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PRELIMINARY STUDY ON *EUBLEMMA* SP. (EUBLEMMINAE): A LEPIDOPTERAN PREDATOR OF *COCCUS VIRIDIS* (HEMIPTERA: COCCIDAE) ON COFFEE PLANTS IN BANDARLAMPUNG, INDONESIA

Indriyati & F.X. Susilo

Division of Plant Protection, Department of Agrotechnology,
Faculty of Agriculture Universitas Lampung
Jl. Prof. Soemantri Brojonegoro No 1, Bandarlampung 35145
E-mail: indri1919@gmail.com
fx.susilo@fp.unila.ac.id

ABSTRACT

***Preliminary study on* Eublemma *sp. (Eublemminae): a Lepidopteran predator of* Coccus viridis *(Hemiptera: Coccidae) on coffee plants in Bandarlampung, Indonesia*.** The objectives of this study were 1) to identify a Lepidopteran predator of the soft green scale *Coccus viridis* and 2) to present preliminary data on the predator's feeding rate. Some coffee leaves where eggs of the Lepidopteran predator have been laid in *C. viridis* colonies were taken from the field and observed in the laboratory. The predator's growth and development was noted and the specimens were identified up to generic level based on the caterpillar morphology. Ten coffee leaves each with certain number of *C. viridis* were also collected from the field, transferred to the laboratory, and each was inoculated with one starved caterpillar that had just formed its protective casing. The number of surviving *C. viridis* was counted daily. This study reveals that the caterpillar, identified as *Eublemma* sp. is found to feed obligately on *C. viridis*. The predation rate of *Eublemma* sp. in laboratory is 97 $\pm$ 11 scales / caterpillar.

Key words: *Coccus, Eublemma*, Lepidoptera, Noctuidae, predator

ABSTRAK

***Studi awal tentang* Eublemma *sp. (Eublemminae): Lepidoptera predator* Coccus viridis *(Hemiptera: Coccidae) pada tanaman kopi di Bandarlampung, Indonesia*.** Tujuan penelitian ini adalah mengidentifikasi Lepidoptera predator kutu tempurung hijau *Coccus viridis* dan menyajikan data awal daya predasinya. Beberapa daun kopi yang terinfestasi *C. viridis* dan diletaki telur Lepidoptera predator diambil dari lapangan dan diamati di laboratorium. Pertumbuhan dan perkembangan predator sejak telur hingga imago dicatat dan spesimennya diidentifikasi sampai taraf genus berdasar karakter morfologi ulat. Sebanyak sepuluh helai daun kopi yang diinfestasi *C. viridis* juga dikoleksi dari lapangan, dibawa ke laboratorium, dan kemudian setiap daun diinokulasi dengan seekor ulat yang dilaparkan dan baru saja membentuk selubung pelindung. Banyaknya *C. viridis* yang takat (bertahan hidup) diturus setiap hari. Studi ini menunjukkan bahwa ulat, teridentifikasi sebagai *Eublemma* sp., merupakan predator obligat pada *C. viridis*. Daya predasi *Eublemma* sp. di laboratorium adalah 97 $\pm$ 11 ekor kutu tempurung/ulat.

Kata kunci: *Coccus, Eublemma*, Lepidoptera, Noctuidae, predator

INTRODUCTION

The Lepidoptera is a diverse insect order. Membering of more than 160 thousand species (estimated; Common, 1990) wherein 157 thousands have been described (NHM, 2014) makes the Lepidoptera one of the four most diverse insect orders of the world (Susilo, 2011). Lepidopteran imagoes can be distinguished into butterflies, moths, and skippers; they generally feed on nectar while their larvae, known as caterpillar, are mostly phytophagous and several hundred species of them are pestiferous to various plants or plant products (Kalshoven, 1981).

Caterpillars of some genera have been known to be predaceous, but information on this is limited. There are only brief mentions in Kalshoven (1981) that caterpillars of some species of *Autoba*, *Catoblemma*, and *Eublemma* feed on coccids and that *Eublemma* caterpillars are predaceous to the soft green scale *Coccus viridis*. In early March of 2014 we found

Lepidopteran larvae feeding on the soft green scale on coffee plants in Bandarlampung, Lampung Province-Indonesia. The objectives of this preliminary study were 1) to identify the Lepidopteran predator with notes of its developmental stages and 2) to present preliminary data on the predator's feeding rate.

