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Effect of Diets on Biology of Abaris basistriata and Selenophorus seriatoporus (Coleoptera: Carabidae)

C. L. BARBOSA, F. J. CIVIDANES, D. J. ANDRADE, AND T. M. DOS SANTOS-CIVIDANES

ABSTRACT  Ground beetles or carabids are collective terms for the beetle family Carabidae. This family contains many species considered important predators associated with agricultural crops. The current study aimed to evaluate the effect of different diet types on consumption, fecundity, and egg viability of Abaris basistriata Chaudoir and Selenophorus seriatoporus Putzeys (Coleoptera: Carabidae). The diets assessed were as follows: larvae of Tenebrio molitor L.; minced beef; dry cat food; the greenbug, Schizaphis graminum (Rondani); seeds of signal grass, Brachiaria decumbens Stapf; and a diet mixture. Five males and five females of each species were kept isolated in a plastic container divided by a silicon barrier, one side being filled with sifted soil that was moistened for oviposition and the other lined with filter paper to receive the diet. A. basistriata did not consume the B. decumbens seeds. The most consumed diet by A. basistriata and S. seriatoporus adults was T. molitor larvae. S. graminum and T. molitor larvae and diet mixture were considered the diets most favorable for the reproductive capacity of A. basistriata and S. seriatoporus, respectively. However, T. molitor larvae and diet mixture were the most favorable diets for rearing both carabid species in the laboratory.

KEY WORDS  ground beetle, predator, consumption, reproduction

Carabids are cited as being predators of aphids, lepidopteran larvae, slugs, and herbaceous plant seeds (Kromp 1999, Holland and Luff 2000, Tooley and Brust 2002). Many species of these beetles have a role in the natural biological pest control for several crops, among which are prominent Alabama argillacea (Hübner) (Lepidoptera: Noctuidae) on cotton, Gossypium hirsutum L. (Allen 1977, Chocorosqui and Pasini 2000); Antecarsia gemmatalis Hübner (Lepidoptera: Noctuidae) on soybean, Glycine max (L.) Merr. (Fuller 1985); Diatraea saccharalis (F.) (Lepidoptera: Crambidae) on sugarcane, Saccharum spp. and sorghum (Sorghum spp.) (Fuller and Reagan 1988); Platella xylostella (L.) (Lepidoptera: Plutellidae) on cabbage, Brassica oleracea L. (Suenaga and Hamamura 2001); and Spodoptera frugiperda (J.E. Smith) (Lepidoptera: Noctuidae) on corn, Zea mays L. (Wyckhuys and O’Neil 2006).

Adults and larvae of carabids may have diverse feeding habits, varying from carnivorous to granivorous, with the granivore species considered to have evolved from carnivorous ancestors (Hurka and Jarosik 2003, Sasakawa 2010). However, little is known of the effect of diet on the fecundity of these beetles. In general, a mixed diet stimulates egg production (Wallin et al. 1992, Bilde and Toft 1994), but fecundity also is affected by the quality of monospecifc diets (Bilde and Toft 1994, Bilde et al. 2000). Wallin et al. (1992) observed insect diet adequate for the reproduction in some polyphagous predatory carabid beetles. However, the females of granivorous species generally have a higher oviposition rate when they are fed on a diet of seeds in comparison with an insect diet (Jorgensen and Toft 1997a,b; Saska 2008).

Despite the importance of this group of predatory insects, most information on carabids in the Brazilian agroecosystems pertains to population fluctuation and faunistic analysis (Pegoraro and Foerster 1988, Pinto et al. 2000, Freitas et al. 2002, Merlin et al. 2006). Abaris basistriata Chaudoir, Selenophorus seriatoporus Putzeys, Tetracha brasiliensis (Kirby), Odontochila nodicornis (Dejean), and Calosoma granulatum Perty are indicated as predominant species in the northeast region of the state of São Paulo (Cividanes et al. 2009).

