The role of physical factors on the existence of insect pests in the corn warehouses in Sumbawa regency

M Zulkarnain¹, M Sarjan², T Tarmizi² and D Darmanto³

¹ Magister Student of Dry Land Management, Post Graduate University of Mataram, Lombok, NTB, Indonesia
² Post Graduate University of Mataram, Lombok, NTB, Indonesia
³ Samawa University, Sumbawa Besar, NTB, Indonesia

*aendzoel1234566@gmail.com

Abstract. The Physical factors of the warehouse must be the main concern in order to optimize storage capacity and maintain commodity quality during the storage period. This study aims to identify pests and assess several physical factors of corn warehouses (such as geographical location, microclimate, quality of storage materials, the physical condition of warehouses, and control efforts) related to the presence of pests in the warehouse. This study was conducted in May up to September 2019. This study covers three regions in Sumbawa Regency (Eastern, Central, and Western). The process of identifying pests is carried out at the Biology Laboratory, Faculty of Mathematics and Natural Sciences, University of Mataram. The data is processed and analyzed by using descriptive methods with a literature review technique. Direct observation is applied in this study for data collection and sampling. The results show that the physical factors of the warehouse support the existence and development of pest populations in the corn warehouses. Furthermore, the data show an increase in population and there are 16 species of pests found in corn warehouses.

1. Introduction
The warehouse, which is one of the steps in the harvest technology line before food reaches the consumer, greatly influences the quality of the stored material. According to Anggara and Sudarmadji, warehouses are one of the most important postharvest handling chains [1]. Decreasing the quality of corn will be exceedingly detrimental on the warehousing system [2]. In corn or sorghum, insect pests can cause 30-40% damage, especially when the moisture content of the seeds reaches 18-20%. According to Rees, there are a number of pest insects that infest storage materials in warehouses [3]. Warehouse pests that infest are generally beetles (Coleoptera) and Ngegat (Lepidoptera), the rest are the Orthoptera and Psocoptera classes.

In principle, there are three factors that affect food commodities stored in the presence of warehouse pests to maintain quality in the warehouse, namely the condition of the commodity or storage material, the condition of the warehouse and the micro-climate of the warehouse that affect the rate of damage to the commodity stored. The results of previous studies in rice warehouses showed that in the microclimate conditions of warehouses with an average temperature of 34 °C, humidity of 59% and good warehouse aeration it was still possible to find warehouse pest insects in the form of Sitophilus oryzae, Tribolium castaneum and Rhyzopertha dominica with severe attack level categories. During the 1.5-
month storage period of rice in the warehouse several changes occurred in the quality and quantity of rice [4].

Referring to the description above, the presence of pest insects in the warehouse during the storage of maize is a serious problem, while information on the role of physical factors in the presence of insect pests in corn warehouses is still lacking. Therefore, the researchers are interested in conducting a study entitled "The role of physical factors on the existence of insect pests in the corn warehouses in Sumbawa regency". This study aims to identify and know the abundance pest insects that attack the commodity of maize and examine some physical factors of corn storage (microclimate, storage material/corn and physical condition of the warehouse) related to the presence of barn pest insects.

2. Materials and methods

This study uses descriptive methods and direct observation with literature study techniques, warehouse surveys, data collection and sampling and identification of insect pests in the Laboratory. Then the data obtained is processed by tabulation. The study was conducted from May up to September 2019. Field research was conducted to obtain warehouse pest insect sampling in three different regions. The three regions cover the East, Central, and West Regions. There are two warehouses in each area, so we get six locations of corn storage. Data collection was carried out 4 times at 7-day intervals to obtain data on diversity and abundance of corn barn pest insects. Data collection at the research location was carried out in 3 ways, namely sampling of corn infested with pest insects on the staple and warehouse floor, and making insect pest traps (such as Light Trap, Yellow Sticky Trap, Bait Trap, and Pitfall Trap). Primary data sources were obtained from direct observation and documentation), while secondary data sources were obtained from stakeholders and observation check list sheets.

Meanwhile, laboratory research was carried out to identify warehouse pest insects. The identification process was carried out at the Biotechnology Laboratory, Faculty of Agriculture and Biology Laboratory, Faculty of Mathematics and Natural Sciences, University of Mataram. Observation parameters studied were the number of insect populations, the abundance of pest insects and the assessment of the presence of warehouse pest insects based on microclimatic factors, storage material factors, shelf life, moisture content, quality and quantity of maize, physical condition factors of the sheds, and pest control efforts.

