Host Diversity of Beauveria Bassiana (Balsamo) Vuillemin on Rice Field in Bolaang Mongondow Regency

Parluhutan Siahaan, Saroyo, Marnix L. D. Langoy and Arie J. Saimima
Departement Of Biology, Faculty of Mathematics and Sciences, Sam Ratulangi University
Jl. Kampus UNSRAT, Bahu, Manado, 95115, Telp: (0431)863886 – (0431) 863786.

Doi: 10.31186/aa.24.2.63-69

ABSTRACT

**Beauveria bassiana** can attack a variety of hosts and their virulence can vary at each host and location. Exploration of the diversity of hosts B. bassiana from local isolates needs to be done as initial information that can explain the ability of B. bassiana in infecting insects. Sampling locations were selected in three district, each district selected three stations and each station consisted of 10 plots. The location of sampling is determined by the purposive random sampling method. Each station was made a plot measuring 1m x 1m and distributed randomly. Every insect infected with B. bassiana was taken and taken to a laboratory for identification. The results showed that there were five insects that hosted B. bassiana, namely Nilaparvata lugens, Scotinophara coarctata, Leptocorisa oratorius, Nezara Viridula and Paraecosmetus pallicornis. The highest host diversity index was found in North Dumoga with a value of 1.47. The highest abundance index was found in N. lugens host in East Dumoga with a value of 43%. The highest density was found in the host N. lugens in Central Dumoga with a value of 1.93 ind / m2. There were indications of differences in virulence of the B. bassiana local isolates that were influenced by the species of host and location.

INTRODUCTION

Rice ecosystems can be an ideal source of entomopathogenic fungi. As reported by Rosmini and Lasmini (2010) there were five entomopathogenic fungi that attacked the green leafhopper (*Nephotettix viresens*) in rice field in Donggala Regency, one of which was Beauveria sp. Exploration of entomopathogenic fungi in rice cultivation needs to be done to provide biological agents that can replace the role of synthetic pesticides (Rizal et al. 2017). Bolaang Mongondow Regency, North Sulawesi Province is a center of rice production that experiences various pest attacks (Mandei et al., 2011; Kila et al., 2016; Kanakan et al., 2017). Naturally, planting sites in this region must contain entomopatogenic fungi that are usually associated with rice pest insects. Exploration of local entomopathogenic fungi can be an environmentally friendly pest control alternative. One of the entomopathogenic fungi that is promising to be utilized is B. bassiana.

Fungi B. bassiana is one of the entomopathogenic fungi that has been known its effectiveness as a plant pest control (Anggarawati et al., 2017). This
color of fungus colonies at in vitro media is white flour. The colonies will turn yellowish or reddish after aging (Effendy et al., 2010). 

*B. bassiana* has been known to attack several species of insects, both pest insects, disease vector insects, and other insects. Previous work of Priyatno et al. (2016) showed that *B. bassiana* attacked stinky bugs (*Leptocorisa oratorius*), black ladybugs, and brown stem plant hopper (*Nilaparvata lugens*). According to Valero-Jiménez et al. (2014) this entomopathogen have also been used to control *Anopheles coluzzii* mosquitoes, a vector for malaria. Mwamburi et al. (2015) reported that *B. bassiana* could be used to control house flies (*Musca domestica*). *B. bassiana* was also reported to attack crickets (*Gryllus* sp.) (Ardiyati et al., 2015).

The virulence of *B. bassiana* has been known to vary depending on the origin, genetic diversity, the stage of the insect and the host. Valero-Jiménez et al. (2016) reported that there were several genes and molecular processes that could influence the virulence of *B. bassiana* against mosquitoes. Huang et al. (2019) reported that *B. bassiana* had different virulence qualities at each stage of *Haemaphysalis longicornis*. In India Bhadauria et al. (2013) reported no correlation between *B. bassiana* virulence and host insect origin. However, in China, Li et al. (2014) reported that *B. bassiana* isolates had different virulence at each host and each location.

