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Protective role of the egg stalk in Chrysopidae (Neuroptera)

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Abstract. First instar larvae of *Chrysopa oculata* Say cannibalize more eggs without stalks than those with. In choice experiments, unfed males and females of *C. oculata* avoid feeding on eggs with stalks, but readily cannibalize those without. The degree of cannibalism is similar in both sexes. Although predation of eggs with and without stalks by hungry adult coccinellids is high, the stalks protect the eggs to some extent.

INTRODUCTION

The eggs of most chrysopid species have thin hyaline pedicels (stalks). Some species lay eggs in clusters without stalks, others in clusters in which the stalks are glued together and others singly on stalks either in loose groups or dispersed. Usually, the larva remains for several hours on the eggshell after eclosion (Gepp, 1984). A protective function of egg pedicel against various biotic and abiotic factors has been suggested but detailed analysis has not yet been made.

Adults of *Chrysopa oculata* (Chrysopidae) are predatory and sometimes cannibalize a large portion of the eggs laid in laboratory cultures. Some experiments show that stalks may have a protective function against egg predation (Chen & Young, 1941), parasitization, and cannibalism (Duelli P. & Johnson J.B. unpubl. in Duelli, 1986). Only a few potential predators of lacewing eggs occur in the native Hawaiian insect fauna (Zimmerman, 1957). The absence of egg stalks in all Hawaiian species of the endemic genus *Anomalochrysa* may indicate this structure in other chrysopid species serves mainly to protect eggs from heterospecific predation (Duelli, 1984).

In this study, experiments with eggs with and without stalks of *C. oculata* were undertaken in order to compare how effectively stalks may prevent the eggs from cannibalism and from predation by adult coccinellids.

MATERIAL AND METHODS

Cultures of *C. oculata* Say, *Coccinella trifasciata* L. and *Cycloneda limbifer* Casey (Coccinellidae) have been maintained in the laboratory for several years. The predators were reared on *Acyrthosiphon pisum* Harris (Aphididae). Adult chrysopids were fed a semi-artificial liquid diet (yeast hydrolysate IMUNA 10 g, sucrose 24 g, water 300 g) and water in addition to aphids. *C. oculata* and *C. trifasciata* were collected in Kemptville, British Columbia, Canada, *C. limbifer* in Cuba, *Coccinella septempunctata* L. (Coccinellidae) was collected in Č. Budějovice, the latter shortly before the experiment. Experiments were conducted under 22 ± 1°C, r.h. 60 ± 20% and fluorescent light, constant photo-regime with 16L : 8D photoperiod.

Experiments on egg cannibalism by the larvae were performed in 9 cm diameter Petri dishes. Either 55 eggs with stalks or 55 of those without were placed in a single dish. The average length of the stalk was 4.9 mm. Out of 55 eggs in total, 5 eggs were laid within one 24 h period and 50 eggs were laid also within a 24 h period but 0–4 days later. In experiments with eggs with stalks, all eggs were on the paper on which they were oviposited by females. In experiments with eggs without stalks, all eggs were placed on the bottom of the dish. No other food was available to prevent newly hatched larvae from killing eggs which had yet to hatch. The survival of eggs in the dish was evaluated 4 days after the eggs should have hatched. Each trial was repeated five times.

Choice experiments with single adults of *C. oculata*, *C. septempunctata*, *C. trifasciata* and *C. limbifer* were performed in Petri dishes 18.5 cm in diameter. The choice tests consisted of eggs with stalks versus those without. A paper square 50 × 50 mm on which 25 eggs with stalks had been laid and a paper square of equal size to which 25 eggs without stalks had been carefully glued were spaced 20 mm from each other and fixed to the lid of each dish. The eggs had all been laid within the same 24 h. No other food was available during the experiments. Each trial was repeated ten times.

