Prey consumption and development of *Chrysoperla externa* (Neuroptera: Chrysopidae) on *Spodoptera frugiperda* (Lepidoptera: Noctuidae) eggs and larvae and *Anagasta kuehniella* (Lepidoptera: Pyralidae) eggs

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Abstract

The Chrysopidae family comprises natural enemies of agricultural and forest pests. This work evaluated the prey consumption and development of one species, *Chrysoperla externa* (Neuroptera: Chrysopidae), fed with *Spodoptera frugiperda* (Lepidoptera: Noctuidae) or *Anagasta kuehniella* (Lepidoptera: Pyralidae) in laboratory conditions. *Chrysoperla externa* was reared with: newly laid or one-day-old *S. frugiperda* eggs; newly hatched, one- or two-day-old *S. frugiperda* larvae; or one-day-old *A. kuehniella* eggs. The number of prey offered varied with the development stage of *C. externa*. Larvae of *C. externa* and prey were transferred every 24 hours to fresh vials. Duration of the larval stage of *C. externa* was similar when fed with newly laid or one-day-old *S. frugiperda* eggs, newly hatched *S. frugiperda* larvae or *A. kuehniella* eggs. Larval survival of *C. externa* was 90.0 ± 2.5% when fed with *A. kuehniella* eggs and 73.3 ± 18.32% with newly hatched *S. frugiperda* larvae. *Chrysoperla externa* consumed high numbers of eggs of *A. kuehniella* and high weights of one-day-old eggs or newly hatched larvae of *S. frugiperda* or eggs of *A. kuehniella*. *Chrysoperla externa* could not be successfully reared in the laboratory on one- or two-day-old *S. frugiperda* larvae, but could on eggs of both preys and newly hatched *S. frugiperda* larvae.

Keywords: biological control, fall armyworm, flour moth, green lacewing, rearing

Introduction

Fall armyworm, *Spodoptera frugiperda* (Smith, 1797) (Lepidoptera: Noctuidae), is a major pest of corn and sorghum crops, and their larvae can feed on plants at all growth stages (Castillejos et al, 2001; Hoballah et al, 2004; Matos Neto et al, 2004). Other than synthetic pesticides, alternative methods to reduce populations of *S. frugiperda* include spraying botanical extracts on young plants (Tavares et al, 2009, 2010a, 2010b) and release of natural enemies including predatory insects, for example of the Chrysopidae, Carabidae, Coccinellidae, Pentatomidae, Anthocoridae, Reduviidae and Pentatomidae families (Figueiredo et al, 2006; Zanuncio et al, 2008; Silva et al, 2009).

Chrysoperla externa (Hagen, 1861) (Neuroptera: Chrysopidae) and other lacewings can control arthropod pests (Barbosa et al, 2008), such as *Alabama argillacea* (Hübner, 1818) (Lepidoptera: Noctuidae), *Aphis gossypii* (Glover, 1877), *Schizaphis graminum* (Rondani, 1852), *Rhodobium porosum* (Sanderson, 1901) (Hemiptera: Aphididae), *Coccus* spp. (Hemiptera: Coccidae), *Orthezia* spp. (Hemiptera: Ortheziidae), *Pinnaspis* spp. (Hemiptera: Diaspididae), *Selenaspidus* spp. and *Leptopharsa heveae* (Drake and Poor, 1935) (Heteroptera: Tingidae) in various field crops (Gao et al, 2007; Pappas et al, 2007; Barbosa et al, 2008; Souza et al, 2008). *Chrysoperla externa* is a natural enemy that feeds on eggs and young larvae, and so can be utilized in biological control programs (Hoballah et al, 2004; Hagerty et al, 2005). Benefits of using *C. externa* as a mass-released biological control agent are that its larvae are tolerant to handling and adults produce large numbers of offspring (Auad et al, 2003). *Chrysoperla externa* has been maintained in the laboratory on an artificial diet; however, *S. frugiperda* may be an alternative food source.

