

1                   **Species composition and diversity of stored**  
2                   **grain pests in fortified rice collected from**  
3                   **different districts of Telangana state**

15

17

18

19

---

**ABSTRACT**

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

20

21

22

23

24

*Keywords:* fortified rice, Shannon-weiner index, Margalef's richness index, Pielou's evenness index, Simpson diversity index.

## 25 1.INTRODUCTION

26 Rice, *Oryza sativa* L. (Gramineae) is the second most important cereal crop in the world after  
27 wheat [2] with Asia being the largest producer and consumer [9]. It is the most important staple  
28 food for half of the world's population and it is grown in over 100 countries of the world [13].  
29 After milling (hulling) process, the rice is polished, and bright, white shiny seed is produced.  
30 During traditional milling process the white rice removes the nutrient-rich bran layers, thereby  
31 making it a poor source of micronutrients. "Nutritional deficiencies" are common in India  
32 causing younger-to-middle-aged Indians to fail to perform at their maximum potential and  
33 putting the elderly at risk of calamitous neurologic events. Food fortification is regarded as one  
34 of the most effective ways techniques of preventing 'hidden hunger', which is scientifically  
35 known to contribute to ill health and subsequently can have lasting consequences for people's  
36 economic prospects and well-being. To address anaemia and micro-nutrient deficiency in the  
37 country, Government of India has approved the Centrally Sponsored Pilot Scheme on  
38 "Fortification of Rice & its Distribution under Public Distribution System". Under this scheme  
39 15 state governments including Telangana have consented and identified their respective  
40 Districts for implementation of the Pilot Scheme. In Phase II of Rice Fortification Programme,  
41 a total of 151 Districts (in 24 states have lifted fortified rice under Targeted Public Distribution  
42 System (TPDS). Nearly 6.83 LMT have been distributed by the States/UTs under the phase  
43 which started from April 2022 [11].

44 Every year nearly 25 to 30% crop yields are destroyed both in field and stores by different  
45 insect pests [12] and post - harvest losses of food grains in India is estimated at around 12 to  
46 16 million MT / year [16] of which 20-25% of grains are destroyed annually due to insect pests  
47 [17] and pests devour about 6.5% of total grains stored in India [14]. A number of insect pests  
48 are reported from stored rice *i.e.*, *Sitophilus oryzae* (Rice weevil), *Oryzaephilus surinamensis*  
49 (Saw-toothed beetle), *Tribolium castaneum* (Red flour beetle) and *Plodia interpunctella* (Indian  
50 meal moth) Rice moth *Corcyra cephalonica* and Angoumois grain moth *Sitotroga cerealella*  
51 [19]. Among the stored grain pests, Rice weevil *Sitophilus oryzae* (L.) (Coleoptera:  
52 Curculionidae) is regarded as the most serious stored grain pest of various cereals such as  
53 rice, wheat, maize, barley and sorghum [1] and now its host range has shifted to split pulses  
54 also [8]. Though lot of research has been carried out on rice weevil attacking the milled rice,  
55 so far no work has been attempted on the species composition and diversity of stored insects  
56 in fortified rice. Hence the present study has been taken up to investigate the stored grain  
57 pests and their abundance in fortified rice.

## 58 2.MATERIAL AND METHODS

59

60 The present study was conducted in the Department of Entomology, College of Agriculture,  
 61 Rajendranagar, Hyderabad under laboratory conditions during 2023-2024. For conducting the  
 62 study, the fortified rice samples were procured from the Food corporation of India (FCI)  
 63 godowns of the six districts of Telangana state viz., Jagtiyal, Karimnagar, Bhupalpally,  
 64 Warangal, Ranga reddy and Nalgonda districts from September to October 2023. From each  
 65 place, 2 kgs of the sample was collected from bagged produce by inserting the spear sampler  
 66 at the top, middle and bottom portions of the bags as described by [10]. The samples were  
 67 brought to the laboratory of Department of Entomology and the moisture content of the rice  
 68 samples obtained from each district were determined by using Dickyjohn moisture meter. The  
 69 species composition and relative abundance of the stored grain pests of rice were identified  
 70 in 500g of sample. Insects were sorted according to the species by collecting both dead and  
 71 live specimens. The collected species were placed in 90% alcohol and identified under stereo  
 72 microscope by using standard identification keys [15]. The relative abundance, richness and  
 73 diversity of the species were computed by the following indices using the software; PAST  
 74 (Paleontological Statistics Tool) version 3.25.

