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Review of a doctoral dissertation

titled Selected aspects of ecology and behaviour of predatory mite *Blattisocius mali* – a potential biological control agent against acarid mites

Wybrane aspekty ekologii i zachowania się drapieżnego roztocza *Blattisocius mali* – potencjalnego środka biologicznego do zwalczania rozkruszków

conducted at the Department of Plant Protection, Institute of Horticultural Sciences, Warsaw University of Life Sciences (SGGW), in the scientific discipline of agriculture and horticulture, under the supervision of Dr. hab. Katarzyna Michalska, professor SGGW.

Justification for the review

By Resolution No. 53/RiO-2025/2026, adopted on June 9, 2026, regarding the appointment of reviewers for a doctoral dissertation, I was appointed as a reviewer for the doctoral dissertation of Manoj Kumar JENY, MSc, titled “Selected aspects of the ecology and behaviour of the predatory mite *Blattisocius mali* – a potential biological control agent against acarid mites”. I was notified of this in a letter from the Chair of the Disciplinary Council for Agriculture and Horticulture at the Warsaw University of Life Sciences (SGGW), Dr. hab Elżbieta Wójcik-Gront, prof. SGGW.

Structure of the dissertation – formal assessment

The doctoral dissertation submitted for review has the correct structure appropriate for doctoral theses consisting of a series of published works. The introductory section comprises 69 pages, including an abstract followed by keywords, as well as a corresponding summary and keywords in Polish that are identical to the English version of the paper. This is followed by a list of publications comprising the doctoral dissertation itself. The articles forming the basis of the doctoral dissertation exclusively present original experimental results. These are five peer-reviewed papers published in journals from the JCR list with a combined impact factor (IF) of 13.7 and a total of 490 ministerial points:

1. Jena, M.K. Michalska, K. and Studnicki, M. (2024). The impact of humidity on the functional response of *Blattisocius mali* (Acari: Blattisociidae) preying on the acarid mite *Tyrophagus putrescentiae* published in *Scientific Reports* (14(1): 28051; IF = 3,9; 140 pkt MEiN),

2. Jena, M.K. Michalska, K. and Studnicki, M. (2025). Effects of temperature on functional response of *Blattisocius mali* (Acari: Blattisociidae) preying on the acarid mite *Tyrophagus putrescentiae* published in *Scientific Reports* (15 (1), 15457: IF = 3.9 and Polish Ministry Points = 140
3. Jena, M.K. Michalska, K. and Studnicki, M. (2025 a). Functional response of different life stages of predatory mite *Blattisocius mali* preying on acarid mite *Tyrophagus putrescentiae* published in *Systematic and Applied Acarology* (30 (1), 181-19: IF = 1.2 and Polish Ministry Points = 70)
4. Jena, M.K. Michalska, K. and Studnicki, M. (2025 b) Effect of ages of females and males of *Blattisocius mali* (Mesostigmata: Blattisociidae) on their functional response while preying on the acarid mite *Tyrophagus putrescentiae* published in *International Journal of Acarology* 51 (6): 448-455. (IF =1,0 and Polish Ministry Points =40).
5. Jena, M.K. Studnicki, M. Sochacki, D. and Michalska, K. (2026) Evaluation of the predatory soil mite *Blattisocius mali* (Acari: Blattisociidae) as a biocontrol of agent of the acarid mite *Tyrophagus putrescentiae* (Acari; Acaridae) infesting sored flower bulbs published in *BioControl* (IF =2,7 and Polish Ministry Points =100)

All papers were co-authored. In four of the presented publications, the doctoral candidate is the first author; in the fifth, he is listed as the second author. It is worth emphasising that in all articles, the doctoral candidate is the corresponding author. The leading role of the doctoral candidate in conducting research forming the basis for applying for the doctoral degree is beyond question. This is consistent with the statements of the other co-authors and the information provided in the "Author contributions" section of the article. In all of the works, the doctoral candidate's contributions included the research concept, methodology design, conducting all experiments, validation, formal analysis, resources, data collection, writing—reviewing and editing—visualisation, and fundraising. According to the supervisor's statement, her contributions consisted of conceptualisation, methodology development, critical analysis of the text, editing, and supervision. The contributions of the other co-authors, on the other hand, consisted of participation in the development of the concept, formal analysis, and proofreading and editing of the manuscripts. The subsequent chapters are as follows: comprehensive introduction, research objectives and hypotheses, materials and methods, main results and discussion, conclusions, and references. In the "Materials and Methods" chapter, the doctoral candidate describes the biological material under study and presents the conditions and procedures of the experiments included in the published works that constitute this doctoral dissertation in great detail. The bibliography includes 112 references in English. Copies of the publications included in the doctoral dissertation are listed in the order specified in the Introduction.

