INFLUENCE OF TEMPERATURE VARIATION ON REPRODUCTIVE ATTRIBUTES OF ZYGOGRAMA BICOLORATA (COLEOPTERA: CHRYSOMELIDAE) A POTENTIAL BIOCONTROL AGENT OF WEED PARTHENIUM HYSTOROPHORUS

Rina Saha[1], Manoj Bangadkar[2] and I. A. Raja[3]
1 Dept. of Zoology, S.M.M. College of Science, Umred Road, Nagpur,
2 RTM Nagpur University
3 S.S.C. Aloka,(M.S.) India.
Corresponding author Email : saha.rina.s@gmail.com

Abstract:

The exotic beetle Zygogramma bicolorata is an effective biological control agent of Parthenium hysterophorus in India as it feeds mainly on this weed. In the present study the stress of high and low temperature (200C & 350C) as compared to normal (Control at 270C) on the reproductive performance and different life cycle stages of the Mexican beetle Zygograma bicolorata was investigated. Potential fecundity (number of eggs matured) and realized fecundity (number of eggs laid) are both influenced by temperature variation. Fecundity and percent egg viability increased significantly with increase in the temperature from 200C to 27oC and thereafter declined with further increase in temperature. The development and survival of different life stages were also recorded and egg hatching (in days), larval period, pupal period were affected by the temperature variation. The ideal temperature range for the maximum egg laying, high percentage of egg hatching, maximum survival and complete development were recorded at 270C. These findings may be useful in mass rearing of the beetle in laboratory condition. Key words: Parthenium hysterophorus, temperature, reproductive behaviour, development, survival, Zygogramma bicolorata.

Keywords:

Parthenium hysterophorus, temperature, reproductive behaviour, development, survival, Zygogramma bicolorata.

Introduction:

The weed Parthenium hysterophorus (Asteraceae: Heliantheae) is an economically important weed in India. Earlier it was known to be a weed of fallow and wasteland only but now it has become a menace in almost all types of crops and forest land. Its colonization and dominance in natural habitat and croplands has resulted in disastrous effects on biodiversity in general and crop productivity in particular. Due to the negative impact to native biodiversity, agriculture productivity, and animal and human health, control of Parthenium is becoming a new environmental issue in its invasive range of distribution such as South Asia, Australia and Eastern and Southern Africa (Dhileepan 2009).Various methods such as chemical, physical, legislative, fire, mycoherbicides, agronomic practices, competitive displacement and classical biological control were used in attempts to control this weed. The exotic insect, Zygogramma bicolorata (Coleoptera:Chrysomelidae) is an effective biocontrol agent of P. hysterophorus (Sushilkumar 2005). The beetle as well as Parthenium both are native to Central America. Parthenium was introduced accidentally to Asia, Australia and Africa, where it has been rapidly expanding in recent years and becomes a major invasive weed whereas the beetle was introduced deliberately to Asia and Australia as a biocontrol agent of Parthenium (Mahadevappa 2009). From Mexico, the beetle was first introduced to Australia in 1980 (McFadyen and McClay 1981, as cited in Dhileepan 2009) and to India in 1984 (Jayanth 1987). Along with this species, eight other species of insects and two of pathogens (fungal biocontrol agents) have been released as biocontrol agent for Parthenium in Australia (Dhileepan 2009). But this beetle is the major bicontrol agent of this weed introduced and applied in South Asia. In South Asia, the beetle was reported only from India and Pakistan until 2009 (Dhileepan and Senaratne 2009). It is a multivoltine species and generations cannot be differentiated under field conditions. The life of insects is influenced by various environmental factors, and temperature is one of the most important and critical of the many abiotic factors and it affect both as a stressor and regulator on the growth, development and survival of insects. To achieve successful augmentation of the beetle for its economical use as a biological control agent (McFadyen, 1998), knowledge of its reproductive attributes is essential. Temperature-regulated growth and development is important in understanding the basic biology and ecology of an insect. In the case of economically important insects, such as biocontrol agents, this information is of paramount significance because it helps in paving the way to determining the conditions for mass rearing, and may also aid in the evaluation of relative competitiveness and adaptability to local climate (Frazer and McGregor, 1992). In the present study we evaluate the effect of Temperature on the reproductive performance and life stages of the Mexican beetle Zygograma bicolorata.

