DEVELOPMENT OF CALLOSOBROOTUS MACULATUS (F.) ON SOME PULSES IN BOTSWANA

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ABSTRACT: Some aspects of the biology of Callosobruchus maculatus (F.) were studied on seven pulses viz., Cowpea (5 varieties), Bambara groundnut, Mung bean, Pigeonpea, Lablab, Soya bean and Kidney bean, under ambient laboratory conditions (temperature range: 24 - 28°C and 61 - 77% R.H.). Oviposition by C. maculatus on the above pulses ranged from a mean of 41.10 ± 1.98 to 66.50 ± 4.85 eggs per female. The differences in the number of eggs laid per female were significant (F = 4.2, P < 0.001). With the exception of Lablab, the number of eggs hatched from oviposition by C. maculatus on the pulses was more than 90%. Emergence of C. maculatus from the pulses ranged from 18.83% on Lablab to 76.44% on Black eye cowpea. The differences in emergence numbers were found to be significant (F = 8.7, P < 0.001). The mean developmental period of C. maculatus on the pulses ranged from 30.17 ± 0.01 to 36.86 ± 0.18 days, while the longevity of the adults ranged from 10 - 14 days. Sex ratios of emerged C. maculatus were observed to be approximately 1:1 on all the pulses.

Key words: Callosobruchus maculatus, pulses, development, oviposition, longevity

INTRODUCTION

Pulses, such as cowpeas Vigna unguiculata (L.) Walp., beans Phaseolus vulgaris (L), soybeans Glycine max (L.) Merr, Bambara groundnut Vogandzea subterranea (L.) Thou, mung bean Vigna radiata, lablab Dolichos lablab and pigeonpea Cajanus cajan (L.) Millsp; serve as important sources of dietary protein for many people in the tropics, especially Africa including Botswana (ALLOTTEY, 2003; MISHILI et al., 2009; ALLOTTEY et al., 2010). Due to their high protein contents, pulses are of great dietary importance (FAO, 1989).

Pulses suffer heavy quantitative and qualitative losses from the attack of Callosobruchus species during storage. Beginning from the field and during storage, pulses are attacked by Callosobruchus maculatus (F.), which is a major storage pest of legumes in the tropics and subtropics (CGUNWOLU and IDOWU, 1994, OKONKWO and OKOYE, 1996, RAJA et al., 2000, AJAYI and LALE, 2001, GIGA, 2001; TAPONDJOU et al., 2002, PARK et al., 2003, ALLOTTEY and OYEWO, 2004). The larvae bore into the pulse grains which become unsuitable for human consumption. Severe infestation of cowpeas by C. maculatus can result in losses in storage, ranging from 50 to 90% annually throughout Africa (IITA, 1989). These losses can be reduced or prevented by using appropriate control measures (LALE and MUSTAPHA, 2000; SUBRAMANYAM and HAGSTRUM, 2000; ARTHUR and PHILLIPS, 2002; MAINA and LALE, 2004). However this can only be achieved by sound knowledge of the biology of this important pest species under prevailing environmental conditions.
In Botswana, there has been growing awareness of the damage caused by *C. maculatus* to many of the pulses that are utilised locally. It is envisaged that a thorough understanding of the biology of this important pest under prevailing conditions in Botswana, could lead to effective control of this destructive pest. The objective of the present study was to provide scientific information on the biology of *C. maculatus* on some pulses under ambient laboratory conditions in Botswana.

**MATERIALS AND METHODS**

Ten cultures of *C. maculatus* were established in Kilner jars (16 cm deep × 9 cm diam.). Each culture contained 400 g black-eyed cowpeas with 50 randomly selected adults of *C. maculatus*. The cowpeas were obtained from the main mall of Gaborone, while the insects were obtained from laboratory cultures of the Insectary of the Department of Biological Sciences, University of Botswana, Gaborone.

