



INFECTION ABILITY OF THE ENTOMOPATHOGENIC FUNGUS *CORDYCEPS MILITARIS* ON LARVAE AND PUPAE OF NETTLE CATERPILLAR *Setothosea asigna* (Lepidoptera: Limacodidae)

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ABSTRACT

Combination between organochlorine and clean weeding is suggested for continuously nettle caterpillar outbreak in oil palm plantation. Insecticides lead to natural enemies died, clean weeding caused food shortages and lack of refuge areas for these natural enemies. *Cordyceps militaris* is one of fungus biological controls agent to *Setothosea asigna*. This fungus is possible to produce in large quantities on maize. *C. militaris* is typically sprinkled or sprayed onto palm circle as pupae targeted. Several studies have shown that *C. militaris* can also infect larval stages of *S. asigna* in the laboratory. This study aim is to confirm that *C. militaris* in maize media, at optimal dose 15 g/100 ml (based on previous study) could induce infection on both *S. asigna* larval and pupal stages. Four days after application ('daa'), 100% mortality was observed in *S. asigna* larvae. Dead larvae were characterized by brown coloration, larval excretion, intact but fragile larvae, and mycelial growth on their cuticula surface. Infected pupae are not visible externally because they are protected by cocoons. After 16 'daa' there were difference between infected and control pupae. Infected pupae were still in the final larval stage, covered in mycelium, and died. Control pupae had developed into adults with buds of wings, head, and body. *C. militaris* on maize and PDA medium was white or lacked pigment. *C. militaris* derived from infected larvae and pupae were able to grow and produce blackish conidia on PDA. *C. militaris* conidia from larvae had already formed in large quantity after 6 days on PDA, while the pupae were only in the early stages of conidia formation. *C. militaris* derived from maize formed only mycelium without conidia for these 6 days. This study concluded that *C. militaris* could infect both larval and pupal stages of *S. asigna*.

Keywords: fungus, *Cordyceps*, entomopathogen, pupae, nettle caterpillar

INTRODUCTION

Setothosea asigna (Lepidoptera: Limacodidae) is one of nettle caterpillar (NC) species that often causes severe problem to oil palm plantations in North Sumatra. *S. assign* severity levels vary from low to very high. Arsi *et al.* (2022) reported pest severity of *S. asigna* in Buay Rawan District, South Oku in range of 5.77%-13.00%. But, pest severity of NC could be so high that plants defoliate 94% of their leaves, and there is equal to 40% decrease in per hectare production. *S. asigna* consume oil palm leaf voraciously both in immature and mature oil palm plants (Ginting *et al.*, 2015). Diratika *et al.* (2020) stated that NC attacks usually occur during in transition from dry season to the rainy season. According to Wood and Kamrudin (2019), NC outbreak began in late 1950s to early 1960s. The cause of this pest outbreak was the use of organochlorine insecticides

which kill natural enemies of insects more effectively than killing these pests themselves. NC outbreaks decrease when insecticide use is stopped, but NC outbreaks will reappear. Clean weeding (CW) cultivation techniques were also an additional factor in the frequent occurrence of NC outbreaks. CW causes the loss of shelter, refugia, and nectar as food for natural enemies of the NC. The use of synthetic chemicals for pest control can also have negative impacts to environment and human health (Saranya and John 2021).

One alternative for controlling the *S. asigna* is the use of *Cordyceps militaris* entomopathogenic fungus as biological agent (Saranya and John 2021). *Cordyceps* sp. known as caterpillar fungus which infected to insects and other arthropods. Insect orders frequently infected by *Cordyceps* sp. are Lepidoptera, Coleoptera, Hymenoptera, Orthoptera, Diptera, Blatodea, Mantodea, Odonata, and Hemiptera (Rani *et al.*, 2025). However, the main host of *Cordyceps* sp. are Lepidoptera and Coleoptera orders. Ramadani *et al.*, (2016) reported that *Oryctes rhinoceros* (Coleoptera: Scarabaeidae) larvae could be infected by the fungus *Cordyceps* sp. that grown on rice bran media. On 21 days after application, the fungal mycelium had already covered of the *O. rhinoceros* larvae. Singh *et al.* (2024) reported that there are more than 750 *Cordyceps* species found in North America, Europe, and Asia. Rani *et al.* (2025) also confirmed that the distribution area of *Cordyceps* sp. fungi includes India, the highlands of China, Japan, Germany, the USA, Mexico, Canada, Denmark, and Italy.

