

The Inventory of Leaf Beetles (Coleoptera: Chrysomelidae) from Soraya Research Station Leuser Ecosystem, Indonesia

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Abstract: The Soraya Research Station is a search area which was originally a former forest concession area. The purpose of this study was to determine chrysomelid beetles found at the Soraya Research Station in the Leuser Ecosystem, which was carried out using an exploratory method through direct observation of the object using the insect net at 60 points following an existing trail. This research was conducted in August 2020-February 2021. The results showed that the leaf beetles (Chrysomelidae) obtained were 37 species and 370 individuals, consisting of 6 subfamilies, namely Subfamily Galerucinae (17 species), Cassidinae (9 species), Criocerinae (7 species), Eumolpinae (2 species), Cryptocephalinae (1 species), and Alticinae (1 species). The index value of beetle diversity in forest habitats at the Soraya Research Station is categorized as moderate (2.85).

Keywords: Chrysomelidae; Coleoptera; Inventory; Leuser ecosystem; Soraya research station

Introduction

Coleoptera or beetles are a group of insects that have the highest variety of diversity in the class of insects. This group of insects is found throughout the world and spread in various habitats. Chrysomelidae or leaf beetles are one of the families belonging to the order Coleoptera. This family has the highest species diversity with around 36,000 species spread throughout the world (Sánchez-Reyes et al., 2019). Since they rank among the top families in terms of global diversity, leaf beetles (Coleoptera: Chrysomelidae) serve as a paradigm for assessing the seasonal impacts of abiotic variation on herbivorous insect communities (Niño-Maldonado et al., 2017; Marquina et al., 2021).

The diversity of beetles in a habitat is influenced by various environmental factors such as diversity of plant vegetation and organic matter, habitat fragmentation, changes in temperature (climate), habitat conditions and changes in plant age, landscape complexity, land use, species and intensity and human activities (Ulina, 2017; Winotai, 2014). Chrysomelidae

beetles can be found in almost all species of habitats, such as forests, shrubs, meadows, and along streams. This group of beetles feed on various species of plants, ranging from grass to large plants (trees). In addition, Chrysomelidae can also be found on plant parts, seeds or other stored materials. In light of the fact that leaf beetles are almost exclusively phytophagous, their capacity to occupy a variety of feeding niches and their host specificity to almost all groups of plants are key factors in determining how successful they are in ecosystems (Lee & Beenen, 2020). The larvae can be found on leaves, surfaces or as leaf miners; other larvae feed on plant roots, plant litter, or submerged plant parts (Sánchez-Reyes et al., 2019). The majority of chrysomelid species have feeding behaviors that are phytophagous, a strong bond with their host plants, and a high sensitivity to microclimate variation. One of the most major trophic groups that reacts strongly to climatic changes is phytophagous insects (Lucio-Gracia et al., 2022; Ariati et al., 2019). Their existence is essential in both natural and human-made ecosystems, as they contribute to other organisms' diets or important nutrient cycling processes

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(Sánchez-Reyes et al., 2019; Ordóñez-Reséndiz et al., 2014). Additionally, the environmental factors affect their physiological systems.

In tropical forests, food and host plant availability, as well as environmental factors, are strongly correlated with the diversity and distribution of Chrysomelidae beetles. The Soraya Research Station, located in the Leuser Ecosystem Area (LEA), is one place that is still very natural and has a high level of biodiversity. The Soraya Research Station, described by Suwarno et al. (2019), is a hilly low land tropical rainforest region that has a very high biodiversity, particularly in the insect group. Several related studies on the diversity of Chrysomelidae beetles or leaf beetles have been carried out, including Ordonez-Ressndiz et al. (2014) on the biodiversity of chrysomelidae in Mexico. Sanchez-Reyes et al. (2014) on the diversity and distribution of Chrysomelidae by altitude in Mexico's Peregrina Canyon Tamaulipas. Furthermore, Amrulloh et al. (2020) reported on the diversity and abundance of leaf beetles in four species of land use in the landscape of Bukit Dua Belas National Park and Hutan Harapan, Jambi. There results showed that the number of species and the number of individual beetles found from one location to another varied greatly. The Leuser Ecosystem is one of the most important conservation areas on earth. The Leuser Ecosystem is a tropical rain forest which has nearly 50% of the world's most biodiversity, but only 4% of the diversity of tropical forests in a national parks and other conservation areas.

Method

Study Site

This research was conducted at the Soraya Research Station, Sultan Daulat District, Subulussalam City, the Capital of Aceh Province. This research was conducted from August 2020 to February 2021.