3. Results and discussion

3.1. Insect pests corn identified

There were 3 insect orders identified in three warehouse areas such as the Coleoptera, Lepidoptera, and Psocoptera. All those three orders were found in all warehouses. The same results apply for families, genera, and species for the Central and Eastern Territories, except the Western Region which shows different identification results from the two storage regions mentioned previously. From a total of 12 families, 15 genera, and 16 species of postharvest insect pests identified in the Western Region, not found 4 families from 12 families, namely Ptinidae, Silvanidae, Pyralidae, Psyllipsocidae, and one species (D. minutus) from the Bostrichidae family. In addition to these 4 families and one species, the same family, genus, and species are found with the other two Regions (Table 1).

Table 1. Insect pest postharvest corn warehouse in three regions, Sumbawa regency

| Order          | Family      | Genus    | Species   | Regional Warehouse |
|----------------|-------------|----------|-----------|--------------------|
| Coleoptera     | Bostrichidae| Rhyzopertha | R. dominica | +  +  +          |
|                |             | Dinoderus | D. minutus | -  +  +          |
| Curculionidae  | Anthribidae | A. fasciculatus | +  +  +    |
|                | Sitophilus  | S. zeamais  | +  +  +    |
| Dermestidae    | Altigenus   | A. fasciatus | +  +  +    |
### Table 1. Cont.

| Order       | Family         | Species                  | Total Population | Pi (%) |
|-------------|----------------|--------------------------|------------------|--------|
| Coleoptera  | Bostrichidae   | *R. dominica*            | 72               | 0.68   | 0.10 | 1.18 |
|             |                | *D. minutus*             | -                | 0.00   | 0.02 |
| Curculionida| Curculionidae  | *S. zeamais*             | 162              | 1.54   | 0.31 | 1.07 |
|             |                | *A. fasciatus*           | 17               | 0.16   | 0.13 | 0.46 |
| Dermentidae |                | *A. fasciatus*           | 3                | 0.03   | 0.01 | 0.12 |
| Nitidulidae |                | *C. lugubris*            | 7674             | 72.98  | 2.16 | 11.74 |
|             |                | *C. dimidiatus*          | 530              | 5.04   | 0.20 | 0.41 |
| Ptinidae    |                | *L. serricorne*          | -                | 0.02   | 0.02 |
| Silvanidae  |                | *O. surinamensis*        | -                | 0.06   | 0.12 |
| Tenebrionida|                | *T. castaneum*           | 2010             | 19.12  | 0.36 | 7.54 |
|             |                | *A. laevisgatus*         | 24               | 0.23   | 0.08 | 0.12 |
|             |                | *C. cephalonica*         | 14               | 0.13   | 0.03 | 0.06 |
| Lepidoptera | Galeridae      | *P. farinalis*           | -                | 0.00   | 0.15 |
| Pyralidae   |                | *S. cerealella*          | 4                | 0.04   | 0.02 | 0.02 |
| Gelechiidae |                | *E. sarcitrella*         | 5                | 0.05   | 0.01 | 0.00 |
| Psocoptera  | Psyllipsocidae | *Liposcelis* sp.         | -                | 96.50  | 76.97 |

**Note:** the + and - signs indicate pest insects found based on the corn storage area.

#### 3.2. Abundance of corn store insects

The abundance of populations and individual insect pests of corn warehouses in the three regions showed different results in each region. The region with the least abundant pest insect population was found in the Central Region with 199,693 populations, followed by the Eastern Region with 29,933 populations, and the least population found in the West with 10,515 populations (Table 2).

