# Strong Evidence for Intraspecific Competition in Bean Beetles, *Callosobruchus maculatus*

Lawrence S. Blumer[1], Walter-John H. McGowan[1], Benem-orom A. Davids[1], and Christopher W. Beck[2]
[1]Morehouse College and [2]Emory University, Atlanta

## Abstract

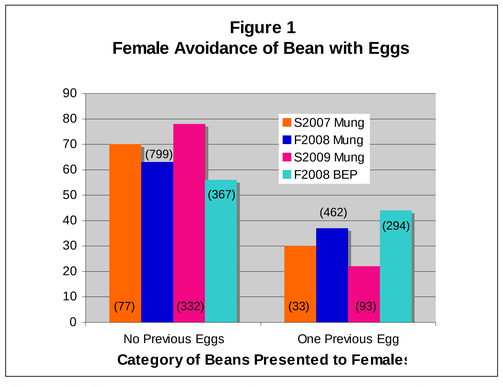
Beck and Blumer presented a Major Workshop at ABLE 2008 in which female bean beetles, *Callosobruchus maculatus*, preferentially laid eggs on beans that did not have the eggs of another female. This behavioral response suggested that females were trying to avoid putting their offspring in competition with the larvae of other females. However, data on survival to adult emergence of eggs laid alone (no competition) or in combination with other eggs from the same female (sibling competition) did not demonstrate competition. New data collected by undergraduate students at Morehouse College provide strong evidence for sibling competition in *C. maculatus* using both large and small host bean species.

## Introduction

Bean beetles (seed beetles), *Callosobruchus maculatus* (Coleoptera: Bruchidae), complete their entire larval and pupal development inside the seed on which their mother deposits each egg. Since adult beetles do not feed and larvae are unable to move from one bean to another, the resources in a given bean are critical for adult survival to emergence and future reproduction. These life history circumstances create the potential for severe competition between larvae inside a given bean and therefore strong selection on females (photograph below) to avoid putting their offspring in competition by avoiding beans with eggs already present.

We previously showed, in a simple guided-inquiry laboratory study (ABLE 2008), that females avoid laying eggs on beans that have an egg previously laid by another female when given a choice between beans with no eggs and beans with one egg already present (Figure 1). However, interpreting this behavior as a response to minimize competition between larvae requires direct evidence of competition such as a decrease in survival to adult emergence as a function of the number of eggs laid on individual beans.

In this study we asked: Is competition occurring between bean beetle larvae inside individual beans? We report on four independent undergraduate student experiments that provide strong evidence for intraspecific competition and contrast with the data presented by Beck and Blumer at ABLE 2008.




Female *Callosobruchus maculatus* on mung bean. Scale is 1mm grid. Eggs are spindle shaped and glued to bean surface.

Figure 1. Female avoidance of beans with eggs. Female bean beetles laid significantly more new eggs on mung beans with no previous eggs than on beans with one egg from a previous female (S2007, $\chi^2$=16.8, df=1, p<0.0001; F2008, $\chi^2$=89.5, df=1, p<0.0001; S2009, $\chi^2$=133.3, df=1, p<0.0001). Data were from 15 replicates in which a female choose among 5 one-egg and 5 no-egg beans in S2007, and 28 and 18 replicates in F2008 and S2009 in which a female choose among 10 one-egg and 10 no-egg beans. A significant preference for no-egg beans also was observed with black-eye peas (BEP) ($\chi^2$=7.8, df=1, p=0.0051) (21 replicates with 10 one-egg and 10 no-egg beans). The total number of new eggs laid is shown in parentheses.

## Methods

A total of 2652 individual mung beans (*Vigna radiata*) (upper right photograph, left dish) and 1451 black-eye peas (cowpeas, *Vigna unguiculata*) (upper right photograph, right dish) were isolated with known numbers of *C. maculatus* eggs laid on the seed surface. No fewer than 56 different females bean beetles laid these eggs. Beans with eggs were maintained at 30° C for a minimum of 5 weeks and the subsequent emergence of an adult beetle was determined. The emergence success per egg laid was calculated.

Beans with one egg are the no competition controls whereas beans with two or more eggs laid by the same female are the potential sibling competition treatments.

## Results

**Mung Beans** Although there was no significant difference in the per egg survival for one, two and three eggs per bean in an experiment performed in S2007 in which there was only 18% survival for singly laid eggs (no competition controls) ($\chi^2$=0.86 df=2 p=0.65) there were highly significant decrease in survival per egg for one, two, three, and four eggs per bean in F2008 ($\chi^2$=15.6 df=3 p=0.0014) and one versus two eggs per bean in S2009 ($\chi^2$=5.5 df=1 p=0.019) (Figure 2). The survival of single eggs was 27% and 43% in these later experiments.

