



## Diversity of Insect Pests from District Kolhapur, Maharashtra, India, with Special Reference to Stored Cereal Grains with New Records

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### Abstract

One of the biggest challenges to stored grain is insect infestation. Coleoptera, Lepidoptera, and Psocoptera are the predominant stored grain pests in Kolhapur district. A survey of stored grain pests was performed across various localities in the study area, where insects were collected and identified to evaluate the diversity of species associated with stored cereals. In total, 20 insect species were documented as damaging cereal grains in storage, of which three are newly recorded in India, seven are new to Maharashtra, and one species was identified only to the genus level. *Sitophilus oryzae* and *Sitotroga cerealella* are the principal pests of rice, while *Tribolium castaneum* and *Rhyzopertha dominica* are the key secondary pests. This study outlines the significance and diversity of stored grain pests in Kolhapur district. Identifying pest diversity is crucial for developing effective control strategies.



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### Introduction

Grain storage insect pests typically consume grains that have been stored, bore into kernels, damage the germ, generate heat, and ultimately destroy grain products that have been stored. The Food and Agriculture Organization (FAO) estimates that approximately 10% of the world's food production is destroyed by insects while it is being stored. Significant losses result from this, mostly in the form of nutritional depletion and a drop in market value. Furthermore, the grains may become contaminated by their excretory products, could be harmful to

human health. Therefore, rather than quantity, insect infestations mostly result in losses in terms of quality.<sup>1</sup> The cohabitation of primary and secondary pests in one item, the infestation of cereal grain becomes more severe. The most prevalent insect pests on rice are *Sitophilus oryzae* (rice weevil), *Oryzaephilus surinamensis* (saw-toothed grain beetle), and *Tribolium castaneum* (red flour beetle). Ability to eat on the whole grain, *S. oryzae* could be the major primary pest in storage products. *O. surinamensis* and *T. castaneum* are secondary pests that feed on grain infested by other pests, contaminating stored

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products with dead insects and feces.<sup>2</sup> *S. oryzae*, *Rhyzopertha dominica*, *T. castaneum*, *Sitotroga cerealella* (Angoumois grain moth) infest wheat, sorghum, and millets, threshed sorghum is particularly vulnerable to these pests.<sup>3,4</sup> Research on sorghum, pearl millet, or finger millet crop variants reveals variations in insect damage susceptibility; different cultivars and genotypes are being investigated for their potential to combat stored grain insect pests.<sup>5-7</sup> Managing stored grain pests is primarily dependent upon synthetic insecticides,<sup>8,9</sup> however, regular and improper use of these compounds can lead to health issues, environmental contamination, and pest resistance.<sup>10,11</sup> In light of this, it is necessary to develop and make easily available alternative environmentally acceptable control strategies for stored grain pests, such as the use of botanicals, plant extracts, essential oils, etc.

In addition to other primary crops, the Kolhapur district grows cereals and legumes. Cereal grains like rice, wheat, sorghum, and millet are mainly used for human consumption and animal feed. The world's population gets energy, protein, vitamins B and E, and minerals from cereals which are staple foods. They are essential for nutrition in both developed and developing nations and are inexpensive to produce, easily stored, and transportable. An infestation may begin before storage itself, as the crop matures in the field, or after it is harvested and laid out to dry in the sun, insects may infest it by migrating from nearby granaries.<sup>3</sup> After harvest, proper grain storage (moisture:  $\leq 13$ – $15.5\%$ , temp:  $< 15$  °C) is essential for food security because it prevents mould growth, pest infestation, and grain germination, ensuring the safety of stored grains.<sup>12-14</sup> Ten to twenty percent of agricultural products are destroyed annually, and the situation is made worse by inadequate warehouse management or commodity storage.<sup>15</sup> It has been determined to focus on stored grain pests because of the diversity of stored grain pests for the management of stored grains and their pests. In order to offer a foundation for creating efficient integrated pest control techniques, the objective of this study is to investigate the species diversity of insect pests infesting stored cereal grains in Kolhapur district.

### Materials and Methods

In order to collect samples of stored grain insect pests, surveys were carried out in certain grain

