Journal of Experimental Agriculture International

Volume 46, Issue 8, Page 774-782, 2024; Article no.JEAI.121486
ISSN: 2457-0591
(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)

Species Composition and Diversity of Stored Grain Pests in Fortified Rice Collected from Different Districts of Telangana State, India

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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/jeai/2024/v46i82760

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/121486

Original Research Article

Received: 09/06/2024
Accepted: 10/08/2024
Published: 12/08/2024

ABSTRACT

A study was conducted to measure the species composition and diversity of various stored grain insect pests in fortified rice collected from different districts of Telangana,India during 2023-2024. Theresults indicated that a total of six species of stored grain insects belonging to three orders *viz.,*

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Cite as: *E, Manasa, Vijaya lakshmi K, Padmasri A, and Kiran Reddy G. 2024. "Species Composition and Diversity of Stored Grain Pests in Fortified Rice Collected from Different Districts of Telangana State, India". Journal of Experimental Agriculture International 46 (8):774-82. https://doi.org/10.9734/jeai/2024/v46i82760.*

Coleoptera (3), Lepidoptera (2) and Psocoptera (1) were recorded in fortified rice. The six insect species were rice weevil, *Sitophilus oryzae*, Saw toothed beetle, *Oryzaephilus surinamensis*, redflour beetle, *Tribolium castaneum*, Angoumois grain moth, *Sitotroga cerealella*, rice moth, *Corcyra cephalonica* and pscocids. Among all these insects highest population of *O. surinamensis* was recorded in four districts of Telangana except in Ranga reddy and Nalgonda. The diversity indices indicated that Shannon-weiner diversity index (H) was high in Warangal district samples(H=1.426) while the Jagtial population recorded highest Margalef's species richness index (R=1.27). The highest Pielou's evenness index was reported from Nalgonda district (e=75), and Simpson diversity index of stored grain pests was found to be maximum (0.718) in Warangal district rice samples. The knowledge on species composition and diversity helps in planning timely management strategies for stored grain pests.

Keywords: Fortified rice; shannon-weiner index; margalef's richness index; pielou's evenness; index; simpson diversity index

1. INTRODUCTION

Rice, *Oryza sativa* L. (Gramineae) is the second most important cereal crop in the world after wheat [1] with Asia being the largest producer and consumer [2]. It is the most important staple food for half of the world's population and it is grown in over 100 countries of the world [3]. After milling (hulling) process, the rice is polished, and bright, white shiny seed is produced. During traditional milling process the white rice removes the nutrient-rich bran layers, thereby making it a poor source of micronutrients. "Nutritional deficiencies" are common in India causing younger-to-middle-aged Indians to fail to perform at their maximum potential and putting the elderly at risk of calamitous neurologic events. Food fortification is regarded as one of the most effective ways techniques of preventing 'hidden hunger', which is scientifically known to contribute to ill health and subsequently can have lasting consequences for people's economic prospects and well-being. To address anaemia and micro-nutrient deficiency in the country, Government of India has approved the Centrally Sponsored Pilot Scheme on "Fortification of Rice & its Distribution under Public Distribution System". Under this scheme 15 state governments including Telangana have consented and identified their respective Districts for implementation of the Pilot Scheme. In Phase II of Rice Fortification Programme, a total of 151 Districts (in 24 states have lifted fortified rice under Targeted Public Distribution System (TPDS). Nearly 6.83 LMT have been distributed by the States/UTs under the phase which started from April 2022 [4].

Every year nearly 25 to 30% crop yields are destroyed both in field and stores by different insect pests [5] and post - harvest losses of food grains in India is estimated at around 12 to 16 million MT / year [6] of which 20-25% of grains are destroyed annually due to insect pests [7] and pests devour about 6.5% of total grains stored in India [8]. A number of insect pests are reported from stored rice *i.e, Sitophilus oryzae* (Rice weevil), *Oryzaephilus surinam*ensis (Saw-toothed beetle), *Tribolium castaneum* (Red flour beetle) and *Plodia interpunctella* (Indian meal moth) Rice moth *Corcyra cephalonica* and Angoumois grain moth *Sitotroga cerealella* [9]. Among the stored grain pests, Rice weevil *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae) is regarded as the most serious stored grain pest of various cereals such as rice, wheat, maize, barley and sorghum [10] and now its host range has shifted to split pulses also [11]. Though lot of research has been carried out on rice weevil attacking the milled rice, so far no work has been attempted on the species composition and diversity of stored insects in fortified rice. Hence the present study has been taken up to measure the composition and diversity of stored grain pests and their abundance in fortified rice.

