Ovipositional Preferences of Two Squash Bug Species, *Anasa tristis* and *Anasa armigera* (Heteroptera: Coreidae), for Different Cultivars and Species of Cucurbitaceae

Mary L. Cornelius

USDA, Agricultural Research Service, Invasive Insect Biocontrol and Behavior Lab, Beltsville Agriculture Research Center, 10300 Baltimore Avenue, Building 007, Beltsville, MD 20705 (mary.cornelius@ars.usda.gov)

Received 21 December 2017; Editorial decision 12 February 2018

Abstract

The ovipositional preferences of two squash bug species, *Anasa tristis* (DeGeer) (Heteroptera: Coreidae) and *Anasa armigera* Say (Heteroptera: Coreidae), were evaluated in paired choice tests of different species and cultivars of plants in the family Cucurbitaceae. Females of *A. tristis* preferred to oviposit on the cultivar from which they were reared over three other cultivars of the same species. However, females did not show any ovipositional preference for different cultivars when they had no previous exposure to either cultivar. Females of *A. tristis* were equally likely to oviposit on *Cucurbita pepo*, *Cucurbita maxima*, and *Cucurbita moschata* but were significantly more likely to oviposit on *C. pepo* than on cucumber and watermelon. Females of *A. armigera* were equally likely to oviposit on *C. pepo* or cucumber, regardless of the species they were reared on. When *A. armigera* was reared on *C. pepo*, females were more likely to oviposit on *C. maxima* than on cucumber and less likely to oviposit on *C. moschata* than on cucumber.

Key words: oviposition behavior, squash, pumpkin, cucumber, watermelon

common squash bug, *Anasa tristis* (DeGeer) (Heteroptera: Coreidae), is a major pest of cucurbit crops in the United States (Doughty et al. 2016). It is found throughout the United States, and in Mexico, Central America, and Canada (Wadley 1920, Beard 1940). It is also a vector of cucurbit yellow vine disease, *Serratia marcescens*, which can cause severe crop damage (Bruton et al. 2003, Pair et al. 2004, Wayadande et al. 2005). Studies on pest control strategies for squash bugs have included the use of insecticidal sprays, trap crops, mulches, row covers, and biological control (Cartwright et al. 1990, Olson et al. 1996, Pair 1997, Lu et al. 2003, Dogramaci et al. 2004, Decker and Yecargan 2008, Schmidt et al 2014, Cornelius et al. 2016). Research has also explored the possibility of using RNAi techniques for immuno-suppression (Shelby 2013).

Several studies have been conducted to evaluate the feeding preferences, fecundity, and nymphal development of *A. tristis* for different cultivars and species of Cucurbitaceae (Novero et al. 1962, Bonjour and Fargo 1989, Bonjour et al. 1993, Vogt and Nechols 1993, Cook and Neal 1999). Studies found that nymphal development and survival and adult fecundity were higher on *Cucurbita pepo* L. and *Cucurbita maxima* Duchesne compared with *Cucurbita moschata* Duchesne ex Poir., watermelon, *Citrus vulgaris* Las, (Thunb.) Matsum.& Nakai, cucumber, *Cucumis sativus* L., and muskmelon, *Cucumis melo* L. There is evidence, however, that squash bugs can rapidly adapt to resistant cucurbit species. Nymphal survival of *A. tristis* on the resistant squash species, Waltham Butternut, increased from about 20% in the first generation to about 45% by the fifth generation (Margolies et al. 1998).

In addition, studies have evaluated the ovipositional preferences of *A. tristis* for different cultivars and species of Cucurbitaceae. In a field test in Illinois, *A. tristis* showed an ovipositional preference for *C. maxima* and *C. mixta* over *C. pepo*, *C. moschata*, and *C. ficifolia* Bouché (Howe and Rhodes 1976). In Oklahoma, the ovipositional preference of *A. tristis* for different cultivars and species of Cucurbitaceae was evaluated in field tests. In a comparison of five cultivars of *C. pepo* and one cultivar of *C. moschata*, the number of egg masses per leaf was highest for straightneck and crookneck squash, *C. pepo*. Also, *A. tristis* showed an ovipositional preference for two cultivars of *C. pepo*, Yellow Straightneck and Jack O’ Lantern, over cucumber, watermelon, and muskmelon (Bonjour et al. 1990).

