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BROWNTAIL MOTH DEFOLIATION STUDY--CAPE COD NATIONAL SEASHORE

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SUMMARY

The browntail moth, Euproctis chrysorrhoea, was accidentally introduced into Massachusetts in the 1890's. After its rapid spread in Northeastern North America, the insect declined, and by the 1960's was found in several maritime localities. On the outer Cape, the insect was restricted to three discrete populations on coastal dunes, feeding primarily on beach plum. In the early 1980's the numbers and range of the browntail began to increase, and the outer tip of Cape Cod is now generally infested. Although beach plum remains a preferred host, the insect now infests a larger number of hosts, and has moved inland from the coastal dune habitat. Continued episodes of defoliation have weakened and killed some trees, particularly beach plum, an important species for stabilizing dunes. In addition to defoliation, the insect has specialized setae or hairs containing toxins. These urticating hairs readily penetrate the skin and can cause a severe rash and other health related problems. Management options to reduce browntail moth numbers and exposure to urticating hairs include restriction of access to infested areas, removal of host plants or webs containing overwintering larvae in high use areas, use of insecticides, and enhancement of biological control agents. The current situation on the outer Cape suggests that a strategy of no action will likely result in the continued outbreak and spread of the browntail moth.

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INTRODUCTION

The browntail moth, Euproctis chrysorrhoea (L.) (Lepidoptera: Lymantriidae), was discovered in North America in Somerville, MA in 1897. The original introduction was thought to have occurred several years before on roses imported from Holland or France (Marlatt 1911). Like its close relative the gypsy moth, Lymantria dispar (L.), the browntail moth is native to Eurasia with a history of periodic outbreaks and widespread defoliation of forests, shade trees, and orchards. The most preferred hosts are in the Families Roseacea and Fagaceae. The host range, however, is wide. Records compiled by Schaefer (1974) list several several hundred host plants in 36 Families from North America and Eurasia.

After its accidental introduction into Massachusetts, the browntail moth spread rapidly and caused widespread defoliation, reaching its maximum range about 1915 (Burgess 1923). At that time, the insect was found from Long Island NY, throughout most of New England to New Brunswick and Nova Scotia, Canada, a distribution of ca. 150,000 km² (Schaefer 1974). The insect then began a dramatic decline in numbers and range, and by the late 1960's was found on islands in Casco Bay, off Portland, ME, and in several localities on Cape Cod. The distribution in 1973 was 4.8 km² (Schaefer 1974), with the largest Cape populations in three areas within the confines of the Cape Cod National Seashore. These populations were on secondary coastal dunes, on the bayberry (Myrica pensylvanica) --beach plum (Prunus maritima)--black cherry (Prunus serotina) habitat of Randall (1962).. Larvae fed primarily on beach plum, black cherry, and

salt spray rose, Rosa rugosa.

During the period between 1973 and the present the browntail moth has undergone a dramatic increase in numbers in the outer Cape. Snowden (1986) noted a large increase in browntail moth in 1982.

In addition to its noxious properties as a defoliator, browntail moth larvae and adults contain large numbers of urticating setae containing toxins. These setae penetrate the skin and can cause a severe dermatitis.

The most comprehensive research program on the browntail moth in North America was the dissertation study of Paul Schaefer (1974) on my project funded by the Life Sciences and Agriculture Experiment Station, University of Maine. This study of the population ecology of the browntail moth was conducted on islands in Casco Bay, ME and on Cape Cod, including three populations in the Cape Cod National Seashore, on Long Point, Race Point, and High Head.

OBJECTIVES

Because of the concerns of the recent outbreak of the browntail moth, a Cooperative Agreement between the National Park Service and the University of Massachusetts was initiated to study the current distribution and impact of the browntail moth in the Cape Cod National Seashore. The objectives of the study were:

1. Determine the current distribution of the browntail moth within the Cape Cod National Seashore.
2. Predict short-term (ten year) changes in browntail moth

distribution in and around the National Seashore.

3. Determine overall effect of browntail moth on host plant species within the Seashore (especially beach plum, black cherry, oak, willow, shad bush, and salt spray rose) and monitor the survival and growth rate of these species.
4. Identify those environmental factors that affect browntail moth distribution.
5. Provide recommendations concerning control of the moth, should control prove warranted given National Park Service pest management policies.

MATERIAL AND METHODS

The distribution of the the browntail moth was determined by survey of silken webs in which aggregates of larvae overwinter. The survey was conducted in April, 1986, prior to foliation of deciduous trees when the off-white webs, or "flags", are most visible on the terminals of shrubs and trees. Where winter webs were observed, they were checked to determine if they were constructed in the fall of 1985. A few webs constructed by the previous (1984) generation were found, but were darker, and often tattered and covered with green mold. The survey was conducted from Wellfleet to the tip of the Cape in Provincetown.