Based on this information it can be seen that *B. bassiana* can attack various hosts and their virulence can vary at each host and location. For this reason, a preliminary study on the diversity of *B. bassiana* hosts originating from local isolates, Bolaang Mongondow Regency needs to be done. This study aims to analyze the diversity, abundance, and density of host insects infected by *B. bassiana* local isolates.

**MATERIALS AND METHODS**

The study was conducted from April 2019 to February 2020 in Bolaang Mongondow Regency, North Sulawesi. Three sub-districts were taken as sample locations and three stations were made as replications in each sub-district. Station selection was carried out using a purposive random sampling method based on rice age. Each station was made with a plot size of 1m x 1m, 10 plots were distributed randomly. All fungal-infected insects were collected and then were identified and selected at the Laboratory of Biological Agents, Center for Plant Protection and Horticulture, North Sulawesi Agriculture and Animal Husbandry Office.

A = \frac{\text{Number of individual species of the host}}{\text{Number of individual of all species}} \times 100\%

Host diversity index was calculated using the Shannon-Wiener Diversity Index (Stilling, 2012).

H' = -\sum_{n=1}^{s} \frac{p_l \ln p_l}{P_l}

H' = \text{Diversity Index}  
P_l = \text{Comparison of the number of i-th individuals (n_i) with the total number of whole individuals (N)} 

s = \text{The number of species in the sample}

The Host Abundance Index was calculated using the Abundance Index according to Fachrul (2007).

Host Density Index was calculated using the Density Index according to Stilling (2012).

\[ D = \frac{\sum x_i}{L} \]

\[ x_i = \text{Number of i-individuals} \]

\[ L = \text{area of sample (m}^2) \]

The identification of entomopathogenic fungi using the method in accordance with Nuraida and Hasyim (2009), Herdatiarni et al. (2014), Kulu et al. (2015), Trizelia et al. (2015), and Priyatno et al. (2016).

**RESULTS AND DISCUSSION**

**Exploration of the host *B. bassiana***

The exploration showed that insects infected with *B. bassiana* were found in each district. Five species of host insects infected with *B. bassiana* were found in all district. The host insects were *Nilaparvata lugens*, *Scotinophara coarctata*, *Leptocorisa oratorius*, *Nezara viridula*, and *Paraeucosmetus pallicornis*. Data from Central Dumoga, North Dumoga, and East Dumoga showed that the highest infected *B. bassiana* insect was *N. lugens* with successive values of 1.93, 1.40, 1.07 and the
lowest was *N. viridula* with successive values i.e. 0.20, 0.17, and 0.07 (Table 1).

Insects found infected with *B. bassiana* were common insect pests found in the rice ecosystem. *N. lugens* was one of the main pests of rice that is plastic which was easy to adapt to the environment and attacked the plant by sucking the liquid stem to dry (Nurbaeti *et al*., 2010). *S. coarctata* was a pest that caused huge losses in rice plantations because it attacked almost all stages of rice growth (Sepe and Demayo, 2017). *L. oratorius* is an important pest of rice because its presence can cause yield losses. Generally these pests attack at generative growth in rice (Kartohardjono *et al*., 2009). *N. viridula* is a pest that is commonly found in Legumes (CABI, 2016). This pest is an important pest in rice plants which causes considerable damage and is detrimental to the economy (Jones, 1988). *P. pallicornis* was a new pest since the 1980s that caused damage in rice plants in Bolaang Mongondow which had been watched out (Sembel, 2014).

**Diversity Index of *B. bassiana* Host (H’)**

Diversity index of *B. bassiana* host varied among district. The highest value was found in North Dumoga District (H’=1.47), followed by Central Dumoga District (H’=1.45), with the lowest was found in East Dumoga District (H’=1.38) (Figure 1).

