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Types and Percentations of Parasitization Egg Parasitoids *Spodoptera frugiperda* J, E. Smith in North Sulawesi

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Abstract— *Corn (Zea mays L) is the main commodity of agricultural crops in Indonesia. There are two groups of corn that are cultivated, namely ordinary corn (food corn) and sweet corn. Food corn is mainly used as a raw material for making food, which is used as a raw material for making animal feed raw materials and other industrial products. Easy cultivation, can grow in various conditions, stable selling prices and easy to market are the main driving force for high interest of the farming community to cultivate it. Spodoptera frugiperda larvae are polyphagous and attack many plant species. S. frugiperda larvae feed on more than 350 species of plants in 76 families. S. frugiperda is a typical migratory pest and this migratory behavior is an adjustment strategy to find a more profitable habitat. S. frugiperda is one of the most dangerous invasive pests due to its short life cycle. An adult female lays 900 – 1200 eggs in her life cycle. The purpose of the study was to inventory and analyze the egg parasitoid of S. frugiperda and the percentage of parasitization*

The analysis of the types of egg parasitoids of S. frugiperda was carried out through an inventory and identification process, while the percentage of parasitization was carried out using a randomized block design consisting of 5 treatment groups of eggs from 5 regions and three replications.

The results of the inventory and identification contained two types of parasitoids, namely: Telenomus sp. and Trichogramma sp. The highest percentage of total parasitization was from Manado City at 85% and the lowest was from Bolaang Mongondow at 5%. Telenomus sp. higher percentage of parasitization than Trichogramma sp. Parasitization percentage of Telenomus sp. on eggs of S. frugiperda the highest came from Manado by 63% and the lowest came from Tomohon by 3%, while the percentage of parasitization of Trichograma sp. The highest came from Manado at 22%, and the lowest came from Bolaang Mongondow Regency at zero percent.

In conclusion, there are 2 types of egg parasitoids in S. frugiperda eggs, namely the parasitoid Telenomus sp and the parasitoid Trichogramma sp., the percentage of parasitization of Telenomus sp. on eggs of S. frugiperda the highest sample from Manado and the lowest sample from Tomohon. Percentage of parasitization of Trichograma sp. the highest sample of S. frugiperda eggs from Manado, and the lowest sample from Bolaang Mongondow.

Keywords— ***Percentage parasitization, parasitoids, Spodoptera frugiperda.***

I. INTRODUCTION

Corn (Zea mays L) is the main commodity of agricultural crops in Indonesia. There are 2 groups of corn that are cultivated, namely ordinary corn (food corn) and sweet corn, both of which have high economic value. Food corn is mainly used as raw material for making animal feed and other industrial product materials (Kurniati, 2012). Cultivation is easy, can grow in various conditions, stable selling prices and easy to market are the main driving force for high interest of the farming community to cultivate it.

The attack of Spodoptera frugiperda J. E. Smith (Lepidoptera; Noctuidae) which appeared in mid-2019 has become an important problem in maize cultivation. The potential for attack is high and can disrupt the availability/production of maize in Indonesia. S. frugiperda was published as a new pest in Indonesia and in April 2019, it was found to have attacked maize plantations in West Sumatra Province (Nonci, et. al. 2019). Now S. frugiperda has been found attacking and damaging in many areas of maize cultivation throughout Indonesia, including in North Sulawesi Province.

Imago S. frugiperda is an aviator and has a high cruising ability (Jia, et. al., 2020). Adult insects can fly 100 km in one night (CABI, 2019). This migratory ability allows rapid population increase in new areas because natural enemies are not carried away. This insect has polyphagous characteristics with its main host being food plants from the Graminae group including corn, rice, sorghum and sugarcane (Montezano, et. al., 2018)., The larval host of S. frugiperda is more than 350 types of plants, covering 76 families. S. frugiperda is a typical migratory pest (Nagosi, et. al., 2008; Westbrook, et. al., 2016).

The common name of this pest is the armyworm S. frugiperda or the armyworm frugiperda or abbreviated as UGF. Nonci, et. al. (2019), stated that yield losses of 15-73% can occur if the plant population is attacked by 55-100%, when the infestation occurs in young corn plants with curled leaves. Losses due to S. frugiperda attack varied depending on the age of the affected maize plant. Yield loss also depends on the variety planted and the cultivation technique used. CABI, (2019) reports, in Africa and Europe the value of economic losses is between 8.3 - 20.6 million tons per year or US $ 2.5 - 6.2 billion per year due to S. frugiperda pests.