In contrast, there are no studies on the biology of the horned squash bug, *Anasa armigera* Say (Heteroptera: Coreidae). It was mentioned as a pest of squash in several early reports (Parshley 1918, Drake and Harris 1926, Britton 1937, Gould 1944). It is found throughout the eastern United States and as far north as Ontario and Quebec in Canada. It is found as far west as Oklahoma, Kansas, and Texas, and it has been newly recorded in Arkansas (Chordas and Kovarik 2008). An anecdotal report suggested that *A. armigera* preferred cucumber over squash (Parshley 1918). *A. armigera* is less common than...
A. tristis. In a 2-yr field study, A. armigera comprised only 4.3% of wild squash bug egg masses collected in squash fields at the Beltsville Agricultural Center in Maryland (Cornelius, unpublished).

This study examined the ovipositional preferences of A. tristis and A. armigera for different species of Cucurbitaceae in paired choice tests. This study also evaluated the ovipositional preferences of A. tristis for different cultivars of C. pepo and determined if the cultivar on which squash bugs were reared affected their ovipositional preferences for other cultivars.

Materials and Methods

Insect Rearing

A. tristis and A. armigera, were collected from squash, C. pepo, fields at the Beltsville Agricultural Research Center, Beltsville, MD, and maintained in laboratory colonies in cylindrical plastic containers (19.3-cm height by 20.0-cm diameter) (Pioneer Plastics, Inc., Eagan, MN) in an incubator (25°C; 16:8 [L:D] h). Each container had a hole (approximately 14-cm diameter) in the lid covered with a fine mesh screen, a filter paper on the bottom, and two cotton plugged glass shell vials filled with water attached with a rubber band to prevent them from rolling. Both species were maintained on fresh cuttings of cucurbit plants grown in a greenhouse and fruit of either yellow squash or zucchini purchased at a local organic market. A. tristis was reared exclusively on yellow squash (C. pepo cv. Slick Pik YS26). Because there was no published information on rearing A. armigera, this species was divided into two groups: one group was reared exclusively on yellow squash (C. pepo cv. Slick Pik YS26) and the other group was reared exclusively on cucumber (C. sativus cv. Diva).

Ovipositional Preference Tests

Ovipositional preference tests were conducted with squash bugs of both species that were reared exclusively on yellow squash (C. pepo cv. Slick Pik YS26). All A. tristis used in ovipositional tests were reared on the same cultivar in order to examine whether there was evidence of induced preference for the cultivar on which they were reared. In addition, ovipositional tests were conducted with A. armigera that was reared exclusively on cucumber. Paired choice tests were conducted using different cultivars of C. pepo and different species of Cucurbitaceae (Table 1). All plants used in tests were grown from seed (Johnny’s Selected Seeds, Winslow, ME) in a greenhouse. Ovipositional tests were conducted in 61 x 61 x 61-cm screened cages (Bioquip Products, Rancho Dominguez, CA) with lumite screening (Lumite, Inc. Alto, GA) in a temperature controlled room (25°C; 12:12 [L:D] h). For each replicate, two potted test plants of the same age were placed in opposite corners of a cage. Each test plant was either a different species or a different cultivar of Cucurbitaceae from the other test plant. For each replicate, five-mating pairs were collected from cages and released into the center of the screened cage. Mating pairs were used in order to ensure that all of the females in each replicate had mated. After 48 h, plants and mating pairs were removed from the screened cage. For each replicate, new test plants and new mating pairs were introduced into the screened cage. The position of the two test plants (different cultivars or species) in each corner was rotated between replicates. There were at least eight replicates for each test. After 48 h, the number of egg masses and the total number of eggs per mass were counted on each test plant. Egg masses deposited on the screened cage were