The *C. militaris* fungus belongs to Ascomycota phylum, Cordycipitaceae family, which has sexual and asexual reproductive phases (Johri *et al.*, 2022). The development of sexual phase of the *C. militaris* fungus occurs in insect host which will produce sexual spores or ascospores. The asexual phase of *C. militaris* can occur in organic materials which will produce conidia spores. The asexual phase of *Cordyceps* sp. can grow on artificial media such as PDA (potato dextrose agar) (Mugiarto *et al.*, 2021); SDAY (sabouraud dextrose agar plus yeast extract) (Shrestha *et al.*, 2005); liquid media containing nutrients such as ammonium sulphate, magnesium sulphate, potassium phosphate, peptone and yeast (Rozsa *et al.*, 2020); rice bran (Ramadani *et al.*, 2016); corn, rice bran, and rice (Ginting *et al.*, 2015; Ginting *et al.*, 2026). Both ascospores and conidia can cause infection to insect hosts (Saranya and John, 2021). The ability of *C. militaris* to be cultivated in inexpensive artificial media such as corn, rice bran, and rice polish allows the fungus to be mass-produced by farmers or planters for biological control (personal communication).

Biological pest control methods are methods of manipulating pathogens to cause negative impacts on pest's target (Aprianda *et al.*, 2021). The aims of using *C. militaris* fungi as biological control agent are to cut off the *S. asigna* metamorphosis cycle so that the following season population of this pest will decrease below the damage threshold (Ginting *et al.*, 2015). In oil palm plantations, *C. militaris* is usually found naturally in pupal stage of nettle caterpillars with an infection rate of 7.25 – 11% (Wibowo *et al.*, 2022). Mugiarto *et al.* (2021) reported the application of *C. militaris* augmented in corn, mixed with soil, and then spread on oil palm weeded circle to control *S. asigna* pupae. These applications prevented *S. asigna* outbreaks within 398 hectares of oil palm plantations in

2020. Wibowo *et al.*, (2022) reported that the application of *C. militaris* propagated in corn with concentrations of 10 g/liter and 20 g/liter was able to cause 95-100% mortality of *S. asigna* larvae in the laboratory. Ginting *et al.*, (2015) tried various concentrations of corn propagated media; Ginting *et al.*, (2026) tried various augmenting media for *C. militaris* targeting to *S. asigna* larvae. Both experiments were able to cause up to 100% mortality in larval stages of *S. asigna*. The application of the *C. militaris* fungus was also carried out by the Tinjowan plantation in North Sumatera by spraying the fungus solution on oil palm weeded circle to control pupal stage of NC (personal communication). This study aim is to reconfirm the infection ability of *C. militaris* on pupae and larvae of *S. asigna*, with an optimal dose 15 g/100 ml of *C. militaris* in corn propagated media. The dose of fungus solution is according to previous research by Ginting *et al.*, (2015).

MATERIALS AND METHODS

The study was conducted from January to June 2026. Samples of larvae and pupae of *S. asigna*, fungal culture of *C. militaris* propagated in corn media were obtained from Tinjowan plantation, PT Perkebunan Nusantara IV Regional II, Ujung Padang District, Simalungun Regency, North Sumatera Province. The infection process of larvae and pupae with *C. militaris* culture was carried out in the laboratory of the Faculty of Agriculture, Prima Indonesia University (UNPRI), Jalan Danau Singkarak, Gang Madrasah, Medan, North Sumatera. Microscopic observation of *C. militaris* was carried out in the UNPRI Integrated Laboratory, Jalan Sampul no. 3 Medan City, North Sumatera.

The tools used this this study were blender, sieve, electric scale, sprayer, spray bottle, plastic box size (31x22x13) cm and (21x13x8) cm, petri dish, laminar air flow, bunsen, light microscope. The materials used were *C. militaris* fungus propagated in corn media, alcohol, cling wrap, PDA (potato dextrose agar), methylene blue dye, final instar of larval and pupal of *S. asigna*.

