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Uninvited guests: New stored mangrove rice insect pests in Guinea-Bissau

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A R T I C L E I N F O

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A B S T R A C T

Mangrove swamp rice is vital for food security in Guinea-Bissau, yet insect infestations cause significant post-harvest losses worldwide. This study identified insect pests affecting stored rice seeds using both morphological identification and DNA barcoding. In 2022, 64 rice samples were collected from 13 villages across 3 coastal regions yielding 1504 insect specimens, classified into 13 morphotypes from Coleoptera, Lepidoptera, and Hemiptera orders. DNA barcoding confirmed the identity of six species, including global primary rice pests *Sitophilus oryzae* Hustache, 1930, *Rhyzopertha dominica* (Fabricius, 1792), and *Sitotroga cerealella* (Olivier, 1789), and the secondary pests *Tribolium castaneum* (Herbst, 1797) and *Cryptolests pusillus* (Schénherr, 1817). This is the first record of these taxa in mangrove swamp rice seeds in West Africa. Four species are reported for the first time to Guinea-Bissau: *S. oryzae*, *C. pusillus*, *Platymetopus vestitus* Dejean, 1829 (Coleoptera), and *S. cerealella* (Lepidoptera). Among these, *R. dominica* had the highest relative abundance (68%), while *S. oryzae* appeared in all regions. R*hyzopertha* dominica and *S. cerealella* were prevalent in Cacheu and Oio. Their widespread presence across Africa suggests a broader distribution. Effective management strategies include hermetic storage, cleaning, biological control, and efficient drying techniques. This study holds significant importance as it presents findings related to the under-researched African rice species (*Oryza glaberrima*) and a specialized cultivation system: mangrove swamp rice. Findings offer valuable insights into storage practices to enhance food security in rice-producing regions and pave the way for future research on pest management and sustainable rice storage solutions.

1. Introduction

Rice is a worldwide staple crop, with high importance to food safety and security in countries where the population relies on it for daily consumption (Mohidem et al., 2022). Specifically, in Guinea-Bissau (West Africa), a unique and ancestral method of rice cultivation, known as mangrove swamp rice (*bolanha salgada* in Creole), is still preserved. In this system, the coastal mangrove trees naturally form an internal barrier, protecting the rice fields from inundation and wind erosion (Sandoval et al., 2024). Despite mangrove forests being present in other rice producing countries, mangrove swamp rice production is only found in West Africa: Guinea-Bissau, Guinea Conakry, Gambia,

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Senegal, Sierra Leone, Nigeria (Defoer et al., 2002). Guinea-Bissau, with 49% of mangrove rice area, is the country that occupies the largest area on this type of rice production (Balasubramanian et al., 2007). Its cultivation is a manual labour- and knowledge intensive system, demanding the construction and maintenance of dikes and bunds protecting the rice plots (Martiarena and Temudo, 2023). This system contemplates both Asian (*Oryza sativa* L.) and African rice (*O. glaberrima* Steud.) species. The majority of rural Guinea-Bissau's population depends on rice for meals from breakfast to dinner, and ensuring consistent rice production from year to year is of utmost importance, being a key crop for food security needs.

