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BIOLOGICAL CHARACTERIZATION OF INSECT PESTS *Spodoptera exigua* Hubner ORIGIN NORTH SULAWESI

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Abstract

One component of integrated pest control is biological control or biological control based on the bioecology of the pest by taking into account the results obtained and their long-term effects through ecology and economy. The success of controlling a type of pest requires studies on various factors that affect the life of a pest, namely biology, morphology, ecology, genetics, and evolution. Knowledge of the biology of a pest species will provide appropriate information in breaking the life cycle or making the surrounding environment not provide optimal carrying capacity so that the pest population can be suppressed below the economic threshold. *Spodoptera exigua* is a polyphagous insect pest that eats from many plant types. In the larval stage, this pest attacks more than 20 species of cultivated and wild plants. For over twenty years, the onion caterpillar *S. exigua* has been the main target for chemical control but is still the main pest on onion crops. Spodoptera exigua attacks occur throughout the year in North Sulawesi and are spread over a wide geographical range, allowing genetic differences within the species. Gene mutations cause the occurrence of genetic diversity in a species in a population. High genetic diversity in individuals in a population can be one inhibiting factor in successfully controlling a pest species. Increasing knowledge about the biology of a pest species is very important to understand its habits, reproductive ability, and distribution which will later be used to limit and control the pest population.

Keywords: Biological characters, pests, insects, *Spodoptera exigua*.

INTRODUCTION

In Indonesia, *Spodoptera exigua* (Lepidoptera; Noctuidae) is one of the classic pests that often causes crop failure in some types of crops (Rauf, 1999*). Spodoptera exigua* is a polyphagous insect that attacks more than 20-50 species of cultivated and wild plants (Azizah & Azirun, 2006; Zheng et al., 2000). Plants that host these pest larvae include red onion, scallion, chives, tomatoes, potatoes, nuts, eggplant, tomatoes, cabbage, alfalfa, cotton, corn, and mahogany trees. These pests occur throughout the year in tropical and sub-tropical regions and will be higher in the dry season (Moekasan *et al.*, 2012).

S. exigua has the potential to become an important pest because it attacks plants in groups and has high fecundity, which in a year produces more than two generations, thus allowing a large number of

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damaged plants (Rauf, 1999). Spodoptera exigua is reported in India to be an important pest in tobacco plants (Shahanks, 2015), whereas in Indonesia, it is an important pest in Shallots in Palu, Central Sulawesi, and in the lowlands of the island of Java (Fransen, 1930; Rukmana, 1995; Pasaru, 1994), on leaf and shallots in Minahasa, North Sulawesi (Manueke, 1995; Paparang, 2016) and important pests in soybean in West Java (Arifin & Marandi, 1992). (Rauf, 1999). This pest attack on a 49-day-old shallot plant can reach 62.98% (Sutarya, 1996). Over the past twenty years, the onion *S. exigua* caterpillar pest has always been the main target of chemical control. However, until now, it remains a major pest on onion plants (Rauf, 1999).

Onion *S. exigua* caterpillar pests are known to spread over a wide geographical range, making differences in intra-species genetic diversity possible. This onion caterpillar has a variety of body colors; there is a green one that is brown. As for the green ones, there is a rather dark green found in larvae that live in the lowlands, while bright green is found in larvae that live in the highlands. Several research reports suggest that these pests have been resistant to several types of insecticides used in Indonesia, especially on the island of Java (Rauf, 1999).

The occurrence of genetic diversity in individuals in a population is caused by gene mutations (Suryo, 1995). A gene mutation can be caused due to natural factors, such as self-adjustment to the environment and the host, and artificial factors, such as the continuous use of insecticides. So far, research on genetic studies of *S. exigua* onion caterpillar pests in Indonesia, especially in North Sulawesi, has yet to be reported.

Cultivation of onion plants, especially shallots, and leeks, in North Sulawesi, especially the Tomohon, Langowan, and Modoinding areas, is a business that has been carried out for decades and is known as an area with a high level of economic income from the agricultural sector. The method of controlling *S. exigua* pests commonly used by farmers in these three areas is spraying insecticides. For over twenty years, the onion caterpillar, *S. exigua*, has been the main target for chemical control but is still the main pest on onion plants (Rauf, 1999). Pest control strategies in Indonesia led to the development of integrated pest management (IPM), which requires a basic understanding of the biology and ecology of the target pests. The onion caterpillar pest *S. exigua* can spread quickly in the lowlands and highlands. It was also reported that this pest has great biotic potential, which tends to cause great damage to the plants it attacks. The biology of the *S. exigua* pest, which includes the life cycle, stages of development, and the personality of the female imago, is strongly influenced by climatic factors, food, and natural enemies, so these factors also limit the life and development of this pest. Engineering against limiting factors can be one of the supports in implementing IPM.

