J. HPT Tropika
Vol. 20, No. 2, September 2020
Pages: 85–91

ISSN: 1411-7525
E-ISSN: 2461-0399
DOI : 10.23960/j.hptt.22085-91

NATURAL INCIDENCE OF ENTOMOPATHOGENIC FUNGUS *Nomuraea rileyi* ON *Spodoptera frugiperda* INFESTING CORN IN BENGKULU

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Manuscript received: 5 April 2020. Revision accepted: 8 May 2020

ABSTRACT

Natural incidence of entomopathogenic fungus* Nomuraea rileyi *on* Spodoptera frugiperda *infesting corn in Bengkulu. *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) is a new invasive pest in corn. The intensive use of synthetic insecticides for pest control causing various problems such as resistance, pest resurgence, and environmental damage. To solve these problems, entomopathogenic fungi could be used as an alternative in pest management. Therefore, this study was aimed to determine the natural incidence of *Nomuraea rileyi* (Farlow) Samson (Hypocreales: Clavicipitaceae) entomopathogenic fungus on *S. frugiperda* in Bengkulu. The research was carried out by exploring the corn producing areas in Bengkulu for *N. rileyi* incidence. The results showed that the *N. rileyi* was occurred naturally infected *S. frugiperda* larvae reached 79.0%. Meanwhile, the percentage of crops damage due to *S. frugiperda* was ranged from 40.0 to 96.0%. The highest natural incidence of *N. rileyi* were found in the Village of Bukit Barisan and Tugu Rejo (79.0%), followed by Pulo Geto Baru (25.0%), and Taba Mulan (5.3%) while the lowest incidence was in Sidomulyo (1.0%). The infected larvae were not found in the Napal, Beringin Raya 1, and Beringin Raya 2, despite the percentage of *S. frugiperda* attacks was reached 50.0; 50.0 and 74.0%, respectively.

Key words: corn, natural incidence, *Spodoptera frugiperda, Nomuraea rileyi*

INTRODUCTION

Corn is a strategic national commodity that included in the special program for rice, corn, and soybeans, as *Upaya Khusus Padi, Jagung, dan Kedelai* (UPSUS PAJALE) from the Ministry of Agriculture. To increase the corn yields, a pest management strategy have to be developed, particularly for important insect pest. *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) is important insect pest of field corn in Indonesia (Trisyono *et al.,* 2019).

A new invasive of armyworm has been discovered in the world, the *Fall Armyworm* (FAW) or *S. frugiperda*. The *S. frugiperda* attacks crops such as corn, rice, and wheat. *S. frugiperda* is a native pest of the tropics and subtropics in America (Goergen *et al.,* 2016) and difficult to control due to the rapid spread of adults. The *S. frugiperda* was reported for the first time on the Africa in 2016 (Goergen *et al.,* 2016), and has attacked more than 30 countries in Africa (Huesing, 2018). This pest had also been reported in Karnataka, India (Sharanabasappa *et al.,* 2018a), specifically in the District of Bihar, Chhattisgarh, Gujarat, Maharashtra, Odisha, Tamil Nadu, Telangana, and West Bengal (EPPO, 2019), Myanmar (Yee *et al.,* 2019), Sri Lanka (Wanasinghe *et al.,* 2019) and Thailand (IPPC, 2018).

Losses due to this pest in 12 countries of Africa was ranged from 8.3 to 20.6 million tons per year, valued 2.481–6.187 million USD/year (Shylesha *et al.,* 2018). Baudron *et al.* (2019) reported that *S. frugiperda* infestation in corn was ranged from 26.4 to 55.9% reducing yields of 11.57%. The level of damage to leaves, silk, and corncobs ranged from 25 to 50% reducing yields of 58.0% (Chimweta *et al.,* 2019). FAW was first reported on March 2019 in West Pasaman (West Sumatra Province) Indonesia and caused major damage with larvae population reached 2–10 larvae per plant (Nonci *et al*., 2019). *S. frugiperda* has also been reported in Lampung Province (Trisyono *et al*., 2019; Lestari *et al*., 2020) and West Java Province (Maharani

et al., 2019). Early *et al.* (2018) explained that the spread of *S. frugiperda* can occur through the trade of vegetables and fruits between countries.

