RESEARCH REPORT

Tar spot of maple: where did it come from and is it getting worse?

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What are those polka-dot trees?
Questions like these one are becoming more common with our recent outbreaks of tar spot on maples in southern Ontario and neighbouring areas. Many visitors come to this region in the fall expecting to see the golden red hues of our national emblem, but instead are greeted with big black splotches on yellowing leaves of Norway maple. The black blotches belong to a disease called tar spot.

Figure 2: Norway maple leaf in mid July with two yellow spots which developed from infection by spores of the tar spot fungus a month previously

What is tar spot?
Tar spot is a fungal disease. A large variety of plants have their own tar spot diseases such as maple, willow, holly, tulip tree, oak, and even goldenrod. The disease looks similar on these plants with a thickened black layer on the upper side of the leaf blades. The size of the circular or elliptical spots can range up to several cm across, depending on host and pathogen species.

In 1998, studies at Cornell University (Hudler et al. 1998, Mycotaxon 68:405) revealed that the fungus *Rhystisma acerinum* is the cause of tar spot on Norway maple (*Acer platanoides*). Both the plant host and the fungal pathogen were imported from Europe. A native tar spot species, *R. americanum*, occurs on the native red and silver maples (*A. rubrum* and *A. saccharinum*). The researchers also stated that tar spot of Norway maple was found most commonly in the American Northeast, and southern Ontario (Hudler et al. 1987, Plant Dis. 61:75). Norway maple is thought to be the most common street tree in these areas, partly because it was so extensively planted after countless shade trees were lost to Dutch elm disease in the mid-1900's (Nowak and Rowntree 1990, J. Arboricult. 16:291).

Where did this disease come from?
In Europe, tar spot is found on a variety of maples, including Norway maple and sycamore maple (*A. pseudoplatanus*), which the are two most common maple species. There have been several scientific studies on maple tar spot in Europe starting in the late 1800's (Müller 1893, Wissenschaft. Bot. 25:607; Müller 1912, Central. Bakter. 36:67; Jones 1923, Ann. Bot. 39:41; Schweizer 1932, Planta 16:367). After those reports, there was very little research activity on tar spot in Europe until the 1970's, when air pollution effects on tar spot were reported in Britain (Bevan & Greenhalgh 1976, Env. Pollut. 10:271; Vick & Bevan 1976, Env. Pollut. 11:203). In the last 20 years, tar spot of maple seems to have been increasing in frequency across the eastern Great Lakes Region and most of the American Northeast. For such a noticeable disease, there has been amazingly little scientific research done on tar spot in North America. Extension specialists in New York were first alerted to the presence of large black spots on Norway maple in 1983 in upstate New York (Hudler et al. 1987). In searching through American records, Hudler et al. (1998) found that this disease on Norway maple had been first reported in Ohio in the 1940's, and an extension report (counties.cce.cornell.edu/niagara/hort-news-fall-98.html) from Cornell University speculates that the fungus was introduced into North America in the late 1930's.

Figure 1: An overwintered leaf of Norway maple with a tar spot that has soaked up water and opened up the slits to release spores in late May.

When did tar spot arrive in Ontario?
The tar spot of native maples has probably been here since maples reclaimed their territory after the last ice age. These native tar spots show fluctuations in severity from year to year, depending on rainfall at the time of spore dispersal and infection, and there is some anecdotal evidence that they are becoming more severe. As for tar spot on Norway maple, a report from 1957 states that "tar spot was moderate in a small plantation of *A. platanoides* near Kingsville, Ontario" (Can. Pl. Dis. Surv. 37:116). At the University of Guelph, we noticed that Norway maple trees on campus were showing very high levels of tar spot in the late 1990's. A documented report of the first appearance of tar spot on Norway maple comes from a research study on an island in Lake Huron where the disease was first noticed in 1998 (Webster et al. 2005, For. Ecol. Mgt. 208:85). The fungus may have been in Ontario prior to 1990, but noticeable outbreaks on Norway maple did not seem to occur until after the mid-1990s.

Is tar spot of maple becoming more severe?