Feeding damage on the most impacted host, beach plum, was assessed by observing the spring feeding behavior of larvae after emergence from the winter webs. At High Head, Truro, 187 beach plum and 78 shad bush, Amelanchier canadensis, were marked in July of 1985. The beach plums, located on secondary coastal

dunes, had a history of browntail moth infestations dating to the 1960's, but population levels were highest during the past several seasons. The shad bush, adjacent to the dunes, were apparently first infested in 1982, when the insect began to move inland. The condition of the trees was recorded in July, 1986 as: healthy; in poor condition with few leaves; or dead or with no current growth or foliage and not expected to refoliate or survive to the next growing season.

To assess the effects of browntail moth feeding on past patterns of growth, branch stems from 10 beach plum, black cherry, bear oak, or shad bush were collected. Samples of each species were collected in Pilgrim Heights; beach plum and black cherry were collected from Long Point; shad bush, beach plum, and oak from Head of the Meadow; beach plum and shadbush from High Head. From Marconi Beach, an area with no history of browntail moth, samples of beach plum, black cherry, and oak were collected. Samples were taken to the laboratory and air dried for six months. One end of the ca. 4 inch branch samples was sanded, and a line was scribed through the center. Growth rings were measured along the line with an ocular micrometer in a dissecting microscope. Data were recorded for growth in years 1975-1984.

Urticating hairs of larvae were examined using an International Scientific Instrument (ISI) Super IIIA scanning electron microscope.

RESULTS AND DISCUSSION

Life cycle.

The browntail moth has two discrete feeding periods; after larvae (primarily 3rd stage) emerge from communal, silken webs in spring, and in late summer, after emergence from eggs laid in July. The amount of feeding of the late summer generation is minimal; larvae skeletonize leaves on which egg masses are laid, then feed on adjacent leaves (Fig. 1).



Figure 1. Larvae feeding on leaf in August after emerging from the buff-colored egg mass, which is covered with hairs from the abdomen of the female.

As larvae feed, they produce silk, the beginning of the overwintering web (Fig. 2). The webs usually contain the progeny of one egg mass, but where populations densities are high, the webs can be larger, containing progeny from more than one mass.



Figure 2. Late summer feeding and silking of browntail moth larvae. The webbing together of leaves begins the construction of the silken web in which larvae overwinter.

Schaefer (1974) found that the webs on the Cape contained an average of 560 larvae. Larvae emerge from webs in April, before foliation of their hosts. This generation causes the noticeable defoliation.

On completing development, larvae silk a leaf or groups of

leaves together and pupate. Some pupational webs contain large numbers of pupae where population densities are high. Adults emerge in mid-July. Females release a sex pheromone to attract males, mate, and lay a mass of ca. 500 eggs. The egg mass, covered with setae from the abdomen of the female, is deposited on leaves, with a preference shown for plants that were not defoliated earlier in the season (Schaefer 1974). Larvae hatch in August.

Current distribution of the browntail moth on the outer Cape.

The survey of the overwintering population of browntail moth conducted in April 1986 showed the southern limit of the insect to be Ballston Beach, Truro, just south of the Pamet River. From there, the insect extends to the tip of the Cape in Provincetown, a distance ca. 19 km (12 mi.). Along the ocean side of the Cape, the infestations of browntail moth (primarily on beach plum) from Ballston Beach to Longnook Beach are generally light, with heavy population densities along Highland Beach and Head of the Meadow Beach. Moderate populations occurred between Highland Beach and Race Point. On the Bay side of the Cape, Herring Point Beach and Long Point had moderate to high populations, and Pilgrim Beach, Pond Village, and Great Hollow Beach had light populations. Areas with high populations of brown tail would be expected to have widespread defoliation; moderate populations, noticeable defoliation, with about 50% of the foliage consumed; light populations, spotty areas of defoliation.

The three discrete populations found in the Cape Cod National Seashore in 1973 have expanded to a nearly continuous population around the outer Cape, with areas inland from the dunes now infested. A point of early spread from the dunes is at High Head, an event that Snowden (1986) indicated occurred in 1982. The southern expansion in the range, from High Head in 1973 to Ballston Beach is about 4 km (2.5 mi.). The town of Truro, north of the Pamet River, is generally infested. Bear oak, Quercus ilicifolia, is a preferred host (Fig. 3), and winter webs were commonly found in typical forest settings and along roadsides. Webs were also found on beach plum and fruit trees in yards. Although web densities were not assessed, the area infested and web numbers between Head of the Meadow and High Head appeared to be much larger in 1986 than in 1985.

