Journal of Advances in Biology & Biotechnology

Volume 27, Issue 8, Page 655-660, 2024; Article no.JABB.120017
ISSN: 2394-1081

Impact of Different Food Sources on the Developmental Biology and Host Preferences of the Red Flour Beetle *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae)

Sake Manideep [a*], S.N. Salma Banu [a], Talapala Sai Kumar [a], S.V. Sangeetha [a], Tulasi B [a], S. Padmashree [a], K. Kruthi Reddy [a] and K.S. Kedswin [a]

[a] Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore (Tamil Nadu), India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/jabb/2024/v27i81180

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/120017

Original Research Article

Received: 25/05/2024
Accepted: 26/07/2024
Published: 30/07/2024

ABSTRACT

An experiment conducted at the seed center laboratory at Tamil Nadu Agricultural University during June 2022 evaluated the host preferences and developmental biology of the red flour beetle *(Tribolium castaneum)* across three food sources*:* broken rice with rice flour, broken wheat with wheat flour, and tapioca flour*.* Beetle development was observed in ventilated containers under controlled conditions *(*28-30°C, 65% relative humidity*)* with 25 beetles per container*.* Significant differences in beetle survival and development*.* Wheat flour was the most favourable host, with 304

**Corresponding author: E-mail: sakemanideep15@gmail.com;*

Cite as: *Manideep, Sake, S.N. Salma Banu, Talapala Sai Kumar, S.V. Sangeetha, Tulasi B, S. Padmashree, K. Kruthi Reddy, and K.S. Kedswin. 2024. "Impact of Different Food Sources on the Developmental Biology and Host Preferences of the Red Flour Beetle Tribolium Castaneum (Herbst) (Coleoptera: Tenebrionidae)". Journal of Advances in Biology & Biotechnology 27 (8):655-60. https://doi.org/10.9734/jabb/2024/v27i81180.*

live adults, followed by broken wheat (145 live adults. Rice flour supported 20 adults and 11 larvae, indicating moderate suitability. Whole rice grains and tapioca flour were the least effective, with only dead adults and few larvae. Despite host quality variations, the developmental stages (egg incubation: 4-7 days, larval: 65-70 days, pupal: 6-9 days) were consistent across food sources. Wheat flour is the most supportive environment for *T. castaneum* development.

Keywords: Red flour beetle; post-harvest food loss; pest; wheat flour; rice; tapioca flour.

1. INTRODUCTION

Post-harvest food losses during storage are significant and arise from various factors, including pest infestations, which can cause considerable damage to stored cereals, pulses, and oilseeds depending on the crop, storage conditions, and post-harvest processing methods [1,2,3]. Among the pests, the red flour beetle (*Tribolium castaneum* Hbst.) is problematic in tropical regions. As a secondary pest, the beetle primarily infests grains that are already damaged and cannot penetrate intact grains [4]. It thrives on a variety of stored products, including wheat flour, dried fruits, and legumes, due to its adaptability to low humidity conditions, which are facilitated by specialized cryptonephridial conditions [5]. The red flour beetle's feeding habits reduce the mass and quality of stored grains, increase their moisture content and temperature, and can lead to a significant decrease in germination capacity [6,7]. Furthermore, heavy infestations result in discoloured, mold-prone flour with a disagreeable odor due to the beetles scent glands [8,9].

The life cycle of red flour beetles includes the egg, larval, pupal, and adult stages, with the most prolific reproductive period occurring between one week and two months post-emergence [10]. Females lay hundreds of eggs throughout their lifespan, contributing to the beetle's high infestation potential [11]. The ability of the species to reproduce continuously in warm conditions further intensifies its pest status. Effective pest management strategies necessitate understanding the beetle's biology and development, such as determining the number of larval instars through measurements like head capsule width, following Dyar's rule [12,13]. Additionally, diet plays a crucial role in beetle development and reproductive success, with larger amounts of flour supporting higher oviposition rates and faster development [14]. The present study focused on the biology and host preferences of red flour beetles across various substrates, including wheat flour, broken wheat, rice flour, rice, and tapioca flour.

2. MATERIALS AND METHODS

To investigate the host preferences and developmental biology of the red flour beetle (*Tribolium castaneum*), three food sources were prepared: broken rice with rice flour, broken wheat with wheat flour, and tapioca flour. Each combination was placed in separate ventilated plastic containers covered with a muslin cloth. Mixed-age adult beetles were introduced at a sex ratio of 1 female to 4 males, with 25 beetles (5 females and 20 males) per container. The containers were maintained at a constant temperature of 28-30°C and 65% relative humidity. Adult red flour beetles used in this study were sourced from the seed center laboratory located adjacent to TNAU and RI College. Beetle development was monitored daily, and the duration of each developmental stage was recorded, including the incubation (egg to larva), larval (larva to pupa), and pupal (pupa to adult) periods. Observations were made using a digital microscope. Each treatment was replicated three times to ensure the reliability of the results, with appropriate controls were maintained to account for external variables. Statistical analysis was performed using software like SPSS to study the effect of different host materials on insect populations. Using descriptive statistics, data was summarized and analyzed by ANOVA for significant differences between the groups.