In addition to ensuring a successful crop production, farmers must also guarantee that the rice seeds remain viable for next year's planting cycle. Seeds are stored for extended periods, and it is well known that pests and diseases pose the greatest threat to their preservation (Benjamin et al., 2024). In the case of Guinea-Bissau, no previous studies exist with stored seeds pests and with estimations of loss regarding stored rice. According to FAO (2018) and Hassan et al. (2023), it is estimated that every year during storage, 10–40% of the world grain crop is lost due to insect infestations, resulting in a significant effect on global food security. As other seeds, rice seeds are rich in protein, carbohydrate (mainly starch, a primary energy source for insects), fibre, minerals and vitamins (Okpile et al., 2021), essential for insect's growth and reproduction. Such composition makes seeds highly attractive - and consequently vulnerable - to insect pest attacks, which cause significant economic losses by consuming, spoiling, or contaminating stored seeds. These infestations lead to reduced protein content and lower germination rates, impacting the overall seed quality. Addressing this decline highlights the importance of identifying and controlling storage insect pests to prevent serious damage (FAO, 2018). The majority of stored insect pests are either from Coleoptera or Lepidoptera orders, and these insect pests can be categorized into two groups: primary insects, which directly infest whole grains, and secondary insects, which feed on already damaged or processed grains. Primary insects develop from larvae to adults inside rice grains and consume the endosperm, being able to attack grains with intact hulls, and thus, are generally more destructive, especially in short-term storage (FAO, 2018). Secondary insects can only eat on the surface of the grain, attacking already damaged grains, either by natural or artificial causes (Atungulu et al., 2019). Globally, the most important rice stored primary insect pests are: rice weevil (*Sitophilus oryzae* Hustache, 1930), lesser grain borer [*Rhyzopertha dominica* (Fabricius, 1792)], Angoumois grain moth [*Sitotroga cerealella* (Olivier, 1789)]; and the secondary insect pests: rust-red flour beetle [*Tribolium castaneum* (Herbst, 1797)], rice moth [*Corcyra cephalonica* (Stainton, 1866)], saw-toothed grain beetle [*Oryzaephilus surinamensis* (Linnaeus, 1758)], and flat grain beetle [*Cryptolestes pusillus* (Schénherr, 1817)] (FAO, 2018; Atungulu et al., 2019). From those, only two species (*R. dominica* and *T. castaneum*) are reported to Guinea-Bissau (Dia and Sembene, 2021; Fägerström, 2024a, 2024b). This evident knowledge gap about the West African region, particularly Guinea-Bissau, along with the potential economic losses caused by pests in stored rice, highlights the critical need for accurate taxonomic identification to enable effective pest management and safeguard long-term food security, even more in such an important and specific rice agroecosystem as mangrove swamp rice. Taxonomic identification can be currently achieved using morphology and molecular methods, the later allowing the use of tissue samples taken from any life stage or almost any body part to identify the organisms (Hebert et al., 2003), through molecular DNA barcoding techniques for species identification regardless of organism developmental stage.

This study aims to identify and characterize insect species in stored mangrove swamp rice intended for sowing from the main production regions in Guinea-Bissau - Cacheu (north), Oio (center-north), and Tombali (south) - for assessing potential as storage pests affecting food security. The main objectives are to (i) document insect species present in stored mangrove swamp rice seeds in Guinea-Bissau, and to (ii) assess and describe the identified species with potential to act as storage pests, potentially impacting food security.

2. Material and methods

2.1. Field collection

Stored mangrove swamp rice samples intended for sowing (*Oryza sativa* and *Oryza glaberrima*, ≈1.0–1.5 kg each) were collected from June 22 to July 2, 2022, during the pre-sowing season. These samples represented different varieties and storage containers/structures (please see Conde et al., 2024) with a total of 13 villages sampled in three coastal mangrove rice-producing regions of Guinea-Bissau (Fig. 1). Each sample was placed in labelled plastic bags and processed at the Plant Protection Services Laboratory, Ministry of Agriculture, Guinea-Bissau, to further analysis.

2.2. Morphological identification

Two hundred grams of each rice sample were analysed in a stainless-steel basin, with the help of entomological tweezers to find and collect all insects present. Specimens were morphologically separated as morphotypes, and taxonomically identified to the species level, whenever possible, using a StereoBlue stereo microscope (euromex) and by using taxonomic revision articles (Thomas, 1988), taxonomic keys (Lompe, 2010), and reference books on stored pests (Shepard, 1947; Hagstrum et al., 2012).

The number of individuals per morphotype was recorded and the specimens were preserved in 96% ethanol for further molecular analysis. All the morphotypes were photographed using a CMEX-5f stereomicroscope's camera.

2.3. Genetic identification

A total of 92 samples were selected for genetic analysis, representing up to 13 specimens per morphotype representing all villages and regions (Table S1). Preserved specimens in 96% ethanol were further processed for DNA barcoding. DNA extraction and sequencing followed the general pipeline in use by the InBIO Barcoding Initiative (Ferreira et al., 2018). Genomic DNA was extracted from a middle leg of each individual using the EasySpin Genomic DNA Microplate Tissue Kit (Citomed, Odivelas, Portugal) according to the manufacturer's protocol. The cytochrome *c* oxidase I (*COI*) barcoding gene fragment was then amplified as two overlapping fragments (LC and B2), using two sets of primers: LCO1490 (Folmer et al., 1994) + Ill_C_R (Shokralla et al., 2015) (325 bp fragment) and BF2 + BR2 [422 bp fragment (Elbrecht and Leese, 2017)]. The PCR products were then sequenced in a MiSeq benchtop system. OBITools (https://git.metabarcoding.org/obitools/obitools) was used to process the initial sequences which were then assembled into a single ~658 bp *COI* fragment using Geneious 9.1.8. (https://www.geneious.com). The sequences obtained were compared against BOLD database using the Identification engine (http://www.boldsystems.org/, September 28, 2024) and comparing the similarity (%) of the best and the second-best hits for assessing taxa identification. No identification with less than 98.5% of similarity was considered for species level, 98% for genus level (with a single case of 86%), and 94% for order level. All sequences generated were submitted to BOLD and GenBank databases.