In southern Ontario, there are frequent newspaper reports on maple tar spot, such as in the St. Catharines Standard (Aug 31 2005, page A6; Nov 7 2003, page A4), Barrie Examiner (Sept 20 2004, page A1), Orillia Packet & Times (Sept 7 2004, page A1). In November 2007, maple tar spot was even on Canadian National News on television, twice. In some of these reports, the tar spot epidemics on Norway maple were said to have caused premature defoliation, while other reports have found tar spot to be merely an aesthetic nuisance without seeming to cause any serious effects. There are also some anecdotal reports that the native tar spot on red and silver maples is increasing. Some people have speculated that the increased levels of tar spot in the last 15 years are a result of increased pollution emission controls. There are studies which indicated that tar spot is sensitive to air pollutants such as sulfur dioxide (Bevan & Greenhalgh 1976; Vick & Bevan 1976), although another study has contradicted this finding (Leith & Fowler 1988, New Phytol. 108:175).

Figure 3. Silver maple with fingerprint textured tar spots in mid September

Is there any research on tar spot in Ontario?

In the mid-1960's there was some early research on the native tar spots on red maple and mountain maple, cause by *R. americanum* and *R. punctatum*, respectively, conducted at the University of Toronto (Duravetz & Morgan-Jones 1971, Can. J. Bot. 49:1267). Although Norway maples were certainly around at that time, there was no mention made of disease on this host. This provides some indirect evidence that *R. acerinum* was not noticeably present in southern Ontario at that time. In 2006, we received funding from Landscape Ontario for a study on tar spot. The purpose of this work was to examine the epidemiology of this disease, by gathering overwintered maple leaves from multiple locations in southern Ontario weekly from March through August in 2006 and 2007, and inspecting them for the presence of spores of the tar spot fungus. We found that spore release from tar spots on Norway maple occurs over a four-week period, from late May to late June, and that the start of the spore release period coincided with full leaf expansion in Norway maple. Another objective of this research was to confirm the genetic identity of the organism causing tar spot on Norway maple in Ontario, as well as its relationship to tar spot on other European maples and North American maples. We used DNA sequencing to confirm that tar spot on Norway maple in southern Ontario is indeed caused by the European species, *R. acerinum*, by comparing the sequences to sycamore maple samples obtained from Germany and England. We also found that native maple species such as red maple and silver maple have tar spot caused by *R. americanum,* and that the speckled tar spot caused by *R. punctatum* is found locally on striped maple (*A. pensylvanicum*) as well as on big-leaf maple (*A. macrophyllum*) samples obtained from Vancouver Island.

How do the tar spot fungi survive through the year?

The tar spot fungi share similar life cycles. Fallen leaves bearing the tar spots will overwinter. With the onset of warmer weather in spring, the black spots begin to produce spores internally. After extended rainfall or prolonged wetting, the black spots absorb moisture, and the spore producing bodies open (Figure 1) to eject tiny, thin sticky spores which are carried by wind to newly expanded maple leaves. These tiny spores infect the leaves and a few weeks later, small yellow spots become visible (Figure 2). The yellow spots expand slowly, and begin to develop small black spots. Here the pattern of develop differs between tar spot on silver maple and that on Norway maple. On silver maple, there is more commonly a single or just a few black spots within a larger yellow spot that merge and expand in size up to 1.5 cm across, forming a fingerprint pattern (Figure 3). On Norway maple, there are many distinct black spots starting at a pinhead size (Figure 4) and expanding to a few millimeters across. These individual black spots generally grow together and form large spots (Figure 5). The third species, which is found on striped maple, forms a speckled pattern where the individual small spots never merge into a large spot (Figure 6). The spots continue to enlarge through the growing season but often reach their full size before the end of the August in southern Ontario. After the end of June, no new spots are initiated. Our preliminary work with fungicides on Norway maple in summer 2007 indicates that existing spots will continue to develop in summer even with the use of systemic fungicides that can penetrate into the leaf tissue. This suggests that fungicide applications after the infection period in late May through late June are probably ineffective at normal rates applied for foliar diseases of woody ornamental plants.

Figure 4. Norway maple in mid August with discrete black heads with larger yellow patches caused by the tar spot fungus.

How can maple tar spot be managed?

