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Status of *Paliga auratalis* (Lepidoptera: Crambidae) as black potato pest and its control strategy using natural enemies

Erniwati[a*], Tiara Sayusti[b], Woro Anggraitoningsih Noerdjito[a]

[a]Zoology Division, Research Center for Biology, Indonesian Institute of Science,
[b]Animal Bioscience Program, Department of Biology, IPB University

ABSTRACT

Plectranthus rotundifolius (Lamiales: Lamiaceae) is an edible tuber that is widely distributed in Asia, covering India, Sri Lanka, Malaysia, and Indonesia. *P. rotundifolius,* which is commonly called black potato in Indonesia, has the potential to be developed for national food diversification due to its high carbohydrates. However, one of the challenges in black potato cultivation is the existence of leaf-eating caterpillar. This study aimed to evaluate the status of *Paliga auratalis* (Lepidoptera: Crambidae) larva as an insect pest in black potato plant and to develop the control strategy by using parasitoid as the natural enemies. Observation and collection of *P. auratalis* and other potential insect pests were conducted in 12 black potato plantations located in five provinces of Java island. The life cycle of *P. auratalis* was observed in the laboratory of Zoology Division, Research Centre for Biology, Indonesian Institute of Science. Rearing of unhealthy *P. auratalis* larvae was also conducted to observe the parasitoid. We identified five moth larvae species that infested black potato plants: *Argyrograma* sp., *Pycnarmon cribata*, *Pleuroptya punctimarginalis*, *Rehimena diemenalis*, and *Paliga auratalis*. Our results showed that *P. auratalis* larva is the main insect pest in Java island with the serious attack status and black potato was recorded as a new host plant. *Paliga auratalis* spends its lifecycle from eggs to adulthood between 25 – 32 days with a total number of eggs of about 60-80 per female individual. We also identified two parasitic wasps as the parasitoid of *P.auratalis*: *Cryptopimpla* sp. (Hymenoptera: Ichneumonidae) and *Aspanteles* sp. (Lepidoptera: Barconidae), which can potentially be developed as biological control agents for *P. auratalis*.

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* Corresponding authors:
ernirnwt@gmail.com

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1. Introduction

Chinese potato, *Plectranthus rotundifolius* (Poir.), also known as black potato in Indonesia, is an edible tuber that is widely distributed in tropical South-East Asia and Southern Africa. Due to the taxonomic problems, *P. rotundifolius* has several synonyms: *Coleus rotundifolius* (Poir.), *Coleus dysentericus* (Bak.), *Solenostemon rotundifolius* (Poir.), and *Plectranthus tuberosus* (Blume.). In Africa, black potato tubers are used as a potato substitute and the leaves are usually used as a medicinal plant for dysentery and eye disorder treatments (Venter et al., 2000). Other species within the genus of *Plectranthus* are also used as a medicinal plant for various disease categories such as digestive disease, skin, respiratory, infections or fever, urinary system, and pain treatment (Lukhoba et al., 2006). A study on physicochemical analysis of black potato showed that the tuber has several essential minerals and various active substances such as tannins and flavonoids, which generate antioxidant and anti-inflammatory activities (Joy and Sidhuraju, 2017).

In Indonesia, black potato is less popular compared to sweet potato and cassava. Whereas, black potato is potential to be developed for national food diversification due to its high carbohydrates, protein, fat, and fibre content, which provide 400 calories per 100 g dry boiled samples (Priya and Anbuselvi, 2013). Besides that, black potato is tolerant to temperature, high rainfall, and direct sunlight conditions. Therefore, black potatoes are frequently found and cultivated in the coastal agriculture areas. On Java island, the black potato has become a traditional snack that is often sold as a boiled potato and can be found in the traditional markets near plantation areas. To date, Maja and Curug Bitung region located in Lebak regency, Banten Province, has become a centre for tuber production, including black potato. In this area, black potato production reaches 7-8 tons per hectare. However, one of the challenges faced in the development of black potato is the potential of pest and pathogen infestations.

