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Morphological and Physicochemical Characterization of *Rhychoporus* spp. on Aren Plants as a Food Source in Minahasa Regency, North Sulawesi

Sandra Augustien Korua

Agrotechnology Study Program, Faculty of Agriculture, Christian University of Indonesia Tomohon, Indonesia

E-mail: sandraa.korua68@gmail.com

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ABSTRACT

Rhychoporus spp., commonly known as the sago beetle Rhychoporus ferrugineus, is a pest that affects aren, rumbia, and coconut plants. Despite its pest status, the larvae of Rhychoporus spp. have long been recognized for their value as food and as ingredients in medicine and cosmetics. This comprehensive research, which thoroughly investigates the morphological characteristics and nutritional components of Rhychoporus spp. found in aren plants in Minahasa Regency, North Sulawesi Province, aims to provide a reliable and valid understanding of this species. The findings of this study have potential applications in the fields of entomology and food science. For entomologists, the detailed morphological characteristics of Rhychoporus spp. can aid in species identification and classification. For food scientists, the nutritional components of the larvae can be used to explore its potential as a food source and its applications in medicine and cosmetics. A descriptive method was used, involving field and laboratory research. The field study was conducted in Walensorit Village, Minahasa Regency. Morphological research used the Mizzi method, with measurements conducted using Carl Zeiss and Hirox KH8700 microscopes. The nutritional analysis included moisture, ash, protein, fat, carbohydrate, and fiber content, using standard methods such as drying, Kjeldahl analysis, Soxhlet extraction, and proximate analysis. The average body length of Rhychoporus spp. was 28.574 mm, with variations in abdomen length (8.936 mm), pronotum length (7.899 mm), head size (6.299 mm), and pronotum width (6.508 mm). The physicochemical analysis revealed that the larvae contain 70.04% water, 3.66% minerals, 1.35% calcium, 1.18% phosphorus, and 0.66% coconut minerals. The protein content was 7.78%, fat 19.04%, crude fiber 0.62%, and carbohydrates 2.33%. These comprehensive findings contribute to a better understanding of the species and its potential uses.

Keywords:
Morphology; Physicochemical Properties; Rhychoporus spp; Aren Plant

1. Introduction

North Sulawesi has many plantations, including coconut, clove, nutmeg, vanilla, cocoa, aren (sugar palm), sago, and rumbia. Among these primary plantation commodities, three plants belong to the Palmae family: aren (sugar palm), rumbia, and coconut (Novarianto, 2024). The government has developed these plants year after year, in line

with efforts to increase the country's foreign exchange through non-oil and gas export commodities, which play an essential role in Indonesia's economy. In addition to domestic needs, processed products from aren, rumbia, and coconut, particularly from coconut plants, are also exported to several countries in the form of coconut wood industry products, such as VCO, nata de coco, coconut flour, coconut shell charcoal, and coconut oil, as well as rumbia products, technical alcohol, and palm sugar (Halib et al., 2012; Hidayah and Hidayah, 2020; Rohman and Indrayanto, 2024; Yin et al., 2024)

Data from the North Sulawesi Plantation Office in 2009 show that damaged land covers an area of 21,941 ha out of a total plantation area of 395,665 ha, resulting in declining productivity. This is because of pest attacks. Although efforts have been made by the provincial government of North Sulawesi with a coconut plant rejuvenation development program covering an area of 1,895 hectares through the state budget and a rehabilitation development pattern for coconut plants through the state budget, controlling bud rot over 1,014 hectares, *Sexava* spp. over 300 hectares, and *Oryctes* spp. over 350 hectares, pest attacks persist.

Rhychoporus spp. is a pest that damages plants in the palm family (Ames, 1998; Wahizatul Afzan Azmi et al., 2013). This has been recorded as one of the leading causes of death for coconut plants in several regions of Indonesia. One of the regions in East Java in 2000, known as one of the centers for coconut production, suffered losses of tens of thousands of hectares, and the southern coastal areas nearly faced extinction due to this pest. (Francardi et al., 2013). The stages of damage are the larvae and imago of the *Rhynchophorus* spp. Beetle (Hoddle et al., 2024).

