Open Access

J. Glob. Innov. Agric. Sci., 2024, 12(x): xxx
ISSN (Online): 2788-4546; ISSN (Print):2788-4538
DOI: https://doi.org/10.22194/JGIAS/24.1493
http://www.jgiass.com

Society for Innovative Agiculture

Impact of Different Diets and Temperature Exposure Intervals on the Biology and Mortality of Dhora Beetle (*Challosobrochus chinensis*: Coleoptera)

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Pulse beetle caused severe damage to the pulses stored for food and seed purpose. This pest is can be Trolled by phosphine fumigation and synthetic insecticides but resistant and residual causes major problems. The experiment was conducted in a stored grain laboratory at ERI, Faisalabad. Twenty dhora beetles were released on three different pulses (chickpeas, kidney beans, and lentils) to evaluate the impact of offered diets on the developmental parameters of *C. chinensis*. The results represented that the offered cereals have a significant impact ($p<0.05$) on the tested developmental parameters with the shortest larval, pupal and adult longevity has been recorded in the case of chickpea cereal with a maximum percentage damage was 57.65% to these grains. In another experiment where insects were exposed to various temperatures i.e. -5 to 40ºC for 10, 30, 50 and 90 minutes and mortality was recorded. Maximum mortality was observed at an extreme temperature 40ºC followed by -5ºC while the mortality level declined as the temperature moved towed room temperature (25ºC) so at 20ºC minimum mortality was observed. The exposure time period also affects the percentage mortality of dhora beetle. Highest mortality was observed at the maximum exposure time period at all levels of the temperature while declined in mortality as exposure time decreased.

Keywords: Dhora beetle, lethal time, temperature, population development, biology, percentage mortality, survival

INTRODUCTION

Legumes play vital role in the diets for developing countries, including Pakistan (Murrell, 2016; FAO, 2018). Dhora beetle (*C. chinensis* L.) Red Flour beetle (*T. castaneum* H.) and saw toothbeetle (*O. surinamensis* L.) are major devastating insect pests for stored grain, particularly pulses (Bhalla *et al*., 2008; Asid, 2015; Sharma, 1984; Egesa *et al*., 2016). Dohra beetles are the most common pests in stored grains including different pulses (Ahmed *et al*., 2001; Aslam, 2004). Pulse beetle (*Callosbruchus chinesis*) may cause major damage to the stored pulses mostly chickpea. (Akhtar *et al*., 2022; Perzada, 2022). The infestation affects pulses viability and other quality metrics (Alemayehu and Getu, 2015). Mungbean and chickpeas appear to be the most prevalent and ideal hosts for *C. chinensis* in terms of egg-laying preference, larval emergence and adult emergence (66.11–70.29%) and stored pulses loss (50.37–57.58) (Ali *et al*., 1999; Akhtar *et al*., 2022). These Pests can be prevented and controlled using many approaches, including chemical treatments, ultrasounds, and traps (Malik *et al*., 2023). Zinc Phosphide and other chemicals have been employed for the past 50 years to reduce stored grain insect pests, but their residues cause environmental pollution and the development of insect resistance (Ahmedani *et al*., 2007; Akhtar *et al*., 2022). Now, various stored grain insect pests from different region particular *R. dominica* are highly resistant to phosphine gas, which was an considered as Most effective fumigant for long-

Ali, Q., A. Aslam, S.M. Hussain, H. Malik, M. Shehzad, T. Nazir, M. Arshad, I. Nadeem, M.F. Akhtar, M.K. Malik, M.B.B. Iqbal, M.J. Saleem, N.A. Anjum and H.U. Shakir. 2024. Impact of Different Diets and Temperature Exposure Intervals on the Biology and Mortality of Dhora Beetle (*Challosobrochus chinensis*: Coleoptera). Journal of Global Innovations in Agricultural Sciences 12(x): xxxxx.
[Received 6 July 2024; Accepted 30 Aug 2024; Published (online) 9 Sep 2024]