Farmers have used some techniques such as insect-resistant plant, insecticides, and biological control for the pests. Environmentally friendly pest control including the use of entomopathogenic fungi could help reducing the use of pesticides and harmful effects on the environment. In contrast to bacterial and viral pathogens of insects, entomopathogenic fungi have the ability to infect the pest by producing enzymes and penetrating the host cuticle. In addition, it also have the potential to cause epizootics during favorable environmental conditions.

Nomuraea rileyi is an entomopathogenic fungus that causes natural infections in various Lepidoptera. This fungus has been reported to infect *S. frugiperda* in Karnataka, India (Sharanabasappa *et al.,* 2018b). Mallapur *et al.* (2018) reported that *N. rileyi* was able to reduce damage to corn leaves caused by *S. frugiperda* from 62.50 to 73.05%. *N. rileyi* could also cause epizootics in Lepidoptera such as *Heliothis zea, Plathypena scabra, Bombyx mori, Pseudoplusia includens, Anticarsia gemmatalis,* and some Coleoptera (Moanaro *et al*., 2017). *N. rileyi* was able to cause mortality of 2nd instar of *S. frugiperda* larvae, neonates, and egg (Akutse, 2019; Cruz-Avalos *et al.*, 2019). However, information about the natural incidence of *N. rileyi* in *S. frugiperda* which infested corn in Bengkulu has never been reported. The purpose of this study was to determine the natural incidence of *N. rileyi* in *S. frugiperda* in the field.

MATERIALS AND METHODS

Research Site. This research was carried out in several corn fields: Sidomulyo and Napal Villages, Seluma District; Pulo Geto Baru, Taba Mulan, Bukit Barisan, Tugu Rejo Villages, Kepahiang District; Beringin Raya 1 and Beringin Raya 2 Villages, Bengkulu City (Figure 1).

Sampling and Identification. The survey was conducted from April to November 2019 in the area of corn production in Bengkulu using scouting system (McGrath *et al.*, 2018). The number of samples was 50

