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# Damage potential of bruchids in different edible legumes and interspecific competition between two species of *Callosobruchus* spp. (Bruchidae: Coleoptera)

T.SRINIVASAN, C.DURAIRAJ AND B.VINOTH KUMAR
*Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore - 3.*

**Abstract : Six edible legumes *viz.*, green gram, black gram, chickpea, pigeonpea, pea and cowpea were subjected to infestation by two species of bruchids *viz.*, *Callosobruchus maculatus* and *C. chinensis* to study the extent of damage under single-species and mixed population conditions. Green gram was found to be the most suitable host in terms of suitability index for *C. maculatus* and *C. chinensis* under single-species (0.0545 and 0.0627, repsectively) and mixed population conditions (0.0556 and 0.0510, respectively). On the contrary, red gram was the least preferred host for *C. maculatus* and *C. chinensis* both under single-species (0.0439 and 0.0445, respectively) and mixed population (0.0397 and 0.0389, respectively) conditions. The competition between these two species implied that though both the species coexist together during storage, *C. maculatus* was dominant over *C. chinensis*.**

***Key words: Callosobruchus spp.- damage potential- edible legumes - interspecific competition.***

## Introduction

The bruchids, *Callosobruchus maculatus* and *C. chinensis* are the most devastating and widespread storage pests that infest edible legumes including mung bean, black gram, chickpea, pigeonpea, pea and cowpea (Arora, 1977; Singhal, 1986) in the field as well as during storage. The initial infestation originates in the field where the adult beetles lay eggs on green pods and the larva bore through pod and feed on the developing seed (Southgate, 1979) and field level infestation accounts to only 1-2% damage. When the seeds are harvested and stored, the insects continue to feed, emerge to adults and cause further infestation which results in total destruction of seeds within 3-4 months.

During storage it is common that mixed populations of two different species occupying similar niche occur. Under such conditions, competition exists and one will drive out the other. This has been experimented with protozoan populations (Gause, 1934) and in granary insects (Crombie, 1945). In edible legumes, the species of *C. maculatus* and *C. chinensis* are found singly or under mixed conditions. Studies by Lale and Vidal (2001) dealt with competition between *C. maculatus* and *C. subinnotataus*. Similarly Giga and Smith (1991) studied the competition between *C. maculatus* and *C. rhodesianus* while Utida (1953) included *C. chinensis* and *C. quadrimaculatus* for his study. The present study provides understanding on the competition

**Table 1. Egg laying by *C. maculatus* and *C. chinensis* under single-species and mixed conditions**

| Host | Single-species conditions | | Mixed populations |
|---|---|---|---|
| | *C. maculatus* | *C. chinensis* | |
| Green gram | 132.00 b | 58.00 e | 118.33 |
| Cowpea | 185.33 a | 82.00 b | 134.00 |
| Black gram | 116.67 c | 65.00 d | 199.67 |
| Pea | 94.33 d | 71.67 c | 126.00 |
| Bengal gram | 119.67 c | 99.67 a | 106.00 |
| Red gram | 115.00 c | 61.00 de | 138.13 |
| Level of significance | ** | ** | NS |
| CD (0.05) | 4.72 | 2.76 | - |
| CV (%) | 6.43 | 6.58 | - |

All values are mean of six replications
In a column, means followed by the same letter are statistically non-significant (P = 0.05)
NS Non significant
** Significant at 1% level

**Table 2. Percentage survival by *C. maculatus* and *C. chinensis* under single-species and mixed conditions**

| Host | Single-species conditions | | Mixed populations | |
|---|---|---|---|---|
| | *C. maculatus* | *C. chinensis* | *C. maculatus* | *C. chinensis* |
| Green gram | 47.76 a | 90.21 a | 81.77 ab | 18.23 d |
| Cowpea | 43.52 b | 72.50 b | 77.57 b | 22.43 c |
| Black gram | 48.51 a | 89.26 a | 83.50 a | 16.50 d |
| Pea | 50.96 a | 60.99 c | 59.35 d | 40.65 a |
| Bengal gram | 47.34 ab | 62.65 c | 81.63 ab | 18.37 d |
| Red gram | 31.94 c | 52.36 d | 66.74 c | 33.26 b |
| Level of significance | ** | ** | ** | ** |
| CD (0.05) | 3.87 | 5.76 | 5.68 | 2.66 |
| CV (%) | 7.28 | 6.84 | 6.41 | 9.05 |

All values are mean of six replications
In a column, means followed by the same letter are statistically non-significant (P = 0.05)
** Significant at 1% level

