

Survey of Insects and Mites Associated with Stored Rice In Nigeria.

***Ezeobiora, I.B., Kemabonta, K.A., Makanjuola, W.A**
Department of Zoology,
Faculty of Science, University of Lagos, Akoka, Lagos State
Corresponding Author: ifeomaezeobiora@yahoo.com

doi: <https://doi.org/10.46912/napas>.

Abstract

Insect pest infestation causes quantitative or qualitative losses in stored Rice. Proper identification of the insect species infesting stored Rice is critical for making pest management decisions. This study assesses the species composition and abundance of insect pests of stored Rice in Nigeria. Imported and Local Rice samples each weighing one kilogram were obtained every 6 months from three randomly selected vendors in randomly selected markets in 14 towns in 14 states in Nigeria. 50g were weighed from each sample and kept in vials, covered, strapped with rubber band and kept in the laboratory. The Rice samples were sieved to collect all adult insects present after Six months in storage. Sampling lasted for two years (2016-2017). There were 11 species of insect pests and one Mite species in the stored Imported and Local Rice samples. Most of the species were from the order Coleoptera with the percentage occurrence of 80.9% in Imported Rice and 82% in Local Rice. The insect species composition includes *Sitophilus oryzae*, *Cryptolestes ferrugineus*, *Sitophilus zeamais*, *Psocids*, *Sitotroga cerealella*, *Ahasverus advena*, *Tribolium castaneum* *Oryzaephilus surinamensis*, *Oryzaephilus mercator* and *Rhyzopertha dominica*. The Psocid and mite species could not be identified. *Sitophilus oryzae* was the main insect pest of Rice with the percentage occurrence of 39.23% in Imported Rice and 26.87% in Local Rice. The outcome of this study is very important in planning control measures as the knowledge of the species composition and abundance of insect pests is an important component of pest management in stored Rice in Nigeria.

Keywords: stored rice, insect pests, species composition, mites, psocids

Introduction

Rice, *Oryza sativa*, forms the staple diet of about half of the population all over the world and is the world's largest food crop (Sangeetha *et al.*, 2020). Within the West African sub-region, Nigeria is the highest consumer of Rice. It is cultivated and consumed in all parts of the country. The Nigerian per capita consumption levels have grown significantly at 7.3% per annum with the annual average per capita consumption increasing from 3kg in the 1960s to 22kg in the late 1990s (Akaeze, 2010). An average Nigerian consumes 24.8 kg of Rice per year, representing 9 percent of annual calorie intake (IRRI, 2001). The demand for Rice in Nigeria increased at a much faster rate than in any other African country since the mid-1970s. However, production did not keep pace with demand. Rice was, therefore, imported to bridge the demand-supply gap (Daramola 2005, FAO, 2001).

Nigeria has become a major rice importer in the world market. Estimates indicate that Rice imports represent more than 25 percent of agricultural imports and over 40 percent of domestic consumption (FMARD, 2004). These estimates do not consider the unrecorded smuggled Rice into Nigeria (Rahji, 2005).

Insects are the major threats for causing the post-harvest losses in stored food grains. Several types of insects occur which cause infestation in stored food grains. These are the primary, secondary and tertiary insect pests. Primary insects attack the grains first. They develop and reproduce quickly in the optimal conditions, which allows for large populations. They are usually more destructive than secondary pests, especially in short-term storage of food grains (Banga *et al.*, 2018). Secondary insects follow the primary insects. They feed on the grains broken by the primary insects. Tertiary insects feed on broken grains, grain dusts, and powder left by the primary and secondary insect pests.

The infestation may take place at the processing warehouse, in transit, at the store or even at home (Ogebege and Edoreh 2014). They cause qualitative as well as quantitative losses in cereals, grains, food legumes and oilseeds during storage. They are also responsible for dissemination and proliferation of

microorganisms including mycotoxigenic fungi. High postharvest losses are believed to be among the primary causes of food shortage and rural poverty (Kamara *et al.*, 2014). To successfully manage insect pests and reduce the losses caused by insects in storage, it is necessary to know the types of insects occurring in specific food grains (Sheetal Banga *et al.*, 2020). This study was therefore conducted to carry out survey of insect and mites associated with stored Rice in Nigeria.