The *C. militaris* fungus was cultivated in corn media by the Tinjowan Plantation. NC infected cocoons by *C. militaris* were collected from oil palm plantations and then washed thoroughly. Ten cocoons were opened, removing its shell, and collected the mummified white pupae. The mummified pupae and 100 ml water were ground in a blender. The water was then filtered and placed in a spray bottle. One kg of cracked corn was washed thoroughly 4-5 times and steamed for 15 minutes. The steamed corn was stirred every 5 minutes. After it was semi-soft, the corn was removed from kitchen stove and cooled. The cooled corn was placed in a (31x22x13) cm plastic box and sprayed with *C. militaris* liquid from the mummified pupae. The plastic box was tightly sealed with transparent tape and stored for 21 days. The corn culture was ready for use once the white mycelium had grown. All work was carried out in a semi-sterile process to prevent contamination.

The study used a Completely Randomized Design (CRD) with two treatments, application *C. militaris* to larval dan to pupal of *S. asigna*. The *C. militaris* solution containing 15 g of propagated fungus in corn media with 100 ml of water (15g/100 ml), which was sprayed on *S. asigna* larvae and pupae. The concentration 15 g/100 ml of the

C. militaris solution was based on previous research by Ginting *et al.*, 2015. Each treatment was repeated six times and placed randomly. The observed variable was the number of larval and pupal mortality. Observations on larvae were carried out at 4th 'daa', while pupae observed at 16th 'daa'. The effect of fungal infection on larvae and pupae was measured qualitatively through morphological and microscopic observations. Mortality number of larvae and pupae measured quantitatively using t-tests compared between control and treatment. However, due to human error, quantitative testing on pupae was eliminated so that the focus observation was only on morphological and microscopic. The t-test value was obtained by entering the control and treatment mortality data into the formula in the Window Excel 2019 program.

The infection process of *S. asigna* larvae and pupae using *C. militaris* fungal culture is as following description. Each replication contains 10 last instar larvae (instar 8-9) of the same size and 10 healthy pupae. The control and treatment boxes with size (21x13x8) cm have ventilation hole in the lid. The inside of the larval boxes is given oil palm leaves as food, while the inside of the pupae boxes is given soil from oil palm weed circle.

One box for each replication was treated with 15 g of *C. militaris* in corn culture and 100 ml of water, while one control box was sprayed with water. The *C. militaris* culture and water were blended until evenly mixed, filtered, and then poured into a hand sprayer. The *C. militaris* solution was then sprayed evenly on the larvae and pupae. The *C. militaris* culture and control were only applied once both in larvae and pupae of *S. asigna*.

RESULTS AND DISCUSSION

Propagation of *C. militaris* on artificial media

The propagation of *C. militaris* fungus on corn media was white after 21 days of incubation (Figure 1). In this study, the culture solution can cause infection and death in both *S. asigna* larvae and pupae. The volume of corn culture media is not too much but is still able to cause death in the larvae and pupae. *C. militaris* isolated from corn media and then grown on PDA also produced white cultures. At 16 days after being grown on PDA, the *C. militaris* isolates from larvae and pupae were blackish in colour. Meanwhile, the *C. militaris* culture from corn remained white (Figure 2).



Figure 1 Corn media for propagating *Cordyceps militaris* fungus at 21 days, white in colour, and ready to be used for biological control of *Setothosea asigna* (Lepidoptera: Limacodidae).

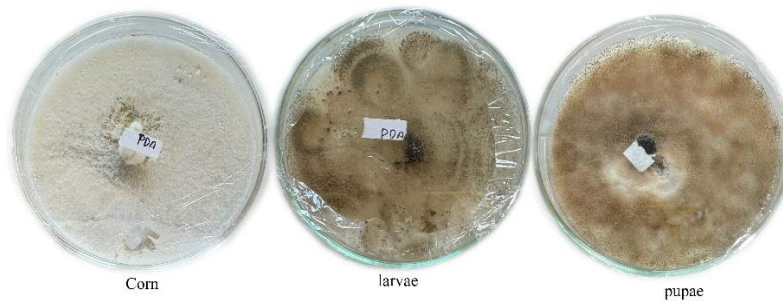


Figure 2 *C. militaris* at 16th days after being grown on PDA (potato dextrose agar), the fungus from the corn media was white, while the culture from infected larval and pupal tissue was blackish.