No webs were observed in the Beech Forest area of Provincetown, or on locusts, although beeches and locusts are on host lists for browntail moth. The insect does not feed on conifers, but webs were found on isolated oaks in pine stands.

Effects of defoliation.

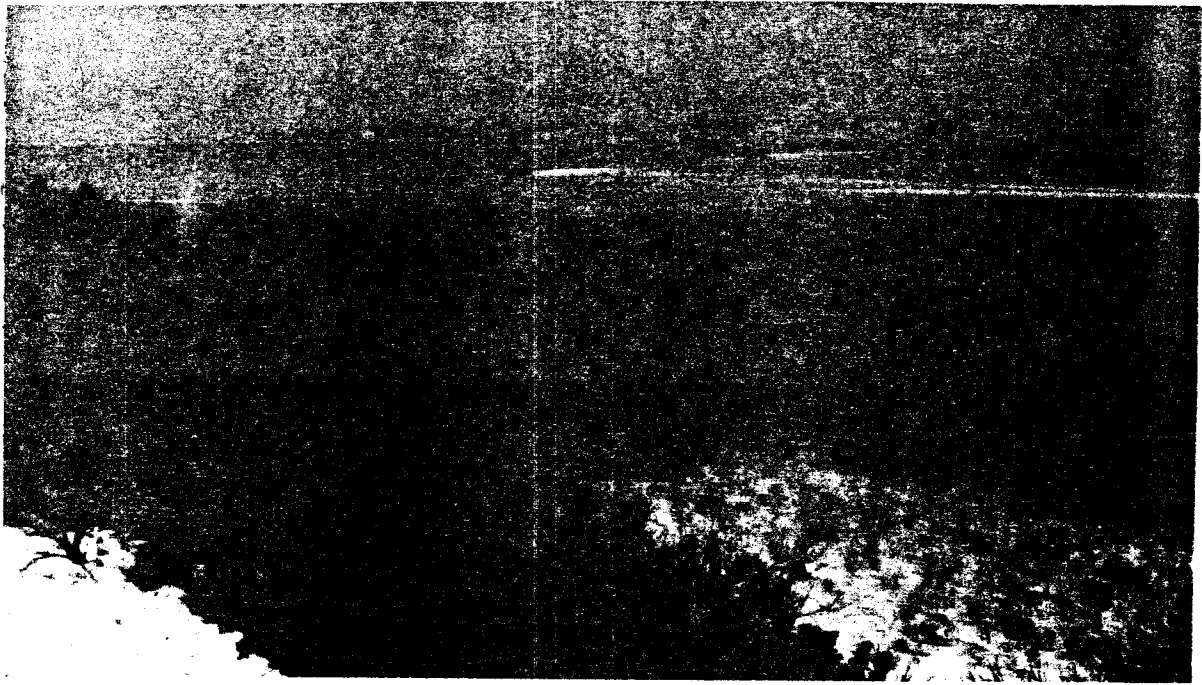
The effects of defoliation are most pronounced in beach plum (Fig. 4). The trunk and lower branches of beach plum are covered with sand, and the terminals appear as small shrubs. Beach plum, bayberry, Myrica pensylvanica, black cherry, salt spray rose, poison ivy, Rhus radicans, and American beach grass, Ammophila breviligulata, comprise the major plant community on the coastal dunes of the Cape. Beach plum, in addition to their value in stabilizing dunes, provide added beauty to the dunes

during blossoming in the spring and the fruit is valued for preserves.



Figure 3. Full grown larva of browntain moth on bear oak.

Schaefer (1974) noted that larvae emerging from the winter webs often fed on buds or on emerging foliage. Emerging larvae congregate and bask on webs, then forage for food. Where heavy early feeding occurs, there is no leaf growth during the current, or in succeeding seasons (Fig. 5). The consequence of early feeding is very evident from the amount of branch and tree death in beach plum.



Figures 4 and 5. Defoliation of beach plum on Long Point, Provincetown (above) and effects of early spring feeding on beach plum (below). Early feeding on buds results in no foliage in the current or succeeding years. Continued episodes of defoliation are causing mortality to beach plum on the outer Cape.

Of the 187 beach plums at High Head marked in July, 1985, 24 (12.8%) appeared to be healthy in July, 1986. Those ranked in poor condition, with little growth in the current year, numbered 103 (55.1%). Sixty (32.1%) were dead or had no live buds or foliage and would not be expected to refoliate during the current or the next growing season.

Shad bush in the High Head area were apparently first defoliated by browntail moth in 1982. Some trees were dead in 1985, and those living had dead branches and sparse amounts of foliage (Fig. 6).

