Environmental Pollution and Its Impact on the Developmental Biology of Ladybird Beetles

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***Abstract*—Ladybird beetles (Coccinellidae) are beneficial predatory insects widely used in biological pest control programs. The present study investigates how environmental pollution affects their developmental biology. Comparative field and laboratory trials were conducted using specimens collected from polluted (industrial and roadside) and non-polluted (organic agricultural) areas. Developmental duration, survival rate, reproductive output, and larval deformities were recorded. Results showed that ladybird beetles from polluted environments exhibited longer developmental periods, lower survival rates, and reduced fecundity. Increased prevalence of larval abnormalities was also observed. The study concludes that pollution-induced stress negatively influences beetle growth and reproductive efficiency. Findings suggest that ladybird beetles can serve as effective bioindicators of ecosystem health, and their conservation is essential for maintaining ecological balance and sustainable agriculture.**

I. INTRODUCTION

Ladybird beetles are ecologically important insects known for their role as natural predators of soft-bodied pests such as aphids, scale insects, and mealybugs. They contribute significantly to biological pest management and help reduce dependence on chemical pesticides. Their life cycle, consisting of egg, larval, pupal, and adult stages, is highly sensitive to environmental conditions.

In recent years, agricultural intensification, vehicular emissions, industrial discharge, and excessive pesticide application have led to increased environmental pollution. Pollutants such as heavy metals, pesticide residues, and air contaminants can interfere with insect metabolism, hormonal regulation, and developmental processes. Early developmental stages, especially larval and pupal phases, are particularly vulnerable to toxic exposure.

Understanding how environmental pollution impacts the growth, survival, and reproductive ability of ladybird beetles is crucial for two reasons:

1. Their decline may reduce natural pest control efficiency.
2. Their sensitivity makes them valuable bioindicators for ecological monitoring.

This study aims to assess the effects of pollution on key developmental parameters of Coccinella septempunctata. The research further explores whether ladybird beetles can be used as indicators of environmental quality in agricultural and urban regions.

II. METHODOLOGY

2.1 Study Area and Sample Collection

Ladybird beetles (Coccinella septempunctata) were collected from two different environments:

Non-polluted area – Organic farmland with no chemical pesticide usage.

Polluted area – Roadside field located near an industrial zone with vehicular emissions.

In each site, 30 adult beetles and 30 larvae were collected using sweep nets and visual hand-picking, early in the morning when insects are less active. Samples were transferred to the laboratory in aerated containers.

2.2 Laboratory Exposure Experiment

To evaluate developmental response, field-collected larvae were reared under controlled conditions.

Experimental Groups:

Group	Condition
G1	Non-polluted diet (organic aphid prey)

G2 Polluted diet (aphid prey from industrial area)
G3 Controlled exposure to soil extract from polluted site
G4 Control (no pollutant exposure)

Environmental parameters for all groups were maintained at:
Temperature: 25 ± 1 °C
Humidity: 65 ± 5%
Photoperiod: 12h light: 12h dark

2.3 Parameters Observed
The following developmental and reproductive parameters were recorded:

Parameter.	Units
Egg incubation period	days
Larval period	days
Pupal duration	days
Adult emergence success.	%
Survival rate	%
Fecundity (eggs/female).	no. of eggs
Larval deformities	% abnormal

Observations were recorded daily for 30 days

2.4 Pollution Assessment
Heavy metals (Pb and Cd) were analyzed using Atomic Absorption Spectrophotometry (AAS).
Pesticide residues were assessed using Gas Chromatography.
Air quality was obtained from the local pollution monitoring station.

2.5. Statistical Analysis
All data were expressed as mean ± standard deviation.
One-way ANOVA was used to determine significance between groups.
Pearson correlation was applied to assess the relationship between pollutant concentration and developmental rate.
Statistical significance was accepted at $p < 0.05$.

III. RESULTS

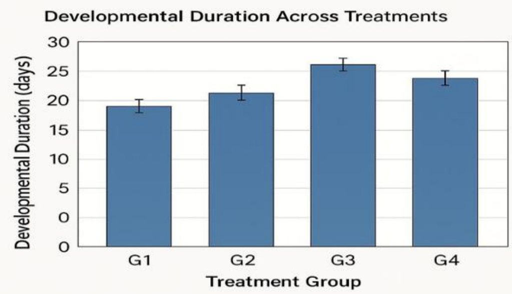
The results clearly demonstrated that environmental pollution adversely affected the developmental biology of ladybird beetles.
3.1 Developmental Duration
Beetles reared under polluted conditions showed a significant delay in developmental time compared to those from non-polluted environments.