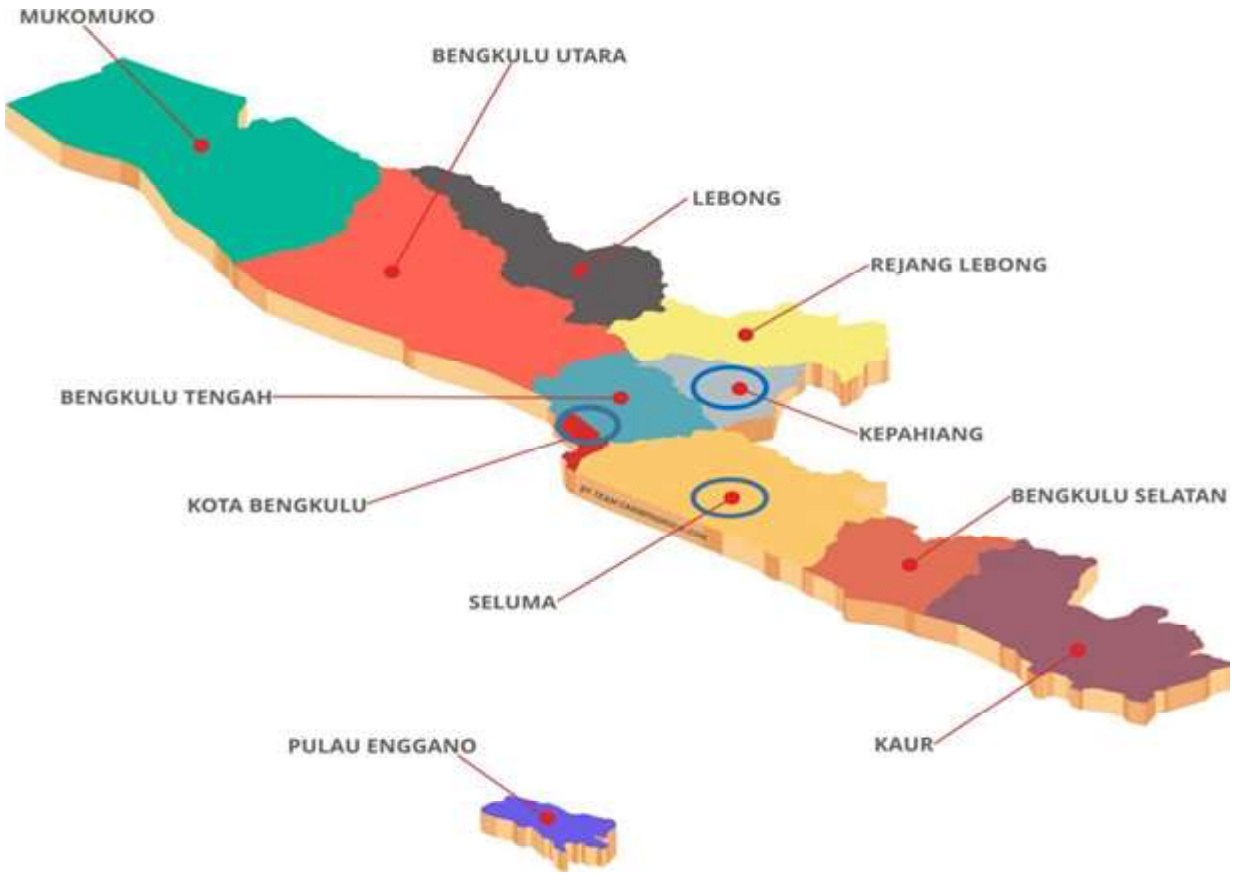

Figure 1. Map of research site (blue circle is an area of research). Source: https://www.google.com/search?q=peta+bengkulu&safe.

plants per location. Identification of insect and entomopathogenic fungi was carried out at the Plant Protection Laboratory, Faculty of Agriculture, University of Bengkulu. Larvae found were also taken to the Laboratory for rearing to imago and morphologically identified.

Observation of Symptoms and Population of *Spodoptera frugiperda* Larvae. Observation of symptoms of *S. frugiperda* attacks was carried out directly on all parts of the corn crops. The symptoms were then confirmed by examining the larvae in the leaf rolls and then photographed. The number of larvae was counted.

The Incidence of *Spodoptera frugiperda* and *Nomuraea rileyi* in the Corn Planting Area. The corn areas from each district were surveyed and identified for the incidence of *S. frugiperda* and *N. rileyi*. From each location, a total of 50 plants were observed. The number of larvae infected by *N. rileyi* was recorded and the percentage was calculated. The percentage of pest attacks and the incidence of *N. rileyi* were calculated using the following formula (Mallapur *et al*., 2018):

$$\text{The crop damage percentage} = \frac{\sum \text{damage crops}}{\sum \text{overall crops}} \times 100\%$$

$$\text{The incidence of } N.rileyi = \frac{\sum \text{larvae infected with } N.rileyi}{\sum \text{overall larvae}} \times 100\%$$

Observation of *N. rileyi* was conducted by observing dead larvae infected by pathogens, and then the larvae were taken to the laboratory to be isolated and morphologically identified using a binocular microscope based on Dutta *et al.* (2014).

Data Analysis. The incidence of *N. rileyi* and crops damage due to *S. frugiperda* was calculated by counting the number of infected larvae and the number of plants attacked in the field.

RESULTS AND DISCUSSION

The symptoms of *S. frugiperda* attack start from the whorls, resulting the ragged holes on the leaves (Figure 2). Severe feeding activities by *S. frugiperda* larvae can cut off plant growth points and produce sawdust-like larval droppings. Large pest populations could cause defoliation and resulted in yield losses. Older instar larvae were cannibals, therefore only one or two larvae were found in each plant. Shylesha *et al.* (2018) reported that, *S. frugiperda* was a polyphagic important pest in corn. The first larval instar feed in groups on the underside of young leaves which caused a "window-pane" damage, and cuts off the growing point of corn plants.

The imago of *S. frugiperda* was characterized by two white spots on the front wing. The pupae were reddish brown. New larvae come out of white eggs (neonates) and become light brown. The larvae had an inverted "Y" symbol on the head and 4 large spots (pinacula) on the segment 8 abdomen (Figure 3). The characteristics of these insects were in accordance with the descriptions of *S. frugiperda* (Sharanabasappa *et al.,* 2018a).

