DEVELOPMENT AND DISTRIBUTION STATUS OF *SEXAVA CORIACEA* (ORTHOPTERA: TETTIGONIIDAE) ON COCONUT CROPS IN NORTH MALUKU

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Info Artikel

Keywords:
quarantine pest; copra; midribs, long-horned grasshopper

Abstract

Sexava coriacea is the most important pests on coconut in North Maluku. The insects known as coconut treehoppers cause damage to foliar defoliation. S. coriacea attacked coconut crops in Sula-Mangoli Islands first reported by C Willemse in 1930. The reports of the pest monitoring program over the last ten years showed symptoms of moderate attack levels on the leaves which could be controlled. In 2022, there were another pest outbreaks in Halmahera and Sula Islands that inflicted serious leaflets damage on coconut. The research aimed to study the development and distribution of S. coriacea on coconut plantations in the Maluku Islands. The study was used a purposive sampling method in the planting area which showed symptoms of an attack and the presence of the pest target. The pest specimens obtained were identified by morphological characteristics. Leaf damage level obtained was further developed with five categories; healthy, mild, moderate, severe, and very severe. The results showed S. coriacea found in Galela, Sahu, Bacan, and Sanana. Damage rates of coconut crops were calculated in North Halmahera reached 76-100%; West Halmahera reached 26-50%; South Halmahera reached 1-25%; and Sula Islands reached 51-75%.

Kata kunci:
hama karantina, kopra, pelepah daun, belalang pedang

Abstrak

Sexava coriacea adalah hama penting pada kelapa di Maluku Utara. Serangga dikenal sebagai belalang kelapa menyebabkan kerusakan pelepah daun. *S. coriacea* pertama kali dilaporkan oleh C Willemse tahun 1930 menyerang kelapa di Kepulauan Sula-Mangoli. Laporan pemantauan hama pada sepuluh tahun terakhir menunjukkan gejala serangan daun dari sedang sampai berat namun masih dapat dikendalikan. Tahun 2022, ledakan hama terjadi di Halmahera dan Kep Sula mengakibatkan kerusakan daun cukup serius. Penelitian bertujuan mempelajari perkembangan dan status sebaran *S. coriacea* pada perkebunan kelapa Maluku Utara. Kajian menggunakan metode *purposive sampling* pada area perkebunan yang menunjukkan gejala serangan dan keberadaan hama target. Spesimen diidentifikasi berdasarkan karakteristik morfologi. Tingkat kerusakan daun dihitung berdasarkan empat katogori meliputi sehat, ringan, sedang, berat dan sangat berat. Hasil menunjukkan *S. coriacea* ditemukan di Galela, Sahu, Bacan dan Sanana. Tingkat kerusakan kelapa di Halmahera Utara mencapai 76-100%, Halmahera Barat 26-50%, Halmahera Selatan 1-25% dan Kep Sula mencapai 51-75%.

INTRODUCTION

Coconut (Cocos nucifera) is the one of leading plantation products in North Maluku in addition to cloves, cashew nuts, and cocoa beans (BPS, 2021). North Maluku consisted of a group of islands that have a long coastline dominated by coconut crops. There were ten regencies of North Maluku province consisting of Ternate, Tidore Islands, West Halmahera, North Halmahera, Central Halmahera, South Halmahera, East Halmahera, Sula Islands, Taliabu Island, and Morotai Island. Annual production data showed a decline on copra yields in four main coconut crops area including West Halmahera, North Halmahera, South Halmahera, and the Sula Islands was marked by the reduced volume of coconut shipments for export.

Copra was used to extract coconut oil to become Virgin Coconut Oil (VCO) and consumed directly as a part of a food ingredient in the world (Arunima and Rajamohan, 2016; Mulyadi et al., 2023). Copra has been exported to China, Spain, India, Malaysia, Netherlands, Singapore, and USA reached 34,565 tons (Djoni et al., 2013). The contribution of Indonesian coconut products reached 30,12% for the world. The Philippines, India, Brazil, and Srilanka contributed 25,85% of coconuts; 17,54%, 4,95%, and 3,47% respectively (Aulia et al., 2020). Copra production decline reached 65% in the last five years of total production in North Maluku especially originated from Sula Islands and Halmahera (IAQA, 2021).