MATERIALS AND METHODS

Study Site. Observations were done over dozens of coffee plants in Universitas Lampung complex, Bandarlampung, and at the university's Plant Pests Laboratory, Faculty of Agriculture, in the period of March-May, 2014.

Some coffee leaves where eggs of the Lepidopteran predator have been laid in the midst of *C. viridis* colonies were taken from the field and observed in the laboratory. An Olympus dissecting microscope was used to daily observe the predator's biological development from egg stage to the emergence of their adult moths. The Lepidopteran predator was then identified up to generic level. Identification was based on the caterpillar morphological characters. Determination of family name was based on the number of ventral prolegs (Peterson, 1984; Stehr, 1987) while that of generic name was based on the following key characters (Beardsley, 1982): 1) type of crochets, 2) body setal structure, and 3) height ratio of the 8^{th}:7^{th} spiracles.

The predator's feeding rate was determined in the laboratory. A number of predatory larvae were taken from the field and acclimated in the laboratoy for 18 hours without prey. Ten coffee leaves each with certain number of *C. viridis* were then collected from the field and transferred to the laboratory. In the laboratory, each of those leaves was then inoculated with one starved Lepidopteran predator larva that had just formed its protective casing. The number of surviving *C. viridis* was counted daily using a hand-tally counter. Counting was stopped when the survival number has no longer decreased; otherwise, the larval predator has pupated. Predation was determined by substracting any two consecutive survival numbers. Cummulative predation was determined by adding up any two consecutive numbers of predated *C. viridis*.

RESULTS AND DISCUSSION

Biological Development and Identification. Figure 1 displays eggs of the Lepidopteran predator. These globular eggs were laid singly and in between *C. viridis* individuals (Figure 1A). The eggs are whitish-yellow in color and with a diameter of 0.3 $\pm$ 0.0 mm (n = 40; Figure 1B). Our rearing resulted in two gravid female predators; one laid 35 eggs total, the other 42.

The larval Lepidopteran predator has peculiar habit during their feeding on *C. viridis*. The neonate larva (Figure 2A) does not directly feed on *C. viridis* imago(es); instead, it first goes underneath of a female *C. viridis* to search for and eat her laid-eggs and newly-hatched crawlers. The larva then continues to eat; this time it eats *C. viridis* eggs which are still inside the body of their mother. That way, this female's ventral body parts and reproductive organs are totally damaged which soon causes her death. The larval predator leaves the cadaver, i.e. her dorsal integumental remnant (Figure 2B), to search for other groups of *C. viridis* eggs and crawlers. As it eats them up, a group at a time, the larval predator molts and grows larger.

Eating up larger-sized *C. viridis*, a larger predatory larva spins a protective casing. The casing consists of larval silken threads and remnants of *C.*

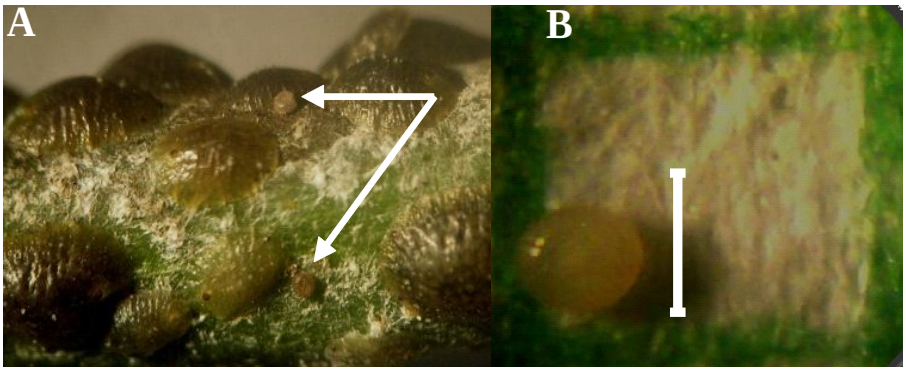

Figure 1. Eggs of the Lepidopteran predator, *Eublemma* sp. (A) Two predator's eggs laid in between their prey individuals, *C. viridis* (arrows indicate the positions of the eggs). (B) One predator's egg is enlarged (bar = 0.5 mm)

viridis prey. The casing also gets larger as the size of the larval predator increases (Figure 2C). The casing protects the predator from ants that try to tend the scales. The full-grown larval predator sizes 6.2 ± 0.2 mm (n = 10, Figure 2D).