term pest control (Awais *et al*., 2020). Non-judicious use of synthetic pesticides for stored insect pest management has revealed various adverse impacts on the climate change and caused the poisoning of beneficial organisms (Rajasri and Rao, 2013).The use of different chemicals to control insect pests has numerous disadvantages, including the fact that many insecticides have a severe impact on animals as well as human health causing a variety of diseases (Bhalla *et al*., 2008; Tahmasebi, 2022). The egg-laying capacity of the store grain insect pest, particularly the dhore beetle, is decreased at extreme temperatures, such as high and low temperatures (Kamble *et al*., 2016). As a non-invasive and safe alternative, many countries currently utilize the manipulation of temperature to manage insects instead of chemicals. they optimize the suitable temperature to illuminate the infestation and ensure that no insecticide residues contamination occurs (Alemayehu and Getu, 2015). Different pulses also impact the life cycle of the dhora beetle (Bhattacharya and Banerjee, 2001). There are no dhora beetle-resistant pulses available for storage. So understanding the host range and biology of the dhora beetle is very important to minimize the pest incidence. For this purpose, the biological life cycle on different three important pulses i.e. kidney beans, chickpeas, and lentils were studied to assess the host preference of *C. chinensis*. In present study dhora beetle was also exposed to different temperature for different time period to evaluate the best storage temperature.

MATERIALS AND METHODS

The experiment was executed at stored grain laboratory (SGL) at Entomological Research Institute, Ayyub Agricultural Research Institute, Faisalabad.

***Collection and rearing of insect*:** The population of dhora beetle was collected from grain market Faisalabad. Collected dhora beetle was reared in the Glass Jars (05 litter capacity) under controlled conditions (temperature: 32±2 °C, humidity: 70±5% and Dark and light hours (12: L and 12: D)). After 72 hours, the adults of the dhora beetles were removed from the Jars for the development of the homogenous population and this process was repeated for next three generations. Homogeneous population was maintained for further experiment.

***Influence of diet on the biology of the dhora beetle*:** Three different pulses (chickpeas, kidney beans, and lentil) were used in the study. Each treatment was replicated three times. All pulses were sterilized at 70°C in incubator for 15 minutes than put into the glass jars (2.5 litter capacities). The opening mouth of the jars was covered with muslin cloth. Twenty adults of dhora beetle were released in each replicate. Insects were released on pulses (chickpeas, kidney beans, and lentil) to check the egg laying preference, larval emergence, larval developmental time period, pupal developmental time period and adult longevity (male and female longevity). Oviposition (number of eggs laid on seeds/grains/pulses), larvae emergence (number eggs hatched), adult emergence (adults emergence holes on seeds), Damage to seeds by *C. chinensis* was established by the round shaped exit holes on the seed coat which was made by newly emerged adults while weight loss due to Dhora beetle of each pulses was assessed by measuring the weight of fresh seeds of each pulses (n_2) and weight of damaged seed/grains due to dhora beetle (n_1) with the weighing balance (G&G®, Capacity 220g) and losses of grains were assessed by using the following formula:

$$\text{Total grain loss (\%)} = \frac{n2-n1}{n2} \times 100$$

In order to calculate the developmental durations, one day old dhora beetle was released on three different cereals, allowed to lay eggs, after that each cereal containing one egg each was placed in growth chamber to estimate larval, pupal and adult duration respectively.

***Effect of temperature and exposure time period*:** Insects were exposed to -5, 15, 20, 25, 30, 35 and 40 ºC for 10, 30, 50 and 90 minutes. Each treatment was replicated three times. The chickpea was sterilized at 70°C for 15 minutes and then put into the glass jars (2.5 litter capacities). Twenty adults of homogenous population of dhora beetle were released into the Jars containing Chickpea. The Jars were paced in the incubators at required temperature of each treatment for 10, 30, 50 and 90 minutes. Then the Jars were placed at favorable temperature for 72 hours and data regarding percentage corrected mortality was observed. Corrected mortality was calculated from observed mortality data using Abbott's formula.

***Statically analysis*:** The recorded Data was analyzed by analysis of variance (ANOVA) by using STATISTICA software. The significant result was compared using tukey's HSD test.

RESULTS AND DISCUSSION

***Influence of diet on the biology of the dhora beetle*:** The results are significantly different from each other so each pulses produces significant impact on the biology of the dhora beetle. The results revealed that the highest number of eggs was laid during first couple days (17.33 and 19.33 during first and second day respectively) while after the third day of observation gradually egg laying capability of dhora beetle declined (7.00 and 5.67 during the fourth and fifth days of observation respectively). Dhora beetle preferred the chickpeas (27.33) for egg laying while lentil was minimum preferred (14.67) (Figure 1) but Yunus *et al*., 2015 conducted studies on five different pulses and contradicted with present studies and described that dhora beetle showed maximum preference to kidney beans (147.67) followed by mung beans (132.67) while minimum preferred chickpeas (63.00).

