

Predatory behavior of mirid bug, *Cyrtorhinus lividipennis*, on rice plants with different nitrogen regimes

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The mirid bug, *Cyrtorhinus lividipennis*, is a plant-feeding and predatory insect, preferring plant- and leafhopper eggs and young nymphs (Shepard et al 1987). It is now one of the important predators of brown planthopper (BPH) *Nilaparvata lugens* and whitebacked planthopper (WBPH) *Sogatella furcifera* (Heong et al 1991). Its populations were highly correlated with planthoppers maintaining a high density in the field even in the absence of BPH, but Laba and Heong (1996) found no preference for BPH and WBPH eggs. Tritropic interactions among plants, herbivores, and natural enemies can be affected profoundly by host-plant quality, architecture, and distribution (Boethel and Eikenbary 1986). *C. lividipennis* population density increased significantly in the field with higher N fertilization through improved nutrient conditions in rice plants (Meerzainudeen and Kareem 1999). Through a series of laboratory experiments, we tried to quantify the influence of N on the predatory behavior of *C. lividipennis* in rice.

Rice plants (IR64) under four N regimes—200, 100, 50, and 0 kg ha⁻¹ (labeled 200N, 100N, 50N, and 0N, respectively)—were studied. Ammonium nitrate was applied at different rice growth

stages. An electronic chlorophyll meter (SPAD 502, Minolta Camera Co., Osaka, Japan) was used to assess tissue N. By pooling the data from all plant growth stages, a relationship between leaf N content (N) and leaf SPAD readings was found to be $N\% = 0.1151 \text{ SPAD} - 1.2772$ ($F = 162$, $P < 0.001$). This linear model was used to predict the N content of plants for all the experiments. The insects employed in this experiment were successively mass-cultured on host plants with low (0N) and high (200N) N regimes and were labeled 0NGi and 200NGi for BPH and 0NFi and 200NFi for mirid bug, respectively (i is the number of successive generations on rice plants with the same N regime).

Gravid BPH females were confined in a mylar cage on 45-d-old rice plants (main stem and one primary tiller per pot) with four N regimes for oviposition for 24 h. Four potted rice plants with four N regimes (200N, 100N, 50N, and 0N) were arranged randomly in a plastic tray covered by a cylindrical plastic cage (height, 80 cm) with fine nylon mesh on top and one 3-cm-long window on the side wall for insect infestation. Seventy-two hours after infestation by five newly molted mirid bug females confined in a plastic tray, the healthy and

attacked BPH eggs were counted by dissecting the leaf sheaths and midrib tissues under a binocular microscope. To determine the predatory preference for BPH eggs on the different parts of the rice plant, we attached the sachets on the leaf sheath and leaf blade at 5 cm above the soil and at 3 cm from the collar for oviposition by gravid BPH females. The predatory capacity of mirid bug on BPH eggs was qualified by detecting the number on BPH eggs consumed by one newly emerged female adult in 24 h under different egg densities on rice plants with low and high N regimes.

Cyrtorhinus lividipennis can complete its life cycle on the rice plant (Yu et al 1996). However, its predatory performance was positively affected by the N content of the host plant. Rice plants with higher N content were apparently softer, with more succulent tissues than in plants with lower N content. Female adults preferred to attack the BPH eggs in plants with higher N content than in plants with low N in both the greenhouse and darkroom ($P < 0.0001$) (Fig. 1). They also preferred feeding on BPH eggs in the midrib of the rice leaf blade ($P < 0.0001$). Very few eggs laid in the leaf sheath were attacked on both the 0N and 200N rice plants. Further-