Materials and Methods

Sampling of grain, identification and counting of insect pests:

An invitation was sent to entomologists across 14 States in 14 towns randomly selected from five agroecological zones in Nigeria (Figure 1). They were asked to buy one kilogram (kg) (or approximately two small measure) of Rice, both imported and local, from three different vendors in their local markets. A plastic bag for grain sample collection was sent to them. The locality, market and GPS from which samples were collected was requested. Each sample collection (Local and Imported Rice) was replicated three times for two years (2016/2017). The samples collected were taken to the Entomology Laboratory, Department of Zoology, University of Lagos for storage. 50g of each sample was weighed and kept in vials, covered with muslin cloth and strapped with rubber band to prevent escape of the insects or cross infestation from other vials. They were kept in the laboratory for 6 months under ambient conditions (32 - 35°C and 55 - 67% R. H.).

After 3 months in storage, Rice samples in each vial was sieved and insect pest infestation was determined by identifying and counting the number of adult insect pests present in each vial. Insect species were identified under a stereo microscope using Insect Identification keys (Rees, 2004). The names were confirmed by entomologists at the Stored Products Research Institute, Lagos. The Lepidopteran insects collected were preserved in the brown triangular envelopes. Other live and dead insects collected were placed in 100ml capacity bottles filled with 70% alcohol and kept for molecular studies. Insects were sorted according to species and counted for each, noting down the numbers.

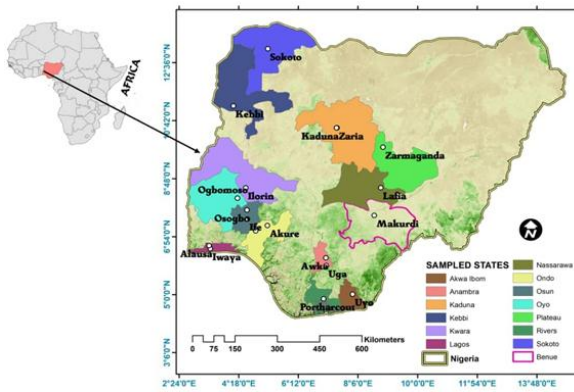


Fig. 1: Map showing the sampled locations in Nigeria

Data Analysis

Data collected were analyzed using relevant statistical packages (SPSS and PAST). The diversity indices used include Margalef index, Shannon Weiner diversity index, Simpson dominance index and Evenness index to determine species diversity. The higher the value of H' , the greater the diversity

Results

Composition of Insect Pests of Stored Rice in Lagos.

A total of 5,601 insects pests from 3 insect orders and one Acarina (Arachnida) were recorded from both Local and Imported stored Rice across Nigeria. The insect orders include Lepidoptera, Coleoptera and Psocoptera while the eight families include Bostrichidae, Anobiidae, Gelechiidae, Psocidae, Tenebrionidae, Cucujidae, silvanidae and Curculionidae. There were nine genera and 11 species. The one species of Acarina order could not be identified (Figure 2). Most of the species for both imported and local rice were from the order Coleoptera representing a total 1972 (80.9%) and 2583 (82%) respectively. This was followed by the Psocoptera representing a total of 283 (11.6%) and 361 (11.5%) individuals in both Imported and Local Rice respectively, while the order Acarina had the least number of species (1) at 6 (0.2%) and 0 (0%) individuals respectively. *Cryptolestes ferrugineus* had the highest percentage total occurrence in Imported Rice at 39.23% and 15.31% respectively (Figure 2), while *Sitophilus oryzae* and *Sitophilus zeamais* had the highest occurrence in Local Rice at 26.87% and 15.12% respectively (Figure 2).

There were 8 families in both Imported and Local rice (Figure 7). Family Curculionidae had the highest abundance of 1322 and 1311, while Bostrichidae had the lowest of 0 and 1 in both the Imported and Local Rice respectively

(Figure 7). The species frequency of occurrence across the sampled states showed that Lagos Rice had the highest frequency of insect pest species occurrence in both the Local and Imported Rice (Figure 4).

