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Common practices and abundance of insects in rice mills in Polonnaruwa district of Sri Lanka

D.M.S.K. Dissanayaka and L.K.W. Wijayaratne

Department of Plant Sciences, Faculty of Agriculture, Rajarata University of Sri Lanka, Puliyankulama, Anuradhapura, Sri Lanka.

Abstract

The facilities and conditions available in rice mills have a direct impact on the quantitative and qualitative output of rice production. Despite the great contribution towards the national rice production from Polonnaruwa district, no recent updates on the existing conditions of rice mills in this area are available. Insect infestation in feed mills is reported from other countries but such information in Sri Lanka is minimum. The current study survey investigated the existing condition of rice milling industry and insect infestation in mills in Polonnaruwa district. The mills were randomly selected and information on the milling process is collected. The samples of milling output were collected from different locations of the mills and analyzed for the presence of insects and their diversity. Large, medium and small-scale rice mills were found. The milling and storage capacity, and presence and diversity of insects varied with the type of mill. The current study provides insights on the existing status of rice milling industry and the abundance of insects in such facilities in Polonnaruwa district. This information would be important for decision making to augment the efficiency in rice milling and to design appropriate protective methods safe guard the milling output from insect infestations.

Keywords. Mill capacity, insects, rice production, storage capacity

1. Introduction

Rice is rich in nutritional properties [1,2,3] and accompanies many physicochemical properties of consumer preference [4,5]. These factors have made it high in consumer acceptance. Rice is consumed by more than half of the world population [4] and is the staple food of Sri Lankans [6]. Paddy cultivation is a main income source of about one billion households in the world [7]. In Sri Lanka, the annual paddy production in one season is 1.9 million MT and 14% of this production is from Polonnaruwa district [8]. Among the agro-based industries in Sri Lanka, rice milling is ranked first with over 7000 mills located throughout the country. The majority of the rice mills belongs to the private ownership and is categorized based on the size as traditional, semi modern and modern mills. The traditional mills are mostly functioned at the village level and produce relatively small quantities of rice for consumption at the household level. The remaining modern and semi-modern mills operate at the commercial scale and handle larger quantities of rice milling. Categorization of local rice mills is such that 25% are traditional mills, 35% semi-modern mills and 40% modern type mills [9,10]. Given these data reports the conditions existed a few years back, the updated information is required to understand the existing situation of the rice milling industry in Polonnaruwa district.

The feed mills harbor stored-product insects and can be seen at different places of the mills [11]. The insects associated with the mill reduce the quality of the final product and its market value. Information on the insects associated with flour mills is documented in other countries [12,13].

Corresponding Author: wollylk@yahoo.com

Although previous studies conducted in Sri Lanka have reported the prevalence of insects in grain storage [14] and possible management methods [15, 16, 17], information on insect pests in rice milling facilities is not available. Availability of such information is mandatory for the development of integrated pest management programs in these facilities. Therefore, the objectives of this study were to survey the rice milling procedure, mill capacity, average rice production, employment of labourers, presence of insects, their diversity and abundance in the rice mills in the Polonnaruwa district of Sri Lanka.

2. Materials and methods

The experimental design used in the study was completely randomized design. Within Polonnaruwa district, 35 rice mills were selected and their information was collected using a questionnaire. The information collected included steps involved in rice milling; milling capacity; average daily production output in mills; labour use in the mill; availability, abundance and diversity of insects. To examine the abundance of insect species, the sampling was done in different areas of the mill. The samples collected were brought to the laboratory, kept inside plastic bottles (500 mL) covered with perforated lids and maintained inside the incubator (FH-1200, Hipoint Laboratory, Taiwan) at 30±1ºC, 65±1% relative humidity (r.h.). After 2 weeks, the adults emerged from the samples were counted. The insects were identified based on their body characteristics and photographs [18, 19].

Daily average production of paddy, number of labourers employed and storage capacity of a mill were calculated as percentage of total number of mills surveyed. The abundance of different species of insects found in different locations of small, medium and large-scale mills are presented as the numbers found in a particular location.