Data Collection

Sampling of Chrysomelidae beetles in the field was carried out using an exploratory method on six trails at the Soraya Research Station. Each track/trail, determine dasmany as 10 sampling points. The distance between one sampling point and the next point is 250–300 m. Sample collection for each sampling point was carried out in an area of 20 m x 20 m, each for 30 minutes. Each location point is repeated three times. Beetles are caught using insect nets. The beetle samples collected in this study were only carried out on leaf beetles and not on other species of beetles. Sampling was carried out from 09.00-17.00 WIB. Coordinates of each sampling location point were recorded, and environmental physical factors were measured.

Preservation of specimens is done by putting the sample into a bottle that has been filled with 70% alcohol, for preservation this is a preservation method that is carried out immediately after sampling in the field. This is done to keep the sample from being easily damaged or decomposed. The water used to combine with the alcohol should be distilled water, and the solutions should be fully mixed because alcohol and water do not mix well (Kumar et al., 2022).

Identification

The beetles that have been used as dry specimens are then identified. Identification is done by observing the characteristics of each Chrysomelidae. According to Abdullah et al. (2021) and Mohamedsaid (2006) there are three morphological characters of beetles that are important as a reference in identifying, observing the three morphological characters are body parts such as head, pronotum, antennae, and texture of elytra. Identification was done by looking at the morphology of the beetles using the Dino-Lite Digital Microscope AM2III Series (small beetles) and referring to the identification books of Lawrence et al. (1994) and Mohammed said (2006), as well as published journals such as Bezdek et al. (2004) and Mohamedsaid et al. (2011). The identification process was carried out at the Ecology Laboratory, USK FMIPA Department.

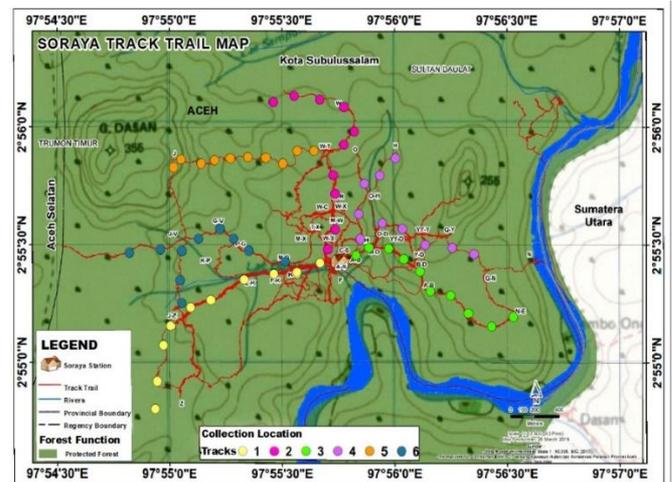


Figure 1. Beetle sampling location points

Data Analysis

Data from observations of leaf beetles (Chrysomelidae) caught in the Soraya Research Station area were analyzed descriptively by describing the morphology of the beetles and grouped by subfamily, genus and species. The description of beetle morphology includes the main characteristics such as color and texture of the elytra, pronotum, and antennae. In addition, the beetle's body length was also measured

(mean \pm standard deviation, n=number of individuals). The data presented in the form of tables and figures.

Result and Discussion

The results of the identification of leaf beetle samples (Chrysomelidae) obtained at the Soraya Research Station of the Leuser Ecosystem Area were obtained as many as 370 individuals and 37 species, which belong to 6 subfamilies, namely the Galerucinae sub family (17 species), Cassidinae (9 species), Criocerinae (7 species), Eumolpinae (2 species), Cryptocephalinae (1 species), and Alticinae (1 species).

Figure 2 showed there were 6 sub families found at the study site with the highest percentage in the subfamily Galerucinae. The next most subfamily is

Criocerinae with 7 species (19%) and 67 individuals (18%). Subfamily Criocerinae generally eat dicotyledonous plants and monocotyledonous plants (Reid, 2017; Wiratno & Rokhimatun, 2012). The next subfamily is Cryptocephalinae with 1 species (3%) and 30 individuals (8%). This subfamily is very unique because it's small and strong, cylindrical in shape and has a head that is embedded in the prothorax almost to the eye. When disturbed, beetles from the subfamily Cryptocephalinae will fold their legs and fall to the ground pretending to be dead (Reid, 2017; Lee & Sekerka, 2018). Most Cryptocephalinae larvae and adults live on leave sand are generally polyphagous. The following subfamily Eumolpinae are 2 species (5%) and 39 individuals (10%). The subfamily Eumolpinae has 500 genera and 7000 species recorded in the world (Reid, 2017; Alouw, 2007).