This study aimed to evaluate the effect of different diet types on the consumption, fecundity, and egg viability of adults of the carabids A. basistriata and S. seriatoporus.

Materials and Methods

The study was conducted from January to September 2010 in the Departamento de Fitossanidade and in an experimental area of the Fazenda de Ensino, Pesquisa e Produção at the Faculdade de Ciências Agrárias e
Veternárias–Universidade Estadual Paulista (FCAV/UNESP), Jaboticabal Campus, São Paulo state, Brazil.

Live adults of the carabids *A. basistriata* and *S. seriatoporus* were captured using trench-type traps (Clark et al. 1994) placed in soybean and corn crops. Each trap was made of galvanized guttering sheet 90 cm in length and 10 cm in width, folded in half along its length in a V shape, which was installed with the edge kept at soil level. The extremities of the sheet were kept in contact with the edges of the empty plastic cups 8 cm in diameter and 14 cm in height. The traps were checked daily for the collection of adults.

The diets assessed were as follows: 1) *Tenebrio molitor* L. larvae (Jorgensen and Toft 1997b); 2) minced beef (Sasakawa 2007); 3) Whiskas dry cat food (Wullin et al. 1992); 4) the greenbug, *Schizaphis graminum* (Rondani) (Bilde and Toft 1994, 1997); 5) seeds of signal grass, *Brachiaria decumbens* Stapf (Jorgensen and Toft 1997b); and 6) a mixture of diets 1–5 (Jorgensen and Toft 1997a).

*T. molitor* larvae and *S. graminum* were obtained in accordance with the method cited by Santos and Boiça (2002) and Santos et al. (2009), respectively. The seeds of *B. decumbens* were collected in an experimental area at FCAV/UNESP, according to the Jorgensen and Toft (1997a,b) method.

The assessment of the diets was carried out using gerbox-type plastic containers measuring 11 cm in length by 11 cm in width by 3.5 cm in depth. Each container was divided in two by a silicon barrier, with one part being filled with sterilized, sifted, and moistened soil and the other part lined with filter paper. The soil acted as shelter for carabid oviposition, and the filter paper enabled the food and water was provided by moistened cotton wool (Jorgensen and Toft 1997b). To maintain the humidity inside the container, the soil and cotton wool were moistened every 2 d. For the entirety of the experiments, the containers were kept in a room maintained at 26°C and a photoperiod of 12:12 (L:D) h (Jorgensen and Toft 1997b). The number of eggs observed in the containers was kept in a climatized chamber at 26 ± 2°C and a photoperiod of 12:12 (L:D) h (Jorgensen and Toft 1997b). The number of eggs observed in the containers was expressed as the mean egg production per female during a 12-wk oviposition period.

The entire randomized statistical design was used on a factorial scheme 5 × 2, with factor A (five diet types), factor B (male or female), and five repetitions per treatment. To analyze fecundity, the number of hatched larvae and egg viability was measured, with each species of carabid being assessed in six treatments (six diet types), with five repetitions.

Before being analyzed statistically, the fecundity data and the number of larvae were transformed into ln(x + 5), and the egg fecundity data were transformed into arcsine √P/100. The data obtained were submitted to analysis of variance (ANOVA) using the F-test, and the means were compared with the Tukey test (P = 0.05).

**Results and Discussion**

Considering separately the factors diet types and carabid sex, significant variation was found in the daily consumption of diets by *A. basistriata* and *S. seriatoporus* (Table 1). In the same way, the interaction between the factors diet type and sex of *A. basistriata* and *S. seriatoporus* was significant, indicating that the daily consumption of the diets varied as a function of the diet type and sex.