3. Results

3.1 Main steps followed in rice milling

The milling process followed in large scale commercial mills involves a number of operations that produce higher yields of superior quality rice from paddy (Fig. 1). The main steps involved are mentioned below.

1. Pre-cleaning the paddy prior to milling
2. Removing the husk (outermost layer) from the paddy
3. Polishing or whitening the brown rice to remove the bran layer
4. Separating the broken grains from the whole kernels
5. Bagging the milled rice

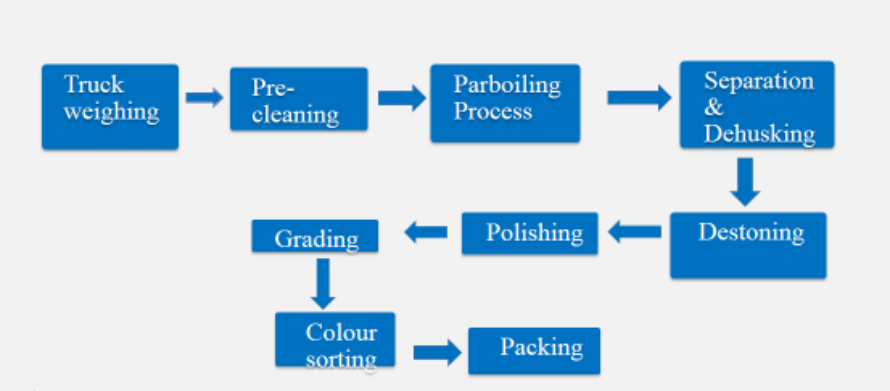

Figure 1. Flow diagram showing the main steps followed by a commercial scale rice mill in Polonnaruwa district.

While the above steps are followed during the production of raw rice, an additional step of parboiling of paddy following pre-cleaning takes place in the production of parboiled rice. Here, the paddy is soaked in water followed by steaming, drying and milling of paddy.

Pre-cleaning

This step involves the removal of foreign material such as straw, weed seeds, soil and other inert materials from paddy. This is required to increase the hulling efficiency and the milling recovery. The first step involves the removal of the objects that are larger than the grain. Either a flat oscillating screen or a rotary drum screen allows the grain to pass through but retains straw. The second separation retains the grains but allows broken grains, small stones and weed seeds to pass through. Air aspiration removes the dust and the empty grains. The medium and large-scale mills use advanced machineries such as modified rotary cleaners and de-stoner machines for the separation of debris from rice.

Removing the husk

The husk is removed from the paddy by friction and this process is called dehusking. It is done by passing the paddy grains between two abrasive surfaces that are moved at different speeds. The husk separated from paddy is removed by suction (aspiration). An efficient dehusking removes 90% of the husk in a single pass. After the husk is removed, the brown rice goes to a paddy separator. Those kernels which are not de-husked in the first pass, will be separated and returned to the dehusker. Rubber roller huller is commonly used for dehusking.

Whitening or Polishing Process

White rice is produced from brown rice by removing the bran layer. The bran layer is removed from the kernel by applying friction to the grain surface. During this process, the grains are pressed against an abrasive surface. The amount of bran removed is normally between 8-10% of the total paddy weight but this varies with the variety and degree of whiteness required.

Paddy separation

The output from the huller is a mixture of paddy rice, brown rice, husk, broken paddy, and sometimes bran. The huller aspirator removes the lighter material such as husk, bran and very small brokens. The remainder is passed onto the paddy separator where the unshelled paddy rice

is separated from the brown rice. The amount of paddy present depends on the efficiency of the dehusker, and is generally less than 10%.

In addition to the above procedures, grading and color sorting of milled rice are done. After going through the polishing process, the milled grains are passed through the 'Grader' machine, which removes deformed and broken grains. Once these unwanted and deformed grains are removed, the remaining batch of grains is moved to the 'color sorter machine' where stones are removed.

Packing: The milled rice is stored in polypropelene bags and stored in warehouses and/or distributed through the supply chain to the whole sellers, retailers and consumers.