The Relative Abundance (RA) of each species was determined as the sum of individuals of a given species divided by the total number of individuals across all five species identified as potential pests, expressed as a percentage:

$$RA_i = \frac{x_i}{\sum_{i=1}^{5} x_i} \times 100$$

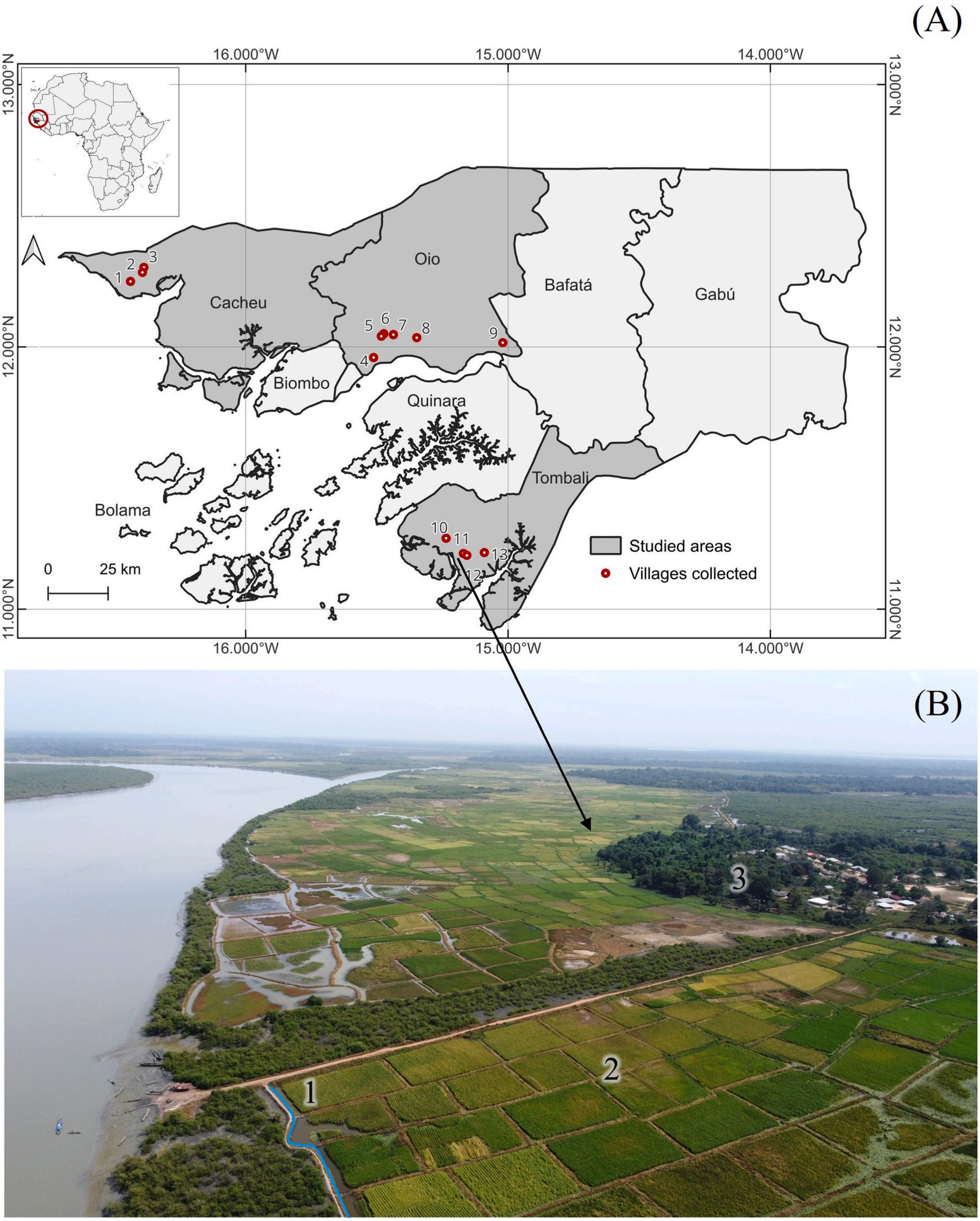

Fig. 1. (A) Geographical location of the studied regions and respective villages where samples were collected. Number of the villages in each region correspond to 1. Elalab, 2. Djobel, 3. Elia (Cacheu), 4. Rotxum, 5. Uncur, 6. Blaftxur, 7. N'Tchugal, 8. Sugun, 9. Malafu (Oio), 10. Quibil, 11. Cafine, 12. Cafale, 13. Caiquenem (Tombali). For geographic coordinates please check Table S4; (B) Example of a rice field (*bolanha* in Creoule) of mangrove swamp rice production, in Cafine village, Tombali south region of Guinea-Bissau, where (1) dike; (2) rice field; (3) village. The large (salty) water mass visible corresponds to the Cumbidja inlet, originating from the Atlantic Ocean.

Where RA = Relative Abundance; x_i corresponds to the number of individuals of each pest species identified, being $i = 1$ *Rhyzopertha dominica*, $i = 2$ *Tribolium castaneum*, $i = 3$ *Cryptolestes pusillus*, $i = 4$ *Sitophilus oryzae*, $i = 5$ *Sitotroga cerealella*.

This calculation reflects the proportional presence of each pest species in the study area, relative to the total identified pest sampled in each region.

2.4. Characterization of the identified pest species

To characterize the insect species identified as stored rice pests, a comprehensive bibliographical research was conducted. The scientific names of these pest species were revised based on Global Biodiversity Information Facility database (GBIF, https://www.gbif.org/, October 1, 2024) and the NCBI Taxonomy browser (https://www.ncbi.nlm.nih.gov/taxonomy, October 1, 2024). Information on pest type, economic importance, origin, distribution, and life cycle was gathered from several bibliographic documents (Rees, 2007; Trematerra and Throne, 2012; FAO, 2018). Pest types were classified, according to the literature (FAO, 2018; Atungulu et al., 2019) as primary for species that infest whole grains directly, and secondary for species that feed on grains that are already damaged or processed.

3. Results