**Table 3. Mean developmental period of *C. maculatus* and *C. chinensis* under single-species and mixed conditions**

| Host | Single-species conditions | | Mixed populations | |
|---|---|---|---|---|
| | *C. maculatus* | *C. chinensis* | *C. maculatus* | *C. chinensis* |
| Green gram | 30.82 a | 31.17 a | 31.17 a | 33.97 a |
| Cowpea | 33.12 ab | 31.87 a | 38.22 cd | 40.20 d |
| Black gram | 34.19 bc | 36.12 b | 35.53 bc | 36.49 abc |
| Pea | 36.02 cd | 36.10 b | 35.44 bc | 36.47 ab |
| Bengal gram | 37.23 d | 36.57 b | 33.87 ab | 39.46 cd |
| Red gram | 34.27 bc | 38.61 b | 38.61 d | 39.36 bcd |
| Level of significance | ** | ** | ** | ** |
| CD (0.05) | 2.80 | 2.85 | 2.85 | 2.98 |
| CV (%) | 6.92 | 6.89 | 6.82 | 6.72 |

All values are mean of six replications
In a column, means followed by the same letter are statistically non-significant (P = 0.05)
** Significant at 1% level

**Table 4. Suitability index of *C. maculatus* and *C. chinensis* under single-species and mixed conditions**

| Host | Single-species conditions | | Mixed populations | |
|---|---|---|---|---|
| | *C. maculatus* | *C. chinensis* | *C. maculatus* | *C. chinensis* |
| Green gram | 0.0545 | 0.0627 | 0.0556 | 0.0510 |
| Cowpea | 0.0495 | 0.0584 | 0.0425 | 0.0404 |
| Black gram | 0.0493 | 0.0540 | 0.0433 | 0.0422 |
| Pea | 0.0474 | 0.0495 | 0.0447 | 0.0434 |
| Bengal gram | 0.0450 | 0.0491 | 0.0542 | 0.0465 |
| Red gram | 0.0439 | 0.0445 | 0.0397 | 0.0389 |

between *C. maculatus* and *C. chinensis*, the two important species of Indian sub-continent, on six different edible legumes.

**Materials and Methods**

The bruchid species, *C. maculatus* utilized for this work was obtained from a culture maintained continuously at the Biocontrol Unit of Tamil Nadu Agricultural University, Coimbatore, following the procedure of Strong *et al.* (1968). Permanent culture of the beetles was established on green gram obtained from local Departmental Stores and once a month subculturing was done in order to maintain a continuous culture. The insects were maintained at a temperature of 30 ± 5°C and 70 ± 5% R.H. throughout the period of study. The seeds of the edible legumes *viz.*, green gram, cowpea, black gram, pea, bengal gram and red gram were obtained from the Department of Pulses, Tamil Nadu Agricultural University, Coimbatore, and were cleaned free of debris before using them for the experiments.

To understand the behaviour of mixed and competing populations, the trend of population growth in single-species as well as mixed populations (Utida, 1953) need to be studied. For single-species studies, all the edible legumes were subjected to infestation by *C. maculatus* under no-choice conditions (Gibson and Raina, 1972). One hundred seeds of each legume were confined separately in polythene bags of dimensions 9x6.5 cm and five pairs of freshly emerged adults of *C. maculatus* were released into each bag fastened to nylon threads on a wooden setup and left undisturbed. The same procedure was followed using five pairs of *C. chinensis* also.Six replications were maintained for each legume. The following observations were made after three days of releasing the adults.

i) r of eggs laid (visually counted under a microscope)

ii) Percentage survival using the formula by Howe (1971)

$$\text{Percentage survival} = \frac{\text{No. of adults emerged}}{\text{No. of eggs laid}} \times 100$$

iii) Mean developmental period or the time taken for 50 per cent adults to emerge using the formula by Howe (1971).

$$\text{Mean developmental period} = \frac{d_1a_1 + d_2a_2 + d_3a_3 + \ldots..+d_na_n}{\text{Total number of adults emerged}}$$

where,

$d_1$ =day at which the adults started emerging ($1^{st}$ day)

$a_1$ =number of adults emerged on $d_1^{th}$ day

iv) Suitability index using the formula by Howe (1971)

$$\text{Suitability index} = \frac{\text{Log (per cent survival)}}{\text{Mean developmental period}}$$

For mixed population studies three pairs each of *C. maculatus* and *C. chinensis* were released into polythene bags containing different edible leguminous seeds. Six replications were maintained. After the commencement of the adult emergence the *C. maculatus* and *C. chinensis* were individually observed and their developmental periods recorded separately. The suitability index of the two species was

also worked out separately based on the respective data.

