


SCIENTIFIC NOTE

Assessing southern pine beetle (Coleoptera: Curculionidae) success in eastern white pine (Pinaceae) on Long Island, New York, United States of America

Kevin J. Dodds¹ , Jonathan Janelle¹, and Kathy Schwager²

¹State, Private, and Tribal Forestry, Forest Health Protection, U.S. Forest Service, Durham, New Hampshire, 03824, United States of America and ²Environmental Protection Division, Brookhaven National Laboratory, Upton, New York, 11973, United States of America

Corresponding author: Kevin J. Dodds; Email: Kevin.J.Dodds@usda.gov

(Received 27 February 2024; accepted 24 April 2024)

Abstract

Southern pine beetle, *Dendroctonus frontalis* Zimmermann (Coleoptera: Curculionidae: Scolytinae), has expanded its range further into northeastern United States pitch pine (*Pinus rigida* Miller) (Pinaceae) forests and established populations on Long Island, New York, since 2014. Although rare, small plantations of eastern white pine, *Pinus strobus* Linnaeus (Pinaceae), also occur on Long Island and may be attacked by *D. frontalis*, providing opportunities to assess economic and ecological impacts of the beetle in an uncommon host. We sampled overstorey tree health in three *P. strobus* stands to assess stand-level damage caused by *D. frontalis* and documented *D. frontalis* attack density and brood gallery estimates in *P. rigida* and *P. strobus*. *Dendroctonus frontalis* attacked 37–55% of trees in the stands. Attack density, successful brood galleries, and brood gallery length were higher in *P. rigida* than in *P. strobus*. There was variation in these variables among four heights on tree boles. No difference was found for unsuccessful galleries between the two pine species. Information on *D. frontalis* behaviour and colonisation success in regionally abundant stands of *P. strobus* will be helpful in assessing risk to the region.

Southern pine beetle (*Dendroctonus frontalis* Zimmermann) (Coleoptera: Curculionidae: Scolytinae) was detected on Long Island, New York, United States of America, in 2014, attacking and killing pitch pine, *Pinus rigida* Miller (Pinaceae). Since then, annual damage has occurred across the Central Pine Barrens and adjacent areas on Long Island. *Dendroctonus frontalis* impacts in these stands have been severe and compounded by mesophication, and they threaten the persistence of *P. rigida* in these forests (Nowacki and Abrams 2008; Heuss *et al.* 2019). Unfortunately, *D. frontalis* has not been limited to Long Island and was found infesting trees elsewhere in the northeast United States of America – in Connecticut in 2015, and on Martha's Vineyard and Nantucket, Massachusetts, during summer of 2023. In addition, adult *D. frontalis* have been collected in pheromone-baited detection traps in Maine, New Hampshire, Rhode Island, and upstate New York, where infestations have yet to be detected (Dodds *et al.* 2018; Kanaskie *et al.* 2023; Fig. 1).

The presence of *D. frontalis* on Long Island and in portions of New England represents a range expansion and is related to warming that is projected to continue over the coming decades (Intergovernmental Panel on Climate Change 2023). Warming temperatures are expected to further release climate constraints on *D. frontalis*, likely resulting in greater access to stands of

Subject editor: Jon Sweeney

© United States of America Department of Agriculture, Forest Service, 2024. This is a work of the US Government and is not subject to copyright protection within the United States. Published by Cambridge University Press on behalf of Entomological Society of Canada.

