Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2020; 8(5): 1356-1360

Received: 08-06-2020
Accepted: 12-08-2020

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Prevalence of grain insect pests in milled rice stored in public warehouses

Dr. SVS Gopala Swamy, S Vishnuvardhan and B John Wesley

Abstract
A study was conducted to know about various insect pests associated with rice stored in public warehouses *i.e.*, at FCI, Nalgonda and SWC, Vadlakonda, Telangana state and CWC, Machilipatnam, Andhra Pradesh State during the period 2014 to 2016. The data indicated the prevalence of red flour beetle, *T. castaneum* throughout the year in higher numbers in stored parboiled rice as well as raw rice. In addition, the populations of psocids in parboiled rice and rusty grain beetle in raw rice were also found creating problem. At CWC, Machilipatnam, there were three spurts observed in the population of *Tribolium* with the mean number of insects per trap 161.0 during 1st fortnight of July; 186.0 during 1st fortnight of September; and 98.0 during 1st fortnight of December, 2015. While there were three peaks in the population of flat grain beetle with the mean number of insects per trap 98.75 during 1st fortnight of April, followed by 61.25 during 1st fortnight of December, 2015 and 63.25 during 1st fortnight of February, 2016. The study suggests the predominance of these insects throughout the year in rice stored at warehouses in spite of all the prophylactic and control measures taken up on schedule basis.

Keywords: Public warehouses, stored rice, grain insects, control measures, fumigation

Introduction
Rice (*Oryza sativa* L.) is an important staple food for many people worldwide. In India, rice is procured and stored in warehouses at various places by Food Corporation of India (FCI), Central Warehousing Corporation (CWC) and State Warehousing Corporation (SWC) for maintenance of operational stocks required for regular supply to the Public Distribution System and buffer stocks to ensure national food security at times of natural calamities and droughts. Before reaching to the consumers, agricultural commodities suffer significant losses during various operations, such as harvesting, threshing, winnowing, bagging, transportation, storage, processing, value addition and exchange [2]. During storage, food grains are vulnerable to various abiotic factors such as temperature and relative humidity and biotic stresses like rodents, insect pests and diseases; thus suffer huge losses. FAO estimates that each year, approximately one-third of all food produced for human consumption in the world is lost or wasted. This food wastage represents a missed opportunity to improve global food security.
Among all the biotic factors, insect pests are considered most important and cause huge losses in the stored grains [1, 20]. The stored grain insect pests can be categorized on the basis of their feeding behaviour as internal and external feeders or major and minor pests based on the severity of damage, they cause [6]. Red flour beetle, *Tribolium castaneum* (Herbst) is one of the major and most destructive insect pests of stored commodities [15], although considered as a secondary pest, it primarily attacks milled grain products, such as flour and cereals, beans, nuts, pasta and biscuits causing considerable loss and damage. Both adults and grubs cause damage to the grains and the infestation by these products results in an unpleasant smell due to the secretion of benzoquinones from abdominal glands of beetles, thereby the stored food materials become unfit for consumption purpose [14]. Similarly, both larvae and adults of rusty grain beetle, *Cryptolestes ferrugineus* (Stephens) feed on germ and endosperm, heavy infestations of which cause grain heating and spoilage. Thus, insects cause both qualitative and quantitative losses by feeding damage and by contaminating the product with webbings, excreta, exuviae, body odour and frass [22]. The population dynamics of *T. castaneum* in rice is strongly influenced by seasonal temperature changes [5]. The knowledge of insect pest populations and their control strategies can help in reducing losses during the storage by which timely preventive actions can be taken effectively. Keeping this in view, a study was conducted to understand the incidence of various grain insects and their population pattern in

rice stored at three different public warehouses in Telangana and Andhra Pradesh states.