**Results and Discussion**

Under single-species conditions, the most preferred ovipositional host for *C. maculatus* was cowpea (185.33 eggs/100 seeds) followed by green gram (132.00 eggs/100 seeds) (Table 1). Similarly, when *C. chinensis* was allowed for oviposition, bengal gram was the most preferred host (99.67/100 seeds) followed by cowpea (82.00/100 seeds). Higher ovipositional preference of black gram and green gram was observed by Ramzan *et al.* (1986) under single species conditions. In general *C. chinensis* were less fecund than *C. maculatus*. However under mixed conditions black gram contained the highest number of eggs (199.67/100 seeds) followed by red gram (138.13/ 100 seeds). The highly preferred hosts under single-species conditions, cowpea and bengal gram were less preferred when competition for resources existed. Under mixed conditions it seems that the adult females tend to waste most of the time in unsuccessful oviposition attempts while the less preferred host black gram was preferred by a group of opportunistic adult females. Utida (1953) observes competition for oviposition site between two species occupying similar ecological niche. But egg laying had no impact on the extent of survival as evident from the following paragraphs.

Under single-species conditions, per cent survival of *C. maculatus* was significantly highest in pea (50.96%) while green gram encouraged the highest survival (90.21%) for *C. chinensis* (Table 2). But, it should be noted that pea was the least preferred host for *C. maculatus* for oviposition and green gram the least preferred one for *C. chinensis*. This suggests an inverse relationship between egg laying and survival percentage. Regarding per cent survival under mixed conditions, black gram was the most preferred host for *C. maculatus* and pea the most preferred for *C. chinensis*. Black gram as a suitable host for survival of *C. maculatus* has already been proved by Ramzan *et al.* (1986).

Shorter mean developmental time implies that the insect can complete its life cycle in a shorter time and hence can complete more generations per year and hence more damage. Green gram registered the shortest mean developmental period both by *C. maculatus* and (30.82 days) and *C. chinensis* (31.17 days) (Table 3). Under mixed conditions too, *C. maculatus* completed its life cycle in a shortest span of 31.17 days and *C. chinensis* 33.97 days in green gram. In general, the developmental time tend to prolong for both species of *Callosobruchus* under mixed conditions. Utida (1953) attribute this to larval stage competition. Thanthianga and Mitchell (1990) also observed that larval competition at initial stages tend to prolong the developmental period.

The suitability index which is a measure of per cent survival and mean developmental period revealed that green gram was the most preferred host for *C. maculatus* (0.0545) and *C. chinensis* (0.0627) under single-species conditions (Table 4). Under mixed conditions too, green gram was the most preferred host for *C. maculatus* (0.0556) and *C. chinensis* (0.0510). Similarly red gram was the least preferred host both under single-species and mixed conditions.

These studies reveal that green gram was the most preferred host for *C. maculatus* and *C. chinensis*. Even when different legumes were kept under storage, green gram will

be the most preferred and hence most suffered host. This study underlines the importance of plant protection measures that need to be taken for green gram. Giga and Smith (1987) stated that growth and development of *C. maculatus* was faster in green gram in terms of oviposition, growth and development. Further, another find of noteworthy importance is the dominance of *C. maculatus* over *C. chinensis*. Under mixed populations, aspects of interference include competition for oviposition site, prevention of completion of copulation by individuals of the same or the other species, egg mortality due to mechanical interference of adult individuals and competition for food materials in the larval stage (Utida, 1953). Lotka (1934) studied mathematically the problem of competition between two species belonging to the same ecological niche and reached the following conclusions. i) each species inhibits its own potential increase more than that of the other and both continue to coexist, ii) the first species inhibits the potential increase of the second species and drives out the later from the given space, iii) the second one drives out the first, iv) the inhibition of each species by the other is greater than its own inhibition. Competition between *C. maculatus* and *C. chinensis* in the present study corresponds to second or third system of competition mentioned above.

The present studies reveal that *C. maculatus* and *C. chinensis* are major pests and may cause adequate damage if left unchecked. It appears that *C. maculatus* with its ability to lay more eggs and produce more adults than *C. chinensis*, and shorter developmental period (Lale and Vidal, 2001) is a dominant species in mixed populations. Utida (1952, 1953) also found that *C. maculatus* was more successful in cultures than *C. chinensis*. The results of this study should however be interpreted partly within the limits of the environmental conditions under which the experiments were conducted. These results are discussed on the general background of population theory.

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