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Recovery and distribution of *Anthribus nebulosus*, a scale predator introduced into Virginia in 1981

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Abstract:

Anthribus nebulosus Forster (Coleoptera: Anthribidae) is a scale predator native to Eurasia that was imported from Hungary in the 1970s and released in Virginia Beach, VA, in 1981 as a potential biological control against soft scale insects. First recovery of *A. nebulosus* in Virginia Beach occurred in 2010, 29 years after release. Subsequent surveys of soft-scale infested oaks over a 3-year period indicated that *A. nebulosus* had spread up to 32km from the initial site in multiple cities and directions, but further spread was limited by geographic barriers.

Introduction:

Anthribus nebulosus Forster (Coleoptera: Anthribidae) is one of two common anthribid European species that are predators of soft scale (Hemiptera: Coccidae) insects and their eggs (Valentine 1998). Both *A. nebulosus* larvae and adults feed on all stages of soft scales. Its life history closely follows the life cycle of scale insects (Kosztarab and Kozar 1983) with adults appearing in spring to lay a single egg inside the ovisacs of female soft scales. Egg hatch typically occurs in June and July, during which *A. nebulosus* larvae feed on soft scale eggs and nymphs and pupate under the female scale cover. In Europe, newly emerged adults enter diapause in August, hibernating in bark cracks or the empty ovisacs of host scale insects (Gonget 2003).

Anthribus nebulosus is known to prey on at least 15 species of scale insects in Europe and Central Asia, three of which are considered pest species in the eastern United States (Hoebeke and Wheeler 1991). In the mid-Atlantic region, *Parthenolecanium quercifex* (Fitch) (Hemiptera: Coccidae), oak lecanium, is a frequent pest of oaks planted as urban street trees. Willow oak, *Quercus phellos* L. is a shade tree widely planted in many street medians, parking lots, and parks throughout the region, and is commonly infested with *P. quercifex* and associated parasites and predators (Schultz 1984, Robayo 2015). Surveys in years following the 1981 Virginia releases of *A. nebulosus* determined that the beetles released in Blacksburg, VA survived with specimens recovered in low numbers (Hoebeke and Wheeler 1991). However, there was no evidence to confirm establishment of *A. nebulosus* at or near the Virginia Beach release site (Hoebeke and Wheeler 1991). A number of *A. nebulosus* were collected from sites in the northeastern U.S. beginning in 1989, and in subsequent years from western Massachusetts and Connecticut to eastern New York (Hoebeke and Wheeler 1991). The presence of large numbers of *A. nebulosus*

in parts of Connecticut and Massachusetts combined with none being found between there and Virginia suggested that populations in New England were long-standing and adventitious, rather than the product of intentional releases (Hoebeke and Wheeler 1991). It is purported to have been accidentally introduced to the United States as early as the late nineteenth or early twentieth century, before passage of the Plant Quarantine Act of 1912 (Hoebeke and Wheeler 1991).

In 2010, adult *A. nebulosus* were collected from *Q. phellos* infested with heavy *P. quercifex* populations at two urban landscape sites in Virginia Beach within 6km of the original release site. These two sites originally served as the Virginia component of a Clemson University oak lecanium management project also conducted in North Carolina, South Carolina, and Georgia. The objective of the project was to develop an effective and integrated scale insect management program, part of which involved the use of yellow sticky cards deployed on each cardinal point of the tree, and the collection of terminal samples to determine the composition and impact, as well as the seasonal activity, of natural enemies (Camacho 2015). While monitoring parasitoid activity using the sticky cards, *A. nebulosus* was discovered among other *P. quercifex* predators and parasitoids for the first time since 1981.

The unexpected collection of *A. nebulosus* on urban street trees in Virginia Beach prompted additional surveys to delimit the establishment of the predator nearly three decades after its release. The objective of this study is to determine the adult activity period at the aforementioned two sites, and the extent of distribution of *A. nebulosus* since its 1981 release.

