Chalcodermus aeneus (Coleoptera: Curculionidae): historical pest status, potential for spread, and current management

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Abstract
The cowpea curculio, Chalcodermus aeneus Boheman (Coleoptera: Curculionidae), was first described from samples collected by Chevrolat in Mexico in 1837. Cowpea, Vigna unguiculata (L.) Walp. (Fabaceae), has nothing to do with the original hosts of this curculio species, because cowpea is from the Old World, specifically Africa, and C. aeneus has never been reported in the Old World. Cowpea curculio has been reported as a major pest of cowpea in the southeastern USA for well over a century. The distribution of C. aeneus in the US in 1910 was reported to be in the states of Texas, Louisiana, Alabama, Florida, Georgia, South Carolina, North Carolina, Oklahoma, Maryland, and Missouri. Outside of the US, C. aeneus is found in Mexico, Belize, Guatemala, Honduras, Nicaragua, and Peru. This curculio causes tremendous damage to cowpea, so much so that it can render cowpea production unsustainable in a curculio-infested region. Recent deficiencies in viable commercial insecticide controls have led to repeated collapses of acreage in Georgia. In experiments reported here, as much as 60% yield loss occurred with only moderate C. aeneus infestations. Heavy curculio pressure shut down cowpea production in our test, even with fairly effective foliar insecticides. Fortunately, C. aeneus is not easily transported in cowpea shipments around the world because it reproduces only in green pods, from which it leaves to pupate in the soil before the grain dries. This curculio can be quarantined effectively from large scale movement via shipping due to its reproductive biology, but spreads easily via a land to cowpea crop “bridge.” In the southeastern US, research efforts are underway to identify means to reduce the overwintering populations, with the goal of regional eradication sometime in the future.

Key Words: cowpea; southern pea; Vigna unguiculata; cowpea curculio; Chalcodermus aeneus

Resumen
El curculio (picudo) de caupí, Chalcodermus aeneus Boheman (Coleoptera: Curculionidae), se describió por primera vez a partir de muestras recolectadas por Chevrolat en México en 1837. El caupí, Vigna unguiculata (L.) Walp. (Fabaceae), no tiene nada que ver con los hospederos originales de esta especie de picudo, porque el caupí es del Viejo Mundo, específicamente África, y C. aeneus nunca se ha sido reportado en el Viejo Mundo. El curculio de caupí ha sido reportado como una plaga importante de caupí en el sureste de los Estados Unidos por más de un siglo. Se informó que la distribución de C. aeneus en los EE. UU. en 1910 se encontraba en los estados de Texas, Luisiana, Alabama, Florida, Georgia, Carolina del Sur, Carolina del Norte, Oklahoma, Maryland y Missouri. Fuera de los Estados Unidos, C. aeneus se encuentra en México, Belice, Guatemala, Honduras, Nicaragua y Perú. Este curculio causa un tremendo daño al caupí, tanto que puede hacer que la producción de caupí sea insostenible en una región infestada por el mismo. Las recientes deficiencias en su control por medio del uso de insecticidas comerciales viables han llevado a colapsos repetidos de ares de caupí en Georgia. En los experimentos informados aquí, se produjo una pérdida de rendimiento de hasta el 60% con solo infestaciones moderadas de C. aeneus. La fuerte presión del curculio detuvo la producción de caupí en nuestra prueba, incluso con el uso de insecticidas foliares bastante efectivos. Afortunadamente, C. aeneus no se transporta fácilmente en los envíos de caupí en todo el mundo porque se reproduce solo en las vainas verdes, de las cuales sale para pupar en el suelo antes de que se seque el grano. Este curculio puede ser puesto en cuarentena de manera efectiva de un movimiento a gran escala a través del envío debido a su biología reproductiva, pero se propaga fácilmente a través de un “puente” de tierra al campo de caupí. En el sureste de los EE. UU., se están realizando investigaciones para identificar los medios para reducir las poblaciones invernales, con el objetivo de la erradicación regional en algún momento en el futuro.

