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EFFECT OF TEMPERATURE ON THE COMPETITIVENESS OF THREE STORED PRODUCT INSECTS

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ABSTRACT

Competitiveness is an important feature in insect biology. Three srtored product pests viz., *Trogoderma granarium, Tribolium castaneum, Oryzaephilus surinamensis* were evaluated for their competitiveness at 35, 25 and 40 °C. The results revealed that within 6 months, *T. castaneum* and *O. surinamensis* could not displace the *T. granarium*, but at 35 °C, *T. granarium* was able to displace the *O. surinamensis*. It was found that *T. granarium* at 25 °C continued to be dominant for long periods without being affected by other species. It was in the dormant larval or egg stage despite the death of all adults, and the increased at 40°C.

Key words: *Trogoderma granarium, Tribolium castaneum, Oryzaephilus surinamensis*, superior, competitor, density, heat, determinants, competition, tolerance, preferences, dormancy, displacement, abundance

Competition theory had an important role in the development of general environmental theory and the interpretation of data. Competition is one of the basic vital factors that shape patterns of distribution, increase, and diversity in ecological communities (Tikhonov and Monasson, 2017), Invasive species are thought to be highly competitive, but few have failed to prove themselves. It turns out that competitiveness is related to the biotic resistance (Yannelli et al., 2017). *Trogoderma granarium* larvae have a long dormant period. *Trogoderma granarium, Tribolium castanum*, and *Tribolium confusum*, the number of eggs laid by females was affected by the relative humidity; and *T. castaneum* and *T. confusum* could not lay eggs 20 and 30% RH. Highest percentage of eggs hatched at 50% RH 20% RH prevented the larvae from turning into pupa (Falah ad Azher, 2020). The saw-grain beetle, *Oryzaephilus surinamensis* is an important pest of stored food (May, 2022). Competition among insects increases with the increase with population density and physical closeness. Evolution and competition tend to be stronger between insect food specialists in so far as they affect general feeding. However, specialized overlap is not everything (Bird et al., 2019).

Despite studies on competition behaviour in beetles of stored products, many have focused on competition for one species. This competition is determined by many biotic and abiotic conditions, including temperature and type of food. There is still insufficient information on the effect of these conditions on the competition of *T. granarium* with other insects (Guedes et al., 2010; Oliveira et al., 2015; Kavallieratos, et al., 2017). The present study aims to evaluate the effect of temperature on the the competition between three stored products pests viz., *T. granarium, T. castaneum* and *O. surinamensis*.

MATERIALS AND METHODS

The three species of beetles *T. granarium, T. castaneum* and *O. surinamensis* were obtained from the Store Pests Laboratory, Plant Protection Department, College of Agricultural Engineering Sciences, University of Baghdad. The mass culture was raised on crushed wheat, to detect the dominant species. Three competition experiments were conducted for each two species separately, at three temperatures (25, 35, and 40 °C), and for three storage periods (60, 120, and 180) days. Each treatment was replicated thrice, and each replicate included 20 pairs of adults (Qader et al., 2022). SAS (2018) program was used to evaluate their significance using ANOVA (LSD, p=0.05) was used.

RESULTS AND DISCUSSION

Competition between two types of storage insects and at a temperature of 25 °C and a relative humidity of 65% and periods of 60, 120, 180 days, when evaluated maximum population density (245.67 individuals) for the *T. castaneum*, when competing with the *O. surinammsis*. These environmental conditions are best for *T. castaneum*, but worse for *T. granarium*, whose

