*Viburnum dentatum*) we first found on Tuckernuck in September 2011. In subsequent years we learned that the larva is a leafminer only when very young, soon disappearing into the petiole and then under the bark of the stem. The following spring, it cuts a flap in the bark and spins its cocoon there, and in June 2016 we managed to rear adults from three of these cocoons. In 2017 we found similar *Marmara* leaf mines leading into stems of marsh elder (*Iva frutescens*), and in 2018 we were able to rear a single adult, confirming that it is another new species, distinct from *M. viburnella*. More specimens will be needed before this species can be described. In 2019 we reared yet another previously unknown species of *Marmara* from leaf mines on sandplain blue-eyed grass (*Sisyrinchium fuscatum*). *Cerodontha edithae* (Agromyzidae) was described by

Eiseman & Lonsdale (2018) from a specimen reared from an iris leaf mine found at Stump Pond. In 2020 we collected more larvae of a new *Brachys* species (Buprestidae) of which we had reared a single adult the previous year, as well as larvae of a probable new *Coptodisca* species (Heliozelidae) on scrub oak that we have found only in the vicinity of Stump Pond.

An *Asphondylia* (Cecidomyiidae) gall we found on seaside goldenrod (*Solidago sempervirens*) had never been reported by anyone previously, although we later found more of them in northern Maine and southern Connecticut. We sent the adult midges to Netta Dorchin, who reported: "This is most probably a new species but the molecular data were unable to separate it from a population I have from *Solidago bicolor* [silverrod] from Virginia. The two populations are mixed together and I won't be able to understand what's going on there and how many species are involved until I have bigger samples from both host plants for molecular study." Our specimens were mentioned in her recent paper on goldenrod *Asphondylia* species (Dorchin et al. 2015). Dave Wagner informed us that the gracillariid moths we reared from leaf mines in bayberry belong to an undescribed species in a new genus that he and Don Davis are describing; we also reared adults of a *Parornix* species they are describing that mines leaves of maleberry (*Lyonia ligustrina*).

In addition to discovering some galls and leaf mines for the first time on Nantucket, we specifically looked for examples of other leaf mines that we have found elsewhere but are (or were) unknown to science. As a result, we were able to rear an adult of a buprestid beetle that mines in trailing arbutus (*Epigaea repens*) leaves; this specimen was included in the type series of the new species, *Brachys howdeni* (Hespenheide & Eiseman 2016). Agromyzid flies we reared from leaf mines on cow-wheat (*Melampyrum lineare*) were included in the type series of *Liriomyza pistilla* (Lonsdale 2017). From mines in fronds of cinnamon fern (*Osmundastrum cinnamomeum*), we reared *Chirosia filicis* (Anthomyiidae), a species that had no known host plants before we reared it from interrupted fern (*Osmunda claytoniana*) in New York. Thanks to our rearing efforts elsewhere, we were able to identify the mines of *Gynnidomorpha romonana* (Tortricidae) on sea lavender and *Pseudodineura parva* (Tenthredinidae) on wood anemone. We documented the immature stages of both of these species for the first time in recent papers

(Eiseman & Jensen 2015; Eiseman et al. 2015). The first paper also documents the discovery of the aphid genus *Staticobium* in North America (including on Nantucket). In 2016, we sought out patches of frostweed (*Crocanthemum*) to look for an undescribed species of *Mompha* (Momphidae) that is known to mine its leaves, and we succeeded in rearing two adults. We have sent these to Terry Harrison, who will eventually be describing this species.

We suspect that we have now documented most of the galls and leaf mines that will be encountered on Nantucket and Tuckernuck by the casual—or not so casual—observer. However, we believe that quite a few more can be found by seeking out potential host plants that we have not yet had the opportunity to examine. There is also much remaining to be learned from survey efforts focused on searching for galls and leaf mines that we have already documented, but for which the insects responsible are not yet fully identified. If these are found when the larvae are still inside them, they can be collected and the adults can be reared. This will at minimum result in new natural history information, and may well result in additional new species being discovered. So far, expanding our efforts to include rearing free-living larvae of sawflies, beetles, and microlepidoptera has not resulted in further new scientific discoveries, but it has added a number of new species to the island's list, so there is likely much left to be learned by continuing with this approach.

