Nitidulidae (Coleoptera) Diversity in Three Natural Preserves in Portage County, Ohio[1]

ROGER N. WILLIAMS, JACQUELYN L. BLACKMER[2], DOUGLAS S. RICHMOND, AND M. SEAN ELLIS, Department of Entomology, Ohio Agricultural Research and Development Center of The Ohio State University, Wooster, OH 44691

ABSTRACT. **A comparative study was initiated to determine if habitat influences the abundance and richness of nitidulid beetle fauna at three sites (Kent Bog, Tinkers Creek, and Gott Fen) managed by the Division of Natural Areas and Preserves of the Ohio Department of Natural Resources. These sites in Portage County were sampled from early May through late October of 1990. Six sampling techniques were used at each site: Skalbeck traps, windowpane traps, Japanese beetle traps, gallon jug traps, greenhouse flat traps, and carrion traps. Baits included: whole wheat bread dough, fermenting brown sugar, cantaloupe, carrion, and banana. Most frequently collected nitidulid species were *Stelidota geminata* (Say), *Glischrochilus quadrisignatus* (Say), *G. fasciatus* (Olivier), and *Carpophilus lugubris* Murray. At these three sites, several species of nitidulids appeared to be rare: *Glischrochilus obtusus* (Say), *Glischrochilus sanguinolentus rubromaculatus* (Reitter), *Carpophilus hemipterus* (L.), *C. sayi* Parsons, *Cryptarcha concinna* Melsheimer, *Cryptarcha strigatula* Parsons, *Colopterus maculatus* (Erichson), *C. semitectus* (Say), *Cychramus adustus* Erichson, *Epuraea helvola* Erichson, *E. rufa* (Say), *Prometopia sexmaculata* (Say), *Pallodes pallidus* (Beauvois), and *Phenolia grossa* (Fabricius). Kent Bog appeared to have the greatest overall diversity of nitidulid species, followed by Tinkers Creek and Gott Fen. Species composition appeared to be most similar between Kent Bog and Tinkers Creek. A total of 30 species were collected with all attractants. Of these, 24 species were taken at Kent Bog, 15 species at Gott Fen, and 21 species at Tinkers Creek. All species are new records for Portage County.**

Ohio J. Sci. 92 (4): 82–87, 1992

INTRODUCTION

A comparative study was conducted among three habitats from early May through late October of 1990 to determine if a particular habitat influenced nitidulid species richness and abundance. The sites were selected because of their diverse and dissimilar flora, and because of their proximity to one another. The first site, Gott Fen, is a 5.5 ha boreal fen, or calcareous marl bog. The alkaline springs associated with this fen have a pH of 8-9 and a year-round temperature of 12.2° C, creating a micro-environment that enables Canadian-type vegetation to exist. Unique flora include showy lady's slipper, white wand-lily, round-leaved sundew, cotton grass, sphagnum moss, shrubby cinquefoil, tamarack, sage willow, and bayberry. Kent Bog, the second site, is a 16.9 ha acid peat bog with a pH of 4-5. Within this bog is the largest and southernmost stand of native tamarack in the continental United States. Other unique flora include the Virginia chain fern, goldthread, leather-leaf, blueberry, and yellow bartonia. The third site, Tinkers Creek, is a 318.1 ha marsh and swamp forest which offers a diversity of plant species. Cattail, willow, buttonbush, alder, shrubby dogwood, and red maple are quite common in and around the marsh region, and swamp white and pin oak dominate in the bottomland forests. Drier sites at Tinkers Creek are occupied by white, red, and chinquapin oaks, sugar maples, white pine, flowering dogwood, big-tooth and quaking aspens, and wild black cherry.