Palabras Clave: caupí; guisante del sur; Vigna unguiculata; curculio de caupí; Chalcodermus aeneus

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the 19th century, cowpea was the top legume forage crop for cattle in the southeastern US, and had begun to be common in more northern states by 1909 (TenEyck & Call 1909). In the 1920s, greater acreage of cowpea was grown in the US than soybean. Cowpea field production peaked in 1937 at 2.4 million ha (5,836,000 acres), nearly all in the Southeast (Anonymous 1957). At that time, cowpea was planted for grain and hay forage, as well as for human consumption. Around the time of World War II, soybean acreage grew exponentially, while cowpea acreage collapsed, likely because of the ease of soybean mechanization, reduced pest problems, and other factors (Fig. 1). By 2011, the US ranked very low in worldwide production of cowpea, representing a scant 0.1% of world value of this crop, with fewer than 32,400 ha in the US for dry seed production (Quinn & Myers 2002), and less than half of that for fresh or fresh frozen food consumption (C.T. Harvey, personal communication). In the most intensively cropped areas of the Southeast, losses due to the cowpea curculio, *C. aeneus* Boheman, have been so severe in recent decades (Chalfant 1997) that large portions of commercial acreage for fresh frozen consumption have moved out of the Southeast to avoid this single pest (Riley et al. 2015). Economically unacceptable losses are occurring even with the most efficacious labeled insecticides available. There is a near zero tolerance for curculio contaminated peas in the frozen pack process (Chalfant 1997). The inability to consistently control the curculio was one of the reasons for the decline in cowpea production in Georgia from 57,490 ha in 1951 to 1,620 ha in 1997.

Ainslie’s 1910 publication, The Cowpea Curculio, placed the distribution of *C. aeneus* in the US in 1910 in eastern Texas, Louisiana, Alabama, Florida, Georgia, South Carolina, North Carolina, and less frequently in Oklahoma, Maryland, and Missouri. Ainslie (1910) stated that “the distribution of this weevil probably coincides with that of the cowpea.” This was later confirmed by Arant (1938) who clearly showed distribution in the Southeast. This pest has not been reported to other cowpea production areas of the world.

In Georgia, southern pea production area has been on the rise in recent years (2,146 ha in 2007; 2,779 ha by 2008; and 3,299 ha in 2009). Increased area accompanied with increasing prices ($18–$20 per bushel) resulted in a state farm-gate value of $12 million in 2009 (Boatright & McKissick 2010). Along with this increase in acreage came more problems with *C. aeneus*. In 2010 and 2011, multiple reports of curculio outbreaks and control failures led to field tests. Field trials indicated that pyrethroid tolerance, or possibly resistance, was on the rise in Georgia (Tables 1 & 2) similar to that reported by N’Guessan & Chalfant (1990). Pyrethroids are the primary insecticides used to control *C. aeneus* throughout the southeastern US, because resistance has already eliminated efficacy of many older insecticides. Consequently, the planted hectares dropped again in 2011 to 2,279 ha, and to 2,010 ha in 2014 (Wolfe & Stubbs 2015).

In the absence of *C. aeneus*, southern pea returns to the farm in terms of land, capital, and management would be approximately $988 to $1,853 per ha (Coolong et al. 2012), with the additional benefit of soil improvement as a nitrogen-fixing green manure crop or a livestock feed crop after peas have been harvested. With pre-harvest costs at $865 per ha, it is an ideal low cost, low risk investment (Ferreira 2011) compared to other vegetable crops. However, in the presence of *C. aeneus*, fresh frozen pea production has been reported to be uneconomical (C.T. Harvey, personal communication). In this report, we documented the severe impact of *C. aeneus* on southern pea production in 2 selected recent field tests, discuss possible management options, and comment on the potential for spread of *C. aeneus* to other cowpea production areas of the world.

### Materials and Methods

In Trial 1, cowpea variety ‘Pinkeye Purple Hull,’ was direct seeded into 2-row plots in 1.8 m × 18.3 m beds on 28 May 2014, and maintained with standard cultural practices at the Lang-Rigdon Farm, Georgia Coastal Plain Experiment Station, Tifton, Georgia, USA. A total of 123 kg per ha of 10–10–10 soil fertilizer was applied to Tift pebbly clay loam field plots at planting. Irrigation was applied at about a half inch per wk with an overhead sprinkler system. In a randomized complete block design with 4 replications, applications of insecticide (Table 1) were made 30 Jun, and 7, 10, 15, and 18 Jul 2014. Cowpea was harvested from 3 m of 2 rows on 24 Jul, and assessed for yield quality. A subsample of 100 pods was separated and categorized as “stung” (curculio oviposition or feeding injury, see Fig. 2) or blemish free. Peas were shaded and percent peas with curculio oviposition wounds were counted. Data were analyzed by PROC GLM and LSD tests for separation of means (SAS Institute 2003).