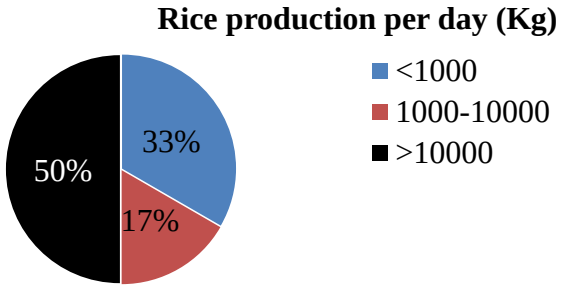

Figure 2. Average rice production in mills in Polonnaruwa district.

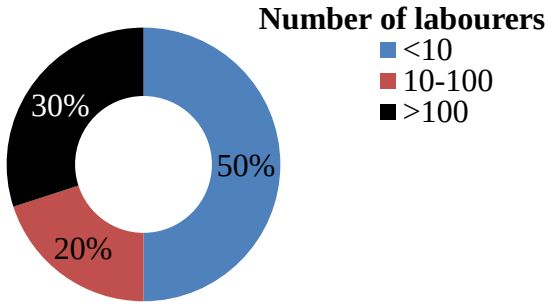

Figure 3. Percentage of labourers employed in a mill in Polonnaruwa district.

3.2 Milling output and presence of insects

In terms of the average rice production of the mills, 50% of total mills surveyed are large scale mills with an average production more than 10,000 kg/day (Fig. 2). The second highest frequency was of small scale with less than 1000 kg capacity per day. The medium scale mills (only 17% of total mills) have production of 1000-10,000 kg rice/day. The majority (50%) of mills had <10 labourers employed (Fig. 3). The number of labourers employed in a mill is not proportional to the average production per day possibly due to the fact that the large-scale mills are highly mechanized. Therefore, small number of labourers were sufficient to operate the large-scale mills. In storage of paddy, every mill had their own storage facility except a few small-scale mills. Nearly, 50% of rice mills were large scale and had the storage capacity of 50,000 kg (Fig. 4). Of these large-scale mills, 4 mills had silos. Other mills used large warehouses where paddy was stored in polysack bags. The abundance and location of insects inside the mills varied according

to the size of the mill (Fig. 5). In large scale mills, higher number of insects were found in floor dust. The floor dust was contaminated with *Tribolium castaneum* and *Sitophilus oryzae*. Of these two insect species *S. oryzae* was more abundant than *T. castaneum*. The large-scale mills were highly mechanized and difficult to be cleaned resulting in the higher abundance of insects. *Sitotroga cerealella* was only observed in paddy stores. Other than the floor dust, *T. castaneum* was also present at the elevator, packing area, conveyer and paddy cleaner.

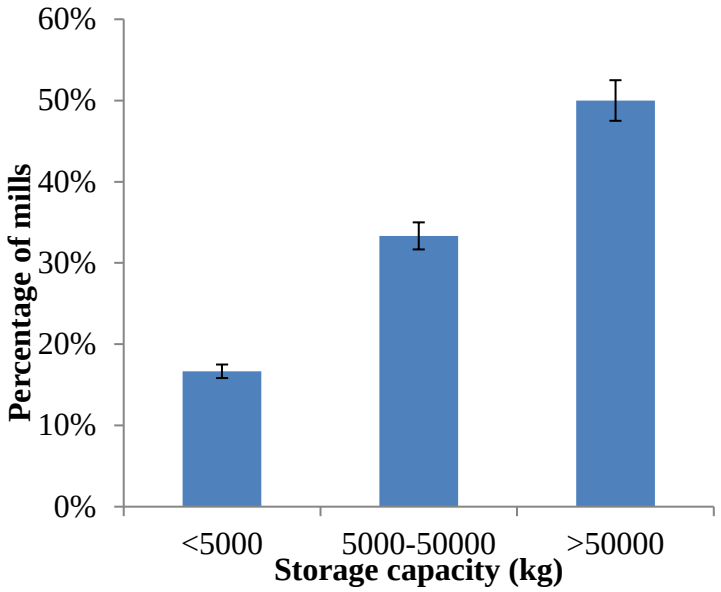

Figure 4. Percentage of storage capacity of paddy in the mills in Polonnaruwa district.

