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Life History and Notes on the Biology of *Stelidota octomaculata* (Coleoptera:Nitidulidae)

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Abstract

The life history of *Stelidota octomaculata* (Say) was studied in Ohio and Pennsylvania. This insect damages acorns and affects the establishment of oak seedlings. Acorns deployed in wire cages and pitfall traps plus a sampling of naturally occurring acorns were used to monitor insect activity. Adults overwinter in forest litter and begin feeding on undamaged germinating or damaged acorns in spring. Acorns damaged by the beetles may fail to produce seedlings. Beetle reproduction occurs in spring and early summer inside acorns both above and below ground. Reproduction ceases in late July to early August. Adult activity may continue until early December in some years. In the laboratory, a life cycle was completed in about 34 days at 22° to 26°C. The maximum number of offspring from a female was 933 and the maximum lifespan at room temperature was 238 days. Acorns of all oak species tested plus seeds of 28 other species were suitable for larval development.

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Introduction

Stelidota octomaculata (Say) was first reported in association with northern red oak, *Quercus rubra* L., acorns collected in August and September in Illinois by Winston (1956). He listed this insect with other arthropods found in acorns but no other information was presented. Williams and Kreuger (1985) reported rearing *S. octomaculata* in the laboratory on chinese chestnuts, *Castanea mollissima* Blume, though it was not one of several sap beetle species associated with damaged chestnuts in Ohio groves. Galford (1986) reported that a *Stelidota* sp. was a possible primary pest of germinating northern red oak acorns. This species was later identified as *S. octomaculata* and laboratory tests confirmed the ablity of this insect to destroy germinating acorns (Galford 1987). An unidentified nitidulid was reported by Krajicek (1960) in association with red oak acorns that germinated in the spring in Iowa but failed to produce seedlings. The species involved may have been *S. octomaculata* since this species was found to be a pest of germinating red oak acorns in Ohio in spring (Galford et al. 1988).

The life history and biology of *S. octomaculata* were studied in the field and laboratory from 1986 to 1989 in Ohio and Pennsylvania. This paper reports the results of those studies.

Methods

Field Studies

From 1986 to 1988, field studies were conducted in mature oak forests in the upland, unglaciated region of southern Ohio. In 1989, studies were conducted in the Moshannon State Forest in central Pennsylvania, a mountainous, unglaciated region. The study areas in southern Ohio were in mature oak-hickory forests composed primarily of white oak, *Quercus alba* L., black oak, *Q. velutina* Lam., chestnut oak, *Q. prinus* L., scarlet oak, *Q. coccinea* Muenchh., and northern red oak, *Q. rubra* L. In Pennsylvania, the study areas were in stands dominated by northern red oak, though some white, black and/or chestnut oaks were found.

Acorns used for field and laboratory studies were collected in autumn and stored at 5^0 to 7^{0}C in dry sand or peat moss in sealed plastic bags. Several small holes 2 to 3 mm in diameter were punched in the bags for aeration. Acorns of most species of oak were still usable after 1 to 3 years of storage. However, white and chestnut oak acorns germinated and filled the bags with roots in 2 to 3 months.

Acorns of most species of oak found in the Northeast plus seeds of 28 other species of trees and shrubs were tested as potential hosts for *S. octomaculata*. The seeds used in these studies were collected or purchased as available and most were used within a few days after acquisition.

Unless otherwise noted, only sound, viable acorns without signs of damage from other insects were used in these studies. Acorns used in the biological studies in the laboratory were washed in tap water, soaked for 2 to 3 minutes in a 2.5 percent sodium hypochlorite (50 percent bleach) solution, rinsed in tap water, and then soaked in distilled water for 30 minutes.

Sprouted acorns of northern red, white, or bur oak were wrapped in 1/4-inch (ca. 6-mm) hardware cloth cages for rodent protection and deployed in the Ohio forest in 1986 to monitor the activity periods of the nitidulids. A wire flag was inserted through each cage into the ground to prevent rodents from carrying off the cages and also to mark the sites. The cages were thoroughly covered with leaf litter. In early March, 10 cages, each containing 5 acorns, were deployed at intervals of 3 m on a south slope. At intervals of 7 to 21 days until November, the cages were removed and replaced with others containing fresh acorns. In the laboratory, the cages were opened and the acorns examined. The acorns were then placed in covered, 1-l battery jars to rear out any insects in the acorns.