The predatory larva is of eruciform-type with some specific characters. It has three pairs of thoracic legs, two pairs of ventral prolegs (located at A5 and A6), and one pair of anal prolegs (at A10), respectively. Each proleg is equipped with uniordinal crochets. Figure 3 shows lateral penellipse arrangements of the anal crochets. All prolegs initially function as walker legs. However, as the larva molts and starts forming protective casing, the anal prolegs grow larger and become the largest pairs. In the process, their plantae tilt upward, securing them at a posterio-dorsal position. With that position, these prolegs can no longer function as walkers. Instead, they then assume a new function, i.e. tightly hold the protective casing.

Figure 4 shows obtected pupae of the predator. Newly formed pupae are yellowish brown with black spots at eye position (Figure 4A). Older pupae turn darker and stouter (Figure 4B). Pupal size is 5.0 ± 0.2 mm (n = 10; Figure 4B). The entire pupal development (5.3 ± 0.9 days, n = 3) occurs inside a cocoon which basically is the final form of the larval protective casing. The larval casing is a dome-like while the pupal cocoon is oblonged. Pupal molting inside the cocoon results in a moth which makes its way out via a very neat polar papillum (Figure 4C).

The emerging moths are of typical noctuids (Figure 5). Their body builts are robust with dull-dark appearance. Their labial palpi, filiform-type antenae, and other appendages on the head are fair in sizes. Being similar to the appearance of the overall body surface camouflages the appendages, regardless of their sizes. Dorsal markings on forewings vary from almost none to prominent (Figure 5). Wings are ornamented with

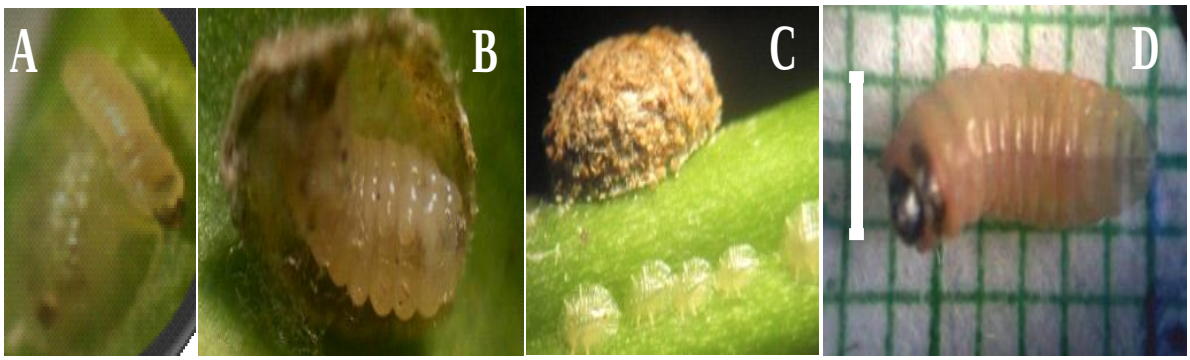

Figure 2. Larvae of the Lepidopteran predator, *Eublemma* sp. (A) Neonate larval predator. (B) Larval predator leaves remnant of *C. viridis* cadaver. (C) Larval predator with protective casing consisting of remnants of *C. viridis* prey. (D) Full-grown larval predator (bar = 2 mm)

Figure 3. Uniordinal-lateral penellipse crochets of the larval Lepidopteran predator, *Eublemma* sp.