2. MATERIALS AND METHODS

The present study was conducted in the Department of Entomology, College of Agriculture, Rajendranagar, Hyderabad under laboratory conditions during October, 2023. For conducting the study, the fortified rice samples were procured from the Food corporation of India (FCI) godowns of the six districts of Telangana state *viz.,* Jagtiyal, Karimnagar, Bhupalapally, Warangal, Ranga reddy and Nalgonda districts from September to October 2023.

2.1 Sampling

From each place, 2 kgs of the sample was collected from bagged produce by inserting the

spear sampler at the top, middle and bottom portions of the bags as described by [12]. The samples were brought to the laboratory of Department of Entomology and the moisture content of the rice samples obtained from each district were determined by using Dickyjohn moisture meter.

2.2 Species Identification

The species composition and relative abundance of the stored grain pests of rice were identified in 500g of sample. Insects were sorted according to the species by collecting both dead and live specimens. The collected species were placed in 90% alcohol and identified under stereo microscope by using standard identification keys [13]. The relative abundance, richness and diversity of the species were computed by the following indices using the software; PAST (Paleontological Statistics Tool) version 3.25.

Shannon-Wiener Diversity index: $H = -\Sigma Pi \ln Pi$

Where, $Pi = S / N$
S = No. of species
N = total No. of individuals
In = logarithm to base e

Measurement of species richness: Margalef's index was used as a simple measure of species richness.

Margalef's index = $(S - 1) / \ln N$
S = total number of species
N = total number of individuals in the sample
In = natural logarithm

Measurement of evenness: Pielou's eveness index is used to calculate the evenness of species in the community.

Pielou's Evenness Index $e = H / \ln S$
H = Shannon – Wiener diversity index
S = total number of species in the sample

Relative abundance = ni X 100/N
N: the total number of individuals of all species
ni: the number of individuals of species

Simpson's diversity Index (SDI)

$D = \Sigma n (n-1)/ N(N1)$
n = total number of organisms of a particular species
N = total number of organisms of all species

3.RESULTS AND DISCUSSION

The results obtained from the studies recorded six species of stored grain pests in fortified rice collected from different districts of Telangana which belongs to three orders *i.e,* Coleoptera 3 species, Lepidoptera 2 species and Psocoptera 1 species. Among them three species were primary pests *viz., Sitophilus oryzae, Sitotroga cereallela*, and *Corcyra cephalonica*, three species of secondary pests, *Tribolium castaneum, Oryzaephilus surinamensis*. and one species of Psocid. From the six districts, a total of 341 stored grain pests were obtained from 500 g sample of each district (Table 1) Out of 341 individuals, *Oryzaephilus surinamensis* recorded the highest population (124), followed by psocids (108), *Tribolium castaneum* (53), *Sitophilus oryzae* (43), *Sitotroga cereallela* (9), while *Corcyra cephalonica* population was lowest (4) among all the species. Among the districts, the highest population of stored grain pests were recorded in fortified rice samples collected from Nalgonda district (77) followed by Ranga reddy (74), Warangal (59), Jagtial (51) and Bhupalapally (42), while lowest number of stored pests were recorded from Karimnagar district (38). The moisture content of the rice samples collected from the six districts ranged from 9 to 14.7%. Nalgonda district recorded the highest moisture content of 14.7% which might have resulted in the build up of highest population of the stored grain pests from Nalgonda samples, while lowest moisture content (9%) recorded from Karimnagar and and Bhupalappy (9.5%) might have contributed to the less build up of stored grain pests (38 and 42, respectively).