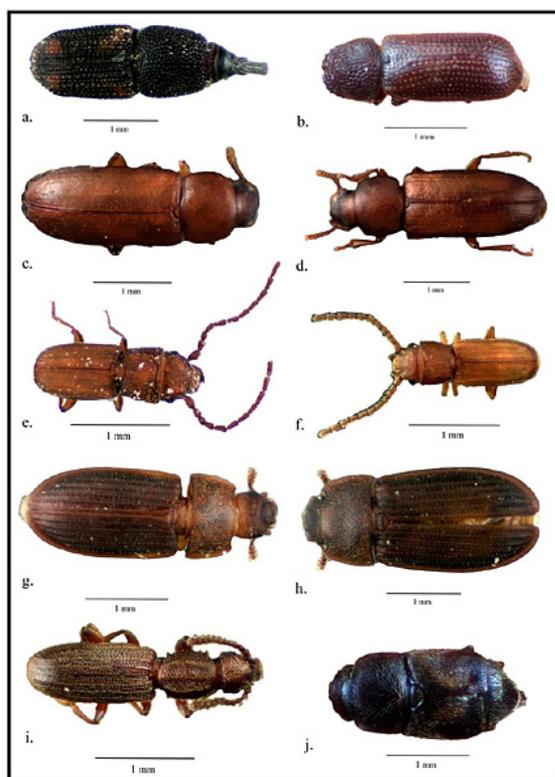
storage sites, such as farmers' residences, godowns, markets, and grocery shops, between 2019-2023. Using forceps, fine brushes (0no., 1no., 2no., 3no.) or aspirator, samples were hand-picked from stored commodities such as rice, wheat, maize, and millets. Grain samples (100–200 g) were drawn randomly from different depths and locations within storage units using a grain sampler to ensure representative sampling. Clean, micro centrifuge tubes (1.5ml and 2ml) and airtight plastic containers (50ml, 100ml, 500ml, 1000ml.) were used to keep samples and they were labelled with the date, grain type, and collection location. Samples that are collected were taken to the laboratory for further analysis. Ethyl acetate or chloroform were used to kill the sampled specimens. The sampled specimens were preserved using 70% ethyl alcohol. They were preserved dry after being pinned (with entomological pins numbers 0, 00 and 4) and properly dried for 48 hours at 40–45 °C for effective dehydration in an insect drying chamber. In order to facilitate future taxonomic verification and study, all preserved specimens were labelled with collection details and kept in the laboratory reference collection. Standard taxonomic keys and reference literature of Pratt and Scott,<sup>16</sup> Sengupta *et al.*,<sup>17</sup> Gorham,<sup>18</sup> Klimaszewski and Watt,<sup>19</sup> Rees,<sup>20</sup> Duff,<sup>21</sup> Friedman *et al.*,<sup>22</sup> Park *et al.*,<sup>23</sup> Washington,<sup>24</sup> Kumar,<sup>25</sup> Tyagi *et al.*,<sup>26</sup> images on the bug guide website<sup>27</sup> and GBIF website<sup>28</sup> were used to identify specimens. The Olympus CX31RTSF microscope, which was connected to the HDMI digital camera, was used to take photos using TCCapture software. The photos were stacked in Helicon Focus 7 and then edited using Photoshop CS3. The measurements were taken using Image J program.

### Results

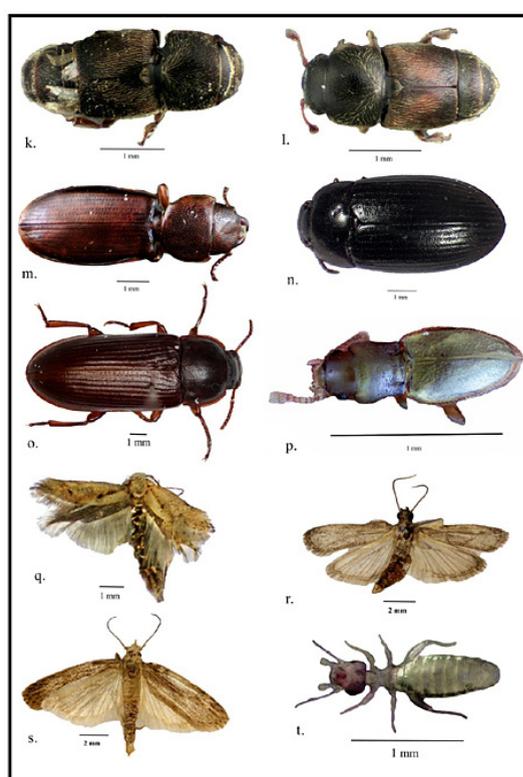
During the investigation, 20 species from the Coleoptera, Lepidoptera and Psocoptera insect orders were recorded as pests of cereals. The primary and secondary stored grain pests found in cereal grains (rice, wheat, emmer wheat, great millet, pearl millet, finger millet and sorghum) from the Kolhapur district are listed in Table 1. The current study reports, cereals contain sixteen species belong to the order Coleoptera (Image 1 a-j, Image 2 k-p), three species belong to the order Lepidoptera (Image 2 q-s), and one belongs to the order Psocoptera (Image 2 t). Of the 20 species of stored cereal pests, seven are primary and thirteen are secondary. *Sitophilus*