After 2 yr of continuous cowpea plantings (2014–2015), allowing *C. aeneus* populations to overwinter unimpeded, southern pea variety ‘Pinkeye Purple Hull,’ was direct seeded in Trial 2 into 2-row plots in 1.8 m × 18.3 m beds on 20 Apr 2016. This was located in the block noted earlier. A total of 168 kg per ha of 5–10–15 was applied to Tift pebbly clay loam field plots at planting. Irrigation was applied at about a half inch per wk with an overhead sprinkler system. In a randomized complete block design with 4 replications, 4 applications of insecticide (see treatments in Table 2) were made on 9, 14, 16, and 20 Jun 2016, beginning at first bloom. Control plots received no insecticide treatment. Peas were harvested from 3 m of 2 rows on 24 Jul and assessed for yield quality. A subsample of 100 pods was separated and categorized as “stung” or blemish free. Peas were shaded and percent cowpea with curculio oviposition wounds were counted. Data were analyzed by GLM and LSD tests for separation of means (SAS Institute, Cary, North Carolina, USA).
Untreated check 488 ab
Besiege® 512 ml + MSO 0.25% v/v 438 abc
Besiege® 731 ml + MSO 0.25% v/v 525 a
Double Take™ 2EC 292 ml + MSO 525 a
Lannate® 2.4LV 3.5 L + Dibrom® 8EC 1.75 L + PBO-8 292 ml 475 ab
Brigade® 2EC 468 ml + PBO-8® 292 ml 475 ab
Karate® 2.80CS 140 ml + PBO-8® 292 ml 475 ab
Vydate® 2L 4.68 L + PBO-8® 292 ml 413 bc
Vydate® 2L 4.68 L 375 c

Table 1. Efficacy of insecticides on cowpea curculio as indicated by “stung” pods, percent “stung” southern peas, and clean peas produced per subsample and estimated overall per hectare in Trial 1 at the Lang-Rigdon Farm, Tifton, Georgia, USA in 2016.

<table>
<thead>
<tr>
<th>Insecticide treatment1 - formulated product rate per hectare</th>
<th>Wt. (g) of “stung” pods per 100</th>
<th>Percent damaged peas</th>
<th>Total clean wt. (g) peas per 3 m</th>
<th>Kg of clean peas per ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated check</td>
<td>488 ab</td>
<td>52% a</td>
<td>130 d</td>
<td>586 b</td>
</tr>
<tr>
<td>Besiege® 512 ml + MSO 0.25% v/v</td>
<td>438 abc</td>
<td>25% b</td>
<td>230 c</td>
<td>1296 a</td>
</tr>
<tr>
<td>Besiege® 731 ml + MSO 0.25% v/v</td>
<td>525 a</td>
<td>33% b</td>
<td>215 c</td>
<td>1134 a</td>
</tr>
<tr>
<td>Double Take™ 2EC 292 ml + MSO</td>
<td>525 a</td>
<td>23% bc</td>
<td>249 bc</td>
<td>1267 a</td>
</tr>
<tr>
<td>Lannate® 2.4LV 3.5 L + Dibrom® 8EC 1.75 L + PBO-8 292 ml</td>
<td>475 ab</td>
<td>22% bcd</td>
<td>231 c</td>
<td>1114 ab</td>
</tr>
<tr>
<td>Brigade® 2EC 468 ml + PBO-8® 292 ml</td>
<td>475 ab</td>
<td>20% bcd</td>
<td>252 bc</td>
<td>1466 a</td>
</tr>
<tr>
<td>Karate® 2.80CS 140 ml + PBO-8® 292 ml</td>
<td>475 ab</td>
<td>21% bcd</td>
<td>263 abc</td>
<td>1154 a</td>
</tr>
<tr>
<td>Vydate® 2L 4.68 L + PBO-8® 292 ml</td>
<td>413 bc</td>
<td>7% cd</td>
<td>324 a</td>
<td>1392 a</td>
</tr>
<tr>
<td>Vydate® 2L 4.68 L</td>
<td>375 c</td>
<td>5% d</td>
<td>309 ab</td>
<td>1432 a</td>
</tr>
</tbody>
</table>

