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Notes on the Biology and Hosts of *Stelidota ferruginea* (Coleoptera: Nitidulidae)

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Abstract

The nitidulid *Stelidota ferruginea* Reitter was reared from damaged acorns of laurel oak, *Quercus laurifolia* Michx., and live oak, *Q. virginiana* Mill., collected in Sarasota County, Florida. This sap beetle has been reared in the laboratory solely on northern red oak, *Q. rubra*, acorns for more than 3 years (27+ generations), and can breed in viable or nonviable acorns. In the laboratory, *S. ferruginea* can develop in the seeds of several tree species. New information on the biology of *S. ferruginea* is presented.

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Introduction

There are three species of nitidulids, also called sap beetles, in the genus *Stelidota* in the United States: *S. geminata* (Say), *S. octomaculata* (Say), and *S. ferruginea* Reitter. According to Connell (1984), *S. ferruginea* is synonymous with *S. strigosa* of Horn (1879) and Parsons (1943) for specimens collected north of Mexico. *S. strigosa* (Gyllenhal), however, is a valid species found in tropical America from Mexico to South America.

S. geminata, the strawberry sap beetle, can be an economic pest on ripe strawberries. Multimillion dollar losses to this sap beetle have been reported (Gertz 1968; Weiss and Williams 1980). The strawberry sap beetle is commonly collected from damaged and rotting fruits and vegetables (Weiss and Williams 1980). This species also has been reared from rotting northern red oak, *Quercus rubra* L., acorns collected in Ohio and Pennsylvania (Galford, unpublished). The biology of *S. geminata* was reported by Weber and Gonnell (1975).

S. octomaculata breeds in acorns (Galford 1987) and can affect northern red oak seedling establishment (Galford et al. 1988). The life history of this species was reported by Galford et al. (1991). *S. octomaculata* can reproduce in both viable and nonviable acorns, above or below ground.

There is little information on the life history of *S. ferruginea*. Peng and Williams (1990) reported rearing this and other sap beetle species on an artificial diet. In the field, adults of *S. ferruginea* has been collected with fruit baits and it has been found at sap flows on trees (Weiss and Williams 1980). *S. ferruginea* has been collected in most eastern states from Florida to Michigan and as far west as Oklahoma. In this paper we report that acorns of laurel oak, *Q. laurifolia* Michx., and live oak, *Q. virginiana* Mill., are hosts of *S. ferruginea* in Florida, and present new information on the biology of this insect.

Methods

Rearing Beetles from Acorns

Laurel oak acorns (966) were collected on January 2-4, 1988, in a small (ca. 1 ha) woodlot adjoining a drainage canal within the city limits of Sarasota, Florida. The woodlot contained a mixture of laurel oak, red maple, *Acer rubrum* L., and several species of palm trees. There were few herbaceous understory species in the woodlot because of the dense shade cast by the closed-canopy overstory. Also, the public woodlot may have been occasionally cleared of undergrowth by city park maintenance personnel.

Only 13 of the 966 acorns collected in 1988 were undamaged. The remaining 953 acorns had been damaged by grey squirrels, *Sciurus carolinensis*. In most cases, one-third to one-half of the cap ends of the acorns had been eaten by the squirrels; they then dropped the uneaten parts. Some of the squirrel-damaged acorns sprouted when kept under moist conditions in the laboratory.

In 1989, the acorn crop failed in central Florida and no acorns could be found. On November 23, 1990, 452 live oak acorns, that had recently fallen were collected in the picnic area at Myakka River State Park in Sarasota County, Florida. Most of the acorns collected appeared viable and only 67 had been damaged by rodents, insects, or other animals. Myakka River State Park comprises about 6,000 ha and has a large component of oak, palm trees, and many other native tree and shrub species. Attempts are made to maintain the park in a natural state. However, the large population of feral hogs in the park readily consume the acorn crop and their rooting activities prevent natural regeneration of oak and other species of plants.