Material and Method:

Stock culture Adults of Z. bicolorata were obtained from Parthenium plants during July to August in the laboratory. Beetles were reared in the plastic jars and feed daily on excised leaves of Parthenium weed at 27±20C Temperature, 65±5% RH Humidity in Biotechniques B.O.D. incubator. The wilted leaves replaced daily with fresh ones. Newly hatched larvae were reared in petri dishes and when fully grown were transferred to plastic jars filled with moist sand, for pupation. Freshly emerged adults from the stock culture were isolated for use in experiments. Experimental set-up Freshly emerged adult beetles were sexed and 10 replicates consisting of a 3 female and 2 male each were placed in plastic petri plates (9.0 × 2.0 cm) maintained at 200C, 270C and 320C. The beetles were allowed to mate and eggs laid each day were counted and transferred to another petri dish in aseptic condition at the same temperature. Eggs were checked daily for hatching and empty egg shells were counted to assess hatching success. The life cycle, duration of each stages of life history and reproductive behaviour of the beetle were recorded daily at the different temperature.

Result and Discussion:

In Z. bicolorata, the developmental period of all the immature are shown in table 1. Results revealed that all the life stages depended significantly on temperature. The duration of first, second, third and fourth instars larvae were significantly different. The total larval duration decreased with increase in temperature. A statistically significant decrease in total developmental period was recorded with an increase in temperature from 200C to 320C. First instar larvae suffered the highest mortality, while the pupal stage had the lowest mortality at all constant temperatures. Our results establish that temperature plays a determining role in the development and survival of the life history stages of Z. bicolorata. The role of temperature in influencing all levels of biological organization in phytophagous insects has been previously proved (Ivanovic and Nenadovic, 1999). The effect of temperature variation on the reproductive attributes of the Mexican beetle Z. bicolorata shown in table 2. The results revealed that all the reproductive attributes i.e. Preoviposition period, oviposition period, post Oviposition period, fecundity and egg viability are depended significantly on temperature (Table 2). The number of egg lying per female in its complete life span was found highest at 270C and it falls down with increase or decrease in temperature from 200C to 32oC and 270C to

200C. The percent egg viability was found highest at 27oC and with further increased or decreased temperature from 270C egg viability was decreased than observed at 270C. I larval period (days) II larval period (days) III larval period (days) IV larval Period (days) Total larval period (days) At 20oC

5.25±0.138 4.824±0.247 5.1±0.16 4.28±0.238 19.64±0.679 At 27oC 4.873±0.24 4.32±0.34 4.55±0.16 3.49±0.318 17.86±0.408 At 32oC 4.19±0.209 3.84±0.23 3.89±0.18 3.57±0.268 16.44±0.625 Table 1: Effect of temperature variation on the larval developmental period of the Mexican beetle Z. bicolorata. Pre-oviposition period (days) Oviposition period (days) Post-oviposition period (days) Fecundity Egg viability (%) At 200C 13.10±0.31 87.80±1.40 21.50±0.78 608.50±18.33 65.40±1.69 At 27oC 7.10±0.38 63.00±1.20 14.40±0.69 987.30±15.56 89.20±1.51 At 32oC 9.60±0.31 31.40±0.99 17.40±0.60 679.90±13.79 60.30±1.67 Table 2: Effect of temperature variation on the reproductive attributes of the Mexican beetle Z. bicolorata.

Conclusion:

Our results establish that temperature plays a role in the development and survival of the life history stages of Z. bicolorata. The role of temperature in influencing all levels of biological organization in phytophagous insects has been previously proved (Ivanovic and Nenadovic, 1999). The decrease in the incubation period of Z. bicolorata with increase in temperature probably results from accelerated embryogenesis, causing early hatching of neonate instars. In phytophagous insects, temperature probably has an indirect action on a host plant that accelerates/decelerates its development and changes the qualitative and quantitative composition of nutritious matter, as well as of allelochemicals (Ivanovic and Nenadovic, 1999). The reduction in larval period with increase in temperature owing to increased metabolic activity and feeding activity has also been suggested in predaceous coleopterans (Srivastava and Omkar, 2003;