The H’ value obtained indicated that the diversity of host *B. bassiana* in all district was considered to be in the medium category (Alikodra, 2002). This showed that *B bassiana* had moderate or quite diverse hosts. Ecosystem conditions were quite balanced to sustain the survival of *B. bassiana*. Among the sample districts, East Dumoga district was the weakest district in supporting the life of *B. bassiana* while North Dumoga was an excellent district in supporting the life of this fungus.

The diversity index was highly dependent on

![Figure 1. Population Fluctuations of Hemiptera (Alydidae) (Left) and Coleoptera (Coccinellidae) (Right), the dominant catch with a sweep net.](image)

| Location (District) | Host Species (Infected Insects) | Means  |
|---------------------|---------------------------------|--------|
| Central Dumoga      | *Nilaparvata lugens*            | 1.93   |
|                     | *Scotinophara coarctata*        | 1.47   |
|                     | *Leptocorisa oratorius*         | 0.93   |
|                     | *Nezara viridula*               | 0.20   |
|                     | *Paraeucosmetus pallicornis*    | 1.17   |
| Total               |                                  | 5.70   |
| North Dumoga        | *Nilaparvata lugens*            | 1.40   |
|                     | *Scotinophara coarctata*        | 0.80   |
|                     | *Leptocorisa oratorius*         | 1.10   |
|                     | *Nezara viridula*               | 0.17   |
|                     | *Paraeucosmetus pallicornis*    | 0.87   |
| Total               |                                  | 4.33   |
| East Dumoga         | *Nilaparvata lugens*            | 1.07   |
|                     | *Scotinophara coarctata*        | 0.53   |
|                     | *Leptocorisa oratorius*         | 0.40   |
|                     | *Nezara viridula*               | 0.07   |
|                     | *Paraeucosmetus pallicornis*    | 0.40   |
| Total               |                                  | 2.47   |
the evenness of the number of individuals between species rather than on richness per species. So the high or low value of the diversity index depends on the evenness between species (Solle, et al., 2017). This indicated that the difference in the number of fungal infections between hosts in the District of North Dumoga was not large because it had the highest diversity index, which was proportionally inversed to the District of East Dumoga. The low diversity index value indicated the difference in the number of infections between hosts was very large when compared to the other two districts.

**Abundance Index of Host B. bassiana**

The results showed that B. bassiana was abundant in N. lugens host in all district with the following values; Central Dumoga District 34%, North Dumoga District 32%, and East Dumoga 43% (Table 2).

The high abundance of B. bassiana in N. lugens showed that these hosts were most often attacked by B. bassiana. This could possibly be caused by the population size of the pest (N. lugens) being quite high. According to Mardiana (2018) and Chandra (2019) population size can affect the spread of pathogens. In this case the greater the size of the N. lugens population, the more individuals in this population were infected by B. bassiana. The phenomena was found on N. viridula, the abundance of B. bassiana in these insects were very low, ranging from 3 - 4%. This showed that the population N. viridula was very low in rice plants in the three districts.

The Abundance Index obtained explains the high and low values of the diversity index. As mentioned earlier that the difference in the number of individuals between species can affect the value of the diversity index obtained. The difference in the number of species between infected species in North Dumoga was low. The difference in the value of the abundance index between N. lugens (32%) and L. oratorius (25%) was 7%. The difference in value of abundance index between N. lugens (32%) and S. coarctata (18%) was14% and the difference in value of abundance index N. lugens (32%) with N. viridula (4%) was 28%, these were what causing the high value of diversity in the North Dumoga District. The opposite result was found in East Dumoga District where the difference between the abundance index values of N. lugens (43%) and S. coarctata (22%) was 21%. The difference in the value of abundance index of N. lugens (43%) with L. oratorius and P. pallicornis (16%) was 27%, while the difference in the value of abundance index of N. lugens (43%) with N. viridula (3%) was 40%. The difference in the index of abundance among different species of hosts was very large in East Dumoga, this caused the value of the diversity index in this area to be the lowest compared to the other two districts.