The main factor that influences the total decrease in coconut yield is pest outbreaks caused by Sexava coriacea (Orthoptera: Tettigoniidae). The pest belongs to the suborder Ensifera which can attack coconut leaves massively and quickly (Lahati and Saifudin, 2022). C Willemse identified Sexava from South Halmahera (Obi Islands) in 1953 and allocated the species correctly to S. coriacea (Willemse, 1979). Darwis (2004) reported that the Sexava attacked coconut plants in Talaud and Sangihe Island at a very severe level. The young grasshoppers are known as hoppers, for at this stage they are flightless until eats banana leaves as an alternative host plant (Lloyd, 1981; Doubell, 2017). Normally, young Sexava takes four weeks for hoppers to become adults but when the pests found coconut trees, their development switches to the fast track.

As the coconut plantation in one place begins to run out, the winged adults release distinctive sounds (species-specific calling songs) which tell others in the group that they must move to come and when groups merge, they form a swarm (Gu et al., 2012; Alouw and Hosang, 2016). Sexava eats its entire body weight every day and a whole swarm can consume all leaf midrib of coconut and oil palm (Egonyu et al., 2022). Following the flow of leaf midrib means that the pests always heading toward areas of the plantation start to grow. Eco-friendly traps to control Sexava were conducted in Talaud District, North Sulawesi in 2007 to bring down the population of the insects (Hosang and Alouw, 2010).

The presence of the Sexava insects in Indonesia was designated as a quarantine pest including S. coriacea (local name: Ambon treehopper), S. nubila (Boto-boto treehopper), and S. karnyii (Togean treehopper). The insects cut a swathe of destruction through their remaining copra supplies in Indonesia, they are called the long-horned grasshoppers (Syahlan et al., 2017; Wagiman et al., 2019), katydids (Tan et al., 2020), and Bush crickets (Jackson, 2001). In North Maluku, S. coriacea is a protected species yet Agricultural Quarantine Agency is also at the forefront of anti-treehopper control. Regulation in the food trade countries feels a particular responsibility as they alone have the scientific knowledge and the financial means to pursue pest control.

Coconut treehoppers are not found only in the developing countries of Southeast Asia and elsewhere but also in isolated islands. Indonesia is an archipelago country consisting of several islands and much of the coastal land has been depleted by excessive coconut monoculture. S. coriacea was first reported by C Willemse (1930) in Sula-Mangoli, Buru, Bacan, Halmahera, Sangir, and Ambon Islands. The specimens were collected by Rijksmuseum van Natuurlijke Historie (RNH), Leiden. This together with the coconut treehoppers invasion is causing serious problems for an otherwise prosperous land. S. coriacea still can't travel far by themselves but the task force has to make sure that cargo ships as pathway food trades must be sterile from eggs, nymphs, and imago. At all costs, the treehoppers must be kept from spreading to other areas.

The research was aimed to study the development and distribution of S. coriacea on coconut plantations in the Maluku Islands. Pest monitoring was carried out to obtain the latest data on the distribution of pests in the North Maluku region on coconut commodities. This data was used as a reference in determining the map of the national distribution area and the basis for making decisions on quarantine measures in the field.

MATERIAL AND METHODS

Pest monitoring

Monitoring and discovery of coconut treehoppers were carried out from March to April 2022 on three major islands in North Maluku including Halmahera Island, Bacan Island, and Sula Islands. The research method was used purposive sampling based on signs and symptoms of pest attacks on coconut crops. Symptomatic coconut leaves were observed in North Halmahera, West Halmahera, South Halmahera, and Sula Islands. Observation of insect population was counted directly on coconut crops.