Ginting et al. (2026) stated that *C. militaris* propagation in bran, rice, and corn media produced yellow and white mycelium and conidia. Both conidia colours were infective to *S. asigna*. There was a tendency that corn media had highest conidial density. Higher conidial density correlated to faster infection rates.

C. militaris is a fungus in the phylum Ascomycota that reproduced both sexually and asexually. The fruiting body of *C. militaris*, which emerges from the host insect, is essentially a stromal network containing perithecia. Within these perithecia, ascus sheaths were formed, each containing eight sexual spores or ascospores (Sung et al., 2007, Johri et al., 2022). *C. militaris* also produces asexual spores or conidia. Ascospores and conidia that fall onto organic substrates such as corn, bran, and rice (Ginting et al., 2026) can grow into mycelium to produce subsequent conidia, or fungi in the asexual reproductive cycle (Johri et al., 2022).

The ability of *C. militaris* from corn propagation media to infect *S. asigna* larvae

Solution of *C. militaris* from corn media successfully infected the last instar of the *S. asigna* larvae (instar 8-9). The ability of *C. militaris* infection is proven by the occurrence of larval death, in other words, conidia or asexual spores of *C. militaris* can infect its host insect. The dead infected larvae can be grown on PDA and are able to produce conidia. A total of six replicate boxes with a total number 60 larvae, respectively, the number of larvae that died on 1-4 days after application: 38.33%; 66.67%; 96.67%; and 100% (Figure 3). The t-test value for the comparison between control and treatment is p value = 0.025031. P-value <0.05; the mortality results are significantly different between control and treatment larvae.

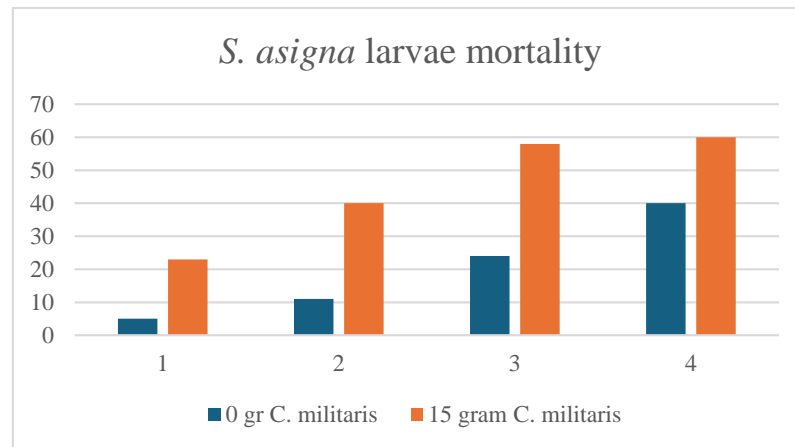


Figure 3 Mortality rate of *Setothosea asigna* (Lepidoptera: Limacodidae) larvae after application of *Cordyceps militaris* in corn propagation media was able to cause 100% larval mortality on 4th day.

Dead treated larvae were characterized by a brown colour, exuded bodily fluids, and wrinkled integuments. Some larvae were also in brown colour but had no exuded contents. Two days later, mycelium was found growing on the surface of these intact larvae (Figure 4). Control larvae sprayed with water also died, but this was due to stress and lack of fresh feeding. On the first day of application, dead treated larvae were brown, while control larvae were alive and remained green.



Figure 4 *S. asigna* larvae died due to the application of *C. militaris* fungus propagated in corn media, one of morphological characteristics was brown body colour, without bodily fluids coming out and covered with mycelium (white arrow).

The ability of *C. militaris* from corn propagation media to infect *S. asigna* pupae

The *C. militaris* from corn propagation media was able to cause infection in *S. asigna* pupae. The pupae are protected by a cocoon, so at 4 days after fungus application, the difference surface between healthy and infected cocoon was unknown. The cocoon was split on the 16th day after infection, and the difference between infected and healthy pupae was visible. This study found that conidia or asexual spores of *C. militaris* can infect *S. asigna* pupae. Pupae infected with a 15 g/100 ml *C. militaris* solution, as many as 91.67% were remain in larvae last instar already inside in cocoon (prepupa phase). These infected last instar larvae failed to transform into pupae, which are characterized

by the visible form of winged imago candidates. 98.33% of the treated pupae had mycelium growing on their bodies (Figure 5). Only one (1.6% of the treated pupae) had no visible mycelium on their body surface (Table 1).