In North Sulawesi Province the presence of the pest S. frugiperda was discovered in October 2019. The first attack of S. frugiperda occurred in Tomohon City on sweet corn plants, then it was found in corn plantations in Minahasa Regency and was subsequently found to have attacked corn plantations in various districts and cities (BBPOPT, 2019). Mamahit, et. al. (2020) reported that S. frugiperda was found attacking in several villages in Minahasa Regency, including; Toraget, Taraitak, Karondoran, Winebetan, Upper Kaayuran, Walengko, Noongan, South Raringis, Toure, Wasian and Leleko villages with S. frugiperda attack rates ranging from 30% - 70%.

Efforts to deal with it in various places encountered serious problems. Synthetic insecticides are the first and foremost choice for controlling S. frugiperda. Its use is carried out on a scheduled basis and ignores ecological considerations. The safety of agricultural products has a high chance of being contaminated with hazardous materials. Death of natural enemies, and resistance, resurgence, emergence of secondary pests will inevitably occur. Likewise, biodiversity and environmental health will get worse. At the same time, with increasing public awareness of health, the demands for the faithful safety of agricultural products also increase and synthetic pesticides are the largest contributor to agricultural products contaminated with hazardous materials.

Parasitoids as the main component in pest control, have an important role as a natural controller of pest insect populations. The character of S. frugiperda as an invasive insect that is able to fly far from one place to another, ensures that this migration has little chance of being followed by parasitoids from its area. The availability of local parasitoid species and information on the level of parasitization are very important information in the effort to determine policy steps for controlling S, frugiperda through biological control techniques. .

Based on the description above, the research related to the inventory of egg parasitoids of S. frugiperda and to analyze the level of parasitization from egg group samples from several regions in North Sulawesi.

II. RESEARCH METHODS

1. Time and Place of Research

The research was carried out by collecting and collecting S. frugiperda egg groups from the field, starting in September 2020 until February in 2021. S. frugiperda egg groups were collected from the farmers' corn plantation area. The maintenance and identification of S. frugiperda egg groups was carried out in the laboratory of the Biological Agency for the Protection and Testing of the Quality of Food Crops and Horticulture, Sulawesi Province.

2. Materials and Tools

The materials and tools used in this research are:

a. Groups of S. frugiperda eggs were taken from farmers' plantations in Kolongan Village, Kalawat District, North Minahasa Regency, Matani Village, South Tomohon District, Tomohon City, Tonsewer Village, Tompaso District, Minahasa Regency, North Mopuya 2 Village, North Dumoga District, Bolaang Mongondow Regency, and Paniki Village. Below Mapanget District, Manado City, which will be used for test activities.

b. 90% alcohol, used to kill parasitoids that came out of the egg group for the identification process, was used as a mark on each treatment plot for easy observation.

c. Cotton, used as a test tube cover when rearing the egg parasitoid S. frugiperda

d. Microscope, used for the identification of parasitoids

e. Test tube size 20 mm x 15 mm, used for rearing groups of S. frugiperda eggs.

f. Petridish dish, a place to place parasitoids during identification

g. Plastic container, used to put test tubes containing S. frugiperda/parasitoid egg groups

h. Writing utensils for the needs of recording the data obtained

III. RESEARCH METHOD

The study was conducted using a randomized block design (RAK), and was repeated 3 times. As the treatment, samples of S. frugiperda eggs were collected from five regions, namely: Kolongan Village, Kalawat Subdistrict, North Minahasa Regency, Matani Village, South Tomohon Subdistrict, Tomohon City, Tonsewer Village, Tompaso District, Minahasa Regency, North Mopuya 2 Village, North Dumoga District, Bolaang Mongondow Regency, and Paniki Bawah Village, Mapanget District, Manado City. For each village, three locations of corn planting areas were assigned to be experimental units for collecting S. frugiperda eggs.

S. frugiperda egg groups were collected as much as possible from three different maize planting areas (as replicates). In total there are 15 experimental units which are corn plantations owned by farmers.

4. Observed Variables

The things that become the observation variables are:

a. Types of Egg Parasitoids

The eggs that have hatched are observed and differentiated between parasites or not. Eggs that are not parasitized will produce S. frugiperda larvae, while parasitized eggs will appear parasitoids. Furthermore, each tube where the egg group is reared which shows parasitized eggs is inserted with cotton containing 90 alcohol which has been dropped to kill the insects inside. The next process is identification with an identification book (Borror, et. al. 1992) to see the type of parasitoid using a binocular microscope. The types of parasitoids can be identified which shows the diversity of parasitoids that parasitize the eggs of S. frugiperda.

b. Parasitization Rate

To determine the level of parasitoid parasitization used the formula:

$$P (\%) = n / N \times 100\%$$ (Sasmita and Baehaki, 1997)

P = parasitization rate

n = number of groups of parasitized eggs

N = number of egg groups reared.