The larvae of *Rhychoporus* spp. are detrimental to palm tree farmers because this pest attacks the trunk or growth point of plants that have been affected or enter through mechanical wounds, such as those left by the ceteng of fronds. This attack made Palmae plants unable to produce new leaves, and subsequently, the plants could not be produced. According to previous reports, the damage caused by this pest can lead to plant death. This is detrimental to farmers because the production of aren plants is disrupted. Caterpillars damage trees by boring into the trunk or shoots of the coconut tree to seek out young tissues that contain much moisture (Chougale et al., 2023; Pracaya, 2003; Rakubu et al., 2024)

The larvae of *Rhychoporus* spp. have long been known by the community in the Minahasa Regency, North Sulawesi Province, as a food source referred to as "Lingsen" or "Water." The community processes *Rhychoporus* spp. larvae as a satay. The larvae are grilled over a fire-like satay and can be prepared by frying them in a pan without cooking oil.

The *Rhychoporus spp*. It is essential to study Sulawesi because of the diversity of flora and fauna, which is a high Wallacea zone. Many researchers from around the world visit Sulawesi to study its flora and fauna because of its high level of diversity. Many members of *Rhychoporus* spp. species with intra-and interspecies morphometric similarities are interesting to study. This phenomenon is also found in Apis dorsata, where Apis dorsata in Thailand is morphologically different from Apis dorsata in North Sulawesi; however, many experts still classify them as one species.

In addition to its beneficial role in society, when viewed biologically, the identity of the taxonomy and lineage of Rhynchoporus spp. found in Minahasa is not yet clearly understood. *Rhynchoporus* spp. (*Rhynchoporus* ferrugineus) originate from South Asia and Melanesia. Based on the theory of evolution, species that have been geographically

isolated for years can change certain traits owing to mutations influenced by the environment, potentially leading to speciation or the emergence of a new species. Additionally, *Rhynchoporus* spp. are invasive species that typically have a high level of adaptability; therefore, it is necessary to study the morphological identification and physicochemical properties of *Rhynchoporus* spp. from North Sulawesi.

2. Materials and Methods

2.1 Place and time

Field research was conducted in Walensorit Village, Minahasa Regency. The research was conducted at the Anatomy and Physiology Laboratory of the Biology Department, FMIPA, Manado State University.

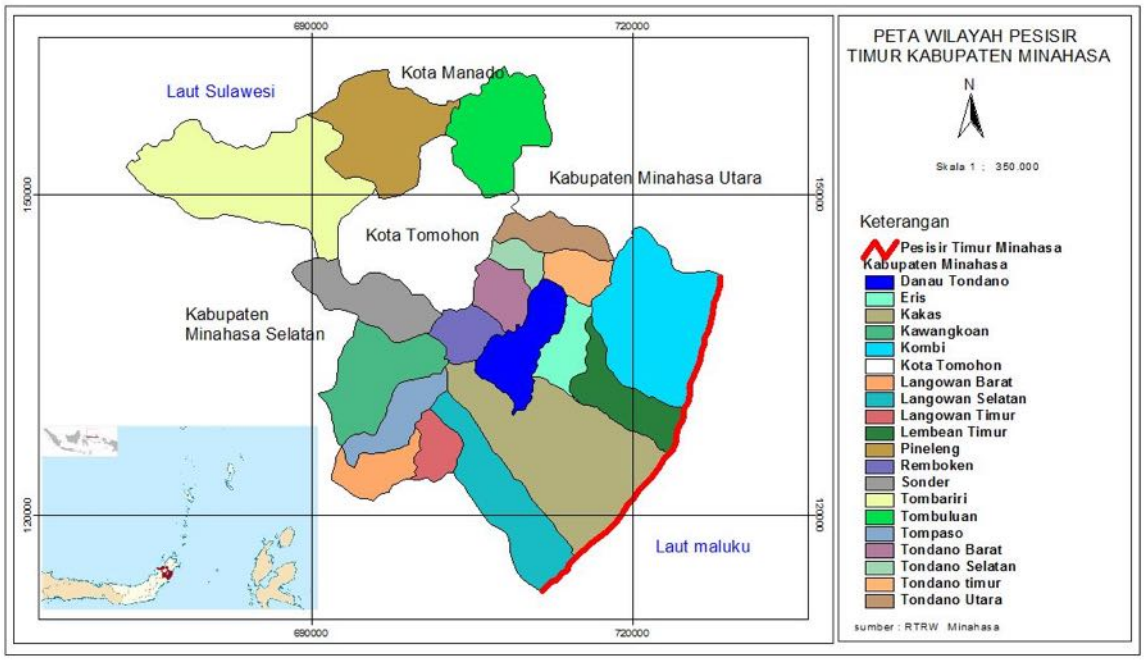

Figure 1. Map of the eastern coastal area of Minahasa Regency

2.2 Tools and Materials

Live samples of larvae and images of *Rhychoporus* spp. were brought to the laboratory, and the imago was preserved in 70% ethanol. Village Thirty individuals from both the larva and imago were collected from Walensorit Village.