The investigation into the pathogens associated with post-harvest of black potato tubers in Nigeria showed that four fungi species namely *Aspergillus niger*, *Fusarium oxysporum*, *Penicillum expansum,* and *Rhizopus stolonifer* were consistently isolated from the diseased tubers (Mohammed et al., 2013). In India, the infestation of nematode on the root-knot of black potato caused the malformed of tuber and the loss of harvest yield up to 92% (Nisha and Sheela, 2006). Black potato in India is also infested by various species of insect pests including the two beetle species *Nupserha vexator* (Cerambycidae) and *Leucopholis coneophora* (Scarabaeidae) (Palaniswami, 1994). The new beetle species in the

family of Chrysomelidae, *Longitarsus serrulatus* is also found feeding on the leaves of black potato (Prathapan et al., 2005). The infestations of pathogens and pests on the black potato plants were initially controlled by the usage of fungicides and insecticides. However, their use is being de-emphasized due to the ecological and human health consideration caused by its residues in the crops (Enyiukwu et al., 2014).

Indonesia has not to concern yet to study this crucial herbaceous crop. The data related to the pathogen and pest infestations of black potato have not been provided. Thus, this present study provides for the first time the potential insect pest which infested black potato in Indonesia. Our study was also aimed to evaluate the status of *Paliga auratalis* as an insect pest of black potato and to develop the control strategies for handling the infestation of *P. auratalis* by using parasitoid.

2. Materials and methods

2.1. Sampling sites and specimen collection

The potential insect pest sampling was conducted on 2013 – 2014. Specimens were collected from 12 sites of black potato plantation which distributed in five provinces in Indonesia i.e., Banten, West Java, a special region of Yogyakarta, Central Java, and East Java (Fig. 1). Sample collection was conducted by observing the black potato planting plot. One hundred leaves which contained insect eggs or infested larvae were collected from a single plot of black potato plantation for each sampling sites and were placed in the labelled rearing boxes.

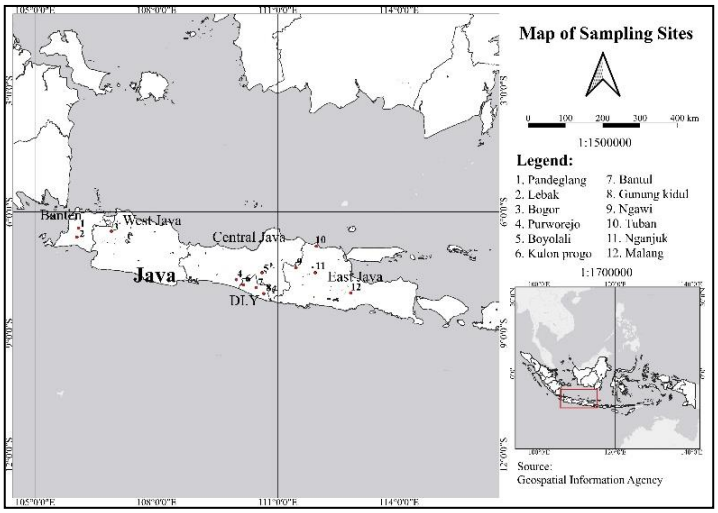

Fig. 1. Java Island map showed 12 sampling sites in five Indonesia's provinces i.e., Banten, West Java, Central Java, D.I Yogyakarta, and East Java

2.2. Sample identification

Insect identification from the larval stage was very difficult due to the various unformed characters. Thus, we reared the larvae from the field in the laboratory to get the adult stage for easier identification. Rearing activity was carried out in the Entomology laboratory, Zoology Division of Biology Research Centre, Indonesian Science Institute (LIPI) with 26 °C exact room temperature and 64% of humidity.

The moth larvae collected from the field were kept in plastic boxes with 6 x 5.5 x 2 cm in size. Each box was filled with one observed larva and fed with fresh black potato leaves. Food was changed every day from a black potato crop that was grown for rearing purposes. The Development of larvae to the adult stage was recorded and photographed. The adult stage of *P. auratalis* was then fed by honey to determine the life span (Morton, 1979). The emerged moth was then identified up to species level using the specimen types in Museum Zoologicum Bogoriense (MZB) and identification keys of Moths (Fabricius, 1793; Kalshoven, 1981; Robinson et al., 1994).

2.3. Life cycle observation

The same age of adult male and female of *P. auratalis* were paired and released in a 60 x 50 x 60 cm rearing cage to find out their life cycle and development. The cage was equipped by black potato potted plants, for breeding and laying of eggs. The hatched eggs were reared individually in a plastic box 6 x 5.5 x 2 cm in size and fed by fresh black potato leaves. Observations were conducted every day to obtain the morphological data and the time required

2.4. Attack status determination

The moth larvae species which found attacking black potato plantations in 1-2 provinces were classified as light attack. Moth larvae species which found attacking black potato plantations in 3 provinces were classified as a moderate attack, and moth larvae species which found attacking in 4-5 provinces were classified as a serious attack. During the larvae rearing, the level of leaf consumption by *P. auratalis* larvae as the main pest of black potato was also determined by calculating consumed leaf area divided by total leaf area times 100%.