Diversity Indices of insect and mite species of Rice across Nigeria

Lagos had the highest species diversity of insect in Imported Rice ($H' = 1.962$) followed by Ife ($H' = 1.503$) and Makurdi was the least ($H' = 0.318$) (Table 2). The study site that had the most evenly distributed insect species was Ogbomoso ($e^{H'/S} = 0.999$) while the least evenly distributed was Makurdi ($e^{H'/S} = 0.687$). Highest degree of species concentration in Imported Rice was at Makurdi ($D = 0.825$) and Lagos had the least ($D = 0.154$) concentration of species (Table 2).

Lagos had the highest species diversity of insects in Local Rice ($H' = 2.117$) followed by Ife ($H' = 1.521$) and Kebbi was the least ($H' = 0.5878$) (Table 3). The study site that had the most evenly distributed insect species was Lafia ($e^{H'/S} = 0.9348$) while the least evenly distributed was Ife ($e^{H'/S} = 0.6535$). Highest degree of insect species concentration in Local Rice was at Kebbi ($D = 0.6016$) and Lagos had the least ($D = 0.1311$) concentration of insect species (Table 3).

The highest diversity occurred in Lagos state in both Local and Imported Rice, while the lowest diversity occurred in Makurdi for Imported Rice and in Kebbi for Local Rice (Figure 5). The mean diversity of insect species between the Local and Imported Rice showed that the Local Rice had a higher diversity of insect species than the Imported Rice (Figure 6).

The oneway ANOVA analysis showed that there was no significant difference ($P < 0.05$) in the population of insect species across the sampled locations and between the sources (Local and Imported Rice (Table 4).

In both the Local and Imported Rice, the species taxa were dependent on the sample size. The highest species taxa were found in Lagos for both Imported and Local Rice (Figure 8-9).

Figure 8 shows the sample adequacy for species richness for Imported Rice. In the Imported Rice, the species taxa were highest (9) for Lagos with a sample size of 200, while in Ife, the species taxa was just above six even above a sample size of 100. The lowest species taxa of two was found in Zaria, Sokoto, Awka, Ogbomoso and Makurdi even after a sample size of 50.

Figure 9 shows the sample adequacy for species richness for Local Rice. The species taxa was highest (9) for Lagos and six for Ife and both species taxa leveled out after a sample size of 100 while the lowest species taxa (1) was found in Awka.

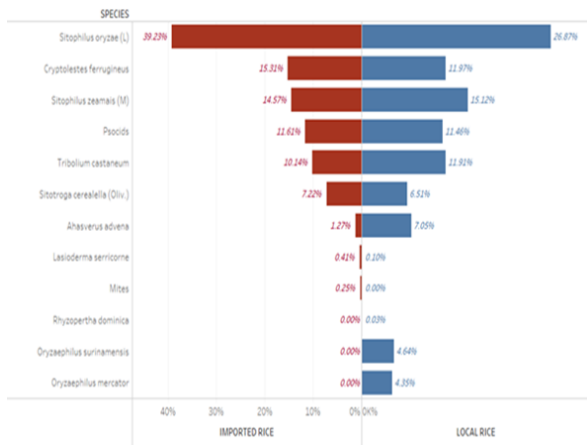


Fig. 2: Inverted pyramid showing percentage distribution of insect pests for both local and imported rice in Nigeria.

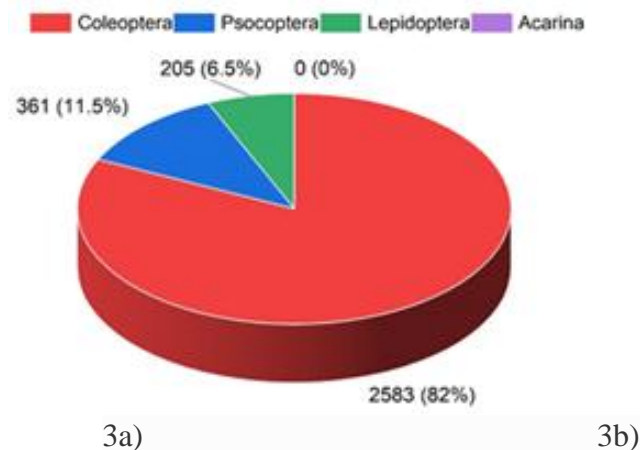


Fig. 3: Pie-charts showing percentage abundance of the insect species collected with total counts for order in (a) imported and (b) local rice across different sampling locations.