On April 9, 1986, in Ohio, 25 whole nuts each of northern red oak, chestnut oak, shagbark hickory, *Carya ovata* (Mill.) K. Koch, and 10 nuts of black walnut, *Juglans nigra* L., were deployed individually in wire cages under leaves. An electric drill was used to make two 1/8-inch (ca. 3-mm) holes in the sides of each nut. The nuts were alternated 1 m apart in a row following the contour of a hill. On April 30 the nuts were removed, bagged individually and returned to the laboratory where they were examined and placed in rearing jars.

In October of 1986, 1987, and 1988, 50 northern red oak acorns were placed under each of seven wooden-frame cages (ca. 91 cm square by 30 cm high) covered on the tops and sides with 1/4-inch hardware cloth but open on the bottoms. The cage frames were constructed from pressure-treated 5- by 5-cm lumber. The leaf litter was raked from an area ca. 1 m square and the 50 acorns were spaced evenly on the area and covered with leaves. A cage was then placed over the acorns. Shallow trenches (ca. 5 cm deep) were dug under the bottom edges so that the cages sat in the ground. Soil and forest litter was raked against the sides of the cages to reduce penetration by rodents. In 1986 and 1987 all of the cages were placed under acorn-bearing trees. In 1988, four cages with acorns were placed under non-oak species in December when insect activity had ceased.

Acorns that failed to produce seedlings were removed from the frame cages in late May, checked for insect damage, and placed in rearing jars in the laboratory to rear out any insects. Acorns that produced seedlings were cut off the seedlings and placed in rearing jars.

Pitfall traps were constructed using 1-pint (473-ml) glass canning jars with two-piece metal lids. The sealing lid was replaced with 1/4-inch mesh hardware cloth of equal diameter. The hardware cloth was glued inside the band with epoxy ribbon adhesive to prevent rodents from pulling it out. A 10-oz (296-ml) plastic drinking cup containing a crumpled paper towel was placed in each pint jar. Twenty ml of water were added to the cup to prevent desiccation of the acorn bait. Then 8 to 10 acorn halves were added to each jar and lids placed on the jars. The jars were buried with the lids flush with the ground. Rain shields were provided by positioning plastic lids (15 cm in diameter) supported on landscaping nails (25 cm long) approximately 7 cm above the tops of the jars.

In 1987, 10 pitfall trap sites were established about 3 m apart on a south-facing midslope in southern Ohio. These sites were flagged and numbered and used again in trapping studies in 1988. The pitfall traps were installed in mid-February and removed in late October to early December. The traps were checked and the acorn baits renewed at intervals of 3 to 21 days as follows: in the laboratory the 10-oz plastic cups containing the paper towels, water, and the acorn baits were prepared and sealed individually in plastic bags numbered according to trap site; in the field the new baits were exchanged for the old baits, which were bagged and returned to the laboratory where the contents of the cups were checked for insects. The acorns from the cups were placed in jars to rear out any insects.

In 1989, 56 pitfall traps were installed on May 1 and 2 in Pennsylvania and were checked at intervals of 6 to 9 days through June 12. Four traps were installed in each of fourteen 4-acre plots being used for studies on factors limiting oak seedling establishment in Pennsylvania. An additional four pitfall traps were installed away from the study plots and were checked weekly from June to early November to monitor the seasonal activity of *S. octomaculata* in central Pennsylvania.

A good crop of northern red oak acorns in the autumn of 1988 in central Pennsylvania allowed periodic sampling of acorns throughout the spring and early summer of 1989. Acorn samples were taken from under leaf litter, rodent caches, and from newly established seedlings.