In the laboratory the collected acorns were divided into three lots and were placed in 1-liter glass jars which were covered with glass plates. The jars were kept at 20° to 25°C. Each day, for 3 months, the acorns from each jar were poured into a white plastic box and any insect larvae or adults found in the box were removed.

Nitidulid larvae emerging from the acorns were placed in 1-oz (30-ml) plastic portion cups filled with moist sterilized masonry sand for pupation. The surface of the sand was scarified to facilitate larval penetration. The cups were capped with plastic lids, kept at 20° to 25°C, and examined daily for adults.

Newly emerged adults were sexed immediately after collection. Males and females were placed separately in culture dishes containing red oak acorns cut into halves. The beetles were sexed using three characters: females have five abdominal segments and males have six segments, the sixth being very small: The metasternum of the female just anterior of the first abdominal segment is flat at the midline while in the male this area is slightly concave: The metatibia of the male is distinctly curved or bowed and abruptly dilated in the distal one-fourth; in the female, the metatibia is nearly straight and gradually dilated.

The beetles can be sexed in the pupal stage using a binocular microscope and the following character: female pupae have two small unnamed cone-shaped protuberances on the ventral surface of the abdomen, just anterior to the anus. These structures are absent on male pupae. The structures are difficult to see on new, white pupae and are more easily seen just before adult emergence. The pupae are fragile and must be manipulated with a small, moistened, artist's brush.

Biological Studies

Thirty pairs of adult *S. ferruginea* reared from larvae emerging from the laurel oak acorns collected in Florida in 1988 were used for studies on the biology of the beetles. The biological studies were conducted in an environmental chamber operated at 24° to 25°C. The chamber was lighted from below with two 15-watt fluorescent bulbs and kept on a 10:14 hour light/dark cycle.

Acorns used in these studies were collected in autumn or early winter and stored at 5° to 7°C in dry sand in sealed plastic bags. Acorns of northern red oak, white oak, *Q. alba* L., and bur oak, *Q. macrocarpa* Michx., were collected in Ohio. Laurel oak acorns were collected in Florida. Just before use for insect rearing, the acorns were washed in tap water, soaked for 2 to 3 minutes in a 50-percent commercial bleach solution, rinsed in tap water, and then soaked for 30 to 40 minutes in distilled water.

For laboratory rearing of the beetles, 30 plastic culture dishes (150 by 20 mm) were lined with filter paper kept moistened with distilled water throughout the study. Each culture dish was provided with half an acorn each of red, white, laurel, and bur oak, and a pair of unfed beetles. The beetles were transferred at 10- to 12-day intervals to new dishes containing fresh acorns until the female died. Mature larvae (larvae wandering in the dishes) were removed daily from the dishes and their numbers recorded. Up to 25 larvae were placed in a 1-oz plastic portion cup about three-quarters filled with moist masonry sand. The contents of some cups were inspected periodically to determine the progress of development of the life stages.

Adult beetles and mature larvae were easily manipulated with forceps without injury. The fragile pupae were manipulated with a moistened, camel's-hair brush.

Fecundity for each pair of beetles was determined. Fourteen to sixteen days after a pair of adult beetles had been removed from a culture dish, the acorns in each plate were dissected. Numbers of larvae, pupae, and new adults were counted and added to a tally of offspring produced by that particular pair of beetles.

Number of larval instars was determined by measuring the head-capsule width of all larvae from a 14-day-old culture. Larvae were kept on ice while the head capsules of the larvae were measured with a binocular micrometer. Larval lengths were measured concurrently. The size of beetle eggs found in the culture dishes was determined with a binocular micrometer; 630 adults were sexed as described previously to determine the sex ratio.

To determine the preovipositional period, four culture plates, each containing two pairs of beetles and four red oak acorn halves were used. Beetles introduced into the culture dishes were unfed and had been allowed to emerge naturally from the sand in the pupation cups. At 24-hour intervals, the beetles were transferred five times to new culture dishes containing fresh acorns. The culture dishes

from each ovipositional period were examined daily to determine the maturation period.