*oryzae*, *Rhyzopertha dominica*, *Tribolium castaneum*, *Tribolium confusum*, *Sitotroga cerealella*, *Corcyra cephalonica*, and *Cadra cautella* are documented as the primary pests of stored cereals. *Oryzaephilus surinamensis*, *Cryptolestes pusillus*, *Cryptolestes pusilloides*, *Lophocaterus pusillus*, *Lophocaterus* spp., *Carpophilus dimidiatus*, *Carpophilus cheesmani*, *Carpophilus oculatus gilloglyi*, *Holoparamecus caularum*, *Alphitobius diaperinus*, *Tenebroides mauritanicus*, and *Tenebrio molitor* are the documented secondary pest species. The most damaging cereal pests in the study area were determined to be the rice weevil *S. oryzae*, lesser grain borer *R. dominica*, and almond moth *C. cautella* which attack variety of cereals, including rice, wheat, maize, great millet, pearl millet,

finger millet, and emmer wheat. *T. castaneum*, *T. confusum*, *O. surinamensis*, *C. pusillus*, *A. diaperinus*, *T. mauritanicus*, and *T. molitor* attack rice, wheat, and great millet secondarily. *S. cerealella* was the major lepidopteran pest found only on rice. *C. pusilloides*, *L. pusillus*, *Lophocaterus* spp, *C. dimidiatus dimidiatus*, *C. cheesmani*, *C. oculatus gilloglyi*, *H. caularum*, and *C. cephalonica* feed on only rice or wheat. *C. pusilloides*, *Lophocaterus* spp, *C. cheesmani*, *H. caularum*, *A. diaperinus*, *T. mauritanicus*, *T. molitor*, *C. oculatus gilloglyi*, and *C. cephalonica* are rare species, as only one or two specimens of these species were found from a single collection locality. Millet and maize had the highest pest population, whereas rice and sorghum had the lowest.



**Fig. 1:** Habitus of *Sitophilus oryzae* (a), *Rhyzopertha dominica* (b), *Tribolium castaneum* (c), *T. confusum* (d), *Cryptolestes pusillus* (e), *C. pusilloides* (f), *Lophocaterus pusillus* (g), *L. pusilloides* (h), *Oryzaephilus surinamensis* (i), *Carpophilus dimidiatus* (j).



**Fig. 2:** Habitus of *Carpophilus cheesmani* (k), *Carpophilus oculatus gilloglyi* (l), *Tenebroides mauritanicus* (m), *Alphitobius diaperinus* (n), *Tenebrio molitor* (o), *Holoparamecus caularum* (p), *Sitotroga cerealella* (q), *Cadra cautella* (r), *Corcyra cephalonica* (s), *Liposcelis* spp. (t).

Three of the 20 recorded species- *C. oculatus gilloglyi*, *C. cheesmani*, and *H. caularum*, are reported for the first time from India as secondary pests of rice and wheat. On the other hand, seven beetle species- *T. confusum*, *C. pusilloides*, *L. pusillus*,

*C. dimidiatus dimidiatus*, *T. mauritanicus*, *T. molitor* and *A. diaperinus* have been identified as secondary pests of rice, great millet and wheat (Table 1). Due to a unavailability of more specimens, *Lophocaterus* spp could only be identified at the genus level.

**Table 1: Diversity of stored grain insect pests of cereal grains of Kolhapur district.**

Sr. No.	Stored grain insect pests	Host cereals	Pest status	Orders	Families
1	<i>Sitophilus oryzae</i>	Rice, Wheat, Great Millet, Maize, Emmer Wheat, Sorghum	Primary pest	Coleoptera	Curculionidae
2	<i>Rhyzopertha dominica</i>	Rice, Wheat, Great Millet, Pearl Millet, Finger millet, Sorghum	Primary pest	Coleoptera	Bostrichidae
3	<i>Tribolium castaneum</i>	Rice, Wheat, Maize	Primary pest	Coleoptera	Tenebrionidae
4	<i>Tribolium confusum</i>	Wheat, Great Millet, Sorghum	Primary pest	Coleoptera	Tenebrionidae
5	<i>Cryptolestes pusillus</i>	Rice, Wheat	Secondary pest	Coleoptera	Laemophloeidae
6	<i>Cryptolestes pusilloides</i>	Wheat	Secondary pest	Coleoptera	Laemophloeidae
7	<i>Lophocaterus pusillus</i>	Rice	Secondary pest	Coleoptera	Lophocateridae
8	<i>Lophocaterus</i> spp.	Rice	Secondary pest	Coleoptera	Lophocateridae
9	<i>Oryzaephilus surinamensis</i>	Rice, Great Millet, Sorghum	Secondary pest	Coleoptera	Silvanidae
10	<i>Carpophilus dimidiatus dimidiatus</i>	Rice	Secondary pest	Coleoptera	Nitidulidae
11	<i>Carpophilus cheesmani</i>	Wheat	Secondary pest	Coleoptera	Nitidulidae
12	<i>Carpophilus oculatus gilloglyi</i>	Rice flour	Secondary pest	Coleoptera	Nitidulidae
13	<i>Holoparamecus caularum</i>	Rice	Secondary pest	Coleoptera	Endomychidae
14	<i>Tenebroides mauritanicus</i>	Rice, Wheat, Great Millet	Secondary pest	Coleoptera	Trogositidae
15	<i>Alphitobius diaperinus</i>	Rice, Wheat, Great Millet	Secondary pest	Coleoptera	Tenebrionidae
16	<i>Tenebrio molitor</i>	Rice, Wheat, Great Millet	Secondary pest	Coleoptera	Tenebrionidae
17	<i>Sitotroga cerealella</i>	Rice	Primary pest	Lepidoptera	Gelechiidae
18	<i>Corcyra cephalonica</i>	Wheat	Primary pest	Lepidoptera	Pyrilidae
19	<i>Cadra cautella</i>	Rice, Wheat, Maize, Great Millet, Emmer Wheat, Sorghum	Primary pest	Lepidoptera	Pyrilidae
20	<i>Liposcelis</i> spp.	Rice, Wheat, Great Millet, Maize	Secondary pest	Psocoptera	Liposcelididae