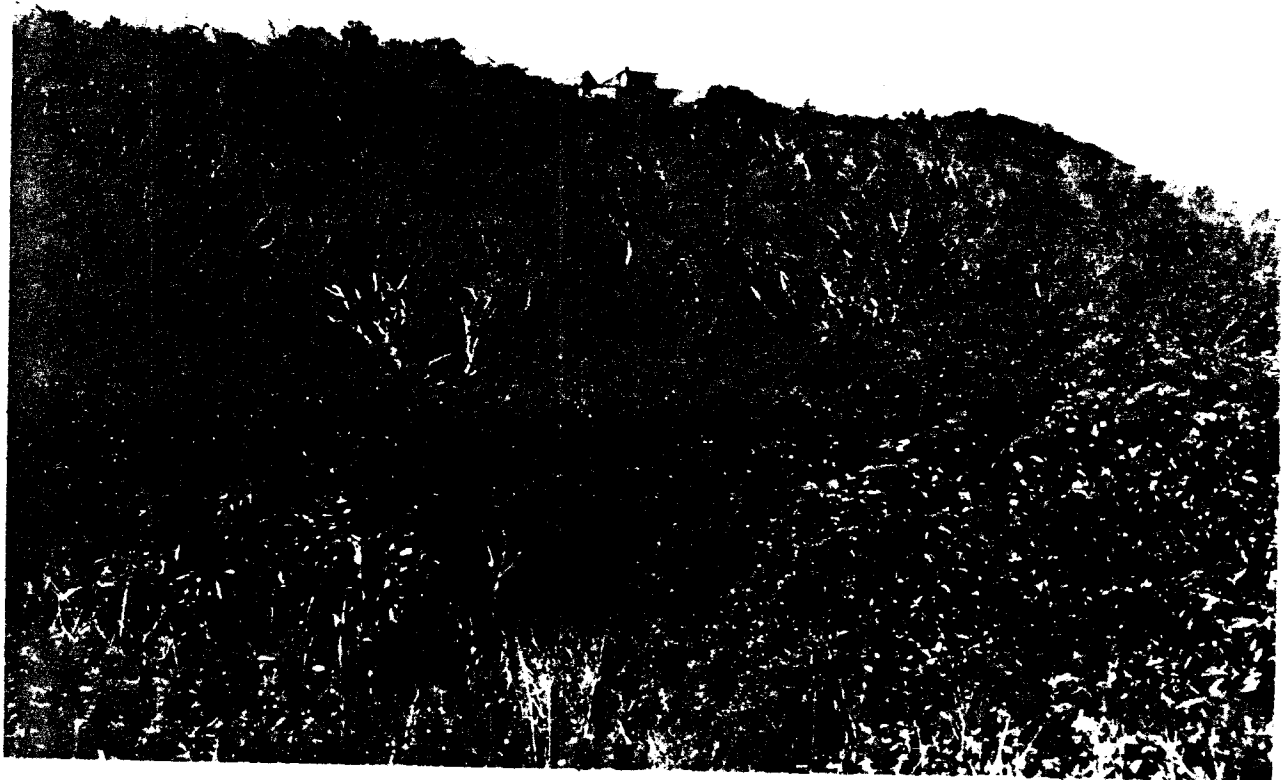


Figure 6. Shad bush in poor condition on hillside at High Head.

The population of browntail moth on shad bush was light in 1985, likely a result of the paucity of leaves on which female moths could oviposit in 1984. Survival was high; 75 (96.2%) of the 78 trees marked in 1985 were alive in 1986, but remain in poor condition.

In some areas, particularly around Pilgrim Heights, bear oak are being defoliated (Fig. 7). Defoliation of oaks has been spotty, and likely dates back only several years. No mortality of oaks was noted.



Figure 7. Defoliation of bear oak in Pilgrim Heights.

Many black cherry in areas where browntail moth feeding has been heavy are in poor condition. Black cherry is frequently infested with tent caterpillar, Malacosoma americana, as well as with browntail moth. Both species are early spring defoliators, and commonly occur together on cherry. It is not possible to determine whether the poor condition is due solely to browntail moth defoliation.

Salt spray rose is less abundant on dunes than beach plum, but is a preferred host (Fig. 8). It is commonly defoliated, but is more tolerant than beach plum. The only mortality observed was in 1985 in one ca. 7 meter patch of rose on Long Point.