A total of 64 samples (22 Cacheu, 25 Oio, 17 Tombali) of stored mangrove swamp rice for sowing were collected, provided by 30 farmers distributed by 13 villages of 3 coastal regions of Guinea-Bissau, considering different rice varieties and/or different storage containers (Table S2, Figs. S1A–F). Both storage containers/structures and rice varieties (consequently rice species) depend on regions and ethnicities' traditional knowledge.

3.1. Morphological identification

A total of 1504 insect specimens were detected in the collected samples (Figs. S1G–M) of stored mangrove swamp rice seeds (226 Cacheu, 1156 Oio, 122 Tombali). Morphological identification resulted in 13 morphotypes (Fig. S2). The morphotypes were divided into 3 orders: Coleoptera (10 morphotypes, 1229 individuals), Lepidoptera (2 morphotypes, 188 individuals) and Hemiptera (1 morphotype, 87 individuals) (Table 1, Table S1). Based on morphologic characters, all specimens were identified at order level, six at family level and five morphotypes were identified at genus/species level. (Table 1).

3.2. Taxa identification by DNA barcoding

From a dataset of 92 samples selected for genetic identification representing the 13 morphotypes and the distinct geographic origins, 74 resulted in DNA barcoding sequences. The limitation of sequencing the DNA barcodes of the remaining samples resulted from DNA unsuccessful amplification due to DNA degradation and contamination with bacteria. All generated sequences are available in the BOLD (S0001, S002-S074) database. Based on DNA barcoding analysis, all thirteen morphotypes were identified at order level, twelve at family level and nine morphotypes were identified at species level, corresponding to six species in total (Table 1, Table S3). The identifications obtained via DNA barcoding corroborate the morphological identification results, confirming the previous taxa and improving the level of identification, namely at species resolution (Table 1, Table S3).

3.3. Stored pests in mangrove swamp rice

The results allowed the identification of six insect species (Table 1), only one of which is not considered as a pest: *Platymetopus vestitus* Dejean, 1829, a ground beetle (Carabidae) regarded as a beneficial insect and typically an agricultural ally with a predatory role (Adhikari and Menalled, 2020). The five pest species identified are reported as stored rice pests worldwide (Berhe et al., 2022), three of them are considered primary insect pests of stored rice (*Sitophilus oryzae*, *Rhyzopertha dominica*, and *Sitotroga cerealella*), and two are secondary pests (*Tribolium castaneum* and *Cryptolests pusillus*) (Table 2).