MATERIALS AND METHODS

Diverse methods of trapping the beetles were deemed necessary to capture the maximum number of species of Nitidulidae within each area. Six sampling techniques were used at the Ohio Department of Natural Resources (ODNR) sites in Portage County: Skalbeck traps (Skalbeck 1976), windowpane traps (Peck and Davies 1980, Chapman and Kinghorn 1955), Japanese beetle traps (Williams et al. 1990), gallon jug traps (Robert Androw, pers. comm.), greenhouse flat traps, and carrion traps. The latter two were our own design used for the first time in these studies. Traps were baited with cantaloupe, carrion, whole wheat bread dough, banana, or fermenting brown sugar. Each lure was used twice at each site. Baits were replaced and beetles removed on a weekly basis except the carrion traps which were left for two to three weeks. Insects removed from traps were labeled in the field and returned to the laboratory for processing.

Two Skalbeck traps were placed at each site on 1 May and run until 25 October 1990. These traps consisted of a wide-mouth, one pint canning jar with 0.64 cm hardware cloth inside the canning ring. A 15.5 cm^2 piece of Masonite®, which serves as a rain and sun shield, is fastened to the center of the screen with a 0.48 x 6 cm bolt and is stabilized by two 0.48 x 4 cm bolts that are placed on opposite sides. The Masonite is attached about 3 cm above the surface of the lid to allow insects access. Whole wheat bread dough (WWBD) was used as the bait because of its attractiveness to a wide array of nitidulid beetles (Miller and Williams 1982). The bread dough recipe used included: 0.4 kg of whole wheat flour, 11.5 g of sugar or honey, 296 ml of warm water, and a 7 g package of dry active yeast. Approximately 30 g of dough were wrapped in a piece of fiberglass screen to prevent the beetles from

[1]Manuscript received 10 April 1992 and in revised form 13 July 1992 (#92-11).

[2]Present Address: Department of Entomology, University of Arizona, Tucson, AZ 85721

becoming imbedded in the dough. The bait was placed in the canning jar, and the trap lid was attached. Traps were set in holes 15 cm in diameter and 7-10 cm deep. A stake was driven in the ground to which the trap was wired to discourage raccoons and other scavengers.

Two windowpane traps were placed at each site to obtain data on nitidulid beetles that might be flying through the areas. Traps consisted of a 60.96 cm^2 piece of Plexiglas® connected on each side to a 2.54 x 10.16 x 91.44 cm board. The window traps were erected by digging holes approximately 30.48 cm deep and setting the stakes at either end of the windowpane in the holes. Troughs, consisting of pieces of PVC pipe 15.24 cm in diameter that had been split lengthwise and then sealed on each end so they would hold water, were placed underneath the window trap. Insects flying into the windowpane would drop into the troughs where they were trapped in detergent water. The insects were collected from the troughs using a large household strainer and fresh soapy water was added to replenish losses. Traps were put out on 23 May and specimens were collected weekly through 7 September.

Two Japanese beetle traps (Trece®,white) with clear plastic bags as receptacles were set out at each site 6 June through 25 October. These traps were hung from metal rods approximately 1 m above the ground. In previous tests we had found that nitidulids in the genus *Meligethes* are attracted to the white trap (Williams, unpublished). These traps were also used for sampling at ground level (top of trap ca. 0.3 m above surface) from early June through the first week of September. However, traps were modified by replacing the plastic bags with 3.79 liter plastic containers that were suspended from a metal rod ca. 2 cm above ground level. Banana and whole wheat bread dough baits were placed inside small plastic containers that were covered with a fine mesh screen, and then these containers were placed inside the 3.79 liter containers in 2.5 cm of detergent water. Seven traps were placed at each location (three contained banana, three whole wheat bread dough, and one was a blank control). Traps were randomized and spaced approximately 2 m apart in a row. Traps were serviced weekly from 30 May through 1 September.

Nitidulid beetles collected from the modified Japanese beetle traps were used to compare habitat similarities with regard to species richness and abundance. Two similarity indices were used: Jaccard (j/(a+b-j)), where "j" is the number of species in common, and "a" and "b" are the number of species in each habitat; and Sorenson modified (2jN/(aN+bN)), where "jN" is the sum of the lesser of the two values when each species is compared between habitats, and "aN" and "bN" are the total number of individuals for each species and habitat (Southwood 1978).