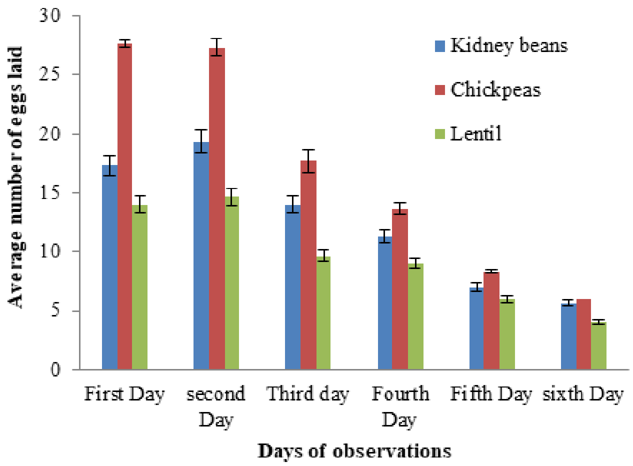

Figure 1. Impact of three different pulses (kidney beans, chickpeas and lentils) on egg laying preference by Dhora beetle.

The impact of three types of pulses (kidney beans, chickpeas, and lentils) was examined for larval emergence from the eggs. All pulse significantly impacted on larval emergence from the eggs. The results revealed that the highest eggs were hatched on 3rd (8.00) and 5th days (11.00) while the lowest larval emergence was observed on 2nd (3.67) and 10th (2.33) days of observation. Maximum eggs were hatched on chickpeas (11.00) while minimum larval emergence was observed on lentil (8.00) on 5th days of observation (Figure 2). Miah, 2020 examined the preference of two species of dhora beetle 09 varieties of mungbean and described that no significant impact on larval emergence of dhora beetle on different varieties of the mungbean. Khedkar *et al*., 2023 described the partially similar results as he observed that the maximum percent larval emergence was found to be on ICCL-86111 (87 percent) while lowest on BDN-9-3.

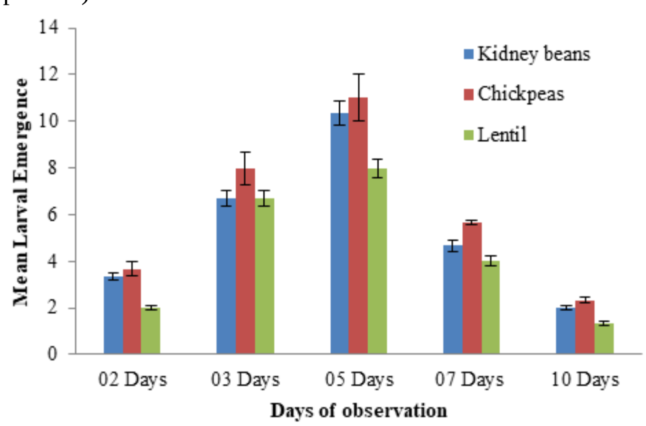

Figure 2. Impact of three different pulses (kidney beans, chickpeas, and lentil) on mean larval emergence preference by Dhora beetle.

Similarly, all three tested pulses significantly impacted on the adult emergence. The results revealed that the highest adult emergence was observed on 25th (12.67) and 30th (9.67) days while the minimum emergence was observed on 35th (2.33) days and 15th (0.67) days of observation after hatching of the eggs. Maximum adult emergence was observed in the case of chickpea (14.00) while minimum adults were observed in the case of lentils (11.00) on the 25th days of observations (Figure 3). Khedkar *et al*., 2023 results were also partially similar to studies as he considered the different verities of one pulses. He observed that highest number of adults were emerged (75.00 percent) from Phule vikrant. Goutam *et al*., 2018 also observed in line results and described that the average adult emergence period required for dhora beetle was 29.0 days.