Nuts of the following tree species were tested as suitable hosts for the development of one or more generations of *S. ferruginea*: white, red, and bur oak; black oak, *Q. velutina* Lam.; pin oak, *Q. palustris* Muenchh.; chinquapin oak, *Q. muehlenbergii* Engelm.; and chestnut oak, *Q. prinus* L.; oriental chestnut, *Castanea* sp.; black walnut, *Juglans nigra* L.; Persian (English) walnut, *J. regia* L.; shagbark hickory, *Carya ovata* (Mill.) K. Koch; pecan, *C. illinoensis* (Wang) K. Koch; American beech, *Fagus grandifolia* Ehrh.; filbert, *Corylus* sp.; and Brazil nut, *Bertholletia excelsa* H.B.K. Field corn, *Zea mays* L., also was tested as a laboratory host. Nuts or seeds of these species were cut open or cracked to allow insect feeding and oviposition. Nuts were placed on moist filter paper in culture dishes and insects were reared as described previously.

Results and Discussion

Insects Reared from Field-Collected Acorns

Two hundred and forty-five *S. ferruginea* adults were reared from 327 larvae that emerged from the 953 laurel oak acorns collected in 1988 in Sarasota, Florida. In addition, 37 adults of *S. geminata* were reared from the same acorns. These adults were abnormally small and easily confused with adults of *S. ferruginea*. Also emerging from the laurel oak acorns were 403 larvae of the weevil *Conotrachelus posticatus* Boheman, 1 larva of a *Curculio* sp., 135 adult moths of *Valentia glandulella* (Riley), and 30 adults of the moth *Moodna ostrinella* (Gleims). Several undetermined species of insects also emerged from the acorns, including parasites of the acorn insects.

Forty-six larvae of *S. ferruginea* were reared from 452 live oak acorns collected in 1990 in Myakka River State Park in Sarasota County, Florida, confirming live oak acorns as a host for the species. The small number of damaged acorns (67) in the collection plus the dilution effect of the large acorn crop in the park may have been factors in the small number of sap beetles reared from the acorns. Also, an unknown number of acorn insects escaped from the container of live oak acorns during transit from the field to the laboratory.

Numbers and species of acorn insects emerging from the live oak acorns collected in 1990, other than nitidulids, were not closely monitored. However, in addition to the acorn insect species reared from the laurel oak acorns in 1988, several larvae of the weevil *C. naso* LeConte emerged from the live oak acorns. Gibson (1964) provided information on the biology and life history of *C. naso* and other *Conotrachelus* weevils that feed on acorns.

Biological Data

Biological data on 23 pairs of F₁ beetles reared at 24° to 25°C and a 10:14 hour light/dark cycle are given in Table 1. Seven of the original 30 pairs from the study escaped. Each pair of beetles produced an average of 497 offspring (range:174 to 823). Average longevity of females was 123 days (range:74 to 188 days). The longevity of male beetles was not recorded though many of the males outlived their mates. Development from eggs to newly eclosed adults averaged 22 days and ranged from 20 to 26 days. Although some beetles surfaced from the sand pupation medium 2 days after eclosion, most did not surface for 3 or 4 days. Eggs took 3 to 4 days to hatch. Development from newly eclosed larvae to mature larvae averaged 9 days. The duration of the individual instars was not determined. The prepupal period averaged 3.5 days and the pupal period averaged 6 days.

Measurement of the head capsule width of 107 larvae from a 14-day-old culture revealed three distinct peaks of 0.24 mm, 0.40 mm, and 0.56 mm. Thus, *S. ferruginea* has the same number of larval instars as *S. geminata* (Weber and Connell 1975) and *S. octomaculata* (Galford et al. 1991).

First-instar larvae ranged in length from 0.96 to 1.12 mm, second instars were 1.6 to 2.16 mm, and third-instar mature larvae were 3.5 to 4.08 mm.

Females began to lay viable eggs between 24 to 48 hours after they were paired with males and placed on acorns. Egg production increased greatly after the second day. The sausage-shaped beetle eggs ranged in length from 0.56 mm to 0.68 mm and averaged 0.64 mm. Newly laid eggs were shiny with a pearl-like appearance and slowly developed a dull, opaque appearance just before hatch.