Prey consumption of lacewings has been studied in the laboratory (Nakahira et al, 2005; Pappas et al, 2008a, 2008b; Souza et al, 2008), greenhouse (Cole et al, 2006; Barbosa et al, 2008) and field (Hagerty et al, 2005; Kovanci et al, 2007). The predator has been trialled with different prey types (Silva et al, 2004; Kunkel and Cottrell, 2007) and diets (Sattar et al, 2007; Sattar and Abro, 2009), including algae (Zaki and Gesraha, 2001), honeydew (Hogervorst et al, 2008) and pollen grains (Berkvens et al, 2008). *Anagasta kuehniella* (Zeller, 1879) (Lepidoptera: Py-

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ralidae) is a potential food source for lacewings but its rearing demands intensive labor and space (Pappas et al, 2007, 2008a, 2008b). Another potential food source for *C. externa*, *S. frugiperda*, was offered ad libitum to larvae (Auad et al, 2003). The development of *C. externa* reared on different prey types has been studied (Silva et al, 2004; Gao et al, 2007; Souza et al, 2008), but data on the effect of different ages of *S. frugiperda* on the development of *C. externa* are scarce.

The objective of this study was to evaluate the consumption rates and development of *C. externa* reared on different age *S. frugiperda* eggs and larvae or *A. kuehniella* eggs.

Materials and Methods

Experiments were carried out at EMBRAPA Maize and Sorghum in Sete Lagoas, Minas Gerais State, Brazil in the laboratory (25 ± 1°C, 70 ± 10% R.H. and 12:12 L:D).

Anagasta kuehniella, *C. externa,* and *S. frugiperda* were obtained from laboratory-reared colonies at EMBRAPA Maize and Sorghum. *Anagasta kuehniella* larvae were reared in plastic trays (30 x 20 x 10 cm) covered with organza and fed with a diet of 600 g of corn meal, 600 g of wheat bran and 3% yeast (Wade et al, 2008; Tavares et al, 2009). *Chrysoperla externa* adults were kept in PVC tubes (700 mm wide x 30 cm height) and their larvae were fed an artificial diet of 45 g of honey, 45 g of yeast, and 10 ml of water (Lawo and Romeis, 2008). *S. frugiperda* adults were kept in cages, and their larvae were kept in 50 ml disposable plastic cups sealed with a transparent acrylic cover. Adults were fed with a solution of 25 g of sugar, 0.5 g of ascorbic acid, and 500 ml of water and their larvae were fed with 8 g of artificial diet consisting of 2 kg of beans, 950.4 g of wheat germ, 608.8 g of yeast, 61.2 g of ascorbic acid, 37.8 g of methyl parahydroxybenzoate (nipagim), 240 g of agar, 49.8 ml of formaldehyde, 16 l of water, and 49.8 ml of inhibitor solution (418 g of propionic acid, 42 g of phosphoric acid, and 540 ml of water).

Newly hatched F2 generation *C. externa* larvae were removed from the colony and isolated in glass tubes with flat bottoms (2 cm wide x 10 cm height). These larvae were reared on one of six diets: (T1) newly laid or (T2) one-day-old *S. frugiperda* eggs; (T3) newly-hatched, (T4) one- or (T5) two-day-old S. *frugiperda* larvae; or (T6) one-day-old *A. kuehniella* eggs. The hypothesis was that older eggs and larvae of *S. frugiperda* may have lower nutritional value and/or raised physical barriers against predation by *C. externa* larvae (Auad et al, 2003). The number of prey offered depended on the life stage of *C. externa*: 40 units (number of eggs/larvae) daily for first instars; 80 units daily for second instars; and 120 units daily for third instars. The presence of scales in the eggs of *S. frugiperda* was not observed (i.e. mixed eggs with or without scales) (Beserra and Parra, 2004). *Chrysoperla externa* larvae and their prey were transferred with a slip-away brush every 24 h to new glass tubes.

We recorded observations every 24 h to determine: survival of *C. externa* larvae; duration of each *C. externa* life stage; and prey consumption (number and weight of eggs or larvae consumed). The design was entirely randomized, with four replications, each with five *C. externa* larvae per treatment.

Data were subjected to analysis of variance (ANOVA) and to Tukey's post-hoc tests ($P < 0.05$) with the computer program MSTAT-C, version 2.1 (Supplier: EMBRAPA Maize and Sorghum) (Russel, 1989).

Results

Chrysoperla externa had three instars. The duration of each life stage was similar when larvae were fed with newly laid or one-day-old *S. frugiperda* eggs, newly-hatched *S. frugiperda* larvae or *A. kuehniella* eggs (Table 1). Survival of first instar *C. externa* was higher with newly hatched *S. frugiperda* larvae or *A. kuehniella* eggs. However, the survival of *C. externa* varied between instars, with higher rates for second instars fed one-day-old *S. frugiperda* eggs or *A. kuehniella* eggs, and for third instar larvae reared on eggs of both prey (Table 2).