Table 1. Diversity of Chrysomelidae beetle species at Soraya Research Station

Subfamily	Genus	Species	Total
Galerucinae	Aulacophora	<i>Aulacophora foveicollis</i>	68
		<i>Aulacophora indica</i>	4
		<i>Aulacophora lewisii</i>	2
		<i>Aulacophora palliata</i>	4
		<i>Aulacophora</i> sp. 1	6
		<i>Aulacophora</i> sp. 2	27
		Altica	<i>Altica cyanea</i>
	Arcastes	<i>Arcastes biplagiata</i>	11
	Cerophysa	<i>Cerophysa</i> sp.	3
		<i>Cerophysa calvariensis</i>	17
		<i>Cerophysa pussila</i>	2
	Haplosianida	<i>Haplosianida</i> sp.	2
	Monolepta	<i>Monolepta bifasciata</i>	2
		<i>Monolepta</i> sp.	2
	Neolepta	<i>Neolepta biplagiata</i>	25
	Paleosepharia	<i>Paleosepharia malayana</i>	2
		<i>Paleosepharia zakrii</i>	12
<i>Lema quadripunctata</i>		2	
Criocerinae	Lema	<i>Lema solani</i>	2
		<i>Lema</i> sp. 1	2
		<i>Lema</i> sp. 2	2
		<i>Lema</i> sp. 3	2
		<i>Oulema melanopus</i>	55
		<i>Neolema</i> sp.	2
		<i>Adiscus</i> sp.	30
Cryptocephalinae			
Alticinae	Hypasis	<i>Hypasis</i> sp.	3
	Colaspoides	<i>Colaspoides tuberculata</i>	35
Eumolpinae	Megascelis	<i>Megascelis texama</i>	4
	Aspidimorpha	<i>Aspidimorpha</i> sp.	2
Cassidinae	Charidotella	<i>Charidotella sexpunctata</i>	2
	Cassida	<i>Cassida circumdata</i>	4
		<i>Cassida catenata</i>	2
<i>Cassida</i> sp.		2	
	Dactylispa	<i>Dactylispa aspera</i>	11
	Deloyala	<i>Deloyala guttata</i>	4
	Promecotheca	<i>Promecotheca</i> sp.	2
	Thlaspida	<i>Thlaspida biramosa</i>	11
Total of species			37
Total of individu			370

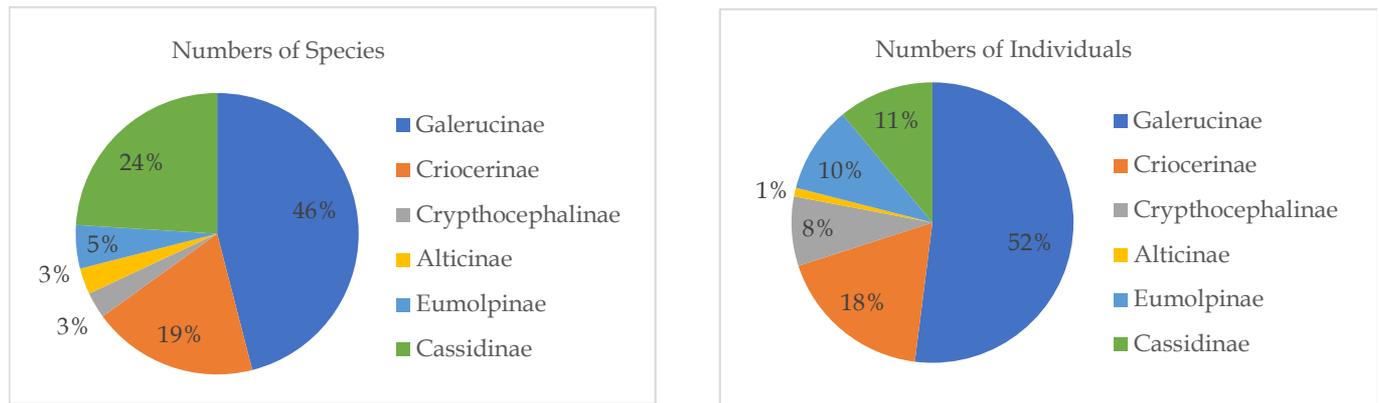


Figure 2. The proportion of leaf beetle species and individuals in soraya research station

Adult Eumolpinae beetles are polyphagous (eat a variety of foods). This group is able to attack monocot and dicot plants. In addition, this group of beetles eat the leave so of the Leguminosae group, but some also eat the fruit of the host plant. Due to the habit of eating polyphagous Eumolpinae, this beetle can be a pest for various crops including fruit trees. In addition, this beetle is also involved in the spread of various plant viruses. All larvae of the root-eating Eumolpinae beetle are polyphagous (Reid, 2017; Wali & Soamole, 2015; Alouw & Novianti, 2010).

