Table 2. Estimated structural coefficients of unrestricted model and results of hypothesis testing.

	Table wine	Sparkling wine	Dessert wine	Vermouth	Wine cooler
INT	3938369 (13.15)*	223264 (2.545)*	583074 (14.27)*	115939 (16.716)*	–9561508 (–7.289)*
T	644210 (12.10)*[z]	91757 (2.932)*	–26694 (–3.676)*	7124.12 (5.780)*	955053 (8.797)*
Z	6046570 (6.564)*	236010 (1.854)**	–128577 (–1.023)	128625 (6.030)*	16730171 (4.076)*
ZT	–696400 (–8.396)*	–62404 (–1.735)	23868 (2.109)**	–8886.98 (–4.627)*	–1231801 (–4.632)*
DW[y]	1.576	2.764	1.162	2.167	3.003
Ho: p=0[x]	Incon.	Incon.	Incon.	Failed to reject	Incon.
Test 1 Ho: B2 = 0					
F value	43.092	7.005	1.047	36.360	16.614
P > F	0.0001	0.020	0.324	0.0001	0.015
Test 2 Ho: B3 = 0					
F value	70.497	8.099	4.449	21.407	21.455
P > F	0.0001	0.013	0.054	0.0001	0.009
Test 3 Ho: B2 and B3 = 0					
F value	37.871	5.917	4.253	19.884	21.305
P > F	0.0001	0.015	0.038	0.0001	0.007

[z]Figures in parentheses are T values for Ho: parameter = 0.
[y]DW = Durbin-Watson test statistic.
[x]p = Rho, coefficient of autocorrelation. Region of rejection = 0.05.
*Significant at the 0.05 percent.
**Significant at the 0.10 percent.

investment and revitalize the industry. A reduction in the excise tax for wine will not only help to increase consumption but tax revenue as well. The increased revenue could be used to promote the state's viticulture industry.

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BLUEBERRY GALL MIDGE: A PEST ON RABBITEYE BLUEBERRY IN FLORIDA

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Abstract. **On 20 Feb. 1992, rabbiteye blueberry (*Vaccinium ashei* Reade) flower buds emerging from dormancy at the University of Florida Horticultural Unit in Gainesville were seen to be drying up and disintegrating. By 6 Mar., almost all flower buds had been destroyed on many plants. Microscopic examination showed the buds to be infested with larvae of the blueberry gall midge, *Dasineura oxycoccana* (Johnson). Extensive damage to the rabbiteye blueberry crop was noted on eight commercial farms and two research plantings from Hillsborough County to Alachua County, with flower bud loss ranging from 20% to 80% depending on location and cultivar. Highbush blueberry flower buds were much less damaged than rabbiteye buds. Rabbiteye vegetative meristems that emerged from 1 Mar. through 20 May were heavily infested by midge larvae. Vegetative growth was**

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greatly curtailed, and most leaves produced during this period were damaged and distorted. Similar damage to flower buds and leaves has been observed in previous years suggesting that the midge has been a serious but undiagnosed problem in north-central Florida for at least a decade. In states north of Florida, this species has been reported to damage vegetative meristems of blueberry and cranberry, but damage to flower buds has never been reported.

Rabbiteye blueberries are native in north Florida, and improved cultivars have been cultivated from Marion County north through the Panhandle since 1960. Efforts to breed low-chill rabbiteye varieties that could be cultivated as far south as the north end of Lake Okeechobee have met with limited success (Lyrene and Crocker, 1983; Lyrene and Sherman, 1984; Lyrene, 1989). Although many clones selected from the breeding program appear to foliate normally in the spring in the Highlands County area, yields in this area have been low and erratic compared to those obtained in south Georgia and in the Florida Panhandle.

Several distinct problems appear to be reducing yields on rabbiteye blueberries in central and north-central Florida. Leaf diseases and warm temperatures in the fall reduce flower bud formation. Botrytis blight (*Botrytis cinerea* Pers. ex Fr.) and thrips [*Frankliniella bispinosa* (Morgan)] sometimes attack the flowers and prevent successful pollination. In some years, fruit set has been poor even though large numbers of flowers opened and appeared healthy (Lyrene and Crocker, 1983). Fruit-set problems have been especially severe on large farms, in the warmer production areas, and after winters with above-normal mean temperatures. Pollination insufficiency due to lack of native bee pollinators, a lingering effect of insufficient chilling the preceding winter, and high temperatures during flowering are among the factors that may contribute to poor fruit set.