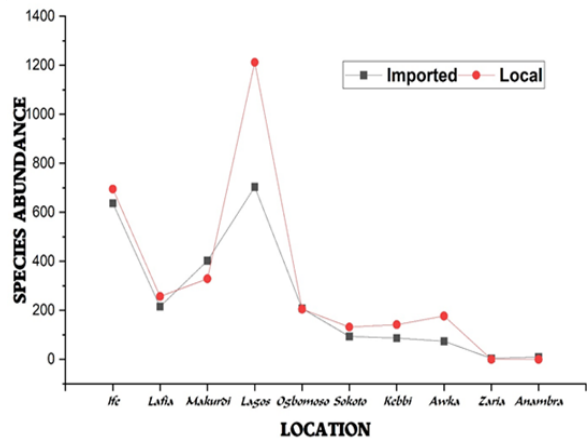


Fig. 4: The insect species frequency of occurrence across the sampled states.

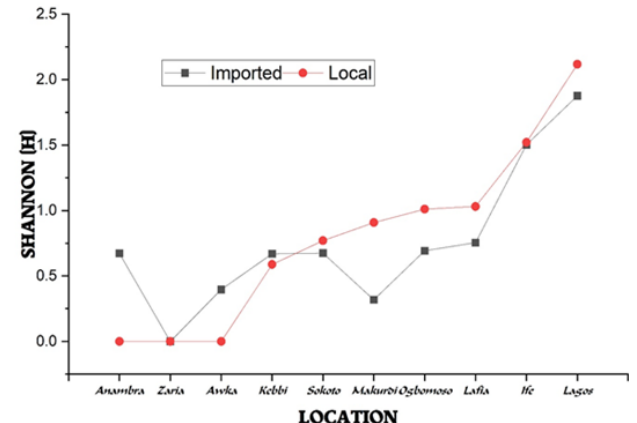


Fig. 5: Shannon-wenner index showing the species diversity in both imported and local rice across the sampled locations.

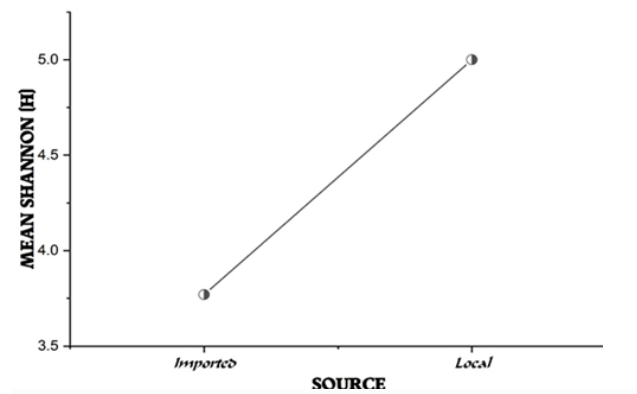


Fig. 6: Mean species diversity of the local and imported rice.

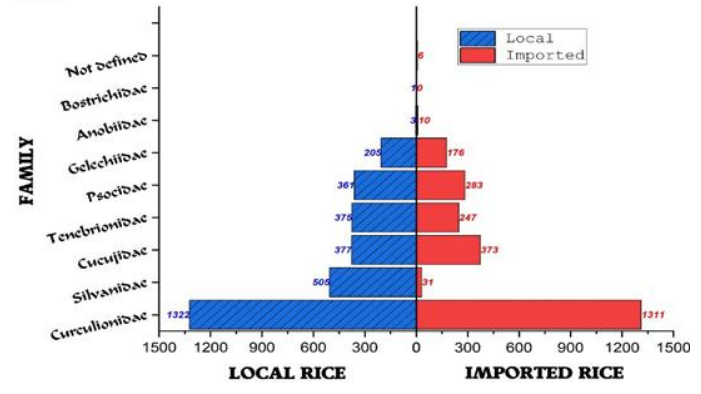


Fig. 7: Distribution of Families Present In Both Imported And Local Rice.