3. RESULTS

The study on the host preferences and developmental biology of the red flour beetle (*Tribolium castaneum*) revealed notable differences in the survival and development of the beetles across various food sources.

The biology of the red flour beetle (*Tribolium castaneum*) encompasses distinct developmental stages, starting with an egg period that lasts between 4 to 7 days. Following this, the beetle enters the grub (larval) period, which spans 65 to 70 days and involves progression through 1 to 6 instars. The pupal period, during which the beetle

transforms from larva to adult, lasts for approximately 6–9 days. The adult longevity of the red flour beetle varies significantly depending on the host food source, with some adults surviving for extended periods when provided with optimal nutrition. This variation in lifespan highlights the impact of host quality on the life cycle and reproductive success of beetles.

Wheat flour was identified as the preferred host, yielding the highest total adult population of 304 live beetles. This indicates that wheat flour provides the most conducive environment for the beetle's life cycle, supporting optimal conditions for reproduction and survival. Broken wheat was the second most favourable host, with 145 live adults, demonstrating its significant suitability for beetles. Both wheat-based hosts are highly supportive of the developmental needs of beetles.

In comparison, rice flour was preferred to support 20 live adults and 11 larvae. This suggests that although rice flour is adequate for the early stages of beetle development, it may not be as supportive of adult survival and longevity. Whole rice grain, on the other hand, showed poor suitability, with only 12 dead adults and 2 larvae observed, indicating that it does not provide suitable conditions for beetle development. Tapioca flour was found to be the least preferred host, with 12 dead adults and no larvae, highlighting its inadequacy as a beetle food source.

Despite the differences in host suitability, the developmental stages, including the incubation period (4-7 days), larval period (65-70 days), and pupal period (6-9 days), were relatively consistent across all food sources. However, the study noted significant variations in adult multiplication and longevity, which were influenced by the type of host. These results suggest that although the early stages of the beetle’s life cycle can be supported by a variety of food sources, the quality of the host plays a crucial role in adult survival and reproductive success. The findings emphasize that wheat flour is the most favourable environment for the red flour beetle’s life cycle, followed by broken wheat, with rice flour being moderately suitable, and whole rice grain and tapioca flour being less effective, particularly the latter, which is unsuitable for supporting the beetle’s development and survival. The results did not differ significantly, indicating that host materials did not greatly affect the overall insect population.

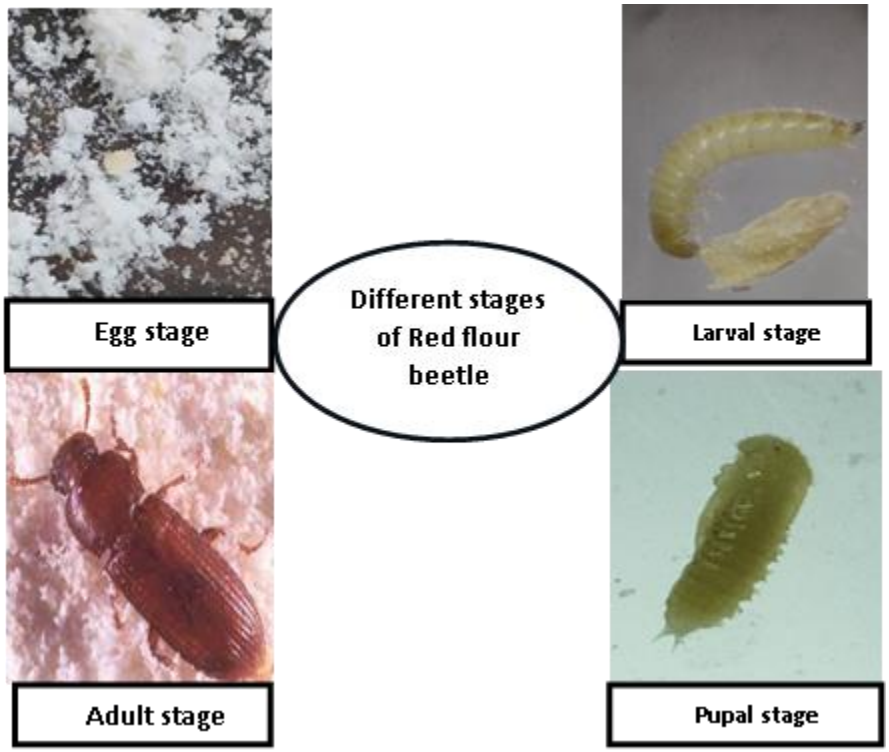

Fig. 1. Life stages of red flour beetle

Table 1. Host preference and population dynamics of red flour beetle across various flour and grain types