The most common recommendations for controlling tar spot involve reducing the amount of overwintering fungus by collecting as much of the fallen leaves bearing tar spots as possible. This management system is effective only if everyone in the neighbourhood participates, and if no one attempts to compost some leaves in their back yard. Homeowner composts rarely reach the very high temperatures which are necessary to kill off fungal spores and other overwintering fungal growth. Furthermore, the thick tar-like fungal

growth of tar spot fungi may be more resistant to degradation during composting than common fungal growth found on vegetables and flowers. Also, it is becoming increasingly popular to mulch leaves by using mower adapters to chop up leaves into smaller bits to allow them to break down over winter and act as a natural fertilizer in the spring. However, the end products of this mower mulching process are well - dispersed small bits of leaf tissue still bearing recognizable tar spot tissue, which may survive through winter. Whether composting in the back yard or mulching in the front yard or even composting by municipalities, research is needed into the survival of the tar spot fungi, and ways to promote its decomposition.

Figure 5. Norway maple in late October with large tar spots.

The 1998 extension report from New York mentions that in an outbreak near Cornell University with premature defoliation of maple leaves bearing many tar spots, there were also other fungi involved in causing the leaves to fall. Our observations are that even very heavy levels of tar spot on Norway maple leaves (more than 5 spots per leaf) have not seemed to cause premature defoliation in many cases.

Norway maple is notorious for hanging on to its leaves much longer than native maple species, and this probably has to do with the more northerly locations and shorter daylengths where the stock originated. From our research, we have found that the tar spot fungi are obligate parasites which means that they requiring living plant tissue to feed on, and are not easily grown on artificial media. Obligate parasites that have co-evolved with their hosts, such as *R. acerinum* on Norway maple, are often in tune with their hosts such that they do not drive their hosts to extinction. In theory, tar spot diseases on Norway maple and native maples are aesthetic nuisances and do not cause excessive damage on their hosts. It is only when the host plant species have been extensively altered, such as by breeding, or when placed in a unsuitable growing environment, that their obligate parasites become more than a nuisance.

What future research is needed on tar spot?

Other questions that still remain to be answered include the following:

a) Which pathogen causes tar spot on sugar maples (*Acer saccharum*)? We have some preliminary evidence that the Norway tar spot fungus (*R. acerinum*) is able to infect sugar maple, but need to confirm this by more research.

b) Which fungicides are effective in preventing infection or eradicating infection? There are no fungicides registered for tar spot control in Canada. Hudler et al. (1987) found that the disease could be controlled by spraying with benomyl, mancozeb, or triadimefon at budbreak and twice more at 15 day intervals, while copper hydroxide at the rate used was not effective. Benomyl and triadimefon are not registered for any crop in Canada. There is a need to test the efficacy of newer fungicides such as the demthylation inhibitors (e.g. propiconazole in Banner or myclobutanil in Nova), as well as the strobilurins (trifloxystrobin in Compass or azoxystrobin in Heritage).

c) Why is tar spot increasing in incidence and severity across the Northeast region?

This question is often asked, but the answers have all been speculative (e.g. decreased air pollution, global warming, wetter springs, etc.). There is a need for a systematic survey of the literature and statistical correlation with environmental variables such as weather and pollution indices to see whether some strong relationships exist.

Compared to other highly visible diseases in the urban environment, we know much less about maple tar spot diseases. More research is needed on the biology of the fungal pathogens to provide management options for this disease, and to give a better understanding of these fascinating organisms.

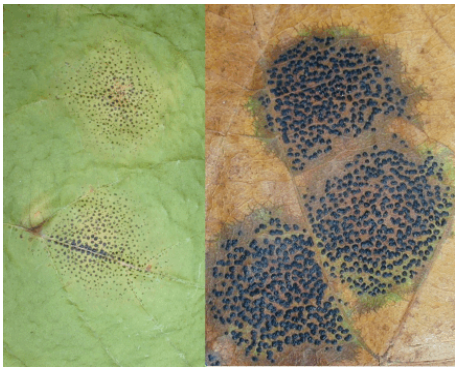

Figure 6: Composite image of the speckled tar spot on striped maple (left) and big-leaf maple (right)

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