larvae have entered a dormant state, or their adults are killed, which did not allow an increase in their population density. The statistical analysis indicated that the results were significant for the change in population density, as well as for the overlap between time and the change in population density. Table 1 reveals the population density and competition between two species at 35 °C and 65% relative humidity at 60, 120 and 180 days, respectively. These data reveal maximum population density @396.67 individuals for *T. castaneum*, when it competed with the *O. surinamensis* @ (30.00 individuals). It is followed by population density @345.33 individuals for *T. granarium*, when it competed with *O. surinamensis*, @ 24.33 individuals. It is followed by the third level of population density, @ 311.66 individuals for *T. castaneum*, when it competed with *T. granarium*, (@139.00 individuals). These environmental conditions show the best for *T. castaneum* and the worst for *O. surinamemsis*. The statistical analysis indicated that the results were significant for the change in population density as well the overlap between time and change in population density. Table 1 reveals that there was a change in the population density when competing between two species and at 40 °C and a relative humidity of 65% in the periods of 60, 120 and 180 days, respectively. Maximum population density was of *T. granarium* (434.3), when it competed with *O. surinamemsis* (12.33 individuals). It is followed by *T. granarium* (383.67) when it competed with *T. castaneum* (98.33 individuals). It was found that these environmental conditions were the best for *T. granarium*, and the worst for *O. surinamemsis*. Statistical analysis indicated the significance of the results, the change in population density and the progression of time, as well as the overlap between them. Thus, the rise in temperature was the most suitable for *T. granarium*, and in all competitions with others temperature of 25 and 30°C, were the most suitable for *T. castaneum*. There are significant differences in the population density of insects at different temperatures and time periods.

These data also revealed that an increase in the storage period does not necessarily lead to an increase in population density. The environmental impact on insects when they compete, it becomes clear that the difference in the population density occurs as a result of the positive or negative effect of temperature and for different periods (Okrikata and Ogunwolu, 2019). A study of the biology of *T. granarium* described its survival as an invasive species, finding that temperature seriously affects population growth. Knowing the insect's potential growth rate also makes it easier to estimate its numbers over time, and therefore its potential outbreaks. at 40^{o}C, the intrinsic rate of increase indicates that in this temperature range, *T. granariun* is able to increase its population size, as well as its ability to spread, becoming more virulent in stored products (Papanikolaou, et al., 2019). The results present study corporates with those of Collins et al. (2019) when analyzing the stability of competing insect species on a single food source dertemine which species win. Present results are also consistent with those of Lee et al. (2020)

Table 1. Two Species of stored insects competed at 25°C; Two types of stored insects competed at 35°C; Two types of stored insects competed at 40.0°C

Species	Time/ days			Mean	Time/ days			Mean	Time/days			Mean
	60	120	180		60	120	180		60	120	180	
	Population density				Population density				Population density			
T. granarium	27	19	12	19.33	177	149	91	139.00	231	400	520.0	383.67
T. castaneum	129	197	261	195.67	272	322	341	311.66	93	132	70.0	98.33
T. castaneum	149	276	312	245.67	293	412	485	396.67	63	183	217	154.33
O. surinamemsis	53	42	18	37.67	47	31	12	30.00	33	0.0	0.0	11.00
O. surinamemsis	192	94	88	124.67	51	22	0.0	24.33	37	0.0	0.0	12.33
T. granarium	62	47	28	45.67	286	351	399	345.33	337	421	545	434.33
Mean	102.00	112.50	119.83	---	187.67	214.50	221.33	---	132.33	189.33	225.33	---

LSD value for time: 29.53 NS, population density: 29.53*, overlap: 52.79*; LSD value for time: 36.97 NS, population density: 44.05*, overlap: 71.24*; LSD value for time: 43.91*, population density: 56.07*, overlap: 78.33*

in which synchronization between species is driven by the environment, while competition between species becomes less positive or more negative. In the same way, the strength of competition has a greater negative effect on the relationship between species when one has a more variable growth rate than the other (Lee, et al., 2020). The type of competitor superior in temperature resistance is superior to other competitors (Bale et al., 2002; Thierry et al., 2019). Non-diapausing larvae were more susceptible than diapausing larvae and showed a delayed response in terms of completing their biology to reach the adult stage, in contrast, diapausing larvae had no delayed response compared to the controls, the life stage with the highest level of tolerance in the eggs (Gourgouta and Athanassiou, 2021). An important component of the biology of *T. granarium* is the long diapause in the larval stage (Athanassiou, 2022). In the study under 25± 1 ºC and 50± 5% RH, *T. castaneum* shows the fastest total development (Đukić et al., 2022).

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AUTHOR CONTRIBUTION STATEMENT

The idea of research, conducting experiments, analyzing the results, and writing was done by the researcher.

CONFLICT OF INTEREST

No conflict of interest.

REFERENCES

Affognon H, Mutungi C, Sanginga P, Borgemeister C. 2015. Unpacking postharvest losses in sub-saharan Africa: A meta-analysis. World Development 66: 49-68.