The data obtained were statistically analyzed using IBM SPSS Ver. 21 and if it was significantly different, it was continued with the BNT test with a level of 0.05.

IV. RESULTS AND DISCUSSION

1. Types of Parasitoids

Inventory and identification carried out on egg parasitoids obtained by rearing egg groups against egg groups of S. frugiperda found that there were two types of egg parasitoids. The parasitoid is Telenomus sp. (Figure 1) and Trichogramma sp (Figure 2). Telenomus sp. has a black body, tapered abdomen, small body size ranging from 0.5 to 1 mm and has a club-shaped antennae with an antenna segment of 10 to 11 segments. While the parasitoid Trichogramma sp. small size about 0.4 mm, wings rounded and transparent, yellowish clear body color. To distinguish the two parasitoid species based on morphological characteristics, it is presented in table 1 (Borror, et. al. 1992).

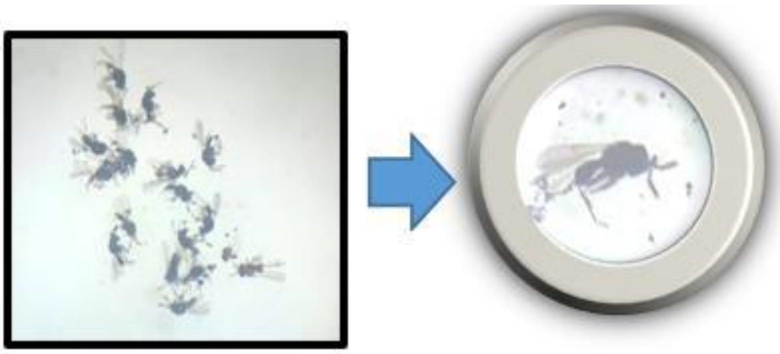

Fig.1: Imago Telenomus sp.

Fig.2: Imago Trichogramma sp.

Table 1. Identification of morphological features of the parasitoid Telenomus sp and Trichogramma sp

Morphological Characteristics	*Telenomus* sp.	*Trichogramma* sp
Body Color	Black	Clear Yellowish
Body Size	Bigger	Smollerl
Antenna	10 – 11 segments, elbow-shaped	6 segments, at the end there are short hairs
Wings	hind wings smaller than front	feathery wing edges
Tarsus	5-seged tarsus	3-seged tarsus

Based on the research results, it is known that the parasitoid Telenomus sp. more dominant than Trichogramma sp. (Table 2). The results showed that Telenomus sp. Most of the eggs came from the S. frugiperda egg group from the entire sampling area compared to Trichogramma sp. The difference in numbers between Telenomus sp. and Trichogramma sp is thought to be due to the cruising ability of Telenomus sp. which is better than Trichogramma sp. Susiawan and Netti, (2006) said Telenomus sp. have the ability to spread and adapt better to agricultural ecosystems in various regions. Meanwhile, the movement of Trichogrammatoidea parasitoid is more limited and only four meters from the point of release (Usyati, et. al. 2003). Rieske and Buss (2001), said that the richness of the diversity of distribution, and the abundance of species varied according to the place and time of sampling.

Table 2. Number of parasitoids in the egg group of S. frugiperda from several areas

Area of Origin	Number of Parasite Eggs	Type of Parasitoid	
		Telenomus sp	*Trichogramma* sp
Manado	23	17	6
North Minahasa	11	7	4
Tomohon	2	1	1
Bolmong	2	2	0
Minahasa	12	9	3
Total		36	14