75 **Shannon-Wiener Diversity index:**  $H = - \sum P_i \ln P_i$

76 Where,  $P_i = S / N$

77 S = No. of species

78 N = total No. of individuals

79 ln = logarithm to base e

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

82 Margalef's index =  $(S - 1) / \ln N$

83 S = total number of species

84 N = total number of individuals in the sample

85 ln = natural logarithm

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

88 Pielou's Evenness Index  $e = H / \ln S$

89 H = Shannon – Wiener diversity index

90 S = total number of species in the sample

91 **Relative abundance** =  $n_i \times 100/N$

92 N: the total number of individuals of all species

93  $n_i$ : the number of individuals of species

94

95 **Simpson's diversity Index (SDI)**

96 
$$D = \sum n(n-1) / N(N-1)$$

97  $n$  = total number of organisms of a particular species98  $N$  = total number of organisms of all species99 **3.RESULTS AND DISCUSSION**

100

101 The results obtained from the studies recorded six species of stored grain pests in fortified rice  
 102 collected from different districts of Telangana which belongs to three orders *i.e.*, Coleoptera 3  
 103 species, Lepidoptera 2 species and Psocoptera 1 species. Among them three species were  
 104 primary pests *viz.*, rice weevil *Sitophilus oryzae*, Angoumois grain moth *Sitotroga cerealella*,  
 105 and rice moth *Corcyra cephalonica*, three species of secondary pests, red flour beetle  
 106 *Tribolium castaneum*, Saw-toothed beetle *Oryzaephilus surinamensis*. and one species of  
 107 Psocid. From the six districts, a total of 341 stored grain pests were obtained from 500 g  
 108 sample of each district (Table 1) Out of 341, species, *Oryzaephilus surinamensis* recorded  
 109 the highest population (124), followed by psocids (108), *Tribolium castaneum* (53), *Sitophilus*  
 110 *oryzae* (43), *Sitotroga cerealella* (9), while *Corcyra cephalonica* population was lowest (4)  
 111 among all the species. Among the districts, the highest population of stored grain pests were  
 112 recorded in fortified rice samples collected from Nalgonda district (77) followed by Ranga  
 113 reddy (74), Warangal (59), Jagtial (51) and Bhupalapally (42), while lowest number of stored  
 114 pests were recorded from Karimnagar district (38). The moisture content of the rice samples  
 115 collected from the six districts ranged from 9 to 14.7%. Nalgonda district recorded the highest  
 116 moisture content of 14.7% which might have resulted in the build up of highest population of  
 117 the stored grain pests from Nalgonda samples, while lowest moisture content (9%) recorded  
 118 from Karimnagar and and Bhupalappy (9.5%) might have contributed to the less build up of  
 119 stored grain pests (38 and 42, respectively).

120

121 The relative abundance (%) of the stored grain pests recorded from the six districts  
 122 also showed the similar trend (Table 2) and among all the storage pests, *O.surinamensis*  
 123 was the most dominant species with a mean abundance of 39.78% followed by Psocids which  
 124 occupied the second position (32.50%). The mean % abundance of *Tribolium castaneum* and  
 125 *Sitophilus oryzae* were 14.00% and 11.59%, while lowest % abundance was recorded in  
 126 *Sitotroga cerealella* (2.60%) and *Corcyra cephalonica* (1.22%). The relative abundance of the  
 127 stored grain pests reported from each district indicated that, in Jagityal, highest abundance of  
 128 *O. surinamensis* (47%) was recorded which was followed by psocids (27.4%), rice weevil *S.*  
 129 *oryzae* (11.7%), red flour beetle *T. castaneum* (9.8%) while least species composition was  
 130 observed with Angoumois grain moth *S. cerealella* (1.96%) and rice moth *C. cephalonica*  
 (1.96%). In Karimnagar district, highest composition of *O. surinamensis* (42.1%) followed by