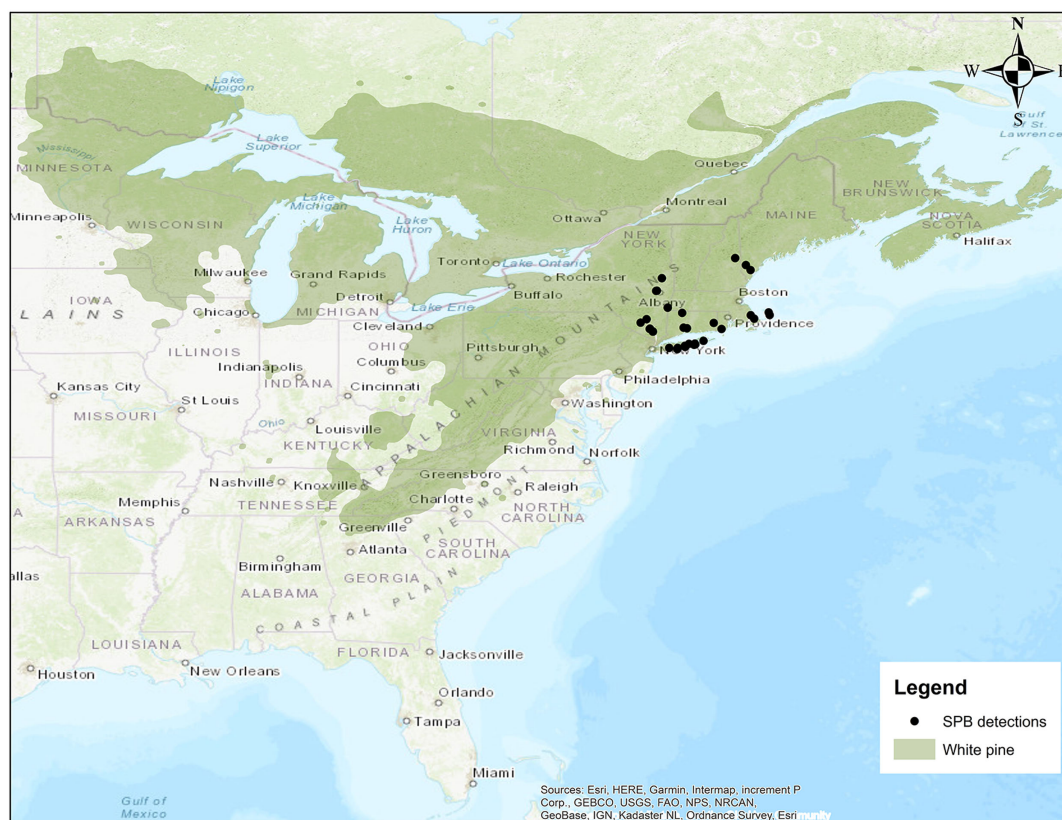


Figure 1. Map depicting *Dendroctonus frontalis* positive trap locations in New York and New England, United States of America, along with the distribution of *Pinus strobus* in North America.

P. rigida farther north, as well as to stands of jack, *Pinus banksiana* Lambert, and red pine, *Pinus resinosa* Aiton, (both Pinaceae) (Lesk *et al.* 2017). In much of the region, eastern white pine, *Pinus strobus* Linnaeus (Pinaceae), is the most common pine species on the landscape (Fig. 1). *Pinus strobus* is a host of *D. frontalis* in southern Appalachia (Hopkins 1899; Hain *et al.* 2011); however, there is little data about stand- or tree-level interactions, particularly in northern regions of the United States of America.

The distributions of *P. strobus* and *D. frontalis* have historically overlapped in the mid-Atlantic and along portions of the Appalachian Mountains in the southeastern United States of America. There is evidence that *D. frontalis* can cause mortality in *P. strobus* stands in southern Appalachia and that infestations can be sustained in these stands (*i.e.*, produce enough brood to maintain spot growth through a season; Hain *et al.* 2011). For example, *P. strobus* were attacked and killed in pine-dominated forests that also contained *P. rigida* and other hard pine species in North Carolina (Knebel and Wentworth 2007). In a separate study in North Carolina, infestations mapped from the air were used to assess *D. frontalis* host preference across multiple years and suggested that *P. strobus* is much less preferred compared to most common hard pines in the area (Anderson and Doggett 1993). *Pinus strobus* mortality caused by *D. frontalis* has also been noted in portions of West Virginia (Hopkins 1899). Attack and within-tree brood estimates for *D. frontalis* in *P. strobus* are more limited. One lab study suggested that *P. strobus* was a less suitable host than the more commonly used loblolly pine, *Pinus taeda* Linnaeus (Pinaceae), based on within-phloem life history estimates (Gardner 2011).