Materials and Methods

An attempt was made to know about various insect pests associated with rice stored in various public warehouses *i.e.*, at FCI, Nalgonda and SWC, Vadlakonda, Warangal district of Telangana state and CWC, Machilipatnam, Krishna district of Andhra Pradesh State from June, 2014 to April, 2015. The storage facilities are rectangular compartments with RCC roof at CWC, Machilipatnam (capacity: approx. 5000 MT) and ACC roof at FCI, Nalgonda and SWC, Vadlakonda (capacity: approx. 5000 MT and 10000 MT, respectively). In each compartment there were 12 stacks and one stack is liquidated randomly at every 3 months interval. The stack weights ranged from 120 to 160 MT depending upon total weight of consignment at the time of receipts of the stocks. Rice is commonly stored in jute bags of 50 kg capacity. The grain moisture ranged from 12 to 14% (wet basis) during the storage period. The grain stacks were maintained by the warehousing agencies while adopting mandatory spraying and fumigation schedules. The scheduled dis-infestation programmes included fumigation at 45 to 60 days interval using aluminium phosphide 56% (F) tablets and post fumigation surface treatments with deltamethrin 2.5% WP @ 120 g/100 m^2 and malathion 50% EC @ 30 ml/100 m^2. Dichlorvas 76% EC @ 1:150 dilution with water was also used for air discharge in the godowns.

Grain samples (5 - 6 kg) were drawn from each stack from the periphery using a spear following the standard sampling procedure. Immediately after collection, they were observed for the insects; total number of insects were counted, and then expressed as number of insects per 500 g sample. Average population per month was worked out. The red flour beetle, *T. castaneum* was the only major insect found in all the warehouses. However, after certain period in raw rice at CWC, Machilipatnam in addition to the red flour beetle; rusty grain beetle, *C. ferrugineus* was also found to exist. Since it is fast moving and difficult to count, monitoring of insect populations was done using TNAU stack probes for another 18 months *i.e*., 36 fortnights starting from the first fortnight of December, 2014. A total of four traps (one trap on each side) were installed in a stack at a height of 6 feet and the number insects collected in the traps were recorded at fortnight intervals. The data were subjected to statistical analyses with randomised block design to find out significance of variance.

Results and Discussion

In both the warehouses (FCI, Nalgonda and SWC, Vadlakonda) of Telangana, parboiled rice was stored while at CWC, Machilipatnam raw rice was stored. There were significant differences in the incidence levels of various insects in the storage facilities at different places and also between raw rice and parboiled rice. The red flour beetle, *T. castaneum* was found to exist causing considerable damage in parboiled rice as well as raw rice. At FCI, Nalgonda, the number of *Tribolium* insects/ 500 g sample ranged from 8.0 during March, 2015 to 18.83 during July, 2014 (Table 1). The numbers varied between 7.11 during April, 2015 and 16.89 during January, 2015 at SWC, Vadlakonda. Similarly, the insect population at CWC, Machilipatnam ranged from 7.5 during December, 2014 to 19.64 during July, 2014. The monthly average populations were 13.78, 13.0 and 12.88 insects per 500 g sample at FCI, Nalgonda; SWC, Vadlakonda and CWC, Machilipatnam; respectively. Though a set pattern in the incidence of red flour beetle was not existed, the data indicated its prevalence throughout the year in higher numbers in stored rice. Particularly, the numbers were high during the rainy season and found decreased by March and April months. Several peaks in their incidence also indicated the presence of overlapping generations and showed the influence of intermittent fumigations performed for their control at scheduled intervals (Fig 1).