## Discussion

In Bohemia, Central Europe, Stejskal *et al.*<sup>29</sup> compared the risk of pest infestation in 147 grain stores, focusing on vertical silo stores and horizontal flat stores. Both grain store types were infested with beetles, mites, and psocids. In both kinds of shops, the primary grain pests were *S. oryzae*, *R. dominica*, *O. surinamensis*, *Lepidoglyphus destructor*, *Acarus siro*, *Tyrophagus putrescentiae*, *Lachesilla pedicularia*, and *C. ferrugineus*. The present study reports 16 coleopteran species, three lepidopteran species, and one psocid. Similar findings were reported by Rajendran and Chayakumari,<sup>30</sup> who investigated insect infestation on eight types of stored sorghum and millets and identified six coleopterans, three lepidopterans, and one psocid species as cereal-damaging insects during storage, resulting in loss of quantity and nutritional quality. Raoul and Leonard<sup>31</sup> recorded 12 stored grain insect species from Logone Valley, Africa. According to their studies, eight species are known to attack cereals, including five primary pests and five Coleopterans that harm the legume seeds. Major pests of legumes are members of the Bruchidae family, with *Sitophilus* being the main cereal pest and *Callosobruchus* causing legume. According to survey conducted by Askira *et al.*<sup>32</sup> in Maiduguri's main grain markets, four insect pests have a major impact on stored cereal grains, including rice, sorghum, millet, and maize. An overview of damage symptoms and the biology of 11 major pests of stored grains, such as rice weevil, *S. oryzae*, lesser grain borer, *R. dominica*, *T. granarium*, etc., was given by Srivastava and Subramanian.<sup>33</sup> These pests can be categorized based on their feeding behavior or severity of damage. Based on literature reviewed,<sup>28,34-37</sup> three species- *C. oculatus gilloglyi*, *C. cheesmani*, and *H. caularum*, recorded during the study validate its new record for India. Furthermore, seven species found during the study: *T. confusum*, *C. pusilloides*, *L. pusillus*, *C. dimidiatus dimidiatus*, *T. mauritanicus*, *T. molitor* and *A. diaperinus* confirm the new records for Maharashtra. The documentation of new records of stored grain pests from India (three species) and Maharashtra (seven species) is therefore scientifically significant. These records help to improve our knowledge of the biodiversity and biogeographical distribution of the pest, and they

may reveal recent import, range expansions, or previously overlooked species. Due to shortage of specimens, *Lophocaterus* spp. Could only be identified at the genus level.

## Conclusion

This study records three species of beetles from India and seven species from Maharashtra as secondary pests on stored grains for the first time. If the focus is on in-depth examination of pests that attack grains over a long period, more species from stored grains will be added to this work. The results show that a variety of primary and secondary stored grain pests, including internal feeders and external feeders, are found among stored grain pests, causing contamination and indirect damage. Studying the life cycles of these pests will help in managing stored grain pests through efficient control methods.

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## Conflict of Interest

The authors do not have any conflict of interest.

## Data Availability Statement

This statement does not apply to this article.

## Ethics Statement

This research did not involve human participants, animal subjects, or any material that requires ethical approval.

## Informed Consent Statement

This study did not involve human participants, and therefore, informed consent was not required.

## Permission to Reproduce Material from other Sources

Not applicable.

**Author Contributions**

- **Sunil Madhukar Gaikwad:** is involved in research design, specimen identification, and manuscript writing.

- **Dhanashree Ramchandra Salunkhe:** collected, identified, photographed, and gathered biological data of species under study.

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