Review Article

POPULATION DYNAMICS AND ECOLOGICAL ROLE OF *CHRYSOPERLA* SPP. IN MAJOR AGRICULTURAL CROPS: A REVIEW

ABSTRACT

The growing global population, projected to reach 9.7 billion by 2050, demands sustainable agricultural practices to ensure food security. The widespread use of chemical pesticides has raised concerns due to their harmful impacts on health and ecosystems. As a result, Integrated Pest Management (IPM) strategies, including biological control, have gained prominence. *Chrysoperlacarnea*, commonly known as the green lacewing, is a key predator in biological pest control, effectively managing pest populations across various crops. This review examines the population dynamics of Chrysoperla spp. in sunflower, brinjal, cotton, okra, chilli, tomato, fennel, coriander, and mustard. The studies highlight how *Chrysoperla* populations are influenced by abiotic factors such as temperature and humidity, as well as biotic factors like prey availability. Positive correlations between predator and pest populations were noted across crops, emphasizing *Chrysoperla'*s role in pest suppression. Additionally, intercropping strategies, particularly in fennel and coriander, have shown to enhance *Chrysoperla* populations, indicating the potential of such practices in improving pest control outcomes. Overall, *Chrysoperla* spp. are vital to sustainable pest management, reducing dependency on chemical pesticides and supporting environmentally friendly and economically viable agriculture within IPM frameworks.

Keywords:Abiotic factors, Biological control, Chrysoperlacarnea, Integrated Pest Management (IPM), Intercropping, Population dynamics, Sustainable agriculture

1. INTRODUCTION

The global population has more than tripled over the past century, reaching 7.3 billion today, with projections suggesting it could rise to 9.7 billion by 2050 (UN estimates). This rapid growth demands a reliable supply of high-quality, affordable food. However, the extensive use of pesticides in agriculture to meet these demands has sparked significant concerns due to their potential adverse effects on human health, wildlife, aquatic life, and ecosystems. These concerns have driven the pursuit of more sustainable, eco-friendly pest control methods. Biological pest control, a cornerstone of Integrated Pest Management (IPM), stands out as a highly sustainable and cost-effective approach. It minimizes environmental impacts while effectively managing pest populations without disrupting the natural balance (2).

One of the most widely distributed species employed in biological control is the green lacewing, *Chrysoperlacarnea*. Belonging to the family Chrysopidae and order Neuroptera, *C. carnea* is found across southern Africa, the South Atlantic islands, the Middle East, Western Asia, and the Indian subcontinent (17). This cosmopolitan predator is particularly effective during its larval stage, preying voraciously on soft-bodied pests such as aphids, thrips, psyllids, whiteflies, and the eggs of various lepidopteran pests across different crops (15). The adults, characterized by pale green bodies, long antennae, and transparent wings, feed on pollen, nectar, and honeydew. The *C. carnea* group comprises at least 20 species, distinguishable primarily by their unique vibrational duetting songs. Neuropterida, among the most ancient lineages within Holometabola, is believed to have diverged from a common ancestor with Coleoptera and Strepsiptera around 276 million years ago (5). The first recorded discovery of a *Chrysoperla* species in India, specifically *Chrysoperlacarnea*, is credited to the British entomologist Frederick Vincent Theobald in the early 20th century. Theobald's work was pioneering in the field of agricultural entomology. Theobald discovered *Chrysoperlacarnea* in various parts of India, with significant observations in agricultural regions where pest control was a major concern. However, the exact location within India where the first specimen was collected is not specifically documented in the available historical records. Theobald's contributions laid the groundwork for subsequent research on biological pest control in India, emphasizing the importance of natural predators like *Chrysoperla* in managing agricultural pests. Available literature reveals that extensive research has been conducted on various aspects of *Chrysoperla* spp. Stephens (Chrysopidae: Neuroptera) in different parts of the world.

2. POPULATION DYNAMICS IN DIFFERENT CROPS

Before delving into the specific crops, it is essential to understand the pivotal role that *Chrysoperla* spp. plays in integrated pest management (IPM) across diverse agricultural ecosystems. As a generalist predator, this green lacewing species has been extensively studied for its ability to suppress pest populations in various crops, thereby contributing to sustainable farming practices. The following sections will explore the population dynamics of *Chrysoperla* spp. in different cropping systems, highlighting its interactions with both abiotic and biotic factors. By examining these dynamics across a range of crops—each with its own unique environmental conditions and pest challenges—this review aims to underscore the versatility and ecological importance of *Chrysoperla* spp. in modern agriculture.