In addition to the problems mentioned above, flower bud degeneration of unknown etiology has been observed on rabbiteye blueberries in north-central Florida in several of the past 15 years. In the spring of 1992 this degeneration was found to be due to the blueberry gall midge (*Dasineura oxycoccana* Johnson), which has long been known to attack vegetative buds of blueberry and cranberry in states farther north but has not been known to attack flower buds. The purpose of this paper is to describe the damage caused by this midge in Florida in 1992, to review known habits of the pest, and to discuss the potential impact of the midge on future rabbiteye blueberry culture in Florida.

Observations at the Horticultural Unit, Gainesville, 1992

On 20 Feb. flower buds were found to be aborting on large numbers of rabbiteye blueberry plants of many varieties at the Horticultural Research Unit in Gainesville. Degeneration occurred at or near the time of meiosis, when the scales of the inflorescence buds were beginning to separate, exposing the individual flower buds within. Flower buds that had appeared healthy a week earlier were brown and drying, and individual flower buds within the inflorescence were abscising from the peduncle. In some sections of the field more than 90% of the flower buds were destroyed within a 2-week period centering on 20 Feb. In high-density nurseries, damage was greatest in the interior of the nursery, with plants around the perimeter receiving less damage. On plants where only some of the buds were damaged, damage was greatest on the lower branches. The blueberry plantings at the Horticultural Unit cover about 5 hectares, and include nurseries of various ages, genotypes, and planting densities. When extraneous variables were accounted for, it appeared that bud degeneration was greater in certain areas of the farm than in others. Damage also varied greatly according to the variety and species of blueberry. Highbush varieties were much less damaged than rabbiteye varieties. Among rabbiteye varieties, flower bud destruction ranged from nearly complete to minor.

On 20 Feb., degenerating flower buds were collected and opened under a stereoscopic microscope and were found to be infested with midge larvae. Essentially every flower bud was infested on plants in some nurseries. The number of larvae per bud ranged from one to nine. Full-grown larvae averaged about 1 mm long and 0.3 mm wide. In many of the buds, the larvae appeared to be feeding on the pedicels that held the individual flower buds to the peduncle within the developing flower cluster. Destruction of flower buds was rapid after infestation. Midge larvae collected in Gainesville were identified as a *Dasineura* species by Raymond J. Gagné, Systematic Entomology Laboratory, U.S. Department of Agriculture, Washington, D.C.

On 8 Mar., branches with degenerating flower buds were placed in an incubator, and adult flies began to emerge by 20 Mar. Specimens were sent to Gagné, who determined them to be *Dasineura oxycoccana* (Johnson).

The midge problem was first noted on early flowering rabbiteye varieties. On 6 Mar., when nearly all flower buds on many early varieties had been destroyed, little or no damage could be found on buds of late-flowering rabbiteyes such as 'Powderblue', 'Premier', and 'Brightwell'. However, some flower buds on these late-flowering rabbiteyes subsequently became infested, and midge larvae were actively destroying late flower buds on the cultivar 'Centurion' on 11 Apr.

Flower buds on individual plants often vary considerably in stage of development. Buds on the lower part of the plant sometimes reach various developmental stages as much as one month ahead of the buds on the vigorous upright shoots at the top of the plant. On many plants, nearly all the earlier-developing flower buds were destroyed before the later buds showed signs of infestation. However, on such plants, the later buds were also destroyed later in the growing season. It appeared that midge eggs continued to be deposited on buds for at least 2 months during January, February, and March.

Shortly after vegetative bud break, vegetative meristems on rabbiteye plants at the Horticultural Unit, became infested with midge larvae. As late as 20 May, most new meristems on many rabbiteye plants were still being infested. The larvae fed on the youngest leaves, causing the leaves to curl around them. When opened, each leaf curl contained from one to ten midge larvae. It appeared to require less than 10 days for infested meristems to be killed. Death of the apical meristem stimulated growth of lateral meristems, but these also became infested and were killed. On many cultivars, continual destruction of the vegetative meristems caused the plants to have very sparse foliation as late as 1 June. After mid-May, infestations of new meristems declined rapidly, and the plants were able to produce

normal vegetative growth throughout the remainder of the growing season.

Observations in Plantings at Other Locations in Florida

Between 15 Mar. and 25 Mar., ten additional field plantings of rabbiteye blueberries were examined in north and central Florida, and the percentage of the flower buds that had been destroyed by gall midges was estimated for each location (Table 1). The locations ranged from Highlands County to Alachua County. Damage was found at all but one location, and five of the ten locations had 50% or greater loss of flower buds. Within the surveyed area in Florida, there was no evidence that damage was greater in the south and less in the north. All of the surveyed locations also had highbush blueberries, and at all locations, midge damage on highbush was far less than on rabbiteye.