Of 630 beetles sexed from the laboratory culture, 328 were females and 302 were males. Adult beetles ranged in length from 1.7 to 2.6 mm and averaged 2.3 mm. There was no significant difference in length between males and females. Beetles with the widest thoraxes generally were males but thorax width was not a reliable character for routine sexing of the insects.

Nuts of all tree species tested allowed development of *S. ferruginea* from eggs to adults. Multiple generations have been reared on several kinds of nuts but northern red oak acorns are used for routine rearing because their high tannin content inhibits the development of many troublesome microorganisms.

Summary

S. ferruginea has been found breeding naturally in laurel and live oak acorns in Florida. In the laboratory, beetles will reproduce in nuts of several tree species. We have reared *S. ferruginea* solely on northern red oak acorns for more than 27 generations with no apparent decline in the insects. We have used both viable and nonviable acorns.

Preliminary tests have shown that *S. ferruginea* can destroy small, germinating northern red oak and laurel oak acorns under laboratory conditions. Adults readily consume the tender radicles of acorns as they germinate. Adults then oviposit in the acorns and the combination of adult and larval feeding can destroy acorn viability. However, the larger radicles of medium to large germinating acorns are less damaged by the small beetles. Seedlings can be produced even from heavily infested acorns. Germinating acorns of several small-seeded oak species in the South could be readily damaged by *S. ferruginea*. However, field studies are needed to determine if the insects have any impact on oak seedling establishment.

S. ferruginea resembles *S. octomaculata* in that both feed on acorn radicles and both are capable of reproducing in both viable and nonviable acorns. As a result these two *Stelidota* species can be either primary or secondary pests of acorns whereas *S. geminata* breeds only in nonviable acorns. We have found it difficult to maintain a laboratory culture of *S. geminata* solely on acorns. Thus, acorns are likely opportunistic hosts of *S. geminata* but are major hosts of *S. ferruginea* and *S. octomaculata*.

The complete life history of *S. ferruginea* has not yet been studied. Beetles are known to be active in Sarasota County, Florida, from November into February when live and laurel oak acorn hosts are available. Adults of this species have been collected in spring, summer, and autumn in other states. Because *S. ferruginea* readily reproduces in many kinds of seeds in the laboratory, the beetles may use hosts other than acorns for field reproduction. However, acorns are one of the largest seeds and most abundant seed sources available in eastern forests and may be the most common hosts of the beetles throughout their known range.

S. ferruginea has been collected as far north as Michigan and Wisconsin but we did not collect this insect in 5 years of extensive studies of insects feeding on acorns in southern Ohio. Thus, it is probably a southern species that occasionally migrates north. Research is needed to determine the abundance of this insect throughout its range and it's effect, if any, on oak seedling establishment.

Table 1.—Summary of biological data for *S. ferruginea* reared on northern red oak acorns at 24° to 25°C on a 10:14 hour light:dark cycle

Life stage	Ave. number of days (range)
Egg to newly eclosed adult	22 (20 to 26)
Preoviposition period	3 (2 to 4)
Egg	3.5 (3 to 4)
1st instar to mature larvae	9 (8 to 11)
Prepupae	3.5 (3 to 4)
Pupae	6 (5.5 to 6.5)
Female longevity	123 (74 to 188)
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Fecundity (Ave. no. of eggs/ 23 females)	497 (174 to 823)

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The nitidulid *Stelidota ferruginea* Reitter was reared from damaged acorns of laurel oak, *Quercus laurifolia* Michx., and live oak, *Q. virginiana* Mill., collected in Sarasota County, Florida. This sap beetle has been reared in the laboratory solely on northern red oak, *Q. rubra*, acorns for over 3 years (27+ generations) and can breed in viable or nonviable acorns. In the laboratory, *S. ferruginea* can develop in the seeds of several species of trees. New information on the biology of *S. ferruginea* is presented.

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Keywords: Nitidulidae; *Stelidota*; acorn insects.

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