Laboratory Studies

Techniques for rearing *S. octomaculata* on acorns in the laboratory have been described (Galford 1987). In these studies the nitidulids were reared as follows: Plastic culture dishes (150 by 20 mm) were lined with filter paper moistened with distilled water; two or three acorns cut into halves were placed cut side down on the filter paper and a pair of beetles introduced. The filter paper was kept moist throughout the studies. The beetles were transferred fortnightly to new dishes with fresh acorns until the female died. Mature larvae were removed daily from the dishes and the number of larvae recorded.

The beetles are easily sexed as adults or pupae. The pupae are fragile and must be manipulated with a small, moistened, camel's-hair brush. The adults are easily manipulated with forceps without injury. The common character of six abdominal segments in males (the sixth being very small) and five in the females was used in sex identification. We found that with experience the following characters also are useful: the sternum just anterior to the first abdominal segment is concave in males and flat to slightly convex in females; the metatibia are slightly bowed in males but not in females; female pupae have two small, unnamed, cone-shaped protuberences on the ventral surface of the abdomen, just anterior to the anus. These structures are lacking on male pupae.

Twenty culture dishes, each with one pair of beetles, were set up for each of the following kinds of acorns: northern red, black, white, chestnut, and bur oak, *Q. macrocarpa* Michx.; 10 dishes were set up for chinkapin, *Q. muehlenbergii* Engelm., and five were set up for pin oak, *Q. palustris* Muenchh.

Ten dishes, each with one pair of beetles, were set up as follows: five dishes were provided with nonviable northern red oak acorns which had dead cotyledons that had turned brown, and five were provided with viable acorns just beginning germination. The nonviable acorns were partially cut open to allow the beetles access to the cotyledons. To prevent acorns from rolling in the dishes, a small area was cut off the side of each acorn with the cut side down on the filter paper.

Sixteen dishes, each with one pair of beetles removed between April 9 and May 15, 1988, from pitfall traps in Ohio, were set up with northern red oak acorns to observe the fecundity and longevity of the spring population of beetles.

Seeds of other trees and shrubs used to rear the beetles were cut open or cracked and placed on moist filter paper. The insects were reared as described peviously. Two or three dishes, each with three pairs of beetles, were set up for each seed species and observed until reproduction occurred or the beetles died.

Mature larvae (wandering larvae without a brownish cast to the gut) were removed daily from the culture dishes with forceps. Up to 50 larvae were placed in a 1-oz (ca. 30-ml) plastic portion cup about three-quarters filled with moist masonry sand or moist tissue paper, the latter allowing observation of development.

Eggs were obtained for observation as follows: acorn meats were partially sliced with a scalpel and placed in dishes containing several mated females; the acorn meats were removed daily and checked for eggs which were laid between the slices. Acorn slices with eggs attached to them were removed from the oviposition dishes and held on moist filter paper in petri plates until they hatched. The development of these larvae was followed daily to determine the number of larval instars and stadia. The widths of the head capsules of the larvae were measured daily with a binocular micrometer. The number of larval instars was further ascertained by measuring the head-capsule width of all of the larvae from a 15-day-old culture. The larvae were killed in alcohol to facilitate the measurements.

Sex ratios of the beetles were determined from both laboratory-reared and field-collected insects using the previously described morphological characters.

A brief study was conducted on the affects of temperature and light on beetle reproduction as follows: forty dishes, each with red oak acorns and a pair of beetles, were set up; half of the dishes were kept in an environmental chamber at 26.7°C and half in a chamber set at 21.1°C. Half of the dishes in each chamber were kept in a sealed box double covered with black plastic. Both chambers were lighted with eight 15-watt florescent bulbs and kept on a 16:8 hour light/dark cycle. The beetles were transferred to fresh acorns fortnightly.

Results and Discussion

Field Study Results

Because of rodent damage few data were collected in 1986 from the experiment using acorns deployed in the small wire cages. Some cages were ripped apart by large rodents while small rodents managed to chew the acorns through the wire mesh. Acorn losses to rodents was total in some areas, minimal in others. However, enough data were collected that year to determine that *S. octomaculata* became active March 21 to 30, started reproducing April 9 to 30, stopped reproduccion July 10 to 16, and ceased activity by October 16. There was little activity from July 16 to August 26 and peak autumn activity occurred in mid-September.