**Density Index of B. bassiana Based on Its Host**

Density Index in all district showed that N. lugens insects had the highest density per m². Successively from the District of Central Dumoga, North Dumoga, and East Dumoga, the values were as follows; 1.93 ind/m², 1.40 ind/m², 1.07 ind/m² (Table 3).

The Density Index describes the population size in an area that is affected by the habitat area and the number of similar individuals found in the area (Suin, 2003). Based on the data obtained showed that the largest population size was in Central Dumoga where the largest population was found in the population of N. lugens followed by S. coarctata, P. pallicornis, L. oratorius and N. viridula. In North Dumoga the largest population was found in N. lugens followed by L. oratorius, P. pallicornis, S. coarctata, and N. viridula. In East Dumoga the largest population was N. lugens followed

| Location (District) | Abundance Index (%) |
|---------------------|---------------------|
|                     | N. lugens | S. coarctata | L. oratorius | N. viridula | P. pallicornis |
| Central Dumoga      | 34        | 26           | 16           | 4           | 20           |
| North Dumoga        | 32        | 18           | 25           | 4           | 20           |
| East Dumoga         | 43        | 22           | 16           | 3           | 16           |
by *S. coarctata*, *L. oratorius* and the smallest were *P. pallicornis* and *N. viridula* which had the same population size. The intended population size refers to the size of the population affected by *B. bassiana* attacks. Therefore, the population of *N. lugens* was the population of pests experiencing the greatest impact of attacks by *B. bassiana* so that *B. bassiana* isolates from Bolang Mongondow Regency had good effectiveness in controlling the population of *N. lugens*.

The *N. lugens* density index was always the highest and the *N. viridula* was always the lowest in the three district while the other three hosts (*S. coarctata*, *L. oratorius* and *P. pallicornis*) had density index that always varied in each district. This was an indication that there was a difference in virulence at each host and at each location against *S. coarctata*, *L. oratorius* and *P. pallicornis*.

**CONCLUSION**

There were five species of insects found as the hosts of *B. bassiana* with varied diversity index values in each district, namely Central Dumoga 1.45, North Dumoga 1.47, and East Dumoga 1.38. The highest abundance index was found in *N. lugens* host in all districts with the value of Central Dumoga 34%, North Dumoga 32%, and East Dumoga 43%. The highest density index was found in *N. lugens* hosts in all district with a value of 1.93 individuals /m² in Central Dumoga, 1.40 individuals /m² in North Dumoga, and 1.07 individuals /m² in East Dumoga. There were indications of differences in *B. bassiana* virulence by host species and locations that attack *S. coarctata*, *L. oratorius* and *P. pallicornis* insects.

**ACKNOWLEDGMENT**

Thank you to Jusak Wongkar and Susan Wowiling for providing laboratory facilities at the Biological Agency Laboratory, Center for Food Crops and Horticulture Protection, North Sulawesi Agriculture and Animal Husbandry Office. Thanks also to Rivaldo Sahilatua, Marton Puasa, Reynaldo Karuh, Jayens Alotia, and Era Monalisa for helping in collecting and identifying the samples.

**REFERENCES**

Alikodra, H.S. 2002. Pengelolaan Satwa Liar. Jilid I. Fakultas Kehutanan IPB, Bogor.

Anggarawati, S.H., T. Santoso, and R. Anwar. 2017. Penggunaan cendawan entomopatogen *Beauveria Bassiana* (Balsamo) vuillemin
Dan Lecanicillium Lecanii (Zimm) zare & games untuk mengendalikan Helopeltis Antonii sign (Hemiptera: Miridae). Jurnal Silvikultur Tropika, 8(3):197-202.

Ardiyati, A.T., G. Mudjiono, and T. Himawan. 2015. Uji patogenisitas jamur entomopatogen Beaveraia bassiana (Balsamo) vuillemen pada jangkrik (Gryllus sp.) (Orthoptera: Gryllidae). Jurnal HPT. 3(3):43–51.