Based on the symptoms in the fields, *S. frugiperda* larvae was infected by entomopathogenic fungi. These fungi was isolated and cultured on the SMAY medium (Sabouraud Maltose Agar Yeast) and observed under a microscope (Figure 4). Based on

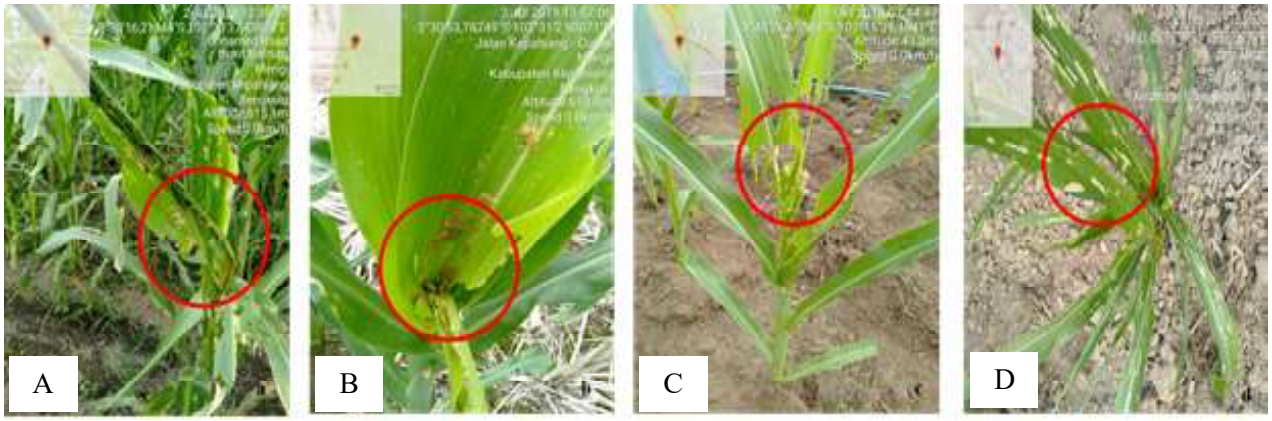

Figure 2. Symptoms of *S. frugiperda* in various areas of corn. (A) Bukit Barisan, Merigi Sub District, Kepahiang District, (B) Pulo Geto Baru, Merigi Sub District, Kepahiang District, (C) and (D) Beringin Raya 1 and Beringin Raya 2, Muara Bangka Hulu Sub District, Bengkulu City.

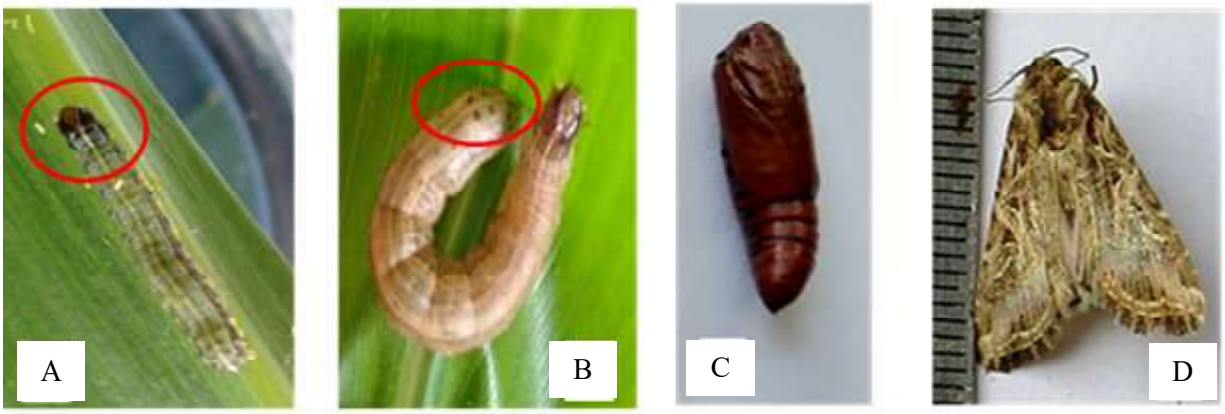

Figure 3. *Spodoptera frugiperda.* (A) 3rd instar larvae, (B) 4th instar larvae, the larvae had an inverted "Y" symbol on the head and 4 large spots (pinacula) on the segment 8 abdomen, (C) Pupa, (D) Imago.