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TABLE 1: Survey locations. Numbers correspond with points mapped in Figure 1.

Site#	Location	Dates Visited (Surveyors)	Latitude	Longitude
n/a	Coskata	9/9/11 (CSE, NDC, SR); 5/18/12, 8/6/12 (CSE); 6/12/13 (CSE, JAB)	41.34746682	-70.01573337
n/a	Loring	8/28/15 (CSE, JAB)	41.29009736	-70.17408342
n/a	Lost Farm	6/12/16 (CSE); 6/13/16 (CSE, JAB)	41.27031871	-70.13585113
n/a	Madequecham	9/8/11 (CSE, NDC, SR); 5/20/12, 8/3/12, 6/10/13 (CSE, JAB)	41.25417791	-70.04816116
n/a	Pout Ponds	11/3/13, 7/25/14, 8/29/15, 6/9/16 (CSE, JAB)	41.27684736	-70.04595560
n/a	SHCP	8/27/15 (CSE, JAB)	41.25100569	-70.11980007
n/a	Sheep Pond	8/28/15 (CSE, JAB)	41.26628902	-70.17832509
n/a	Squam Swamp	9/7/11 (CSE, NDC, SR); 5/17/12, 8/8/12 (CSE); 6/12/13, 7/25/14, 6/9/16, 7/27/17, 9/8/19 (CSE, JAB)	41.31838070	-70.00269170
n/a	Trott's Swamp	8/28/15 (CSE, JAB)	41.27628625	-70.14149452
n/a	Tuckernuck 1	9/10/11 (CSE); 7/13-14/12 (JAB)	41.30027530	-70.24731221
n/a	Tuckernuck 2	9/9/11 (CSE, NDC, SR)	41.30911528	-70.26417116
1	TTOR gate	9/9/11 (CSE, NDC, SR)	41.32804934	-69.99645048
2	Sesachacha Pond (N)	9/9/11 (CSE, NDC, SR)	41.30370913	-69.98031942
3	Bike path	9/7/11, 9/9/11 (CSE, NDC, SR); 11/6/11, 6/11/13 (CSE, JAB)	41.29099302	-70.02589343
4	UMass classroom	6/11/16 (CSE, JAB)	41.29582687	-70.04035197
5	Cisco Beach	9/7/11 (CSE, NDC, SR)	41.25254170	-70.15190466
6	UMass	9/10/11 (NDC, SR), 8/26/12 (JAB)	41.29098397	-70.03885487
7	Turner Rd.	9/10/11 (NDC, SR)	41.27317921	-70.03528795
8	Serengeti	9/8/11 (CSE, NDC, SR)	41.26600631	-70.03056299
9	Near *Sphodros*	9/8/11 (CSE, NDC, SR)	41.27785673	-70.05544569
10	*Sphodros*	9/9/11 (CSE, NDC, SR)	41.27728441	-70.05937001
11	Polpis Rd.	9/9/11 (CSE, NDC, SR)	41.28131125	-70.06528395
12	Near the Creeks	8/7/12 (CSE)	41.27583996	-70.09288146
13	Lily St.	9/9/11 (CSE)	41.28563186	-70.10337043
14	Vesper Lane	9/7/11 (CSE)	41.27439123	-70.10005226
15	UMass condo	9/10/11 (NDC, SR)	41.27358975	-70.10274318
16	Hummock Pond	9/8/11 (CSE, NDC, SR)	41.25325852	-70.15504703
17	Madaket	8/7/12; 6/11/13 (CSE, JAB)	41.27373241	-70.20916045
18	NCF Bird Sanctuary	5/3/12 (JAB); 5/18/12 (CSE); 6/8/12 (JAB); 8/6/12, 7/26/17 (CSE, JAB)	41.29130406	-70.10539784
19	Dead Horse Valley	5/18/12, 8/6/12, 6/8/16, 6/10/16, 6/11/16, 9/9/19 (CSE); 5/30/12 (JAB); 8/2/12, 7/31/17 (CSE, JAB)	41.27716187	-70.10199294
20	Maria Mitchell	8/4/12 (CSE, JAB)	41.28039393	-70.10462805
21	Audubon	8/3/12 (CSE, JAB)	41.27601237	-69.98932793
22	Landfill	8/5/12, 6/13/13, 7/26/14 (CSE, JAB)	41.27939498	-70.16592731
23	Ice Pond Lot	9/9/11 (CSE, NDC, SR); 5/18/12, 8/6/12 (CSE); 6/12/13 (CSE, JAB)	41.28347897	-70.17434281
24	State Forest	8/8/12, 6/10/13, 7/27/14, 6/11/16 (CSE, JAB)	41.26059160	-70.07991862
25	Little Sesachacha Pond	8/4/12 (CSE, JAB)	41.29219268	-69.98847701
26	Owl nest box	5/16/12 (CSE, JAB)	41.28242578	-70.07301654