Materials and Methods:

A survey was conducted in eastern Virginia from late March to July, 2011 and 2012 and in northeastern North Carolina in 2013. A beat sheet used for sampling arboreal curculionids was used to survey for the presence of *A. nebulosus*. In 2011, monitoring was initiated weekly at the two sites (Site 1= 36°52'23.8"N 76°10'17.0"W and Site 2= 36°53'50.2"N 76°10'53.3"W) in Virginia Beach 6km from where 300 beetles were originally released in 1981. The survey radiated from the original release site in multiple directions wherever *Q. phellos* infested with *P. quercifex* were found on public property or with permission from a property owner. A scale-infested branch was struck several times with the beat sheet positioned beneath, and beetles were collected. The survey extended outward through adjoining municipalities and continued until *A. nebulosus* was no longer collected.

Concurrently, samples were taken from scale-infested trees with the predator present near the Hampton Roads Agricultural Research and Extension Center, Virginia Beach, each week to ensure that adults could still be recovered. Surveying was suspended in July, 2011. Recovered adult beetles were counted and preserved in vials in 70% ethanol along with the date and site. Identification was confirmed and voucher specimens deposited in the Virginia Tech Insect Collection, Blacksburg, VA. Positive sites were used as a point of reference for extending the survey. In May, 2012, surveying resumed and extended to additional sites in the cities of Virginia Beach, Chesapeake, Norfolk, Portsmouth, and Suffolk. In May, 2013, monitoring extended southward into North Carolina and westward to sites beyond recovery points of the previous year.

Results and Discussion:

The survey at the two sites where initial recoveries occurred in 2010 found adult *A. nebulosus* at low numbers in April of both 2011 and 2012 with higher numbers between mid-May and late June (Figures 1 and 2). Radiating out from the original release site in Virginia Beach (36° 53' 36" N; 76° 7' 42" W), the surveys in 2011 and 2012 confirmed the establishment of *A. nebulosus* in previously unexplored locations in the cities of Virginia Beach, Norfolk, Chesapeake and Portsmouth (Figure 3). In 2013, surveying failed to confirm establishment in Hampton, Petersburg and Richmond, and south into North Carolina. The collective data reflected that *A. nebulosus* had spread from the initial release location approximately 23km west in Norfolk, 27km south in Virginia Beach, 31 km southwest in Chesapeake, and 32km west in Portsmouth. A geographical barrier was noted between the positive and negative sites. Locations separated from the positive sites by large bodies of water or swamps were negative for *A. nebulosus*. Our survey found a preference for hosts in managed landscapes of urban and suburban areas where *Q. phellos* is a common street tree and large infestations of *P. querciflex* were present. Trees in these habitats were ideal sampling sites for recovery of *A. nebulosus*.

This study provides evidence of establishment and spread of *A. nebulosus* over four cities in southeastern Virginia since its release in 1981. Its presence adds to the beneficial insect complex previously reported (Schultz 1984, Robayo 2015) that suppresses outbreaks of *P. quercifex* in urban landscapes.

Appendix 1. *Quercus phellos* literature review

Quercus phellos, commonly called willow oak, is a deciduous, medium to large-sized southern tree in the red oak group of oaks. Introduced in 1723 to the United States, it is now

predominantly found in floodplains and adjacent slopes, in the rich uplands of New York, and in the bottomlands of the Coastal Plain from New Jersey and southeastern Pennsylvania down south to Georgia and northern Florida (Dirr 1998). It also occurs west to Texas and north in the Mississippi Valley to southeastern Oklahoma, Arkansas, southeastern Missouri, southern Illinois, southern Kentucky, and western Tennessee (Little 1979).

Q. phellos is an attractive and hardy tree, often growing from 40 to 60 feet in height with a comparably wide spread (Dirr 1998). The bark of *Q. phellos* is gray-brown and becomes roughened by ridges and furrows in its old age. Its leaves are alternate, simple, narrowly elliptical or lance-shaped, and 2 to 5.5 inches in length with slightly wavy and entire margins. They are medium to dark green in color and glabrous above, while the underside is hairy along the midrib (Dirr 1998). The overall growth habit of the tree is pyramidal in youth and later develops a dense oblong-oval or rounded crown as it reaches maturity. *Q. phellos* is monoecious, with male and female flowers, which emerge the week before the leaf buds open, occurring in separate catkins on the same tree.

Known for its rapid growth and long life, it is an important source of lumber and pulp as well as a valuable species to wildlife for its annual acorn production (Cypert and Burton 1948). Further, *Q. phellos* is a favored shade tree and widely planted as an ornamental despite its deciduous nature. Its finer-than-most texture, combined with its medium size, makes it ideal as an avenue, street or boulevard tree; in this capacity it can be seen everywhere. *Q. phellos* is planted liberally in many street medians and large parking lots throughout the region.