Table 1: Shows the Fishers Least Square Significant Difference of the Insect Species Across Sampled Locations.

	Mean	Groups
Lagos	6.63813	A
Ife	4.41497	B
Lafia	2.14699	C
Ogbomoso	2.0315	D
Sokoto	1.93205	E
Kebbi	1.87988	E
Anambra	1.7371	E
Makurdi	1.44224	F
Awka	1.36469	F G
Zaria	1	G

Means that do not share a letter are significantly different.

According to the Fishers LSD, the insect species between Sokoto and Kebbi are not significantly different from each other. The insect species in all the other sampled locations were significantly different from one another.

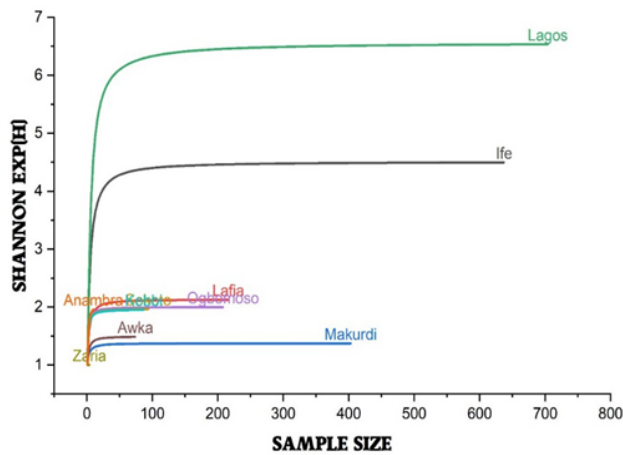


Fig. 8: Sample adequacy for species richness for imported rice.

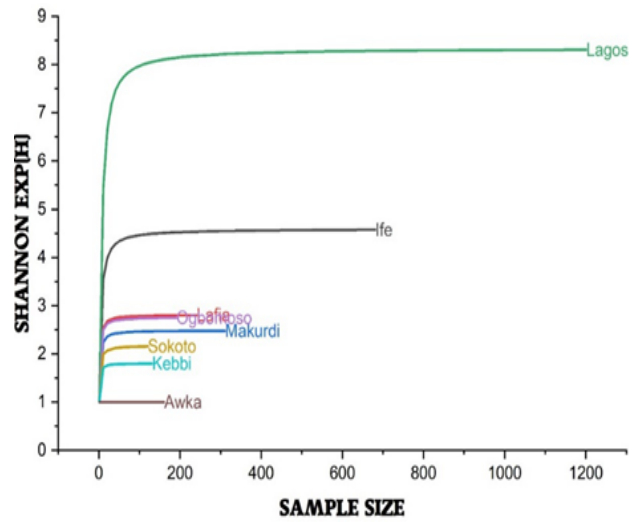


Fig. 9: Sample adequacy for species richness for local rice.

Table 2: Diversity Indices of Insect Species Associated with Imported Stored Rice in Nigeria.