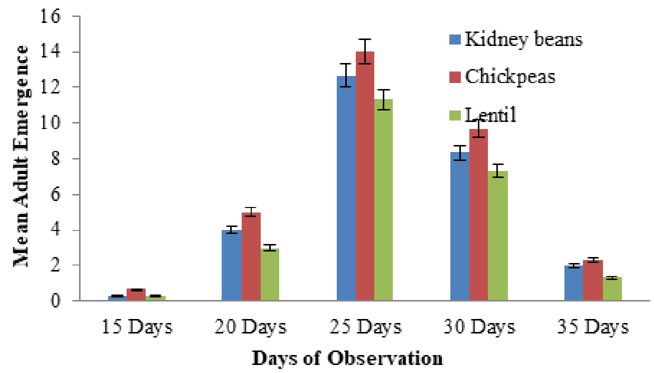

Figure 3. Impact of three different pulses (kidney beans, chickpeas, and lentils) on adult emergence by Dhora beetle.

The impact of different type of pulses on the biology of dhora beetle was examined by feeding beetle on three different types of pulse. Significant difference among the biological attributes associated with the type of feed offered to *C. chinensis* has been recorded ($P<0.05$). The results in table 1 represents that shortest larval longevity has been recorded in case of chickpea cereal (15.60) while longest larval developmental time period was observed in lentil (24.00). Similarly, longest pupal duration was observed in lentil (7.50) while shortest duration was observed in the case of chickpeas (4.30). The results showed that adult longevity for both male and female was longest in the case of lentil (9.94 and 12.00 respectively) while shorted male and female longevity was observed in chickpeas (6.60 and 9.12 respectively) (Table 1). Hosamani *et al*., 2018 observed similar results and described that the shortest average incubation, larval and pupal perod was observed in chicpeas (4.0, 12.0, 6.0, 9.0 respectively) while the longest period was observed in the case of cowpeas (4.0, 14.0, 6.0, 7.0 respectively). Jaiswal *et al*., 2018 conducted studies on biology of C. chinensis but he considered only various varieties of the one pulses i.e. chickpea and observed similar results of developmental time period of dhora beetle. He observed that adult life spane for male was 9.30 days while female live longer for 10.05 days. Mishra *et al*., 2023 elauate the life span of dhora beetle on chickpeas and observed the partially similar results because they worked only on one pulses i.e. chickpea and described that the oviposition period was 5.33 days while in the case of a larval and pupal period, it took 22 days. Male longevity was recorded as 8.0 whereas female longevity was 10.33 days. Khedkar *et al*., 2023 results was also partially similar to studies as he considered the different verities of one pulses. He found that the longest male adult longevity was 10.00 days on BDN-9-3 While female longevity was on Phule Vikram (12.91 days). The maximum percent larval emergence was found to be on ICCL-86111 (87 percent) while lowest on BDN-9-3. Maximum larval-pupal life span was observed on BDN9-3 (26.26 days) whereas minimum on ICCL-86111 (24.12 days). Highest male longevity was observed in Digvijay (8.87 days) and the lowest of females in ICCCV-3137 (9.98 days). Augustine and Balikai, 2019 evaluate the host preference of the dhora beetle on cowpeas and observed that the incubation period of the eggs of dhora beetle was 4.6 ± 0.70 days while the total development period was 30.90 ± 4.28 days. The females of the dhora beetle lived longer (9.50 ± 1.58 days) as compared to the male (8.30 ± 1.25 days). Goutam *et al*., 2018 also described the similar results that larval and pupal duration was 12.0 and 7.0 days respectively but he reared the pulse beetle on gram seeds.

Table 1. Impact of three different pulses (kidney beans, chickpeas and lentil) on the biology of Dhora beetle.

Diet	Larval duration	Pupal duration	Male longevity	Female longevity
Chickpea	15.6±1.01a	4.3±0.44a	6.6±0.96a	9.1±0.73a
Kidney bean	20.0±0.89b	7.1±0.79b	9.9±0.71b	11.4±0.44b
Lentil	24.0±0.63c	7.50±1.2c	9.9±1.2c	12±0.96c

A significant difference (P<0.05) among the grain damage (%) by *C. chinensis* when fed on three different cereals has been recorded. The maximum damage to grains (57.65%) was recorded in the case of chickpeas while 44.96% damage to kidney bean grains was recorded (figure 4). Aslam *et al*., 2018 results are partially correlated with this study because he worked on lesser grain borer with different set of diets and he observed that maximum attack was observed on oat diet as compared to the others. Perzada, 2022 depicted that *C. maculatus* (Coleoptera: Bruchidae) caused serious grain weight losses of pulses as compared to other insect pests.

