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Louis F. Wilson
USDA Forest Service

Jeffrey A. Corneil
Michigan State University

Walter A. Lemmien
Kellogg Forest

SUSCEPTIBILITY AND INJURY OF SOME HYBRID WALNUTS BY THE BUTTERNUT CURCULIO (COLEOPTERA: CURCULIONIDAE)

Louis F. Wilson, Jeffrey A. Corneil, and Walter A. Lemmien[1]

The butternut curculio, *Conotrachelus juglandis* LeConte (Coleoptera: Curculionidae), injures the shoots and nuts of various species and hybrids of *Juglans* in eastern North America. This insect was described in 1876 (LeConte, 1876); its life history has been studied in Connecticut (Britton and Kirk, 1912) and in West Virginia (Brooks, 1922). Its range, however, extends from the New England states through southern Canada to the Great Plains and south to Kansas, Alabama, and Georgia, contiguous with the natural range of butternut (*J. cinerea*), its native host.

This weevil was found in 1975 in a hybrid *Juglans* research planting at the Kellogg Forest near Augusta in Kalamazoo County, Michigan. As little is known about this insect in Michigan, we undertook this study to learn its life history, some of its habits, and injury to its hosts. Although this weevil attacks young shoots and nuts, only the life history and damage on the shoots were studied because most of the trees were too young to bear nuts. Britton and Kirk (1912) and Brooks (1922) adequately discuss the damage to the nuts of walnuts and butternuts.

STUDY AREA

The study area was a putative hybrid walnut plantation (compartment 20A) of the Kellogg Forest, Augusta, Kalamazoo County, Michigan. The plantation was established in 1968 and consisted of open-pollinated progeny of the following species and hybrids: *Juglans nigra* (black walnut), *J. cinerea* (butternut), *J. regia* (English walnut), *J. sieboldiana* (Japanese walnut), *nigra* × *sieboldiana, regia* × *nigra* and *sieboldiana* × *cinerea*. The *nigra* was planted in part as a buffer along two edges of the plantation. Also, a large *nigra* provenance planting was adjacent to the hybrid plantation.

The trees were arranged in randomized block design with eight replicates comprising 26 seed sources (Funk, 1971). Each block consisted of five trees planted 10 feet apart in a row.

HOST SUSCEPTIBILITY

Host susceptibility was determined by evaluating the degree of successful weevil attacks and adult feeding on samples of each hybrid. A successful attack meant that the curculio larva had constructed a tunnel in the host's current growth tissues. Tunnels were located in the field by the blackish frass-ejection hole on the shoot.

In late July of 1975 and 1976, the number of attacked trees was counted after the females had oviposited. An injury index was then developed for each hybrid to get a better estimate of the degree of attack. Branch samples 1 m long were collected from the lower crowns of the two most southerly trees in each plot, taken to the lab, and dissected. On each branch the number of larval tunnels, egg niches, adult feeding wounds, and wound scars were counted. The injury index was then calculated for each hybrid or species according to the following formula: Injury Index = (mean number attacks per tree) × (percent trees attacked). The indices were contrasted using Scheffe's method of multiple comparisons to see if there were significant (0.05 level) differences.

[1]Authors are respectively: Principal Insect Ecologist, USDA Forest Service, North Central Forest Experiment Station, in cooperation with Michigan State University East Lansing, MI 48824; graduate student, Department of Forestry, Michigan State University; and Senior Resident Forester, Kellogg Forest.

RESULTS

In general, trees with Japanese walnut parentage were attacked most by the weevil; from 90 to 100% of the progeny were attacked in 1975 and 1976 on these hosts (Table 1). Conversely, black walnut was the least attacked, 17% or less when planted among the hybrids. The adjacent walnut stand, which was a regional provenance planting of pure *nigra*, was not attacked.