	Ife	Lafia	Makurdi	Lagos	Ogbomoso	Sokoto	Kebbi	Awka	Zaria	Anambra
Taxa_S	6	3	2	8	2	2	2	2	1	2
Individuals	637	216	403	704	208	94	87	74	4	10
Dominance_D	0.265	0.5746	0.8252	0.164	0.5004	0.5183	0.5238	0.7663	1	0.52
Simpson_1-D	0.735	0.4254	0.1748	0.836	0.4996	0.4817	0.4762	0.2337	0	0.48
Shannon_H	1.503	0.7548	0.3179	1.877	0.6927	0.6747	0.6691	0.396	0	0.673
Evenness_e^H/S	0.7495	0.709	0.6871	0.8169	0.9996	0.9817	0.9762	0.743	1	0.9801
Brillouin	1.481	0.7316	0.3112	1.849	0.6788	0.6483	0.6411	0.3689	0	0.5347
Menhinick	0.2377	0.2041	0.09963	0.3015	0.1387	0.2063	0.2144	0.2325	0.5	0.6325
Margalef	0.7744	0.3721	0.1667	1.068	0.1874	0.2201	0.2239	0.2323	0	0.4343
Equitability_J	0.8391	0.687	0.4587	0.9027	0.9994	0.9734	0.9653	0.5714		0.971
Fisher_alpha	0.9167	0.493	0.2742	1.265	0.3067	0.3589	0.3651	0.3788	0.4279	0.7517
Berger-Parker	0.394	0.7315	0.9032	0.2273	0.5144	0.5957	0.6092	0.8649	1	0.6
Chao-1	6	3	2	8	2	2	2	2	1	2

Table 3: Species diversity indices of insect species associated with local stored rice in Nigeria.

	Ife	Lafia	Makurdi	Lagos	Ogbomoso	Sokoto	Kebbi	Awka
Taxa_S	7	3	3	10	3	3	2	1
Individuals	695	257	329	1212	205	132	142	177
Dominance_D	0.2615	0.3754	0.4677	0.1311	0.3925	0.4932	0.6016	1
Simpson_1-D	0.7385	0.6246	0.5323	0.8689	0.6075	0.5068	0.3984	0
Shannon_H	1.521	1.031	0.9079	2.117	1.011	0.7702	0.5878	0
Evenness_e^H/S	0.6535	0.9348	0.8264	0.8308	0.9165	0.7201	0.9	1
Brillouin	1.498	1.009	0.8906	2.095	0.9851	0.739	0.5696	0
Menhinick	0.2655	0.1871	0.1654	0.2872	0.2095	0.2611	0.1678	0.07516
Margalef	0.9169	0.3604	0.3451	1.268	0.3757	0.4096	0.2018	0
Equitability_J	0.7814	0.9386	0.8264	0.9195	0.9206	0.7011	0.8481	
Fisher_alpha	1.083	0.4768	0.4557	1.492	0.4981	0.5463	0.3296	0.14
Berger-Parker	0.3784	0.4669	0.6292	0.1856	0.522	0.5758	0.7254	1
Chao-1	7	3	3	10	3	3	2	1

Table 4: ANOVA

	DF	Sum of Squares	Mean Square	F Value	P Value
Location	9	11808.68977	1312.07664	7838.05287	0.00001
Source	1	197.15972	197.15972	1177.78814	0.00001
Model	10	12225.62071	1222.56207	7303.31282	0.00001
Error	2737	458.16912	0.1674		

At the 0.05 level, the population means of Location are significantly different.

At the 0.05 level, the population means of Source are significantly different.

Discussion

Insect pests of stored Rice were mainly from the order Coleoptera and the most destructive tropical species belong was from the genera *Sitophilus* and *Tribolium* (Bello *et al.*, 2001., Beckett, 1994). The major insect pests found in this study were *Sitophilus oryzae*, *Cryptolestes ferrugineus*, *Sitophilus zaemais*, *Psocids* and *Tribolium castaneum*. These species occur worldwide and have been described as major insect pests of stored grains. (Carvalho *et al.*, 2013).

At 6 months of storage, the genus *Sitophilus* was the most destructive and caused losses of up to 90% of the stock of sorghum or maize (Nukenine *et al.*, 2002; Boura, 2006). *Sitophilus oryzae* was the most frequent and most abundant species of stored Rice in Nigeria. In this study, it was the primary insect pest of stored Rice. (Batta, 2004) reported significant losses to stored Rice due to *Sitophilus oryzae*. Their feeding converts kernels into hollowed out husks, particles of endosperm, dust and frass accelerating the multiplication of other insects and storage.