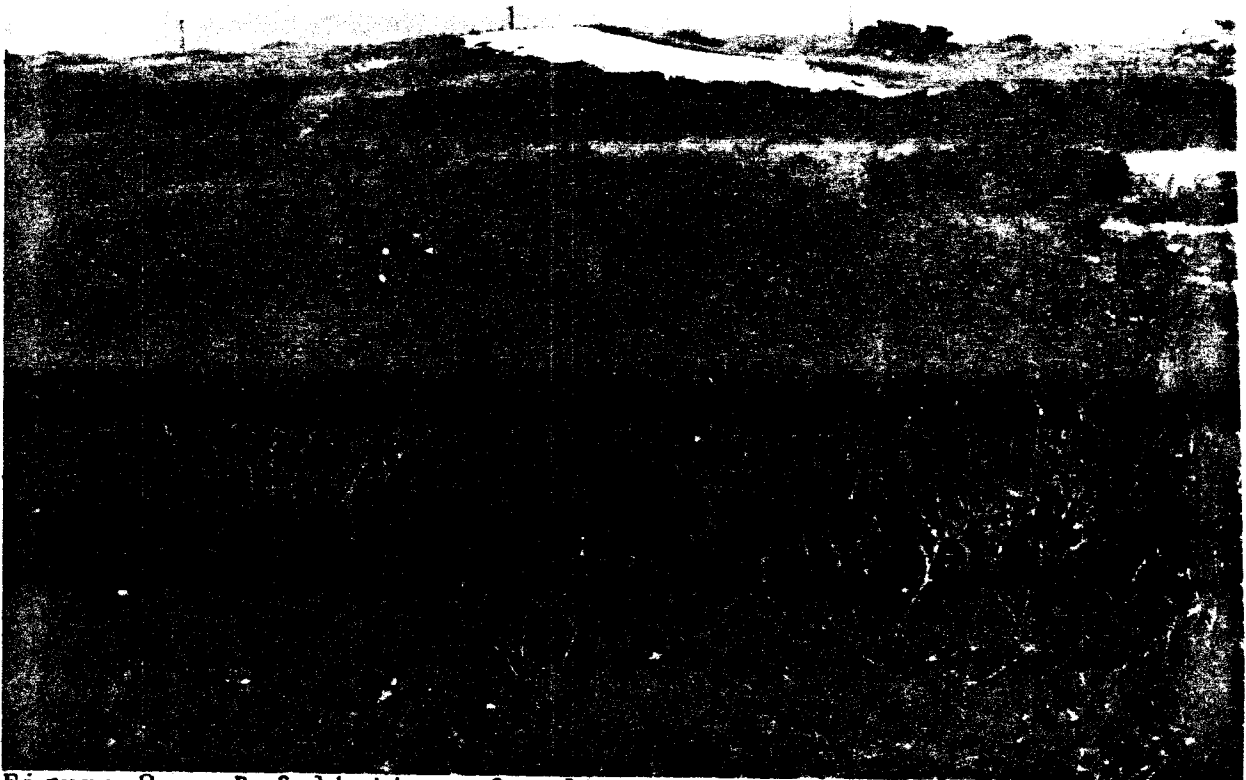


Figure 8. Defoliation of salt spray rose at High Head. Rose is more tolerant to defoliation than beach plum.

Growth ring data from branches were not of value in assessing the impact of browntail moth feeding on stem growth. There was considerable variation in yearly growth of stems that did not correlate with past histories of defoliation. When data for each species were grouped by year for each site, the variance was high. Growth ring analyses using the bole of trees has been a useful technique to determine past defoliation history for some species of forest defoliators (e. g. spruce budworm). Of primary interest was the assessment of defoliation on the most impacted host, beach plum. In retrospect, samples should have been taken from the bole of beach plum, but this would have required a considerable amount of excavation to acquire samples. Other aspects of this study have documented that continued episodes of defoliation does weaken and can kill beach plum.

Environmental factors.

Much of the focus of the study of Schaefer (1974) was on environmental factors, biotic and abiotic, affecting the Cape populations of the browntail moth. Factors influencing the survival of browntail moths include low winter temperatures, parasites, predators, pathogens, and food quality of the hosts. Mortality of larvae in winter webs was ca. 20%. Low winter temperatures on the Cape will not likely be a major mortality factor, since the insect is common to more northern latitudes and high levels of mortality do not occur until temperatures reach -25°C and below. Lethal winter temperatures are not common on the Cape due to the moderating influence of the ocean.

In response to the introduction of the gypsy moth and the browntail moth, an ambitious program was initiated by the U.S.

Department of Agriculture to introduce parasites and predators from Eurasia. Schaefer (1974) found seven introduced species of parasites in browntail moth populations. Four species accounted for appreciable mortality, Montodontomerus aureus (Hymenoptera: Tormidae), Cotesia (Apanteles) lacteicolor (Hymenoptera: Braconidae), Townsendiellomyia nidicola and Compsilura concinnata (Diptera: Tachinidae). C. lacteicolor was not found parasitizing larvae on the Cape and M. aureus is both a larval parasite and a detrimental hyperparasite of beneficial parasitic dipterans.