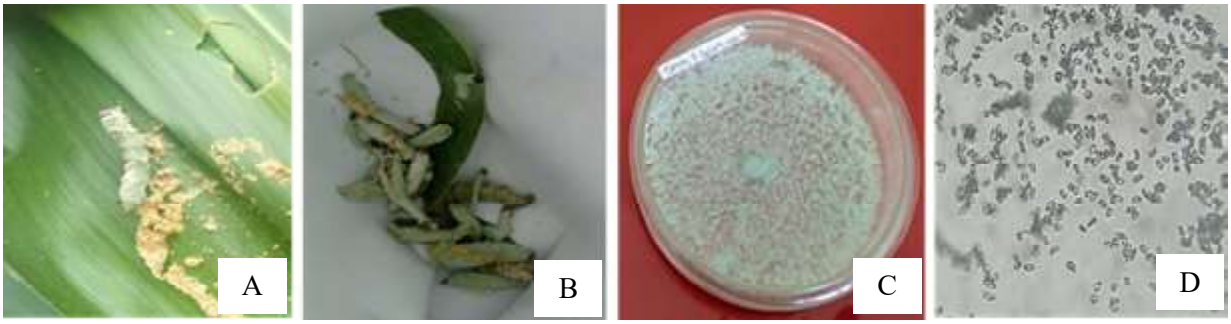

Figure 4. Entomopathogenic fungi. (A) and (B) *S. frugiperda* larvae infected by *N. rileyi* in the field, (C) Colony of *N. rileyi* on SMAY media, (D) Conidia of *N. rileyi*.

morphological data, the fungal pathogen infecting *S. frugiperda* larvae was *N. rileyi.* Morphologically, *N. rileyi* were septate, transparent, and branched hyphae. Branched conidiophores formed near the septa, with a number of 2–6 phialides. The phialides usually subglobose or short cylinders, with transparent and smooth wall. The conidia appears in chains, very ellipsoidal, smooth wall, and transparent. This research was in line with the results of Dutta *et al.* (2014).

The percentage of natural incidence of *N. rileyi* in *S. frugiperda* larvae were varied from 1.0 to 79.0%. The highest natural incidence of *N. rileyi* were found in Bukit Barisan and Tugu Rejo (79.0%), followed by Pulo Geto Baru (26.0%), and Taba Mulan (5.3%). The lowest incidence of *N. rileyi* was in Sidomulyo (1%), while the percentage of corn crops damaged by *S. frugiperda* was ranged from 40 to 96% (Table 1). *N. rileyi* infecting *S. frugiperda* were not found in the Napal, Beringin Raya 1, and Beringin Raya 2 despite the percentage of *S. frugiperda* attacks reached 50.0, 50.0 and 74.0%, respectively. This probably caused by environmental conditions that were less supportive for the development of entomopathogenic fungi. Merigi and Kabawetan Sub District has a higher altitude compared to other areas around (610–1077 m asl) (Table 1), so that the temperature is lower compared to other regions of Napal, South Seluma Sub District (44 m asl) and Beringin Raya, Muara Bangka Sub District (8.1–14.2 m asl).

The suitable areas for the development of fungi will cause natural and epizootic infections. The geographical location, climate, habitat, altitude, and pH of the soil or organic matter impact the presence of fungal species and responses of fungi species to these condition varies. Temperature also influences fungal efficacy (Abd El-Ghany, 1995; Abdel-Raheem 2020).