In addition to the red flour beetle, the populations of psocids, *Liposcelis bostrychophila* Badonnel (Psocoptera: Liposcelididae) in parboiled rice at both the warehouses of Telangana and rusty grain beetle, *C. ferrugineus* in raw rice at CWC, Machilipatnam were also found creating problem. As the rusty grain beetle prefers warm humid climate, its abundance was more at CWC, Machilipatnam which is in the sea coast. During the period of 18 months, there were three spurts observed in the population of *Tribolium* with the mean number of insects per trap 161.0 during 1st fortnight of July; 186.0 during 1st fortnight of September; and 98.0 during 1st fortnight of December, 2015 (Table 2). While there were three peaks in the population of flat grain beetle with the mean number of insects per trap 98.75 during 1st fortnight of April, followed by 61.25 during 1st fortnight of December, 2015 and 63.25 during 1st fortnight of February, 2016. Except for a brief period during July to September, 2015 the numbers of insects of rusty grain beetle were found more than the numbers of red flour beetle in entire period of monitoring (Fig. 2). Psocid damage was related with the presence of localised fungal growth which serves as a good food for them [10]. On the other hand, heavy infestations of psocids have been common in bulk grain storage due to repeated poor phosphine fumigation programmes for disinfestations of primary insect feeders [16]. Primary pests, such as *Tribolium*, also eat psocids and keep the populations very low [21]; due to this reason, the outbreaks of psocids were attributed to a consequence of the absence of other more damaging pests [13]. The flat grain beetle is one of the major insect pests of stored grain where moisture content is higher than normal and often occurs in mixed infestations with *T. castaneum*. Larvae and pupae are protected from predation or cannibalism because they develop singly under the seed coat covering the germ of cereal seeds [19]. Their population growth rates are primarily affected by grain temperature and moisture.

Likewise, strong resistances to phosphine have already been reported elsewhere in both psocid [11] and in the flat grain beetle populations [12]. It was also observed that fumigant surviving resistant populations of *T. castaneum* are responsible for re-infestations of stored rice within the short period [17]. Similarly, rusty grain beetle was found more tolerant than red flour beetle. On the other hand, maintenance of optimum concentrations of phosphine gas during fumigation that can result in 100 per cent mortality of all the stages of all the existing insects is a difficult task. It is also noteworthy that fumigation of all the compartments at once is not practically possible; hence re-infestations from the adjacent compartments are generally expected. In the same way, populations would not be expected to increase indefinitely because at some point the resources would become limited and populations would decline [9]; and in case of a public warehouse they migrate to the freshly arrived stocks where the procurement is a continuous activity. In addition, over reliance on phosphine for grain disinfestations has led to the development of resistance in major insect pests

of stored grain all over the world [7], which emphasizes the research needs of resistance monitoring and development of appropriate management strategies including new fumigation protocols, dosages and exposure periods.

Parboiling refers to partial boiling of rice, mostly done while still in the husk and it is also an economical way to improve the storage stability mainly to reduce insect infestation [3]. It was also reported earlier that parboiled rice was completely immune to the attack of several externally feeding insects including *T. castaneum* [18]. Yet, the insect populations were found to cause damage to the parboiled rice. The abundance of these insect pests is mainly influenced by grain moisture, form of the grain (raw/parboiled), prevailing weather conditions and the periodical protection measures taken by the warehouse management. Nevertheless, the Food and Agriculture Organization of the United Nations reiterates the need of investments in improved storage, processing and preservation to retain the nutritional value of food products as a key policy action to ensure greater affordability of healthy diets, rather than investing in highly processed foods [8].