The progeny of the *nigra* × *sieboldiana* parent sustained significantly higher injury and was 10 times more susceptible than black walnut (Table 1). Progeny from *sieboldiana* were the second most injured, and those of *sieboldiana* × *cinerea* and *regia* × *nigra* were third. Both the *sieboldiana* and the *nigra* × *sieboldiana* progeny were 100% attacked by the weevil, but the latter had almost twice as much injury. *J. regia* and *cinerea* were injured about the same as *nigra* and these three together were the least susceptible. *J. regia*, however, had a higher percentage of trees attacked (71 to 95%) than the others (42 to 48% for *cinerea* and 15 to 17% for *nigra*). Adult feeding ranked almost parallel to the larval feeding intensity but the differences between them were far less. The *nigra* × *sieboldiana* progeny had more than four times as many feeding wounds and *sieboldiana* had two times as many feeding wounds as *nigra, cinerea* or *regia.*

DEGREE OF INJURY

The number of attacks to the tree was analyzed and correlated with the degree of injury. Sixteen trees were chosen from the study area in the fall of 1977 after damage was nearly complete, four trees from each of the significantly different Index categories (Table 1). First, damage was characterized for each tree. Then three branches from each of the upper, middle, and lower portions of the crown were selected on each tree, and larval and adult feeding injuries were counted on the current year's shoot. Attacks per shoot were then plotted on the Injury Index.

RESULTS

A highly significant linear relation exists between the attacks per shoot and the Injury Index (Fig. 1). Trees in the least injured category had less than one attack per branch. Sparse and widely scattered shoot and leaf wilting occurred on these trees with no impact to growth or form.

Table 1. Susceptibility and injury to various walnut progeny by the butternut curculio, 1975-1976.

Juglans–Female Parent (Male open-pollinated	Seed Sources (No.)	Progeny Trees 1976 (No.)	Tree Mean Height 1976 (Meter)	Trees Attacked 1975 (Percent)	Trees Attacked 1976 (Percent)	Mean Injury Index 1976[a]
nigra × *sieboldiana*	1	20	4.4	100	100	24.0 a
sieboldiana	1	14	5.6	100	100	14.3 b
sieboldiana × *cinerea*	7	243	4.8	90	90	8.9 c
regia × *nigra*	4	57	2.7	88	81	7.8 c
regia	1	19	2.1	95	71	4.3 d
cinerea	2	55	4.7	42	48	2.8 d
nigra (within stand)	10	41	4.8	15	17	2.3 d
nigra (adjacent stand)	10	160	4.9	0	0	0 e

[a]Indices followed by the same letter are not significantly different at the .05 level.

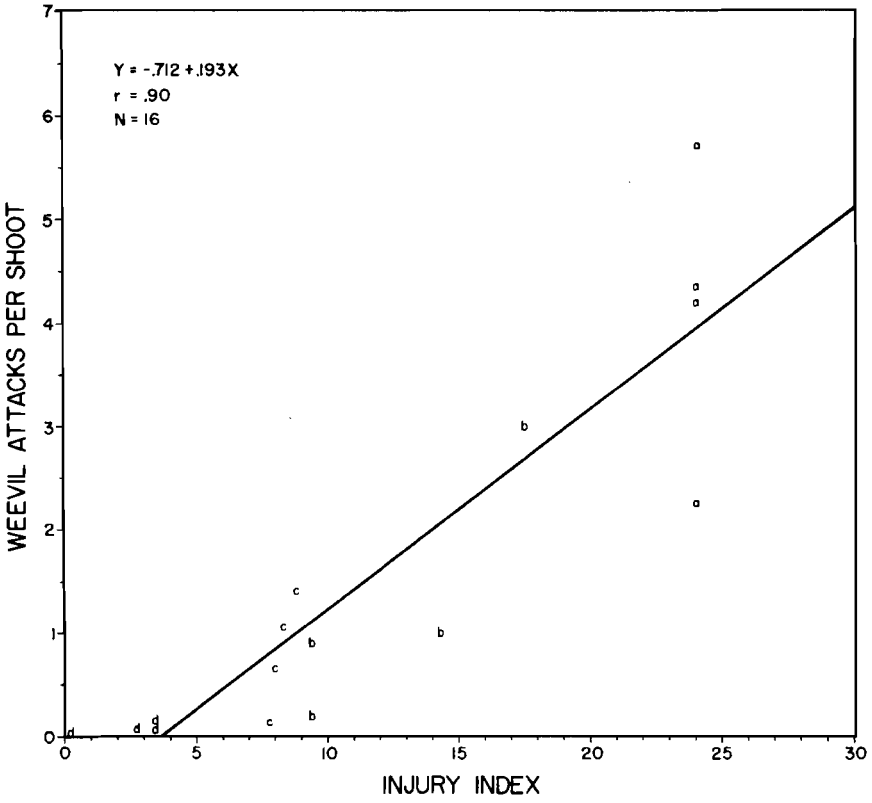

Fig. 1. Relation between Injury Index and attacks per shoot of the butternut curculio. Data points lettered a-d indicate significant differences at the 0.05 level.