There are a few insect pests that serve as damaging agents for *Q. phellos*, even though it is hardy. Trunk borers, including red oak borer (*Enaphalodes rufulus*), carpenterworm (*Prionoxystus robiniae*), and living-beech borer (*Goes pulverulentus*), are insect pests that degrade saw log quality, and weevils (*Curculio spp.*) attack acorns. However, in eastern Virginia, oak lecanium scale (*Parthenolecanium quercifex*) is a notably significant pest (Schultz 1984).

Appendix 2. *Partholecanium quercifex* literature review

Female *P. quercifex* are two to six mm in diameter with a round, reddish-brown cover when mature. Once females mature, they become stationary on the branch and develop hardened ovisacs, under which they lay thousands of eggs in April and May that resemble fine pollen. Egg-hatch releases pale orange crawlers, or first instars, that move to the underside of leaves and feed until late summer. The second instars return to twigs to overwinter and complete development the following spring (Schultz 1984).

P. quercifex is capable, in large numbers, of severely reducing tree vitality and causing entire branch or crown dieback (Schultz 1984). Feeding can cause stunted plant development in general, including underdeveloped flowers as well as premature leaf drop. Sucking sap from the leaves and twigs of the tree with piercing-sucking mouth parts, *P. quercifex* excrete honeydew that promotes sooty mold fungus; additionally, heavy amounts of dripping honeydew are potentially damaging to structures or objects below, such as cars in parking lots where *Q. phellos* is often planted. The pest is very prevalent in such situations where the tree experiences stress from the hot, exposed, paved surrounding environment and where it is often constrained to a growing area ultimately too small for healthy development.

Beneficial insects can also be observed in most infestations of *P. quercifex*. Specifically, five species of Hymenoptera have been identified in eastern Virginia and have been found to be effective as biological control agents (Schultz 1984). These species include *Encyrtus fuscus* and *Blastothrix* sp. (Encyrtidae) which are internal parasites of the adult female, *Coccophagus lycimnia* (Aphelinidae) which is an internal parasite of the immature stages, *Eunotus lividus* (Pteromalidae) which is an egg predator, and *Pachyneuron altiscutum* (Pteromalidae) which serves as a secondary parasite (Schultz 1984). In addition, *A. nebulosus*, is known to prey upon *P. quercifex*.

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Figure Captions

Fig. 1. *Anthribus nebulosus* adults collected from two sites in Virginia Beach, VA -2011.

Fig. 2. *Anthribus nebulosus* adults collected from two sites in Virginia Beach, VA -2012.

Fig. 3. Dispersal map of *Anthribus nebulosus* in southeastern Virginia (initial 1981 release site is starred)