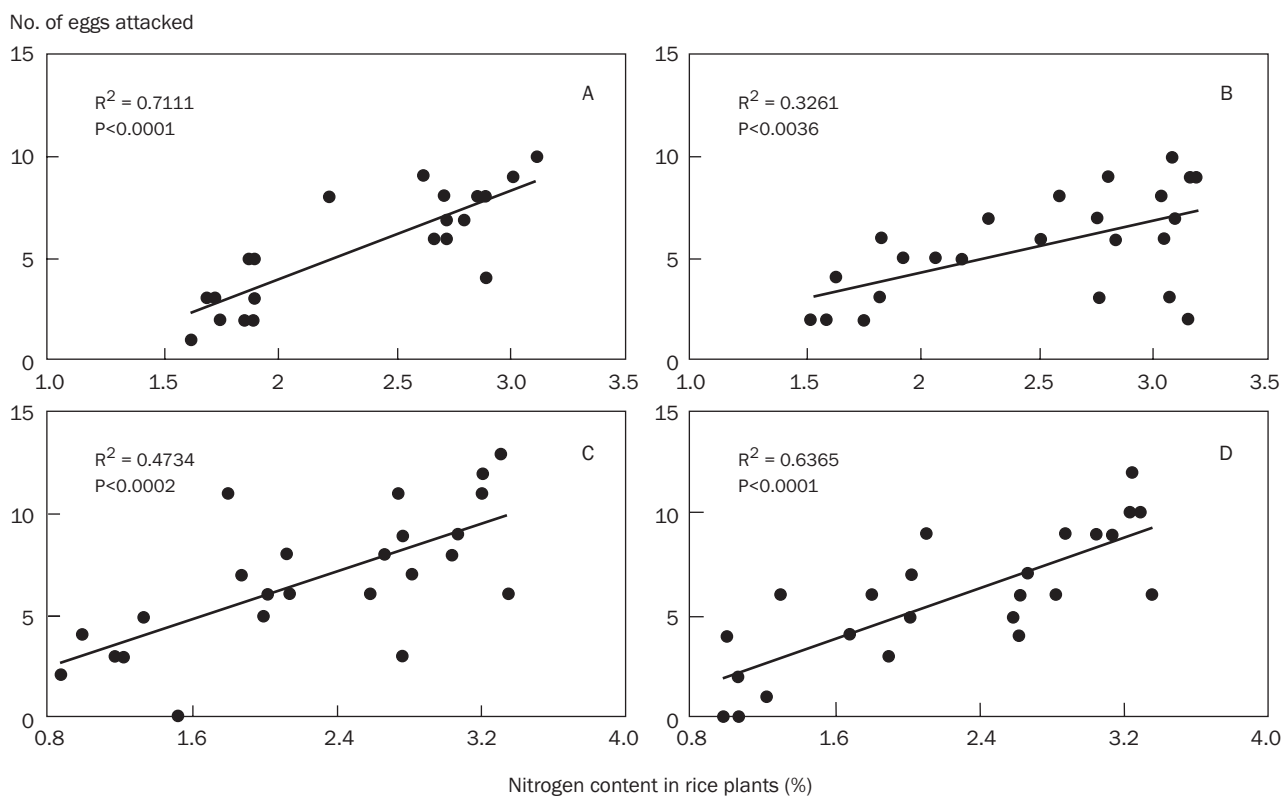


Fig. 1. Number of BPH eggs attacked by *C. lividipennis* populations on rice plants with different N contents.

A: 200NF2 population in the greenhouse.

B: 0NF2 population in the greenhouse.

C: 200NF2 population in the darkroom.

D: 0NF2 population in the darkroom.

more, the number of BPH eggs attacked in the leaf blade was markedly higher on the 0N rice plants than on the 200N rice plants ($P = 0.0245$). However, no significant differences in predatory preference were found between 0N and 200N rice plants ($P = 0.0686$), while a markedly higher predatory rate in total eggs, more than twice, was recorded on the 0N plants than on the 200N plants ($P < 0.0001$).

The functional responses of *C. lividipennis* populations reared with BPH eggs on rice plants with low and high N fertilizers were typically Holling's Type II (Fig. 2). The bugs preying on BPH eggs on 0N rice plants had significantly higher attack rates than those on 200N rice plants.

Meanwhile, no observable differences in handling time were found between bug populations. These suggest that the high N fertilizer decreases the predatory capacity of *C. lividipennis* on BPH eggs.