131 psocids (27.4%), red flour beetle *T. castaneum* (13.1%) rice weevil *S. oryzae* (5.26%) and  
132 least composition of rice moth *C. cephalonica* (2.36%) were observed. In Bhupalapally district  
133 also highest composition of *O. surinamensis* (69%) followed by psocids (16.66%) was  
134 observed while least composition of rice weevil *S. oryzae* (4.76%), red flour beetle *T.*  
135 *castaneum* (4.76%), Angoumois grain moth *S. cerealella* (4.76%) and rice moth *C.*  
136 *cephalonica* (0) was observed.

137 In Warangal district also the species *O. surinamensis* (33.89%) recorded highest abundance  
138 followed by psocids (30.5%), rice weevil *S. oryzae* (18.6%), red flour beetle *T. castaneum*  
139 (10.16%) and least composition of Angoumois grain moth *S. cerealella* (3.38%) and rice moth  
140 *C. cephalonica* (1.69%) was observed. Ranga reddy district species composition of stored  
141 grain pests slightly deviated from the other districts which recorded highest abundance of  
142 psocids (43.75%) followed by *O. surinamensis* (39%), rice weevil *S. oryzae* (17.1%), red flour  
143 beetle *T. castaneum* (9.37%) and least composition of Angoumois grain moth *S. cerealella*  
144 (4.68%) and rice moth *C. cephalonica* (1.56%). In Nalgonda district red flour beetle *T.*  
145 *castaneum* continued to remain as the dominant species (36.36%) followed by psocids  
146 (35.06%), rice weevil *S. oryzae* (14.28%), *O. surinamensis* (12.9%), and while least abundance  
147 of Angoumois grain moth *S. cerealella* (1.29%) and rice moth *C. cephalonica* (0) was observed  
148 The results are on par with the survey conducted by [5] on insect pests of stored cereal grains  
149 in New Zealand and they found that the most frequently encountered stored grain pests in  
150 cereal grains were *O. surinamensis* followed by *Cryptolestes ferrugineus* and *Corticicara*  
151 *hirtalis*. The results were also in accordance with the studies conducted by [18] who collected  
152 the stored grain pests from three rice warehouses in Klang Selangor, Malaysia and the main  
153 insect species reported from all the warehouses were *Oryzaephilus surinamensis*, *Tribolium*  
154 *castaneum*, *Sitophilus oryzae* and *Cadra cautella*. Highest composition of *Oryzaephilus*  
155 *surinamensis* followed by *Cadra cautella* and least composition of *Tribolium castaneum* and  
156 *Sitophilus oryzae*. Studies conducted by [3] concluded that the damage caused by the primary  
157 pests increase the potential for multiplication of secondary pests. Many of the stored grain  
158 pests were in the order of Coleoptera and the most destructive tropical species belong to the  
159 genus *Sitophilus* and *Tribolium* [7]. The above results are contrary to the studies conducted  
160 by [4] who reported *Sitophilus zeamais* and *Cryptolestes ferrugineus* (Stevens) as the most  
161 abundant insect species in stored rice in Portugal were). The variation in the results obtained  
162 from the present studies could be attributed to the change in the environmental conditions,  
163 place of study, the duration of the storage period and the rice variety used in the study.

164 The various following diversity indices of stored grain pests calculated from the data obtained  
165 from the six districts of Telangana were represented in table 3 and in the fig 2.