### Table 2. Total population and abundance of corn insect pest in three storage warehouse areas, Sumbawa regency.

| Order       | Family         | Species                  | Western | Central | Eastern | Pi (%) |
|-------------|----------------|--------------------------|---------|---------|---------|--------|
| Coleoptera  | Bostrichidae   | *R. dominica*            | 72      | 191     | 354     | 0.68   | 0.10   | 1.18   |
|             |                | *D. minutus*             | -       | 5       | 7       | 0.00   | 0.02   |
| Curculionida| Curculionidae  | *S. zeamais*             | 162     | 619     | 319     | 1.54   | 0.31   | 1.07   |
|             |                | *A. fasciatus*           | 17      | 269     | 139     | 0.16   | 0.13   | 0.46   |
| Dermentidae |                | *A. fasciatus*           | 3       | 15      | 35      | 0.03   | 0.01   | 0.12   |
| Nitidulidae |                | *C. lugubris*            | 7674    | 4308    | 3515    | 72.98  | 2.16   | 11.74  |
|             |                | *C. dimidiatus*          | 530     | 406     | 122     | 5.04   | 0.20   | 0.41   |
| Ptinidae    |                | *L. serricorne*          | -       | 47      | 6       | -      | 0.02   | 0.02   |
| Silvanidae  |                | *O. surinamensis*        | -       | 118     | 35      | -      | 0.06   | 0.12   |
| Tenebrionida|                | *T. castaneum*           | 2010    | 728     | 2256    | 19.12  | 0.36   | 7.54   |
|             |                | *A. laevisgatus*         | 24      | 167     | 35      | 0.23   | 0.08   | 0.12   |
|             |                | *C. cephalonica*         | 14      | 53      | 18      | 0.13   | 0.03   | 0.06   |
| Lepidoptera | Galeridae      | *P. farinalis*           | -       | 2       | 44      | -      | 0.00   | 0.15   |
| Pyralidae   |                | *S. cerealella*          | 4       | 36      | 7       | 0.04   | 0.02   | 0.02   |
| Gelechiidae |                | *E. sarcitrella*         | 5       | 20      | 1       | 0.05   | 0.01   | 0.00   |
| Psocoptera  | Psyllipsocidae | *Liposcelis* sp.         | -       | 192669  | 23040   | -      | 96.50  | 76.97  |

**Note:** Pi = Pest Insect Abundance Index

Population abundance per region is strongly influenced by its height from sea level. The Central Region is the highest plateau of sea level (103 masl) and the highest number of population, while the Eastern
and Western Regions are respectively at an altitude of 10 meters above sea level and 5 meters above sea level and relatively close to the shoreline with a lower population than the Central region. Fitriana et al. states that the Arthropod population is not affected by altitude [5]. Based on the highest abundance of pest insects in the corn shed, there are three highest numbers of individuals from 12 families and 16 species found in three different storage sheds. The three highest numbers of individuals come from three families and three species. The Carpophilus lugubris species are from the Nitidulidae family, one species (Liposcelis sp.) From the Psyllipsocidae family, and one species (Tribolium castaneum) from the Tenebrionidae family (Table 2).

The highest population abundance obtained in Liposcelis sp. (Psyllipsocidae) in the Central Region (Table 2). The high number of individuals in Liposcelis sp. (Psyllipsocidae) 192,669 individuals or population abundance which dominates 96% of other species and families because these species are known as high-temperature tolerant species (45-55°C). In addition, Liposcelis sp. also known as a serious pest in the storage structure and standard practice of protection agricultural commodities [6]. The report is strengthened by the results of research obtained that, the highest index of pest insect abundance based on population abundance in the three storage areas found in species of Liposcelis sp. with a percentage of population abundance of 89.83% (Table 2).

The number of individuals in the Liposchelis sp species was found in large numbers in the two experimental regions, namely in the Central Region with 192,669 individuals and the Eastern Region with 23,040 individuals, while in the West Region the same species of pest insects were not found in order to obtain an abundance of pest insects of 89.83%. There are 7,674 Carpophilus lugubris in the Western Region, 4,308 in the Central Region, and 3,515 individuals in the Eastern Region with an insect abundance of 6.45%. Furthermore, the third-highest number of pest insect individuals is the Tribolium castaneum family Tenebrionidae species, with the highest number of individuals obtained in the Eastern Region with 2,256 individuals, the Western Region by 2,010 individuals, and the lowest number of individuals found in the Central Region with 768 individuals with an abundance of pest insects by 2.10%. In addition to the three species, the population abundance index in other species and families has a very small abundance, which is less than 1% (Table 2).

3.3. Assessment of the existence of warehouse pest insects based on several physical factors of warehouses

Geographic Location Factors. Sumbawa Regency is one of the regencies in the West Nusa Tenggara Province (NTB), which is located at the western end of Sumbawa Island, at positions 116 "42 'to 118" 22' East Longitude and 8 "8" to 9 "7 'South Latitude with an area of 6,643.98 km². Based on topographical conditions, the land surface in the Sumbawa Regency region is uneven or tends to be hilly with altitudes ranging from 0 to 1,730 meters above sea level (masl), around 355,108 ha or 41.81% at an altitude of 100 to 500 meters, and altitudes ranging from 10 to 650 masl for cities [7].