Although most of the nuts were lost to rodents, *S. octomaculata* adults were collected from some of the deployed red oak and chestnut oak acorns and the hickory nuts and black walnuts. There was some reproduction in the nuts of all four species.

Rodent damage associated with the small wire cages that occurred in 1986 prompted a change to pitfall traps for monitoring beetle activity in 1987 to 1989. Preliminary tests in 1986 demonstrated that it was necessary to glue the wire discs in the jar lids to prevent rodents from ripping out the wire to reach the acorns. Initially the rodents pulled some traps out of the ground but they ceased this activity after one or two attempts.

Interestingly, when preliminary tests of the pitfall traps were being conducted in late summer of 1986, it was noted that rodents rarely disturbed traps baited with oriental, *Castanea* sp., chestnuts. but disturbed all traps baited with acorns, hickory nuts, or black walnuts. Also, all primary pests of acorns were caught in traps baited with chestnuts: the weevils *Conotrachelus posticatus* Boheman and *C. naso* LeConte; larvae of the acorn moth *Valentinia glandulella* (Riley); and *S. octomaculata.* The weevils and the nitidulids reproduced in the chestnuts and larvae of the acorn moth completed development into adults. American chestnuts, *Castanea dentata* (Marsh.) Borkh., may have been a host of the insects before the chestnut blight disease, *Cryphonectria parasitica* (Murr.), eliminated American chestnut from eastern forests.

The results of the pitfall studies in Ohio in 1987 and 1988 are given in Table 1. Beetle activity began three weeks earlier in 1987 than in 1988 due to an early warming trend in late February of 1987 compared with the cool, late spring that occurred in 1988. Reproduction also commenced several weeks earlier in 1987 than in 1988. In both years, reproduction ceased in late July or early August when daytime temperatures consistently reached 30° to 35°C. Reproduction was not observed in autumn. Although beetle activity slowed during the hottest weeks of summer it never entirely stopped. Fewer beetles were caught in 1988 (594) than in 1987 (1004). Below normal rainfall and poor acorn crops in both years combined with continuous removal of trapped beetles may explain the drop in population.

Table 1.—Activity periods of *S. octomaculata* as shown by catches in 10 pitfall traps in Ohio, 1987 and 1988

Trapping dates	Number of beetles caught	Trapping dates	Number of beetles caught
1987		*1988*	
2/17 – 3/4	0	3/8 – 29	0
3/4 – 9	2	3/29 – 4/1	3
3/17 – 24	5	4/1 – 7	4
3/24 – 4/7	36[a]	4/7 – 15	9
4/7 – 14	[b]	4/15 – 26	12
4/15 – 22	67[a]	4/26 – 5/5	12
4/22 – 28	30[a]	5/5 – 12	22[a]
4/28 – 5/7	55[a]	5/12 – 18	30[a]
5/7 – 21	150[a]	5/18 – 27	21[a]
5/21 – 6/2	72[a]	5/27 – 6/1	9[a]
6/2 – 17	57[a]	6/1 – 15	13[a]
6/17 – 7/9	44[a]	6/15 – 24	5[a]
7/9 – 30	109[a]	6/24 – 7/8	1[a]
7/30 – 8/19	78[a]	7/8 – 22	15[a]
8/19 – 26	63	7/22 – 8/5	22[a]
8/26 – 9/1	21	8/5 – 10	5
9/1 – 10	37	8/10 – 17	7
9/10 – 16	30	8/17 – 24	9
9/16 – 22	35	8/24 – 31	10
9/22 – 10/1	51	8/31 – 9/7	17
10/1 – 8	9	9/7 – 14	82
10/8 – 15	9	9/14 – 21	77
10/15 – 22	18	9/21 – 28	51
10/22 – 29	6	9/28 – 10/4	67
10/29 – 11/4	11	10/4 – 12	14
11/4 – 13	5	10/12 – 19	76
11/13 – 12/9	4	10/19 – 26	1
12/9 – 15	0	Total	594
Total	1004		
(Traps removed 12/15)		(Traps removed 10/26)	

[a]Reproduction in acorns in traps.
[b]All traps vandalized.