All equipment used in handling insects was dry-heat treated at 100°C for at least 3 h as a routine measure to prevent disease or cross infestation. The pulses were dry-heat treated for 2 hours in an oven at 80°C, except for soya bean that was treated at 60°C to prevent oil extraction from the seeds; before experimentation. The procedures for maintaining cultures were similar to those described by ALLOTEY and GOSWAMI (1992). All cultures and experimental jars were maintained at room temperature (range 24 - 28°C) and 61 - 77% R.H. with alternating 12-h light and 12-h dark cycle.

The experimental pulses utilized were 5 local varieties of cowpeas (*Vigna* spp.): Black eye, BOOS-C, Tswana, Local landrace B and B319; Bambara groundnut (*Voandzeia subterranea*); Soya bean (*Glycine max*); Pigeon pea (*Cajanus cajan*); Kidney bean (*Phaseolus vulgaris*); Lablab (*Dolichos lablab*) and Mung bean (*Vigna radiata*). The pulses were obtained from the Agriculture Research Centre, Sebele, and locally from the market.

Ten replicates were set up per pulse in glass jars (7.5 cm × 3.0 cm diam.), and newly emerged adults (less than 24 hrs old) of *C. maculatus* were introduced at a ratio of 1 male: 1 female per 30 seeds per jar. Each jar was covered with a muslin cloth secured in place by a rubber band to allow for aeration. After 14 days, dead adults were removed with forceps and the eggs laid on the seeds in each jar were counted. The number of hatched eggs was also recorded. Adult weevils emerging at the end of the developmental period were counted on a daily basis until there was no further emergence. The sex ratio of emerged adults was also determined.

To determine the longevity of the weevils for each pulse variety, 30 adults were randomly selected from those emerging each day and kept in jars (7.5 cm × 3.0 cm diam.). Five replicates were set per pulse. The jars were covered with muslin cloths held in place with rubber bands and mortality of adults was recorded on a daily basis, and the longevity determined when all the weevils were dead.
RESULTS AND DISCUSSION

The results from the experimental studies were analysed using the analysis of variance (1 way ANOVA). Oviposition and egg hatchability of *C. maculatus* on the six pulses, including five varieties of cowpeas have been given in Table 1. There was a significant difference (F = 4.2, P < 0.001, Table-4a) between the different pulses; the highest oviposition was recorded on the cowpea varieties, Local landrace B and B319 (x = 66.50) and lowest on cowpea variety Tswana (x = 41.10). Oviposition by *C. maculatus* on seeds has been reported to be affected by plumpness, wrinkling of seed coat and perhaps by the size and hardness as well as their odours (NWANZE and HORBER, 1976; ALLOTEY and DANKWAH, 1995). Many factors affect the number of eggs laid by females. For example, populations from different areas vary in their fecundity on the same number, species and cultivar host species (AJAYI and LALE, 2001). The pulse seeds used in the present study all had smooth coats but their sizes differed relatively. Size apparently had no effect on oviposition by *C. maculatus* and so the observed differences could have been due to surface odours of the seeds, which might attract or repel the weevils (NWANZE and HORBER, 1976; ALLOTEY and OYEWO, 2004). Egg hatchability of *C. maculatus* was more than 90% on all the pulses except on Lablab, where the hatchability was 89.2%. There was a significant difference (F = 4.4, P < 0.001, Table-4b) in the number of eggs hatched on the different legumes.