It should be emphasised that the series of publications that comprise this doctoral dissertation involve well-planned and well-executed research.

In summary, from a formal standpoint, I have no objections to the structure and content of this dissertation. Undoubtedly, the doctoral candidate's contribution to the works attached to the dissertation is predominant, ranging from the conception, through the execution of the entire experiment, to the analysis of the results and preparation of the

publications, as indicated by the statements signed by the co-authors of each paper. I find the inclusion of these papers in the doctoral dissertation to be entirely justified.

Research topic

The doctoral dissertation submitted for review concerns the potential use of the predatory mite *Blattisocius mali* (Oudemans) to control *Tyrophagus putrescentiae*, a serious pest of ornamental bulbous plants, including lilies, tulips, gerberas, and greenhouse-grown cucumbers.

The research topic undertaken by the doctoral candidate aligns perfectly with the principles of integrated pest management (IPM), which aims to utilise all available methods for controlling pest, disease, and weed populations in a manner that is economically viable and safe for humans and the environment. Within this system, particular importance is placed on biological plant protection methods that utilise the natural enemies of pests. Consequently, a key challenge for modern science is the search for and evaluation of new organisms that can serve as effective biological pest-control agents.

The doctoral candidate met these expectations by undertaking research on the predatory mite *Blattisocius mali*, which, owing to its ability to feed on various groups of small arthropods, including mites and the eggs of certain insect species, may serve as a valuable component of integrated pest management (IPM) programs. The use of this species in biological pest control may help reduce the use of synthetic plant protection products and, consequently, enhance the environmental safety of horticultural production.

The present study expands our understanding of the biology and potential of *B. mali* as a biological control agent against *T. putrescentiae*. Undoubtedly, the research topic presented here may be of interest to bulb growers, especially those cultivating lilies and tulips, who have been seeking effective and safe methods to control bulb rot for many years.

It should be emphasised that following the withdrawal of a significant number of synthetic plant protection products, the options for controlling seed rot during bulb storage are very limited and, in practice, boil down mainly to the selection and elimination of infected material. In this situation, the use of a biological control agent, such as *B. mali*, may offer a valuable alternative to conventional methods and help reduce losses caused by *T. putrescentiae* during the production and storage of ornamental bulbous plants.

Performance Evaluation

The Title of the Dissertation

In my opinion, the title of the dissertation should reflect the actual content of the publications comprising the doctoral thesis and clearly indicate the species of mite under investigation, namely *Tyrophagus putrescentiae*. In its current wording, the title suggests that the research also concerns other species of harmful mites, which is not reflected in the presented results.

The introduction is presented as a literature review and covers topics directly related to the subject of this doctoral thesis. Its strength lies in its clear structure and logical organisation of

content, which allow the reader to gradually familiarise themselves with the research issues and rationale for the study.

In the subsection “Predatory Mites in the Biological Control of Insects and Mites”, the doctoral candidate discussed the importance of biological plant protection methods in the context of Integrated Pest Management (IPM), which has been in effect in the European Union since 2014. He discussed the potential of using predatory mites as natural enemies of pests, highlighting the biotic and abiotic factors that influence their effectiveness. Of particular note is the presentation of arguments justifying the need for research on the functional responses of predators and the assessment of their effectiveness in different environmental conditions. In the following subsection, the doctoral candidate characterises functional responses as one of the fundamental tools used to assess the potential of predators in biological pest control. He presented the most commonly used functional response models and discussed their assumptions, applications and limitations. In the final subsection, the doctoral candidate discusses the members of the *Blattisociidae* family, with particular emphasis on the species *B. mali*, which was the subject of the study.