The data above shows the characteristics of the various study sites that affect the distribution of diversity and abundance of pest insects in the study area. In theory, the abundance of insect species is largely determined by its reproductive activities supported by a suitable environment and the need for adequate food sources in the environment. Research result Capinera, altitude affects the difference in temperature, humidity, and wind that affect the development and reproduction of insects [8]. Further research results Hoiss et al which states that the number of insect species decreases with increasing latitude or altitude due to environmental influences [9]. In addition, higher places can slow down insect reproduction so that the number of generations and the number of insect populations tends to be less [10].

3.3.1. Micro climate factors. The microclimate plays a role in the presence of insect pests in the warehouse. The microclimate elements that are strongly influential in the presence of pests and diseases include temperature and humidity [11]. Theoretically, the storage room for quality grain products has a temperature range of 25 °C-27 °C with 70-75% air humidity [12]. The condition of the corn storage warehouse showed minimum temperature and humidity of 26.91 °C and 53.21%, maximum
temperature, and humidity of 32.05 °C and 71.21% with average temperatures and humidity of 29.46 °C and 62.61%.

The results of temperature and humidity measurements in the warehouses in all regions are in the range of optimum temperatures and relatively dry air humidity, so it is suspected to have the potential to increase the presence and development of insect pests in the storage warehouse. Based on Petzoldt and Seaman, an increase in temperature will increase the growth of insect pests and will result in increased damage caused [11].

3.3.2. Storage material factor. The quality of stored materials can be reviewed through several quality components based on the Indonesian National Standard (SNI) 01-03920-1995 such as; sosoh degree, moisture content, maximum other colors, maximum damage grain, and maximum broken grain.

The quality component of corn shows a stable value at the degree of sosoh and the maximum broken grain with values of 96.67% and 2.33% respectively at the beginning and end of the inspection, while the component of water quality, other maximum color grains, and maximum damaged grains are found changes at the time of examination at the beginning and end of the study. Changes in the quality component of maize on the component of water content by 0.03%, maximum other color grains of 0.01% and maximum damaged grains of 0.28%.

In general, the quality component values obtained in Table 4 are still within safe limits because they meet the Indonesian National Standard (SNI) 01-03920-1995 [13]. Some changes to the components of the water content quality, maximum other colors, and maximum damaged grains still show values less than 1% (<1%). However, this condition can increase in a certain time if it is associated with a long shelf life, which means a decrease in the value of quality can reach 10-15% in storage materials in the warehouse.

3.3.3. Storage time. Based on the observation checklist sheet information, the shelf life of maize in the three warehouse areas if averaged is less than 3 months. This shows that the storage period of corn in the Sumbawa Regency area is classified as short-term shelf life. According to Saenong et al stated that the storage period between 1-3 months is categorized as a short-term saving period, and applies the FIFO (first in-first out) mechanism, i.e [14]. corn that is put in earlier will be removed earlier from the warehouse storage. However, this does not rule out the possibility of damage to storage materials in the warehouse caused by insect. Anggara and Sudarmadji contend that generally warehouse pest insect infestations begin to occur after a shelf life of 1 month [1]. The report is in line with the results of the current study, which shows that the shelf life has the potential to invite several species of insect pest’s hat reduce the quality of corn components and have a direct impact on the quality and quantity of material stored.

3.3.4. Physical condition of warehouse factor. Based on the results of the inspection and assessment of the physical condition of the corn warehouses, the physical condition of the warehouses at the current study site is categorized in good condition in all study areas, except the West Region which is categorized into a fairly good category. The Central and Eastern Regions have the construction conditions of buildings (roofs, walls, doors, MCK facilities, ventilation, and lighting), conditions of facilities and equipment in the warehouse are available and according to standards, because they are made of strong materials, suitable sizes and good conditions. Whereas the Western Region has a smaller warehouse size and capacity compared to the other two regions, the arrangement of the aisles, the measuring instrument for the scales, and the warehouse floor are not in accordance with the National Standardization Agency. West Region Warehouse does not have a corridor arrangement; some corners of the floor have gaps or cracks wide enough. This can be used as a shelter or to hibernate pest insects when the warehouse is empty. In addition, scattered corn on the floor and used sacks containing leftover corn kernels can invite corn-destroying insects.
3.3.5. Control factors. Control of pest insects and pathogenic fungi in the corn storage warehouse of Sumbawa Regency in general using chemical fumigants with active ingredients Phosphine (PH3) and Methyl Bromide (CH3Br). Efforts to control pest and fungal pathogenic insects in two research areas, namely the Central and Eastern Regions are still in conditions that are good enough whereas in the Western Region the implementation of control measures is still very poor. Efforts to control those carried out in these three regions still allow an increase in the diversity and abundance of corn storage pest insects. This is evidenced by the discovery of 16 different insect pest species whose population has increased from the first observation to the last observation.