Influence of temperature and exposure time period: The graph shows that maximum mortality was observed at extreme temperature 40ºC followed by -5ºC while mortality level declined as the temperature moves towed room temperature (25ºC) so at 20ºC minimum mortality was observed. Exposure time period also affects the percentage mortality of dhora beetle. highest mortality was observed at maximum exposure time period at all levels of the temperature while declined in mortality as exposure time decreased (Figure 3). Ahmad, 1989 described the similar results and observed that stored grain insect pests liked to develop pest populations narrow range of temperatures (15º and 35ºC). Hence for disinfection from stored grain insect pests, the temperature (50-60 ºC) of the stored area or equipment should be raised for a specific period to eliminate the insects. Bhalla *et al*., 2008 also described the results in line and mentioned that raising the temperature to 50ºC by introducing the high temperature through the stored house and this eliminate almost all kind of insect pests. Aslam *et al*., 2018 results are partially correlated with this study because he worked on lesser grain borer with different set of diets. He observed that temperature was directly affected the development of the lesser grain borer. Hasan *et al*., 2017 depicted the similar results but he also execute trial on different stored grain insect pest (rice weevil) as he observed that rice weevil has significantly influence by manipulation of temperature.

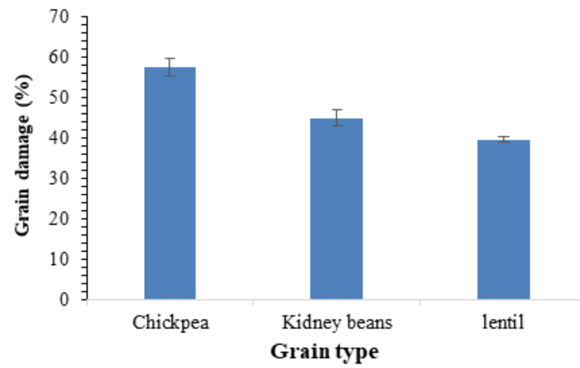

Figure 4. Impact of three different pulses (kidney beans, chickpeas and lentil) on grain damage by Dhora beetle.

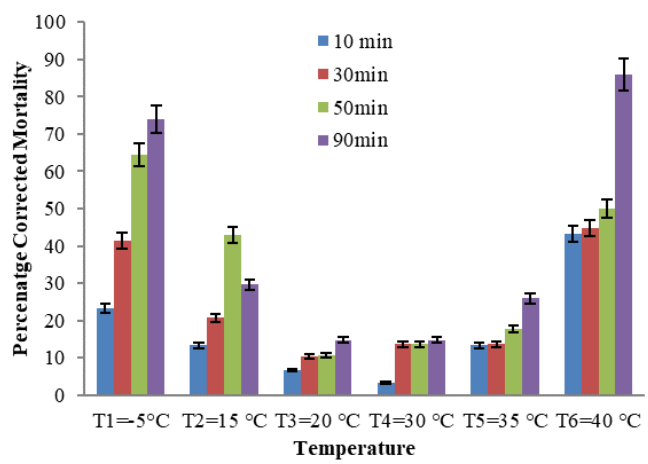

Figure 5. Percentage corrected mortality of Dhora beetle at different temperature and exposure time period.

Conclusion**:** The study concluded that pulses significantly impacted on the egg laying preference, egg hatching, adult emergence and biology of the dhora beetle. Similarly, different temperature regimes and exposure time period also significantly impacted on the mortality of the dhora beetle. Based on the findings of current research the temperature, which adversely effects the beetles has been explored so if the grains are exposed to that temperature for optimum time, grain damage due to stored insects could be declined.

Authors' contributions**:** Q. Ali and H. Malik supervise and design the research, A. Aslam corresponded the research paper, conduct the research and write the research article, S. M. Hussain and M. Arshad Provide research material, T. Nazir and M. shehzad Proof read the manuscript, M. F. Akhtar, M. K. Malik M. J. Saleem statistically analyzed the data, I. Nadeem, M. B. B. Iqbal, N. A. Anjum, H. U. Shakir helped in writing the manuscript and interpretation of data.

Conflict of interest**:** The authors declare no conflict of interest.

Acknowledgement**:** All Authors acknowledged the Entomological Research Institute, Faisalabad for provided a platform to conduct research,

Ethical statement**:** Not Applicable

Availability of data and material**:** We declare that the submitted manuscript is our work, which has not been published before and is not currently being considered for publication elsewhere.

Code availability**:** Not applicable.

Consent to participate**:** All authors submitted consent to publish this research article in JGIAS

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