166

**167 Shannon – Weiner diversity index (H):**

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

**177 Margalef's species richness index (R):**

178 Margalef's richness index is a measure of the number of species present in a population. In  
179 the present study Jagtial (R=1.27) followed by Warangal districts (R=1.22) showed the highest  
180 Margalef's species richness index. While Rangareddy (R=1.16), Karimnagar (R=1.10)  
181 Bhupalapally (R=1.07), followed the intermediate trend and least species richness of stored  
182 pests was observed in Nalgonda (R=1.443). The wide variation in the species composition of  
183 the stored grain pests and absence of rice moth collections from Nalgonda district resulted in  
184 recording lowest species richness of stored grain pests from this district

**185 Pielou's Evenness index (e):**

186 Evenness compares the homogeneity of the population in terms of the abundances of its  
187 species. The Values range from zero to one, with zero signifies no evenness and one, a  
188 complete evenness. In the present study more evenly distributed species was observed in the  
189 Nalgonda (e=0.75) followed by Warangal (e=0.73), Karimnagar (e=0.69) and Rangareddy  
190 (e=0.68). and Jagtial (e=0.63). Among all the districts Bhupalapally which recorded lowest pest  
191 population as well as less species diversity showed the least evenness distribution of stored  
192 grain pests in fortified rice.

**193 Simpson diversity index:**

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

200

201 **Table 1. Species composition of stored grain pests in fortified rice collected from**  
 202 **different districts of Telangana during 2023-24.**

Location	<i>Sitophilus oryzae</i>	<i>Tribolium castaneum</i>	<i>Oryzaephilus surinamensis</i>	<i>Sitotroga cerealella</i>	<i>Corcyra cephalonica</i>	<i>Psocid</i>	Total
Jagtial	6	5	24	1	1	14	51
Karimnagar	2	5	16	0	1	14	38
Bhupalapally	2	2	29	2	0	7	42
Warangal	11	7	20	2	1	18	59
Ranga Reddy	11	6	25	3	1	28	74
Nalgonda	11	28	10	1	0	27	77
Total	43	53	124	9	4	108	341

203

204 **Table 2. Relative abundance (%) of stored grain pests in fortified rice collected from**  
 205 **different districts of Telangana during 2023-24.**

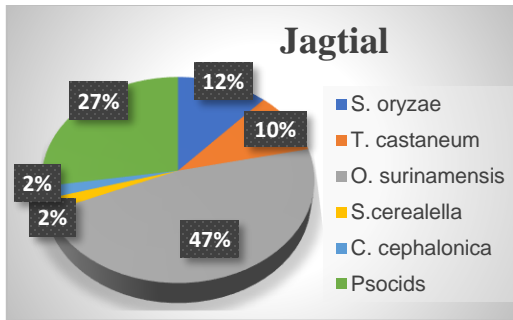
Location	<i>Sitophilus oryzae</i>	<i>Tribolium castaneum</i>	<i>Oryzaephilus surinamensis</i>	<i>Sitotroga cerealella</i>	<i>Corcyra cephalonica</i>	<i>Psocids</i>
Jagtial	11.76%	9.80%	47.00%	1.96%	1.96%	27.45%
Karimnagar	5.26%	13.15%	42.10%	0%	2.36%	36.84%
Bhupalapally	4.76%	4.76%	69.04%	4.76	0%	16.66%
Warangal	18.64%	11.86%	33.89%	3.38%	1.69%	30.5%
Ranga reddy	14.86%	8.10%	33.78%	4.05%	1.35%	37.83%
Nalgonda	14.28%	36.36%	12.9%	1.47%	0%	45.76%
Mean population	11.59%	14.00%	39.78%	2.60%	1.22%	32.50%

206 **Table 3. Diversity indices of stored grain pests in fortified rice collected from**  
 207 **different districts of Telangana during 2023-24.**

Location	Shannon-Weiner index (H)	Margalef's Richness index (R)	Pielou's Evenness 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