The tools used in this study included a set of surgical instruments for morphological analysis, glass slides, Petri dishes, a Carl Zeiss binocular microscope, a Hirox KH8700 digital 3D stereomicroscope with body organ measurement software and video, a Parkin Elmer UV-Vis spectrophotometer, a set of Eppendorf micropipettes, a Mammert incubator, an Eppendorf ultracentrifuge, Pyrex glassware, an analytical balance, sample bottles, and sample boxes. The materials used were 70% alcohol, Merck pure ethanol, and labeled paper.

2.3 Research Procedure

2.3.1 Sampling

The larvae and imago of *Rhychoporus* spp. from aren plants were collected in Walensorit Village. (AR). The *Rhychoporus* sp. Larvae and Imago
from aren plant, can be seen in Figure 2.

Figure 2. *Rhychoporus* sp. Larvae and Imago from aren plant

2.3.2 Sample Handling

The samples were divided into three groups: morphological character analysis, physicochemical property analysis, and DNA genetic diversity analysis. The samples used for morphological character analysis were soaked in 70% alcohol, whereas samples used for DNA genetic diversity analysis were soaked in 90% alcohol. The sample bottles were stored in a sample box and labeled for transport to the laboratory.

The aren plant waste collected from Walensorit Village was stored in plastic containers, and *Rhychoporus* spp. larvae and imagoes were collected from the aren plant waste and cleaned. Subsequently, *Rhychoporus* spp. they were brought to the laboratory for testing. The Waste material from *Rhychoporus* spp. Activities and Collecting the Larvae and Imago of *Rhynchophorus* spp. can be seen in Figure 3.

Figure 3. The Waste material from *Rhychoporus* spp. Activities (A) and Collecting the Larvae and Imago of Rhynchophorus spp. (B)

2.3.3 Morphometric Analysis of Rhychoporus sp.

The following morphological parameters were measured: Total body length (l), Abdomen length (al), Pronotum length (pl), Pronotum width (pw), Head size (hs), and Distance from the tip of the rostrum to the antenna (ta).

The morphological characterization of *Rhynchophorus* spp. was conducted using the methodology outlined by Mizzi et al. (2009). Measurements were obtained using a Carl Zeiss binocular microscope and a Hirox KH8700 digital stereomicroscope stereo microscope. Morphometric analysis was performed following the procedures detailed by Mizzi et al. (2009) (Mizzi et al., 2009). The measurement techniques are according to the Mizzi method in Figure 4.

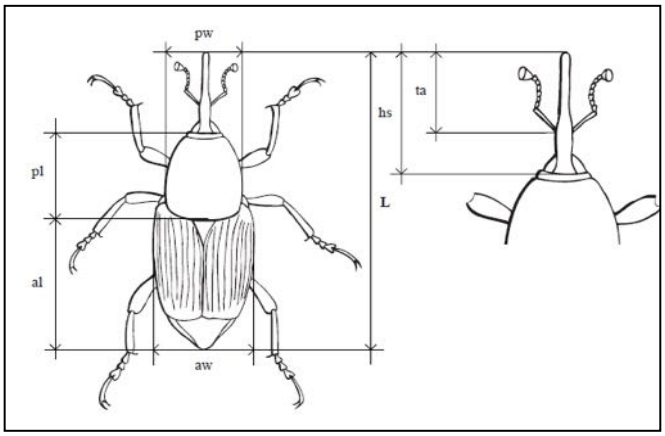

Figure 4. Measurement techniques according to the Mizzi method

3 Results and Discussion

3.1 Morphological Characteristics of Rhychoporus spp. on Aren Plants in Minahasa

Based on measurements of the Morphological Characteristics of *Rhychoporus* spp. from aren plants in Minahasa Regency, North Sulawesi Province, it was found that the average body length (L) of the insects from the aren plants was a maximum of 38.133 and a minimum of 18.121, with an average morphometric measurement of 28.574. The results of the morphological measurements of *Rhychoporus* spp. on aren Plants in Minahasa Regency, North Sulawesi Province, are shown in Table 1.