Bhadauria, B.P., P.K. Singh, P. Shailesh, N.W. Zaidi, and U.S. Singh. 2013. Characterization and biocontrol potential of entomopathogenic fungus, Beaveraia bassiana isolates against Spilarctia obliqua. J. Environ. Biol. 34(4):17-21.

CABI. 2016. Nezara viridula (Green Stink Bug). https://www.cabi.org/isc/datasheet/36282. Diakses pada tanggal 08 Juli 2020.

Chandra, E. 2019. Pengaruh faktor iklim, kepadatan penduduk dan angka bebas jentik (ABJ) terhadap kejadian demam berdarah dengue (DBD) di Kota Jambi. Jurnal Pembangunan Berkelanjutan. 1(1): 1-15. DOI: 0.22437/jpb.v2i11.5101.

Effendy, T.A., R. Septiadi, A. Salim, and A. Mazid. 2010. Jamur entomopatogen asal tanah lebak di sumatera selatan dan potensinya sebagai agensia hayati walang sangit (Hemiptera: Miridae). Jurnal HPT. 19(4):419-423. DOI: 10.21082/jhort.v19n4.2009.p%25p

Huang, Z., G. Yu, Z. Zhang, and R. Zhang. 2019. Phylogenetic relationships and effectiveness of four Beaveraia bassiana sensu lato strains for control of Haemaphysalis longicorns (Acari: Ixodidae). Exp. Appl. Acarol. 77(1): 83-92. DOI: 10.1007/s10493-018-0329-9.

Jones, W. A. 1988. World review of the parasitoids of the southern green stink bug Nezara viridula (L). (Heteroptera : Pentatomidea). Ann. Entomol. Soc. Am. 81: 262-273. DOI:10.1093/aeosa/81.2.262.

Kanakan, R., J.E.X. Rogi, and P.C.H. Supit. 2017. Jenis ikan potensi produksi sari sawah (Oryza sativa L.) di kawasan damuwa kabupaten Bolaang Mongondow dengan menggunakan model simulasi tanaman. Cocos, 1(3):1-15.

Kartohardjono, A., D. Kertoseputro, and T. Suryana. 2009. http://bbpadi.litbang.pertanian.go.id/index.php/publikasi/artikel-ilmiah/hama-padi-potensial-dan-pengendaliannya-2009. Diakses pada tanggal 08 Juli 2020.

Kila, A.H., C.L. Salaki, and E. R. M. Meray. 2016. Serangan dan populasi Scotinophara sp. pada tanaman padi sawah di Kabupaten Bolaang Mongondow Timur. Eugenia, 22 (3):108-115. DOI:10.35791/eug.22.3.2016.14105.

Kulu, I.P., A.L. Abadi, A. Afandhi and Nooraidawati. 2015. Morphological and molecular identification of Beaveraia bassiana as entomopathogen agent from Central Kalimantan Peatland, Indonesia. International Journal of ChemTech Research, 8(4): 2079-2084.

Li, M., S. Li, A. Xu, H. Lin, D. Chen, and H. Wang. 2014. Selection of Beaveraia isolates pathogenic to adults of Nilaparvata lugens. J. of Insect Sci. 14(32):1-12. DOI:10.1093/jias/14.1.32.

Mandei, J. R., T. Katiandagho, C. R. Ngangi, J. N. and Iskandar. 2011. Penentuan harg pokok beras di Kecamatan Kotamobagu Timur Kota Kotamobagu. Agri-Sosioekonomi, 7(2): 15-21. DOI:10.35791/agrososek.7.2.2011.87.

Mardiana, D. E. 2018. Pengaruh imunisasi dan kepadatan penduduk terhadap prevalensi penyakit difteri di Jawa Timur. Jurnal Berkala Epidemiologi, 6(2):122-129. DOI:10.20473/jbe.v6i22018.122-129.