In Pennsylvania in 1989, 1,315 beetles were caught in 56 pitfall traps from May 1 to June 15. This population, while not high, combined with the acorn weevil, *C. posticatus,* and the acorn moth, *V. glandulella,* to destroy all of the above-ground germinating acorns that escaped wildlife predation. A drought in central Pennsylvania in 1988 may have affected the sap beetle population. Additional studies are needed on the population dynamics of the beetles in relation to climatic conditions and ecological factors.

The four pitfall traps maintained from June 14 to November 9 in Pennsylvania revealed that sap beetles were active throughout the summer and early autumn. However, reproduction slowed in late July when daytime temperatures ranged from 27° to 32°C and ceased by August 15. Cold weather slowed beetle activity in late October and no beetles were caught during the last trap period (November 2 to 9).

In Pennsylvania and Ohio, samples of acorns found under leaves, buried acorns, acorns still attached to new seedlings, acorns on top of logs, and acorns removed from seedlings sprouting from rodent caches revealed that sap beetles reproduce both above and below ground. In Ohio, in 1987, some acorns planted about 2.5 cm deep in early June in forest plots used in other studies were destroyed or heavily damaged by *S. octomaculata.* The most common site of reproduction in Pennsylvania was in partially buried acorns still attached to new seedlings. In samples taken under oak tree canopies in early July, 36 of 67 (54 percent) acorns still attached to new seedlings were infested with *S. octomaculata.* Only 7 of 42 (17 percent) acorns still attached to new seedlings were infested with larvae in samples taken under non-oak species. The latter seedlings originated from acorns that had been dispersed by rodents. Four larvae were found inside the root of a wilted, first-year oak seedling that had several weevil feeding punctures just below the crown. The female sap beetle probably laid her eggs inside one of the weevil holes. This was the only instance of *S. octomaculata* in oak seedling roots.

Observations of the acorns placed under the large frame cages in Ohio in 1986 to 1988 supported the data from the other studies. All of the acorns under the cages were destroyed as they germinated in 1986 and 1987 by a combination of feeding from the acorn weevil *C. posticatus, S. octomaculata,* and the acorn moth *V. glandulella.*

In the spring of 1989, insects destroyed all of the germinating acorns under the three cages placed under seed-bearing oaks in October; 126 oak seedlings were produced from the 200 acorns placed under cages beneath non-oak trees in December of 1988 after insect activity had stopped. Fifty-seven acorns failed to germinate and only 17 were destroyed by insects, 12 by *S. octomaculata.*

Laboratory Study Results

Biological data on *S. octomaculata* from laboratory studies conducted at room temperatures (22° to 26°C) are given in

Table 2.—Summary of biological data for *S. octomaculata* reared at 22° to 26°C on northern red oak acorns

Life stage	Ave. number of days
Egg to adult	28.5 (26 to 35)[a]
Preoviposition period	5 (3 to 11)
Egg	4 (3.5 to 4.5)
1st instar	3.5 (3.5 to 4.5)
2nd instar	3 (2.5 to 4.0)
3rd instar	5 (3.5 to 7.0)
Prepupae	4.5 (4 to 6)
Pupae	8.5 (8 to 10)

[a]Plus another 3 or more days to emerge from the pupation medium.

Table 2. A maturation feeding or preoviposition period of about 5 days was required. Eggs took 3.5 to 4.5 days to hatch, most hatching within 4 days. The beetles had three instars as determined by daily observations and measurements of head capsules; 87 percent (98 of 113) of the head-capsule measurements of larvae from a 14-day-old culture fell within three classes: 0.28 to 0.32 mm, 0.44 to 0.48 mm, and 0.64 to 0.68 mm. The stadia averaged 3.5, 3.0, and 4.5 days for instars 1, 2, and 3 respectively. The prepupal period averaged 4.5 days for larvae placed on moist sand for pupation. The prepupal period averaged almost a day longer for larvae placed on moist tissues for pupation. The beetle larvae quickly formed pupation cells in sand but not in tissues, which delayed pupation. The pupal stage lasted 8 to 10 days with most emerging in 8.5 days. However, the beetles did not surface from the sand for 3 or more days.