The fewest leaf beetle groups found in the Alticinae subfamily were 1 species (3%) and 3 individuals (1%). This beetle is the least found because this subfamily of beetles has the advantage of jumping farther so it is a little difficult to catch, this subfamily is easier to identify because the things of the hind legs are larger than the front legs and consist of strong muscles used for jumping purposes (Amrulloh et al., 2022; Johnson, 1998; Staines, 2012; Phillips, 1996).

The number of species obtained in this study is relatively large based on the length of the collection period. This is presumably because the habitat conditions at the Soraya Research Station have varied species of vegetation. Based on existing monitoring data, the number of tree-habitual vegetation species is approximately 400 species (FKL, 2019). Some of the vegetation becomes host plants and partly feeds for leaf beetles, including some herbaceous and herbaceous vegetation. Several species of vegetation that become host plants for leaf beetles are *Silybunadans*, *Potentilla*, *Acacia crassicarpa*, *Carduus l*, *Cucumis sativus* and *Cirsium mill* (Duan et al., 2021; Sekerka, 2015; Singh & Rathinam, 2005; Kalshoven, 1981).

The beetles collected are from the Chrysomelidae family. This family, better known as the leaf beetle, comes from the Latin word chryso which means golden. Chrysomelidae is the second largest family in the order Coleoptera. Morphologically, Chrysomelidae beetles are almost the same as beetles from other families, but

Chrysomelidae beetle shave special characteristics, namely their tarsi structure which looks like 4-4-4, butis 5-5-5 and has eleven antenna segments (Rahayu et al., 2021; Fang et al., 2011; Prathapan & Shameem, 2015).

According to Takizawa & Mohammedsaid (2019), adult beetles from the Chrysomelidae family have a body length between 6 to 11 mm and have an oval body shape. The legs are rather short, the hind femora are larger. Chrysomelidae beetles are phytophagous insects known to feed on a wide variety of plants and plants from grasses to large plants. The Chrysomelidae family consists of several subfamilies including Galerucinae, Criocerinae, Eumolpinae, Crytocephalinae, Altycinae and Cassidinae.

Subfamily Galerucinae
Aulacophora foveicollis

The beetle *Aulacophora foveicollis* is a species of beetle belonging to the family Chrysomelidae which is polyphagous and can attack more than 81 plant species (Rashid et al., 2014; Alouw & Hosang, 2008). Based on observations of morphological forms, this beetle is generally yellow in color and has a body length of about 10 mm. The body is slightly rounded, and the elytra are shorter than the body, have an antenna with a filiform species (the shape of the antenna from base to tip is uniform like a thread, each segment has the same size).

Beetles of the genus *Aulocaphora* have one characteristic, namely on the pronotum there is a transverse indentation. This is in accordance with what was stated by Bhowmik et al. (2022). The imago of the beetle *Aulacophora foveicollis* has a bright yellow and plain abdomen and elytra, and a black mesothorax and metathorax. The adult beetle has a head that is not elongated like a snout, long antennae of filiform species, in females it has a special feature, namely the shape of the pointed end of the abdomen. The average length of this beetle was 9.1 mm ± 0.99 (n=10). This beetle is collected while perching on the leaves of cempedak (*Artocarpus kemando* mix).

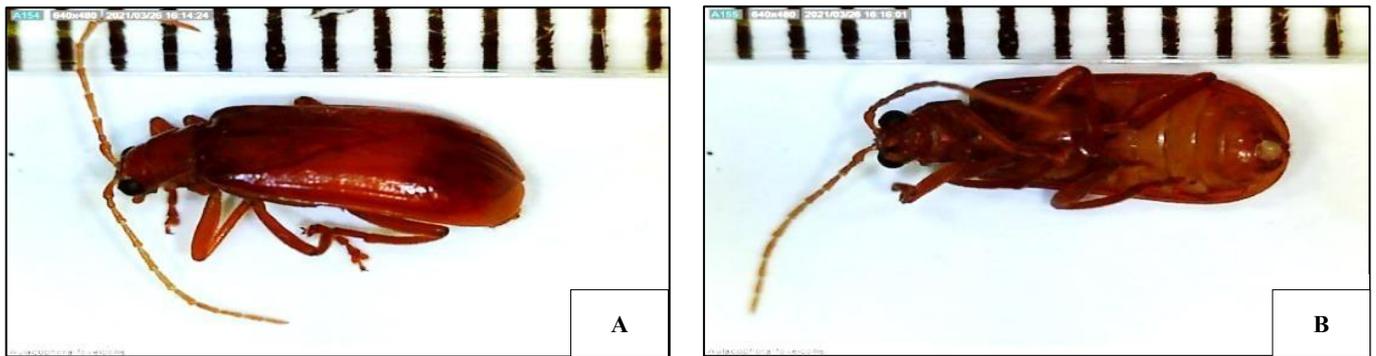


Figure 3. *Aulacophora foveicollis* (A) dorsal and (B) ventral

Aulacophora sp2

Aulacophora sp2 has a body length of 12-13 mm with reddish brown elytra. Pronotum *Aulacophora sp2* is not very long, the average length is 11mm ± 1.41 (n=10) and

has a transverse line in the middle. On the antennae, antenna number 1 has a brown spot at the base and a total of 11 antenna.