Before the choice experiments started, adults of *C. oculata* and *C. trifasciata* were in laboratory rearing where aphid prey was present in surplus. Two different series of experiments were designed for coccinellids *C. limbifer* and *C. septempunctata*. In the first series, adult coccinellids were given aphids in excess before the experiments. In the second series, the coccinellids had been starved before the experiments, either in nature (*C. septempunctata*) or in the laboratory (*C. limbifer*). Each type of trial was repeated ten times. Experiments were discontinued when more than 50% of adults died, i.e. after 90 h in experiments with *C. oculata* and after 100 h in all experiments with coccinellids.

The Mann Whitney U test was used to compare survival of eggs with and without stalks in experiments on egg cannibalism by the larvae. The Wilcoxon paired-sample test was used to compare numbers of eggs with or without stalks eaten by adult chrysopids and coccinellids in the choice experiments.

RESULTS

After the eclosion, unfed larvae of *C. oculata* cannibalized significantly more of conspecific eggs without stalks than those with (Fig. 1). The differences between the survival of eggs with and without stalks in all age groups were statistically significant ($P = 0.0317$, $P = 0.0079$, $P = 0.0079$, $P = 0.0159$ and $P = 0.0079$ for experiments with eggs laid with 0, 1, 2, 3 and 4 days interval).

Cannibalism of eggs with stalks by both sexes of *C. oculata* was extremely low and eggs without stalks were mostly eaten (Fig. 2A). The differences between cannibalized numbers of eggs with and without stalks were statistically significant ($P = 0.0117$ for male and $P = 0.0078$ for female *C. oculata*). Most of the eggs with stalks, which adults did not cannibalize, hatched (90.2% with male and 93.8% with female predators). The hatchability of eggs without stalks, which survived the cannibalism, was only half as much as for eggs with stalks (44.6% with males and 44.2% with females). 10 female *C. oculata* laid 233 eggs during the experiment. 30% of these eggs were cannibalized and only 25.1% have hatched.

Fig. 1. Survival of eggs of *C. oculata* that hatched in 9 cm diameter Petri dish. 50 eggs + 5 eggs (0–4 days older), either eggs with ■ or without ■ stalks, present in a single trial. $P < 0.05$ *, $P < 0.01$ ** (Mann-Whitney U test).

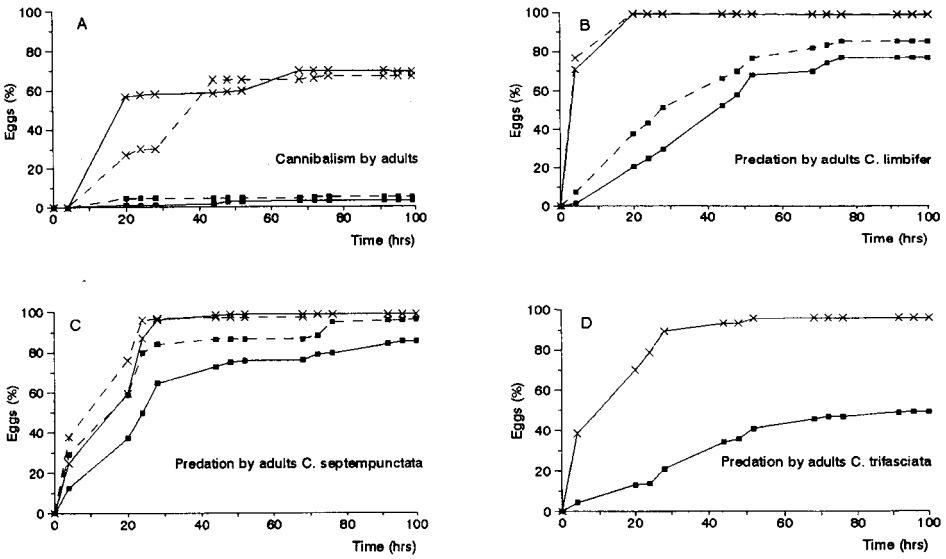

Fig. 2. Canibalism and predation of eggs with ■ or without × stalks of *C. oculata* in choice experiments. A – males - - -, and females —— of *C. oculata*; B – adults of *C. limbifer* from a laboratory culture fed on *A. pisum* ——, and adults *C. limbifer* from the same culture but deprived of food for 5 h prior to the experiment - - -; C – field collected adults of *C. septempunctata* - - -, and field collected adults of *C. septempunctata* given an excess of *A. pisum* for 24 h prior to the experiment ——; D – adults of *C. trifasciata* from a laboratory culture fed on *A. pisum* ——.