Table 1 - Duration (mean ± standard error of mean) of the developmental stages (DS) (first instar – FI, second instar – SI, third instar – TI, larval – L, pupal – P, and from larval to adult – LA) of *Chrysoperla externa* (Neuroptera: Chrysopidae) fed with newly laid (T1) or one-day-old *Spodoptera frugiperda* (Lepidoptera: Noctuidae) eggs (T2); newly hatched (T3), one- (T4) or two-day-old (T5) *S. frugiperda* larvae; or one-day-old *Anagasta kuehniella* (Lepidoptera: Pyralidae) eggs (T6).

DS	T1	T2	T3	T4	T5	T6
	Duration (days)					
FI	3.0 ± 0.20[a]	2.9 ± 0.09[a]	2.90[a]	3.40[a]	2.60[a]	3.20[a]
SI	3.1 ± 0.21[a]	3.0 ± 0.10[a]	3.10[a]	-	-	2.80[a]
TI	3.8 ± 0.28[a]	3.4 ± 0.14[a]	3.7 ± 0.07[a]	-	-	3.30[a]
L	9.9 ± 0.85[a]	9.3 ± 0.70[a]	9.7 ± 0.67[a]	-	-	9.30[a]
P	10.2 ± 0.92[a]	10.0 ± 0.80[a]	8.3 ± 0.53[b]	-	-	10.6 ± 0.46[a]
LA	19.7 ± 1.87[a]	19.0 ± 1.70[a]	18.7 ± 1.57[a]	-	-	19.9 ± 1.39[a]
CV	8.45%					

means followed by the same letter per line do not differ by the test of Tukey ($P < 0.05$); CV= Coefficient of variation

Table 2 - Survival (mean ± standard error of mean) of the developmental stages (DS) (first instar – FI, second instar – SI, third instar – TI, larval – L, pupal – P, and from larval to adult – LA) of *Chrysoperla externa* (Neuroptera: Chrysopidae) fed with newly laid (T1) or one-day-old *Spodoptera frugiperda* (Lepidoptera: Noctuidae) eggs (T2); newly hatched (T3), one- (T4) or two-day-old (T5) *S. frugiperda* larvae; or one-day-old *Anagasta kuehniella* (Lepidoptera: Pyralidae) eggs (T6).

DS	T1	T2	T3	T4	T5	T6
	Survival (%)					
FI	55.0 ± 2.50b	55.0 ± 2.50b	95.0 ± 2.96a	0.00c	0.00c	95.0 ± 2.50a
SI	79.2 ± 4.40b	85.4 ± 4.74a	71.3 ± 2.97b	0.00c	0.00c	100.0a
TI	100.00a	100.0a	21.7 ± 5.42b	0.00c	0.00c	93.8 ± 2.46a
L	45.0 ± 2.50c	45.0 ± 2.50c	73.3 ± 18.32b	0.00d	0.00d	90.0 ± 2.50a
P	45.0 ± 2.50b	45.0 ± 2.50b	20.0 ± 5.00c	0.00d	0.00d	90.0 ± 2.50a
LA	45.0 ± 2.50b	50.0 ± 2.77b	20.0 ± 5.00c	0.00d	0.00d	90.0 ± 2.50a
CV	6.47%					

means followed by the same letter per line do not differ by the test of Tukey (P < 0.05); CV= Coefficient of variation

Chrysoperla externa did not reach the pupal stage on a diet of one- or two-day-old *S. frugiperda* larvae. *Chrysoperla externa* did pupate on a diet of eggs or newly hatched larvae of *S. frugiperda* or *A. kuehniella* eggs, although the duration of the pupal stage was shorter when they were fed young larvae than with eggs of either prey (Table 1). Pupae survival of *C. externa* fed with *S. frugiperda* eggs was higher than with newly hatched *S. frugiperda* larvae. However, pupae survival was highest for *C. externa* fed with *A. kuehniella* eggs (Table 2).