Two fermenting brown sugar traps were placed in each site on 24 July. Large numbers of *Glischrochilus obtusus* (Say) have been collected in southern Ohio with this attractant (Robert Androw, pers. comm.). These traps were made from plastic 3.79 liter milk jugs with 6 cm2 entrances on opposite sides cut in the upper half to allow insects access. The bait was composed of 0.4 kg of brown sugar, 3.79 liter of water, and 3.5 g of dried yeast. Approximately 500 ml of this mixture was placed in each milk jug. Jugs were then hung about 1.3 m above the ground from a wire. On 4 October additional brown sugar traps were placed in the field and maintained for three weeks. However, these traps, which consisted of two solid plastic planting flats (50.8 x 25.4 x 5.08 cm) were placed on the ground. The bottom flat was filled with the same amount of brown sugar solution as previously described above, and the top flat was inverted and placed to provide a rain cover. Twist ties were used at the corners to keep the two flats together. Top flats were modified by cutting three 7.62 cm x 1.91 cm slits on each side and two equal slits in each end, providing access for the insects. Fresh brown sugar mixture was added weekly as collections were made.

Two cantaloupe traps were placed at each site beginning on 2 August. A cantaloupe was cut into six wedges, with the rind left in place. Newspaper was wrapped around each wedge of cantaloupe, ensuring that the ends were left open to allow an entrance for the beetles. These baits were then placed in a ventilated plastic greenhouse flat. Another flat was placed on top of the first one, forming a raccoon-proof box, and the two were bound together with twist ties. These traps were placed on the ground and collected and changed weekly for eight weeks.

The bait in each of two carrion traps at each site consisted of a chicken leg and a third of a fish (bluegill). Each meat was placed in a wide-mouth, one pint canning jar with the lid removed. One jar of each meat (chicken and fish) was then placed in a white, plastic 7.5 liter bucket and covered by an inverted apple crate with a 45.72 x 60.96 cm plywood rain shield attached. Chicken wire netting was placed around the crates to discourage small animals, and stakes were driven at angles through the wire and into the ground to secure the crates. Large pieces of wood were placed on top to further discourage raccoons. These treatments were collected every two to three weeks from 1 May through 9 August.

RESULTS

The most abundant nitidulid species trapped were those that are frequently considered pest or nuisance species. The strawberry sap beetle, *Stelidota geminata* (Say) was the most common insect in our survey (Table 1). The picnic beetles, *Glischrochilus quadrisignatus* (Say) and *G. fasciatus* (Olivier), were second and third in abundance, respectively. The fourth most abundant species was the dusky sap beetle, *Carpophilus lugubris* Murray.

The majority of species trapped were collected in moderate numbers, with season totals between 10 and 100 (Table 1). Some nitidulids were less frequently collected (Table 2).

Glischrochilus siepmanni Brown was recovered from whole wheat bread dough, fermenting brown sugar, banana, and cantaloupe baits from May through October at Gott Fen, but was not found until late August at Kent Bog, and September and October at Tinkers Creek. The cantaloupe substrate collected the most specimens (N = 126), followed by the fermented brown sugar traps (N = 72).

Cantaloupe traps were placed in each of the three sites in Portage County anticipating the capture of *G. sanguinolentus* (Olivier) along with other nitidulid beetles. The fermenting brown sugar traps were placed in the field

TABLE 1

Most abundant nitidulid beetles collected during 1990 at three ODNR natural preserves in Portage County, OH.[1]

Species	Site and total number collected		
	Kent Bog	Gott Fen	Tinkers Creek
Amphicrossus ciliatus (Olivier)	19	4	9
Carpophilus freemani Dobson	10	0	4
Carpophilus lugubris Murray	186	210	130
Carpophilus corticinus Erichson	47	12	10
Conotelus obscurus Erichson	0	15	0
Cryptarcha ampla Erichson	38	18	44
Epuraea peltoides Horn	20	0	44
Epuraea alternata Parsons	37	0	0
Glischrochilus fasciatus Olivier	630	74	43
Glischrochilus quadrisignatus (Say)	2,102	226	95
Glischrochilus sanguinolentus (Olivier)	26	12	25
Glischrochilus siepmanni Brown	3	374	4
Lobiopa undulata (Say)	1	9	0
Meligethes nigrescens Stephens	5	82	5
Omosita colon (L.)	20	1	28
Stelidota geminata (Say)	4,737	2,390	3,527
Total specimens	7,881	3,427	3,968

[1]If fewer than 10 beetles were caught over the entire season they are listed in Table 2.