Table 1: Oviposition and hatchability of *C. maculatus* reared (10:1♂ / 30 seeds/replicate) on different pulses

<table>
<thead>
<tr>
<th>Pulse variety (n = 10)</th>
<th>Oviposition(x ± SE)</th>
<th>Hatchability(x ± SE)</th>
<th>Hatchability (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cowpea variety</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local landrace B</td>
<td>66.50 ± 4.65d (35–96)*</td>
<td>65.10 ± 4.81c (35–94)</td>
<td>97.9</td>
</tr>
<tr>
<td>B005-C</td>
<td>56.30 ± 7.05c (19–50)</td>
<td>55.80 ± 6.95b (19–89)</td>
<td>99.1</td>
</tr>
<tr>
<td>Black eye</td>
<td>44.10 ± 3.31a (28–60)</td>
<td>43.30 ± 3.41a (26–56)</td>
<td>98.2</td>
</tr>
<tr>
<td>B319</td>
<td>56.50 ± 4.18d (37–91)</td>
<td>64.50 ± 4.05c (37–85)</td>
<td>96.9</td>
</tr>
<tr>
<td>Tswana</td>
<td>41.10 ± 1.89a (31–50)</td>
<td>40.00 ± 1.94a (30–49)</td>
<td>97.3</td>
</tr>
<tr>
<td>Bambara groundnut</td>
<td>47.50 ± 3.42b (32–64)</td>
<td>47.40 ± 3.37a (32–63)</td>
<td>94.9</td>
</tr>
<tr>
<td>Mung bean</td>
<td>47.00 ± 4.19b (28–69)</td>
<td>45.30 ± 4.40a (28–63)</td>
<td>96.4</td>
</tr>
<tr>
<td>Lablab</td>
<td>50.00 ± 3.57 b (37–69)</td>
<td>44.60 ± 3.37a (31–60)</td>
<td>89.2</td>
</tr>
<tr>
<td>Pigeon pea</td>
<td>46.20 ± 3.16b (26–61)</td>
<td>44.20 ± 2.86a (25–56)</td>
<td>95.7</td>
</tr>
<tr>
<td>Soya bean</td>
<td>46.10 ± 2.85b (35–58)</td>
<td>45.60 ± 2.75a (35–56)</td>
<td>98.9</td>
</tr>
<tr>
<td>Kidney bean</td>
<td>46.60 ± 4.70 b (25–63)</td>
<td>45.60 ± 4.53a (24–62)</td>
<td>98.3</td>
</tr>
</tbody>
</table>

n = number of replicates, *Ranges are given in parentheses. Means within data column followed by the same superscripts are not significantly different (p>0.005, by the Student-Newman-Keuls method for multiple comparison).*

Emergence of *C. maculatus* from the legumes was highest on cowpea variety Black eye (76.44%) and lowest on Lablab (18.83%) (Table-2). Emergence of *C. maculatus* from the different pulses can be summarised in decreasing order as follows: Black eye (76.44%) > Mung bean (70.64%) > Tswana (67.75%) > B005-C (63.44%) > Bambara groundnut (61.42%) > Pigeonpea (55.56%) > B319 (48.68%) > Local landrace B (48.16%) > Lablab (18.83%) (Table-2). There was no emergence from Soya bean and Kidney bean. This failure
to emerge was also recorded by GOKHALE (1973). In general, there was a significant difference (F = 8.7, P < 0.001, Table-4c) in the emergence of adult weevils on the different pulses. Peak emergence of C. maculatus was reached on day two on most pulses. The peak of daily emergence of C. maculatus on each pulse is characteristic of the insects' ability to utilise the seeds (ALLOTEY and OYEWO, 2004), and early peak indicates that particular variety is more susceptible to bruchid attack than others. Many pulses contain certain inhibitors that affect the digestibility of proteins by the bruchids, and it is the concentration of these inhibitors that determine the susceptibility or resistance of the legume (DONGRE et al., 1996; IGNACIMUTHU et al., 2000; SRINIVASAN and DURAIRAJ, 2007).