The ability of a secondary pest to become established in stocks depends on damage caused by primary pests that infested the seed coat, enabling the secondary pests to get inside the grain (Beckel, 2007; Nansen *et al.*, 2009). It can be assumed that the population of *Cryptolestes*

ferrugineus which is a secondary pest was high in this study because of the high infestation of *Sitophilus oryzae* which may have promoted the establishment of *C. ferrugineus* in stored Rice. The presence of secondary insects often indicates that the grain is not in superlative condition and that measures should be implemented to protect the grain from further decline in quality (Banga *et al.*, 2020)

The occurrence of *Oryzaephilus surinamensis* was low in both the Imported and Local Rice. This result differed from the result of study of abundance of storage pests in Rice in Malaysia where the highest species abundance recorded was *O. surinamensis*.

Nansen *et al.*, (2009) in their study recorded that counts of *C. ferrugineus* appeared to have a progressively negative effect on the density of *Rhyzopertha dominica*. This may explain the very low counts recorded for *R. dominica* in this study.

The result obtained from this study suggest that Imported Rice is less susceptible to insect pest species than the Locally produced Rice. This result is corroborated by (Kamara *et al.*, 2014), who reported a similar observation. Imported Rice grains may have come from large capacity Rice mills where they are processed to produce highly polished grains than the locally produced Rice which undergo poor processing and poor polishing practices. Poor processing

result in a final product with a high percentage of broken grains and debris in Local Rice (FAO, 2004). Some studies have also shown that an increase in polishing reduced Rice susceptibility to insect pest infestation (McGaughey, 1974). This may explain why the higher diversity of insect pests was found on the Local Rice.

Psocids also known as booklice are frequently found in stored-product grains, often in extremely high numbers. Currently, psocids are perhaps the most important category of emerging insect pests in stored grains and related commodities (Nayak *et al.*, 2005, Opit and Throne 2008a and b., Nayak *et al.*, 1998). They have been found in stored grains as they appear to be tolerant to traditional fumigants and contact insecticides at rates lethal to major Beetle and Moth species. Such species include *Liposcelis bostrychophila*, *Liposcelis entomophila* (Enderlein) and *Liposcelis paeta* Pearman (Nayak *et al.*, 1998). The psocids observed in this study could not be identified. They were kept in vials containing alcohol for molecular analysis.

Mites have been recorded to be found on stored Rice (Hajizadeh *et al.*, 2011, Noei *et al.*, 2007). The Mite sample in this study could not also be identified. Further studies on this, was to carry out a molecular characterization of the Mite so as to ascertain its name.

Information about the number of insects in the samples or the percentages of samples infested is essential in estimating the overall level of insect infestation in the commodity (Obeng-Ofori, 2008). The knowledge of the diversity of the insect pests associated with stored Rice is the first step to develop control methods that will protect Rice seeds, minimize food losses and therefore ensure food security.

References

- Akaeze, H.O. 2010. Consumer preference for Imported Rice in Nigeria-perceived quality differences or habit persistence? Thesis Submitted to Michigan State University for the Degree of Master of Science Agricultural, Food and Resource Economics, UMI Dissertation Publishing. 129pp
- Banga, K.S., Kotwaliwale, N., Mohapatra, D., Giri, S.K. 2018. Techniques for insect detection in stored food grains: An overview. *Food Controls*; 94:167-176.
- Batta, Y.A. 2004. Control of Rice Weevil (*Sitophilus oryzae* L.) (Coleoptera: Curculionidae) with various formulations of *Metarhiziumanisopliae.*, *Crop Prod.*, 23:103-108.
- Beckett, S.J., Longstaff, B.C., Evans, D.E. 1994. A comparison of the demography of four major stored grain coleopteran pest species and its implications for pest management. *Proceedings of the Sixth International Working Conference on Stored-Product Protection*, pp. 491-497.
- Boura, A.F. 2006. Sensibility of the different stocks of *Sitophilus zeamais* on white corn CMS 8504 and efficacy of traditional practices of storage, Master Thesis, ENSAI, University of Ngaoundéré, p. 61. (in French).
- Carvalho, M.O., Faro, A., 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.
- Federal Ministry of Agriculture and Rural Development (FMARD) 2004. Ministerial Press Briefing by Minister of Agriculture and Rural Development on the State of Nigerian Agriculture at Maizube Farms. May 16, 2004, Niger State.
- Food and Agricultural Organization (FAO) 2001. FAO Rice Conference 2001. Accessed Online at www.fao.org On 23rd July, 2007.
- Hajizadeh, J., Noei, J., Salehi, L., Ostovan, H. 2011. Cheyletid Mites associated with stored Rice in Iran; the first record of *Chelacheles strabismus* from Iran and a key for their identification. *Journal of Entomological Society of Iran*, 30(2 (47)), 85-88.
- International Rice Research Institute (IRRI) 2001. Rice Statistics. Accessed Online at <http://oryza.com/africa/nigeria/index.shtml> on 27th July, 2007.
- Kamara, J.S., Kanteh, S.M., Bockari-Gevao, S.M., Jalloh, S. 2014. Infestation, Population Density and Sterilization Effects on Rice Weevils (*Sitophilus oryzae* L.) in Stored Milled Rice Grains in Sierra Leone. *International Journal of Agriculture and Forestry*, 4(1): 19-23.
- McGaughey, W.H. 1974. Insect development in milling Rice effect of variety, degree of