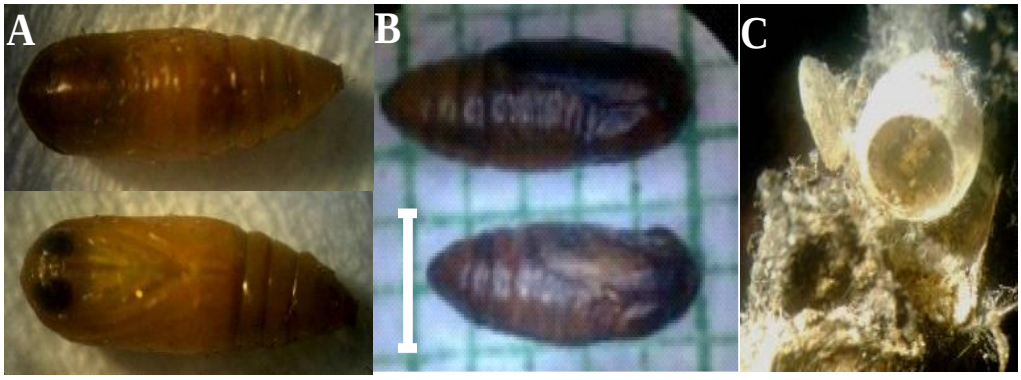

Figure 4. Pupae and cocoon of the Lepidopteran predator, *Eublemma* sp. (A) Newly formed pupae. (B) Older pupae (bar = 2 mm). (C) A cocoon with an open papillar cap.

Figure 5. Moths of the Lepidopteran predator, *Eublemma* sp., with various markings on their forewings (A, B, C) (bars = 3 mm)

dense fringes along their apex (Figure 5). Wingspan is 14.1 ± 0.3 mm (n = 10).

As a rule, larvae of Lepidoptera are each equipped with four pairs of ventral prolegs (A3, A4, A5, A6) and one pair of anal prolegs (A10) (Peterson, 1984). Some families, however, posses less than four ventral prolegs, i.e. none (Nepticulidae; Opostegidae; Limacodidae; Stehr, 1987), one (A6; Geometridae; Peterson, 1984; Stehr, 1987), two (A5, A6; Noctuidae in part), or three (A4, A5, A6; Noctuidae in part; Nolidae in part; Peterson, 1984). As previously mentioned, our larval specimens have two ventral prolegs (A5, A6); that means, they should be included in the Noctuidae family.

As also shown (Figure 3), the specimen's crochets are of uniordinal type. According to Beardsley (1982), this type of crochets belongs to two noctuid genera, i.e. *Eublemma* and *Amyna*. Beardsley (1982) delimits the two genera by the body setal character and the height ratio of the 8th:7th spiracles. Body setae of *Amyna* are dark with dark ring around the setal bases. Moreover, the height ratio of 8th:7th abdominal spiracles is more than twice for *Amyna*. Our specimens cannot be *Amyna* because they are equipped with pale body setae without dark basal ring and with 8th:7th spiracle height ratio of less than twice—in fact, both spiracles are of similar height and size. Therefore, we identified our specimens as *Eublemma* sp.

Predation Rate. One starved *Eublemma* sp. caterpillar on a coffee leaf predated a total of 97 ± 11 individuals of *C. viridis* in six days (Figure 6). In the first two days, the prey's population was cut in-half by the predator. At the end of the sixth day, the surviving *C. viridis* prey on the coffee leaf became no more than 16% of their initial total number (averaged 155 individuals).

Discussion. The genus *Eublemma* of the subfamily Eublemminae consists of 339 world species (Kumar & Ramamurthy, 2012); which mostly, if not all, are predatory (Pierce, 1995). The predatory species of this genus feed obligately on coccoids (Pierce, 1995) including *Eublemma* sp. in this study that feeds on the soft green scale *C. viridis*. The most notable *Eublemma*