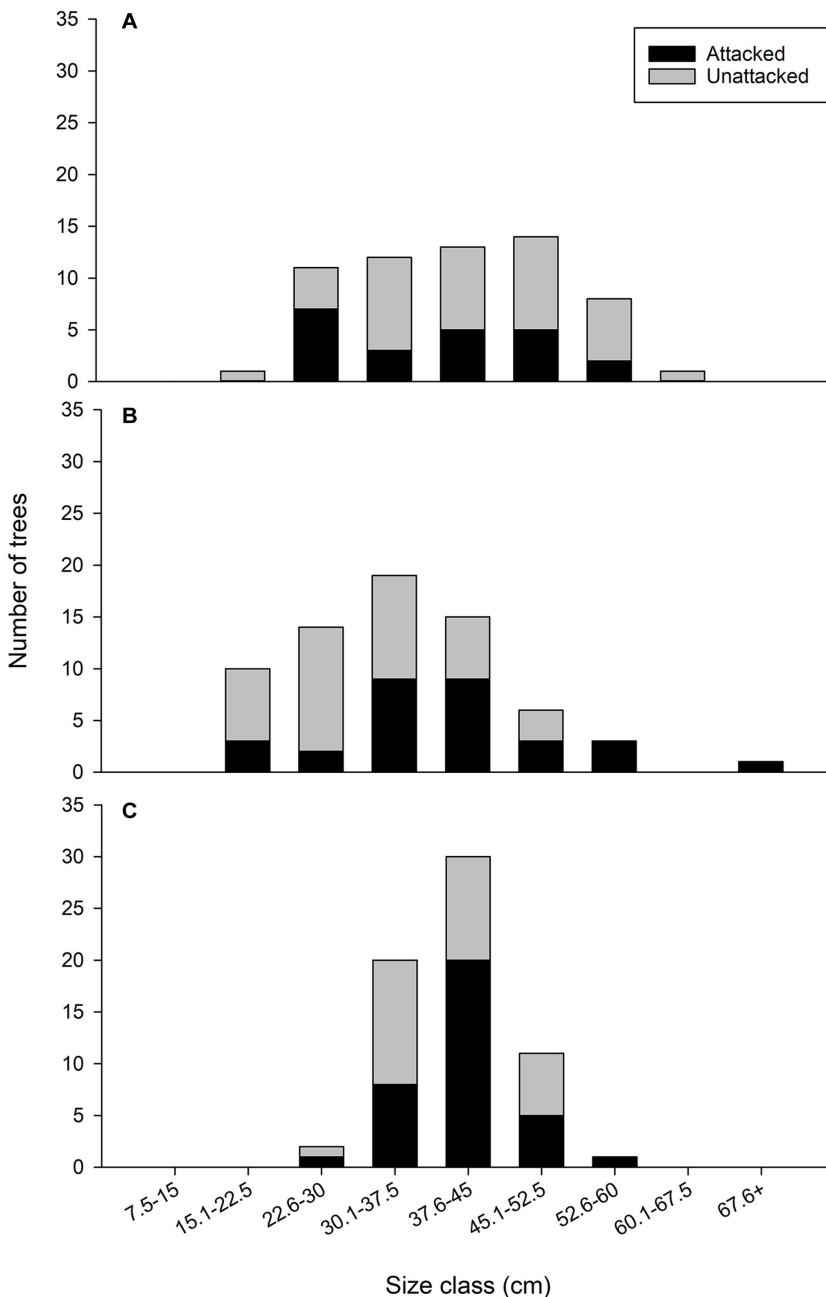


Figure 2. Size class distribution of *Pinus strobus* (≥ 7.5 cm dbh) attacked and unattacked by *Dendroctonus frontalis* in **A**, Brookhaven National Lab 1 (BNL1), **B**, Brookhaven National Lab 2 (BNL2), and **C**, Southaven County Park 1 (SH1) stands on Long Island, New York, United States of America.

Although limited in distribution on Long Island, *P. strobus* has been intermittently infested by *D. frontalis* since 2015, providing opportunities to study interactions between the beetle and an uncommon host tree. Knowledge of *D. frontalis* behaviour in *P. strobus* is lacking but important for assessing risk to an important timber species. We evaluated *D. frontalis* impact at the stand

level in forests dominated by *P. strobus* and compared attack density and within-tree estimates in *P. strobus* and *P. rigida* on Long Island.

We visited and sampled *P. strobus* stands on Long Island that were infested during summer and fall 2022. Two stands (each ~1 ha) on Brookhaven National Lab lands (BNL1, BNL2) and one stand (~1.5 ha) in Southaven County Park (SH1) were sampled using 11.3-m fixed-radius overstorey plots to record tree species, diameter at breast height, canopy class, and *D. frontalis* attacks. Sampling occurred in early February 2023. A minimum of three plots were established across each stand.