Fig 2. Parasitoid test. A. Parasitoid rearing cage, B. *P. auratalis* larvae

2.5. Parasitoid ability test

Parasitoid wasps from infected larva were observed and one of them was identified as *Cryptopimpla* sp., the most potential parasitoid of *P. auratalis* larvae. We used 3rd instar larva of *P. auratalis* as host of the wasp to test the parasitic ability. Three pairs of *Cryptopimpla* sp. were moved into the 60 x 50 x 60 cm rearing cage contained black potato plant in the plastic pot (diameter 9.8 cm, height 12 cm) which has been infested by 10 larvae using an aspirator (Fig. 2). Black potato plants were replaced when the leaves were run out. After 20 days, the number of *P. auratalis* larvae that had successfully grown into adult stage was recorded to determine the parasitic ability of *Cryptopimpla* sp..

3. Results

3.1. Identification and potential pest evaluation

Four groups of insects i.e., moth, grasshopper, ladybug, and white grub were identified. Based on the evaluation results, moth larva is known more potential to be the pest of black potato than other insect groups. We identified five moth larvae species which are included into two families of Crambidae: *Argyrograma* sp., *Pycnarmon cribata,* and *Paliga auratalis*, and Pyralidae: *Pleuroptya punctimarginalis* and *Rehimena diemenalis* (Fig. 3). *Paliga*

auratalis and *P. cribrate* were often found living together in the wide plantation of black potato. They have a similar morphology which difficult to distinguish, especially in larvae stages of first and second instar.

Fig. 3. Five species of moth larvae found in black potato plantations in Java. A. *Paliga auratalis*, B. *Pycnarmon cribata*, C. *Rehimena diemenalis*, D. *Argyrograma* sp., E. *Pleuroptic punctimarginalis*. Black bar = 5 mm

In the adult stage, *P. auratalis* has dark yellow wings with 3 patterns of brown wavy lines on the forewings. The outer margins on the wings are black and grey (Fig. 3A), While *P. cribrate* has white wings with orange and black spots scattered on the forewings. The outer margin has a thin orange line on the inside and grey on the outside (Fig. 3B). *Rehimena diemenalis* has dark grey wings with vertical light blue stripes and broad white spots. The outer margin is light grey with a glossy white stripe (Fig. 3C). *Argyrograma* sp. which was found has dull brown wings with irregular dark brown spots and white stripes on the median area (Fig. 3D). *Pleuroptic punctimarginalis* has light brown wings with dark brown and grey stripes on the forewings. The outer margins on the wings appear transparent (Fig. 3E).

We determined the attack status of each moth larvae species based on the number of attacks in the five provinces in Java (Table 1). *Paliga auratalis* was found in all five provinces and classified as serious attack status. Whereas, *Pycnarmon cribata* was only found in three provinces i.e., Banten, West Java, and East Java with moderate attack status. Other two larvae of moth species of *Argyrograma* sp., *P. punctimarginalis*, and *R. diemenalis* were only on light attack status of. Based on the leaf consumption level calculation, *P. auratalis* can consume black potato plant leaves about 25 - 100%.

3.2. Life cycle of *P. auratalis*

The life cycle of *P. auratalis* from egg to adult in the laboratory was around 25-32 days (Fig. 4). Three adult pairs of *P. auratalis* which were released in the rearing box laid the eggs on the black potato leaves vein after 2-3 days. The eggs were round shape and small, only about 1-2 mm in diameter with milky white colour. After 4-5 days, the eggs hatched into larval first instar about 0.5 - 1.5 mm in length with a clear colour and black-headed. First instar larva was then moulting into the second instar after 2-3 days with 3-5 mm length and milky white coloured. Second instar larva changed into the third instar in 3-4 days with about 13 mm in length and light green colour with black dots on the dorsal. Third instar larva changed into the fourth instar in 1-2 days with about 15 mm in length, reddish dark green body and thickened black spots on the dorsal. Afterwards, the fourth instar changed into the fifth instar in 3-4 days. At this stage, body length was stable but the larva continues to gain weight, the body also turned red with thicker black spots. Four to five days after changing cuticles, this fifth instar larva was not very active and began to produce nets, that was a sign of entering the pre-pupa period. One day later, the larva turned into a pupa. The pupal period was 8-10 days before becoming a moth. The adult stage of *P. auratalis* in the laboratory which was fed by honey reaches 45-60 days of life span. One adult female can produce 60-80 eggs during the oviposition phase.