TABLE 2

Nitidulid species considered "rare locally" at three sites in Portage County, OH, 1990.[1]

Species	Site and total number captured		
	Kent Bog	Gott Fen	Tinkers Creek
Carpophilus hemipterus (L.)	0	2	0
Carpophilus sayi Parsons	5	1	2
Colopterus maculatus (Erichson)	0	0	3
Colopterus semitectus (Say)	1	0	0
Cryptarcha concinna Melsheimer	3	0	1
Cryptarcha strigatula Parsons	6	0	0
Cychramus adustus Erichson	1	0	0
Epuraea helvola Erichson	1	0	7
Epuraea rufa (Say)	6	0	0
Glischrochilus obtusus (Say)	0	0	2
G. sanguinolentus rubromaculatus (Reitter)	0	0	1
Pallodes pallidus (Beauvois)	5	0	4
Phenolia grossa (Fabricius)	7	0	0
Prometopia sexmaculata (Say)	0	0	1
Total specimens	35	3	21
Total specimens Tables 1 and 2	7,916	3,430	3,989
Total species Tables 1 and 2	24	15	21

[1]"Rare locally" by our definition means that fewer than 10 specimens were taken during the study at all three sites.

specifically with the hope of capturing *Glischrochilus obtusus* (Robert Androw, pers. comm.).

Windowpane traps were not effective in catching nitidulid beetles (Table 3). Only 13 specimens in five species were collected using this technique.

Nitidulid beetles taken over the entire season were analyzed with regard to bait and trapping method (Table 3). Both species richness and abundance show similar trends when used to gauge success. Whole wheat bread dough collected the greatest diversity, with 20 species and 8,269 specimens, followed by banana and cantaloupe with 19 and 18 species, and 5,462 and 1,038 specimens, respectively. Fermenting brown sugar ranked fourth with 12 species and 417 specimens in the aerial trap, and 10 species and 82 specimens in the ground trap.

Overall diversity of nitidulids trapped was greatest at Kent Bog with 24 species taken, followed by Tinkers Creek with 21, and Gott Fen with 15 (Table 2). Nitidulid species composition was most similar between Tinkers Creek and Kent Bog when modified Japanese beetle traps were used. Interestingly, these are also the two sites that are most similar in flora composition. Jaccard's similarity index corroborated this observation with an index of 0.69 between Kent Bog and Tinkers Creek, whereas the Kent Bog and Gott Fen comparison produced an index of 0.47, and the Gott Fen and Tinkers Creek comparison produced an index of 0.39. Sorenson's modified similarity index, however, produced slightly different results. Gott Fen and Tinkers Creek were more similar (0.77) with regard to nitidulid composition than were Kent Bog and Tinkers Creek (0.66), or Kent Bog and Gott Fen (0.52).

Sorenson's modified similarity index includes species abundance in the calculations, whereas Jaccard's index only considers richness. Species abundance varied between sites, primarily because of one species, *S. geminata*. Therefore, Jaccard's index probably provides a better measure of the nitidulid community similarities.

Several of the nitidulid species trapped at these sites appear to be localized or rare in Ohio (Table 2). The designation of "rare locally" is not significant in itself because it is based on numbers taken in our trapping regime, which may not account for species in narrowly-defined niches. We have arbitrarily included species in this list where less than 10 specimens were collected for the entire collection period at all three preserves.