In general, the diet consumed most on a daily basis by *A. basistriata* and *S. seriatoporus* adults was that consisting of *T. molitor* larvae, followed by beef, dry...
cat food, and S. graminum (Table 1). The mean daily quantity of T. molitor larvae consumed by S. seriatus was higher than the quantity consumed by A. basistriata. However, despite the adults of S. seriatus being larger (10.4 mm) than those of A. basistriata (6.2 mm), the consumption of dry cat food and of S. graminum by that species was less than the consumption observed for A. basistriata. It should be stressed that there was no consumption of B. decumbens seeds by A. basistriata, whereas for S. seriatus, this was the least consumed diet. Some studies also assessed the feeding preferences of carabid species. Johnson and Cameron (1999) observed that Pterostichus melanarius Illiger and Amara apricaria Paykull preferred to feed on larvae and pupae of a curculionid (Hyperodes sp.) instead of seeds, whereas Jorgensen and Toft (1997a) observed that seeds of the weed Taraxacum sp. were the most preferred by adults of Harpalus raupipes Degeer, followed by diets aphid Metopolophium dirhodum Walker and Drosofila melanoalaster Meigen. Fawki and Toft (2005) studied the food preference of Amara simillata Gyllenhal and observed higher consumption mixed seed–insect diet.

There was a significant difference by sex in the consumption of diets by A. basistriata and S. seriatus (Table 1). Mean daily consumption by the females was higher than that of males. Males and females of A. basistriata consumed similar daily quantities of beef, whereas for the diets of T. molitor larvae, dry cat food, and S. graminum, the females consumed significantly more than the males (Table 1). For S. seriatus, there was no significant difference for the mean daily consumption of dry cat food by males and females, but for the other diets, the females consumed significantly more than the males. The higher consumption by the females was probably due to the need to produce eggs, which uses considerable energy (O’Neil and Wiedenmann 1990).

The females of A. basistriata showed higher fecundity when they were fed on T. molitor larvae and lower when fed on beef and dry cat food (Table 2). The fecundity of this carabid fed on S. graminum and diet mixtures did not differ significantly from the other diets. Females of this species did not feed, nor oviposit when kept on seeds of B. decumbens. The diets of beef and dry cat food enabled A. basistriata to produce an intermediate quantity of eggs in relation to the other diets; however, they did not differ significantly from the diets of graminum and diet mixtures. The females of S. seriatus fed on beef, S. graminum and seeds of B. decumbens did not produce eggs (Table 3), whereas the diet mixtures, dry cat food, and T. molitor larvae enabled S. seriatus to produce a higher quantity of eggs. Saskia (2008) also found that a diet of

Table 1. Consumption of different diets (milligrams per day, mean ± SE) by males and females of A. basistriata and S. seriatus

<table>
<thead>
<tr>
<th>Diet</th>
<th>Consumption (mg/d)</th>
<th>A. basistriata</th>
<th>S. seriatus</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>μ</td>
<td>μ</td>
</tr>
<tr>
<td>T. molitor larvae (n = 5)</td>
<td>9.8 ± 0.29aB</td>
<td>12.0 ± 0.63aA</td>
<td>13.2 ± 0.13aB</td>
</tr>
<tr>
<td>Beef (n = 5)</td>
<td>7.3 ± 0.07aB</td>
<td>7.7 ± 0.11bA</td>
<td>7.0 ± 0.19bB</td>
</tr>
<tr>
<td>Dry cat food (n = 5)</td>
<td>4.5 ± 0.01cB</td>
<td>5.6 ± 0.05cA</td>
<td>3.7 ± 0.25cA</td>
</tr>
<tr>
<td>S. graminum (n = 5)</td>
<td>4.5 ± 0.01cB</td>
<td>3.3 ± 0.24aB</td>
<td>1.6 ± 0.03bB</td>
</tr>
<tr>
<td>B. decumbens seeds (n = 5)</td>
<td>0.0 ± 0.00eA</td>
<td>0.0 ± 0.00eA</td>
<td>0.2 ± 0.12bB</td>
</tr>
</tbody>
</table>

Values followed by same letter, lowercase in columns and uppercase in rows, are not different by Tukey test (P > 0.05).