Table 1. The morphological measurements of *Rhychoporus* spp.

Size	Morphological Characteristic (mm)					
	L	al	pl	pw	hs	ta
Max	38.133	13.121	12.438	6.232	9.024	8.242
Min	18.121	4.138	4.51	4.592	4.121	5.012
Average	**28.574**	**8.936**	**7.899**	**6.508**	**6.299**	**6.541**
Sd	8.246	3.319	2.984	1.308	1.857	1.296

Description: L (total body length) al, (abdomen length) pl, (pronotum length) pw, (pronotum width); hs (head size); ta, distance from the rostrum tip to the antenna tip.

In addition to the morphological characterization of *Rhychoporus* spp., observations were made on other body organs, such as the following:

3.1.1 Rhychoporus spp. Antenna

The antenna was observed by photography using a Carl Zeiss binocular microscope and Hirox KH8700 digital 3D stereomicroscope. The results of the observation of the antenna of *Rhychoporus* spp. from the aren plant are shown in Figure 5.

The last segment of the antennae flagella of *Rhychoporus* spp. from the aren plant was black. This color is different from that of *Rhychoporus* spp. from other plants and is suspected to be caused by the color of the plant species.

Figure 5. *Rhychoporus* spp. from aren plant-isolated antenna.

3.1.2 Limb Structure

Figure 6. Front limb structure of *Rhychoporus spp*. from aren plant.

The limb is one of the appendages on the thorax besides the wings; the insect's limb consists of the first segment called the coxa, which attaches directly to the thorax. The second segment, the trochanter, is shorter than the coxa and partially unites with the third segment.

The third segment, the femur, is the largest. The next segment, the tibia, is usually slimmer. The tip had spines on the spur. The final segment is called the tarsus. The tarsus usually consists of 1-5 segments. The limbs obtained from *Rhychoporus* spp. were black and densely hairy, and the hair was clustered on the tibia.

In Figure 7, it can be seen that the front limb femur receptor of *Rhychoporus* spp. is gray. The pronotum is the notum of the prothorax. The thorax is the second part of the insect's body and is connected to the head by a neck called the cervix. The thorax comprises three segments: the proto-thorax, mesothorax, and metathorax. Each thoracic segment can be divided into three parts: the dorsal part is called the tergum or notum, the ventral part is called the sternum, and the lateral part is called the pleuron

(plural = pleura). The pleuron consists of two parts, the episternum and epimeron, separated by an oblique unit. The sclerites found on the sternum and pleuron are known as the sternites and pleurites. The sclerite found on the tergum is called tergite.

The width of the pronotum (pw) showed a maximum average width of 6.232 and a minimum of 4.592, with an average morphometric value of 6.508. The pronotum (pl) showed a maximum average length of 12.438 and a minimum of 4.51, with an average morphometric value of 7.899 and a standard deviation of 2.984.

Figure 7. Front limb femur receptor of *Rhychoporus* spp. from aren plant.

3.1.3 Rhychoporus spp. head

From the research results, the average head size (hs) in aren was found to be a maximum of 9.024 and a minimum of 4.121, with an average morphometric measurement of 6.299.

The head has mouthparts, antennae, and eyes. The position of the head based on the location of the mouthparts of *Rhychoporus* spp. is prognathous (horizontal) because part of the mouthparts faces forward, and this insect is usually active in pursuing prey. The mouthparts of *Rhychoporus* spp. found in coconut larvae in Temboan village, rumbia, and aren in Temboan and Walensorit villages were characterized by the presence of mandibles. Chewing instruments are characterized by mandibles that bite or cut food materials and chew with other parts. This type of mouth is known as the mandibulate type.

Table 2. Analysis of the Physicochemical Properties of *Rhynchophorus* spp. Larvae as a Food Source from Aren Plants in Minahasa Regency, North Sulawesi Province.

Physicochemical Properties	
Parameter	**Analysis Result (%)**
Water Content	70.04
Ash	0.79
Protein	7.78
Fat Content	22.82
Rough Fiber	0.62
Carbohydrates	2.33

The abdomen is the belly part of an insect and is the body part that undergoes only slight changes, including changes in the digestive organs. The research results show the abdomen length (al) of *Rhychoporus* spp. ranges from 13.121 to a minimum of 4.138, with an average morphometry of 8.936.

a. Water Content

The water content of the larvae of *Rhychoporus* spp. from the aren trees was 70.04%. The development of insects is closely related to their environmental conditions. Food quantity and quality are the main factors that significantly affect the life and development of insects. Previous research shows aren trees have a higher water content than rumbia and coconut trees. Similarly, the production results from aren trees, such as aren nila, show a water content composition of 88.85%.