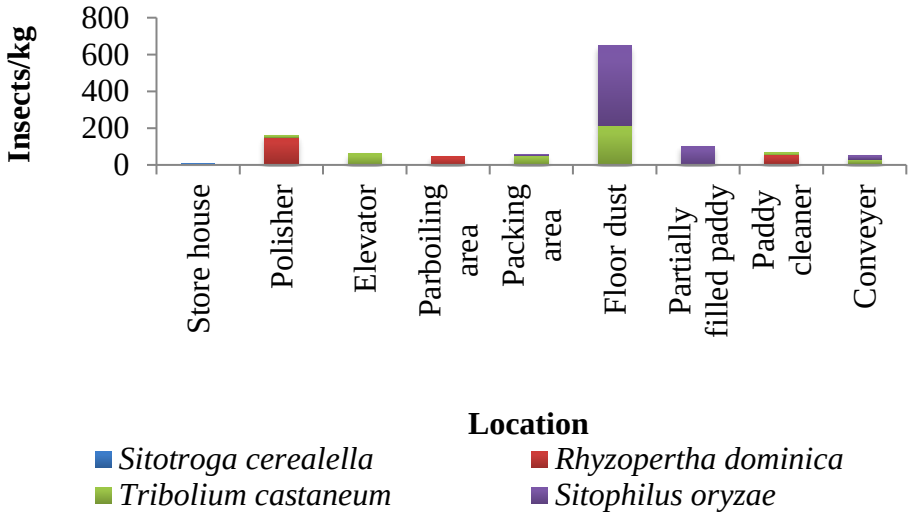

Figure 5. Abundance of insects at different places in large scale rice mill.

In medium scale mills, the highest insect population was observed in the paddy clean dust and the lowest in destoners (Fig. 6). The insect species present were *T. castaneum, Rhyzopertha dominica, Cadra cautella, S. cerealella, S. oryzae, Tenebroides mauritanicus* and grain mites were present. Separator and silking machine were infested by *T. castaneum* only. *Tribolium castaneum* was also present in elevators. Paddy cleaner dust had only *R. dominica* whereas mill floor had only *S. oryzae.* In small scale mills where the involvement of machineries was only a few, the greater number of insects were observed in the dehusker; mainly *S. oryzae* and *T. castaneum. Rhyzopertha dominica* and *T. mauritanicus* were found in destoners in small scale mills (Fig. 7).

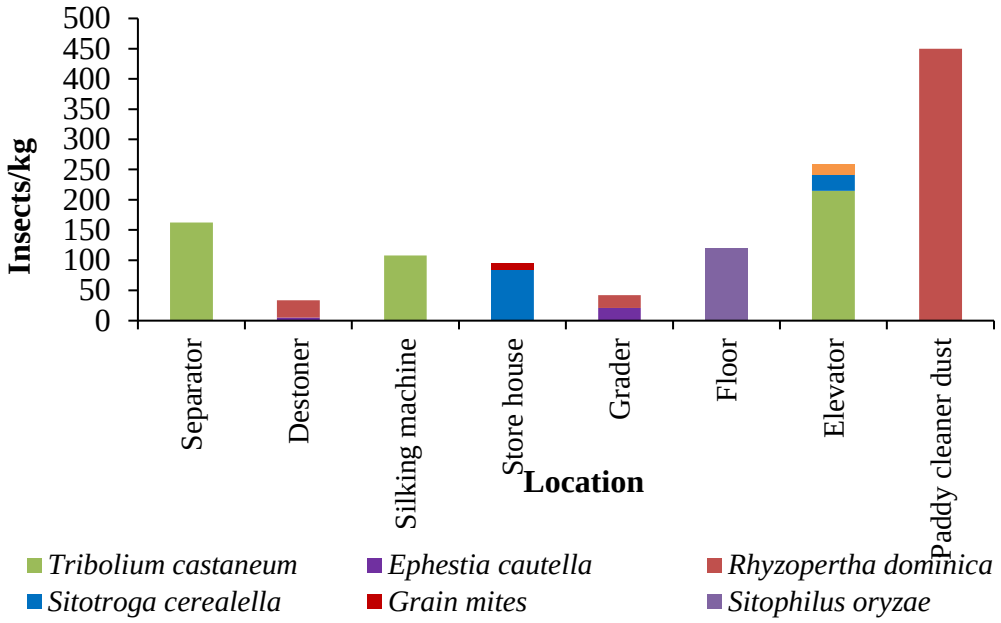

Figure 6. Abundance of insects at different locations in medium scale rice mill.