Chrysoperla externa reached maturity on a diet of newly laid or one-day-old *S. frugiperda* eggs, newly hatched *S. frugiperda* larvae or *A. kuehniella* eggs, and the interval between larvae and adult did not differ between these treatments (Table 1). The survival from larvae to adult of *C. externa* was higher with *A. kuehniella* eggs than with other prey types (Table 2). Adults of *C. externa* showed normal morphology when reared on a diet of newly laid or one-day-old *S. frugiperda* eggs, newly hatched *S. frugiperda* larvae or *A. kuehniella* eggs.

Prey consumption (number of eggs or larvae) of *C. externa* increased with its development from 44.7 to 330.8 *A. kuehniella* eggs. First instar *C. externa* showed higher consumption of one-day-old eggs or newly hatched *S. frugiperda* larvae than with other prey types. *Chrysoperla externa* consumed higher numbers of *A. kuehniella* eggs during its larval stage than with *S. frugiperda* eggs or newly hatched *S. frugiperda* larvae (Table 3). Some *C. externa* larvae preyed on newly hatched *S. frugiperda* larvae but did not consumed them.

First instar *C. externa* larvae consumed a greater weight of one- or two-day-old *S. frugiperda* larvae. Second instar *C. externa* larvae consumed a greater weight of newly hatched *S. frugiperda* eggs or larvae or *A. kuehniella* eggs. Third instar *C. externa* larvae consumed more one-day-old *S. frugiperda* eggs or *A. kuehniella* eggs. Overall, *C. externa* larvae consumed more one-day-old eggs or newly hatched *S. frugiperda* larvae and *A. kuehniella* eggs (Table 4).

Discussion

The three instars detected in *C. externa* were similar to those reported for this predator fed with *Bemisia tabaci* biotype B (Gennadius, 1889) (Hemiptera: Aleyrodidae) nymphs (Silva et al, 2004) and *Myzus persicae* (Sulzer, 1776) (Hemiptera: Aphididae) (Barbosa et al, 2008). Other lacewings have also exhibited three instar stages, including *Ceraeochrysa cubana* (Hagen, 1861) (Neuroptera: Chrysopidae) fed with *A. gossypii* (Alcantra et al, 2008) and *Dichochrysa prasina* (Burmeister, 1839) (Neuroptera: Chrysopidae) fed with *A. kuehniella*, *Ephestia kuehniella* (Burmeister, 1879) (Lepidoptera: Noctuidae) or *M. persicae* (Papas et al, 2007, 2008a). This suggests that newly hatched larvae or eggs of *S. frugiperda* or *A. kuehniella* are adequate for *C. externa* because unsuitable prey or unfavorable environmental conditions may increase or reduce the number of instars (Michaud, 2005; Vandekerkhove et al, 2006). In spite of this, additional nutrients provided in artificial diets, such as essential amino acids and mineral salts offered along with prey can be useful when mass-rearing the predators (Isikber and Copland, 2002; Ragkou et al, 2004; Berkvens et al, 2008).

The equal duration of larval stages of *C. externa* – except those fed with one- or two-day-old *S. frugiperda* larvae – differed from the relatively shorter first and third instars *C. externa* exhibited when fed with *B. tabaci* biotype B nymphs (Silva et al, 2004). The larval stage of *Chrysoperla rufilabris* (Burmeister, 1839) (Neuroptera: Chrysopidae) was shorter with *Monella caryella* (Fitch) or *Melanocallis caryaefoliae* (Davis, 1910) (Hemiptera: Aphididae) alone than with both prey types together, which was attributed to its generalist feeding behavior (Kunkel and Cottrell, 2007). The equal duration of the larval stages of *C. externa* fed with newly hatched *S. frugiperda* larvae or *A. kuehniella* eggs agreed with results for neuropteran predators with this and other prey (Auad et al, 2003; Pappas et al, 2007, 2008a; Souza et al, 2008).

All *C. externa* fed with one- or two-day-old *S. frugiperda* larvae died, suggesting that this predator

Table 3 - Consumption (mean ± standard error of mean) of the developmental stages (DS) (first instar – FI, second instar – SI, third instar – TI, and larval – L) of *Chrysoperla externa* (Neuroptera: Chrysopidae) fed with newly laid (T1) or one-day-old *Spodoptera frugiperda* (Lepidoptera: Noctuidae) eggs (T2); newly hatched (T3), one- (T4) or two-day-old (T5) *S. frugiperda* larvae; or one-day-old *Anagasta kuehniella* (Lepidoptera: Pyralidae) eggs (T6).