1Active ingredients of the commercial products listed are: Besiege = Lambda-cyhalothrin (4.63%) + Chlorantraniliprole (9.26%); Double Take = diflubenzuron (22%) + lambda-cyhalothrin (11%); Lannate = methomyl (29%); Brigade = bifenthrin (25.1%); Karate = Lambda-cyhalothrin (13.1%); Vydate = oxamyl (42%); MSO = Southern Ag methylated seed oil surfactant; PBO-8 = piperonyl butoxide (91.3%).

Results

The results of Trial 1 clearly indicated the severity of C. aeneus damage in southern peas, reaching an average of 52% cowpea in the check (Table 1), all of which are not only unmarketable, but also represent a contaminant in the marketable cowpea. All insecticide treatments significantly reduced percent damaged cowpea compared with the untreated check, but Vydate® (oxamyl) was the best treatment. The addition of PBO-8® (piperonyl butoxide) to any insecticide did not significantly enhance control. Vydate® is not currently labeled on southern peas, and will likely not be available unless recent labeling and production issues are resolved. There was no detectable rate response with Besiege®, the lower rate performing as well as the high rate (Table 1). Stink bugs, the other potential pest in cowpea (Nilakhe et al. 1981) that were monitored in our test, never averaged more than 0.08 bugs per 10 plant sample, so all of the yield loss was attributable to cowpea curculio. Brigade® (bifenthrin) provided significant control and the highest amount of clean cowpea per ha (Table 1).

In Trial 2, cowpea curculio damage was so severe that it arrested blossom set (Fig. 2), so that even small subsamples could not be obtained for shelling. In what could be obtained, an average of 43% damaged cowpea was recorded in the untreated check (Table 2). Only Warrior® (lambda-cyhalothrin) and Vydate® insecticide treatments significantly increased clean cowpea in the subsamples of cowpea compared with the check. All of the yield loss was attributable to C. aeneus because stink bug populations were low. The only labeled product that provided significant control (lambda-cyhalothrin, Warrior®, Table 2) was insufficient to make the field worth harvesting for a commercial grower, and the percent “stung” or grub infested peas indicated a net increase in the C. aeneus population for subsequent plantings based on previous experience with C. aeneus population monitoring (Riley et al. 2015).

Discussion

It is very clear from the 2 tests presented that C. aeneus is the key pest of cowpea in the Southeastern US. Even with typical pest pressure, as in Test 1, 60% of the potential production of clean cowpea is lost without effective sprays. Even with this limited success, contamination of cowpea (5% in the best treatment in this test) can further degrade fresh frozen cowpea value. If populations are allowed to build to extremely high levels, as in Test 2, this curculio effectively shuts down commercially viable fresh frozen cowpea production. This occurs even with fairly efficacious foliar insecticides. Thus, this pest can be considered a limiting pest of crop production, i.e., where it occurs in high numbers there is no viable cowpea production. Also, the potential for

Table 2. Efficacy of insecticides on cowpea curculio as indicated by “stung” pods, percent “stung” southern peas, and clean peas produced per subsample and estimated overall per hectare in Trial 2 at the Lang-Rigdon Farm, Tifton, Georgia, USA in 2016.