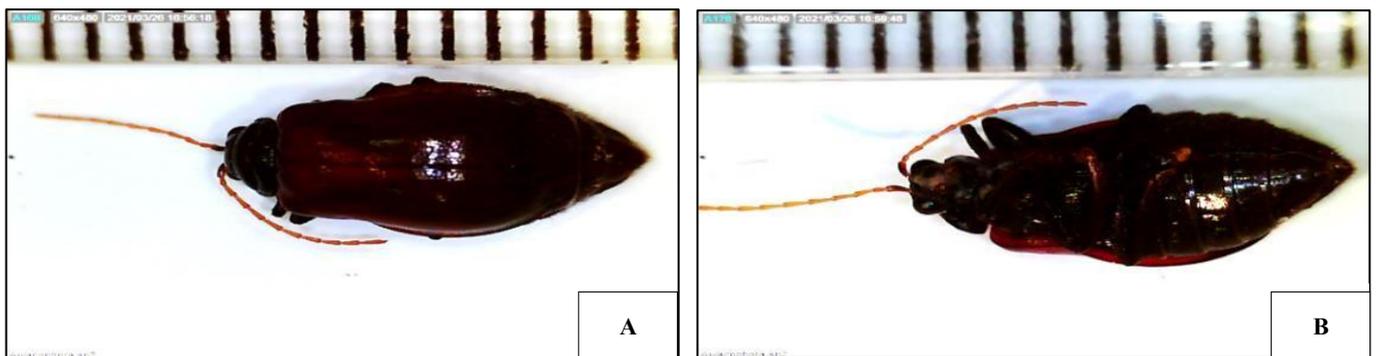


Figure 4. *Aulacophora sp2* (A) dorsal and (B) ventral

Neolepta biplagiata

Based on observations that have been made, the leaf beetle *Neolepta biplagiata* is a species of beetle that has a distinctive feature, namely its elytra have a pattern of 2 white circles, the elytra are shorter than the body so that they do not cover the entire body surface. The head is orange. This beetle has a body length of 7mm, the average length is 6.9 mm ± 1.20 (n=10) oval body shape

(slightly rounded), filiform species antenna. These characteristics are in accordance with those described by Hazmi and Wagner (2013), this beetle has a body length of 4.85-7.75 mm, a reddish-brown head, black elytra, smooth texture with transverse yellowish spots on each disc each elytra. This beetle is collected when it is perched on the leaves of jerik kawa (*Canthium dicocum*).

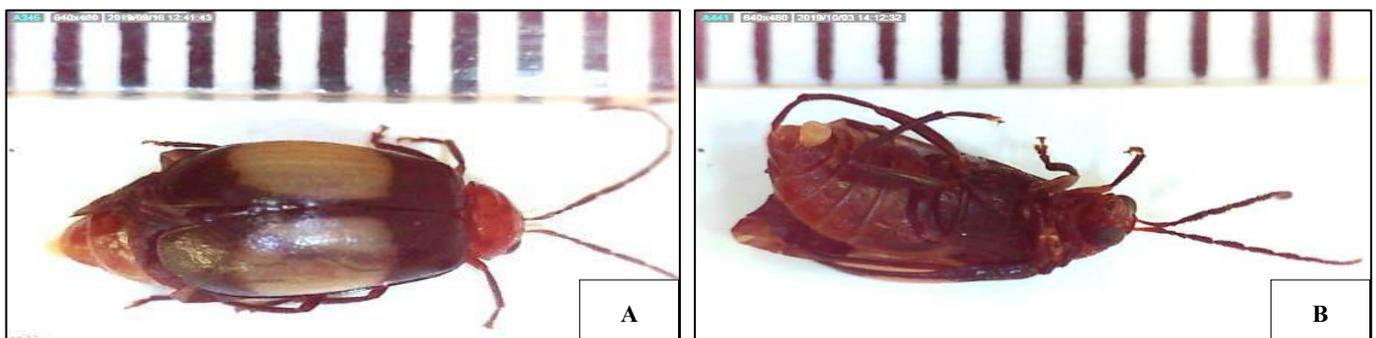


Figure 5. *Neolepta biplagiata* (A) dorsal and (B) ventral

Galerucella calmariensis

Based on the observations that have been made, the light brown *Galerucella calmariensis* beetle usually has a

black triangle or a thin black line, almost none. This beetle has a body length of 4-6 mm, the average length is 5.175 mm ± 2.81 (n=10).