The doctoral candidate presented the current state of knowledge regarding the biology and ecology of this species, while also highlighting existing research gaps, particularly regarding functional responses to varying prey densities and the effectiveness of pest control. Another important element of this subsection is the description of the biology and economic significance of *T. putrescentiae*. This information serves as a rationale for conducting research on the possibilities of biological control of this pest in the future.

The literature review was prepared carefully and covered the most important issues related to the thesis topic.

Research Objective and Research Hypothesis

The study objective was correctly formulated. The doctoral candidate identified the need to investigate the functional response of *B. mali* to various densities of *T. putrescentiae*. In the present study, the doctoral candidate focused on basic abiotic and biotic factors, such as humidity, temperature, age, and developmental stage of the predator, as well as the developmental stage of the prey. The effectiveness of the predator *B. mali* was evaluated on lily and tulip bulbs stored with and without peat at two predator-to-prey ratios (1:40 and 1:20). Five research hypotheses were presented, all of which were precisely formulated.

Materials and Methods

The methodology of the experiments and procedures for rearing *Blattisocius mali* are described clearly and in detail. The detailed presentation of the data analysis methods used in both the experiments on the functional responses of *B. mali* and the studies evaluating the effectiveness of this predator in controlling *T. putrescentiae* is commendable. The selection of analytical methods should be considered appropriate in relation to the research objectives, and their descriptions raise no objections to the study.

Results and Discussion

The papers comprising the doctoral dissertation were arranged by the doctoral candidate in an order that allows readers to follow the individual stages of the research and the research hypotheses tested by the candidate. All papers were peer-reviewed prior to publication; therefore, I will not address specific results but will instead highlight the most significant findings resulting from the experiments and described in the subsequent publications.

The first publication in this series demonstrated a significant effect of relative humidity on the functional response of *B. mali* when feeding on *T. putrescentiae* eggs. In the humidity range of 33% to 92%, the predator exhibited a Type III functional response, whereas, at 33% humidity, a Type II response was observed. The results indicate that the predation efficiency of *B. mali* increased with increasing relative humidity, reaching a maximum at 92%. Of particular interest is the fact that the optimal humidity conditions for the predator are similar to those favourable for the development of its prey, which increases the potential for using *B. mali* in the biological control of *T. putrescentiae* in the future.

The innovative nature of this study deserves special mention. This is the first report indicating that a decrease in relative humidity can lead to changes in the functional response of predatory mites.

In the second publication in the series, the doctoral student and his co-authors analysed the functional responses of the predatory mite *B. mali* to various developmental stages of the *T. putrescentiae* across a wide temperature range (10–35°C), and demonstrated that the functional response coefficient increased with increasing temperature, reaching its lowest value at 10 and 15°C and its highest at 35°C. Processing time was shorter, whereas attack rate and mortality potential were higher at higher temperatures, regardless of whether the prey consisted of *T. putrescentiae* eggs or males of the species.

In the third publication in this series, the authors focused on the functional response of the predator's various developmental stages while hunting the eggs of the mite *T. putrescentiae*. They demonstrated that *B. mali* larvae did not feed on the eggs of their prey. In contrast, the protonymphs, deutonymphs, and adults actively preyed. The maximum predation rates were higher in deutonymphs and females than in protonymphs and males. Deutonymphs and females achieved the highest consumption rates at high prey densities. The authors concluded that all actively feeding life stages exhibited a Type III functional response, which is considered particularly advantageous from the perspective of biological pest control, as predator effectiveness increases with increasing prey abundance. It has been demonstrated that both nymphal stages and adults can play a significant role in controlling the population of *T. putrescentiae*. The greatest strength of this study is its innovative approach to the issue of functional response by considering various developmental stages of the predator. Most studies have analysed only adults, whereas we have demonstrated that juvenile stages can also contribute significantly to the reduction of the target population.

The fourth publication in this series presents the effect of age on functional response parameters in adult males and females of the predatory mite *B. mali* in relation to different prey egg densities. The predators belonged to five age groups and were tested at seven egg density levels, ranging from 109–160. Both male and female *B. mali* exhibited Type III functional responses across all age groups. The time required to process a prey item was the shortest for 10-day-old males and 10- and 34-day-old females.