The relative abundance (%) of the stored grain pests recorded from the six districts also showed the similar trend (Table 1) and among all the storage pests, *O.surinamensis* was the most dominant species with a mean abundance of 39.78% followed by Psocids which occupied the second position (32.50%). The mean % abundance of *Tribolium castaneum* and *Sitophilus oryzae were* 14.00% and 11.59%, while lowest % abundance was recorded in *Sitotroga cerealella* (2.60%) and *Corcyra cephalonica* (1.22%). The relative abundance of the stored grain pests reported from each district indicated that, in Jagityal, highest abundance of *O. surinamensis* (47%) was recorded which was followed by psocids (27.4%), *S. oryzae* (11.7%), *T. castaneum* (9.8%) while least species composition was observed with *S. cerealella* (1.96%) and *C. cephalonica* (1.96%). In

Table 1. Species composition and relative abundance (%) of stored grain pests observed in fortified rice collected from six districts of Telangana immediately after the survey during 2023-24

Location	*Sitophilus oryzae*	*Tribolium castaneum*	*Oryzaephilus surinamensis*	*Sitotroga cerealella*	*Corcyra cephalonica*	*Liposcelis divinitorius*	Total
Jagtial	6 (11.76%)	5 (9.80%)	24 (47.00%)	1(1.96%)	1 (1.96%)	14 (27.45%)	51(14.95%)
Karimnagar	2 (5.26%)	5 (13.15%)	16 (42.10%)	0 (0%)	1 (2.36%)	14 (36.84%)	38(11.14%)
Bhupalapally	2 (4.76%)	2 (4.76%)	29 (69.04%)	2 (4.76%)	0 (0%)	7 (16.66%)	42(12.31%)
Warangal	11(18.64%)	7 (11.86%)	20 (33.89%)	2 (3.38%)	1 (1.69%)	18 (30.5%)	59(17.30%)
RangaReddy	11(14.86%)	6 (8.10%)	25 (33.78%)	3 (4.05%)	1 (1.35%)	28 (37.83%)	74(21.70%)
Nalgonda	11(14.28%)	28 (36.36%)	10 (12.90%)	1 (1.47%)	0 (0%)	27 (45.76%)	77(22.58%)
Total	43 (12.60%)	53 (15.54%)	124 (36.36%)	9 (2.63%)	4 (1.17%)	108 (31.65%)	341

Table 2. Diversity indices of stored grain pests in fortified rice collected from different districts of Telangana during 2023-24

Location	Shannon-Weiner index (H)	Margalef's Richness index(R)	Pielou's Eveness index(e)	Simpson diversity index(1-D)
Jagtial	1.34	1.27	0.63	0.67
Karimnagar	1.25	1.10	0.69	0.66
Bhupalapally	0.98	1.07	0.53	0.48
Warangal	1.47	1.22	0.73	0.74
Ranga reddy	1.41	1.16	0.68	0.71
Nalgonda	1.33	0.92	0.75	0.70