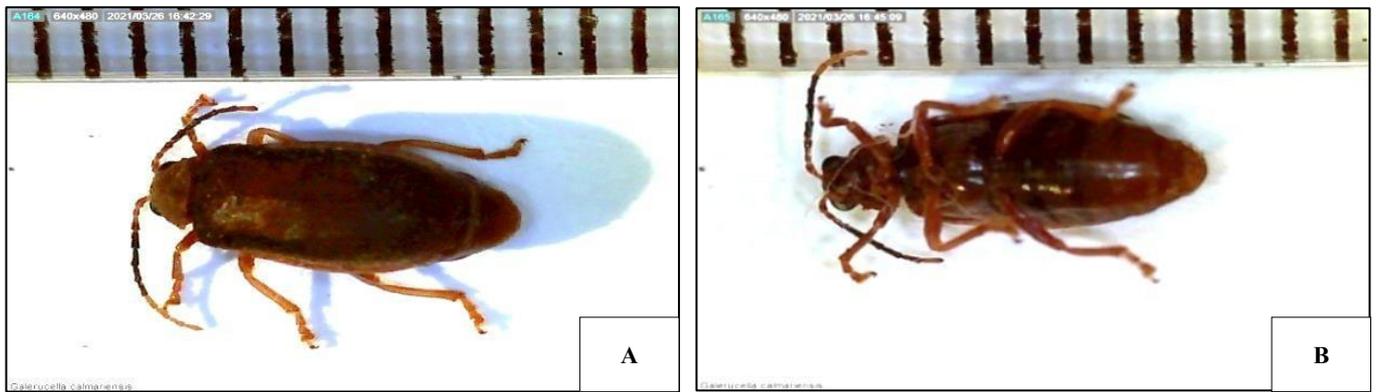


Figure 6. *Galerucella calmariensis* (A) dorsal and (B) ventral

Subfamily Criocerinae

Oulema melanopus

Based on the observations that have been made, this beetle has a black head shape and has a self-defense mechanism. Where this beetle can smear the dirt on its body to cover the bright color and prevent predators from attacking. Apart from that, other traits also give it a shiny black appearance, as opposed to yellow or white.

On average, it was $1.09 \text{ mm} \pm 8.38$ (n=10) in length and had dark blue wing flaps and red legs. The color of the thorax is red to orange to reddish brown. The difference between male and female *Oulema melanopus* is the difference in the shape of the abdominal segments. The male segment is more rounded and flatter or concave, and the female segment is more rounded and convex.

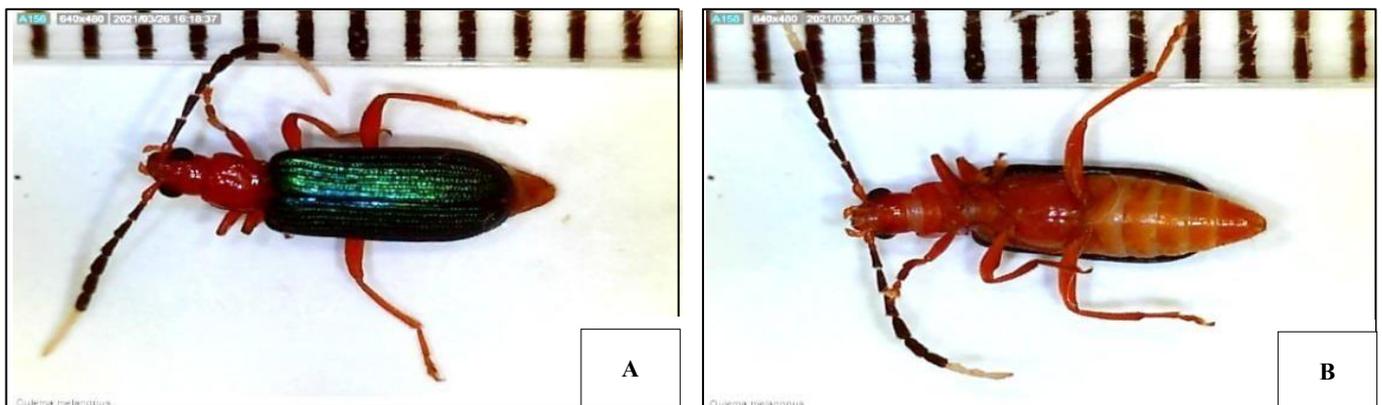


Figure 7. *Oulema melanopus* (A) dorsal and (B) ventral

Subfamily Crythocephalinae

One species of the subfamily Crythocephalinae, namely *Adiscus* sp. Based on the observations that have been made this beetle has a relatively small body length with a size of 5 mm. The average length was $4.575 \text{ mm} \pm$

0.50 (n=10), the head and elytra were brownish red in color and the body shape was convex and rounded. The pronotum is wide and the elytra cover the entire abdomen. The antennae 1-3 and 10-11 are brownish yellow and 4-9 are golden brown.