Table 1. Pest species (Ordo: Lepidoptera) on the black potato plantations in Java Island

Species	Family	Banten	West Java	Central Java	Yogyakarta	East Java
Argyrograma sp.*	Crambidae	+ (1-3)	+ (1-3)			
Pycnarmon cribata **	Crambidae	+ (12)	+ (1-3)			+ (19)
Paliga auratalis ***	Crambidae	+ (87)	+ (5)	+ (5)	+ (5)	+ (42)
Pleuroptya punctimar-ginalis *	Pyralidae					+ (1-3)
Rehimena diemenalis *	Pyralidae	+ (1-3)	+ (1-3)			
Total of species		4	4	1	1	3

Notes: *= Light attack status, ** = Moderate attack status, *** = Serious attack status, the number in the brackets indicate the amount of collected specimen

3.3. Parasitoid wasp of black potato pest

We identified six species of parasitoid wasps which parasitizing *P. auratalis* in Java Island. Those wasps are included to Hymenoptera order and belong into four different families i.e., *Apanteles* sp. and *Cremnops* sp. (Braconidae), *Halticella* sp. (Chalcicidae), *Tetrastichus* sp. and *Elasmus* sp. (Eulophidae), and *Cryptopimpla* sp. (Ichneumonidae) (Table 2).

All of the wasp species were consistently found in Banten and East Java province except *Elasmus* sp. and *Cremnops* sp.. Moreover, we determined two species of *Apanteles* sp. and *Cyptopimpla* sp. as the main parasitoids of *P. auratalis* due to their existence in almost

five observed provinces. However, *Apanteles* sp. has a broader host spectrum than *Cyptopimpla* sp.. Thus, the further examined showed the ability of *Cryptopimpla* sp. were able to parasite four from 10 larvae of *P. auratalis*.

Our further observation to the both of main parasitoids showed that *Apanteles* sp. has an oval-shaped pupa with 3-4 mm in length, milky white coloured, and protected in a cocoon (Fig. 5A). Its pupa became an adult wasp after 6-7 days with the black small body about 3-4 mm with the longer antenna. The female has a short ovipositor at the tip of her abdomen (Fig. 5B). Whereas, *Cryptopimpla* sp. has large and dark brown coloured pupa with almost 1.5 times of *P. auratalis* pupa (Fig. 5C). Adult female of *Cryptopimpla* sp. has a slim body with ovipositor length almost the same to her body length (Fig. 5D).

Fig. 4. Life cycle of *P. auratalis* from egg to adult. Black bar = 5 mm

Table 2. Parasitoid wasp species (Ordo: Hymenoptera) of pest on theblack potato plantations in Java Island

Species	Family	Banten	West Java	Central Java	Yogyakarta	East Java
Apanteles sp.	Braconidae	+	+	+	+	+
Cremnops sp.	Braconidae	+				
Halticella sp.	Chalcididae	+	+			+
Tetrastichus sp.	Eulophidae	+				+
Elasmus sp.	Eulophidae			+		+
Cryptopim-pla sp.	Ichneumo-nidae	+	+		+	+
Total of species		4	5	3	2	2

4. Discussion

The lack of study of pest-infested black potato plants in Indonesia inspired us to conduct this present research. Besides evaluating the status of *P. auratalis* as an insect pest of black potato, this study was also aimed to develop the control strategies by using parasitoid as the natural enemies. We found five moth larva species infested black potato plantations in five provinces of Java Island i.e., *Argyrograma* sp., *Pycnarmon cribata*, *Paliga auratalis*, *Pleuroptya punctimarginalis*, and *Rehimena diemenalis*. We report for the first time that *P. auratalis* was the main insect pest which infested black potato plants in all 12 sampling sites with serious attack status compared to other moth larva species. Moreover, we observed that *P. auratalis* larva was able to consume black potato leaves ranging from 25% - 100%. It might disrupt the process of photosynthesis in black potato plants. *Paliga auratalis* was also reported as insect pest of *sambung nyawa* plants (*Gynura procumbens*) in Indonesia, and the symptoms this caterpillar pest were rolled the leaves and leaves become dry due to the saliva released from the mouth of the larva (Rismayani and Rohimatun, 2017). Larval behaviour releasing saliva from its mouth serves to protect itself from predator attacks (Greeney et al., 2010).