Site#	Location	Dates Visited (Surveyors)	Latitude	Longitude
27	Squam Farm	5/17/12 (CSE); 6/3/12, 7/16/12 (JAB); 6/9/13 (CSE, JAB); 5/16/14 (JAB); 8/27/15 (CSE, JAB)	41.31150395	-69.99850217
28	Madequecham parking	5/20/12 (CSE, JAB)	41.26014065	-70.04990176
29	Milestone 4	5/20/12 (CSE, JAB)	41.26565938	-70.03163558
30	Abrams Point	5/30/12 (JAB)	41.29587976	-70.06333483
31	Stump Pond	7/14/12, 7/19/12, 8/18/12, 9/2/12 (JAB); 8/4/12, 7/30/17, 11/5/17, 9/5/19, 9/24/20, 9/25/20 (CSE, JAB)	41.29027527	-70.00443430
32	Sanford Farm	8/2/12 (CSE); 7/27/17 (CSE, JAB); 5/26/19 (JAB)	41.28211188	-70.13699452
33	Maxcy Pond	8/2/12 (CSE, JAB); 8/18/12 (JAB)	41.28418163	-70.13331905
34	Maxcy Pond North	8/2/12 (CSE, JAB)	41.28714589	-70.13383932
35	Miacomet	8/2/12, 9/6/19 (CSE, JAB)	41.25154970	-70.11493712
36	Near Madequecham	8/3/12 (CSE, JAB)	41.25854775	-70.04954419
37	Almanac Pond	8/4/12 (CSE, JAB), 8/18/12 (JAB), 7/25/14, 7/30/17 (CSE, JAB)	41.28681849	-70.00408997
38	"lily pad pond"	8/4/12 (CSE, JAB)	41.28501152	-70.01960638
39	Milestone cranberry bog	8/4/12 (CSE, JAB), 8/18/12 (JAB), 7/25/14 (CSE, JAB)	41.27564809	-69.99584922
40	Lily Pond Park	8/7/12, 7/28/17, 9/9/19, 9/24/20 (CSE); 6/10/16, 11/1/19 (CSE, JAB)	41.28629881	-70.10349490
41	Coffin Park (South)	8/7/12 (CSE), 11/3/17 (CSE, JAB)	41.28873711	-70.10579179
42	Coffin Park (North)	8/7/12 (CSE)	41.28957186	-70.10571644
43	North Liberty St.	8/7/12 (CSE)	41.28445077	-70.10543732
44	Masquetuck	6/11/12, 7/26/14, 7/28/17, 9/7/19, 9/23/20 (CSE, JAB)	41.29693	-70.02391
45	Gardner Farm	6/13/12 (CSE, JAB)	41.263812	-70.13887
46	Head of the Plains (thistle patch)	6/10/16 (CSE)	41.25999673	-70.17317509
47	Brant Point	11/4/13 (CSE, JAB)	41.289951	-70.09121
48	Polpis Bike Path	7/25/14 (CSE, JAB)	41.284961	-70.05779
49	Norwood Farm	7/26/14 (CSE, JAB)	41.287918	-70.019111
50	Eel Point	7/26/14 (CSE, JAB)	41.296422	-70.196893
51	Linda Loring	7/27/14, 7/27/17 (CSE, JAB)	41.290836	-70.171011
52	Raylene's Bog	7/27/14 (CSE, JAB)	41.284982	-70.02053
53	(Larson) Road to Gibbs Pond	8/29/15 (CSE, JAB)	41.27045484	-70.01700501
54	Polpis Bike Path by Don Allen's	8/29/15 (CSE, JAB)	41.27369327	-70.07768238
55	Water tower	8/29/15 (CSE, JAB)	41.27361197	-70.06945093
56	UMass pond, by info sign #8	8/29/15, 9/8/19 (CSE, JAB)	41.29556845	-70.03938000
57	Radar Hill	11/15/15 (CSE, JAB)	41.28390847	-70.03875002
58	Elin Anderwald's driveway	6/9/16 (CSE, JAB)	41.26926846	-70.06304003
59	Head of the Plains	6/10/16 (CSE)	41.26268883	-70.17138169
60	Corner of Turner & Milestone	6/11/16 (CSE, JAB)	41.26657846	-70.03859001