The potential of *N. rileyi* in Lepidoptera had been reported by Hamirbhai (2010) on *Helicoverpa armigera* with natural incidence reached 14.0%. During this study, infection of *N. rileyi* on *S. frugiperda* varied in various areas due to the environmental conditions. This study was in line with Manjula *et al*. (2003) which stated that temperature, rainfall, and humidity showed a positive correlation with the incidence of disease in

Table 1. Percentage of *N. rileyi* incidence and crops damage found in Bengkulu

No	Location	Altitude (m)	Coordinate	Crops damage (%)	Incidence of *N. rileyi* (%)
1	Sidomulyo, South Seluma Sub District, Seluma District	0	-4°6'18"S 102°33'35" 172°	40.0	1.0
	Napal, South Seluma Sub District, Seluma District	44	-4°5'57,64171"S 102°33'43'61933"E	50.0	0
2	Pulo Geto Baru, Merigi Sub District, Kepahiang District	617	-3°30'53,76042'S 102°31'2'91328"E	62.0	26.0
	Taba Mulan, Merigi Sub District, Kepahiang District	610	-3°29'52,15229"S 102°30'23'7793E	76.0	5.3
	Bukit Barisan, Merigi Sub District, Kepahiang District	619	-3°30'16,25029"S 102°30'23'7793E	96.0	79.0
3	Beringin Raya 1, Muara Bangka Hulu Sub District, Bengkulu City	8.1	-3°45'27,49961"S 102°15'40'51084"E	50.0	0
	Beringin Raya 2, Muara Bangka Hulu Sub District, Bengkulu City	14.2	-3°44'43,83604"S 102°15'38'42532"E	74.0	0
4	Tugu Rejo, Kabawetan Sub District, Kepahiang District	1077	-3°35'19,84333"S 102°37'39'38549"E	90.0	79.0

insects. Similarly, rainfall and humidity also play a role important for the development of entomopathogenic fungi in *S. litura* (Rachappa & Lingappa, 2007). In addition, Choudhary *et al*. (2012) reported that temperature, humidity, and rainfall play an important role in the incidence, distribution, prevalence, and effectiveness of entomopathogenic fungi.

Unlike the use of chemicals pesticide, entomopathogenic fungi have advantages that can survive in nature, reduce repeated applications, save time, energy, costs, and preserve the environment so that it is beneficial for farmers. The high incidence of *S. frugiperda* larvae infected *N. rileyi* affected by rainfall and high humidity which suitable for the growth and development of the fungus. Raindrops help the conidia reached the leaf surface where insects feed, resulting in primary infection. Abd El-Ghany (1995) stated that low humidity has been considered of factors limiting the effectiveness and failures of field trials.

The *N. rileyi* had the ability to infect and caused epizootics naturally if the environmental conditions were suitable, especially high temperatures and humidity in the field.

Entomopathogenic fungi had a broad spectrum such as the ability to infect several species of insects with different states and cause epizootics under natural conditions. Fungal spores infected the insect through integument, multiply in various tissues in the body, and killed the insects by releasing toxins that cause tissue damage. Epizootics depend on the climate factors such as wind, rain, or frequency of contact between insects. The infected insects would stop eating, changing color (beige, reddish, or brown), and eventually die due to being colonized by a fungus. Moisture was very important for the success of fungi as biological control agents. This study showed the potential of *N. rileyi* in the management of *S. frugiperda* in the field. For areas that do not support the development of entomopathogenic fungi, irrigation will help farmers to create environmental conditions that are suitable for the development of *N. rileyi,* because it can reduce temperatures and increase relative humidity in areas that are less supportive.

CONCLUSION

Incidence of entomopathogenic fungus *N. rileyi* occurred naturally in *S. frugiperda* larvae with infection rates ranged from 1 to 79%. Meanwhile, the percentage of crops damage due to *S. frugiperda* ranged from 40.0 to 96.0%. The highest natural incidence of *N. rileyi* were observed in the Village of Bukit Barisan and Tugu Rejo (79.0%), followed by Pulo Geto Baru (25.0%), and Taba Mulan (5.3%) while the lowest incidence occurred in Sidomulyo, South Seluma Sub District, Seluma District 1.0%. The infected larvae were not found in the Villages of Beringin Raya 1 and Beringin Raya 2, Muara Bangka Hulu Sub District, Bengkulu City and the Village of Napal, South Seluma Sub District, Seluma District, although the percentage of *S. frugiperda* attacks reached 50.0, 50.0 and 74.0%.

ACKNOWLEDGMENT

We would like to thank the corn planters in the area of the study site for allowing us to do this research.

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