It should be noted that this study is the first report on the effect of females and males on the functional response.

In the fifth and final publication in this series, the effectiveness of *B. mali* in controlling *T. putrescentiae* in the more practical context of protecting stored tulip and lily bulbs was assessed in this study. The experiments with lilies were conducted both with and without peat, whereas the experiments with tulips were conducted without peat, using predator-to-prey ratios of 1:20 and 1:40, respectively. The *T. putrescentiae* population developed more rapidly in lily bulbs than in tulip bulbs, whereas the development of *B. mali* was faster in tulip bulbs than in lily bulbs. In all combinations, the effectiveness of the predators was high. After introducing *B. mali* at a predator-to-prey ratio of 1:40, *T. putrescentiae* was nearly completely eliminated from lily and tulip bulbs after 25 d. After releasing the predator at a ratio of 1:20, a similar effect was observed in tulip bulbs as early as 15 d.

The doctoral dissertation was summarised with conclusions that confirmed the research hypotheses posed in the introduction and corresponded to the publications cited. It should be noted that all research hypotheses were verified positively.

Questions that emerged while reading the doctoral dissertation:

1. What factors might explain the differences in the population development of *Blattisocius mali* in lily and tulip bulbs?
2. Please explain why, at a comparable density of *B. mali* relative to the prey (1:20), the complete elimination of *T. putrescentiae* occurred more rapidly in tulip bulbs than in lilies, whereas such differences were not observed at the 1:40 density.
3. Can *Blattisocius mali* also serve as an effective biological control agent against mites of the genus *Rhizoglyphus* (*R. echinopus* and *R. robini*) found in tulip and lily bulbs in storage facilities?
4. Can *Blattisocius mali* also be used in biological plant protection against other species of phytophagous mites inhabiting the above-ground parts of plants?

Final evaluation

The doctoral dissertation I reviewed, consisting of five co-authored publications with a clearly dominant contribution from the doctoral candidate, provides valuable information on

the predatory mite *Blattisocius mali*. The doctoral dissertation of Manoj Kumar JENY, MSc expands our knowledge about *Blattisocius mali*. It constitutes a significant contribution to the advancement of knowledge in the field of predatory ecology and biological control against *T. putrescentiae*. The work was prepared and carried out using appropriate methods. It should be emphasised that the series of publications forming the doctoral dissertation includes very well-planned and executed studies, and the results presented in the publications are consistent and well justified. The authors applied a large number of replicates and a modern analytical approach using several models of functional response, which increases the reliability of the results obtained.

It is important to highlight that the results obtained by the doctoral candidate and presented in the publications comprising the dissertation are primarily of cognitive significance. One cannot overlook the fact that the research was conducted exclusively under laboratory conditions, at constant humidity and controlled temperatures. In natural and storage conditions, there are variable environmental factors that can modify the behaviour of both the predator and the prey. For this reason, the possibility of directly transferring the results into practice is limited. The use of *B. mali* as a biological control agent requires confirmation of the results obtained under greenhouse and field conditions, as well as during bulb storage. Despite certain limitations associated with the laboratory nature of the studies, the dissertation merits a high rating and may serve as a significant reference point for further research on the use of predatory mites in the protection of stored products. The doctoral dissertation demonstrates that Manoj Kumar JENY, MSc possesses both general theoretical knowledge in the discipline of horticulture and agriculture, and the ability to independently conduct scientific research. The entire work offers an original solution to a scientific problem in the field of horticulture and displays the doctoral candidate's extensive knowledge.

In conclusion, I believe that the doctoral dissertation submitted for review, authored by Manoj Kumar JENY, MSc meets the criteria for doctoral dissertations specified in Art. 187 of the Act of 20 July 2018 Law on Higher Education and Science (Journal of Laws 2024, item 1571, as amended), and I recommend to the Council of the Agriculture and Horticulture Discipline of the Warsaw University of Life Sciences that Manoj Kumar JENY, MSc be admitted to the subsequent stages of the doctoral procedure.

Gracyna Sówka