Specimens collection

This identification was conducted at the Plant Quarantine Laboratory of Ternate (ISO/IEC 17025: 2017 No. LP-1033-IDN), North Maluku, Indonesia. Specimen identification equipment i.e. stereo microscope, petri dish, dissection set, tweezers, brush, preparation pins, collection box, and keys of Sexava. The materials consisted of cotton, silica gel, transparent nail polish, tissue, filter paper, label, and insect pins. A specimen of cotton in a petri dish was positioned under the microscope and the body parts were observed from the caput, thorax, and abdomen. The subgenital plate is the main characteristic of S. coriacea consisting of the lobe, styli, and cerci of the male imago. Specimens were identified and compared with a literature study according to Willemse (1977). Specimens were inserted using silica gel into the collection box and given a note or label consisting of the scientific name, order, origin or location, collector and analyst name, date's collection, and identification.

Damage rates measurements

Techniques for assessing crop damage caused by Sexava have been developed by Balitka (1990), as follows:

1. *Randomly select 10-20 coconut trees that are attacked by Sexava pests and take/cut off the leaf midrib in the middle of the crown.*
2. *Take/cut the leaflets to 20, 40, and 60 on the youngest leaf midrib without cutting the midrib.*
3. *Measure the area of the leaf eaten on the four leaflets (20, 40, 60, and 80 leaflets) calculated from the base of the leaf midrib.*
4. *To calculate the level of leaf damage, each leaflet taken was measured in two places at a distance of 10 and 30 cm from the base of the leaflet. If the area has been damaged by pests, it can be estimated by using the leaflets to 20 and 40 from the youngest leaf. If this damage occurs in the leaflets to 60 and 80, then use the same number of leaflets from that tree as well in the next observation. Calculation of the area of the whole leaf child is carried out as follows:*

   (Width at 10 cm + width at 30 cm) x 10
5. *If less than half of the leaflets are eaten, the area of the leaf eaten can be calculated using transparent plastic (5 x 20 cm) made of rectangular lines with an area of 1 cm^2 each.*
6. *If more than half of the leaf area is eaten, then only the remaining leaf area is calculated. In this way, the percentage of leaf damage can be calculated.*

The level of damage obtained was further developed with five categories, namely healthy (score 0), mild (score 1 = level of leaf crown damage 1-25%), moderate (score 2 = level of leaf crown damage 26-50%), severe (score 3 = crown damage rate 51-75%), and very severe (score 4 = crown damage level 76-100%) (Wagiman et al., 2012; Lala et al., 2014).