To compare attack density between *P. strobus* and *P. rigida*, we used BNL1 and an adjacent *P. rigida* stand. The *P. rigida* stand was located directly across a small road from BNL1, and both stands were surrounded by a larger forested and urbanised area where *D. frontalis* populations were high during the previous two years and were causing widespread tree mortality evidenced from ground and aerial surveys during that time. From the attacked trees in each area, trees with brood at the mid-larvae stages or later present at breast height were considered for sampling. Trees were selected as randomly as possible, accounting for logistics of safe tree felling in dense stands and adjacency to active roads and trails. Six *P. strobus* and five *P. rigida* were felled on 29–30 March 2023. Tree height, diameter at breast height, total infested bole length, height to base of live crown, and diameter at top and bottom of infestation were recorded. Each infested bole was then partitioned into four equal sections, with length relative to infested bole length. Three 81-cm² bark samples were taken from each section using a 10.2-cm-diameter hole saw and returned to the lab for processing.

Bark samples were dissected under a stereo microscope (Olympus SZ61, Tokyo, Japan). Number of attacks were counted on the outside of each bark sample. Attacks were differentiated from exit holes or ventilation holes by the angle, presence of resin and frass, and position at the base of a gallery (Stephen and Taha 1976). On the phloem side of bark samples, successful and unsuccessful brood galleries were differentiated, based on the presence or absence of resin and larval galleries, and then tabulated. Total successful brood gallery lengths were measured using a chartometer (Map Measurer Classic, Kasper & Richter GmbH & Co. KG, Uttenreuth, Germany). The presence of early- and mid-instar larvae in the phloem and of late-stage larvae or pupae in the outer bark were documented for each sample. Trees were considered successfully attacked if they had either living or dead mid- or late-instar larvae. Brood emergence densities were not used for analyses due to the following concerns: (1) asynchronous development times among trees (*i.e.*, some trees had emergence holes in some portions and late-stage brood in other portions); (2) multiple brood emerging from one exit hole; and (3) potential destruction of brood during dissection.

T-tests were used to compare infested tree variables between *P. rigida* and *P. strobus*. For comparison of attacks, successful galleries, unsuccessful galleries, and gallery length (cm), two-way analysis of variance was used, with tree species and sample position as main effects. Individual bark samples at each height were pooled for analyses, and data were transformed when necessary to meet assumptions of normality and homoskedasticity. Tukey's honestly significant difference tests were used to differentiate significant treatments.

Each *P. strobus* stand was nearly pure and overstocked, with basal area estimates between 48.5 and 53.1 m²/ha (Table 1). Only *P. rigida* and red maple, *Acer rubrum* Linnaeus (Sapindaceae), co-occurred with *P. strobus* in the stands. The average tree diameters were larger at the two Brookhaven National Lab sites than at the Southaven County Park site (Table 1). *Dendroctonus frontalis* attacks killed 36.7–54.7% of *P. strobus* trees (34.4–55% of basal area) across the three stands. Mortality occurred across all tree size classes available (Fig. 2A, B, C) and did not continue into a second year, even though hosts were still plentiful in each stand. This pattern is similar to the impacts in *P. rigida* and *P. rigida*–*Quercus* (Fagaceae) forests on Long Island but without the presence of other tree species in the canopy (Heuss *et al.* 2019). High basal area in *P. rigida* stands has been linked to increased susceptibility to *D. frontalis* on Long Island (Jamison *et al.* 2022), and

Table 1. Stand descriptors, including mean diameter at breast height (dbh), stand basal area (BA), *Pinus strobus* basal area, percent of pine stems killed by *Dendroctonus frontalis*, and percent of *P. strobus* basal area infested in each stand calculated from overstorey plots

Stand	Mean dbh (cm)	Stand BA (m ² /ha)	<i>Pinus strobus</i> BA (m ² /ha)	% <i>Pinus strobus</i> trees killed	% <i>Pinus strobus</i> BA infested
BNL1	40.8 ± 1.4	53.1	52.3	36.7	34.4
BNL2	34.6 ± 1.4	48.5	44.9	44.3	55.5
SH1	31.5 ± 0.8	50.4	50.4	54.7	55.0