| Table 1. | Host plant cultivars and species in the family Cucurbitaceae used in paired choice oviposition tests with the common squash bug, A. tristis, and the horned squash bug, A. armigera |
| Species | Cultivar | Fruit |
|----------|---------|-------|
| C. pepo  | Slick Pik | Yellow straight neck squash |
| C. pepo  | Yellow Crookneck | Yellow crookneck squash |
| C. pepo  | Zephyr | Yellow summer squash |
| C. pepo  | Plato | Zucchini |
| C. pepo  | Tigress | Zucchini |
| C. pepo  | Dunja | Zucchini |
| C. pepo  | Magda | Zucchini |
| C. pepo  | Sunburst | Yellow patty pan |
| C. pepo  | Spaghetti Squash | Spaghetti squash |
| C. pepo  | Jack O’ Lantern | Pumpkin |
| C. moschata | Waltham Butternut | Butternut squash |
| C. maxima | Burgess Buttercup | Butternut squash |
| C. sativus | Diva | Cucumber |
| C. lanatus | Crimson Sweet | Watermelon |

Fig. 1. The ovipositional preferences of A. tristis, reared on the cultivar Slick Pik, for the cultivar Slick Pik compared with other cultivars of the same species, C. pepo. Test plants: 1) Plato, 2) Dunja, 3) Tigress, and 4) Yellow Crookneck. (A) Mean number (± SE) of egg masses per plant. (B) Mean number (± SE) of eggs per plant. For each paired choice test, bars followed by the same letter were not significantly different (Paired t-test: P > 0.05).
not counted. Paired t-tests were used to compare the number of egg masses and the total number of eggs deposited on each test plant.

**Results**

**Anasa tristis**

When different cultivars of *C. pepo* were compared, females were more likely to oviposit on Slick Pik, the cultivar they were reared on, than on Plato, Dunja, or Tigress, but not Yellow Crookneck (Fig. 1). However, there was no difference in ovipositional preference of females for Yellow Crookneck compared with any of the other cultivars tested (Fig. 2).

In paired choice tests, comparing oviposition behavior on *C. pepo* (cultivar: Yellow Crookneck) with other species of Cucurbitaceae, females did not show a preference for *C. pepo* over either butternut *C. moschata* or buttercup *C. maxima*. Females did show a preference for *C. pepo* over cucumber and watermelon (Fig. 3).

**Anasa armigera**

In the laboratory, *A. armigera* was reared successfully from first instar through adulthood on both squash (*C. pepo* cv. Slick Pik YS26) and cucumber (*C. sativus* cv. Diva). In paired choice tests, females reared on cucumber were equally likely to oviposit on either cucumber or *C. pepo* (Fig. 4). Females reared on *C. pepo* had no ovipositional preference for *C. pepo* over cucumber for either cultivar of *C. pepo* tested. Females reared on *C. pepo* were significantly more likely to oviposit on cucumber than on *C. moschata* but were significantly more likely to oviposit on *C. maxima* than on cucumber. There was no significant difference in the ovipositional preference of *A. armigera* for cucumber over watermelon (Fig. 5).

---

**Fig. 2.** The ovipositional preferences of *A. tristis*, reared on the cultivar Slick Pik, for the *C. pepo* cultivar, Yellow Crookneck, compared with other cultivars of the same species, *C. pepo*. 1) Plato, 2) Tigress, 3) Jack O Lantern, 4) Sunburst, 5) Zephyr, 6) Magda, and 7) Spaghetti Squash. (A) Mean number (± SE) of egg masses per plant. (B) Mean number (± SE) of eggs per plant. There were no significant differences.