On 20 Dec. 1991 one hundred and twenty 2-year-old blueberry plants were dug from field nurseries at the Horticultural Unit in Gainesville. These were potted, and placed in a dark refrigerator at about 7C until 1 Feb. 1992, when they were moved to an enclosed greenhouse. By 10 Mar., 20 of the rabbiteye plants had midges in at least some flowers buds. A few of the most heavily infested plants lost 70% of their flower buds to midge infestation. The plants had been dug from various nurseries at the Horticultural Unit, and plants from one of the nurseries were much more heavily infested than those from other nurseries. As in the field plantings, flower buds on highbush plants in the greenhouse suffered little midge damage. By 10 Mar., vegetative meristems were also being killed by midges in the greenhouse. Both highbush and rabbiteye vegetative meristems were being attacked, but damage was greatest on rabbiteye plants. Infestations of new vegetative meristems continued in the greenhouse through 10 Apr., but rapidly declined thereafter. Egg clusters in the process of hatching were found on vegetative meristems surveyed in the greenhouse on 31 Mar. and 7 Apr. The eggs were found in clusters of 5 to 10 on the outer surface of the vegetative meristems.

The source of the midges that infested the greenhouse is uncertain. They may have been brought to the greenhouse in soil from the Horticultural Unit that remained around the roots when the plants were potted in the field. However, rabbiteye blueberry plants that had been growing for the preceding year near but outside the greenhouse in pots of peat and pine bark also were badly infested with midge larvae even before damage became apparent in the greenhouse, indicating that adult flies were present outside in the area around the greenhouse.

Table 1. Estimated percent flower bud destruction by blueberry gall midge in 11 rabbiteye blueberry plantings in Florida in 1992.[z]

Farm County	Rabbiteye Acreage	Flower Bud Loss %
1 Alachua	3	90
2 Alachua	200	20
3 Alachua	5	70
4 Alachua	60	75
5 Alachua	3	50
6 Alachua	80	25
7 Putnam	30	25
8 Marion	3	25
9 Citrus	3	75
10 Hillsborough	1	75
11 Highlands	1	0

[z]Locations are arranged in the table from north to south.

Biology of the Blueberry Gall Midge

Gall midges belong to the family Cecidomyiidae in the order Diptera, or true flies. Adults are generally short-lived, typically surviving only long enough to mate and lay eggs. Most or all of the feeding is done by the larvae. These feed by sucking plant juices, which are broken down by salivary secretions and then ingested. The larval stage may last from less than 2 weeks to more than a year (Gagné, 1989). Gall midge eggs hatch within a few days of deposition. The larvae of some *Dasineura* species pupate in leaf folds produced by their feeding. The larvae of other species drop to the ground when fully grown. These burrow into the ground and may remain in the soil as larvae for extended periods before pupating. The pupal stage is usually of short duration (Gagné, 1989).

Dasineura oxycoccana has been reported on cranberries (*Vaccinium macrocarpon* Ait.) in Massachusetts, New Jersey, Wisconsin, and Washington (Gagné, pers. comm.). It has occasionally caused economic losses in cranberry by killing vegetative meristems. Death of these meristems reduces vegetative growth and can reduce flower bud production for the following season.

The midge has two or three generations per year on cranberry in New Jersey (Barnes, 1948). The eggs are laid near the bases of the terminal leaves. One to five larvae are usually found per vegetative growing point. When full grown, after about 10 days, they are yellow or orange-red in color. Larvae of the first generation spin white cocoons in the cranberry shoot tips, but those of the second descend to the ground and form cocoons in which they pupate the following spring, a few days before emergence as adult midges.

Implications for Rabbiteye Blueberry Cultivation in Florida

Gall midges caused severe flower bud damage on more than half of the commercial rabbiteye blueberry farms surveyed in Florida in 1992. At several locations, losses exceeded 70% of all flower buds. Severe bud loss at the same time of the year and with the same symptoms occurred on at least three rabbiteye blueberry farms in 1991, and heavy bud losses with similar symptoms have been noted in earlier years. Midge damage has not been reported on blueberry flower buds in other states, even though the insect is sometimes present in these states on blueberry vegetative shoots later in the season.