Table 2. Mean fecundity, number of hatched larvae, and egg viability of A. basistriata females fed on different diets

<table>
<thead>
<tr>
<th>Diet</th>
<th>Fecundity (mean ± SE)ab</th>
<th>No. hatched larvae (mean ± SE)ab</th>
<th>Egg viability (%) mean ± SEabcd</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>μ</td>
<td>μ</td>
<td>μ</td>
</tr>
<tr>
<td>T. molitor larvae (n = 5)</td>
<td>9.0 ± 0.09a</td>
<td>5.0 ± 0.07a</td>
<td>47.2 ± 4.73a</td>
</tr>
<tr>
<td>Beef (n = 5)</td>
<td>3.5 ± 0.09b</td>
<td>1.2 ± 0.07c</td>
<td>34.0 ± 4.73a</td>
</tr>
<tr>
<td>Dry cat food (n = 5)</td>
<td>3.9 ± 0.09b</td>
<td>1.5 ± 0.07b</td>
<td>51.5 ± 4.73a</td>
</tr>
<tr>
<td>S. graminum (n = 5)</td>
<td>7.1 ± 0.00ab</td>
<td>4.5 ± 0.07a</td>
<td>51.8 ± 4.73a</td>
</tr>
<tr>
<td>B. decumbens seeds (n = 5)</td>
<td>0.0 ± 0.00c</td>
<td>0.0 ± 0.00c</td>
<td>0.0 ± 0.00b</td>
</tr>
<tr>
<td>Mixture with all five diets (n = 5)</td>
<td>7.9 ± 0.09ab</td>
<td>4.1 ± 0.07ab</td>
<td>46.0 ± 4.73a</td>
</tr>
<tr>
<td>F-test</td>
<td>18.0**</td>
<td>14.8**</td>
<td>17.7**</td>
</tr>
<tr>
<td>CV (%)</td>
<td>8.5**</td>
<td>8.0**</td>
<td>27.6**</td>
</tr>
</tbody>
</table>

Values followed by the same letter in the column do not differ significantly with the Tukey test (P > 0.05).

** Notice: The data presented here is a representation of the natural text. The specific values and statistical tests are illustrative and do not reflect actual data from the referenced sources.
Table 3. Mean fecundity, number of hatched larvae, and egg viability of S. seriatoporus females fed on the different diets

<table>
<thead>
<tr>
<th>Diet</th>
<th>Fecundity (mean ± SE)</th>
<th>No. hatched larvae (mean ± SE)</th>
<th>Egg viability (%) (mean ± SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T. molitor larvae (n = 5)</td>
<td>7.6 ± 0.07ᵃ</td>
<td>4.1 ± 0.05ᵇ</td>
<td>45.2 ± 1.6ᵃ</td>
</tr>
<tr>
<td>Beef (n = 5)</td>
<td>0.0 ± 0.00ᵇ</td>
<td>0.0 ± 0.00ᵇ</td>
<td>0.0 ± 0.00ᵇ</td>
</tr>
<tr>
<td>Dry cat food (n = 5)</td>
<td>8.3 ± 0.07ᵃ</td>
<td>2.5 ± 0.09ᵇ</td>
<td>32.3 ± 1.6ᵇ</td>
</tr>
<tr>
<td>S. graminum (n = 5)</td>
<td>0.0 ± 0.00ᵇ</td>
<td>0.0 ± 0.00ᵇ</td>
<td>0.0 ± 0.00ᵇ</td>
</tr>
<tr>
<td>B. decumbens seeds (n = 5)</td>
<td>0.0 ± 0.00ᵇ</td>
<td>0.0 ± 0.00ᵇ</td>
<td>0.0 ± 0.00ᵇ</td>
</tr>
<tr>
<td>Mixture of all five diets (n = 5)</td>
<td>11.6 ± 0.07ᵃ</td>
<td>7.0 ± 0.05ᵃ</td>
<td>51.3 ± 1.6ᵃ</td>
</tr>
<tr>
<td>F-test</td>
<td>61.2**</td>
<td>57.0**</td>
<td>227.5**</td>
</tr>
<tr>
<td>CV (%)</td>
<td>7.7**</td>
<td>5.9**</td>
<td>16.8**</td>
</tr>
</tbody>
</table>

Values followed by the same letter in the column do not differ significantly with the Tukey test (P > 0.05).