**Fig. 3.** The ovipositional preferences of *A. tristis*, reared on the cultivar Slick Pik, for the *C. pepo* cultivar, Yellow Crookneck, compared with other cucurbit species. Test species: 1) butternut (*C. moschata*), 2) buttercup (*C. maxima*), 3) cucumber (*C. sativus*), and 4) watermelon (*C. lanatus*). (A) Mean number (± SE) of egg masses per plant. (B) Mean number (± SE) of eggs per plant. For each paired choice test, bars followed by the same letter were not significantly different (Paired t-test: *P* > 0.05).
Discussion

**Anasa tristis**

Females preferred to oviposit on the cultivar on which they were reared in paired choice tests with three of the four cultivars tested. However, females did not show any ovipositional preference for different cultivars when they had no previous exposure to either cultivar. These results suggest that squash bugs are capable of rapidly developing an ovipositional preference for the cultivar on which they were reared. This shift in ovipositional preference may enable them to adapt more quickly to less preferred cucurbit species. There is evidence that squash bugs can adapt to a resistant host species within five generations (Margolies et al. 1998).

There was no ovipositional preference for Yellow Crookneck, *C. pepo*, and either *C. maxima* or *C. moschata*. There have been conflicting results concerning the susceptibility of *C. maxima* to squash bugs. Although some studies found that *C. maxima* is susceptible to squash bugs (Novero et al. 1962, Howe and Rhodes 1976), survivorship was significantly lower on *C. maxima* than on *C. pepo* in another study (Vogt and Nechols 1993). In contrast, *C. moschata* has been consistently reported as a resistant species (Novero et al. 1962, Howe and Rhodes 1976, Bonjour et al. 1990, Vogt and Nechols 1993).

Females preferred to oviposit on Yellow Crookneck over either cucumber or watermelon. These results were consistent with another study demonstrating that females showed an ovipositional preference for cultivars of *C. pepo* over both cucumber and watermelon (Bonjour et al. 1990). Also, Cook and Neal (1999) found that squash bug nymphs could not complete development on cucumber. The squash bugs used in the current study were collected from *C. pepo* fields and reared on *C. pepo*. Adult females from this laboratory colony did not deposit any eggs on watermelon in paired choice tests. However, there is evidence that there may be regional differences in the preferences of *A. tristis* populations for different cucurbit crops. For instance, *A. tristis* is a serious pest of watermelon in Texas and Oklahoma (Edelson et al. 2002, 2003; Dogramaci et al. 2004, 2006). Adult squash bugs collected from watermelon would most likely exhibit different host plant preferences from those collected in squash fields. These findings indicate that there may be regional differences in the host plant preferences of squash bug populations for different species of Cucurbitaceae.

**Anasa armigera**

This study represents the first experimental evidence of the host plant preferences of *A. armigera*. Anecdotal evidence suggested that *A. armigera* preferred cucumber over squash (Parshley 1918). However, *A. armigera* was reared successfully in the laboratory on both squash and cucumber. Also, females did not display any ovipositional preferences for either squash or cucumber, regardless of which species they were reared on. When *A. armigera* was reared on *C. pepo*, females showed a significant ovipositional preference for *C. maxima* over cucumber and a significant ovipositional preference for cucumber over *C. moschata*. This study provides the first experimental evidence that both squash and cucumber can serve as suitable hosts for *A. armigera*.

Conclusion

There were differences in the ovipositional behavior of the two squash bug species. Both squash bug species oviposited readily on *C. pepo* and *C. maxima*. *A. armigera* was able to successfully complete development on both cucumber and yellow squash and...
was equally likely to oviposit on both host species. *Cook and Neal (1999)* found that second-instar *A. tristis* nymphs did not gain more weight when fed cucumber than when fed water alone. Therefore, *A. armigera* appears to be better adapted to cucumber than *A. tristis*. There were also differences between the two species in their ovipositional behavior toward watermelon. *A. tristis* did not deposit any egg masses on watermelon in a paired choice test, whereas *A. armigera* was equally likely to lay egg masses on watermelon compared with cucumber. Although *A. tristis* showed a significant ovipositional preference for the cultivar on which it was reared over three other cultivars, there was no evidence that *A. armigera* females showed an ovipositional preference for the cultivar on which they were reared in paired choice tests with cucumber and two cultivars of *C. pepo*.