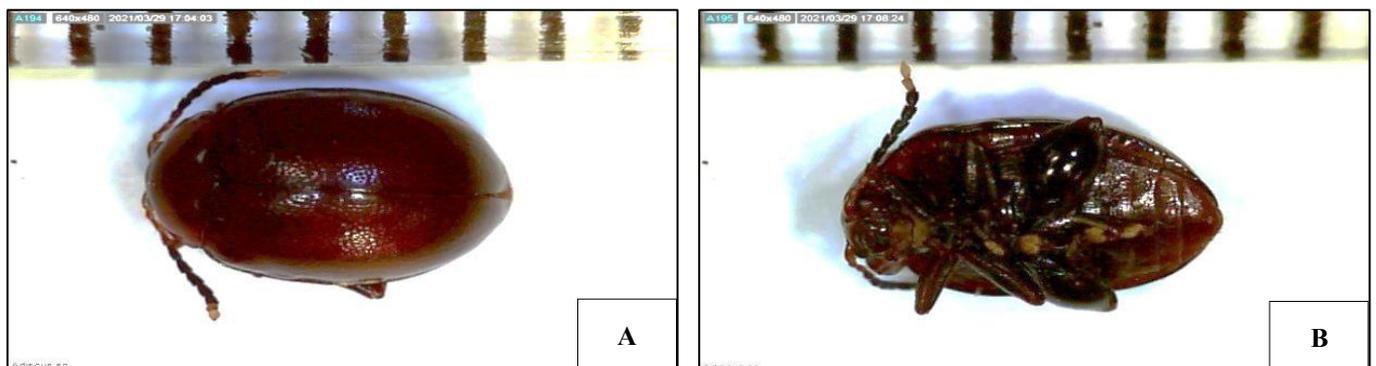


Figure 8. *Adiscus* sp (A) dorsal and (B) ventral

Subfamily Eumolpinae

The species found in the Eumolpinae subfamily is *Colospoides tuberculata*. This species has a special characteristic, namely the color is bright, has a relatively small body length with a size of 5 mm. The mean length

was 4.8 mm ± 0.79 (n=10), the head and elytra were golden green in color and the body was convex and rounded. The pronotum has a length-to-width ratio and the elytra cover the entire abdomen. Antenna 1-3 and 10-11 are reddish-brown in color.

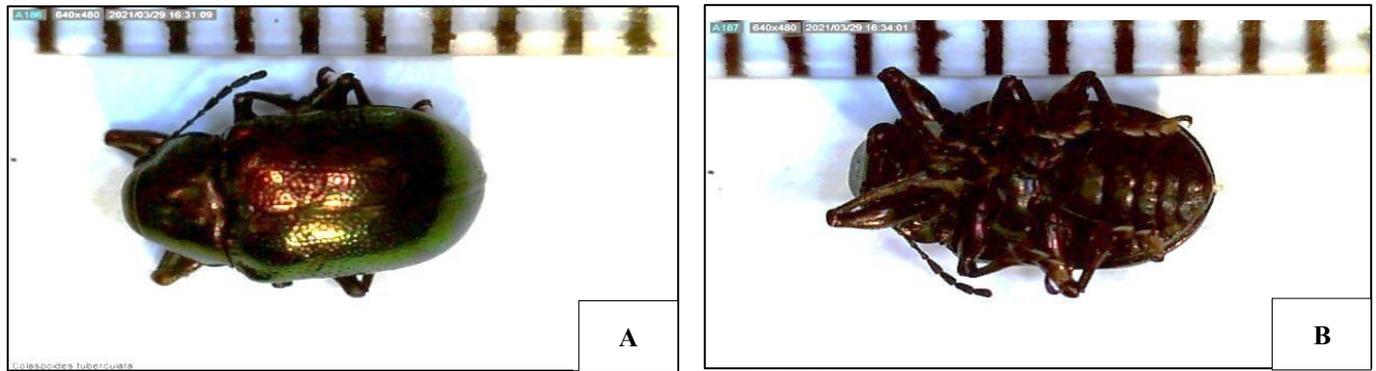


Figure 9. *Colospoides tuberculata* (A) dorsal and (B) ventral

Subfamily Cassidinae

Thalaspida biramosa

This subfamily has a special characteristic that is having a clear part that surrounds the body. *Thalaspida biramosa* has a body length of 6-7 mm. The mean length

was 5.9091 mm ± 0.83 (n=11) The head and elytra were golden green in color and the body was convex and rounded. The pronotum is golden brown and rounded. The elytra cover the entire abdomen. Antenna 1-11 is brownish yellow.