Trees in the next category averaged about one attack per two shoots or about one per each 25 cm of new shoot length. Scattered shoot and leaf wilting occurred on the crown. Form of the trees was only mildly affected and most shoots recovered the year after attack.

The trees in the second most injured category averaged about two attacks per shoot or about one per each 10 cm of shoot. Shoot and leaf wilting was readily observed but was scattered widely throughout the crown. Shoot growth was affected from larval density. Some laterals and an occasional leader shoot were killed back. Tree form was affected mostly if a shoot was attacked two or more years in a row.

Trees in the most injured category averaged about four attacks per shoot or about one per each 5 cm of shoot length. Many shoots were hollowed out from the larvae for more than 30% of their length. Many shoot tips and leaves wilted and numerous shoots died. Less than half of the injured shoots recovered the following year.

DISCUSSION

In Connecticut, Britton and Kirk (1912) found *Juglans* species attacked by the butternut curculio in the following preferred order: *cordiformis, sieboldiana, cinerea,*

regia, nigra, and *mandschurica* (Manchurian walnut). Brooks (1922) noted that *J. cathayensis* (Cathay walnut) was sometimes seriously injured by this weevil and was perhaps about as susceptible as the Japanese walnuts. (*J. cordiformis* and *sieboldiana* are varieties of Japanese walnuts and were combined under *sieboldiana* in our study.) Host preference ranked similarly in our study excluding progeny from *mandschurica* and *cathayensis,* which were not available for comparison. Progeny with Japanese walnut parentage were highly preferred over the other exotic and native hosts. Black walnut appeared to have little or no effect on the susceptibility to attack when crossed with other walnuts, whereas butternut seemed to decrease susceptibility when crossed with Japanese walnut.

English walnut ranked about the same as butternut and black walnut but it may actually be slightly more susceptible. Each year the *regia* shoot tips were killed back by late frost so few shoots were available for weevil attack. An indication that they might be more susceptible is reflected in the *regia* × *nigra* cross, which had significantly higher injury than *regia* or *nigra* alone. The progeny from the *regia* × *nigra* cross had less frost injury each spring than the English walnuts and thus more shoots available for attack. *J nigra* is barely susceptible and seems not to contribute much to susceptibility in other crosses so the *regia* component in this cross most likely contributed to the additional susceptibility.

Black walnut either lacks a substance that attracts the weevil or contains a substance that repels them. Extensive observation in the walnut provenance planting, which was adjacent to the hybrid planting, indicated the adult weevils nibbled only a small amount on the trees. Oviposition was extremely rare and no larval tunnels were found, confirming black walnut as an extremely poor host. Britton and Kirk (1912) and Porter (1932) have also reported that black walnut is seldom attacked by *C. juglandis.*

Butternut was not much more susceptible to injury by the weevil than black walnut, though there was a slightly higher percentage of trees attacked. Though butternut is far less susceptible than the exotic walnuts, the weevil's common name, butternut curculio, is still appropriate because native butternut is its principal host in natural situations. Perhaps natural selection has favored this tree's resistance.

We divided the degree of injury we observed in this study into four injury classes (Table 2) which correspond approximately with the significantly different Injury Index categories. The injury refers to shoots only because most trees in the study were too young to produce nuts. *J. nigra, cinerea,* and *regia* are in the Very Low class with never more than 0.5 weevil attack per shoot. At most this injury would have a slight cosmetic effect on the trees. *J. sieboldiana* × *cinerea* and *regia* × *nigra* are classified Low and have approximately 0.5 to one attack per shoot. Injury at this level should normally not be of concern. *J. sieboldiana* had one to three attacks per shoot and is classified Moderate for

Table 2. Walnut injury categories from the butternut curculio.

Injury Class	Injury Index Range	Approximate Attacks/Shoot[a]	Host Damage
Very Low	0-4	0 – 0.5	Sparse shoot flagging
Low	4-9	0.5 – 1	Scattered, light shoot flagging
Moderate	9-18	1 – 3	Occasional leader shoot mortality
High	18+	3+	Extensive shoot mortality and deformity

[a]Includes larval tunnels and adult feeding wounds.

injury. Although some tree deformity may occur, natural controls should be able to manage the insect. However, if the leader shoots are repeatedly killed back or nut production is curtailed, suppression measures will be necessary. *J. nigra* × *sieboldiana* is classified High for injury and had more than three attacks per shoot. Suppression measures will usually be warranted.

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