Omkar and James, 2004; Omkar and Pervez, 2004). It is probable that the pupa spent more of its time in soil at 20oC so as to avoid the low ambient temperature. The soil probably works as a protective layer. Exposure to higher temperature reduces the developmental period of different immature stages and consequently increases the developmental rate, as was also reported in other studies (Obrycki and Tauber, 1982; Ali Khan and Yousuf, 1986; Orr and Obrycki, 1990; Ponsonby and Copland, 1996; Levesque et al., 2002).We saw significant differences in development time of all life stages, though the effect varied among stages and was least pronounced in pupae. In Z. bicolorata, eggs suffered maximum mortality at higher extremes of temperature (35oC) and those that failed to hatch became flaccid and wrinkled. It appears that the egg contents are perhaps denatured or even desiccated at high temperature as their colour changed from yellow to brownish yellow. Of the immature stages, first instars suffered the highest mortality between 20oC and 30oC with the extremes of temperature tending to be deleterious for their survival. The developmental period of all the immature stages and reproductive attributes depended significantly on temperature.

Acknowledgement:

The authors are thankful to University Grant Commission (UGC), New Delhi for providing the financial assistance and also thankful to Principal S.M.M. College of Science, Nagpur, India for providing laboratory facilities.

Reference:

Ali Khan M. A. and Yousuf M. (1986): Temperature and food requirements of Cheilomenes sexmaculata (Coleoptera:Coccinellidae). Environmental Entomology 15, 800–802.

Dhileepan K. (2009): Managing Parthenium across diverse landscapes: prospects and limitations. In: Management of Invasive Weeds (Inderjit, ed.), 227-259.

Dhileepan K. and Senaratne K.A.D.W. (2009): How widespread is Parthenium hysterophorus and its biological control agent Zygogramma bicolorata in South Asia? Weed Research 49:557–562.

Frazer B. D. and McGregor R. R. (1992): Temperature dependent survival and hatching rates of eggs of seven species of Coccinellidae. Canadian Entomologist 124, 305–312.

Ivanovic J. and Nenadovic V. (1999): The effect of diet and temperature on the life cycle of phytophagous insects. Pesticides 14, 309–327.

Jayanth K.P. (1987): Introduction and establishment of Zygogramma bicolorata on Parthenium hysterophorus at Bangalore, India. Current Science. 56:310-311.

Levesque K. R., Fortin M. and Mauffette Y. (2002): Temperature and food quality effects on growth, consumption and post- ingestive utilization efficiencies of the forest tent caterpillar Malacosoma disstria (Lepidoptera: Lasiocampidae). Bulletin of Entomological Research 92, 127–136.

Mahadevappa M. (2009). Parthenium: Insight into its Menace and Management. Studium Press (India) Pvt. Ltd., New Delhi, India. McFadyen

R. E. C. (1998): Biological control of weeds. Annual Review of Entomology 4, 369–393.

McFadyen R.E. and McClay A.R. (1981): Two new insects for the biological control of Parthenium weed in Queensland. In: Proceedings of the Sixth Australian Weeds Conference (Wilson B.J. and Swarbrick J.D. eds.), 145– 149. Weed Science Society of Queensland, Queensland, Australia.

Obrycki J. J. and Tauber M. J. (1982): Thermal requirement for the development of Hippodamia convergens (Coleoptera: Coccinellidae). Annals of the Entomogical Society of America 75, 678–683.

Omkar and James B. E. (2004): Influence of temperature on the survival, development of immature stages and reproduction of a ladybeetle, Coccinella transversalis Fabricius. Entomon 29, 1–11.

Omkar, Singh S. K., Pervez A. and Mishra G. (2004): Age specific fecundity and natality life-table of an aphidophagous ladybird, Cheilomenes sexmaculata. Biological Memoirs 30, 20–25.

Orr C. J. and Obrycki J. J. (1990): Thermal and dietary requirements for development of Hippodamia parenthesis (Coleoptera: Coccinellidae). Environmental Entomology 19, 1523–1527.

Ponsonby D. J. and Copland M. J. W. (1996): Effect of temperature on development and immature survival in the scale insect predator, Chilocorus nigritus (F.) (Coleoptera: Coccinellidae). Biocontrol Science and Technology 6, 101–109

Srivastava S. and Omkar (2003): Influence of temperature on certain biological attributes of a ladybeetle, Coccinella septumpunctata Linnaeus. Entomologia Sinica 10, 185–193.

Sushilkumar (2005): Biological control of Parthenium through Mexican beetle (Zygogramma bicolorata), National Research Centre for Weed Science, Jabalpur : 87.