Measurements of the various life stages of the beetles revealed the following; female adults from the laboratory cultures ranged in length from 2.5 to 3 mm, averaging 2.8 mm. Males ranged in length from 2.4 to 3.1 mm and averaged 2.8 mm. Adults from the pitfall traps varied more in size and were smaller than cultured beetles. Females ranged in length from 2.1 to 2.9 mm and averaged 2.6 mm; males ranged from 2.3 to 3 mm and averaged 2.7 mm. Although not measured, the pronotums of most adult males were visibly wider than those of females. Sexual differences in pronotum width were noted in *S. geminata* (Say) by Weber and Connell (1975). Eggs of the beetles ranged in length from 0.8 to 0.88 mm; live, mature larvae ranged from 3.2 to 4.8 mm and averaged 4.0 mm.

In the laboratory, eggs were laid in a variety of situations. As stated earlier, the beetles readily laid eggs between slices of acorn meats. They also oviposited in holes that had been punched in acorn meats with a dissecting needle. Eggs were found on top of soil, sand, or filter paper beneath pieces of acorn meats, and between the acorn shell and the cotyledons. The beetles also entered acorns via *Curculio* weevil exit holes for oviposition.

Larvae near maturity quickly emerged from disturbed acorns in the laboratory. This behavior would have survival value in the forest where wildlife readily consumes acorns. Some larvae pupate inside the acorns but most exit and pupate in the soil.

Beetle Fecundity and Longevity

Data for fecundity and longevity in Table 3 are for 55 pairs of the original 115 pairs started. Because of problems with disease in the insects, data were collected only on females living at least 4 weeks. Because of the unknown affects and possible interaction of the disease and species of acorn used for rearing, no analysis was attempted for differences in fecundity and longevity of beetles on different species of acorns. The most eggs produced by a female was 933 on pin oak, a red oak-type acorn; the most produced on white oak was 912. Maximum production by a female was 160 offspring produced in a 14-day period. The maximum longevity recorded for females was 238 days on red oak and chestnut oak.

The average number of offspring produced by each of 16 "wild" females from the pitfall traps in the spring of 1988 was 193 (range: zero to 552). Female longevity averaged 76 days and ranged from 10 to 116 days. The spring population was tested since spring and early summer are the periods of reproduction. Although the averages and ranges for fecundity and longevity of the wild beetles were lower than those for the laboratory strain, some of the wild beetles also died from disease. Pathogenic organisms may be common in the beetles and these organisms would shorten the lives of beetles, especially under laboratory rearing conditions. Thus, averages for fecundity and longevity determined under laboratory conditions could vary depending on the rearing conditions and health of the beetles.

There were differences in the sex ratios of beetles trapped in pitfalls from March to July versus August to November. Of 567 beetles trapped in March to July, 349 were females and 218 were males. Of 1,071 beetles trapped from August to November, 403 were females and 668 were males. Of 4,796 beetles sexed from the laboratory cultures, 2,578 were females and 2,218 were males. A chi-square test based an assumed sex ratio of 1:1 showed that in all cases the sex-ratio differences were significant. The pitfall traps might be selective for males in late summer and early autumn or the traps are less competitive with naturally occurring acorns for females. In spring, when natural acorns are less abundant because of wildlife predation, females may be more easily trapped, or perhaps males do not overwinter as well as females and are less abundant in spring.

At least some females caught singly in traps in late November and early March were fertile and produced offspring without being paired with males. This indicates that some females may overwinter in an inseminated state or that mating is one of the earliest activities in late winter.