Figure 1

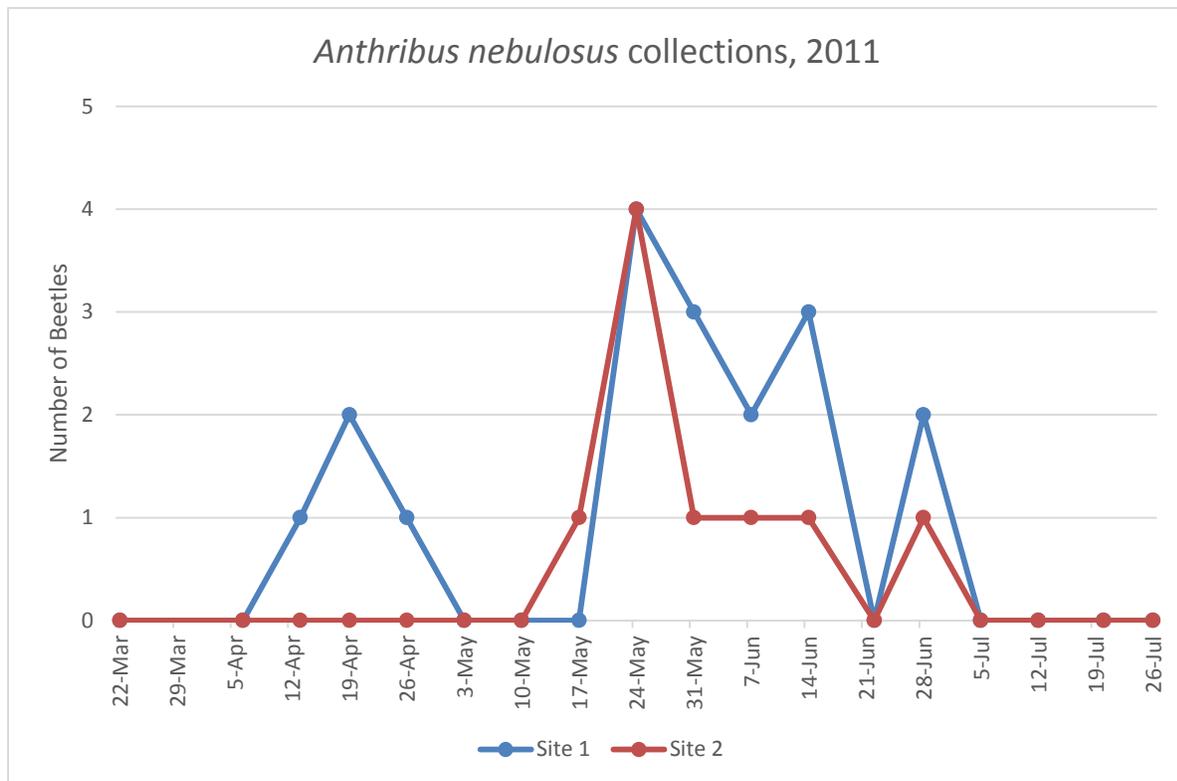


Figure 2

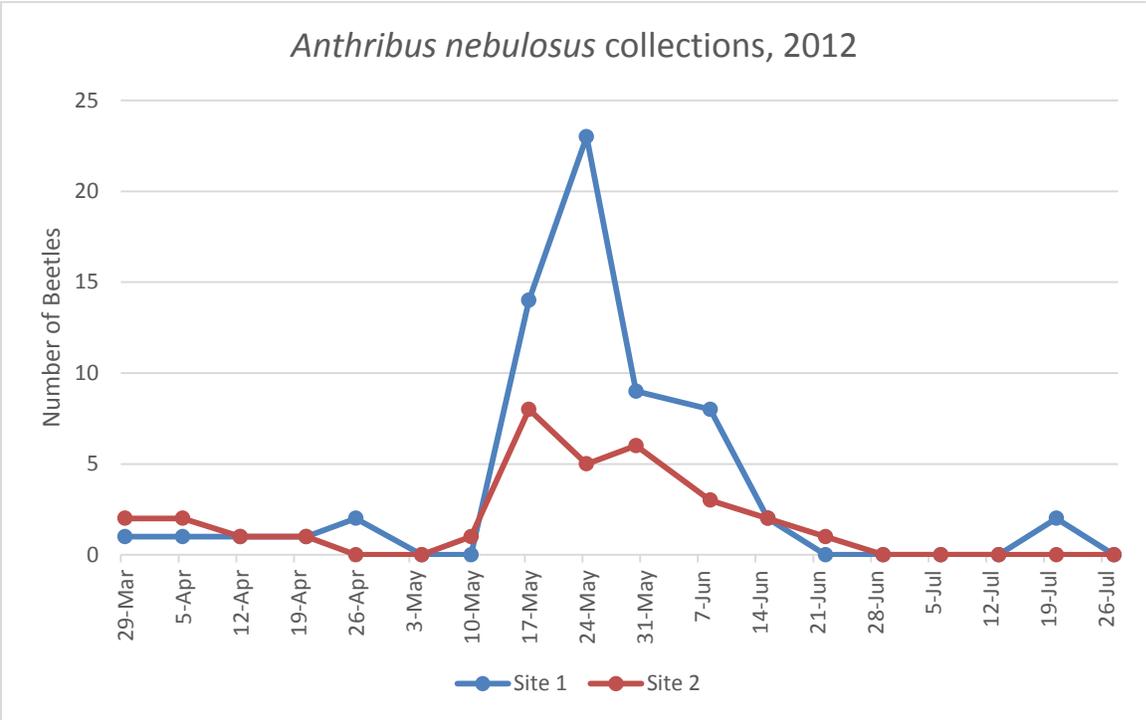


Figure 3