LITERATURE REVIEW

Classification and Distribution of *Spodoptera exigua*

Insect caterpillar pest known as Spodoptera exigua Hubner is included in the order Lepidoptera, sub-order Poliphaga, a family of Noctuidae, genus Spodoptera and species of exigua (Natawigena, 1990).

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Abroad, this pest is known as a lesser armyworm, and in Indonesia is known as the army caterpillar. In Indonesia, these pests were first reported in 1927 when they attacked onion plants in Java. These pests then spread to other islands, including Sulawesi. Several types of armyworms can be found in Indonesia, including Pseudoletia unipuncta, Spodoptera exempta*, S. exigua, S. mauritia, and S. litura* (Kalshoven, 1981). *Spodoptera exigua* Hubner classified :

Filum : Arthropoda
Kelas : Insekta
Ordo : Lepidoptera
Famili : Noctuidae
Genus : Spodoptera
Spesis : *Spodoptera exigua* Hubner

The adult insects are called moths which are known to be very mobile and can fly that can reach tens of kilometers. As a result, this pest has expanded its geographical range widely beyond Asia and has become an invasive species and plant pest almost worldwide. It is suspected that adult moths will move and spread to hotter areas if too cold and return if suitable (Nagoshi et al., 2010; Zheng et al., 2011a; Zheng et al., 2011b).

Morphology of *Spodoptera exigua*

Eggs are placed in groups, white and shaped like discs. On the upper surface, there are smooth bumps composed of ribs (Rondonuwu, 1990). The larvae experience five instars. The initial instar larvae usually live in groups at the end of the leaf with a shiny dark brown head; other body parts are green (Sembel, 2012). After changing the skin, the larvae change color; some remain green, and some are dark brown. Older larvae are 20-25 mm (Rondonuwu, 1990). The characteristic of S. exigua larvae has black stripes on its back (Kalshoven, 1981).

Pupa is brown-like burning, length 10-12 mm. At the end of the abdomen, there is a spine-shaped embellishment, one of the important features for identifying pupae (Brown and Dewhurst in Rondonuwu, 1990).

Male imago has a 19-23 mm wingspan, and female moth wings range from 21-28 mm. The front wing is yellowish gray, and the rear wing is white, except the venation of the wing and outer edge are brown. At the end of the female abdomen, there are fine white scales. Imago body length is 10-14 mm (Rondonuwu, 1990). In general, male moths have a darker color than females, and their body size is smaller than females.

Bionomi *Spodoptera exigua*

These pest insects have perfect metamorphosis through eggs, larvae, pupae, and imago. Imago, commonly called moth, is active at night and attracted to light. Eggs are placed at night with approximately 100 grains once placed. Female moths can put in as many as 500 - 600 eggs (Metcalf and Flint, in Rondonuwu, 1990). The egg stage lasts 2-3 days (Sembel, 2012). The larvae that come out of the eggs live in groups, then spread and perforate the leaves, enter the cavities, and stay inside as long as the food

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is still available. The larvae eat leeks from the inside and leave the epidermal layer so that a transparent white layer appears. Severe attacks cause the leaves to run out and then die. The larval stage duration ranges from 14-15 days (Rondonuwu, 1990).

Towards the humping, larvae fall to the ground and become prepared. This prepupa is not actively eating and not moving. The preproduction period is an average of 2 days (Sembel, 2012). Pupa is brown-like burning and is found in the soil. The pupa stadium lasts 5-10 days (Rondonuwu, 1990).

Imago from this pest is moth-shaped, weighing 10-14 mm. The lifespan of the female imago ranges from 3 - 10 days, with the pre-laying period ranging from 1-3 days. Egg laying takes place on the second to fourth day. The average duration of nesting is 3.4 days, and the average post-laying period is 2.8 days. The Imago stadium lasts 7-10 days (Rondonuwu, 1990). S. exigua pests' attack in its development can be influenced by several factors such as climate, food, natural enemies, and place conditions (Dibyantoro, 1994). According to Kalshoven (1981), onion caterpillars have several host plants other than leaf onions: onion, chives, corn, and beans. Sometimes these pests can be found in tobacco, cotton, potato, tomato, and eggplant plants.

This pest life is also affected by natural enemies. S. exiguous natural enemies include egg parasitoids from the family Proctotropidae and larval parasitoids from Braconidae, Ichneumonidae, and Tachinidae families (Franssen, 1930 in Rondonuwu, 1990).

According to Soehardjan (1993), optimum air humidity and adequate food availability will encourage conditions suitable for developing and spreading insect pest populations. These factors limit the development and activity of insect pest populations in nature, so the population density of a species varies for each region.