RESULTS AND DISCUSSION

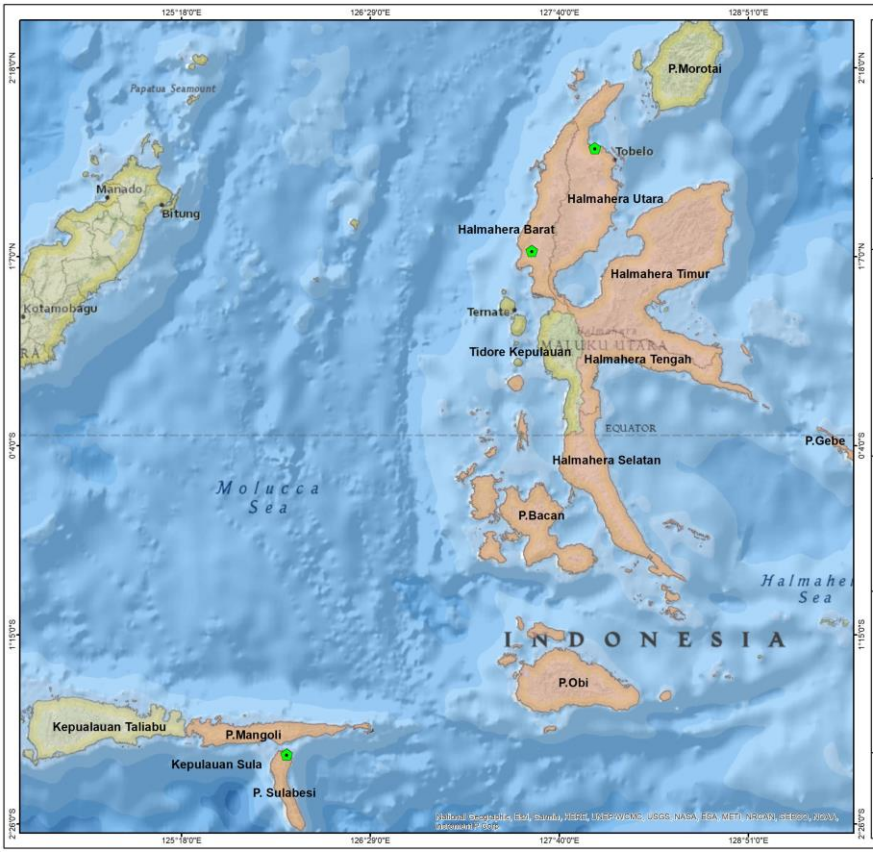
Geographical distribution

Sexava coriacea has a wide host range i.e Asplenium nidus (bird's nestfern), Arenga pinnata (sugar palm), Areca catechu (betelnut palm), Musa spp. (banana), Cocos nucifera (coconut),

ISSN (Print): 1693-0738
ISSN (Online): 2714-5549
Innofarm: Jurnal Inovasi Pertanian Vol. 25 (2), Oktober 2023

Metroxylon sagu (sago palm), orchids, Pandanus spp., Salacca edulis (snake fruit), and Zingiber officinale (ginger). According to Agrawal et al. (2006), the evolution of host plant selection was influenced by plant quality rather than plant diversity in the field. Thus, the Palmae crops are a potential host in terms of quality and quantity for the spread of S. coriacea. The insects were disseminated by fruits, plants, leaves, rhizomes, and soil. According to Quarantine Pests Regulation based on the Minister Agriculture Number 25 the year 2020, one of the quarantine pests from Sexava i.e S. coriacea needed to be wary of pests spreading.

The geographical distribution of S. coriacae was recorded in Sangihe, Talaud, Banggai, Maluku, North Maluku, and Papua islands. Hosang (1989) reported the accidental introduction of S. coriacea in Sangihe Island, North Sulawesi. In 2013, Sexava was reported by the Plant Quarantine Laboratory of Ternate in Pastina, Sula Islands. Recent quarantine pest reports have found the discovery of S. coriacea in North Halmahera, West Halmahera, and Sula Islands (Picture 1).



Picture 1. *Distribution of Sexava coriacea in North Maluku*

Some previous records should be discussed because the exact type was not known. The occurrence of Sexava in the Sula Islands should be confirmed after a comparative test with specimens from Indonesian Coconut and Other Palmae Research Institute (ICOPRI), Manado in 2017. Plant Quarantine Laboratory of Ternate examines the especially critical areas in South Halmahera which were spared before because the coconut crops were too sparse and difficult to attract the pests.