Prepupal larvae inside control cocoons were able to transform into pupae with winged bud at 16 days post-application (Figure 6). 100% of these pupae were not covered by mycelium (Table 1). Based on these data, it is suspected that the pupae were not infected by the *C. militaris* because they were only sprayed with 100 ml of water. Healthy pupae have a 40-days cycle (Simbolon *et al.*, 2020). In this study, human error occurred, resulting in the pupae dying at only 16 days old. Although the pupae were dead, there were no visible signs of *C. militaris* infection.



Figure 5 The cocoon has just formed and contains prepupal larvae. Infection with 15g/100ml of *Cordyceps militaris* solution causes unsuccessful transformation prepupal larvae into pupae and their bodies become covered with mycelium.

Table 1 Morphological formation of pupae infected with *C. militaris* 15 g/100 ml solution

Character	Treatment (%)	Control (%)
Larval form with setae is visible	91,67	0
A combination of the larval form and the winged buds is visible.	3,33	0
The winged bud form is visible	5	100
mycelium	98,33	0

In oil palm plantations, this pupal phase is naturally seen to be infected with *C. militaris*, which is characterized by protruded bright orange fruiting bodies from the cocoons (Wibowo *et al.*, 2022). These fruiting body will produce sexual spores or ascospores. These ascospores then cause new infections in the prepupa larvae which drop from the oil palm leaves (Johri *et al.*, 2022). Wibowo *et al.* (2022) reported natural infection of *C. militaris* in *S. asigna* pupae in four palm oil companies in Bandar Lampung, with infection rates ranging from 7.25 to 11%.



Figure 6 Control pupae sprayed with 100 ml of water were able to transform from prepupa larvae into pupae with the formation of winged bud. The pupae did not show any mycelium growing on their bodies.

Growth of infected larvae, pupae and corn propagation media in PDA

On the 6th 'daa' of the *C. militaris* solution, samples of larvae, pupae, and corn media were tested for infection success by growing them on PDA (potato dextrose agar). Differences in the growth rate of *C. militaris* mycelium and conidia formation were found. *S. asigna* larval tissue grew the fastest in PDA, and the conidia were produced within 6 days (Figure 7). Infected pupae tissue was second in growth rate in PDA. Spores from treated pupae were produced after 12 days in a petri dish containing PDA. Corn media contain *C. militaris* propagation was last in growth rate on PDA and spore production.

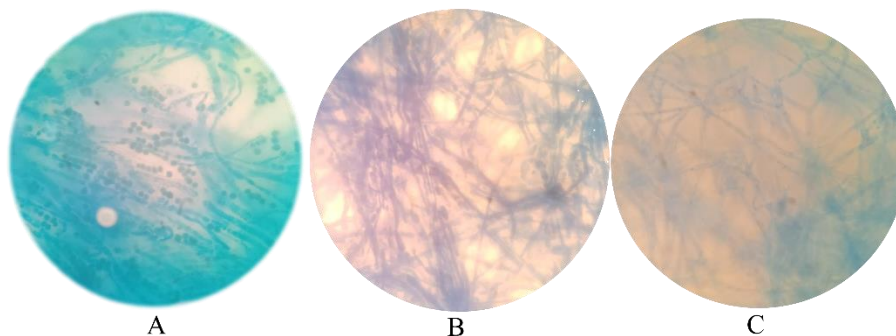


Figure 7 (A) Conidia from a sample of infected larvae by *C. militaris* on PDA (potato dextrose agar), (B) mycelium and a few conidia from a sample of infected pupae, (C) mycelium formation without conidia on PDA from corn propagation media. On the 6th day after application, the infected larval sample produced conidia the fastest (A) compared to samples from pupae (B) and corn media (C).