The shortest developmental period of C. maculatus was recorded on Black eye as 30.17 ± 0.01 days (Table-2). Longer developmental periods of C. maculatus on Pigeon pea and Lablab indicate that either the seeds were not suitable for larval development or the insects could not utilise food material efficiently (MORENO et al., 2000). Hence, longer developmental periods can be associated with seed resistance while shorter developmental periods can be linked with susceptibility. On the basis of this observation, the order of susceptibility of the legumes to C. maculatus is as follows: Black eye (34.25) > Mung bean (32.53) > Tswana (33.44) > B319 (34.20) > Local landrace B (34.25) > B005-C (34.51) > Bambara groundnut (35.59) > Lablab (36.33) > Pigeon pea (36.86). GOKHALE (1973) recorded a developmental period of C. maculatus on Pigeon pea as 25.7 days at 30°C ± 1°C and 55 - 65% R.H. The differences observed in these developmental periods of C. maculatus could be attributed to differences in environmental conditions.

Adult C. maculatus does not feed but rely on food reserves to prolong its life span (HAINES, 1991). In the present study, the longevities of the adults reared on the different pulses were approximately the same, ranging from one to fourteen days. The sex ratios of emerged C. maculatus from paired adults (1:1.0) reared on the different legumes were approximately 1:1 in all the pulses, with the exception of the sex ratio from Tswana which was 1:1.2 (Table-3).

From the present study on the development of C. maculatus on the various pulses, it can be concluded that; there were significant differences (F = 4.2, P < 0.001) in the oviposition by C.maculatus on the various pulse varieties. Egg hatchability was more than 90% on all the pulses except lablab (89.2%). The mean developmental periods were: 34.25 days on local landrace B; 34.51 days on B005-C; 30.17 days on black eye; 34.20 days on B319; 33.44 days on Tswana; 35.59 days on bambara groundnut; 32.53 days on mung bean; 36.33 days on lablab and 36.86 days on pigeon pea. There were significant differences in the emergence of C. maculatus on the pulses (F = 8.7, P < 0.001). However, there was no emergence on soybean and kidney bean. Emergence ranged from 18.83% on lablab to 76.44% on black eye. Longevity of adult C.maculatus from all the legumes ranged from one to fourteen days. The sex ratios of emerged adults reared on the legumes were approximately 1:1 in all the legumes.
Table 2: Emergence and development of *C. maculatus* reared (1♂:1♀ / 30 seeds / replicate) on selected pulses.

<table>
<thead>
<tr>
<th>Pulse variety</th>
<th>n = 10</th>
<th>Adult emergence (x ± SE)</th>
<th>% Emergence (x ± SE)</th>
<th>Dev. Period (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cowpea variety</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local landrace B</td>
<td>32.00 ± 3.11c (17 – 52)</td>
<td>48.16</td>
<td>34.25 ± 0.11 (31 – 40)</td>
<td></td>
</tr>
<tr>
<td>B005-C</td>
<td>30.40 ± 3.81c (18 – 55)</td>
<td>63.44</td>
<td>34.51 ± 0.13 (30 – 41)</td>
<td></td>
</tr>
<tr>
<td>Black eye</td>
<td>33.10 ± 2.91c (17 – 49)</td>
<td>76.44</td>
<td>30.17 ± 0.01 (28 – 37)</td>
<td></td>
</tr>
<tr>
<td>B319</td>
<td>31.40 ± 2.87c (12 – 45)</td>
<td>48.58</td>
<td>34.20 ± 0.17 (29 – 42)</td>
<td></td>
</tr>
<tr>
<td>Tswana</td>
<td>27.10 ± 4.30b (14 – 34)</td>
<td>67.75</td>
<td>33.44 ± 0.14 (30 – 36)</td>
<td></td>
</tr>
<tr>
<td>Bambara groundnut</td>
<td>27.70 ± 2.55b (11 – 39)</td>
<td>61.42</td>
<td>35.69 ± 0.11 (34 – 41)</td>
<td></td>
</tr>
<tr>
<td>Mung bean</td>
<td>32.00 ± 2.68c (19 – 45)</td>
<td>70.64</td>
<td>32.53 ± 0.13 (30 – 39)</td>
<td></td>
</tr>
<tr>
<td>Lablab</td>
<td>8.40 ± 1.18a (5 – 13)</td>
<td>18.83</td>
<td>36.33 ± 0.32 (31 – 41)</td>
<td></td>
</tr>
<tr>
<td>Pigeon pea</td>
<td>24.6 ± 2.00 b (16 – 32)</td>
<td>55.66</td>
<td>36.86 ± 0.18 (33 – 44)</td>
<td></td>
</tr>
<tr>
<td>Soybean</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Kidney bean</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
</tbody>
</table>