Black potato and sambung nyawa plants are placed on different plant families in the plant classification, thus we can determine that *P. auratalis* is the generalist insect pest that has many plants host familes and uses varieties of resources (Fichter 1966). As generalist insect pest, understanding *P. auratalis* life cycles is critical for vegetable cropping success particularly to control *P. auratalis* at the most vulnerable stage in his cycle or if possibly is to control this pest species on all its stages. In this study, we have successfully observed the life cycles of *P. auratalis* which reared on black potato leaves. *Paliga auratalis* has the life cycles from egg to adult around 25-32 days with the longest phase in the larval stage which is about 15 days. It is different from *P. auratalis* life cycles in sambung nyawa plants with the longest phase in the pupal stage i.e., 13 days (Rismayani and Rohimatun, 2017). Whereas in our observation the duration of the pupal stage was about 8 – 10 days. The different result of the data could be influenced by many factors including type of host plant. It is in agreement with other moth species i.e., *Spodoptera litura* that has shorter pupal development on cowpea than Chinese cabbage, sweet potato, and tobacco (Xue et al., 2009).

Synthetic insecticides are effective agents to control the pest which infected the crops. However, their use is being de-emphasized due to the ecological and human health concerns caused by its residues in the crops. Thus, we tried to explore the potential of biological control of *P. auratalis* by using parasitoid. Biological control is an advantageous action of parasites, pathogens, and predators in managing pests and their damage. In the present study, we observed two parasitoid wasp species that potential as the

parasitoid of *P. auratalis* i.e., *Apenteles* sp. and *Cryptopimpla* sp. As parasitoid, these two wasp species live and feed in *P. auratalis* larvae. Our new finding showed that three pairs of *Cryptopimpla* sp. were able to parasite four from 10 larvae of *P. auratalis*. This information should be useful for black potato pest control strategy, particularly using *Cryptopimpla* sp. as the parasitoid.

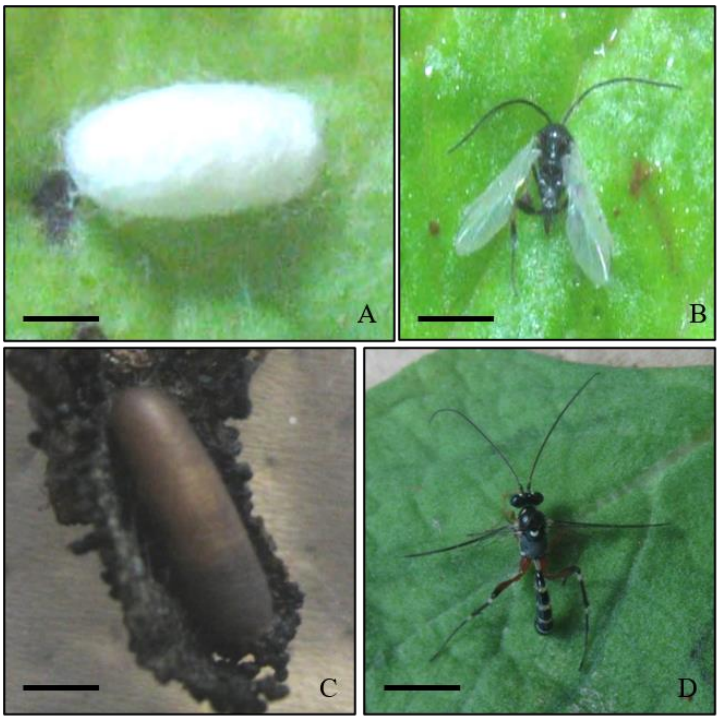

Fig. 5. Two species of wasps as the main parasitoid of *P. auratalis* . A. Pupa of *Apenteles* sp., B. Adult stage of *Apenteles* sp., C. Pupa of *Cryptopimpla* sp., D. Adult stage of *Cryptopimpla* sp.. Black bar = 5 mm

5. Conclusion

The evaluation status of five moth larvae species as potential insect pest on black potato plants confirmed that *P. auratalis* is the main insect pest in Java Island with serious attack status. The black potato is recorded the first time as a new host plant of *P. auratalis*. The life cycles of *P. auratalis* was successfully observed for further understanding the pest management. The parasitoid wasp of *Cryptopimpla* sp. was a potential parasitoid to be a biological control agent of *P. auratalis*.

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Conflict of interest

No potential conflict of interest was reported by the author.

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