Parameters	Wheat Flour	Broken Wheat	Rice Flour	Whole Rice Grain	Tapioca flour
Total adult population	304 live	145 live	20 adults 11 larva	12 Dead 2 larva	12 dead
Host Preference	Most preferred	Most preferred	Preferred	Less Preferred	Least preferred

Fig. 2. Red flour beetles from different hosts

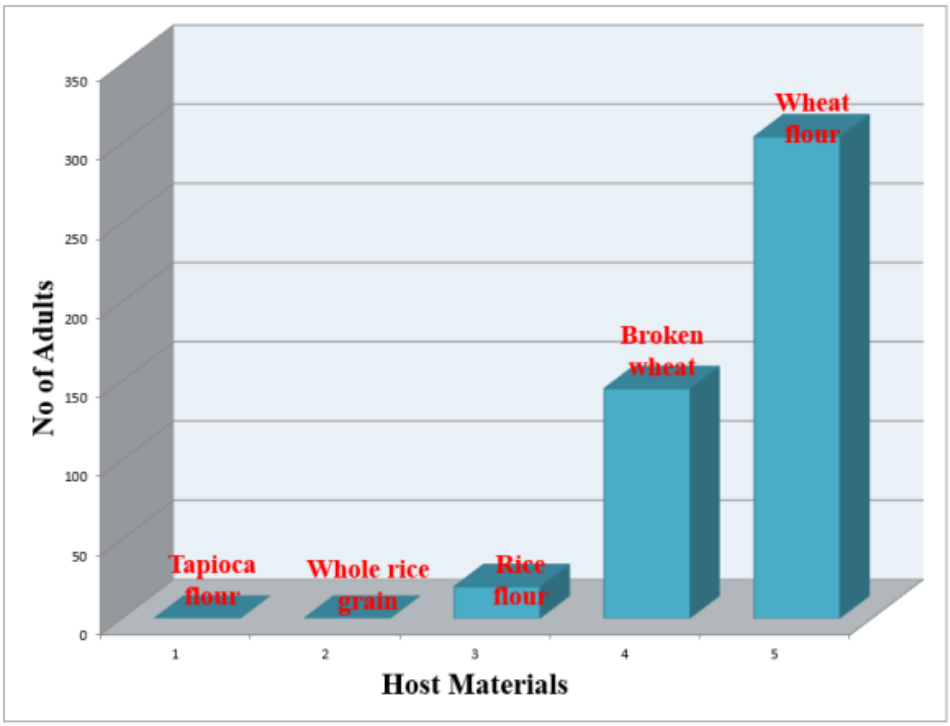

Fig. 3. Number of adult insects in different host materials

Table 2. Descriptive statistics of insect populations

Parameter	Live Adults	Live Larva	Dead Adults	Total Population
Count	5	5	5	5
Mean	93.8	2.6	7.2	103.6
Standard Deviation	132.1	4.8	6.6	124.5
Minimum	0	0	0	12
25th Percentile	0	0	0	14
Median	20	0	12	43
75th Percentile	145	2	12	145
Maximum	304	11	12	304

Table 3. ANOVA test results

Source of Variation	Sum of Squares	df	Mean Square	F Value	P Value
Host Preference	49,324.7	3	16,441.57	1.30	0.5549
Residual	12,640.5	1	12,640.5		

Tribolium castaneum, commonly known as the red flour beetle, exhibits a marked preference for wheat flour, which serves as a suitable host for its development [15,16]. El-Desouky et al. [9] showed that higher densities of *T. castaneum* in wheat flour result in increased production of benzoquinone secretions, indicating a preference and better adaptability of the beetle to this substrate. Larval development is notably quicker in cracked wheat than in other substrates, whereas cracked maize tends to have lower fecundity [17]. The study of the life cycle of *T. castaneum* [18] on different cereal flours highlighted wheat flour as a favourable host due to its ability to sustain the growth and development of the pest insect [15]. The findings of this study align with those of previous studies, demonstrating the suitability of wheat flour as a host for *T. castaneum*. This study shows that wheat flour effectively supports the lifecycle and development of *T. castaneum*, particularly when compared with rice and tapioca flour [5,10].