IR64 had changes in morphological and histological structures, physiological properties, and chemical components, such as a softer and thicker sheath, more succulent plants, higher N content in the sap, and bigger canopy size, leading to modified volatiles and other chemical and visual cues after application of N fertilizer. Such modifications resulted in the enhanced attractiveness of the rice plants to mirid bugs. Similar results obtained from the greenhouse and the dark-

room proved that increased predatory preference for BPH eggs by mirid bugs was attributed mainly to the many cues derived from rice plants with higher N content. A possible explanation for the great number of eggs attacked by mirid bugs on high-N rice plants may be that *Cyrtorhinus*, being plant feeders and hopper predators, seek host plants with higher nutrient contents. Compared with the leaf sheath of low-N plants, the tissues of the midrib in leaf blades are softer and more suitable for feeding by mirid bugs, so hopper eggs on the midrib in leaf blades are attacked easily. This is why significantly more BPH eggs on midribs of leaf blades were consumed. Unfortunately,

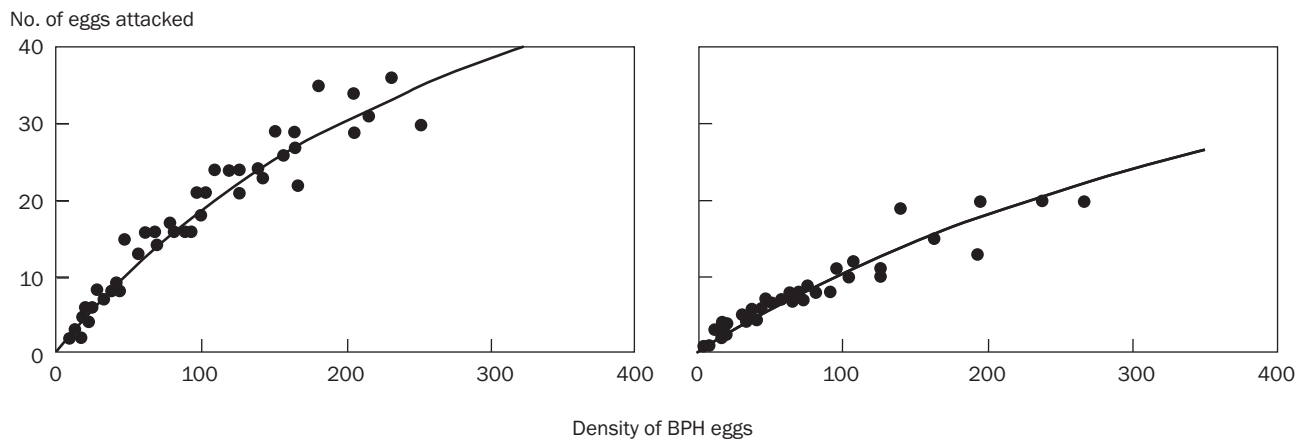


Fig. 2. Functional responses of female *C. lividipennis* adult populations to BPH eggs on rice plants with different N regimes.

A: 0NF2 *C. lividipennis* on 0N rice plants. B: 200NF2 *C. lividipennis* on 200N rice plants.

this characteristic does not make the mirid bug an excellent biological agent because it contributes to lower predatory effectiveness on target eggs in the field and in no-choice experiments with a high N regime. The bigger size and more sources of cues could mislead the orienting, foraging, accessing, and locating of mirid bugs in nontargets or it could extend the range to find targets. Based on this study, the predatory capacity of mirid bugs can be enhanced on host plants treated with high-N fertilizers.

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Neural network approximation of sampling yield-effort curves of rice invertebrates

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Biodiversity studies in ecology and agriculture often begin with the analysis of sampling curves. To measure the completeness of sampling, a sampling yield-effort curve

can be drawn that plots the number of taxa sampled against the sample size (Colwell and Coddington 1994, Zhang and Schoenly 1999a,b). This curve is a step

function with a slope that should decrease as sample size increases and as fewer taxa remain to be sampled. Many models or methods were developed to fit these