Fig. 1: Adult, Egg Hatched Shell and Larvae of *Chrysoperla* sp.

2.1 Sunflower and Safflower

Several studies have explored the influence of abiotic factors and host populations on the dynamics of green lacewing species, particularly *Chrysoperlazastrowisillemi* and other *Chrysoperla* species. In sunflower (*Helianthus annuus*) fields, the highest population densities of *Chrysoperlacarnea* were recorded from mid-March to mid-April during the first year and from mid-April to mid-May in the second year. Correlation analyses revealed a positive and significant relationship between the larval populations of *Helicoverpaarmigera* and *Myzuspersicae* with the predator *C. carnea*, although no significant correlation was found between *H. armigera* eggs and *C. carnea*. The *C. carnea* population was positively correlated with maximum temperature and negatively correlated with relative humidity, while minimum temperature showed no significant correlation with the predator's population dynamics (24).

In 2008 and 2009, though small, C. carnea populations in sunflower ecosystems peaked in the third week of April. Across different sunflower varieties, the highest population density was observed seven weeks after sowing, with a notable decrease by thirteen weeks (30). Predator incidence studies reported *C. carnea* populations ranging from 0.10 to 0.80 individuals per plant, with population peaks varying slightly between 2015 and 2016 (13). A similar trend was observed in safflower, where *C. carnea* appeared approximately one week after the aphid *Uroleuconcompositae*, with predator populations peaking in the third week of January, coinciding with the aphid population peak (21).

2.2 Brinjal

Several studies have explored the seasonal abundance and ecological role of *Chrysoperla* spp. in brinjal (*Solanum melongena*). The relative abundance of *C. carnea* during the peak growing season was recorded at 0.62% during fortnightly intervals from 8:00 AM to 10:00 AM, with observations revealing the presence of *C. carnea* across various life stages, including eggs, nymphs, and adults, significantly contributing to the control of pests such as aphids and jassids (25). An average population of 51.9 individuals per sample was recorded, with notable peaks on June 10th, July 8th, and August 5th, indicating a close association with pest activity on brinjal (4). Environmental factors impacting *C. carnea* populations on brinjal showed a negative correlation with maximum temperature and evening relative humidity, while a positive correlation was noted with minimum temperature, morning relative humidity, and rainfall. These findings suggest that *C. carnea* thrives under specific microclimatic conditions (10).

2.3 Cotton

Research on *Chrysoperlacarnea* populations in cotton fields has spanned several decades, shedding light on its dynamics, environmental interactions, and relationships with insect pests. The presence of *C. carnea* in cotton fields was first documented from mid to late May (6). Similar studies in North Gujarat also identified *C. scelestes* in cotton, castor, and greengram crops around the same time (11). In Andhra Pradesh, lowest populations of *C. carnea* were observed on the cotton whitefly (*Bemisiatabaci*) until October, with rainfall significantly reducing both pest and predator populations (34). Egg-laying by *C. carnea* was noted from early July, with the predator remaining active throughout the season (26). The retention and egg-laying of *C. carnea* were positively correlated with relative humidity and aphid populations but negatively correlated with temperature and wind speed (12).

Further research in Tamil Nadu's primary cotton-producing regions during the winter of 1995-96 and summer of 1996 revealed higher *C. carnea* populations in winter, ranging from 341 to 377 individuals per 20 plants, compared to 198 to 205 in summer (47). Studies across five cotton varieties reported an average of 1.6 to 2.4 individuals per plant, with *C. carnea* populations showing a negative correlation with maximum temperature and positive correlations with both maximum and minimum relative humidity (39). In Punjab, observations over two years (2016-2017) noted low *C. carnea* populations in early June, peaking in the fourth week of June in 2016, and mid-July in 2017, where *C. carnea* emerged as the predominant predator of whitefly (37).

At Navsari Agricultural University, *C. carnea* was reported from the 37th to 2nd Standard Meteorological Week (SMW) and from the 36th to 51st SMW, with peaks in the 46th and 40th SMWs during 2015-16 and 2016-17, respectively. Significant correlations were found between *C. carnea* populations and temperature, along with strong positive correlations with jassid populations (31). The role of *C. carnea* in the biological control of *B. tabaci* on cotton was also highlighted, with significant reductions in whitefly populations (44). In Rajkot, Gujarat, *Chrysoperla* egg populations peaked in early November, showing positive correlations with sunshine hours and negative correlations with rainfall and humidity (29). During the Kharif 2020 season, the highest *C. carnea* egg populations were observed in Bt cotton varieties, with transgenic Super NIAB-142 showing the most significant predator presence across all life stages (45). Positive correlations were noted between *Chrysoperla* populations and temperature and relative humidity during Kharif 2020 and 2021, while negative correlations were found with evening relative humidity (8).