The difference time takes for conidia formation in PDA from infected larval and pupal tissue is thought to be related to the difference of their time of death. Larvae are not covered by a cocoon, allowing *C. militaris* conidia quickly enter to their bodies, leading infection and death. *S. asigna* pupae are covered by a cocoon, requiring time for *C. militaris* conidia to reach the tissue to cause infection and death. When a small amount of treated larval tissue was taken and grown on PDA, the concentration of *C. militaris* fungus was high, allowing rapid mycelium growth and conidia production. When a small amount of pupal tissue was taken on PDA, the concentration was lower, requiring longer

time for mycelium propagation and conidia formation. Corn is not a natural host for the entomopathogenic fungus *C. militaris* (Syarif *et al.* 2023). In this study, although the fungus could grow into mycelium, it took longer for conidia to be produced. Syarif *et al.* (2023) also stated that continuous subculturing of entomopathogenic fungi in artificial laboratory media will reduce their virulence. Virulence will increase again if the entomopathogenic fungi in the artificial media are reinfected into their host insects.

Control suggestions using *C. militaris*

Entomopathogenic fungi such as *C. militaris*, or other well-known entomopathogenic fungi such as *Beauveria bassiana* and *Metarhizium anisopliae* (Gunawan *et al.*, 2024), have the advantage of being able to grow in artificial media. This ability allows entomopathogenic fungi to be propagated independently as needed. The *C. militaris* propagation method used by the Tinjowan plantation is a semi-aseptic process. These advanced equipment such as laminar air flow (LAF) is not used. 70% alcohol must be frequently sprayed on the workbench or hands.

Efforts to control the *S. asigna* using *C. militaris* are carried out while the insect is in the pupal metamorphosis stage (Mugiarto *et al.*, 2021). This control is intended to interrupt the *S. asigna* metamorphosis cycle. *S. asigna* larvae have consumed significant amounts of oil palm leaves, from first to the eighth or ninth instar (Simbolon *et al.*, 2020). This study found that *S. asigna* larvae can die from the application of *C. militaris*. Control of *S. asigna* using *C. militaris* artificial propagation is recommended for both the larval and pupal phases.

CONCLUSION

Cordyceps militaris at a dose of 15 g/100 ml can cause infection and death in the larvae and pupae of nettle caterpillar *Setothosea asigna*.

ACKNOWLEDGMENT

Thanks are given to the Tinjowan plantation unit, PT Perkebunan Nusantara IV Regional II, Simalungun, North Sumatra for the samples of *Cordyceps militaris* in corn propagation media, the larvae and pupae of nettle caterpillar *Setothosea asigna*. Thanks, are also given to Haidar Ramdhani for his suggestions on presenting the research data.

REFERENCES

- Arsi A, Tama AD, Umayah A, Gunawan B. 2022. Population and intensity of *Setothosea asigna* pest attacks on oil palms (*Elaeis guineensis* Jacq) in Gunung Cahya village, Buay Rawan Subdistrict, Oku Selatan regency. *Jurnal Planta Simbiosa*, 4(2): 41-53. DOI 10.25181/jplantasimbiosa.v4i2.2675
- Diratika M, Yaherwandi, Efendi S. 2020. The abundance of predatory bugs (Hemiptera: Reduviidae) of nettle caterpillar on smallholder of oil palm plantations. *Jurnal Penelitian Pertanian Terapan*, 26(1):1-10. DOI:10.25181/jppt.v20i1.1471