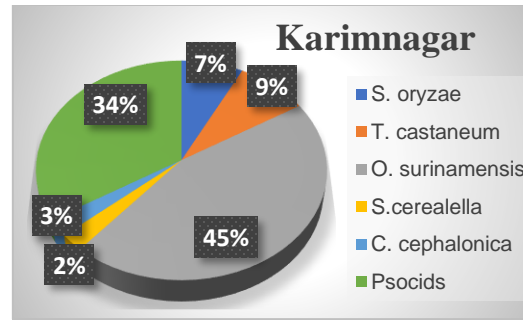
208

209



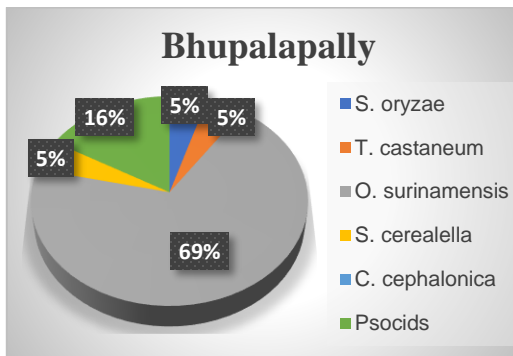
210

(a)



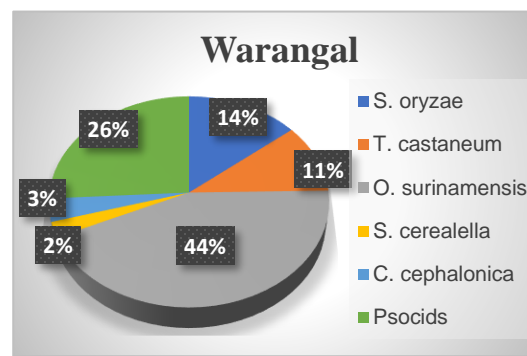
(b)

211



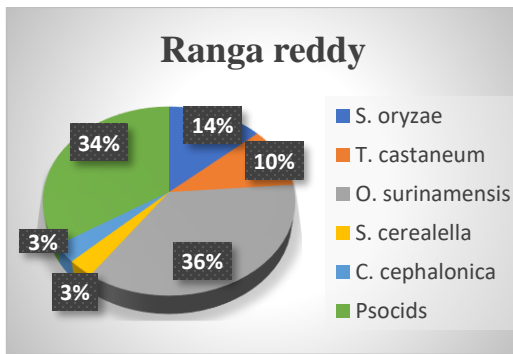
212

(c)



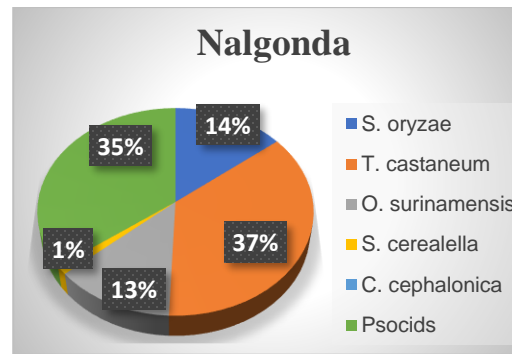
(d)

213



214

(e)



(f)