DISCUSSION

A number of nitidulids are economically important to agriculturists worldwide. Thus, the genera that have received the most attention (*Carpophilus*, *Stelidota*, *Glischrochilus*, and *Meligethes*) in the literature are those which cause direct damage to crops by there feeding or are of concern because they are disease vectors (Miller and Williams 1982). *Stelidota geminata* was the most abundant sap beetle captured in the present study, and also one of the most damaging to the strawberry crop in eastern North America. It damages approximately 10% of the all strawberries grown in Ohio (Weiss and Williams 1978). The picnic beetles, *Glischrochilus quadrisignatus* and *G. fasciatus* are not only pests of fruit crops, contaminants of fruits and vegetables, vectors of plant disease, and nuisance pests at picnics, athletic events, and outdoor weddings (Borror et al. 1989, Parsons 1943), but also play a rather important role as beneficial insects. They have been used in integrated pest management programs to assist in the control of the European corn borer (Luckmann 1963). The picnic beetles enter the holes made by the European corn borer and kill the invading borer larvae. The dusky sap beetle, *Carpophilus lugubris* is attracted to the silks of sweet corn and lays its eggs thereon. Upon hatching, the neonate larvae enter the ear of corn and cause primary damage by feeding on the young kernels thereby rendering the infested ears unmarketable (Harrison 1962). *Carpophilus hemipterus* (L.) is the most common cosmopolitan species. It is not generally abundant in forested areas in Ohio and surrounding states. However, it was found in abundance in high-moisture stored corn near Moreland in Wayne County, OH (Williams 1985, unpublished).

During the present study we encountered several members of the genus *Glischrochilus* for the first time. Since these are among the largest and most brightly colored sap beetles, they are quite conspicuous and easy to identify. According to Blackwelder and Blackwelder (1948), the range of *G. siepmanni* extends south from Quebec to New York and west to British Columbia. Previously, it was believed that *G. siepmanni* was solely a northern Nearctic species found predominantly north of the 42nd parallel. To our knowledge, this is the southernmost point from which *G. siepmanni* has been recovered in Ohio. *G. sanguinolentus* is similar in size to both *G. quadrisignatus* and *G. fasciatus*. However, the elytral markings make this species easily distinguishable. The elytra are black except for a red patch that encloses two black spots and extends across the middle third of the forewings. The numbers of *G. sanguinolentus* recovered from these traps were minimal, but other species of *Glischrochilus*, except *G. obtusus* and *G. sanguinolentus rubromaculatus* (Reitter), were present in relatively large numbers (Table 3). Only one specimen of *G. sanguinolentus rubromaculatus* was captured. This sap beetle differs so dramatically from *G. sanguinolentus* that for the purposes of this paper we are considering it a different species. *G. sanguinolentus rubromaculatus* differs in that very little of the red patch is evident and the two black spots on the elytra are much larger and more pronounced. *G. obtusus* is the largest member of its genus in North America, measuring 8-10 mm long (Brown 1932). The body is black throughout, except that each elytron has a basal and a post median reddish-orange spot; each spot occupies about half the elytral width. Blackwelder and Blackwelder (1948) reported *G. obtusus* from New York, South Carolina, Indiana, Michigan, and Louisiana. More recently, this species has been captured in Fairfield, Scioto, and Vinton counties in southern Ohio (Robert Androw, pers. comm.). On 29 June and 27 September, we recovered a total of two specimens of *G. obtusus* from Tinkers Creek. One was collected from a modified white Japanese beetle trap baited with banana, and one from a cantaloupe trap. No *G. obtusus* were collected from the brown sugar traps as had been anticipated.

Windowpane traps were not very efficient. Slugs entered the troughs of the window traps, especially at Gott Fen

TABLE 3

Nitidulid beetles collected over the entire season at three sites in Portage County, OH, 1990.