Athanassiou C. 2022. *Trogoderma granarium* (khapra beetle). www. cabi. org/cpc/DATASHEET/55010. Accessed July 2023.

Bale J S, G J Masters, I D. Hodkinson et al. 2002. Herbivory in global climate change research: direct effects of rising temperature on insect herbivores, Global Change Biology 8(1): 1-16.

Bird G, Kaczvinsky C, Wilson A E, Hardy N B. 2019. When do herbivorous insects compete? A phylogenetic meta-analysis. Ecology Letters 22(5): 875-883.

Collins C M, Bonds J A S, Quinlan M M, Mumford J D. 2019. Effects of the removal or reduction in density of the malaria mosquito, Anopheles gambiae sl, on interacting predators and competitors in local ecosystems. Medical and Veterinary Entomology 33(1): 1-15.

Daily G. 1997. Economic pathways to ecological sustainability. Bioscience 50: 339-345.

Dasgupta P, Levin S, Lubchenco J. 2000. Economic pathways to ecological sustainability. Bioscience 50(4): 339-345.

Đukić N, Radonjić A, Popović B, Kljajić P, Pražič-Golić M, Andrić G. 2022. The impact of the protein-carbohydrate ratio in animal feed and the initial insect population density on the development of the red flour beetle, Tribolium castaneum. Journal of Stored Products Research 97: 101983.

Falah A S, Azher M A. 2020. Effect of different levels of relative humidity and impurities in three stored insects. Plant Archives 20: 257-261.

Kavallieratos N G, Athanassiou C G, Guedes R N, Drempela J D, Boukouvala M C. 2017. Invader competition with local competitors: displacement or coexistence among the invasive khapra beetle, *Trogoderma granarium* Everts (Coleoptera: Dermestidae), and two other major stored-grain beetles? Frontiers in Plant Science 8: 1837.

Lee A M, Sæther B E, Engen S. 2020. Spatial covariation of competing species in a fluctuating environment. Ecology 101(1): e02901.

May'I Y, Abdul-Kareem S, Mahdii B A. 2016. Biological activity of some plants extract against in the survival of rate adult Oryzaephilus surinamensis (Coleopteran Silvanaidae). Iraqi Journal of Science 1377-1382.

Mwalusepo S, Tonnang H E, Massawe E S, Johansson T, Le Ru B P. 2014. Stability analysis of competing insect species for a single resource. Journal of Applied Mathematics 2014: 1-14.

Okrikata E, Ogunwolu E O. 2019. Determination of the critical period of cyper-diforce® treatment against arthropod fauna and productivity of watermelon. Iraqi Journal of Science 60(9): 1904-1919.

Papanikolaou N E, Kavallieratos N G, Kondakis M, Boukouvala M C, Nika E P, Demiris N. 2019. Elucidating fitness components of the invasive dermestid beetle *Trogoderma granarium* combining deterministic and stochastic demography. PLoS One 14(2): e0212182.

Qader F A, Ameen H N H, Mohammed B M H. 2022, July. Effect of food treated with silica gel on three types of storehouse insects. In IOP Conference Series: Earth and Environmental Science (Vol. 1060, No. 1, p. 012098). IOP Publishing.

Gourgouta M, Agrafioti P, Athanassiou C G. 2021. Insecticidal effect of phosphine for the control of different life stages of the khapra beetle, *Trogoderma granarium* (Coleoptera: Dermestidae). Crop Protection 140: 105409.

S A S. 2018. Statistical analysis system, user's guide. Statistical. Version 9.6th ed. SAS. Inst. Inc. Cary. N.C. USA.

Thierry M, Hrček J, Lewis O T. 2019. Mechanisms structuring host–parasitoid networks in a global warming context: a review. Ecological Entomology 44(5): 581-592.

Tikhonov M, Monasson R. 2017. Collective phase in resource competition in a highly diverse ecosystem. Physical Review Letters 118(4): 048103.

Yannelli F A, Koch C, Jeschke J M, Kollmann J. 2017. Limiting similarity and Darwin's naturalization hypothesis: understanding the drivers of biotic resistance against invasive plant species. Oecologia 183: 775-784.

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