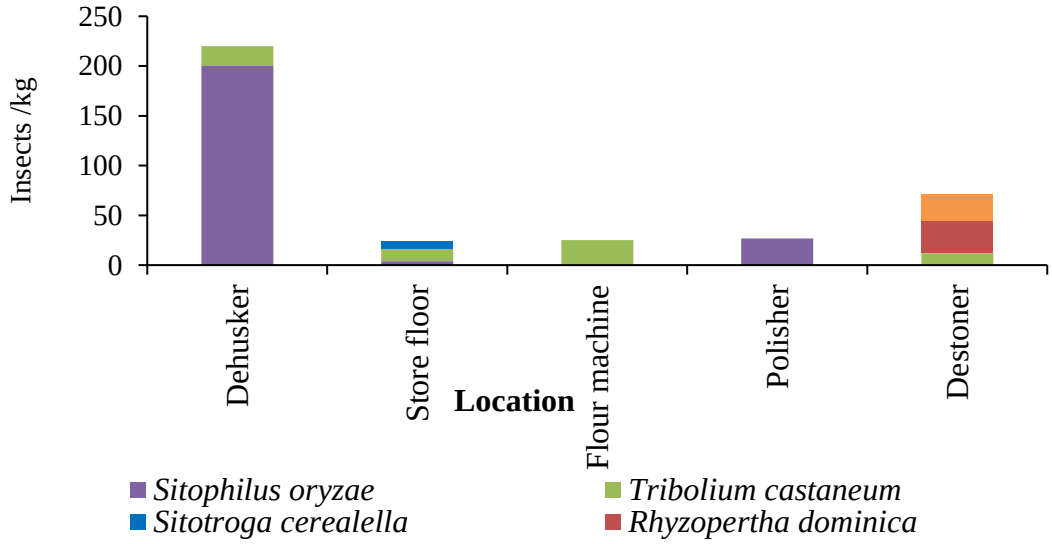

Figure 7. Abundance of insects at different places in a small-scale rice mill.

4. Discussion

A previous study conducted in Sri Lanka has reported that rice milling industry faces different barriers where more than 100 mills had been closed and only about 20 large scale mills continued operations in Polonnaruwa area in 1997 [20]. However as found in the current study, the things have been changed as 50% of total mills in Polonnaruwa were large scale mills. Furthermore, the said previous study reported that based on the scale of operation, mainly small scale and medium scale rice mills are in Hambantota. In comparison, the present study revealed that small, medium and large-scale mills are present in Polonnaruwa district. In comparison, in Indonesia, the majority of rice milling is taken place in small rice mills distributed all over the country [21, 22]. In Thailand small, medium and large-scale rice millers are found [23].

In rice milling and marketing, the final products are very competitive and mainly depend on the buyers [24, 25]. As found in the current study, the operation of large-scale mills has increased number of buyers. Accordingly, the increased cost incurred with the use of modern equipment is bearable for them. Basically, the small rice millers target their products to local or regional markets. Small and medium scale millers face many difficulties and find difficult to compete with large scale millers due to the upgraded technology used by the latter. Furthermore, the large-scale farmers adopt the standards set by the Good Manufacturing Practices (GMP) which help them to maintain their standards higher than the medium and small-scale rice millers [17]. A similar situation is reported in Polonnaruwa district.

A previous study reported that in Hambantota, mainly raw rice is produced [10]. The current study found that in Polonnaruwa, parboiled rice is also produced. In Indonesia, the husk is used as poultry feed after mixed with broken rice [21]. A previous study reported that in Polonnaruwa, the husk is collected and burned [10]. The current study revealed that in Polonnaruwa, the paddy husk is mainly used as poultry feed and fuel source in paddy parboiling.