4. Conclusion and suggestion

4.1. Conclusion
- The corn warehouse pest insect found as many as 16 species are Liposcelis sp., C. lugubris, T. castaneum, S. zeamais, C. dimidiatus, R. dominica, A. fasciculatus, A. laevigatus, O. surinamensis, C. cephalonica, S. cerealella, A. fasciatus, L. serricorne, E. sarcitrella, D. minutus, and P. farinalis.
- The physical factors such as geographic location, microclimate, quality of storage material, the physical condition of warehouses and control efforts play a role in supporting the presence and development of corn warehouse pest insects in the Sumbawa Regency, indicated by the increasing population and abundance of corn warehouse pests.

4.2. Suggestion
The supervision, control, and handling of physical factors (Geographical Location, Micro Climates, Quality of stored materials, physical conditions of warehouses and control measures) are needed in a preventive manner to prevent the explosion of warehouse pest populations.

References
[1] Anggara A W and Sudarmaji S 2008 Ost-harvest Pests And Their Control In the: Darajat AA, Setyono A, Makarim AK, and Hasanuddin A. (eds.). Rice: Production Technology innovation (Jakarta: Balai Besar Penelitian Tanaman Padi. LIPI Press) 441–472
[2] García-Lara S and Bergvinson D J 2007 Integral program to reduce post-harvest losses in maize Agricultura Técnica de México 33 181-189
[3] Rees D 2004 Insect of Stored Products (Australia: CSIRO Publishing)
[4] Pitaloka A L, Santos L and Rahadian R 2012 Overview of Some Physical Factors of Rice Storage, Identification and Attempts to Control Insect Pest Warehouse (Study at 103 Bulog Warehouse Demak Sub Dolog Region I Semarang) Jurnal Kesehatan Masyarakat 1 2 218-217
[5] Fitriana F, Toana M H and Nasir B 2018 Arthropod Diversity in Clove Planting (Syzygium aromaticum L.) With different heights In Oncone Raya Village, South Tinombo District e-J. Agrotekbis 6 4 563-570
[6] Beckett S J and Morton R 2003 The mortality of three species of Psocoptera, Liposcelis bostrychophila Badonnel, Liposcelis decolor Pearman and Liposcelis paeta Pearman, at moderately elevated temperatures Journal of Stored Products Research 39 1 103-115
[7] BAPPPDA Kabupaten Daerah Tingkat II Sumbawa 2015 Geographical Location of Sumbawa Regency (Kantor BAPPPDA Daerah Tingkat II Kabupaten Sumbawa)
[8] Capinera J L 2003 Sweetpotato Weevil, Cylas formicarius (Fabricius) (Gainesville: IFAS University of Florida)
[9] Hoiss B, Krauss J, Potts S G, Roberts S and Dewenter I S 2012 Altitude acts as an environmental filter on phylogenetic composition, traits and diversity in bee communities Proceedings of the Royal Society B 279 4447-4456
[10] Duyck P F, Kouloussis N A, Papadopoulos N T, Quilici S, Wang J L, Jiang C R, Muller H G and
Carey J R 2010 Lifespan of a Ceratitis fruit fly increases with higher altitude *Biological Journal of the Linnean Society* **101** 345–350

[11] Petzoldt C and Seaman A 2010 Climate Change Effect on Insect and Pathogens [Online] Retrieved from: [http://www.climateandfarming.org](http://www.climateandfarming.org) Accessed on: 3 February 2010

[12] Imdad H P and Abjad A N 1995 *Storing Food Ingredients* (Jakarta: Penebar Swadaya)

[13] Badan Standardisasi Nasional (BSN) 2007 *Provisions on Agricultural Commodity Warehouse SNI 7331*

[14] Saenong S, Margaretha S L, Mejaya M J and Subandi S 2006 Acceleration of Corn Seed Distribution Through Communal Scale Seed Production *Proceedings of the National Corn Seminar and Workshop* 820–836