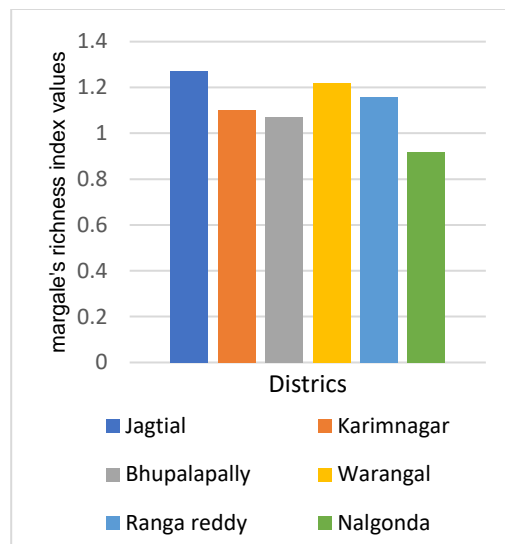
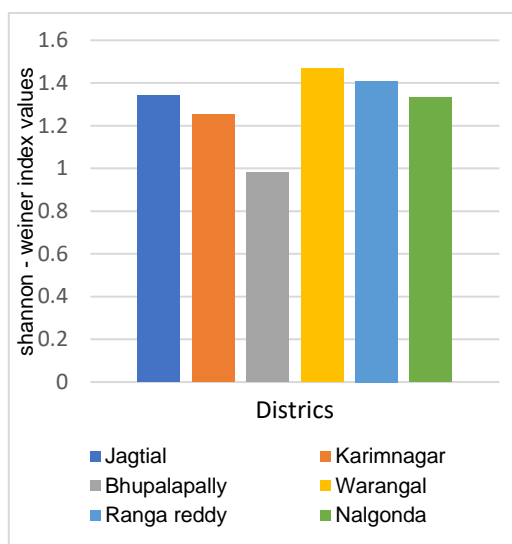
215

216

217

218

**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**

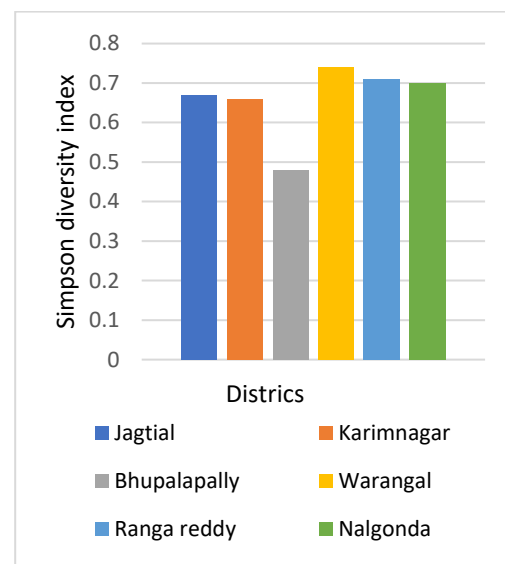
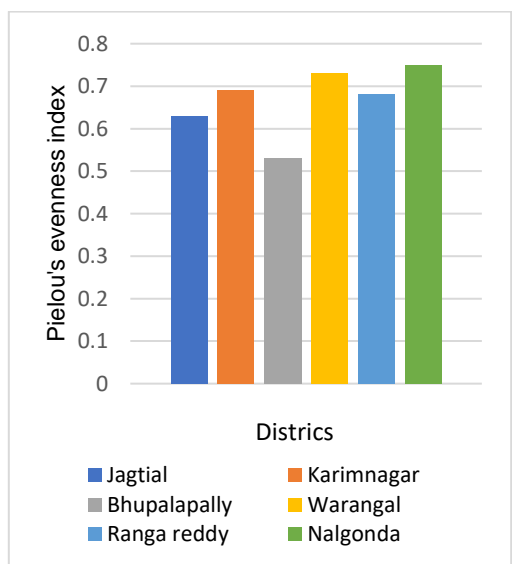


219

220

(a)

(b)



221

222

(c)

(d)

223

224

225

226

227

228

**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 Evenness Index (d) Simpson diversity index.**

## 229 CONCLUSION

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

## 245 REFERENCES

- 246 1. Atwal AS, Dhaliwal GS. Agriculture pests of South Asia and their management. Kalyani  
247 Publishers, Ludhiyana, India. 2002; 427.
- 248 2. Banik, M. Cold injury problems in Boro rice. In Proc. of the workshop on Modern Rice  
249 Cultivation in Bangladesh. Bangladesh Rice Research Institute, Joydevpur, Gazipur,  
250 Bangladesh. 1999;14-16.
- 251 3. Beckett, S.J., Longstaff, B.C. and Evans, D.E. A comparison of the demography of four  
252 major stored grain coleopteran pest species and its implications for pest management. In  
253 Proceedings of the Sixth International Working Conference on Stored-Product Protection.  
254 1994;1: 491-497.
- 255 4. Carvalho, M.O., Barbosa, A.F., Marques, P., Timlick, B., Adler, C. and Mexia, A. Estimation  
256 of population density and spatial pattern of stored paddy rice insect species using unbaited  
257 traps. Working group "integrated protection in stored products" IOBC/wprs Bulletin. 2004;93-  
258 102.
- 259 5. Chapman, R.B., Marris, J.W. and Drummond, J.B. Survey of insect pests of stored grain in  
260 New Zealand. New Zealand Plant Protection. 2016;69: 285 – 289.