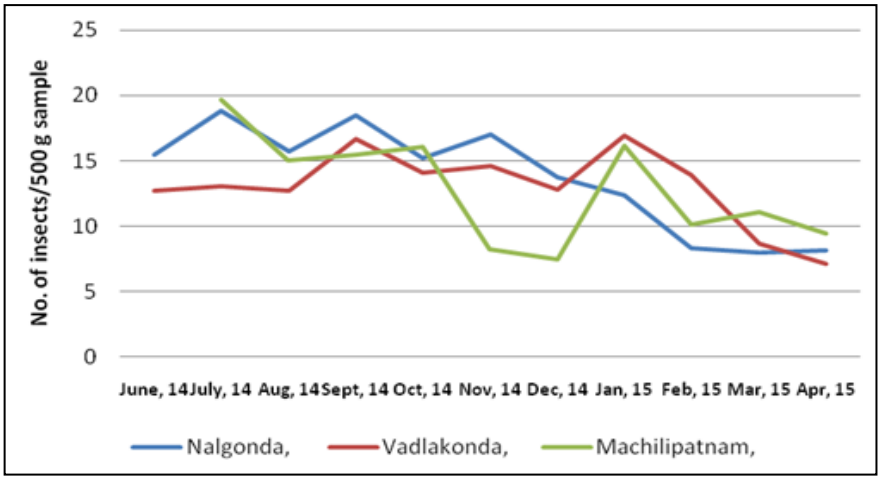

Fig 1: Incidence pattern of red flour beetle in rice stored in warehouses

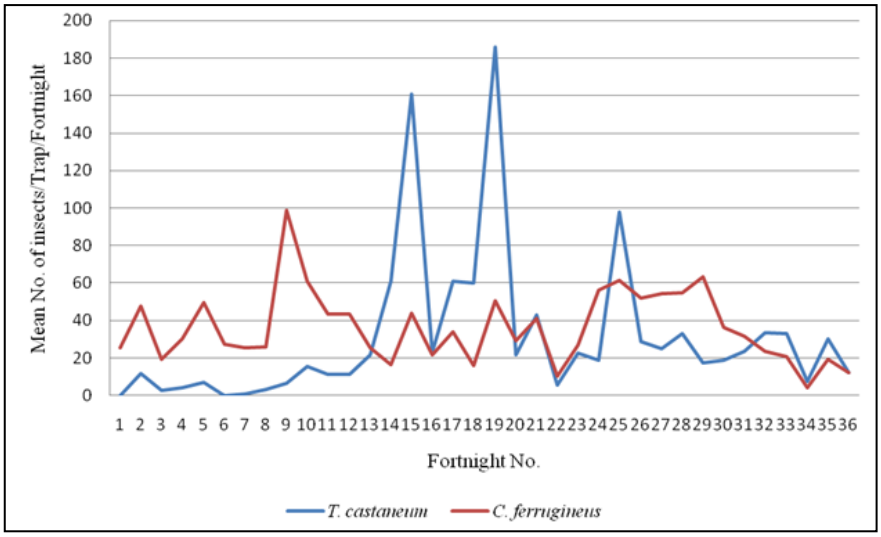

Fig 2: Incidence pattern of red flour beetle and flat grain beetle in raw rice

Table 1: Incidence of red flour beetle, *T castaneum* in rice stored in three different warehouses

Month	FCI, Nalgonda				SWC, Vadlakonda				CWC, Machilipatnam			
	No. of stacks	Sample wt (kg)	No. of insects	Insects/ 500 g	No. of stacks	Sample wt (kg)	No. of insects	Insects/ 500 g	No. of stacks	Sample wt (kg)	No. of insects	Insects/ 500 g
June, 14	12	6.0	186	15.50	12	7.0	178	12.71	-	-	-	-
July, 14	11	5.5	209	18.83	11	6.5	169	13.0	11	5.5	218	19.64
Aug, 14	11	6.0	189	15.75	11	6.5	165	12.69	11	6.0	180	15.0
Sept, 14	10	5.0	185	18.50	10	5.0	166	16.60	11	5.5	171	15.41
Oct, 14	10	5.0	152	15.20	10	5.0	141	14.10	10	6.0	193	16.08
Nov, 14	10	5.0	170	17.0	10	5.0	146	14.60	10	5.8	96	8.28
Dec, 14	9	5.0	138	13.80	10	5.0	128	12.80	10	7.0	105	7.50
Jan, 15	9	5.0	124	12.40	9	4.5	152	16.89	10	6.5	210	16.15
Feb, 15	9	5.5	92	8.36	9	4.5	125	13.89	10	4.4	89	10.14
Mar, 15	8	4.5	72	8.0	9	5.2	90	8.65	8	4.0	90	11.12
Apr, 15	8	5.0	82	8.20	8	4.5	64	7.11	8	4.0	76	9.50
Average± SD				13.78 ± 4.04				13.0 ± 2.94				12.88 ± 4.08