The beetles can reproduce in both viable and nonviable

Table 3.—Reproduction and longevity of *S. octomaculata* reared at 22° to 26°C on acorns from various species of oak

Type of acorn	Number of pairs observed (lab strain)	Ave. number of offspring	Ave. longevity of females
			No. of days
Red	18	403 (56 to 718)	141 (56 to 238)
Black	9	375 (191 to 516)	110 (51 to 154)
White	6	490 (65 to 912)	143 (35 to 225)
Bur	7	422 (140 to 690)	111 (57 to 149)
Chinkapin	6	359 (122 to 648)	106 (69 to 166)
Chestnut	7	383 (185 to 493)	141 (98 to 238)
Pin	2	644 and 933	84 and 183
Average of 55 females (lab strain)		405	125
Average of 16 females collected in pitfall traps		193 (0 to 552)	76 (10 to 116)

acorns. The average number of offspring produced by each of five pairs of beetles kept on viable acorns was 299 while the average produced by females reared on inviable acorns was 322. This supported observations in Pennsylvania that the most common site of beetle reproduction was live acorns still attached to newly established seedlings, but that reproduction also occurred in nonviable acorns found under leaves and on logs and stumps.

Effects of Light and Temperature on Reproduction

The brief study on effects of temperature and light on beetle reproduction revealed that reproduction stopped at a constant 26.7°C regardless of day length. Only 12 larvae were produced by the 10 pairs of beetles reared on the 16:8 hour day and only 23 larvae were produced by the adults reared in the dark. Most reproduction occurred in the first 2-week period, and ceased after 4 weeks. By contrast, the 10 pairs of beetles reared at 21.1°C on the long day produced 700 larvae in 6 weeks. Adults reared in the dark produced more than 1200 larvae in 6 weeks. However, at the end of 6 weeks, reproduction had dropped significantly in the long-day beetles, indicating that both day length and temperature may play a role in beetle reproduction. Although reproduction has not been detected in autumn in the forest most of the beetles removed from pitfall traps in late summer and autumn would readily commence reproduction in the laboratory. However, periods of reduced reproduction have been noted in the laboratory cultures and additional studies are needed on the interrelationships of temperature and day length on beetle reproduction.

Seeds Suitable for Reproduction

Table 4 lists the species whose seeds were suitable hosts for *S. octomaculata* in the laboratory. Black cherry, *Prunus serotina* Ehrh., seeds were tested but the beetles did not feed on black cherry seed, either cracked or germinated. Although *S. octomaculata* bred in black walnuts and hickory nuts deployed in the forest in 1986, we have never found the beetles naturally in seeds other than acorns.

Table 4.—Species whose seeds supported development of *S. octomaculata*

Scientific name	Common name
Acer saccharum Marsh	Sugar maple
A. saccharinum L.	Silver maple
A. rubrum L.	Red maple
Aesculus glabra Willd.	Ohio buckeye
Asimina triloba (L.) Dunal	Common pawpaw
Carpinus caroliniana Walt.	Ironwood or bluebeech
Carya cordiformis (Wang.) K. Koch	Bitternut hickory
C. illinoensis (Wang.) K. Koch	Pecan
C. ovata (Mill.) K. Koch	Shagbark hickory
Castanea sp.	Oriental chestnuts
Cornus florida L.	Dogwood
Corylus americana Walt.	American hazelnut
Corylus sp.	Filbert
Fagus grandifolia Ehrh.	American beech
Fraxinus americana L.	White ash
F. pennsylvanica Marsh.	Green ash
Gleditsia triacanthos L.	Honeylocust
Gymnocladus dioicus (L.) K. Koch	Kentucky coffeetree
Hamamelis virginiana L.	Witch-hazel
Juglans cinerea L.	Butternut
J. nigra L.	Black walnut
J. regia L.	English or persian walnut
Lindera benzoin (L.) Blume	Spicebush
Nyssa sylvatica Marsh.	Black tupelo
Pyrus sp.	Crabapple
Quercus alba L.	White oak
Q. bicolor Willd.	Swamp white oak
Q. coccinea Muenchh.	Scarlet oak
Q. ilicifolia Wang.	Bear or scrub oak
Q. imbricaria Michx.	Shingle oak
Q. laurifolia Michx.	Laurel oak
Q. macrocarpa Michx.	Bur oak
Q. muehlenbergii Engelm.	Chinkapin oak
Q. palustris Muenchh.	Pin oak
Q. prinus L.	Chestnut oak
Q. rubra L.	Red oak
Q. velutina Lam.	Black oak
Vitis sp.	Wild grape
Sassafras albidum (Nutt.) Nees	Sassafras
Viburnum acerifolium L.	Maple-leaf viburnum or arrow-wood