Carvalho et al. reported the presence of *Sitophilus zeamais*, *S. oryzae* and *T. castaneum* in rice mills in Portugal [27]. Hawkin et al. [11, 12] and Semeao et al. [28] reported the presence of *T. castaneum* in the flour mills in Canada. Trematerra and Gentile [29] reported *Ephestia kuehniella* in flour mills in Italy. The present study reported the abundance of *T. castaneum, R. dominica, Cadra cautella, S. cerealella, S. oryzae, T. mauritanicus* and the grain mites in different areas of rice mills. With the scarcity of previous records on the presence of insects in rice mills in Sri Lanka, the findings of this current study would provide important baseline information for the implementation of pest management programs in the rice mills in Polonnaruwa district. The future research also needs to investigate the status of rice milling industry and the insects associated with the mills in other areas of Sri Lanka.

5. Conclusions

Small-, medium- and large-scale rice mills are located in Polonnaruwa district. The machineries are involved in rice milling at all three levels. The labourer employment declines from small- to large-scale rice mills. The diversity and abundance of insects varies with the mill capacity and location inside the mill.

References

1. Juliano, B.O. (2003) Rice Chemistry and Quality. Island Publishing House, Manila.

2. Rohman, A., Helmiyati, S., Hapsari, M. and Setyaningrum, D.L. (2014) Rice in health and nutrition. Int. Food Res. J., 21, 13-24.

3. Abeysekera, W.K.S.M., Arachchige, S.P.G., Ratnasooriya, W.D., Chandrasekharan, N. and Bentota, A. (2017). Physicochemical and nutritional properties of twenty three traditional rice (*Oryza sativa* L.) varieties of Sri Lanka. J. Coastal Life Medicine, 5, 343-349.

4. Cuevas, R.P., Pede, V.O., McKinley, J., Velarde, O. and Demont, M. (2016) Rice grain quality and consumer preferences: a case study of two rural towns in the Philippines. PLoS One, 11, e0150345.

5. Odenigbo, A.M., Ngadi, M., Ejebe, C., Woin, N. and Ndindeng, S.A. (2014) Physicochemical, cooking characteristics and textural properties of TOX 3145 milled rice. J. Food Res. 3, 82-90.

6. Waisundara, V.Y. (2020). Traditional functional food of Sri Lanka and their health significance. In Prakash, J., Waisundara, V., Prakash, V. (Eds.), Nutritional and Health Aspects of Food in South Asian Countries. Academic Press, pp. 143-158.

7. Toriyama, K., Heong, K.L. and Hardy, B. (2004) Rice is life: scientific perspectives for the 21st century. Proceedings of the World Rice Research Conference held in Tokyo and Tsukuba, Japan. Los Baños (Philippines): International Rice Research Institute, and Tsukuba (Japan): Japan International Research Center for Agricultural Sciences. CD-ROM. 590 p.

8. Department of census and statistics (2015) Paddy Statistics, 2015 Yala Season. Accessed from: http://www.statistics.gov.lk/agriculture/Paddy%20Statistics/PaddyStatsPages/PADDY%20STATISTICS%202015%20YALA.pdf. on 24.12.2020.

9. Rupasena, L.P. (2006) Comparative Analysis of Rice Marketing System in Sri Lanka, Pre and Post Liberalized period, PhD Thesis, University of Agricultural Science, Dharwad, India.

10. Wijesooriya, W.A.N. and Priyadarshana, W.H.D. (2013) Structure, Conduct and Performance of Rice Milling Industry in Polonnaruwa and Hambantota Districts of Sri Lanka. Research Report No: 163. Hector Kobbekaduwa Agrarian Research and Training Institute, Colombo, Sri Lanka.

11. Hawkin, K., Stanbridge, D. and Fields, P.G. (2011). Sampling *Tribolium confusum* and *Tribolium castaneum* in mill and laboratory settings: differences between strains and species. The Can. Entomol. 143, 504-517.