<table>
<thead>
<tr>
<th>Insecticide treatment1 - rate per hectare</th>
<th>Wt (g) of “stung” pods per 100</th>
<th>Percent damaged peas</th>
<th>Total clean wt. (g) peas per 3 m</th>
<th>Kg of clean peas per ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated check</td>
<td>77 d</td>
<td>43% a</td>
<td>9.9 cd*</td>
<td>18 cd</td>
</tr>
<tr>
<td>Warrior II® 140 mL</td>
<td>579 a</td>
<td>36% a</td>
<td>107.8 a</td>
<td>193 a</td>
</tr>
<tr>
<td>Venerate™ XC 18.7 L</td>
<td>111 bcd</td>
<td>55% a</td>
<td>8.5 cd</td>
<td>15 cd</td>
</tr>
<tr>
<td>Grandeo® 3.37 kg</td>
<td>104 cd</td>
<td>42% a</td>
<td>3.4 d</td>
<td>6 d</td>
</tr>
<tr>
<td>Avaut® 0.42 kg</td>
<td>245 b</td>
<td>34% a</td>
<td>17.2 cd</td>
<td>31 cd</td>
</tr>
<tr>
<td>Apta® 1.97 L</td>
<td>625 a</td>
<td>35% a</td>
<td>82.7 b</td>
<td>148 b</td>
</tr>
<tr>
<td>Cyclaniliprole 50SL 1.6 L</td>
<td>230 bc</td>
<td>43% a</td>
<td>24.2 c</td>
<td>43 c</td>
</tr>
<tr>
<td>Exirel® 1.49 L</td>
<td>125 bcd</td>
<td>40% a</td>
<td>19.6 cd</td>
<td>35 cd</td>
</tr>
<tr>
<td>Mycotrol® ESO 2.34 L</td>
<td>111 bcd</td>
<td>52% a</td>
<td>8.3 cd</td>
<td>15 cd</td>
</tr>
<tr>
<td>Vydate® 2L 4.68 L</td>
<td>589 a</td>
<td>26% a</td>
<td>124.4 a</td>
<td>223 a</td>
</tr>
</tbody>
</table>

1Active ingredients of the commercial products listed are: Venerate = heat killed Burkholderia spp. strain A396 cells and spent fermentation media 94.46%; Warrior = Lambda-cyhalothrin (22.8%); Grandeo = Chromobacterium subsugae strain PRAA4 1T and spent fermentation media 30.0%; Avaut = indicarocarb (30%); Apta = tolfenpyrad (15%); cyclaniliprole = Iki-3106 50SL ISK Biosciences experimental product; Exirel = cytaniliprole (10.2%); Mycotrol = Beauvaria bassiana GHA (11.3%); Vydate = oxamyl (42%).

Means within columns followed by the same letter are not significantly different (LSD, P < 0.05).
biological control of cowpea curculio reported by Capinera (2001) is not sufficient for rescue treatments, as in Test 2 (Table 2). Even though biological control of adults on the foliage is not likely to be adequate, control of the curculio in the soil phase, especially for overwintering populations, has shown more promise (Riley, unpublished data) but is still very much in the development stage. We believe that cowpea curculio management needs to be at the population level, preferably involving eradication of the pest on a regional scale, as has been done with the boll weevil and other insect pests (El-Sayed et al. 2009).

Finally, the question that is perhaps most troubling is whether or not C. aeneus has the potential for movement to, and establishment in, other parts of the world. Given the estimated > 8 million metric tons of dry cowpea produced worldwide, mostly in Africa (Anonymous 2016), and the stated severity of this pest, this is not a New World weevil that anyone would ever want to be introduced into the African continent. Fortunately, the reproductive biology of C. aeneus is such that it requires both green cowpea pods for larval development, and a soil phase for pupation and adult emergence (Arant 1938). To put this in perspective, it is useful to compare 3 weevil species in terms of their potential for spread via worldwide shipments (Fig. 3). True stored grain species like the cowpea weevil, Callosobruchus maculatus (Fabricius) (Coleoptera: Chrysomelidae), are easily transported in dried cowpea around the world at any time of yr and continue to reproduce in storage. Pepper weevil, Anthonomus eugenii Cano (Coleoptera: Curculionidae), can be shipped only in green pepper pods that have escaped being graded out before shipment, and only when fresh pepper markets are receiving from a pepper weevil-infested region. Pepper weevil does not survive multiple d of freezing, and only reproduces on Capsicum and Solanum (both Solanaceae) species, so even if shipped, it may not become established at the destination. Chalcodermus aeneus, by comparison, is much less likely to be shipped overseas, because by the time the grain is shipped, it is either dry or frozen (neither condition supports C. aeneus reproduction or survival). Thus, fortunately, this severe weevil pest of cowpea is not likely to be accidentally introduced into the Old World.

Acknowledgments

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