Table 2. Average diameter at breast height (dbh), average tree height, average infested bole length, average infested surface area, and percent of surface area infested by *Dendroctonus frontalis* in *Pinus rigida* and *Pinus strobus* sampled for brood estimates

Pine spp.	dbh (cm)	Tree height (m)	Infested bole length (m)	Infested surface area (m ²)	% surface area infested
<i>Pinus rigida</i>	30.7 ± 2.7	20.1 ± 0.9	11.5 ± 1.3	7.9 ± 1.9	79.0 ± 10.9
<i>Pinus strobus</i>	36.5 ± 2.5	25.7 ± 0.8*	15.6 ± 1.2*	13.5 ± 2.3*	90.0 ± 5.3

*Significant difference, $P < 0.05$.

it is likely also important in *P. strobus* stands. Although brood stage was not sampled for every tree during overstorey sampling in the present study, a subset of trees was assessed in each stand. Many trees had unsuccessful attacks at breast height, and when brood was present, development stages were similar.

Trees selected for sampling were estimated to have been attacked by *D. frontalis* during late summer and early fall 2022, based on phloem condition, presence or absence of brood, and crown condition. *Pinus strobus* selected for bark sampling were significantly taller, had longer infested bole lengths, and had more infested surface area than *P. rigida* did (Table 2). Percent surface area infested was equal between the two species. All sampled *P. rigida* were successfully attacked (*i.e.*, produced brood), whereas only 50% of the *P. strobus* were successfully attacked (*i.e.*, had exit holes or late-stage brood in bark). Unsuccessfully attacked *P. strobus* had early- or mid-stage larvae galleries present but no living larval life stages found in the phloem. In most cases, phloem tissue around larval mines was flooded with resin and crystalised resin.

There was no interaction between the main factors for attacks ($F_{3,35} = 2.2$, $P = 0.1$). Average number of attacks (per 81 cm²) were significantly higher in *P. rigida* (1.5 ± 0.1) than in *P. strobus* (0.6 ± 0.1 ; $F_{1,35} = 28.3$, $P < 0.0001$), suggesting the former is a more attractive host than the latter. No differences in attacks from the four heights were found (Table 3), which contrasts with attack patterns on *P. taeda* (Coulson *et al.* 1976) and landing rates on shortleaf pines, *Pinus echinata* Miller (Pinaceae) (Coster *et al.* 1977), in the southeastern United States of America. Understanding suitability for *D. frontalis* between the two hosts was difficult to assess without brood emergence estimates. However, the numbers of successful and unsuccessful galleries and brood gallery lengths provide some indication of suitability. There were no interactions between main factors for successful ($F_{3,35} = 0.8$, $P = 0.5$) or unsuccessful ($F_{3,35} = 1.9$, $P = 0.2$) galleries or brood gallery length ($F_{3,35} = 0.4$, $P = 0.7$). The average number of successful galleries was significantly higher in *P. rigida* (4.6 ± 0.4) than in *P. strobus* (1.1 ± 0.3 ; $F_{1,35} = 57.1$, $P < 0.0001$) and higher in the lower middle bole section compared to the top section (Table 3). There was no difference between average numbers of unsuccessful galleries for *P. rigida* (0.4 ± 0.1) and

Table 3. Average number of attacks, successful galleries, unsuccessful galleries, and gallery length from *Pinus rigida* and *Pinus strobus* bark samples (81 cm²). Different letters within a row indicate significant differences ($P < 0.05$)

Variable	Bole section				Statistics
	Bottom	Lower middle	Upper middle	Top	
Attacks	1.4 ± 0.2 ^a	1.0 ± 0.2 ^a	1.2 ± 0.2 ^a	0.8 ± 0.2 ^a	$F_{3,35} = 2.8, P = 0.06$
Successful galleries	2.7 ± 0.5 ^{ab}	4.1 ± 0.5 ^a	2.9 ± 0.5 ^{ab}	1.7 ± 0.5 ^b	$F_{3,35} = 4.1, P = 0.01$
Unsuccessful galleries	0.9 ± 0.2 ^a	0.3 ± 0.2 ^{ab}	0.1 ± 0.2 ^b	0.3 ± 0.2 ^{ab}	$F_{3,35} = 3.9, P = 0.01$
Gallery length (cm)	14.9 ± 2.3 ^{ab}	20.8 ± 2.4 ^a	15.6 ± 2.3 ^{ab}	10.3 ± 2.3 ^b	$F_{3,35} = 3.4, P = 0.03$