Table 2: Incidence of grain insects in stored raw rice at CWC, Machilipatnam

S. No.	Period of observation	Mean number of insects /trap	
		Red flour beetle	Flat grain beetle
1	1st Fortnight Dec,14	0.0 (0.70)	25.5 (4.34)
2	2nd Fortnight Dec,14	11.75 (2.79)	47.75 (5.57)
3	1st Fortnight Jan,15	3.0 (1.76)	19.25 (3.92)
4	2nd Fortnight Jan,15	4.25 (2.02)	30.25 (4.82)
5	1st Fortnight Feb,15	7.0 (2.51)	49.75 (6.36)
6	2nd Fortnight Feb,15	0.0 (0.70)	27.25 (4.85)
7	1st Fortnight Mar,15	0.75 (1.09)	25.50 (4.19)
8	2nd Fortnight Mar,15	3.50 (1.66)	25.75 (4.42)
9	1st Fortnight Apr,15	6.50 (2.45)	98.75 (8.68)
10	2nd Fortnight Apr,15	15.50 (3.47)	61.0 (6.96)
11	1st Fortnight May,15	11.50 (3.16)	43.50 (5.97)
12	2nd Fortnight May,15	11.25 (3.11)	43.25 (5.85)
13	1st Fortnight Jun,15	21.75 (4.21)	25.50 (4.33)
14	2nd Fortnight Jun,15	61.0 (7.53)	16.75 (3.98)
15	1st Fortnight Jul,15	161.0 (11.68)	43.75 (6.35)
16	2nd Fortnight Jul,15	23.25 (4.27)	21.75 (4.32)
17	1st Fortnight Aug,15	61.0 (7.68)	34.25 (5.88)
18	2nd Fortnight Aug,15	60.0 (7.07)	16.0 (3.90)
19	1st Fortnight Sep,15	186.0 (13.53)	50.50 (7.12)
20	2nd Fortnight Sep,15	21.75 (4.60)	29.50 (4.96)
21	1st Fortnight Oct,15	43.0 (6.43)	41.25 (6.22)
22	2nd Fortnight Oct,15	5.50 (2.42)	10.25 (3.16)
23	1st Fortnight Nov,15	22.75 (4.76)	26.75 (5.18)
24	2nd Fortnight Nov,15	19.0 (4.13)	56.0 (7.44)
25	1st Fortnight Dec,15	98.0 (9.14)	61.25 (7.18)
26	2nd Fortnight Dec,15	28.75 (5.34)	52.0 (7.06)
27	1st Fortnight Jan,16	25.25 (4.86)	54.50 (7.30)
28	2nd Fortnight Jan,16	33.25 (5.54)	55.0 (7.37)
29	1st Fortnight Feb,16	17.50 (4.02)	63.25 (7.97)
30	2nd Fortnight Feb,16	18.75 (4.26)	36.25 (6.02)
31	1st Fortnight Mar,16	23.75 (4.65)	31.50 (5.55)
32	2nd Fortnight Mar,16	33.50 (5.32)	23.75 (4.89)
33	1st Fortnight Apr,16	33.0 (5.61)	20.75 (4.58)
34	2nd Fortnight Apr,16	7.75 (2.82)	4.25 (2.14)
35	1st Fortnight May,16	30.50 (5.53)	19.50 (4.45)
36	2nd Fortnight May,16	12.50 (3.57)	12.50 (3.54)
	SEm±	1.0	1.31
	CD (p=0.05)	2.40	3.15

Conclusion

Even under preventive and curative protection, the prevalence of the insects throughout the study period indicates development of resistance to the insecticides and fumigants that have been used on scheduled basis since several years ago. The information on the existing insect pest populations may be helpful in taking necessary protective measures in time. The study suggests the predominance of red flour beetle and secondary feeders like psocids and rusty grain beetles throughout the year in rice stored at warehouses in spite of all the prophylactic and control measures being taken up by the management on schedule basis. However, the present study necessitates immediate monitoring of resistance development in grain insects and formulating effective management strategies along with search for the alternatives to the currently used insecticides and fumigants.

Acknowledgements

The authors thank the Managers of FCI, Nalgonda; SWC, Vadlakonda, Telangana and CWC, Machilipatnam, Andhra Pradesh for extending cooperation during the study and also Acharya N.G. Ranga Agricultural University for giving this opportunity.

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