Primary pests were the most recorded species per region: *Rhyzopertha dominica* in Oio [889, with 68% of relative abundance (RA)], *Sitophilus oryzae* in Tombali (117, 14% RA) and *Sitotroga cerealella* in Cacheu (112, 13% RA) (Fig. 2). In general, *Rhyzopertha dominica* was the most recorded species (N = 953), present at all the six villages of Oio, representing 50–100% of all collected insects of each Oio's village. This species was also recorded in Cacheu region (64, 28%), only at one of the three villages (Elia), with 40% of the collected species. *Sitophilus oryzae* was the second most recorded species (N = 191), present in all three regions. In third, the most recorded species was the Lepidoptera *Sitotroga cerealella* (N = 188), representing 50% of the records in Cacheu and 7% in Oio region (76). Only 3 taxa were found in the three regions: the primary pest *Sitophilus oryzae*, and both secondary pests *Tribolium castaneum* and *Cryptolestes pusillus* (Table S4, Fig. 2). All five species were recorded in Cacheu and Oio regions, and three species (*S. oryzae*, *C. pusillus*, and *T. castaneum*) were recorded in Tombali (Fig. 2).

Comparing the distribution of insects by sampled rice species (*O. sativa* and *O. glaberrima*), no evidence of preferences was found (Table S5). African rice (*O. glaberrima*) is essentially cultivated by ethnic groups in the northern region of the country, namely Cacheu and also in Oio. In Tombali, the southern region of the country, there was no stored *O. glaberrima* to sample, and only 1 sample was collected in Oio, while in Cacheu 14 samples were collected. Despite the low number of samples from each storage container/structure sampled (Table S2), it is

Table 1
Morphotypes taxonomic identification according to morphology and DNA barcoding.

Morph.	MORPHOLOGIC ID			DNA BARCODING ID		
	Order	Family	Genus/Species	Order	Family	Genus/Species
1	Coleoptera	Bostrichidae	*Rhyzopertha dominica* (Fabricius, 1792)	Coleoptera	Bostrichidae	*Rhyzopertha dominica* (Fabricius, 1792)
2	Coleoptera	Tenebrionidae	*Tribolium castaneum* (Herbst, 1797)	Coleoptera	Tenebrionidae	*Tribolium castaneum* (Herbst, 1797)
3	Coleoptera	–	–	Coleoptera	–	–
4	Coleoptera	Curculionidae	*Sitophilus oryzae* Hustache, 1930	Coleoptera	Curculionidae	*Sitophilus oryzae* Hustache, 1930
5	Coleoptera	–	–	Coleoptera	Tenebrionidae	–
6	Coleoptera	Laemophloeidae	*Cryptolestes* sp. Ganglbauer, 1899	Coleoptera	Laemophloeidae	*Cryptolestes pusillus* (Schénherr, 1817)
7	Coleoptera	–	–	Coleoptera	Scarabaeidae	–
8	Hemiptera	–	–	Hemiptera	Anthocoridae	–
9	Coleoptera	Carabidae	–	Coleoptera	Carabidae	*Platymetopus vestitus* Dejean, 1829
10*	Coleoptera	–	–	Coleoptera	Tenebrionidae	*Tribolium castaneum* (Herbst, 1797)
11*	Coleoptera	–	–	Coleoptera	Bostrichidae	*Rhyzopertha dominica* (Fabricius, 1792)
12*	Lepidoptera	–	–	Lepidoptera	Gelechiidae	*Sitotroga cerealella* (Olivier, 1789)
13	Lepidoptera	Gelechiidae	*Sitotroga cerealella* (Olivier, 1789)	Lepidoptera	Gelechiidae	*Sitotroga cerealella* (Olivier, 1789)

* Larvae.

Table 2
Summary of the characteristics of the main storage rice pests identified, by Order and Family, taxa with common name, pest type categorization, economic importance in rice (*Oryza sativa*), origin, distribution reported and life cycle characteristics.