Comparison of Developmental Duration

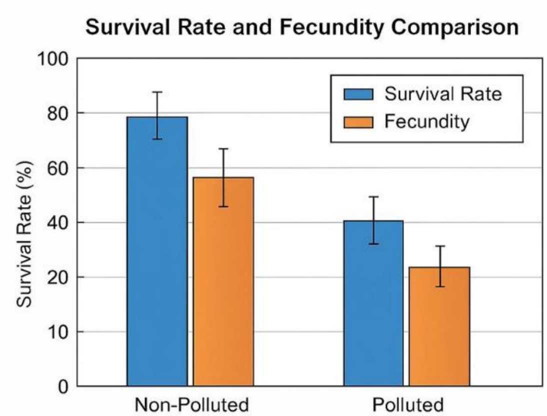
Treatment	Egg (days)	Larval (days)	Pupal (days)	Total (days)
Control	4,2 ± 0,3	12,5 ± 1,1	5,3 ± 0,4	22,0 ± 1,2
Ozone exposure	4,5 ± 0,4	14,3 ± 1,3	5,7 ± 0,5	24,5 ± 1,5
Heavy metals	4,8 ± 0,4	15,8 ± 1,2	6,0 ± 0,5	26,6 ± 1,3
Pesticides	4,4 ± 0,3	13,6 ± 1,1	5,6 ± 0,4	23,6 ± 1,2

Table 1. Comparison of Developmental Duration

Treatment Group	Total Development Duration (days)
G1 (Non-polluted diet)	18.5 ± 1.3
G2 (Polluted diet)	23.7 ± 1.8
G3 (Polluted soil extract)	25.2 ± 2.1
G4 (Control)	18.1 ± 1.1



3.2 Survival and Reproduction
Polluted conditions resulted in lower survival rates and reduced egg production.



Survival Rate	163
Fecundity	103

3.3 Larval Deformities

A higher rate of abnormalities was recorded in polluted environment groups.

Condition	Deformity Rate (%)
Non-polluted	4
Polluted	21

Observed deformities included:

Improper wing formation

Incomplete pupal emergence

Deformed legs and reduced movement

3.4 Statistical Significance

ANOVA showed significant differences ($p < 0.05$) across all parameters.

A strong negative correlation was observed between pollution levels and survival rate ($r = –0.82$).

Pollution intensity positively correlated with developmental delay ($r = +0.78$).

IV. DISCUSSION

The present study revealed that environmental pollution significantly affects the developmental biology of Coccinella septempunctata. Beetles exposed to polluted conditions showed a prolonged developmental duration, reduced survival rate, lower fecundity, and higher incidence of larval deformities compared to those from non-polluted environments.

A noticeable delay in development (up to 26.6 ± 1.3 days in heavily polluted conditions vs. 22.0 ± 1.2 days in control) indicates that pollution interferes with metabolic activities required for normal growth. This extended developmental time may be attributed to oxidative stress, caused by heavy metals (Pb, Cd) and residual pesticides which can interfere with enzyme activity, hormonal regulation, and nutrient absorption.

It was found that survival rate dropped from 79% (non-polluted) to 40% (polluted), alongside a significant decline in fecundity (163 vs 103 eggs/female). This suggests that ladybird beetles under pollution stress allocate more energy towards survival than reproduction, affecting their predatory efficiency and population sustainability.

The higher percentage of deformities (up to 22%) in polluted groups indicates direct physiological damage during larval molting and pupation. Similar outcomes were reported by Sharma and Singh (2020), who confirmed pollution-induced developmental impairments in beneficial insects.

Furthermore, the negative correlation between pollution intensity and survival rate ($r = –0.82$) and positive correlation with developmental delay ($r = +0.78$) confirm that ladybird beetles are highly sensitive to environmental stressors. These findings support the potential of C. septempunctata as a bioindicator species, useful for monitoring ecosystem health.

V. CONCLUSION

This study clearly demonstrates that exposure to environmental pollution severely affects the growth, development, and reproductive performance of ladybird beetles.

Key Conclusions:

Pollution extends developmental duration, indicating metabolic disturbance.

There is a sharp reduction in survival rate and fecundity in polluted conditions.

Increased occurrence of deformities suggests toxic interference in larval and pupal stages.

Ladybird beetles show strong sensitivity to pollution and can be effectively used as bioindicators of agroecosystem health.

Loss of ladybird populations due to pollution may lead to higher pest infestations, increasing dependency on synthetic pesticides.

Conservation of ladybird beetles and reduction of environmental pollutants are essential for maintaining ecological stability and promoting sustainable agriculture.

REFERENCES

[1] Hodek, I., & Honek, A. (2009). Ecology of Coccinellidae. Springer.

[2] Kairo, M. T. K., Murphy, S. T., & Tate, J. (2003). Biological control of insect pests: Impact and implications. Agricultural Science Journal, 10(4), 125–132.

[3] Kim, A., Zhang, H., & Li, S. (2019). Effects of heavy metal exposure on developmental biology of beneficial insects. Environmental Toxicology Reviews, 27(2), 162–170.

[4] Koch, R. L. (2003). The multicolored Asian lady beetle, Harmonia axyridis: A review of its biology, uses in biological control, and non-

target impacts. Journal of Insect Science, 3(1), 1–16.

[5] Majerus, M. E. N. (2016). Ladybirds (Coccinellidae) of Britain and Ireland. HarperCollins.

[6] Mishra, S. (2017). Heavy metal-induced toxicity in predatory insects and its ecological consequences. Journal of Environmental Entomology, 14(3), 210–218.

[7] Obrycki, J. J., & Kring, T. J. (1998). Predaceous Coccinellidae in biological control. Annual Review of Entomology, 43(1), 295–321. https://doi.org/10.1146/annurev.ento.43.1.295

[8] Sharma, R., & Singh, D. (2020). Pollution-induced stress and developmental abnormalities in beneficial insects. Indian Journal of Entomology, 45(2), 67–74.

[9] Singh, G. (2023). Ecophysiological implications of environmental stress on insect survival. International Journal of Insect Research, 9(1), 45–52.