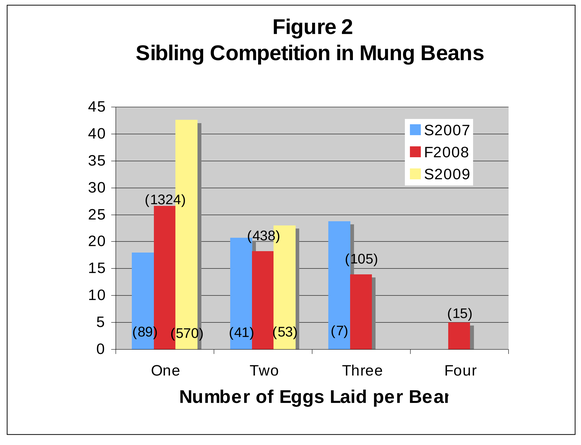



Figure 2. Sibling competition in mung beans. The survival to adult emergence per egg laid decreased as the number of eggs per bean increased in F2008 and S2009, but not in S2007. The number of beans in each category of eggs laid per bean is shown in parentheses.

**Black-eye Peas** There were highly significant decreases in survival per egg for one, two, three, and four eggs per bean in both F2008 ($\chi^2$=52.1 df=2 p<0.0001) and S2009 ($\chi^2$=54.1 df=2 p<0.0001) (Figure 3). The survival of single eggs (no competition controls) was 50% and 48% respectively in each experiment.

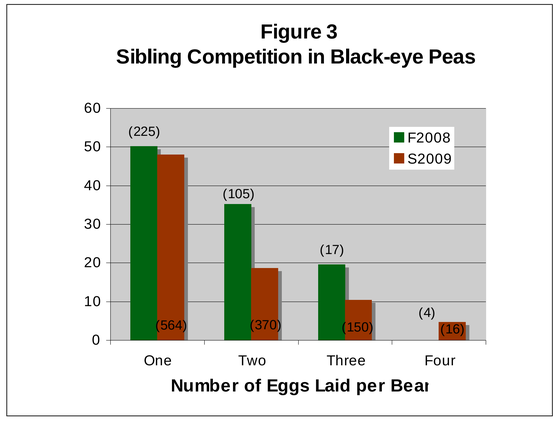



Figure 3. Sibling competition in black-eye peas. Survival to adult emergence per egg laid decreased as the number of eggs per bean increased in both F2008 and S2009. The number of beans in each category of eggs laid per bean is in parentheses.

## Discussion

The pattern of decreasing per egg survival from egg to adult as the number of eggs laid per bean increased is a predicted outcome of competition between larvae in individual beans. Competition in mung beans has been previously described (Mitchell 1975, Ecology 56:696-702). However, we found competition was not evident in mung beans when survival rates were poor (less than 20%) but was clearly observed when per egg survival rates exceeded 25%. Interestingly, in the much larger black-eye peas (each containing much more resource than each mung bean), the same pattern of decreasing per egg survival also was observed. Per egg survival rates were the greatest in black-eye peas (as great as 50%) yet competition remained very evident. This direct evidence for competition suggests that female avoidance of beans with eggs from a previous female (also documented by Mitchell 1975; Messina and Renwick 1984, Ecol. Entomol. 10:225-230) is a response to minimize the negative consequence of competition on the offspring of a female preparing to lay a new egg on a bean already occupied by beetle larvae. Female avoidance of large beans with previously laid eggs also suggests the absence of “wall-making” behavior by larvae (Mano and Toquenaga 2008, Ann. Entomol. Soc. Am. 101:449-455) that minimizes larvae cannibalism in some strains of *C. maculatus*.

## Acknowledgements

Support for the development and dissemination of this competition study was provided by NSF DUE-0535903 and continues with DUE-0815135 and DUE-0814373 to Morehouse College and Emory University.

Blumer received partial support from the NIH NBRS-RISE program at Morehouse College to attend ABLE 2009.

Visit www.beanbeetles.org for information on culturing bean beetles and complete tested guided-inquiry protocols for this and other studies for undergraduate laboratories.

We thank the students in BIO 320L, Ecology Laboratory, at Morehouse College, for designing and conducting the experiments that yielded these data. McGowan collected the data on survival in black-eye peas in S2009 as part of an independent research project.