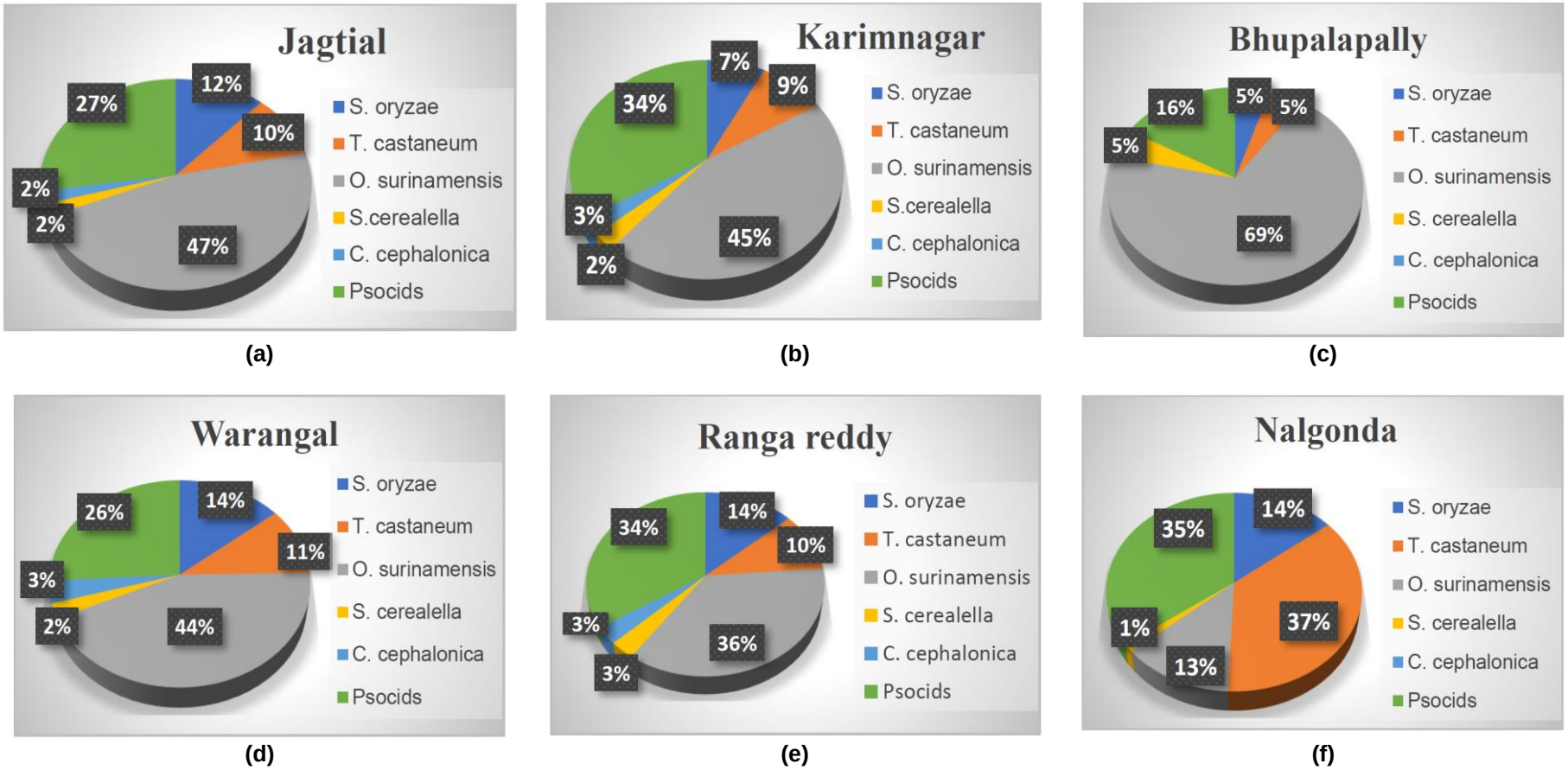

Fig. 1. Relative abundance (%) of stored grain pests in fortified rice collected from different districts of Telangana during 2023-24 (a) Jagtial (b) Karimnagar (c) Bhupalapally (d) Warangal (e) Ranga reddy (f) Nalgonda