Field Observations of Sap Beetle Damage

During these studies field observations of adult *S. octomaculata* feeding damage revealed that the tender radicle (root) shoots of acorns are preferred feeding sites in early spring. Dry winters such as occurred in Ohio in 1986 to 1988, delay germination of red oak acorns. When an early warming trend occurs in late February or early March, damage to radicles by insects is heavy. When a dry spring occurs and seedbeds are not ideal, damaged acorns desiccate without resprouting. In ideal situations, acorns may resprout after being damaged by insects so long as rainfall is adequate and there is no further damage to the acorns. However, the resulting seedlings do not develop the carrot-like taproot that enables them to survive dry periods in late summer. During the summer drought of 1987 in Ohio, examination of the roots of dying white oak seedlings that were established in the fall of 1986 revealed that all of the dying seedlings lacked the long taproot characteristic of oak seedlings. The radicles of these seedlings had been damaged in the fall of 1986 by the weevil *C. posticatus*. Although some of the acorns had resprouted and were able to root before winter, many were frost-heaved in the spring because they lacked the long taproot to anchor them in the ground. Seedlings not completely heaved from the ground subsequently died in the drought.

Summary

S. octomaculata is both a primary and secondary pest of acorns in Ohio and Pennsylvania. The beetle overwinters as an adult, feeds on germinating or damaged acorns in late winter, and begins reproduction in late March to May. The most common sites of reproduction are partially buried acorns still attached to newly established oak seedlings and inviable acorns that escape predation by rodents. Reproduction ceases in mid-July to early August when daytime air temperatures are consistently above 30°C and does not resume until the following spring. Laboratory tests demonstrated that beetle reproduction ceases within 4 weeks at a constant 26.7°C.

The impact of *S. octomaculata* on the establishment of oak seedlings is not completely known. Although a primary pest, this beetle also is highly attracted to acorns damaged by other insects (Galford 1987), including *C. posticatus* and *V. glandulella*. The latter two insects begin feeding on germinating acorns in the spring about 2 to 4 weeks before *S. octomaculata* becomes active. Thus, in many cases *S. octomaculata* merely acts in concert with the other pests in destroying germinating acorns. Current studies in Pennsylvania indicate that many acorns planted about 2.5 to 5 cm deep in autumn may be destroyed in early spring when they germinate by a combination of feeding from *C. posticatus* and *S. octomaculata*. These insects can enter friable soil to reach subsurface acorns. The frequency of this behavior is unknown and it may be determined by the availibility of surface acorns for insect feeding and reproduction. Thus, some damage to germinating acorns by *S. octomaculata* is occurring underground. Additional studies are needed to determine the extent of damage.

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The life history of *Stelidota octomaculata* (Say) was studied in Ohio and Pennsylvania. This insect damages acorns and affects the establishment of oak seedlings. Acorns deployed in wire cages and pitfall traps plus a sampling of naturally occurring acorns were used to monitor insect activity. Adults overwinter in forest litter and begin feeding on undamaged germinating or damaged acorns in March. Acorns damaged by the beetles may fail to produce seedlings. Beetle reproduction occurs in spring and early summer inside acorns both above and below ground. Reproduction ceases in late July to early August. Adult activity may continue until early December in some years. In the laboratory, a life cycle was completed in about 34 days at 22° to 26°C. The maximum number of offspring from a female was 933 and the maximum lifespan at room temperature was 238 days. Acorns of all species tested plus seeds of 28 other species were suitable for larval development.

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