RESEARCH METHODS

This research was conducted in the Department of Pests and Plant Diseases Laboratory, Faculty of Agriculture, Sam Ratulangi University, Manado, and the Biology Laboratory, FMIPA, Manado State University. The implementation time is four months, from March to July 2022. The materials and tools used in this study were all stages of the insect pest Spodoptera exigua., namely egg, larva, and imago stages (male and female), cotton, gauze, cage box, jar, rubber hand, scissors, brushes, tweezers, paper labels, loop, paper, water, insect nets and stationery, digital microscope cameras (Hirox et al. KH 87000) and digital cameras.

This research is exploratory, descriptive research. The parameters observed were: (1) the time required for egg stage, first instar larvae, second instar larvae, third instar larvae, fourth instar larvae, fifth instar larvae, prepupae, pupae, and imago life span. Each stage has three replicates. (2) a percentage of success of eggs into larvae, percentage of success of pupae into imago, sex ratio, and personality of female imago.

Sampling of *S. exigua* in onion-producing areas

Insect samples of S. exigua were collected from leek plantations in several villages in Tomohon

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(Kakaskasen village, Rurukan village, and Wailan village). Search and collection of samples (eggs, larvae, and pupae stages) was carried out in the morning around 06.00 – 08.00 WITA, and to get the image, it was done at night around 19.00 – 20.00 WITA. The eggs, larvae, and pupae found were stored in plastic containers lined with tissue and left open, while the imago stages obtained were stored in glass bottles, then covered with gauze. Each bottle is filled with a maximum of two imago.

Sampling was conducted to obtain as many samples of S. exigua as possible to be maintained and reproduced in the laboratory (rearing) to obtain a second generation ready to be used as a sample for observation of biological studies. The sample collection activity was followed by observing the population of *S. exigua* concerning invasion behavior and larval body color concerning polymorphism patterns in leek cultivation.

Test insect propagation

The insect colony *Spodoptera exigua* used in this study was taken from the field (Tomohon) and then propagated in the laboratory. The images were kept in insect breeding boxes (50 x 50 x 50) m and fed with 10% honey liquid which was absorbed into a lump of cotton. Pesticide-free leek plants are planted in polybags and put in a captive box to lay eggs. The eggs placed on the leeks were collected and placed in a petri dish (Æ 20 cm) lined with blotting paper. After the eggs hatched, the larvae were transferred to a plastic box measuring (35 x 25 x 6) cm lined with blotting paper and fed with pesticide-free leek. Larvae stadia development from instars 1 to 5 is always monitored without moving its place, and the rest is used for further propagation. The larvae to be pupated were transferred to another plastic box containing sterile sawdust. The pupae formed were transferred to the insect breeding box and allowed to become imago. These steps will continue to be carried out until the egg stadia of the second generation's larval stage, pupa stage, and imago stage are obtained in uniform number and age. Each stadia to be observed has three replications: the egg phase consists of 3 egg groups; the larval phase consists of 15 larvae; The pupa phase consists of 15 pupae; and the imago phase consists of three pairs of imago. The number will be maintained by replacing the inventory if any observation samples die.

Biological identification of pests S. exigua

Parameters observed were: length of the egg stage, the larval stage of first instar, second instar, third instar, fourth instar, and fifth instar larval stages; length of pupa period; length of life of male and female imago; imago personality and sex ratio male-female; Observation of Biological Characters including Development and Reproduction of *S. exigua.*

RESULTS AND DISCUSSION

Egg Stage

Spodoptera exigua, or leek caterpillar, has several color variations, namely green, light brown, and brownish-black, and undergoes a perfect metamorphosis. The female imago lays eggs on leeks in groups and is covered with scales from the mother's body. Usually, the eggs will be found on the upper leaves exposed to the sun all day.

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Table 1. Percentage of Success of Egg to Larvae

Number of Egg	Percentage of Success (%) [a]	
	Number of Egg	Egg to Larvae
A	75	86%
B	66	89%
C	79	94%
D	73	76%
E	67	78%

Each group of eggs ranged from 60 - 80 eggs. The eggs are white, round to ovoid in shape. The length of the egg stage ranges from 1-3 days. The percentage of success in hatching eggs is 76 – 94%.

Larval Stadia

The larvae of *S. exigua* had five instars under ideal conditions. If food is lacking, the larvae only reach four instars and then immediately pupate. The larvae of this pest have a characteristic that is the presence of a smooth black line across its back. Newly hatched larvae from eggs will immediately make a hoop into the leaf cavity and live together until the second instar. Most larvae will move to other leaves after entering the third instar. Usually, in the cavity of the affected leaf, only 2-3 larvae will be found. Entering the fifth instar, larvae prefer to be at the base of the leaf, which will eventually pupate on the dry and drooping leaf or the ground. The length of the egg stage ranges from 8-10 days.