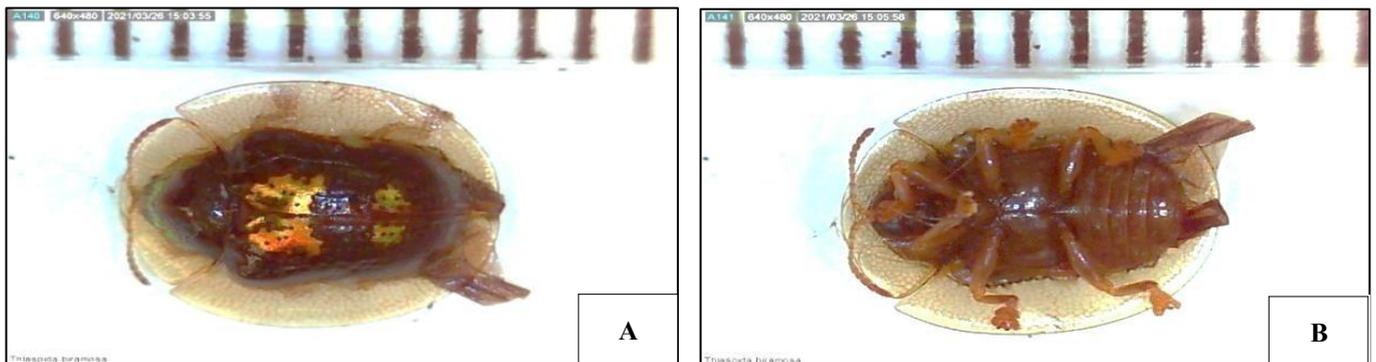


Figure 10. *Thalaspida biramosa* (A) dorsal and (B) ventral

Dactylispa aspera

Based on the results of observations that have been made, it is known that the main characteristics of this beetle are having spines on the upper part of its body, small in size with a body length of 5 mm. The mean

length is 4.977 mm ± 0.90 (n=11), the body is yellowish black, has long antennae and protruding eyes. This is in accordance with the statement of Supriyatin (1977) that adult beetles measure 4-5 mm wide 1.3-2 mm, yellow on the abdomen, other parts are black.

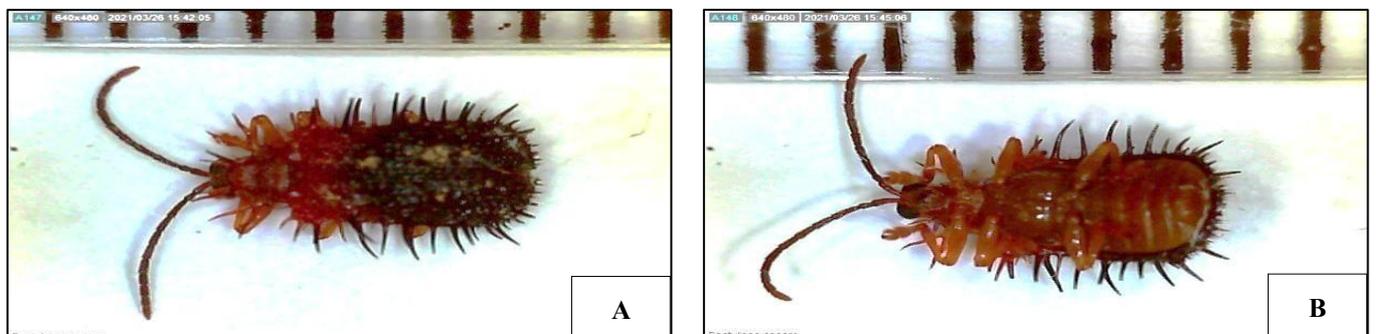


Figure 11. *Dactylispa aspera* (A) dorsal and (B) ventral

Conclusion

Based on the results of the research that has been done, it can be concluded that leaf beetles obtained at the Soraya Research Station were 37 species with 370 individuals. Leaf beetles in the Soraya Research Station area have a moderate diversity index value ($H' = 2.858$). The evenness index value of leaf beetle species at Soraya Research Station is high (0.792). Further research is needed because there are still many other beetles at the Soraya Research Station that have not been caught and identified, so that further research is more open to be carried out from various aspects.

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Author Contributions

Conceptualization, writing—original draft preparation, methodology, formal analysis, investigation, resources, data curation, funding acquisition, N.A.R.; writing—review and editing, visualization, supervision, project administration, validation, S. and A.R. All authors have read and approved the published version of the manuscript.

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Conflicts of Interest

There is no conflict of interest.

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