- Ginting J, Kuswandari RA, Pradana MG. 2026. Effectiveness of *Cordyceps militaris* fungi on various media against nettle caterpillar (*Setothosea asigna* L). *Jurnal Ilmiah Pertanian*, 8(1):69-80. DOI: 10.312891/jiperta.v8i1-6602
- Ginting LA, Oemry S, Lubis L. 2015. Fungal pathogenicity test of *Cordyceps militaris* L. against nettle caterpillar (*Setothosea asigna* E.) (Lepidoptera: Limacodidae) in the green house. *Jurnal Online Agroekoteknologi*, 3(2):785-789. DOI: 10.32734/jaet.v3i2.10367
- Gunawan JF, Rahayuwati S, Pratomo B, Afrianti, S. (2024). The effect of entomopathogenic fungus formulation *Metharizium anisopliae* (Metchnikoff) Sorokin dan *Beauveria bassiana* (Bals.-Criv.) Vuill on the growth and resistance to pests and diseases of oil palm seedlings (pre nursery). *Agroprimatech*, 8(2): 31-48. DOI: 10.34012/agroprimatech.v8i2.5409
- Mugiarto F, Irvanto D, Ardiyanto A, Edyson, Rahmadi. 2021. Utilization of the entomopathogenic fungus *Cordyceps militaris* for controlling nettle caterpillar pests (Limacodidae: Lepidoptera) in oil palm plantations of PT. Bumitama Gunajaya Agro. Proceedings of the National Seminar and Congress of the Indonesian Entomological Association, Bandung Branch, Jatinangor, January 14, 2021.
- Ramadani F, Salbiah D, Sutikno A. 2016. Test of several doses of local entomopathogenic fungi *Cordyceps* sp. on rice bran media against *Oryctes rhinoceros* L, larvae in laboratory. *Jurnal Online Mahasiswa Fapertal*, 3(2):1-9
- Rani T, Kumar P, Mahala SK, Ritika, Kumar G, Sharma A. 2025. The parasitic power of *Cordyceps*. *Vigyan Varta an International E Magazine for Science Enthusiast*, 6(2):197-200.
- Rozsa M, Apahidean M. 2020. Influence of temperature and pH level on mycelial growth in liquid cultures of *Cordyceps militaris* mushroom mycelium. *Current Trends in Natural Sciences*, 9(18): 42-46. DOI: 10.47068/ctns.2020.v9i18.006
- Saranya S, John P. 2021. *Cordyceps militaris: an Emerging Biological Tool in Crop Protection*. Jodhpur India: Agrobios Research. P 203-214.
- Shrestha B, Han S-K, Yoon K-S, Sung J-M. 2005. Morphological characteristic of conidiogenesis in *Cordyceps militaris*. *Mycobiology*, 33(2): 69-76. DOI: 10.4489/MYCO.2005.33.2.069
- Simbolon AMJ, Irni J, Pratomo B. 2020. Feeding preference of nettle caterpillar (*Setothosea asigna*) larvae towards oil palm (*Elaeis guineensis* Jacq.) leaves. *Agrium*, 23(1):1-7. DOI 10.30596/agrium.v21i3.2456
- Singh A, Mishra S, Kumar S. 2024. *Caterpillar fungus: a wild medicinal mushroom of India. Edible and Medicinal Mushrooms of India* vol 1 (ed 1). APRF: New Delhi. DOI: 10.5281/zenodo.10911498. p 55-63
- Shrishri J, Nair YV, Slevapandiyan A. 2022. Cultivation and medical uses of *Cordyceps militaris* (L) Link: a revolutionary entomopathogenic fungus. In *Biologi, Cultivation*,

and Applications of Mushrooms. Singapore: Springer. DOI: 10.1007/978-981-16-6257-7.

Sung G-H, Sung J-M, Hywel-Jones NL, Spatafora JW. 2007. A multi-gene phylogeny of Clavicipitaceae (Ascomycota, fungi): identification of localized incongruence using a combinational bootstrap approach. *Molecular Phylogenetics and Evolution*, 44:1204-1223. DOI: 10.1016/j.ympev.2007.03.011

Syarif MNY, Asib N, Ahmad SN, Bakeri SA, Masri MMM, Omar D. 2023. Identification of *Cordyceps javanica* and its effectiveness in controlling bagworm *Pteroma pendula* Joannis (Lepidoptera: Psychidae). *Serangga*, 28(2):14-27.

Wibowo L, Hariri AM, Fitriana Y, Dirmawati SR. 2022. In vitro study of the potential of *Cordyceps militaris* L. fungus as a biological agent for nettle caterpillar (*Setothosea asigna* E.) at oil palm plantations. *Jurnal Agrotek Tropika*, 10(4):535-540. DOI: 10.23960/jat.v10i4.6351

Wood BJ, Kamarudin N. 2019. A review of development in integrated pest management (IPM) of bagworm (Lepidoptera: Psychidae) infestation in oil palms in Malaysia. *Journal of Oil Palm Research*, 31(4):529-539. DOI:10.21894/jopr.2019.0047.