The results showed that the egg group of S. frugiperda from Paniki Bawah Village, Manado City, from an average of twenty-seven groups of S. frugiperda eggs, was parasitized with twenty-three egg groups, consisting of seventeen parasitoids Telenomus sp. and six parasitoids Trichogramma sp. Egg groups of S. frugiperda originating from Kolongan village, North Minahasa Regency on average, fifty-nine groups of S. frugiperda eggs were parasitized as many as eleven egg groups consisting of seven parasitoids Telenomus sp and four Trichogramma sp, Matani Village Tomohon City an average of thirty-two egg groups S. frugiperda parasitized two egg groups consisting of one Telenomus sp and one Trichogramma sp, S. frugiperda egg group from North Mopugad Village, Bolaang Mongondow Regency on average 37 groups of S. frugiperda parasitized eggs two groups of eggs consisting of two Telenomus sp and 0 Trichogramma sp., and Tonsewer Village, Minahasa Regency on average twenty-six groups of parasitized S. frugiperda eggs totaling twelve egg groups consisting of nine Telenomus sp and three Trichogramma sp. Shylesha et al. (2018) reported finding a natural enemy complex of S. frugiperda, namely the egg parasitoid Telenomus sp. (Hymenoptera: Platygastridae) and Trichogramma sp. (Hymenoptera: Trichogrammatidae)

The egg parasitoid type Telenomus sp. found in 5 source areas of S. frugiperda egg groups, while Trichogramma sp. only found in four regions. This indicates that there are sufficient natural egg parasitoids available at the field level. Sembel (2010), parasitoids play a very dominant role in suppressing the development of plant pest populations. Parasitoids are animals that live on or in the body of the host. Parasite attacks can weaken the host and eventually kill the host, because the host's body fluids are eaten or inhaled by the parasitoid (Sopialena, 2018).

The difference in numbers between Telenomus sp. and Trichogramma sp is thought to be due to the cruising ability of Telenomus sp. which is better than Trichogramma sp. Susiawan and Netti (2006) said Telenomus sp. have the ability to spread and adapt better to agricultural ecosystems in various regions. This allows the search power to find a host, namely S. frugiperda eggs, to be higher. Meanwhile, the movement of the parasitoid Trichogrammatoidea has a more limited range and is only four meters from the point of release (Usyati, et. al. 2003).

2. Percentage of Parasitoid Parasitization

Observation of the percentage of parasitoid parasitization on S. frugiperda (Table 3), showed that in Paniki Bawah Village, Manado City, the highest parasitization rate with an average parasitization of 85%, while the lowest was in North Mopugat Village, Bolaang Mongondow Regency with an average parasitization of only 5%. Furthermore, the Tonsewer Village in Minahasa has an average of 46%, Kolongan Utara Minahasa Village an average of 19%, and Matani Village, Tomohon City an average of 6%.

Table 3 also shows that the average percentage of parasitoids is in the range of 5 - 85 %. In general, the parasitization value can be said to be good because it looks like the natural potential of the parasitoid is quite good. Sembel (2010), stated that parasitoids are the most widely used group of biological agents in biological control programs because they are quite effective in suppressing insect pest populations.

Table 3. Percentage of parasitoid parasitization on eggs of S. frugiperda

Area of Origin	Egg Group Average	Average Parasited	Percentage of Parasitization %
Manado City	27	23	85
North Minahasa	59	11	19
Tomohon City	32	2	6
Bolaang Mongondow	37	2	5
Minahasa	26	12	46

Based on Table 4, the percentage of parasitization of Telenomus sp. on eggs of S. frugiperda in Manado, the highest was 63% and the lowest was in Tomohon at 3%, while the percentage of parasitization of Trichograma sp. the highest in Manado by 22%, and the lowest in Bolaang Mongondow Regency 0%.

Analysis of variance in the percentage of parasitization of Telenomus sp. the eggs of S. frugiperda showed a significant difference (appendix 4). A follow-up test of 5% BNT (Table 4) shows that the average parasitization percentage in Tomohon City and Bolaang Mongondow Regency is not different, while in the other three areas the percentage of parasitization is different. The average parasitization percentage in Bolaang Mongondow Regency was not different from the parasitization percentage in North Minahasa Regency, while in other areas the parasitization percentage was different. Meanwhile, the average percentage of parasitization in North Minahasa Regency, Minahasa Regency and City are all different.

Table 4. Percentage of parasitization of Telenomus sp and Trichogramma s. against eggs of S. frugiperda

Area of Origin	Percentage of Parasitization	
	Telenomus sp	*Trichogramma* sp
Manado City	63 d	22 c
Minahasa Utara	12 b	7 ab
Tomohon City	3 a	3 ab
Bolaang Mongondow	5 ab	0 a
Minahasa	35 c	12 b

Description: Numbers followed by the same letter indicate no significantly different at the level of 0.05

The low percentage of parasitization in the cities of Tomohon and Bolaang Mongondow is thought to be caused by the high use of synthetic pesticides in these two areas. Source The group of S. frugiperda eggs tested from Tomohon City came from the Wawo garden area which is known to be very intensive in horticultural cultivation. The use of synthetic pesticides (insecticides, fungicides and herbicides) in this area is very high. Landis et al. (2000), said that synthetic pesticides, lack of feed for imago, and scarcity of hosts were the inhibiting factors for the development of parasitoids.