Mwamburi, L.A., M.D., Laing, R.M. and Miller. 2015. Effect of surfactants and temperature on germination and vegetative growth of Beaveraia bassiana. Brazilian Journal of Microbiology, 46(1):67-74.DOI:10.1590/S1517-838246120131077.

Nuraida, and A. Hasyim. 2009. Isolasi, identifikasi, dan karakterisasi jamur entomopatogen dari rizosfir pertanaman padi. Jurnal Bioteknologi, 4(2):115-120. DOI:10.20473/jbb.v4i2.35.

Nuraida, and A. Hasyim. 2009. Isolasi, identifikasi, dan karakterisasi jamur entomopatogen dari rizosfir pertanaman padi. Jurnal Bioteknologi, 4(2):115-120. DOI:10.20473/jbb.v4i2.35.

Nuwendjaja, I., A. Giri, F. Prawira, and S. Putra. 2010. Hama Wereng Coklat (Nilaparvata lugens Stal.) dan Pengendaliannya. Balai Pengkajian Teknologi Pertanian. Jawa Barat.

Priyanto, T. P., I. M. Samudra, I. Manzila, D. N. Susilowati, and Y. Suryadi. 2016. Eksporasi dan karakterisasi entomopatogen asal berbagai inang dan lokasi. Berita
Biologi, 15(1):69-79. DOI:10.14203/beritabiologi.v15i1.2859.

Rizal, M., T. E. Wahyono, and C. Sukmana. 2017. Keefektifan Beauveria bassiana dan pupuk organik cair terhadap Nilaparvata lugens. Bul. Littro. 28(1):97-104.

Rosmini and S. A. Lasmini. 2010. Identifikasi cendawan entomopatogen lokal dan tingkat patogenitasnya terhadap hama wereng hijau (Nephotettix virescens Distant.) vektor virus tungro pada tanaman padi sawah di Kabupaten Donggala. J. Agroland. 17(3): 205-212.

Sembel. 2014. Serangga-serangga Hama Tanaman Pangan, Umbi, dan Sayuran. Bayumedia Publishing, Malang.

Sepe, M. and C. Demayo. 2017. Quantitative Description of the Hindwings of the Different Populations of the Rice Black Bug (Scotinophara coarctata) using Landmark-based Geometric Morphometric. Journal of Informatics and Mathematical sciences 9(4): 1053 – 1060. doi: 10.26713/jims.v9i4.1003.

Solle, H., F. Klau, and S. T. Nuhamara. 2017. Keanekaragaman jamur di cagar alam gunung mutis Kabupaten Timor Tengah Utara, Nusa Tenggara Timur . Biota Vol. 2 (3): 105-11. DOI:10.24002/biota.v3i2.1886.

Stilling, P. 2012. Ecology: Global Insights and Investigations. McGraw-Hill, New York.

Suin, N. M. 2003. Ekologi Populasi . Universitas Andalas, Padang.

Trizelia, N. Armon, H. Jailani. 2015. Keanekaragaman cendawan entomopatogen pada rizosfer berbagai tanaman sayuran. Pros. Sem. Nas. Masy. Biodiv. Indon. 1(5): 998–1004. DOI: 10.13057/psnmbi/m010307.

Valero-Jiménez, C. A., A. J. M. Debets, J A. L. van Kan, S. E. Schoustra, W. Takken, B. J. Zwaan, and C. J. M. Koenraadt. 2014. Natural variation in virulence of the entomopathogenic fungus Beauveria bassiana against malaria mosquitoes . Malaria Journal, 13(1):479-187. DOI:10.1186/1475-2875-13-479.

Valero-Jiménez, C. A., L. Faino, D. S. in’t Veld, S. Smit, B. J. Zwaan, and J. A. L. van Kan. 2016. Comparative genomics of Beauveria bassiana : uncovering signatures of virulence against mosquitoes. BMC genomics, 17:986-997. DOI: 10.1186/s12864-016-3339-1.