**Acknowledgments**

I thank Ed Clark and Jing Hu for rearing the two squash bug species and for growing squash plants in the greenhouse. In addition, I thank Jing Hu for assistance in conducting laboratory tests. I would also like to thank Don Weber for helpful comments on a previous draft of this manuscript.

**References Cited**

Beard, R. L. 1940. The biology of *Anasa tristis* De Geer with particular reference to the tachnid parasite, *Trichopoda peninis* Fabke. Conn. Agr. Exp. Stn. Bull. 440: 597–679.

Boujor, E. L. and W. S. Fargo. 1989. Host effects on the survival and development of *Anasa tristis* (Heteroptera: Coreidae). Environ. Entomol. 18: 1083–1085.

Boujor, E. L., W. S. Fargo, and P. E. Bensner. 1990. Ovipositional preference of squash bugs (Heteroptera: Coreidae) among cucurbits in Oklahoma. J. Econ. Entomol. 83: 943–947.

Boujor, E. L., W. S. Fargo, A. A. Al-Obaidi, and M. E. Payton. 1993. Host effects on reproduction and adult longevity of squash bugs (Heteroptera: Coreidae). Environ. Entomol. 22: 1344–1348.

Britton, W. E. 1937. Connecticut State Entomologist, Thirty-sixth Report 1936. Bull. Conn. Agric. Exp. Stn. 289–415. Peiper Press, Wallingford, CT.

Bruton, B. D., F. Mitchell, J. Fletcher, S. D. Pair, A. Wayadande, U. Melcher, J. Brady, B. Bextine, and T. W. Popham. 2003. *Serratia marcescens*, a phloem-colonizing, squash bug transmitted bacterium: Causal agent of cucurbit yellow vine disease. Plant Dis. 87: 937–944.

Cartwright, B., J. C. Palumbo, and W. S. Fargo. 1990. Influence of crop mulches and row covers on the population dynamics of the squash bug (Heteroptera: Coreidae) on summer squash. J. Econ. Entomol. 83: 1988–1993.

Choridas S. III, and P. Kovarik. 2008. Two Coreidae (Hemiptera), *Cheilmanda vittiger* and *Anasa armigera*, new for Arkansas, U.S.A. J. Arkansas Acad. Sci. 62: 145–146.

Cook, C. A., and J. J. Neal. 1999. Feeding behavior of larvae of *Anasa tristis* (Heteroptera: Coreidae) on pumpkin and cucumber. Environ. Entomol. 28: 173–177.

Cornelius, M. L., M. L. Buffington, E. J. Talamas, and M. W. Gates. 2016. Impact of the egg parasitoid, *Gyron pennsylvanicum* (Hymenoptera: Scelionidae), on sentinel and wild egg masses of the squash bug (Hemiptera: Coreidae) in Maryland. Environ. Entomol. 45: 367–375.

Decker, K. B., and K. V. Yearyan. 2008. Seasonal phenology and natural enemies of the squash bug (Hemiptera: Coreidae) in Kentucky. Environ. Entomol. 37: 670–678.

Dogramaci, M. J., W. Shrefler, B. W. Roberts, S. Pair, and J. V. Edelson. 2004. Comparison of management strategies for squash bugs (Hemiptera: Coreidae) in watermelon. J. Econ. Entomol. 97: 1999–2005.

Dogramaci, M. J., W. Shrefler, K. Giles, and J. V. Edelson. 2006. Spatial pattern and sequential sampling of squash bug (Heteroptera: Coreidae) adults in watermelon. J. Econ. Entomol. 99: 559–567.