4. CONCLUSIONS

Based on our experiment to study the biology and host preferences of red flour beetle with 5 different hosts such as wheat flour, broken wheat, rice flour, rice, and tapioca flour. Based on our observations, the incubation period, larval period, and pupal period were more or less equal in all host ranges, whereas adult multiplication and longevity varied with host, which reveals that among the five hosts, wheat flour (adult – 304 live) was the most preferred host, followed by broken wheat (adult – 145 live).

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during writing or editing of manuscripts.

ACKNOWLEDGEMENT

The authors are thankful to Tamil Nadu Agricultural University and Seed Center for providing facilities for the conduct of experiment. We extend our gratitude to Dr. R. Arul Prakash, Associate Professor (Agricultural Entomology) at Tamil Nadu Agricultural University for his guidance throughout the experiment.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Kitinoja L, Gorny JR. Postharvest technology for small-scale produce marketers: Economic opportunities, quality and food safety. University of California Postharvest Horticulture Series No. 21; 1999.
2. Musa SK. Reduction of postharvest losses in vegetables and fruits in a developing country. In J. V. McLoughlin & B. M. McKenna (Eds.), Food Science and Technology: Present Status and Future Direction. Boole Press Ltd. 1984; 165-176.

3. Tindall HD, Proctor FJ. Loss prevention of horticultural crops in the tropics. Progress in Food and Nutritional Science. 1980;4(3-4):25-40.
4. Howe RW. The effect of temperature and humidity on the rate of development and mortality of *Tribolium castaneum* (Herbst). Annals of Applied Biology. 1956;44:356-368.
5. Richards S, Gibbs RA, Weinstock GM, Brown SJ, Denell R, Beeman RW, Sattelle DB. The genome of the model beetle and pest *Tribolium castaneum*. Nature. 2008; 452(7190):949-955.
6. Padin S, Dal Bello G, Fabrizio M. Grain loss caused by Tribolium castaneum, Sitophilus oryzae, and Acanthoscelides obtectus in stored durum wheat and beans treated with Beauveria bassiana. Journal of Stored Products Research. 2002;38:69-74.
7. Faroni LRDA, Sousa AH. Aspectos biológicos e taxonômicos dos principais insetos-praga de produtos armazenados. In Tecnologia de armazenagem em sementes. Campina Grande: UFCG. 2006; 1:371-402
8. Good NE. The flour beetles of the genus *Tribolium castaneum*. Technical Bulletin of the U.S. Department of Agriculture, No. 498. 1936;57.
9. El-Desouky TA, Elbadawy SS, Hussain HBH, Hassan NA. Impact of insect densities *Tribolium castaneum* on the benzoquinone secretions and aflatoxins levels in wheat flour during storage periods. Open Biotechnology Journal. 2018;12:104-111.
10. Park T. Studies in population physiology: The relation of numbers to initial population growth in the flour beetle *Tribolium confusum* Duval. Ecology. 1932;13(2),: 172-181.
11. Bennett S. *Tribolium confusum* (Confused Flour Beetle) and *Tribolium castaneum* (Rust Red Flour Beetle). Journal of Applied Bioscience. 2003;3(93):827-835.
12. Panzavolta T. Instar determination for *Pissodes castaneus* (Coleoptera: Curculionidae) using head capsule widths and lengths. Environmental Entomology. 2007;36:1054-1058.
13. Cazado LE, Van Nieuwenhove GA, O'Brien CW, Gastaminza GA, Murua MG. Determination of number of instars of Rhyssomatus subtilis (Coleoptera: Curculionidae) based on head capsule widths. Florida Entomologist. 2014;97:639-643.
14. Campbell JF, Runnion C. Patches exploitation by female red flour beetles, *Tribolium castaneum*. Journal of Insect Science. 2003;8(3):20.
15. Soomro F, Ahmed W. Study on the life cycle of *Tribolium castaneum* (Coleoptera: Tenebrionidae) on different cereals; 2023.
16. Astuti LP. Host preference of *Tribolium castaneum* (Herbst) on six kinds of flour. Indonesian Journal of Entomology. 2020;17(3):456-507.
17. Skourti A, Kavallieratos NG, Papanikolaou NE. Suitability of semolina, cracked wheat, and cracked maize as feeding commodities for *Tribolium castaneum* (Herbst; Coleoptera: Tenebrionidae). Insects. 2020;11(2):99.
18. Kayode OY, Adedire CO, Akinkurolere RO. Influence of four cereal flours on the growth of Tribolium castaneum Herbst (Coleoptera: Tenebrionidae). Ife Journal of Science. 2014;16(3): 505-516.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/120017