Site#	Location	Dates Visited (Surveyors)	Latitude	Longitude
61	Ram Pasture / Clark Cove	7/27/17 (CSE, JAB)	41.259316	-70.162082
62	Liberty St.	7/28/17, 9/9/19 (CSE)	41.283777	-70.104011
63	Flowering Dogwood	7/30/17 (CSE, JAB)	41.28984	-70.01118
64	Post Oak 3	7/30/17 (CSE, JAB)	41.27906	-70.01333
65	Post Oak 4	7/30/17 (CSE, JAB)	41.27795	-70.01008
66	Wigwam Ponds	7/30/17 (CSE, JAB)	41.27995	-70.01903
67	Grove Lane	7/31/17 (CSE, JAB)	41.283968	-70.114734
68	Bamboo Forest	7/31/17 (CSE, JAB)	41.28167	-70.11834
69	Trail W of Little Sesachacha Pond	6/14/18 (CSE, JAB)	41.294551	-69.990245
70	Madaket Marine	6/15/18 (CSE, JAB)	41.281184	-70.192424
71	Quaker cemetery	6/15/18 (CSE)	41.281336	-70.108179
72	Sconset Dump	6/16/18 (CSE, JAB)	41.258202	-69.981519
73	Reyes Pond	9/5-6/19 (CSE, JAB)	41.290107	-70.025518
74	Quaise	9/5/19 (CSE, JAB)	41.298882	-70.033641
75	Bartlett's Farm	9/7/19 (CSE, JAB)	41.261099	-70.128778
76	Capaum Pond (west side)	9/8/19 (CSE, JAB)	41.291729	-70.140669
77	Old Gaol	9/9/19 (CSE)	41.280988	-70.106347
78	Milk St.	9/9/19 (CSE)	41.279709	-70.105603
79	Windswept Cranberry Bogs	9/24/20 (CSE, JAB)	41.295645	-70.006634
80	Almanac Pond Rd. (between Windswept and Stump Pond parking)	9/24/20 (CSE, JAB)	**41.292884**	**-70.008055**
81	Quaise Pond	9/25/20 (CSE, JAB)	**41.292849**	-70.033676

FIGURE 1: Map of survey locations listed in Table 1.