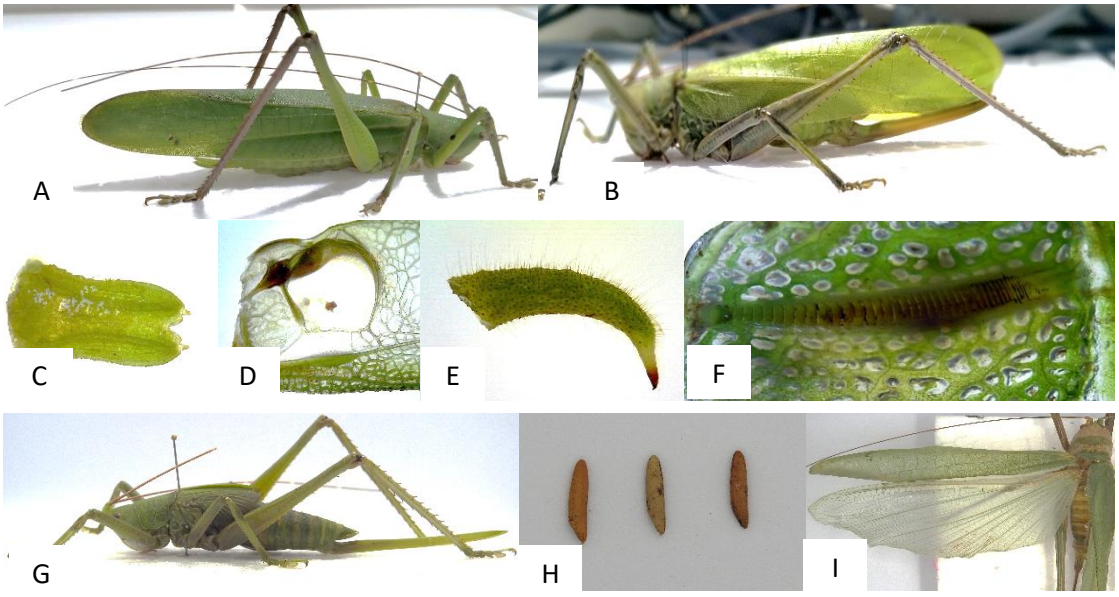
Table 1. *The discovery of S. coriacea in Halmahera and Sula Islands in the last ten years.*

No	***District***	***Pests monitoring period***									
		2013	***2014***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***	***2021***	***2022***
1	*North Halmahera*	-	-	-	-	√	√	-	-	-	√
2	*West Halmahera*	-	-	√	√	√	√	√	√	√	√
3	*South Halmahera*	-	√	-	-	√	√	√	-	-	-
4	*Sula Islands*	√	√	√	√	√	√	√	-	√	√

Source: IAQA Pests Monitoring Reports

Morphological character

S. coriacea generally has morphological characteristics of a large body (reached 60-85 mm), consisting of green or brown body color. In male imago, it has a wide subgenital plate, shorter apical insertion, wider lobe, shorter styli, and has a longer cerci, and a tapered tip. In female imago, the subgenital plate is usually shorter than it is wide, has an ovipositor reached 40-50 mm, and the wing tip usually does not reach the ovipositor tip (Picture 2).



Picture 2. *A: male imago (♂), B: female imago (♀), C: subgenital plate (♂), D: lobe (♂), E: cerci (♂), F: stridulatory (♂), G: nymph (♀), H: wings, and I: eggs.*

Hind legs (femur) are modified very broad and thick which indicates that there's a lot of muscle to move and jump to other leaf midribs. A wingspan of more than 65 mm, the hind femur has no black markings, the femur length reached 43-48 mm. This is a physical adaptation of Sexava to accommodate a jumping lifestyle basically. There are two wings, the one in front that it's quite hard (the fore wing reached 65 mm) and the soft membranous hind wing underneath. Femurs and wings can be used to empower the S. coriacea movement further and faster than if it were just jumping. The oval-shaped membrane (tympanum) in the middle of the body it's a thin membrane on a warm summer night that can make sounds (Shishodia, 2000; Tiwari, 2020). The specific sound produced by the stridulatory is almost hardened and covered by wings. Sexava is a noisy animals and they communicated by sound at night (Bahrun et al., 2013).

Sexava can be distinguished from other species by observing the subgenital plate of male imago (Wilemse, 1977). Alouw and Hosang (2016) explained the subgenital plate of S. nubila is a narrower, shorter cercus, with the tip of the cercus being less pointed than S. coriacea. The female imago was easier to distinguish between S. nubila and S. coriacea, especially since the ovipositor tip of S. nubila was shorter (reached 30-40 mm).

Damage rates

Maximum leaf damage has occurred during the monitoring program at coconut crops in North Halmahera, West Halmahera, and Sula Islands with a temperature/humidity conditions of 32,2°C/60%;

32,7°C/64%; 34,4°C/74% respectively. Precipitation was correlated with temperature and humidity. The optimum humidity for insects to breed reached 73-100% (Singh and Rethinam, 2005).