Order: Family	Species [common name]	Pest type	Economic importance	Origin	Distribution	Type of damage	Life Cycle			References
							Eggs	Larvae	Adults	
Coleoptera: Bostrichidae	*Rhizopertha dominica* [Lesser grain borer]	primary	high	Indian subcontinent	worldwide, especially warm temperate to tropical regions	adults hollow out grains, leaving thin shells, while larvae bore inside, consume the interior, and produce abundant powdery residue, indicative of severe structural damage	laid on commodity or in tunnels bored by adults	internal feeders producing lots of flour, immobile when mature	long-lived, feed and bore into commodity, strong flier	Rees (2007), Trematerra and Throne (2012), FAO (2018), Srivastava and Subramanian (2016)
Coleoptera: Curculionidae	*Sitophilus oryzae* [Grain weevil]	primary	high	India	worldwide	consumes the grain interior, leaving hollow pericarps filled with excrement; damaged grains exhibit emergence holes, float in water, and appear mouldy due to extensive structural destruction	laid singly in prepared hole in grain then covered with waxy plug	immobile, develop concealed within single grain	on emergence leave ragged hole in grain, long-lived, feed, can fly	Rees (2007), FAO (2018), Srivastava and Subramanian (2016)
Coleoptera: Tenebrionidae	*Tribolium castaneum* [Rust-red flour beetle]	secondary	medium	Indo-Australian	worldwide	targets already damaged grains, with larvae actively feeding on debris and surfaces, leaving odorous, contaminated grain residues containing larval remains and live or dead adults	laid amongst commodity	mobile, external feeder	long-lived, feed on commodity, fly short distances	Fasulo (2003), Rees (2007), FAO (2018), Srivastava and Subramanian (2016)
Coleoptera: Laemophloeidae	*Cryptolestes pusillus* [Flat grain beetle]	secondary	low/ medium	Europe	worldwide	damage is indistinguishable from other pests without identifying the insect; larvae and adults feed on and burrow into compromised grains	laid amongst commodity	mobile, external feeders	long-lived, walk with characteristic sway, feed on commodity, fly	Rees (2007), CABI International (2022)
Lepidoptera: Gelechiidae	*Sitotroga cerealella* [Angoumois grain moth]	primary	high	Unknown/ Mediterranean region	worldwide, warm temperate to tropical regions	hollows out grains, filling them with excreta and silken webs; circular emergence holes are visible, while early infestations often remain hidden due to near-invisible larval entry points	laid on commodity	excavate cavity in grain, remain concealed there, make neat hole (covered with silk) in grain surface prior to pupation	exit through hole often leaving silken 'door' still attached to grain, short-lived, do not feed, fly	Rees (2007), FAO (2018), Srivastava and Subramanian (2016)