Interviews with local farmers, it is known that the use of synthetic pesticides is still done regularly/scheduled (5 – 13 times a season). Application of synthetic pesticides is very influential on the life of parasitoids including Telenomus sp. Characters as parasitoids that are actively looking for prey have a high chance of being exposed to synthetic pesticides. Likewise with the Bolaang Mongondow area where the source of the test material is taken from around the rice field, where the conditions for using synthetic pesticides are relatively the same as the City of Tomohon. Manado City, where the majority of farmers only cultivate corn, which is relatively minimal in the use of synthetic pesticides, shows the highest parasitization percentage of the other 4 regions. The state of the vegetation is very supportive of the development and growth of parasitoids in general. In Manado City, around the plantation where the samples were taken, there are many kinds of plants, both planted and wild. The diversity of plants produces a lot of nectar which is a source of food and shelter for Telenomus sp. and other parasitoids. The main source of nutrition for parasitoid adults is flowering plants that produce honey/nectar. Wahyuni et. al. (2013), said that flowering plants as refugia plants are expected to be a place of protection from predators as well as a provider of nutrition for adult parasitoid insects. For the survival of the parasitoid imago requires feed in the form of nectar, honeydew or pollen. The food source can be provided by flowering wild plants. Nicholls and Altieri (2003). said that the longevity and fecundity of parasitoids were positively influenced by the provision of supporting resources such as feed for imago, hosts, temporary shelters (shelters), escape areas (refugia areas), and appropriate microenvironments. Yaherwandi et al. (2008) stated that the diversity of parasitoids can be affected by the availability of flowering wild plants, because some adult parasitoids require pollen and nectar for reproduction and survival.

Analysis of variance in the percentage of parasitization of the parasitoid Trichogramma sp. against S. frugiperda (appendix 5) showed a significant difference at the 5% level based on the area of origin. Further tests with 5% BNT, (Table 4) showed a significant difference in the percentage of parasitization of Trichogramma sp against S. frugiperda in Bolaang Mongondow Regency, Minahasa Regency and Manado City. Meanwhile, between Bolaang Mongondow, Tomohon and North Minahasa regencies there is no difference. The parasitization of Trichogramma sp in S. frugiperda was the best in Manado City (22%) compared to four other areas, namely North Minahasa, Tomohon, and Bolaang Mongondow. The lowest parasitization occurred in Bolang Mongondow (0%). It is strongly suspected that the low percentage of parasitization is due to the ecosystem being short and not continuous. Lowland rice plants are on average 4 months old or shorter, then they are harvested and planted again. Ecosystems are short-lived and changeable including the state of vegetation such as weeds disappearing with the harvest. Tscharntke, et. al. (2001), said that it is difficult for parasitoids to settle in the agro-ecosystem of seasonal crops due to the relatively rapid and drastic changes in the environment. The ability of parasitoids to parasitize is largely determined by environmental conditions. The difference in the level of parasitoid parasitization is of course many factors that influence, including the prolonged summer during the formation of female flowers, the rainy season, the age of the host eggs, the application of insecticides and the number of host eggs available in the field.

Purnomo (2006), stated that the selection of hosts by parasitoid imago is very influential on the continuity of the generation of offspring. Besides the nutritional factor, the availability of suitable space is also the most important thing. Availability of nutrients will be able to increase parasitoid fitness which in turn affects the ability of predation. The cruising range to find a host and the production of eggs that can be laid is getting bigger. Environmental pressures in the form of unwise actions in the use of synthetic pesticides further reduce parasitization. The insecticide chlorphyrifos has a way of disrupting the nervous system and influencing changes in parasitoid behavior (Komeza, et. al. 2001). Wang, et. al. (2008). said contact insecticides can have a negative effect on parasitoids.

V. CONCLUSIONS

There are two types of parasitoids in the egg group of S. frugiperda, namely: Telenomus sp. and Trichogramma sp. The highest total parasitization percentage was in Manado City at 85% and the lowest was in Bolaang Mongondow at 5%. Parasitization rate of Telenomus sp. The highest sample of S. frugiperda egg group from Manado was 63% and the lowest was 3% in the egg sample from Tomohon. The highest percentage of Trichogramma sp parasitization was 22% in the egg sample of S. frugiperda from Manado and the lowest 0% in the egg sample from Bolaang Mongondow.

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