Species	TOTAL NUMBER COLLECTED							
		Brown sugar						
	WWBD[1]	Aerial	Ground	Cantaloupe	Banana	Carrion	Trece	Window
Amphicrossus ciliatus	0	1	3	25	3	0	0	0
Carpophilus freemani	7	0	0	7	0	0	0	0
*Carpophilus hemipterus**	1	1	0	0	0	0	0	0
*Carpophilus lugubris**	338	45	21	30	92	0	0	0
Carpophilus sayi	0	0	0	8	0	0	0	0
Carpophilus corticinus	10	0	0	20	39	0	0	0
Carpophilus maculatus	0	0	0	0	3	0	0	0
Colopterus semitectus	0	0	0	1	0	0	0	0
Conotelus obscurus	8	0	0	0	7	0	0	0
Cryptarcha ampla	37	31	2	6	24	0	0	0
Cryptarcha concinna	0	3	1	0	0	0	0	0
Cryptarcha strigatula	0	6	0	0	0	0	0	0
Cychramus adustus	0	0	0	0	0	0	0	1
Epuraea helvola	4	0	0	0	4	0	0	0
Epuraea Peltoides	27	3	0	2	32	0	0	0
Epuraea alternata	3	0	2	17	15	0	0	0
Epuraea rufa	1	0	0	3	2	0	0	0
*Glischrochilus fasciatus**	307	69	11	162	198	0	0	0
*G. quadrisignatus**	790	140	2	426	1,062	0	0	3
G. obtusus	0	0	0	1	1	0	0	0
G. sanguinolentus	10	24	2	20	7	0	0	0
G. sanguinolentus rubromaculatus	0	0	0	1	0	0	0	0
G. siepmanni	124	80	19	139	18	0	0	1
Lobiopa undulata	5	0	0	0	5	0	0	0
Meligethes nigrescens	42	0	0	0	46	0	4	0
Omosita colon	8	0	0	3	1	37	0	0
Pallodes Pallidus	5	0	0	0	0	0	0	4
Prometopia sexmaculata	1	0	0	0	0	0	0	0
*Stelidota geminata**	6,541	14	19	167	3,909	0	0	4
Totals	8,269	417	82	1,038	5,468	37	4	13
Weeks in the field	25	13	3	12	14	14	20	22

*Pests of agriculture/forest and/or nuisance pests in Ohio.
[1]WWBD = Whole wheat bread dough.

where their numbers sometimes made it difficult to remove insects. As the slugs died and began to decompose, carrion beetles, *Silpha americana* L. and *Nicrophorus* spp. (Coleoptera: Silphidae), were frequently attracted to these traps, not to mention the repulsive odors that had to be endured when working with these collections.

Carrion as bait was incorporated into this study in order to attract a single group of sap beetle in the genus *Nitidula*. According to Dr. Walter A. Connell (pers. comm.), no more than a few *Nitidula* specimens have ever been collected at a single host and those usually from animals that are completely decomposed with only the bones and hide remaining. Carrion was ranked fifth when considering total number of specimens collected. However, *Omosita colon* was the only sap beetle caught.

Unfortunately, results given for the different traps (Table 3) are not directly comparable because of variation in the time of exposure. For example, brown sugar ground traps were utilized only for a short time in comparison to the aerial trap. The windowpane trap was the only trap that collected *Cychramus adustus*, perhaps indicating that it is a transient species at Kent Bog.

Of the species in the rare locally category, *Carpophilus sayi* Parsons and *Epuraea helvola* Erichson were represented by 8 specimens each. Connell (1957) and Skalbeck (1976) considered *C. sayi* rare in Delaware and Minnesota. All of our collections were at wooded areas dominated by hardwood trees. Skalbeck (1976) found *E. helvola* common in pin oak and trembling aspen stands in Minnesota, and found *Glischrochilus obtusus* rarely in pin oak and trembling aspen stands. Two species on our list, *Colopterus semitectus* (Say) and *Prometopia sexmaculata* (Say), are among the principal species of nitidulids found associated with oak wilt infected *Quercus* in West Virginia (True et al. 1960). *Colopterus maculatus* (Erichson) also has been collected from oak wilt fungus mats, oak sap flows, and under oak bark according to Watrous (1980). Watrous considered *Colopterus semitectus* to be a common species in eastern North America and said it is also widespread in Latin America. He reported habitats as: under bark, rotting corn, oak logs, decomposing watermelon rind, maple sap flows, sap on stumps, and in malt traps. In the present study, the driedfruit beetle *Carpophilus hemipterus* was recovered at only one site, Gott Fen, where two specimens were collected. However, this species is quite abundant throughout the world and is known for contaminating stored products such as corn, raisins, dates, and figs (Hinton 1945). Other species collected and considered rare locally also were considered rare by Skalbeck (1976) (i.e., *Cychramus adustus* Erichson and *Phenolia grossa* [Fabricius]). *Cryptarcha concinna* Melsheimer was found by Skalbeck (1976) to be quite variable in abundance in accordance with its habitat. For instance, it was common in pin oak, occasional in trembling aspen, and rare in sugar maple stands.