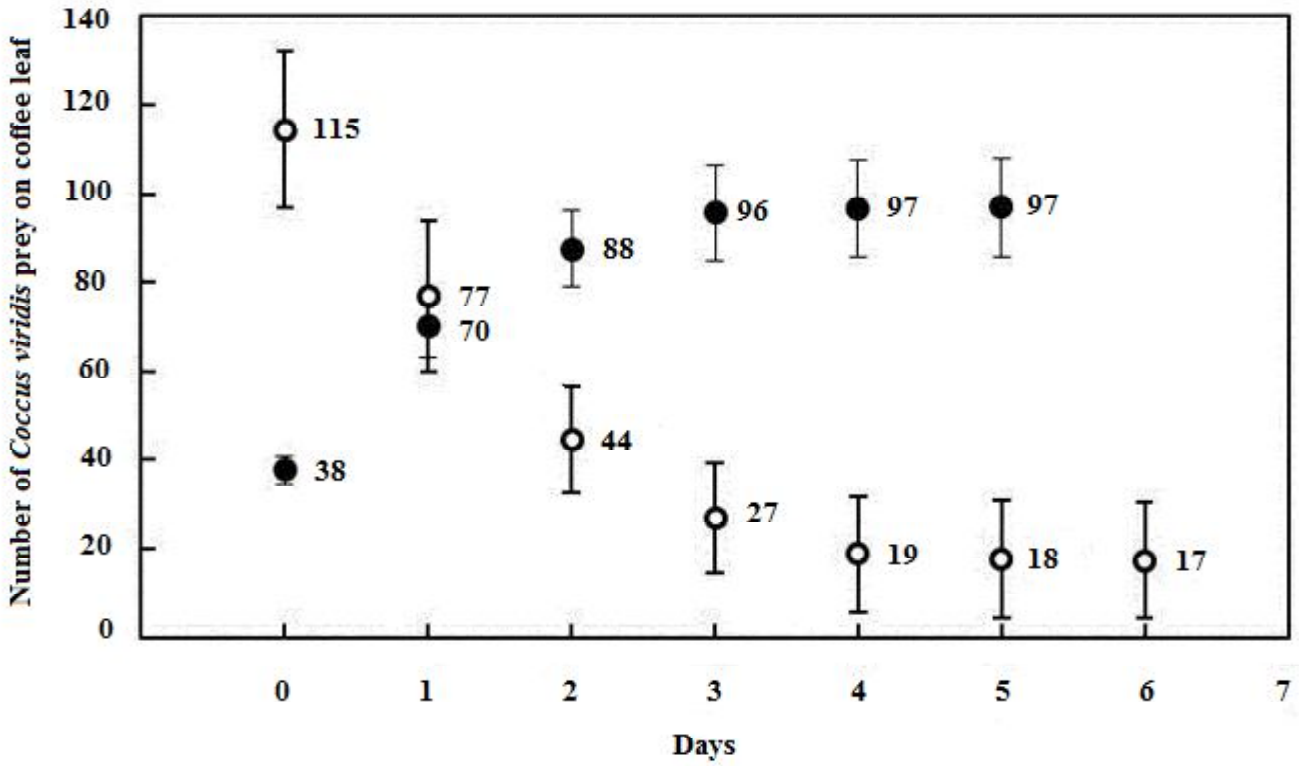

Figure 6. Daily mean numbers of *C. viridis* during six days of predation by a *Eublemma* sp. caterpillar. ○ = surviving; ● = predated. Bars = standard errors of the means

predators, however, are *E. amabilis* that feed on the lac scale *Kerria* sp. or on the wax scale *Ceroplastes* sp. and *E. scitula* that feed on the brown or black scale *Saissetia* sp. (Kumar & Ramamurthy, 2012; Chattopadhyay, 2011; Rahman *et al*., 2009; Awamleh *et al*., 2009; Pierce, 1995; Fernandez *et al*., 1980). The other coccoid-eating species include *E. coccophaga, E. communimacula, E. costimacula, E. deserta, E. dubia, E. gaynery, E. ochrochroa, E. pulvinariae, E. roseonivea, E. rubra, E. trifasciata, E. virginalis,* and *E. vinotincta* (Pierce, 1995). A record of phytophagous *Eublemma* species can be traced in Kravchenko *et al*. (2007) where five of 18 species found in Israel are known to feed on plants in the Asteraceae family while the host plants of the rest (13 species) have not been determined.

In Kalshoven (1981), the Lepidopteran predator of the green soft scale in Indonesia is reported as *Eublemma vacillans* Wlk., but that cannot be used as the binomial name for our specimens. To be correct, *Eublemma vacillans* Wlk. should be written up formally as *Eublemma vacillans* (Walker) (Art. 51.3; ICZN, 1999), meaning that *vacillans* has been previously described by Walker for (and designated it to) a genus other than *Eublemma*. That is true because Walker in 1864 designated the species name *vacillans* to the genus *Zurobata* (Noctuidae) (Kendrick, 2004). Thus, the binomial name *Zurobata vacillans* Walker should be given the taxonomic priority and be the valid binomial name. It follows that, on the one hand, as we consider it to be a *nomen nudum*, *Eublemma vacillans* cannot be used as the designation of our specimens or of any other specimen for that matter. On the other hand, our specimens cannot be *Zurobata vacillans* either, because *Zurobata vacillans* are phytophagous (i.e. feeding on the longan fruit tree in Thailand; Anonymous, 2003) while our specimens are predaceous.