DS	T1	T2	T3	T4	T5	T6
	Consumption (number of eggs or larvae)					
FI	38.1 ± 1.9[b]	31.9 ± 2.6[b]	71.5 ± 4.7[a]	85.7 ± 5.8[a]	43.2 ± 5.2[b]	44.7 ± 0.8[b]
SI	43.4 ± 4.8[b]	48.5 ± 13.8[b]	119.9 ± 28.7[a]	-	-	129.9 ± 2.5[a]
TI	160.9 ± 21.5[b]	169.8 ± 9.4[b]	176.3 ± 30.9[b]	-	-	330.8 ± 2.8[a]
L	242.4 ± 28.2[b]	250.2 ± 15.8[b]	367.7 ± 64.3[b]	-	-	505.4 ± 6.1[a]
CV	9.16%					

means followed by the same letter per line do not differ by the test of Tukey ($P < 0.05$); CV= Coefficient of variation

failed to successfully attack the larger larvae. Larvae of one- or two-day-old *S. frugiperda* exhibited considerable movement away from attacking *C. externa* larvae and their exterior became increasingly tough with age. A lower survival rate of first instar *C. externa* larvae fed with *S. frugiperda* eggs may be attributed to the architecture of the egg masses, which are often covered with scales that hinder the access of natural enemies (Beserra and Parra, 2004; Souza et al, 2008). The chorion hardness of Noctuidae eggs may further thwart first instar *C. externa* larvae, as they have weak mouthparts (López-Arroyo et al, 2000).

A lower survival rate has been reported for *C. externa* fed with *Toxoptera citricida* (Kirkaldy, 1907) (Hemiptera: Aphididae) (Pappas et al, 2008b). On the other hand, the high survival rate of *C. externa* fed with *A. kuehniella* eggs was comparable to rearing with *A. argillaceae*, suggesting that this prey has satisfactory nutritional properties (Souza et al, 2008). Eggs of *A. kuehniella* can be stored frozen, which reduces costs compared with fresh prey, but the freezing period reduces nutritive quality (Mohaghegh and Amir-Maafi, 2007). High larval mortality of *D. prasina* lacewings was also reported after they were fed with *Aphis nerii* (Boyer de Fonscolombe, 1841) (Hemiptera: Aphididae) (Pappas et al, 2007) or *E. kuehniella* (Pappas et al, 2008a, b). Food quality also affected the development and survival of Coccinellidae larva and Pentatomidae nymphs (Isikber and Copland, 2002; Kalushkov and Hodek, 2001, 2004).

A shorter pupal stage, described here in *C. externa* fed with newly hatched *S. frugiperda* larvae, is important for biological control programs, as earlier maturation can lead to a more rapid population increase (Auad et al, 2003; Pappas et al, 2007, 2008a). The duration of larval and pupal stages of *C. externa* were longer with ad libitum provision of food and reduced transfer between tubes (Auad et al, 2003). This suggests that limitation of prey availability and handling may reduce the duration of the larval and pupal stages of this predator.

Prey limitation and increased handling has been previously found to reduce the viability of *C. externa* pupae (Auad et al, 2003). This suggests that the ad libitum availability of *S. frugiperda* in the same tube could improve the developmental success of this predator. The lower survival of third instar *C. externa* larvae and duration of larval and pupal stages fed with newly hatched *S. frugiperda* larvae provided with limited prey and daily tube changes suggests that limited prey and handling are not optimal condition for this predator (Auad et al, 2003).

Although first instar *C. externa* larvae perforated the egg-shell of *S. frugiperda*, this prey was not suitable for development. This has been observed previously for this predator fed with *S. frugiperda* (Auad et al, 2003). Similarly, development was compromised in the ladybeetle predator *Stethorus punctillum* (Weize, 1891) (Coleoptera: Coccinellidae) fed with *Tetranychus urticae* (Koch, 1836) (Acari: Tetranychidae) (Ragkou et al, 2004), and the lacewing *D. prasina* fed with *A. nerii* (Pappas et al, 2007). These results suggest that the survival of *C. externa* may be lower in the corn crop at the beginning of the infestation by *S. frugiperda* (Castillejos et al, 2000; Hoballah et al, 2004), a period during which eggs and adults of this pest are present (Matos Neto et al, 2004, 2005). However, studies involving the association of these insects, especially in the field, should be conducted.