As the areas adjacent to the study areas become disturbed it will be interesting to follow future trends in nitidulid biodiversity. Plans to construct a shopping mall across the highway from Kent Bog may cause drastic changes in the insect fauna in the future. We hope that this study will be of value as a benchmark in determining trends in biodiversity.

ACKNOWLEDGEMENTS. The authors thank Deb Schnipke and Dan S. Fickle for their assistance during this study. We also thank the Division of Natural Areas and Preserves of the Ohio Department of Natural Resources for funding this study. Salaries and research support were provided by State and Federal Funds appropriated to the Ohio Agricultural Research and Development Center, The Ohio State University. OARDC manuscript number 116-92.

LITERATURE CITED

Blackwelder, R. E. and R. M. Blackwelder 1948 Fifth supplement 1939 to 1947 (inclusive) to the Leng catalogue of Coleoptera of America, North of Mexico. John D. Sherman, Jr., Mt. Vernon, NY. 87 pp.

Borror, D. J., C. A. Triplehorn, and N. F. Johnson 1989 An introduction to the study of insects. (6th ed.) Saunders College Publ., Philadelphia, PA. 875 pp.

Brown, W. J. 1932 The North American species of *Glischrochilus* (Coleop.). Can. Entomol. 64: 255-262.

Chapman, J. A. and J. M. Kinghorn 1955 Window flight traps for insects. Can. Entomol. 87: 46-47.

Connell, W. A. 1957 The genus *Carpophilus* in Delaware (Coleoptera: Nitidulidae). Ph.D. Dissertation, University of Maryland, College Park, MD. 99 pp.

Harrison, F. P. 1962 Infestation of sweet corn by the dusky sap beetle, *Carpophilus lugubris*. J. Econ. Entomol. 55: 922-925.

Hinton, H. E. 1945 A monograph of the beetles associated with stored products. Brit. Mus. Nat. Hist. 1: 1-433.

Luckmann, W. H. 1963 Observations on the biology and control of *Glischrochilus quadrisignatus*. J. Econ. Entomol. 56: 681-686.

Miller, K. V. and R. N. Williams 1982 Seasonal abundance of *Stelidota geminata* (Say) in selected habitats. J. Georgia Entomol. Soc. 17: 112-117.

Parsons, C. T. 1943 A revision of Nearctic Nitidulidae (Coleoptera). Bull. Mus. Comp. Zool. 92: 119-278.

Peck, S. B. and A. E. Davies 1980 Collecting small beetles with large-area "window" traps. Coleopt. Bull. 34: 237-239.

Skalbeck, T. C. 1976 The distribution of Nitidulidae in deciduous forests of Minnesota. Ph.D. Thesis, University of Minnesota, Minneapolis, MN. 204 pp.

Southwood, T. R. E. 1978 Ecological methods with particular reference to the study of insect populations. Methuen, London.

True, R. P., H. L. Barnett, C. K. Dorsey, and J. G. Leach 1960 Oak wilt in West Virginia. Bull. 448T, West Virginia University, Agric. Expt. Sta., Morgantown, WV. 119 pp.

Watrous, L. E. 1980 Morphology, reclassification and cladistics of the *Colopterus* genus group (Coleoptera: Nitidulidae). Ph.D. Dissertation, The Ohio State University, Columbus, OH. 551 pp.

Weiss, M. J. and R. N. Williams 1978 Distribution of the strawberry sap beetle, *Stelidota geminata* (Say) (Coleoptera: Nitidulidae). Proc. N.C. Branch, Entomol. Soc. Amer. 33: 55-56.

Williams, R. N., T. P. McGovern, M. G. Klein, and D. S. Fickle 1990 Rose chafer (Coleoptera: Scarabaeidae) improved attractant for adults. J. Econ. Entomol. 83: 111-116.