The results showed that damage leaf symptoms in South Halmehera tend to be low compared to other areas. The low level of leaf damage was caused by unfavorable weather and climatic conditions for the development of S. coriacea. The present monitoring showed rainfall condition in South Halmahera was quite high, making it difficult to find the specimen (Table 2). The presence of coconut treehoppers was closely related to rainfall because the water can wash away eggs, nymphs, and imago on leaf midrib. The number of insect specimens reached 34 (♂) and 20 (♀). This condition is in contrast to North Halmahera, West Halmahera, and the Sula Islands, the duration of sunlight is quite long and high with little rainfall, causing warm weather and very suitable for insect development.

***Table 2.** Pest outbreaks on coconut crops caused by S. coriacea in 2022*

No	District	Location	Damage rate (%)	Classification	∑Specimens (♂/♀)
1	*North Halmahera*				
	Galela	*N 01° 47' 46,2" E 127° 53' 23,6"*	*76-100*	*Very severe*	*18 (15♂/3♀)*
	Tobelo	*N 01° 41' 45,9" E 128° 0' 12,8"*	*51-75*	*Severe*	*9 (3♂/6♀)*
2	*West Halmahera*				
	Sahu	*N 01° 9' 15,0" E 127° 29' 47,0"*	*26-50*	*Moderate*	*3 (3♂/0♀)*
	Jailolo	*N 01°10' 43,6" E 127° 29' 56,7"*	*26-50*	*Moderate*	*4 (1♂/3♀)*
3	*South Halmahera*				
	Bacan	*N 00° 38' 2,9" E 127° 35' 10,8"*	*1-25*	*Mild*	*0 (0♂/0♀)*
	Obi	*N 01° 13' 20,8" E 127° 38' 34,7"*	*1-25*	*Mild*	*0 (0♂/0♀)*
4	*Sula Islands*				
	Sanana	*N 02° 0' 0,1" E 125° 57' 35,7"*	*51-75*	*Severe*	*12 (9♂/3♀)*
	North Sanana	*N 02° 0' 2,2" E 125° 57' 34,3"*	*51-75*	*Severe*	*8 (3♂/5♀)*
				Total :	*54(34♂/20♀)*

Coconut treehoppers were rarely a problem in plantations since 1970. Hosang (1989) explained S. coriacea can be disastrous and most of the time, coconut treehoppers stay in an alternative host (ex: banana plantain) and cause much of the problem in North Sulawesi. The preference of Sexava to eat coconut leaves is because of the trichome content in the leaf midrib so that it is attracted by pests (Sabbatoellah and Hosang, 2006). The level of leaf damage varied from mild, moderate, severe, and very severe on coconut crops in the Maluku Islands, especially in North Maluku. On average, the coconut plantations experienced moderate to severe attacks and caused economic threshold.

Sexava invasion reached a level of economic loss when the crops were still productive. Alouw and Hosang (2016) described the economic injury level of up to >20% that has occurred on palm oil crops caused by S. nubila in Papua. According to Zelazny and Hosang (1988), there are two types of damage, a namely direct attack on young fruits resulting from premature and defoliated midrib causing loss of production. The behavior of the Sexava pest, which is active at night and has a chewing-mouth type, causes massive and rapid leaf damage (Hosang, 2005). The attacks of S. coriacea in South Halmahera were low damage with no specimens and eggs that be found around the plants. S. coriacea usually lays eggs in the ground or undeveloped grasslands, but several reports indicated that eggs were usually laid behind the end of leaf midrib.

CONCLUSION

Quarantine pest reports have found that Sexava coriacea attacks coconut crops in North Halmahera, West Halmahera, and Sula Islands. S. coriacea status is a quarantine-destroying pests whose population and spread is very fast on North Maluku. S. coriacea caused leaf damage from mild to very severe levels.

ACKNOWLEDGEMENT

Part of this research was supported by the DIPA – Indonesian Agricultural Quarantine Agency (IAQA) No. SP-DIPA 018.12.2.649441/2022.

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