These studies collectively underscore the critical role of *C. carnea* in cotton pest management, particularly in regulating *B. tabaci* populations, and highlight the influence of environmental factors on its population dynamics.

2.4 Okra

Chrysoperlacarnea serves as a crucial biological control agent in managing okra pests, particularly *Amrascabiguttulabiguttula* and *Bemisia.* While adult lacewings primarily feed on nectar, pollen, and honeydew, their larvae are active predators that significantly contribute to pest reduction in okra fields (16, 18). The seasonal activity of *C. carnea* fluctuates, with a notable presence observed from the second fortnight of March to late May, peaking at 0.20 individuals per plant (38). During the years 2015 and 2016, *C. carnea* populations reached their highest levels in late July, with relative densities of 22.53% and 27.89%, respectively, during critical crop growth stages (19). Moreover, *C. carnea* maintained a significant presence across different cropping seasons, with average population densities of 2.42, 1.83, and 1.17 individuals per 10 leaves during the Kharif, Rabi, and summer seasons, respectively (3).

2.5 Chilli

In chilli (*Capsicum annuum*) fields, the Neuropteran species *Chrysoperla* spp. plays a significant role in managing pest populations, accounting for 2.22% of the total arthropod population in these ecosystems

(22). The population dynamics of major pests and predators, including *Chrysoperlacarnea*, were studied during the winter of 2015, revealing a population peak from late October to early November, which coincided with optimal temperature conditions favoring their activity (9). A highly significant negative correlation was found between *C. carnea* populations and various temperature measures, indicating that extreme temperatures might limit their activity (14). Studies conducted at VRC, Pantnagar, during the Rabi seasons of 2018 and 2019, identified *C. carnea* as a key predator in chilli crops, showing a positive significant correlation between predator and insect pest populations, underscoring its importance in Integrated Pest Management (IPM) strategies (7). The predatory activity of *C. carnea* larvae was highlighted by the observation of 18,161 aphids, 566 Chrysopidae eggs, and 366 Chrysopidae larvae, emphasizing the critical role of larvae in reducing aphid populations, while the adult stages appeared less influential (20).

2.6 Tomato

Chrysoperla predators are known to feed on soft-bodied insects, playing a crucial role in controlling pest populations on tomato (*Solanum lycopersicum*) plants (46). Among the natural enemies of various insect pests in tomato crops, *Chrysoperlazastrowii* is notably effective. Green lacewings, primarily species of *Chrysoperla*, are fragile, bright green to greenish-brown insects that are prevalent in tomato crops from mid-October to early April (41). The population dynamics of *Chrysoperlacarnea* on tomato crops during the Rabi season of 2007-08 showed a gradual increase, starting at 0.22 individuals per plant in early February and peaking at 1.52 individuals per plant on March 19. This peak was followed by a decline as the tomato crop reached maturity. The study also revealed a positive and highly significant correlation between the *C. carnea* population and temperature ($r = 0.668$), while the correlation with humidity was negative and non-significant ($r = -0.122$). These findings highlight the temperature dependency of *C. carnea* populations in tomato ecosystems (27).

2.7 Fennel

Studies on the diversity of arthropods in fennel (*Foeniculum vulgare*) have identified *Chrysoperlacarnea* as a significant visitor, particularly attracted to the male flowers, highlighting fennel's potential as a conducive environment for supporting *C. carnea* populations (43). Research on *C. carnea* populations in fennel revealed that the mean population was 4.75 individuals in sole cropping. However, when fennel was intercropped with cotton, the mean population significantly increased, ranging between 8.80 and 9.91 individuals, suggesting that intercropping can enhance *C. carnea* presence, likely due to improved microhabitat conditions or increased prey availability (33). Additionally, the diversity of predator species in fennel over two successive growing seasons (2008/2009 and 2009/2010) was explored using yellow sticky traps and sweep nets. The study identified *C. carnea* as a prominent predator, accounting for 20.20% of all predators observed with sticky traps in 2008/2009 and 27.78% in 2009/2010. In contrast, the sweep net method recorded *C. carnea* comprising 25.14% of all predators in 2008/2009 and 24.57% in 2009/2010 (1). Further research investigated the impact of different intercropping patterns on *C. carnea* populations and found that fennel intercropped with sugar beet was particularly attractive to this predator, recording a mean population of 70 *C. carnea* individuals in 2017-18 and 67.50 in 2018-19, underscoring the benefits of intercropping in boosting predator populations (23).