P. strobus (0.4 ± 0.1 ; $F_{1,35} = 0.05, P = 0.8$), but the average numbers in bottom and upper middle bole sections differed significantly (Table 3). Given successful galleries were four times less abundant in *P. strobus* than in *P. rigida*, the latter appears to be a more suitable host, at least during initial attack and egg laying. Gallery length was also substantially longer in *P. rigida* (23.7 ± 1.7) than in *P. strobus* (7.2 ± 1.5 ; $F_{1,35} = 52.0, P < 0.0001$). This result is similar to Gardner's (2011) work comparing gallery length in *P. taeda* and *P. strobus*. Longer gallery lengths were found in the lower middle bole sections than in the tops of trees in the present study (Table 3), whereas Fargo *et al.* (1978) reported that the longest gallery lengths in southeastern *P. taeda* were found at 3.5 m. This height would equate to bottom sections in the present study, where estimates were also higher across bottom to upper middle sections.

Pinus rigida was attacked at a higher density, had more successful brood galleries, and had longer brood gallery lengths than *P. strobus* did, strongly suggesting the former is a better host than the latter. In addition, all attacked *P. rigida* produced living brood. The lack of brood production in several sampled *P. strobus*, coupled with observations from stand inventories that many *P. strobus* were unsuccessfully attacked, further provide evidence that *P. strobus* is not an optimal *D. frontalis* host. Variation in host selection and brood success is not uncommon and has been documented previously for *D. frontalis* for hard pines in the southeastern United States of America (Veysey *et al.* 2003), as well as in other conifer-infesting bark beetles (Amman 1982; Švihra and Volney 1983; Siegert and McCullough 2003).

Understanding *D. frontalis* behaviour in *P. strobus* is important for understanding the risk the beetle poses beyond hard pine and to the most abundant and widely distributed pine in the northeastern United States of America. Opportunities to evaluate *D. frontalis* in *P. strobus* have thus far been limited, but focus should be on collecting tree- and stand-level data in these forests whenever opportunities arise.

Acknowledgements. The authors thank Diana Lynch and Suffolk County Parks for allowing access to Southaven County Park. Polly Weigand and Chris Steigerwald from the Central Pine Barrens Commission provided information on *P. strobus* stands on Long Island. Marc DiGirolomo and Dan Miller provided comments on an earlier version of this manuscript.

Competing interests. The authors declare that they have no competing interests.

References

- Amman, G.D. 1982. Characteristics of mountain pine beetles reared in four pine hosts. *Environmental Entomology*, **11**: 590–593.
- Anderson, R.F. and Doggett, C.A. 1993. Host Preference of Southern Pine Beetle in North Carolina. Department of Forest Research, North Carolina Forest Service, Raleigh, North Carolina, United States of America.