12. Hawkin, K. J., Stanbridge, D.M. and Fields, P.G. (2013) Sampling *Tribolium castaneum* and *Tribolium confusum* in flour mill rollstands. J. Stored Prod. Res. 52, 7-11.

13. Attia, M.A., Wahba, T.F., Shaarawy, N., Moustafa, F.I., Guedes, R.N.C. and Dewer, Y. (2020). Stored grain pest prevalence and insecticide resistance in Egyptian populations of the red flour beetle *Tribolium castaneum* (Herbst) and the rice weevil *Sitophilus oryzae* (L.). J. Stored Prod. Res. 87, 101611.

14. Wijayaratne, L.K.W., Fernando, M.D. and Palipane, K.B. (2009) Control of insect pests under warehouse conditions using smoke generated from partial combustion of rice (paddy) husk. J. Nat. Sci. Foundation of Sri Lanka. 37, 125-134.

15. Wasala, W.M.C.B., Dissanayake, C.A.K., Gunawardane, C.R., Wijewardhane, R.M.N.A., Gunathilake, D.M.C.C. and Thilakarathne, B.M.K.S. (2016) Efficacy of insecticide incorporated bags against major insect pests of stored paddy in Sri Lanka, Procedia Food Sci. 6, 164-169.

16. Narangoda, C. and Karunaratne, S. (2009). Oviposition deterrent and insecticidal activities of some indigenous plant extracts against the rice moth, *Corcyra cephalonica* (Stainton). Vidyodaya, 14, 43-150.

17. Harshani, S. and Karunaratne, S. (2019). Chemical composition and insecticidal effect of fruit peel powders of two citrus species against *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) in stored cowpea (*Vigna unguiculata*). Int. J. Pest Manage. 1-8.

18. Sinha, R.N. and Watters, F.L. (1985) Insect Pests of Flour Mills, Grain Elevators, and Feed Mills and Their Control. Agriculture Canada Publication, Ottawa.

19. Hill, D.S. (1990) Pests of stored products and their control. CBS Publishers and Distributors (Pvt.) Ltd., London.

20. Wickramasinghe, W.D. (1999) Government Intervention in Rice Market. Economic Review (January-March): 12-13.

21. Timmer, C.P. (1996) Does BULOG Stabilize Rice Prices in Indonesia? Should It Try? Bull. Indonesian Econ. Stud. 32, 45-74.

22. Paman, U., Bahri, S., Asrol, A. and Liana, L. (2016) Distribution and use patterns of small-scale rice mills in Kampar Regency, Riau Province, Indonesia. Int. J. Adv. Sci. Eng. Info. Tech. 6, 150.

23. Suebpongsang, P., Ekasingh, B. and Cramb, R. (2020) Commercialisation of Rice Farming in Northeast Thailand. In Cramb R. (eds) White Gold: The Commercialisation of Rice Farming in the Lower Mekong Basin. Palgrave Macmillan, Singapore.

24. Ellis, F. (1993) Private Trade and Public Role in Staple Food Marketing. The Cases of Rice in Indonesia. Food Policy, 18, 428-38.

25. Dharmaratne, T.A. and Hathurusinghe, C.P. (1999) Paddy/Rice Marketing: Perspectives and Prospects in 90's Economic Review, (January-March), 6-11.

26. Forssell, S. (2009) Rice Price Policy in Thailand- Policy making and recent developments, Department of Economics, University of Lund.

27. Carvalho, M. O., Faro, A. and Subramanyam, B., (2013) Insect population distribution and density estimates in a large rice mill in Portugal-A pilot study. J. Stored Prod. Res. 52, 48-56.

28. Semeao, A.A., Campbell, J.F., Whitworth, R.J. and Sloderbeck, P.E. (2013) Movement of *Tribolium castaneum* within a flour mill. J. Stored Prod. Res. 54, 17-22.

29. Trematerra, P. and Gentile, P. (2010) Mass trapping of *Ephestia kuehniella* Zeller in a traditional flour mill. Proceedings of the 10th International Working Conference on Stored-product Protection, Estoril, Portugal, Julius Kuhn-Institute. 748-753.