The absence of C. lacteicolor on Cape Cod might be associated with a lack of preference for dune habitats (Schaefer 1974). With the browntail moth now found in more typical forest habitats, the parasite might be reintroduced from specimens collected from infested islands in Casco Bay, Maine.

Many species of insects like the browntail undergo periodic outbreaks. While mortality factors such as parasites can moderate or extend the period between outbreaks, they do not prevent them. Pathogens, such as the nuclear polyhedrosis virus of the gypsy moth, are often associated with population crashes. The Eurasian literature (listed in Schaefer 1974, 1986) reports a number of pathogens of the browntail moth. Some have not been recovered in North American browntail moth; most likely they were not introduced with the original importation of the insect. Many pathogens are restricted to a single host species. Further study is needed on pathogens of the browntail moth, including exploring the feasibility of importing one or more for release in North America.

The current distribution of the browntail moth suggests a strong affinity for maritime localities. In Eurasia, the insect is best known as a forest and orchard defoliator, and its distribution is continental as well as coastal. There are areas where the insect is most common in coastal areas. The distribution in England is restricted to the southern coast, with periodic outbreaks spreading inland (deWorms 1983). The insect is found along the coast and on islands in the North Sea in The Netherlands (van der Linde and Voute 1967) and West Germany (Lubke 1952). In these sites the common host is sea buckthorn, Hippophae rhamnoides, which occurs in a dune habitat similar to that of Cape Cod.

As a result of the rapid spread after its accidental introduction into the Boston area, the browntail moth was placed under quarantine by the United States Department of Agriculture to reduce the accidental spread into new areas. This quarantine, established in 1912, was recently recinded. The current outbreak on the outer Cape and the lack of a quarantine increases the risk of accidental introduction into new areas.

Long range dispersal of flying insects has also been associated with cyclonic weather. Insects, picked up on winds in frontal systems of storms, can be transported for long distances. The probability of long range dispersal is a function of the timing of storm systems during moth flight and on the size of the source population. The size of the current infestation on the outer Cape will increase the probability of long-range dispersal by wind.

The most common means of dispersal is by flight of female

moths. Schaefer (1974) observed this flight was usually restricted to beach plums near the point of emergence of the moths. Females appeared to avoid flying over open dune areas to adjacent clumps of beach plum. With the insect now reestablished in more typical forest habitats, flight of females would be less constrained by open areas.



Figure 9. A terminal of a beach plum collected in 1985 on High Head containing egg masses and ovipositing females. A total of 44 egg masses were deposited.

The density of moths is very high in some areas. During the period of oviposition at High Head in 1985, beach plums were flecked with white moths. Where numbers of females on some terminals were as high as 44 (Fig. 8), the number of winter webs on trees were less, since some contained larvae from more than

one egg mass. The highest number of winter webs counted on a single beach plum tree was 65, which would yield far more larvae than the tree could support.

The recent resurgence of the browntail moth raises concern about the gradual southward spread of the insect on the Cape and the increased potential for widespread dispersal. During the period of general decline there were several isolated outbreaks in Maine and New Hampshire and the three populations on the outer Cape were sprayed with carbaryl in 1965 and 1966 (Schaefer 1974). The current situation might represent a relatively small and isolated outbreak, such as those occurring previously or it could result in a much larger problem. There has also been a recent increase in numbers of browntail moths on islands in Casco Bay (David Struble, Maine Forest Service, pers. comm.).

The ability to monitor the spread of the insect should be enhanced by capture of males in traps baited with natural or synthetic female sex pheromone. Under a Cooperative Agreement with the USDA Animal and Plant Inspection Service Methods and Development Laboratory, Otis MA, and the Department of Entomology, University of Massachusetts, the active component of the sex pheromone has been isolated from browntail moth, and is now being identified.

Urticating properties of setae.

Among the Lepidoptera, the browntail moth ranks behind the processionary caterpillars in Europe in the severity of the rash produced by their toxic setae.

deJong and his group in The Netherlands have studied some

characteristics of the setae, the toxins, and the dermatitis they cause (deJong 1980, deJong et al. 1975, 1977, 1982, Bleumink et al. 1981; Appendix A). On larvae, from stage two on, these setae are borne on 24 specialized tubercles (Figure 9), with four on the dorsum and laterad of each of segments 3-8.