In Florida in 1992, larvae were not found in fully dormant flower buds. Furthermore, once the flowers reached anthesis, they no longer appeared to be susceptible to damage. Thus, there seems to be a relatively short time during the development of any particular bud when it is vulnerable to the midge. The flower bud damage in Florida, which contrasts with the lack of damage in states farther north, could be a result of warm periods during the winter which allow midge adults to emerge and lay eggs before the flower buds pass the vulnerable developmental stage.

Control measures have not been investigated for the blueberry gall midge in Florida. If insecticides are used, they will have to be applied in a way that minimizes injury to the bees that pollinate blueberry flowers. Because the

period of maximum vulnerability to midges for a flower bud appears to be from 2 to 4 weeks before anthesis, avoiding injury to bees while spraying for midge adults appears feasible. Unfortunately, the flowering period on a single blueberry variety is often very long in Florida, and some scattered flowering often occurs several weeks before peak flowering. Because heavy midge infestations continue on vegetative meristems for more than a month after flowering is complete, it might be possible to reduce midge problems for the following year by spraying to control adults after pollination is complete.

Because rabbiteye blueberries in Florida are being grown in or near the center of origin of the species and its close relatives, it is not surprising that many insect species are occasional pests on the crop. It appears that the blueberry gall midge has the potential to devastate the rabbiteye blueberry crop on certain farms in certain years in Florida. Methods of scouting for and controlling the insect are needed. Control of the gall midge will not eliminate yield problems on rabbiteye blueberries in Florida, but should contribute to higher yields.

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EFFECT OF CHELATED CALCIUM ON THE SHELF-LIFE AND QUALITY OF BLUEBERRY FRUITS (*VACCINIUM ASHEI* Reade)

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Abstract. **Chelated calcium (CaEDTA) was applied as a soil application to rabbiteye blueberry bushes to study its effects on shelf-life and fruit quality. Application of 6,000, 12,000 and 24,000 mg/bush per season was made immediately before bloom in early March. Calcium increased fruit firmness, reduced ethylene production and acidity, and prolonged the shelf-life of fruit.**

Rabbiteye blueberry (*Vaccinium ashei* Reade) has become increasingly popular in the Southeastern United States. The production of this fruit more than doubled between 1982 and 1985 (12). Concomitant with increased volume of fruit production is the need for distribution to greater distances from production areas. The problems associated with greater distribution distances are magnified by the short shelf-life of the fruit. While rabbiteye blueberry is a climacteric fruit, it exhibits low ethylene production (10). Within a few days after harvest, the fruit becomes less firm and develops problems associated with postharvest decay. Calcium is considered an important mediating agent in the control of cell metabolism. It has long been associated with the regulation of ripening processes and postharvest storage life. Maintenance of relatively high Ca concentrations in the fruit tissue resulted in reduced CO_2, soluble pectin and ethylene production (7, 15). Apart from the preventive action of Ca on the occurrence of specific senescence disorders in apple fruits (4, 16), there is evidence for its effects on retarding the rate of fruit ripening. This is usually manifested in lower fruit respiration, softening, color changes and leakage of solutes (6). In apples, ethylene production and fruit softening correlated negatively to Ca concentration in the fruit (13). The concentration of this element in blueberry leaves appeared to be different from these of other elements (1). In high bush blueberry, Ca content was positively associated with yield (14), however, studies on the effects of Ca on quality and shelf-life of the fruit are lacking. The current studies were designed to investigate this subject.

Materials and Methods

Sixteen 9-year-old bushes of rabbiteye blueberry cv. 'Tifblue' were used for this study. The bushes were planted on a sandy loam soil (pH 4.5 to 5.0) at 1.8 × 3.6 m^2 spacing, and received the cultural practices followed by Tuskegee Agricultural Experiment Station during the growing season except for Ca nutrition. Ca as CaEDT (Fe ethylene diaminetetracetic acid) was applied immediately after bloom (early March) as a soil application at 3 rates: high (H), 24,000; medium (M), 12,000; and low (L), 6,000 mg/bush per season. Fruits of each bush were hand-picked early in the morning in early July when they were fully blue. Soon after harvest, the fruits were stored at 5C for 12 hrs to remove field heat, before they were taken to the laboratory for quality attributes and shelf-life studies. Five hundred fruits were used in determining firmness, total soluble solids (TSS), titrable acidity, TSS/acid ratio and pH as described in a previous report (8). Ethylene measurements were performed by enclosing approx. 5 gm sample in a 30 ml glass vial capped with a rubber septum for a duration of 2 hrs. A 1-ml gas sample was withdrawn and analyzed using a Perkin-Elmer Sigma 3B gas chromatograph equipped with a flame ionization detector (FID) and activated aluminium column. For shelf-life studies, one