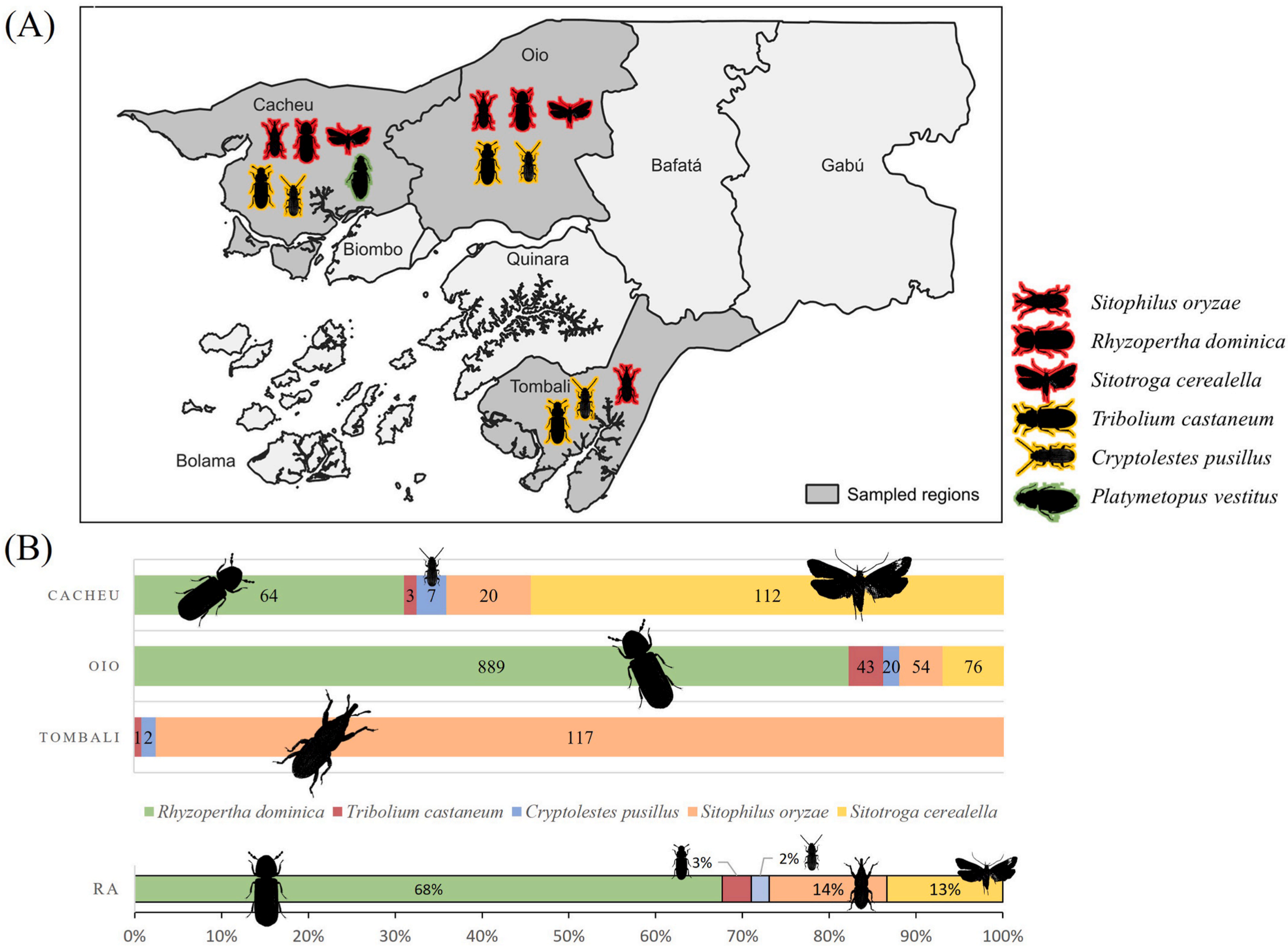

Fig. 2. Insect species distribution among the three sampled regions. (A) Colour shading represents: primary insect pest of stored rice (red); secondary insect pest of stored rice (yellow); not an insect pest of stored rice (green); (B) Number of insect pests per region according to taxa identification by DNA barcoding and the respective Relative Abundance (RA) of each species.

observable that bags are the container with biggest insect diversity, followed by metal barrels (Table S6). The difference in the number of insects for each species in the different containers is connected to the number of containers sampled.

4. Discussion

4.1. Insect diversity of stored mangrove swamp rice seeds

Through DNA barcoding analysis, six insect species were identified in stored rice seeds. This finding enriches overall our understanding of biodiversity in West Africa, particularly in Guinea-Bissau, by applying a multidisciplinary approach that integrates genetic and morphological analyses.

The identified species include the stored rice pests *Rhyzopertha dominica*, *Tribolium castaneum*, *Sitophilus oryzae*, *Cryptolestes pusillus* (Coleoptera), and *Sitotroga cerealella* (Lepidoptera), and also a predator *Platymetopus vestitus* [(Carabidae, Coleoptera) (Sahayaraj and Hassan, 2023)]. All species identified were recorded for the first time in mangrove swamp rice seeds and, notably, four of these - *S. oryzae*, *C. pusillus*, *P. vestitus* (Coleoptera), and *S. cerealella* (Lepidoptera) - are new records to Guinea-Bissau. Previously recorded species in other countries, *R. dominica* and *T. castaneum*, lacked information about their specific collection sources, such as the crop or seed type [as confirmed by the museum preserving these specimens (Fägerström, 2024a, 2024b)]. For instance, one specimen of *R. dominica* was collected in Capé, Bafatá, Eastern region in Guinea-Bissau (Fägerström, 2024a), while *T. castaneum* was documented in Bula, Cacheu region (Fägerström, 2024b), and in rice seeds for trade at the capital Bissau (Dia and Sembene, 2021). This scarcity of information highlights the lack of knowledge that remains in the country and in West Africa, overall.