2.8 Coriander

The activity of *Chrysoperla*species as natural enemies in coriander fields has been well-documented, highlighting their crucial role in pest management (35). These predators are particularly effective against various aphid species found in coriander plants, where they actively reduce pest populations (36). A study conducted over two successive growing seasons (2008/2009 and 2009/2010) assessed the population dynamics of several predators in coriander using yellow sticky traps and sweep nets. The findings revealed eight predator insect species from eight genera under seven families using the sweep net method, while six predator species from six genera under five families were collected using yellow sticky traps. Notably, the sticky trap method recorded 25 *Chrysoperla* individuals (22.32%) in 2008/2009 and 24 individuals (26.67%) in 2009/2010. The sweep net method captured 44 *Chrysoperla* individuals (20.95%) in 2008/2009 and 46 individuals (21.60%) in 2009/2010 (1). Additionally, research on various intercropping patterns found that combining coriander with sugar beet was particularly attractive to *Chrysoperlacarnea* Stephens. This intercropping pattern supported an average of 33.50 *Chrysoperla* individuals in 2017-18 and 31.25 individuals in 2018-19, demonstrating its effectiveness in enhancing *Chrysoperla* populations (23).

2.9 Mustard

The potential of *Chrysoperlacarnea* in controlling the mustard aphid (*Lipaphiserysimi*) in India has been widely recognized, emphasizing its significance as a natural enemy (42). Studies have demonstrated the effectiveness of *C. carnea* in preying on both nymphal and adult stages of *L. erysimi*, contributing substantially to aphid population suppression (32). Population dynamics revealed that *C. carnea* peaked in the fourth week of February on mustard crops when temperatures ranged from 14.1°C to 19.9°C, followed by a decline after the first week of March, which correlated with rising temperatures and reduced prey availability (48). The impact of abiotic factors on *C. carnea* populations in mustard showed a population increase beginning on January 28, peaking in the third week of February with 0.142 individuals per plant, and then declining during the first week of March. This trend highlights a positive correlation between temperature, humidity, and *C. carnea* activity (40). Additionally, research into intercropping patterns found that coriander intercropped with sugar beet attracted a significant number of *C. carnea* individuals, with a mean of 33.50 during 2017-18 and 31.25 during 2018-19 (23). A study conducted over two consecutive Rabi seasons (2020-21 and 2021-22) further confirmed that *C. carnea* remains a consistent natural enemy of insect pests in mustard crops (28).

3. CONCLUSION

The population dynamics of *Chrysoperla spp.* across various crops highlight the critical role these predators play in integrated pest management (IPM) systems. Studies across sunflower, brinjal, cotton, okra, chilli, tomato, fennel, coriander, and mustard have consistently demonstrated the adaptability and effectiveness of *Chrysoperla spp.* as natural enemies of key agricultural pests. The presence and activity of these predators are influenced by a range of abiotic factors, including temperature, humidity, and seasonal variations, as well as biotic factors such as prey availability.

In sunflower, *Chrysoperla spp.* populations align closely with the activity of pests like *Helicoverpaarmigera* and *Myzuspersicae*, with positive correlations found between predator and prey populations. Similar trends are observed in cotton, where *Chrysoperla spp.* effectively target pests such as whiteflies, with populations peaking during optimal environmental conditions. The studies on brinjal, okra, and chilli further emphasize the importance of microclimatic factors in determining the population dynamics of *C. carnea*, particularly its sensitivity to temperature and humidity.

Moreover, intercropping strategies have shown potential in enhancing *Chrysoperla* populations, as demonstrated in fennel and coriander crops. The increase in predator populations under intercropping systems suggests that these agricultural practices can create favorable habitats, thereby improving pest control outcomes.

Overall, the research underscores the significance of *Chrysoperla spp.* as a cornerstone of sustainable pest management. Their ability to thrive in diverse agroecosystems and effectively reduce pest populations positions them as valuable agents in reducing the reliance on chemical pesticides, contributing to environmentally friendly and economically viable farming practices.

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