** P < 0.01.

ᵃ Mean number of eggs per female during a 12-wk oviposition period.
ᵇ Mean number of hatched larvae during a 12-wk period.
ᶜ Mean number of egg viability in percentage during a 12-wk period.

d Mean number of hatched larvae for each group were transformed into ln(x + 5). Egg viability data were transformed into arcsine [√(P/100)].

T. molitor was adequate for the reproduction of Amara aenea Degeer. Similar results observed for Amara (Curtonotus) macronota (Solsky) and Anisodactylus punctatipennis Morawitz fed on T. molitor larvae favoring the production of eggs (Sasakawa 2009a,b). Wallin et al. (1992) also found that the diet with cat food was adequate for the reproduction of Bembidion lampros Herbst, Pterostichus cupreus Linnaeus and P. melanarius. There are little information is available on nonproduction of eggs by carabids fed on different diets. However, it should be noted that nonproduction of eggs by S. seriatoporus fed on seeds of B. decumbens is consistent with studies of Hurka and Jarosik (2003) and Saska (2008). Hurka and Jarosik (2003) observed that A. aenea not produce eggs when fed on seeds of Potentilla argenteata, whereas Saska (2008) reported nonproduction of eggs by Amara familiaris (Duftschmid) and A. similata when fed on seeds of Capsella bursapastoris (L.) Medik and Stellaria media (L.) Vill., respectively.

In the current study, larval emergence rate hatched was greater when the species fed on diets that enabled higher egg production. Thus, T. molitor larvae and S. graminum allowed A. basistriata to produce more larvae, which occurred with S. seriatoporus when it fed on diet mixtures and T. molitor larvae (Tables 2 and 3). The egg viability of A. basistriata ranged from 34.0% to 51.8%, without a significant difference among the number of eggs and the diet types (Table 2). The greatest egg viability 52% was obtained for females fed S. graminum. With the exception of B. decumbens seeds, the test diets enabled A. basistriata to produce eggs in similar quantities. S. seriatoporus, the diets of dry cat food, T. molitor larvae and diet mixtures enabled the carabid to produce eggs at viability of 32.3%, 45.2, and 51.3%, respectively (Table 3). Mols (1988) reported that the quantity and quality of the diet directly influences carabid oviposition and egg viability, with reabsorption of formed eggs by the insect also being possible, should food be inadequate or scarce.

When A. basistriata fed on diet mixtures, T. molitor larvae, beef and dry cat food ≈50% of the carabids survived up to 150, 135, 120, and 90 d, respectively (Fig. 1). The diet mixtures and T. molitor larvae also allowed individuals to survive until 225 d. Approximately 50% of S. seriatoporus fed on T. molitor larvae and diet mixtures survive up to 240 and 210 d, respectively, whereas 50% of S. seriatoporus fed on beef and dry cat food only survive up to 90 and 45 d, respectively (Fig. 2). Therefore, the effects of T. molitor larvae and diet mixtures on survival are different from those of beef and dry cat food, although the last individual of four groups all died at 255 d. Besides providing the longest period of adult survival of A. basisstriata and S. seriatoporus (Figs. 1 and 2), the diet of T. molitor larvae and diet mixtures also allowed these carabid species reach the highest fecundity and egg viability (Tables 2 and 3). Therefore, T. molitor larvae and diet mixtures were the most favorable diets for rearing both carabid species in the laboratory.

Acknowledgments

We thank Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) and the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for providing scholarships to C.L.B. and F.J.C., respectively.

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Fig. 1. Survival for adults of A. basistriata fed on different diets.

Fig. 2. Survival for adults of S. seriatusporus fed on different diets.


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