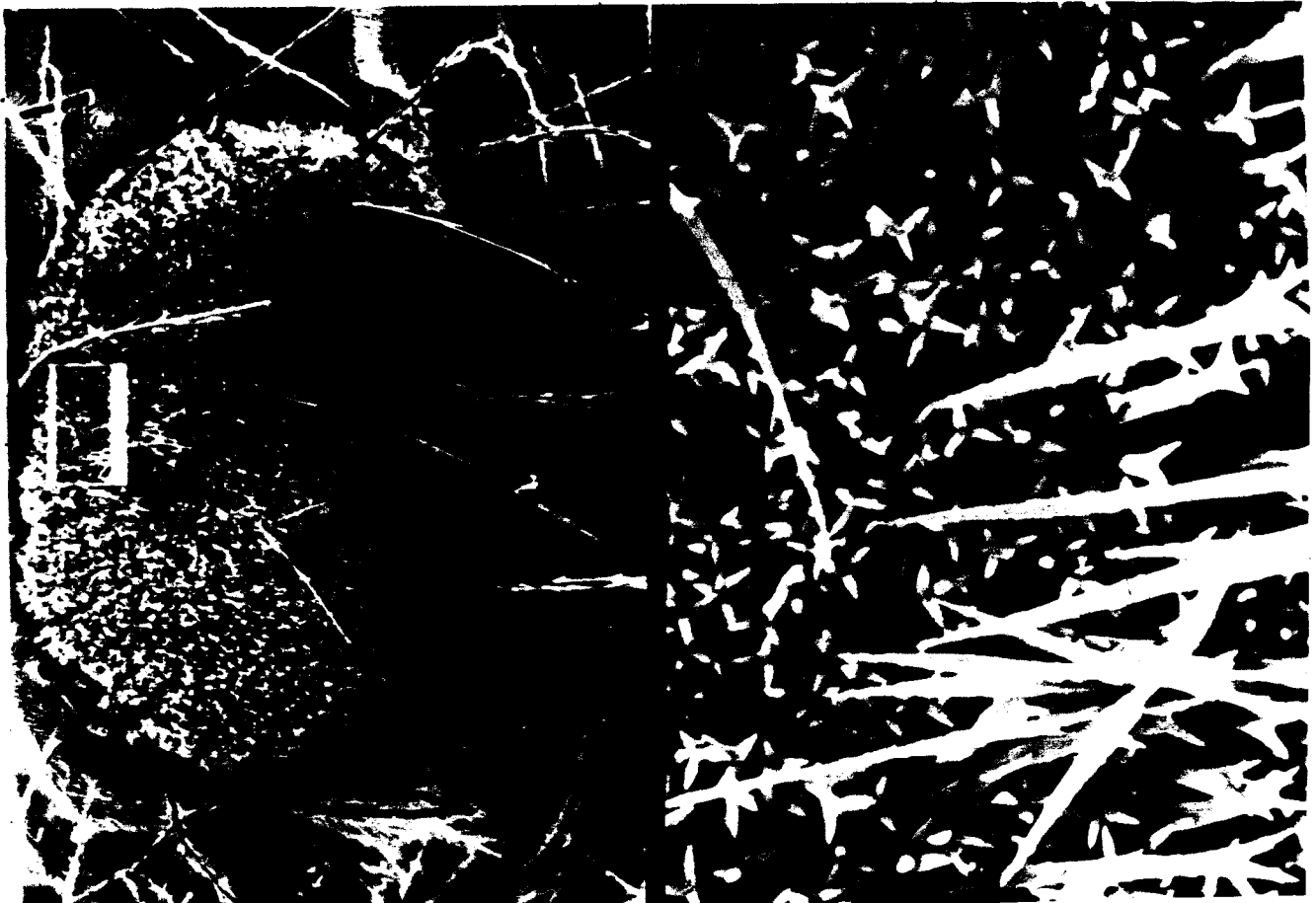


Fig. 10. Tubercule (left) on the abdominal segment of a full-grown larvae containing urticating setae (100X). Densely packed setae (right) are easily dislodged (1000X).

The urticating setae are minute, measuring ca. 150 μ long by 5 μ wide, and are seated within papillae which hold about 7 setae (Fig. 11). The papillae connect with glands producing the toxins which fill the hollow setae. The setae are barbed, and the base is sharply pointed (Fig. 12). They are easily shed, and light enough to be carried by wind.



Figure 11. Papillae containing urticating setae. The papillae connect with glands that produce toxins which fill the hollow hairs.

The dermatitis is caused by penetration of setae into the skin, and by the toxins which include phospholipase A_2 and peptidases. Penetration into the skin triggers direct tissue injury and release of the toxins. The toxins cause a release of histamine to produce an early erythema and weal response. The phospholipidase may also trigger prostaglandin synthesis which may contribute to the long-lasting erythema and to the itching and pain. Blair (1979) studied 36 patients in England with symptoms of exposure to browntail moth and described the symptoms as sometimes episodic, can be continuous, and may be intolerable. Some patients developed conjunctivitis. Rogers and Burgess

(1910) reported the death on one individual working with larvae, presumably from the inhalation of setae. Protection of the skin, eyes, and lungs is advisable when working with the insect.