- 261 6. Csölle I, Felső R and Szabó É. Health outcomes associated with micronutrient- fortified  
262 complementary foods in infants and young children aged 6-23 months: A systematic review  
263 and meta-analysis. *The Lancet* 2022;6 (8): 533-544.
- 264 7. Dal Bello, G., Padin, S., Lastra, C.L. and Fabrizio, M. Laboratory evaluation of chemical-  
265 biological control of the rice weevil (*Sitophilus oryzae* L.) in stored grains. *Journal of stored*  
266 *products research*. 2000;37(1): 77-84
- 267 8. Deepthi, N. and Manjunatha, M. Comparative development of rice weevil, *Sitophilus oryzae*  
268 (L.) in stored split legumes. *Journal of Eco-friendly Agriculture*. 2015;10(2): 180-183.
- 269 9. Gumma, M.K, Nelson, A, Thenkabail, P.S. and Singh, A.N. Mapping rice areas of South Asia  
270 using MODIS multitemporal data. *Journal of applied remote sensing*. 2011;5(1): 053547-  
271 053547.
- 272 10. Hangstrum, D.W. and Subramanyam, B. Monitoring and decision-making tools, In:  
273 Subramanyam, B. and Hangstrum, D.W. (eds), *Alternatives to pesticides in stored product*  
274 *IPM*, Kluwer Academic publishers, Boston, Dordrecht, London. 2000; 1-28.
- 275 11. [https://dfpd.gov.in/Centrally Sponsored Pilot Scheme.htm](https://dfpd.gov.in/Centrally%20Sponsored%20Pilot%20Scheme.htm).
- 276 12. Lal S. and Srivastava B.P. Insect pests of stored wheat in Madhya Pradesh (India). *Journal*  
277 *of Entomological Research*. 1985;9(2): 141-148.
- 278 13. Oko, A.O., Ubi, B.E., Efiue, A.A. and Dambaba, N. Comparative analysis of the chemical  
279 nutrient composition of selected local and newly introduced rice varieties grown in Ebonyi  
280 State of Nigeria. *International Journal of Agriculture and Forestry*. 2012;2(2): 16-23.
- 281 14. Raju, P. The staggering storage losses-causes and extent. *Pesticides*. 1984;18(1): 35-37.
- 282 15. Rees, D.P. 2004. *Insects of stored products*. CSIRO publishing. Book 25-30.
- 283 16. Singh, P.K. A decentralized and holistic approach for grain management in India. *Current*  
284 *science*. 2010;99(9): 1179-1180.
- 285 17. Sujeetha, J.A.R., Abirami, C.K. and Alagusundaram, K. Biointensive safe storage methods  
286 for pulses. *Journal of Biopesticides*. 2014;7(1): 98
- 287 18. Syarifah Zulaikha, S.A., Halim, M., Nor Atikah, A.R. and Yaakop, S. 2018. Diversity and  
288 abundance of storage pest in rice warehouses in Klang, Selangor, Malaysia. *Serangga*.  
289 2018;23(1): 89-98.
- 290 19. Zulaikha, S.A.S. and Yaakop, S. Effect on *Sitophilus oryzae* infestation on amylose content  
291 and weight loss of eight rice varieties. *Pakistan Journal of Agriculture Science*. 2021; 58(6):  
292 1699-1703.

293

294

295