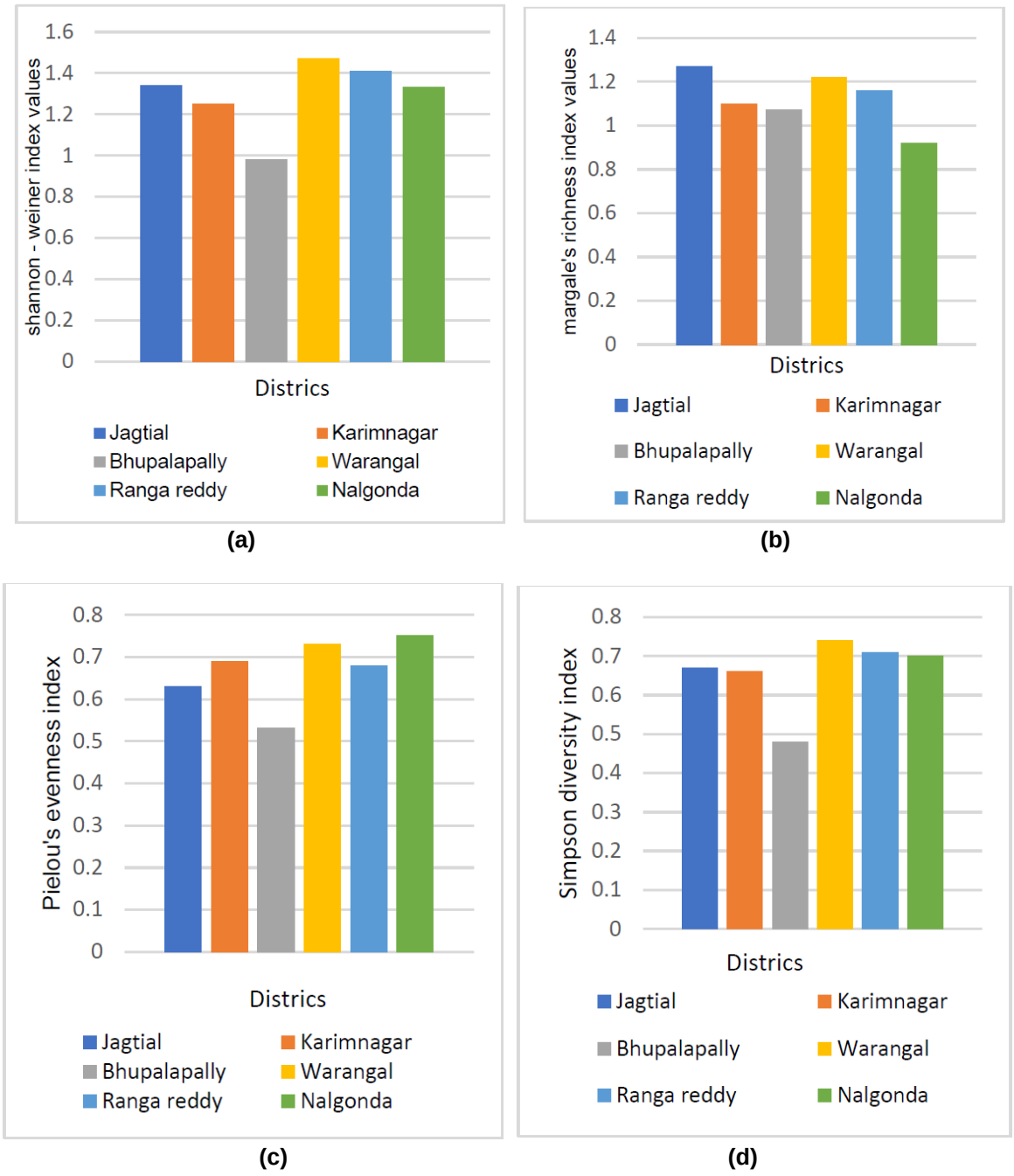

Fig. 2. Diversity indices of stored grain pests in fortified rice collected from different districts of Telangana during 2023-24 (a) Shannon-Weiner index (b) Margalef's richness index (c) Pielou's Eveness Index (d) Simpson diversity index

Karimnagar district, highest composition of *O. surinamensis* (42.1%) followed psocids (27.4%), *T. castaneum* (13.1%) *S. oryzae* (5.26%) and least composition of *C. cephalonica* (2.36%) were observed.

In Bhupalapally district also highest composition of *O. surinamensis* (69%) followed by psocids (16.66%) was observed while least composition of rice weevil *S. oryzae* (4.76%), red flour beetle *T. castaneum* (4.76%), Angoumois grain moth *S. cerealella* (4.76%) and rice moth *C. cephalonica* (0) was observed.

In Warangal district also the species *O. surinamensis* (33.89%) recorded highest

abundance followed by psocids (30.5%), *S. oryzae* (18.6%), *T. castaneum* (10.16%) and least composition of *S. cerealella* (3.38%) and *C. cephalonica* (1.69%) was observed. Ranga reddy district species composition of stored grain pests slightly deviated from the other districts which recorded highest abundance of psocids (43.75%) followed by *O. surinamensis* (39%), *S. oryzae* (17.1%), *T. castaneum* (9.37%) and least composition of *S. cerealella* (4.68%) and *C. cephalonica* (1.56%). In Nalgonda district red flour beetle *T. castaneum* continued to remain as the dominant species (36.36%) followed by psocids (35.06%), *S. oryzae* (14.28%), *O.surinamensis* (12.9%), and while least abundance of *S. cerealella* (1.29%) and *C. cephalonica* (0) was observed. The results are on par with the survey conducted by [14] on insect pests of stored cereal grains in New Zealand and they found that the most frequently encountered stored grain pests in cereal grains were *O.surinamensis* followed by *Cryptolestes ferrugineus and Cortinicara hirtalis.* The results were also in accordance with the studies conducted by [15] who collected the stored grain pests from three rice warehouses in Klang Selangor, Malaysia and the main insect species reported from all the warehouses were *Oryzaephilus surinamensis, Tribolium castaneum, Sitophilus oryzae* and *Cadra cautella*. Highest composition of *Oryzaephilus surinamensis* followed by *Cadra cautella* and least composition of *Tribolium castaneum* and *Sitophilus oryzae* [16]. Studies conducted by [17] concluded that the damage caused by the primary pests increase the potential for multiplication of secondary pests. Many of the stored grain pests were in the order of Coleoptera and the most destructive tropical species belong to the genus *Sitophilus and Tribolium* [18]. The above results are contrary to the studies conducted by [19] who reported *Sitophilus zeamais* and *Cryptolestes ferrugineus* (Stevens) as the most abundant insect species in stored rice in Portugal were). The variation in the results obtained from the present studies could be attributed to the change in the environmental conditions, place of study, the duration of the storage period and the rice variety used in the study. The various following diversity indices of stored grain pests calculated from the data obtained from the six districts of Telangana were represented in Table 2 and in the Fig. 2.