Doughty, H. B., M. Wilson, P. B. Schultz, and T. P. Kukar. 2016. Squash bug (Heteroptera: Coreidae): Biology and management in cucurbaceous crops. J. Integrated Pest Manag. 7: 1–8.

Drake, C. J., and H. M. Harris. 1926. Insect enemies of melons and cucumbers in Iowa. Bull. Iowa Agric. Exp. Stn. 90: 1–12.

Edelson, J. V., J. Duthie, and W. Roberts. 2002. Watermelon seedling growth and mortality as affected by *Anasa tristis* (Heteroptera: Coreidae). J. Econ. Entomol. 95: 595–597.

Edelson, J. V., J. Duthie, and W. Roberts. 2003. Watermelon growth, fruit yield and plant survival as affected by squash bug (Hemiptera: Coreidae) feeding. J. Econ. Entomol. 96: 64–70.

Gould, G. E. 1944. Insect pests of cucurbit crops in Indiana. Proc. Indiana Acad. Sci. 53: 165–171.

Howe, W. L., and A. M. Rhodes. 1976. Phytophagous insect associations with *Cucurbita* in Illinois. Environ. Entomol. 5: 747–751.

Lu, W., J. V. Edelson, J. A. Duthie, and B. W. Roberts. 2003. A comparison of yield between high- and low-intensity management for three watermelon cultivars. HortScience 38: 351–356.

Margolies, D. C., J. R. Nechols, and E. A. Vogt. 1998. Rapid adaptation of squash bug, *Anasa tristis*, populations to a resistant cucumber cultivar. Entomol. Exp. Appl. 89: 65–70.

Novero, E. S., R. H. Painter, and C. V. Hall. 1962. Interactions of the squash bug, *Anasa tristis*, and six varieties of squash (*Cucurbita* spp.). J. Econ. Entomol. 55: 912–919.

Olson, D. L., D. L. Nechols, and B. W. Schurle. 1996. Comparative evaluation of population effect and economic potential of biological suppression tactics versus chemical control for squash bugs (Heteroptera: Coreidae) management on pumpkins. J. Econ. Entomol. 89: 631–639.

Pair, S. D. 1997. Evaluation of systemically treated squash trap plants and attractive baits for early-season control of striped and spotted cucumber beetles (Coleoptera: Chrysomelidae) and squash bug (Hemiptera: Coreidae) in cucurbit crops. J. Econ. Entomol. 90: 1307–1314.

Pair, S. D., B. D. Bruton, F. Mitchell, J. Fletcher, A. Wayadande, and U. Melcher. 2004. Overwintering squash bugs harbor and transmit the causal agent of cucurbit yellow vine disease. J. Econ. Entomol. 97: 74–78.

Parshley, H. M. 1918. Three species of *Anasa* injurious in the north (Hemiptera: Coreidae). J. Econ. Entomol. 11: 471–472.

Schmidt, J. M., S. K. Barney, M. A. Williams, R. T. Bessin, T. W. Coolong, and J. D. Harwood. 2014. Predator-prey trophic relationships in response to organic management practices. Mol. Ecol. 23: 3777–3789.

Shelby, K. S. 2013. Functional Immunomics of the Squash Bug, *Anasa tristis* (De Geer) (Heteroptera: Coreidae). Insects. 4: 712–730.

Vogt, E. A., and J. R. Nechols. 1993. Responses of the squash bug (Hemiptera: Coreidae) and its egg parasitoid, *Gyron pennsylvanicum* (Hymenoptera: Scelionidae) to three *Cucurbita* cultivars. Environ. Entomol. 22: 238–245.

Wadley, F. M. 1920. The squash bug. J. Econ. Entomol. 13: 416–425.

Wayadande, A., B. Bruton, J. Fletcher, S. Pair, and F. Mitchell. 2005. Retention of cucurbit yellow vine disease bacterium *Serratia marcescens* through transstadial molt of vector *Anasa tristis* (Hemiptera: Coreidae). Ann. Entomol. Soc. Am. 98: 770–774.