The higher consumption (number of eggs or larvae) of *A. kuehniella* eggs by *C. externa* during the early and final instars can be attributed to the growth of this Chrysopidae and its increasing food necessity. This was also observed for *C. externa* fed with *B. tabaci* biotype B, *M. persicae*, *A. kuehniella*, or *S. frugiperda* (Silva et al, 2004; Barbosa et al, 2008). Prey density can also affect consumption, as was reported for *Podisus nigrispinus* (Dallas, 1851) (Heteroptera: Pentatomidae) feed with *S. frugiperda* larvae (Zanuncio et al, 2008). Higher consumption of prey provides females with great body mass, which correlates with higher fecundity (Zanuncio et al, 2002, 2005; Lemos et al, 2009). An example is seen for *C. sanguinea*, which is heavier and has higher fecundity when fed with *T. citricida* compared with a diet of *Aphis spiraecola* (Patch, 1914) (Hemiptera: Aphididae) (Michaud, 2000). This is important because body weight indicates the amount of nutrients stored, which can affect mating, dispersion, flight and fecundity in insects (Omkar et al, 2006).

Table 4 - Weight of prey consumed (mean ± standard error of mean) of the developmental stages (DS) (first instar – FI, second instar – SI, third instar – TI, and larval – L) of *Chrysoperla externa* (Neuroptera: Chrysopidae) fed with newly laid (T1) or one-day-old *Spodoptera frugiperda* (Lepidoptera: Noctuidae) eggs (T2); newly hatched (T3), one- (T4) or two-day-old (T5) *S. frugiperda* larvae; or one-day-old *Anagasta kuehniella* (Lepidoptera: Pyralidae) eggs (T6).

DS	T1	T2	T3	T4	T5	T6
	Consumption (weight of prey consumed)					
FI	1.93 ± 0.09[b]	2.07 ± 0.22[b]	3.44 ± 0.23[b]	10.84 ± 0.73[a]	6.15 ± 0.74[a]	1.74 ± 0.03[b]
SI	2.20 ± 0.24[b]	3.15 ± 0.89[b]	5.78 ± 1.38[a]	-	-	5.06 ± 0.10[a]
TI	8.16 ± 1.09[b]	11.03 ± 0.63[a]	8.50 ± 1.48[b]	-	-	12.90 ± 0.11[a]
L	12.30 ± 1.43[b]	16.26 ± 1.03[a]	17.74 ± 3.10[a]	-	-	19.71 ± 0.24[a]
CV	4.81%					

means followed by the same letter per line do not differ by the test of Tukey ($P < 0.05$); CV= Coefficient of variation

The higher consumption (number of eggs or larvae) of *A. kuehniella* eggs by *C. externa* may be due to its smaller size and weight and, consequently, the need of Chrysopidae to eat large numbers. The weight of 40 *A. kuehniella* eggs (1.56 mg) was less than 40 newly laid (2.03 mg) or 40 one-day-old (2.60 mg) eggs, 40 newly hatched (1.93 mg) or 40 one- (5.06 mg), or 40 two-day-old (5.70 mg) *S. frugiperda* larvae. This was observed for *C. externa* and *C. cubana* fed with Pyralidae eggs (Souza et al, 2008). However, the higher consumption (number of eggs or larvae) of *A. kuehniella* eggs by *D. prasina* than of *Toxoptera* sp. (Hemiptera: Aphididae) eggs and/or *Pinnaspis* sp. suggests that this prey is suitable for this predator (Pappas et al, 2008b). Moreover, the similar prey consumption (number of eggs or larvae) of *Diatraea saccharalis* (F., 1794) (Lepidoptera: Pyralidae), *Sitotroga cerealella* (Olivier, 1819) (Lepidoptera: Gelechiidae) and *A. kuehniella* by *Ceraeochrysa cincta* (Schneider, 1851) (Neuroptera: Chrysopidae) larvae (Pappas et al, 2007) suggests that species of Chrysopidae may have different food requirements.

In conclusion, newly laid eggs, one-day-old eggs or newly hatched larvae of *S. frugiperda* can be used as prey for *C. externa*, but the development of this predator was better with *A. kuehniella eggs*, suggesting that the latter may be better suited for mass production.

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