n = number of replicates. *Ranges are given in parentheses. Means within data column followed by the same superscripts are not significantly different (p>0.05, by the Student-Newman-Keuls method for multiple comparison).*

Table 3: Sex ratios of emerged *C. maculatus* reared (1♂:1♀ / 30 seeds / replicate) on different pulses.

<table>
<thead>
<tr>
<th>Sex</th>
<th>Pigeon pea</th>
<th>Local landrace</th>
<th>Black Eye</th>
<th>B005-C</th>
<th>B319</th>
<th>Tswana</th>
<th>Bambara</th>
<th>Mung</th>
<th>Lablab</th>
</tr>
</thead>
<tbody>
<tr>
<td>(♂)</td>
<td>156</td>
<td>156</td>
<td>178</td>
<td>156</td>
<td>123</td>
<td>141</td>
<td>158</td>
<td>42</td>
<td>124</td>
</tr>
<tr>
<td>(♀)</td>
<td>150</td>
<td>173</td>
<td>176</td>
<td>156</td>
<td>148</td>
<td>136</td>
<td>162</td>
<td>42</td>
<td>122</td>
</tr>
<tr>
<td>Sex-Ratio</td>
<td>1:0.1:0</td>
<td>1:0:1:1</td>
<td>1:0:1:0</td>
<td>1:0:1:0</td>
<td>1:0:1:0</td>
<td>1:0:1:0</td>
<td>1:0:1:0</td>
<td>1:0:1:0</td>
<td>1:0:1:0</td>
</tr>
</tbody>
</table>

* = Total number of emerged adults, (♂) = male, (♀) = female

Table 4: Analysis of variance (ANOVA - 1 way) for the various experiments (p < 0.001)

Table 4a: ANOVA for Oviposition

<table>
<thead>
<tr>
<th>Sources of variation</th>
<th>df</th>
<th>ss</th>
<th>ms</th>
<th>F</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between treatment</td>
<td>10</td>
<td>7489.964</td>
<td>748.996</td>
<td>4.2</td>
<td>S</td>
</tr>
<tr>
<td>Error</td>
<td>90</td>
<td>15957.309</td>
<td>177.415</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>109</td>
<td>24356.264</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference, S = significant.

Table 4b: ANOVA for Hatchability

<table>
<thead>
<tr>
<th>Sources of variation</th>
<th>df</th>
<th>ss</th>
<th>ms</th>
<th>F</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between treatment</td>
<td>10</td>
<td>7522.618</td>
<td>752.262</td>
<td>4.4</td>
<td>S</td>
</tr>
<tr>
<td>Error</td>
<td>90</td>
<td>15291.000</td>
<td>169.100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>109</td>
<td>23756.918</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference, S = significant.
Table 4c. ANOVA for Emergence

<table>
<thead>
<tr>
<th>Sources of variation</th>
<th>df</th>
<th>ss</th>
<th>ms</th>
<th>F</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between treatment</td>
<td>8</td>
<td>5178.556</td>
<td>647.319</td>
<td>8.7</td>
<td>S</td>
</tr>
<tr>
<td>Error</td>
<td>89</td>
<td>10984.456</td>
<td>123.262</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference.

ACKNOWLEDGEMENT: We would like to thank Mr. Mosarwe of the Agriculture Research Centre, Sebele, for supplying most of the pulses used in this study.

REFERENCES