Predation of eggs with and without stalks by adult coccinellids was high. Nevertheless, each species destroyed more eggs without stalks than those with (Fig. 2B, C and D). The much smaller but highly mobile adults of *C. limbifer* ate larger numbers of chrysopid eggs without stalks earlier than *C. septempunctata* and *C. trifasciata*. The predation of eggs with stalks was highest in *C. septempunctata* and lowest in *C. trifasciata*. The number of eggs with stalks eaten by coccinellids was lower when the beetles were satiated. *C. limbifer* destroyed more eggs when beetles were deprived of food for 5 h prior to the experiment. Aphids were not present in the field at the time of collection of *C. septempunctata*. Field collected adults of *C. septempunctata* ate a higher number of eggs with stalks than adults kept after the collection on *A. pisum* for 24 h.

The differences between numbers of eggs with and without stalks, eaten by adult coccinellids, were statistically significant in satiated *C. septempunctata*, but they were not statistically significant in hungry *C. septempunctata* adults tested immediately after their collection in the field. The differences between numbers of eggs with and without stalks were statistically significant also in *C. limbifer* ($P = 0.002$ for adults fed with aphids before the experiment and $P = 0.002$ for adults starved before the experiment) and *C. trifasciata* ($P = 0.002$).

DISCUSSION AND CONCLUSIONS

In contrast with eggs of other insect predators, which are often protected by plant tissues, distasteful substances, or firm chorions, the vulnerability of singly laid chrysopid

eggs appear to be reduced mainly by their camouflage colour and long hyaline stems. So far, only females of *Ceraeochrysa smithi* (Navás) and *Nodita floridana* (Banks) are reported to coat stalks of their eggs with droplets of fluids (Eisner et al., 1996). Oily fluid protects eggs of *C. smithi* against ants. Four components of the fluid proved topically irritant in an assay with a cockroach. Although stalks of *C. oculata* are not visibly coated with any liquid, females of this species seem to be able to recognize conspecific eggs by the stalks. In the laboratory culture, the females were regularly observed to avoid feeding on conspecific eggs after having previously slowly moved their palps along the stalk.

Apart of the protective function against predation, stalks may provide also some degree of protection against mechanical injury and overheating. The results of this study demonstrate that the stalks protect effectively eggs of *C. oculata* from cannibalism by first instar larvae and adults.

Although a shortage of aphid prey results in an immediate increase in the cannibalism of eggs in laboratory cultures of *C. oculata*, cannibalism of eggs with stalks by adults of both sexes, in the Petri dishes, was extremely low, but a large number of eggs with stalks laid by the females during the course of the experiment were eaten. This may be due to the toughening of the chorion of eggs during their development and a higher incidence of sterile eggs, laid in absence of males which, presumably, are cannibalized more regularly than those fertile (Philippe, 1971).

The comparison of cannibalism of eggs with and without stalks by both sexes of *C. oculata* (Fig. 2A) with predation of these by adults of *C. limbifer* (Fig. 2B), *C. septempunctata* (Fig. 2C) and *C. trifasciata* (Fig. 2D) indicate that stalks protect eggs more effectively from cannibalism than from predation. Unsatiated beetles, in particular, are very efficient predators. However, starved adults of two tested species of ladybirds were unable to destroy approximately 5 and 20% of eggs with stalks available in Petri dishes. This indicates that the ability to survive of eggs with stalks in nature, where some kind of other prey is usually available, may be expected much higher. The size of beetles might have caused differences in the degree of egg predation by coccinellids. Larger beetles of *C. septempunctata* were observed to bend the pedicels and feed on eggs more easily than smaller adults of *C. limbifer* and *C. trifacsiata*.

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