- Coster, J.E., Payne, T.L., Hart, E.R., and Edson, L.J. 1977. Aggregation of the southern pine beetle in response to attractive host trees. *Environmental Entomology*, **6**: 725–731.
- Coulson, R.N., Foltz, J.L., Hain, F.P., Martin, W.C., and Mayyasi, A.M. 1976. Resource utilization by the southern pine beetle, *Dendroctonus frontalis* (Coleoptera: Scolytidae). *The Canadian Entomologist*, **108**: 353–362. <https://doi.org/10.4039/Ent108353-4>.
- Dodds, K.J., Aoki, C.F., Arango-Velez, A., Cancelliere, J., D'Amato, A.W., DiGirolomo, M.F., and Rabaglia, R.J. 2018. Expansion of southern pine beetle into northeastern forests: management and impact of a primary bark beetle in a new region. *Journal of Forestry*, **116**: 178–191. <https://doi.org/10.1093/jofore/fvx009>.
- Fargo, W.S., Coulson, R.N., Pulley, P.E., Pope, D.N., and Kelley, C.L. 1978. Spatial and temporal patterns of within-tree colonisation by *Dendroctonus frontalis* (Coleoptera: Scolytidae). *The Canadian Entomologist*, **110**: 1213–1232. <https://doi.org/10.4039/Ent1101213-11>.
- Gardner, M.J. 2011. Development of Southern Pine Beetles (*Dendroctonus frontalis* Zimmerman) in White Pine (*Pinus strobus*), a Non-traditional Host. Department of Entomology, North Carolina State University, Raleigh, North Carolina, United States of America.
- Hain, F.P., Duehl, A.J., Gardner, M.J., and Payne, T.L. 2011. Natural history of the southern pine beetle. In *Southern Pine Beetle II. General Technical Report SRS-140. Edited by R.N. Coulson and K.D. Klepzig*. U.S. Department of Agriculture Forest Service, Southern Research Station, Asheville, North Carolina, United States of America. Pp. 13–24.
- Heuss, M., D'Amato, A.W., and Dodds, K.J. 2019. Northward expansion of southern pine beetle generates significant alterations to forest structure and composition of globally rare *Pinus rigida* forests. *Forest Ecology and Management*, **434**: 119–130. <https://doi.org/10.1016/j.foreco.2018.12.015>.
- Hopkins, A.D. 1899. Report on Investigations to Determine the Cause of Unhealthy Conditions of the Spruce and Pine from 1880 to 1893. Bulletin 56. West Virginia Agricultural Experiment Station, Morgantown, West Virginia, United States of America. Pp. 197–461.
- Intergovernmental Panel on Climate Change. 2023. Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II, and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Intergovernmental Panel on Climate Change, Geneva, Switzerland. Pp. 35–115.
- Jamison, E.A.K., D'Amato, A.W., and Dodds, K.J. 2022. Informing adaptive forest management: a hazard rating tool for southern pine beetle *Dendroctonus frontalis* in pitch pine barrens. *Agricultural and Forest Entomology*, **24**: 466–475. <https://doi.org/10.1111/afe.12506>.
- Kanaskie, C.R., Schmeelk, T.C., Cancelliere, J.A., and Garnas, J.R. 2023. New records of southern pine beetle (*Dendroctonus frontalis* Zimmermann; Coleoptera: Curculionidae) in New York, New Hampshire, and Maine, USA, indicate northward range expansion. *The Coleopterists Bulletin*, **77**: 248–251. <https://doi.org/10.1649/0010-065X-77.2.248>.
- Knebel, L. and Wentworth, T.R. 2007. Influence of fire and southern pine beetle on pine-dominated forests in the Linville Gorge Wilderness, North Carolina. *Castanea*, **72**: 214–225. <https://doi.org/10.2179/06-18.1>.
- Lesk, C., Coffel, E., D'Amato, A.W., Dodds, K., and Horton, R. 2017. Threats to North American forests from southern pine beetle with warming winters. *Nature Climate Change*, **7**: 713–717. <https://doi.org/10.1038/nclimate3375>.
- Nowacki, G.J. and Abrams, M.D. 2008. The demise of fire and “mesophication” of forests in the eastern United States. *Bioscience*, **58**: 123–138. <https://doi.org/10.1641/B580207>.
- Siegert, N.W. and McCullough, D.G. 2003. Colonisation of Scots, red, and jack pine logs by *Tomicus piniperda* (Coleoptera: Scolytidae) in Michigan pine stands. *Canadian Journal of Forest Research*, **33**: 2238–2244. <https://doi.org/10.1139/X03-156>.
- Stephen, F.M. and Taha, H.A. 1976. Optimization of sampling effort for within-tree populations of southern pine beetle and its natural enemies. *Environmental Entomology*, **5**: 1001–1007. <https://doi.org/10.1093/ee/5.5.1001>.

- Švihra, P. and Volney, W.J.A. 1983. Effect of English, Siberian, and Chinese elms on the attack behaviour and brood survival of *Scolytus multistriatus* (Coleoptera: Scolytidae). *The Canadian Entomologist*, **115**: 513–522. <https://doi.org/10.4039/Ent115513-5>.
- Veysey, J.S., Ayres, M.P., Lombardero, M.J., Hofstetter, R.W., and Klepzig, K.D. 2003. Relative suitability of Virginia pine and loblolly pine as host species for *Dendroctonus frontalis* (Coleoptera: Scolytidae). *Environmental Entomology*, **32**: 668–679.

Cite this article: Dodds, K.J., Janelle, J., and Schwager, K. 2024. Assessing southern pine beetle (Coleoptera: Curculionidae) success in eastern white pine (Pinaceae) on Long Island, New York, United States of America. *The Canadian Entomologist*. <https://doi.org/10.4039/tce.2024.19>.