Water is an essential material for living organisms. Food type and water content species food type and water content generally influence insect species' development. (Jumar, 2000). Higher moisture content affects the host trees and the food preference for insects, where insects prefer host trees with high moisture content. Therefore, the larvae found on the aren tree had high water content.

b. Ash

The results showed that the ash content of *Rhychoporus* spp. larvae was 0.79%. According to data from the Indonesian Ministry of Health, aren trees have an ash or mineral content of 3.66%, with calcium at 1.35% and phosphorus at 1.18%. Mineral elements are known as organic substances or ash. Currently, it is known that there are 14 different types of mineral elements required by humans for good health and growth. Macro-minerals include Sodium, Chlorine, Calcium, Phosphorus, Magnesium, and Sulfur. Microminerals include Iron, Manganese, Copper, Zinc, Cobalt, and Fluorine. The functions of Sodium and Calcium are related to the formation of blood plasma and bone. Chlorine activates amylase enzymes in the mouth to produce taste carbohydrates. Calcium and Phosphorus play a role in forming bones and teeth and regulating blood circulation. Osteoporosis can occur when the calcium levels decrease.

In individuals with sodium deficiency, there is a feeling of thirst when sodium is lost, leading to a decrease in extracellular fluid, which, in turn, causes a drop in osmotic pressure and body fluids. This results in water entering the cells, thereby increasing the osmotic pressure. The volume of fluids, including blood, decreases, resulting in decreased blood pressure. In the case of sodium deficiency in humans, vomiting or diarrhea can occur.

c. Protein

The larvae of *Rhychoporus* spp. had a protein content of 7.78%. This is because the *Rhychoporus* spp. aren larva chooses food from its host tree, aren, which has a high protein content. Based on a previous study, the protein content of Aren sap is 0.23%, indicating that *Rhychoporus* spp. aren consumes protein from the aren tree, which serves as fuel for its life and as a building material. Protein is an essential nutrient because, in addition to serving as a fuel in the body, it also functions as a building and regulatory substance.

Proteins are amino acids that contain Carbon, Hydrogen, Oxygen, and Nitrogen atoms. Protein molecules contain Phosphorus and sulfur, and some proteins contain trace elements, such as Iron and Copper. As building substances, proteins serve as the material for forming new tissues that constantly occur in the body.

d. Fat Content

The fat content of the larvae of *Rhychoporus* spp. from the aren tree was 22.82%.

e. Rough Fiber and Carbohydrates

The results showed that the crude fiber content of Rhynchophorus spp. larvae from the aren tree were 0.62%, while the carbohydrate content was 2.33%.

4. Conclusion

Based on the results and discussion, the following conclusions can be drawn: The morphological characteristics of *Rhychoporus* spp. from the aren plant in Minahasa Regency were found to be as follows: the average body length (L) was a maximum of 38.133 mm and a minimum of 18.121 mm, with an average morphometric measurement of 28.574 mm. The length of the abdomen (al) of the Rhinchophorus sp. insect from the Aren plant was only 8.936 mm, with a standard deviation of 3.319 mm, and the length of the pronotum (pl) was only 7.899 mm, with a standard deviation of 2.984 mm. The head size (hs) of the Rhinchophorus sp. from the Aren plant was only 6.299 mm, with a standard deviation of 1.857 mm. The width of the pronotum (pw) of Rhinchophorus sp. from the Aren plant was only 6.508 mm, with a standard deviation of 1.308 mm.

Physicochemical analysis of *Rhychoporus* spp. from the aren plant showed that the water content of *Rhychoporus* sp. larvae was 70.04%. The mineral content of *Rhychoporus* sp. was 3.66%, with a total calcium content of 1.35% and a phosphorus content of 1.18%. The protein content was 7.78%. The fat content is 19.04%. The crude fiber and carbohydrate contents were 0.62% and 2.33%, respectively. From the results of this study, it can be concluded that it is necessary to conduct studies on the morphological characteristics and physicochemical properties of *Rhychoporus* sp. as a source of food and medicine in other palm plant species.

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