It is a measure of community's diversity that considers both total number of individuals and taxa. Higher the index value, more the diversity exists in the community. In the present study, Warangal district (H=1.47) showed the highest diversity of stored grain pests followed by Ranga reddy (H=1.41), Jagtial (H=1.34), Karimnagar (H=1.25) and Nalgonda (H=1.246). The lowest Shannon – Weiner diversity index was recorded from Bhupalapally district (H=0.98). Though Nalgonda district recorded the highest abundance of the pest, *Corcyra cephalonica* population was not reported from Nalgonda district which has resulted in less diversity index of the stored grain pests in Nalgonda district when compared to no Warangal and Ranga reddy districts.

Margalef's richness index is a measure of the number of species present in a population. In the present study Jagtial (R=1.27) followed by Warangal districts (R=1.22) showed the highest Margalef's species richness index. While Rangareddy (R=1.16), Karimnagar (R=1.10) Bhupalapally (R=1.07), followed the intermediate trend and least species richness of stored pests was observed in Nalgonda (R=1.443). The wide variation in the species composition of the stored grain pests and absence of rice moth collections from Nalgonda district resulted in recording lowest species richness of stored grain pests from this district Evenness compares the homogeneity of the population in terms of the abundances of its species. The Values range from zero to one, with zero signifies no evenness and one, a complete evenness**.** In the present study more evenly distributed species was observed in the Nalgonda (e=0.75) followed by Warangal (e=0.73), Karimnagar (e=0.69) and Rangareddy (e=0.68). and Jagtial (e=0.63). Among all the districts Bhupalapally which recorded lowest pest population as well as less species diversity showed the least evenness distribution of stored grain pests in fortified rice.

Simpson's diversity index (SDI) takes into account the number of species present, as well as the relative abundance of each species**.** In the present study the SDI was maximum in the Warangal (0.718) followed by Ranga reddy (0.703), Jagtial (0.679), Nalgonda (0.672), and Karimnagar (0.666). The least SDI was recorded in Bhupalapally district (0.488). The lowest Simson index recorded from Bhupalapally district could be attributed to the less abundance of species and no record of rice moth *Corcyra cephalonica* from this district.

4. CONCLUSION

The survey taken up from the six districts of Telangana showed variation in the diversity

indices of the stored grain pests among the districts. Except in Nalgonda and Bhupalapally, all the other four districts recorded six species of stored grain pests in fortified rice. Among them 3 species of coleopterans, 2 lepidopterans and 1 psocid species were observed. Among the stored grain pests, the abundance of secondary pests *viz.,* saw toothed beetle *and* psocids was more than the primary pests, *Sitophilus oryzae* and *Sitotroga cerealella*. Though highest population of stored grain pests were recorded from Nalgonda district, highest diversity indices of the stored grain pests were observed from Warangal district in view of the richness, diversity and distribution of the species observed in the fortified rice of this district. The knowledge on insect diversity and density studies help in planning timely management strategies of stored grain pests.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare 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.

ACKNOWLEDMENT

The authors express their deep gratitude to the Department of Entomology, College of Agriculture, PJTSAU Rajendranagar, Hyderabad for providing essential facilities and smooth conduct of study

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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