- milling, parboiling and split kernels *J. stored production. Res* 10:81-88.
- Nansen, C., Flinn, P., Hagstrum, D., Toews, M.I.D., Meikle, W.G. 2009. Interspecific associations among stored-grain Beetles. *J. Stored Prod. Res.* 45, 254-260.
- Nayak, M.K., Collins, P.J. Reid, S.R. 1998. Efficacy of grain protectants and phosphine against *Liposcelis bostrychophila*, *L. entomophila*, and *L. paeta* (Psocoptera: Liposcelididae). *J Econ Entomol*, 91: 1208– 1212.
- Nayak, M.K., Darglish, G.J. Byrne, V.S. 2005. Effectiveness of spinosad as a grain protectant against resistant Beetle and psocid pests of stored grain in Australia. *J Stored Prod Res*, 41: 455– 467.
- Noei, J., Hajizadeh, J., Salehi, L., Ostovan, H., Faraji, F. 2007. Stigmaeid Mites associated with stored Rice in northern Iran (Acari: Stigmaeidae) *International Journal of Acarology*, 33 (2), 153-156.
- Nukenine, E.N., Monglo, B., Awason, L., Ngamo, L.S.T., Tchuenguem, F.F.N., Ngassoum, M.B. 2002. Farmer's perception on some aspects of Maize production, and infestation levels of stored Maize by *Sitophilus zeamais* in the Ngaoundéré region of Cameroon, *Cam. J. Biol. Biochem. Sci.* 12 (1): 18-30.
- Obeng-Ofori, D. 2008. Management of Stored Product Arthropods Pest, In: *Cornelius E. W. and Obeng-ofori, D.* (eds), Postharvest Science and Technology, College of Agriculture and consumer services, University of Ghana, Legon, Accra, pp 92-146.
- Ogebegebe, A.B.O., Edoreh, J.A. 2014. An Evaluation of Infestation of Insect Pests of Flours in Benin City, Edo State, Nigeria. *Journal of Applied Sciences and Environmental Management* 18(3): 487-494.
- Opit, G.P., Throne, J.E. 2008a. Population growth and development of psocid *Lepinotus reticulatus* at constant temperatures and relative humidities. *J Econ Entomol* 101: 605– 615.
- Opit, G.P., Throne, J.E. 2008b. Effects of diet on population growth of psocids *Lepinotus reticulatus* and *Liposcelis entomophila*. *J Econ Entomol*, 101: 616– 622.
- Rahji, M.A.Y. 2005. Determinants of Efficiency Differentials in Lowland Rice Production Systems in Niger State, Nigeria. *J. Agric. Res.*, 1(1):7-17.
- Sangeetha, J., Thangadurai, D., Fayeun, L.S., Akinwale, J.A., Habeeb, J., Maxim, S.S., Hospet, R., Islam, S. 2020. Origin and Evolution of Rice as Domesticated Food Crop. In: Roychoudhury A. (eds) *Rice Research for Quality Improvement: Genomics and Genetic Engineering*. Springer, Singapore pp 1-14.