Figure 12. Urticating hairs of browntail moth showing the sharp point and barbs. The minute hairs readily penetrate the skin where the toxins are released, producing an uncomfortable rash.

With the increase in numbers and distribution of the browntail moth, more people will be exposed to the urticating hairs of larvae and moths. My experience, common to that of others in areas infested with the insect, is that a rash will ensue if measures are not taken to protect the skin from exposure to the hairs. Unreported cases of exposure are likely to be high, since many individuals are not aware of the presence of or the problems associated with the insect. Rashes are often attributed to other causes, such as poison ivy.

MANAGEMENT OPTIONS

The primary factors determining whether pest management strategies should be considered for the browntail moth in the Cape Cod National Seashore are the potential for continued spread, the impact of defoliation, particularly with beach plum, the health concerns of exposure to urticating setae, and the status of the insect as an exotic (introduced) pest. There are several management strategies which could be considered to reduce numbers and/or exposure to browntail moth. These, in no order of priority, are as follows:

1. **Restriction of access.** Exposure to urticating setae could be reduced by excluding access to areas of high density of browntail moth by fencing or by signs warning of the potential exposure to urticating setae.

2. **Removal of host plants.** A limited amount of removal of host plants in areas of high public use such as picnic areas, parking areas, and narrow pathways to beach areas would reduce exposure to browntail moth. This method was used in 1985 by widening the bicycle path in an infested area between Head of the Meadow and High Head.

3. **Removal of winter webs.** The strategy of clipping and destroying winter webs was commonly used during the initial outbreak of the insect in North America. As a general method in the Seashore it would be economically prohibitive, but a limited amount of clipping would be of value in some high use areas, and

where light infestations are found invading new areas. Safety precautions would be required to those assigned the task of clipping and destroying winter webs.

4. Insecticidal control. The highest efficacy would be obtained by use of registered contact insecticides with long residual activity. Such compounds, however, would have a broad spectrum of activity and higher risk to the environment. The outer Cape has unique habitats with rare species of Lepidoptera (Mello 1986), some of which could be adversely affected by broad spectrum insecticides.

The bacterium Bacillus thuriengensis thuriengensis (BT) produces toxic crystals with insecticidal activity against lepidopteran larvae with a high gut pH. BT is not a contact insecticide, and the toxic crystals must be ingested. Mello (1986) examined the effect of BT (Dipel) applied to several species of host trees, and found the greatest number of insects in drop cloths under treated trees were larvae of the browntail moth; also found were larvae of gypsy moth, tent caterpillar, Amphipyra pyramidoides, and two unidentified larvae. BT would have a minimal impact on non-target insects and the environment. Two periods in the life cycle of the insect could be treated; larvae emerging in spring, and larvae emerging from egg masses in summer. Problems can occur, however, with either of these options. For the spring application, foliage must be available when the BT is applied. Where high populations occur on some hosts, such as beach plum, early feeding of larvae on emerging leaves would result in an inadequate amount of foliage to cover with BT. Large larvae are less susceptible to BT, and

late applications would not provide adequate reduction in numbers. Parasitism, particularly tachinids, attack mid- and late-stage larvae, and those browntail moth larvae surviving an early application of BT would likely be subjected to a high rate of parasitism.

Application of BT against hatching larvae in late summer has not, to my knowledge, been tested under field conditions. Careful monitoring will be required to determine the time of hatch. Larvae begin to produce silken webs shortly after hatch, and as silking increases, the opportunity to obtain adequate coverage of BT on leaves will diminish.

5. Biological control. Although some species of introduced parasites persist on the Cape, it is not expected that they will prevent the current outbreak, but they will moderate the severity and likely extend the period between future outbreaks. With the movement of the insect into forested areas, it is possible that the braconid Cotesia lacteicolor could be reestablished from collections in Casco Bay, Maine. Pathogens of browntail have been neglected in North America, but are being studied in Eurasia. Given careful evaluation, some pathogens may be of sufficient value to warrant consideration for importation and release.

6. No action. For the past two decades the strategy for management of the browntail moth has a very limited amount of clipping of webs; functionally, a no action strategy. There are no current data suggesting that the browntail moth will soon decline to the low levels of a decade ago. A likely consequence

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decline to the low levels of a decade ago. A likely consequence of a no action strategy will be the continued spread of the insect.

ACKNOWLEDGEMENT

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