Seven valid *Eublemma* species names have been attached to Indonesian specimens (Kumar & Ramamurthy, 2012). Three names are attached directly to *Eublemmae*, i.e. *Eublemma carneola* Hampson, *Eublemma pudica* Snellen, and *Eublemma roseonivea* (Walker). The other four are attached through synonymy, as follow. Indonesian *Thalpochares accedens* Felder, Rogenhofer & Poole is the synonym of South African *Eublemma anachorensis* (Wallengren) while our

Thalpochares adulans Felder, Rogenhofer, & Poole, *Anthophila sexta* Guenee & Poole, and *Micra hemirhoda* Walker & Poole are the synonyms of India's *Eublemma dimidialis* (Fabricius). The same, our *Anthophila virginea* Guenee and *Eublemma demba* Swinhoe are the synonyms of Italian *Eublemma ragusana* (Freyer) and India's *Eublemma trifasciata* (Moore), respectively. The taxonomic attachments and affinities as above (Kumar & Ramamurthy, 2012) are well-recognized but none indicates definite affinity to the characters of our specimens; including specifity of their host or prey items. Therefore, as it stands, we cannot designate (or have not been able to designate) any of the seven species names to our specimens (*Eublemma* sp.).

Is *Eublemma* sp. an effective predator? In the laboratory, *Eublemma* sp. shows a relatively high consumption (97 $\pm$ 11 *C. viridis* scales/*Eublemma* sp. larva, Figure 6). The rate is higher than that, for instance, of *E. antonina* which can consume only 18-20 *Antonina graminis* scales/*E. antonina* larva (Nagaraja & Nagarkatti, 1970). That means, *Eublemma* sp. has a high predation potential. Its actual predation, however, needs further investigations. It has not been clear how consistent the predation rate will be in the presence of (1) scale-tending ants and/or (2) natural enemies.

The actual *Eublemma* sp. predation may be lower than potential *Eublemma* sp. predation, considering the following situations. First, the larval *Eublemma* sp. predator may be protected from ants by its body casing but so far no quantitative data available on this. Moreover, as scale-tending ants are in general predatory to non-scale insects (Susilo, 2011), a failure in the part of *Eublemma* sp. to protect itself from ants may lead to shifting its role from the predator of the scales to being the prey of the ants. Second, *Eublemma* sp. eggs seem to be prone to egg predators (i.e. ants and others) because these eggs are laid singly (Figure 1A) and unprotected. Predation to *Eublemma* sp. eggs may lead to low initial population of *Eublemma* sp. larvae. Third, *Eublemma* sp. eggs also seem to be prone to eggs parasitoids. In line to this, *Eublemma* sp. larvae may be prone to parasitoids as well, in spite of their having protective casings. It has been well-known (Kalshoven, 1981) that strong protective casing (consisting of leaf particles, sand and other components) in psychid larvae cannot protect them from parasitoid attacks. In sum, natural enemies and competitors can lower the predation rate of *Eublemma* sp. and quantitative data on *Eublemma* sp. in relation to those factors need to be investigated in further studies.

CONCLUSION

This study reveals that a kind of Lepidoptera larva, identified as *Eublemma* sp. (Eublemminae: Noctuidae) is found to feed obligately on the soft green scale, *C. viridis* (Hemiptera: Coccidae). The predatory caterpillar has two abdominal prolegs (A5 & A6) and anal proleg (A10), each with uniordinal crochets. The predation rate of *Eublemma* sp. in laboratory is 97 $\pm$ 11 scales / caterpillar. Further studies needed include 1) the faunistic studies on Eublemminae in Indonesia and taxonomic studies on Indonesian *Eublemma* sp. and 2) ecological studies on Indonesian Eublemminae.

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