Table 2. Average Larvae Development of *S. exigua* from instar I to V

Larvae Instar	Average Period Larvae (days)
Instar 1 - 2	1.5
Instar 2 - 3	2.0
Instar 3 - 4	3.0
Instar 4 - 5	2.5

Pupa Stage

Pupation is the time when these pests are not actively eating and moving. The young pupae are the same color as the larvae, the green ones remain cloudy green, and the brown larvae the pupae remain brownish. After a few days, all the pupae will be reddish brown. The pupae of this pest do not have a pupae house and are usually found at the base of the stem, protected by dry leaves, or in the soil near the plant, protected by soil particles. The pupa period ranges from 5-7 days. The success of pupae in imago can be seen in Table 3. The results showed that not all pupae would emerge as imago; one factor that influences it is the larvae's adaptability. Visual observations showed that some pupae formed from larvae that could not compete for food showed morphological abnormalities (the shape was not like the normal, slightly curved), and some of the images that appeared had abnormal wings (not developed).

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Table 3. Percentage of Success of Pupae to Imago

	Percentage of Success (%) [a]		Sex Rasio
	Number of Pupae	Pupae to Imago	(♂ : ♀)
A	15	65.22	1 : 1,1
B	26	86.67	1 : 1,2
C	29	96.67	1 : 1,2
D	23	76.67	1 : 1,1
E	19	63.33	1 : 1,1

Imago Stage

The image of this pest is called a moth with gray body color and is very attracted to light. The bodies of male and female moths at first glance look the same, but if you look closely, the abdomen of the female moth looks bigger and rounder than the male. At the end of the abdomen of the female moth, there is a kind of appendage similar to a thorn which is a tool for laying eggs and is also called an ovipositor. The female moth begins to lay eggs within 3-9 days. The ratio of male and female imago comparisons and the lifespan of *S. exigua* imago can be seen in Table 4.

Table 4. Keperidian, Mean Length of Life of Imago *S. exigua* and Comparison of Males and Females (Seks Ratio).

	Long live of Imago (days)			
	Keperidian		Sex Ratio	
	(Egg/ ♀)	Male (♂)	Female (♀)	(♂ : ♀)
S1	271	10,33	7,67	1 : 1,2
S2	406	10,67	9,33	1 : 1,2
S3	397	11,67	8,33	1 : 1,1
Average	358	10,89	8,44	

The group of eggs a female lays in one laying period is an average of 3 to 5 egg groups. The ability of female moths to lay eggs, or called personality, is an average of 358 eggs. Table 5 shows that the average lifespan of male and female *S. exigua* imago showed differences, where the male imago was relatively longer than the female, with an average difference of 2.45 days. From direct observation, it can be seen that the male image can live up to the 12th day while the female image can only live until the 10th day; this is in line with what was stated by Tarumingkeng (1992) that gender is one of the factors that determine the survival of a species. Insect. The time required by one generation in its life cycle reaches 31-38 days. This data aligns with that reported by Darwati in 2002 and Azidah and Azirun in 2006. The time difference is only one to two days due to different temperatures and humidity because, according to Rauf 1999 and Moekasan 2007, high temperatures can accelerate egg and pupae stages.

The conditions in *S. exigua* proved that the male imago had a longer life span, so it could be used as a basis for determining its control strategy. One thing to consider is using sex pheromones to attract male imago into the trap. The development of pheromones, a third-generation insecticide in recent years, has been developed to manage pests of the order Lepidoptera (Sembel, 2012). Table 4 also shows that females dominate the comparison of male and female imago that appears. Conditions like this will affect the number of offspring in the next generation. According to Jumar (2000), changes in the sex ratio in

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insects are not only influenced by the intrinsic factor of insects but also by extrinsic factors such as food, season, and population density.

CONCLUSION

Biological characters *Spodoptera exigua* is a moth active at night, undergoing complete metamorphosis with four alternations of stadia: egg, larva, pupa, and imago. The life cycle of S. exigua on leek plants is 31 – 38 days. The developmental stages of this pest are the egg stage, an average of 2.1 days; the larval stage, an average of 11 days: larvae instar I to instar II, an average of 1.5 days; instar II to instar II, an average of 2.0 days; instar III to instar IV an average of 3.0 days and instar IV to instar V an average of 2.5 days, instar V to pupa an average of 2.5 days. The pupa stage averaged 6.5 days, and the imago stage ranged from 8-12 days, where males had a longer life span than females by an average difference of 2.45 days. The ratio of male and female imago is 1:1,2, so the female is dominant in that generation. The average female moth of S. exigua is 358 grains.

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