Among the new records, *S. oryzae* is widely distributed across the tropics (Adarkwah et al., 2019), including West African countries like Senegal (Guèye et al., 2011), Ghana (Adarkwah et al., 2019), Benin (Santos et al., 2015), and Ivory Coast (Kouassi et al., 2023). *Cryptolestes pusillus* is globally distributed, including in Africa (Berhe et al., 2022), with records from South Africa, Réunion, and Angola (GBIF, https://www.gbif.org/, October 24, 2024). Although there are no specific records from West Africa, the presence of *Cryptolestes* species in the region is likely due to its warm climate and grain storage practices, which provide favourable conditions for these species (Ashby, 1961). The adaptability of this species suggests it could thrive across various African regions. *Platymetopus vestitus* is primarily found in Africa, especially Senegal (Lemaire, 2017). Finally, *Sitotroga cerealella* has a global distribution, including in Africa (Mpofu et al., 2022) and West African countries like Benin (Santos et al., 2015).

4.2. Insect pests associated with stored mangrove swamp rice seeds

Although some insects were not observed in all regions, their widespread presence in Africa suggests they are likely to be found throughout the sampled regions. As expected from a Carabidae, that acts as a predator, no bibliographic records have associated *Platymetopus vestitus* to stored seed damage. Its presence was recorded from only one specimen at Elalab, Cacheu. The remaining five species are economically significant pests known to attack stored seeds worldwide (Berhe et al., 2022). These pests, none of which originate from Africa (Table 2), reduce seed quality, cause weight loss, and diminish nutritional value. Among them, *R. dominica* stands out as particularly destructive, consistently showing the highest relative abundance (Fig. 2). The coexistence of primary and secondary pests highlights a clear ecological relationship: secondary pests feed on previously damaged grains, thus relying on primary pests to initially compromise the seeds (Fig. 2).

Although these species are globally recognized as pests of stored seeds, no studies have been conducted specifically in Guinea-Bissau, within its unique mangrove swamp rice system, or on African rice. In Guinea-Bissau the agricultural systems, ecological conditions, and rice varieties are distinct from rice production in other parts of the world, and rice production has a major role in the country food security. The presence of these species in both *Oryza sativa* and *O. glaberrima* rice species and their widespread distribution across the country points out an unspecific rice species preference and their wide distribution across the regions studied. This information significantly enhances our understanding of rice in an understudied, yet important, rice production system (mangrove swamp rice). The indigenous *O. glaberrima*, which remains under-researched, plays a vital role in agricultural development, thus studying its storage pests can support breeding programs like NERICA ('New Rice for Africa') and ARICA ('Advanced Rice Varieties for Africa') African rice varieties, promoting food security, biodiversity preservation, and the development of resilient rice varieties suited to African ecosystems.

Field observations indicate a shift from traditional storage facilities (such as *fuúle*, *bentén*, and *biré*) toward more commercial structures like bags, metal barrels, and plastic jerry cans, when storing mangrove swamp rice seeds in Guinea-Bissau (Conde et al., 2024). This transition may increase the risk of insect contamination, either through residue transfer from previous contents of a used bag (e.g., corn flour) or compromised containers (e.g., rusted metal tanks). Insect contamination from imported goods also warrants consideration. Proper assessment of storage structure cleaning practices and container sealing effectiveness is essential to prevent pest infestations.

Insect pests in stored rice pose significant challenges, including food loss, economic strain, food insecurity, and health risks. Based on field observations, informal conversations with the farmers, and previous work (Conde et al., 2024), effective mitigation and management strategies should include improved storage practices, such as the use of hermetic containers and thorough cleaning protocols. Additionally, biological control methods, such as natural predators and plant-based repellents, along with efficient drying techniques like solar drying, could also prove beneficial. Studies on loss estimation are required for assessing the extent of damage and formulating effective mitigation strategies. Community education and extension services are vital for equipping farmers with integrated pest management (IPM) techniques and best practices.

These combined measures can protect both rice for sowing and consumption, thereby ensuring food security, economic stability, and public health.

These findings are particularly significant given the limited research on *Oryza glaberrima*, the mangrove swamp rice production system, and the generally understudied context of Guinea-Bissau. This knowledge can guide future research on pest dynamics in various rice-production systems, enhancing storage methods and strengthening food security in the region.

CRediT authorship contribution statement

Sofia Conde: Writing – review & editing, Writing – original draft, Visualization, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Filipa Monteiro:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Resources, Methodology, Investigation, Formal analysis, Conceptualization. **Sílvia Catarino:** Writing – review & editing, Writing – original draft, Visualization, Resources, Methodology, Investigation, Formal analysis. **Maria Rosa Ferreira:** Resources, Methodology. **Sónia Ferreira:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jspr.2025.102567.

Data availability

Data will be made available on request.

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