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MANAGEMENT STRATEGIES OF PALM SUGAR (*Arenga pinnata*) PRODUCTION ON EXTREME LANDSCAPES OF RONGGA, WEST BANDUNG REGENCY

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Abstract

Biodiversity provides a variety of ecosystem services benefiting humans both in the form of goods or services. One of these benefits is the ecosystem services that are useful in the production of palm sugar on the extreme landscape of Rongga District, West Bandung Regency. This study aimed to determine the ecosystem services contained in the palm sugar production system and to create biodiversity management strategies in the palm sugar production system. The method used in this study was a mix method where quantitative and qualitative data were made separately but were still related. The quantitative method was used to analyze the types of ecosystem services, while the qualitative data were used to develop the management strategies for palm sugar production systems. The results showed that ecosystem services that wereessential for the palm sugar production system included pollination services done bypalm sugarinsect pollinators and seed dispersion services carried out by palm civets (Paradoxurushermaprohorditus). Insect pollinators found consisted of nine species from seven families and four orders. The diversity value indicated by the Shannon-Wiener index was at 1.69 indicating that the diversity of insect pollinators to be in the medium category. The obtained evenness value was 0.43 indicating that the evenness of insects to be in the medium category. In addition, traces of palm civets in the form of footprints, droppings, food scraps, and nests. As seed dispensers, palm civets have an indirect relation with insect pollinators to the reproduction of palm sugar plants. The strategies for managing the palm sugar production system have been developed to maintain the presence of palm sugar trees on extreme landscapes in Rongga District.

Keywords *Arenga pinnata*; Ecosystem services, Extreme landscapes, Insect pollinators; palm civets

Introduction

Arenga pinnata is one of the most important plants in the tropics [1]. Palm sugar plants belong to the Arecaceae family whose majority of parts can be produced or utilized to provide income for farmers and to supply local community's needs, including for food security and environmental protection [2, 3]. In terms of ecological use, palm sugar plants can be used to support the habitat of certain faunas as well as to support soil and water conservation programs because their roots have sufficient power to hold soil to prevent erosion [4, 5].

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In terms of economical use, palm sugar plants have a high economical value so they can give financial benefits when developed and produced properly, and thus the opportunity to improve the economy of a region is high. In Indonesia, the biggest palm sugar fields and the most extensive palm sugar production are located in West Java area [6], with an area of 14,204ha, the amount produced of around 22,489 tonnes, and the productivity level of 2,781kg / ha [7]. Thus, the potential to increase the economy of West Java through the production of palm sugar is extremely high.

One area in West Java that produces palm sugar is an extreme landscape in the Rongga District, West Bandung Regency. This region has a high potential for the growth of palm sugar plants because of its altitude of around 700-1100masl. In addition, it has a temperature of 23-26^{o}C and the monthly intensity of rain of 10-100mm in the dry season and 50-350mm in the rainy season [8].

Extreme landscapes are defined not only by their physical, but also their social characteristics. According to [9], extreme landscape is a landscape that has biophysical characteristics such as steep to very steep topography, proneness to disasters (landslides, floods, droughts, earthquakes), and vulnerable social conditions of local communities, for example high levels of poverty, lack of access to adequate natural resources for the majority of the population, and a high potential for social conflict.

The topographical conditions in the extreme landscape of Rongga District are very steep and varied slopes because the area is in a mountainous region. The average degree of slope is around 8% to 47%, and the existing land use types also vary, including primary forests, secondary forests, production forests, agroforestry, *kebun talun*, plantations, bushes/ shrubs, dry agriculture, mixed dry agriculture, rice fields, settlements, and open /empty land [10].

The natural resources utilized by the residents around extreme landscapes come from forests, and forests are defined as ecosystems that provide services in the form of materials that can be used directly or indirectly by humans, for instance clean water, biodiversity conservation, nutrition cycle, and soil conservation [11]. In addition, forests also provide ecosystem services that have both cultural and supporting values. Trophic and reciprocal interactions provide important ecosystem services in the form of increasing crop production that is useful for humans [12]

One important ecosystem services in the palm sugar production systems is the aspect of pollination, as it is one of the most important environmental services for crop production. Around 35% of plants supplying food on this earth need other media as pollinators [13]. According to [14], pollination on palm sugar is carried out not by the wind, but by insects, because the palm sugar flowers are included in the monoecious unisexual group. These are similar to those of monoecious palm plants having different flowering time between males and females, thus requiring insects for pollination [15].

In addition, another ecosystem service that is important for the palm sugar production system is the aspect of plant seeds dispersion, and for this aspect, animals, one of which is a palm civet (*Paradoxurus hermaphroditus* Pallas, 1777), have an important role as seeds disperser for most plant species [16]. However, this aspect is not regarded with the same concern compared to the aspect of pollination because many studies discuss the evaluation of ecosystem services rather than measure the ecological functions [17]. Nevertheless, seed dispersion is a key phase in the process of regenerating plant populations [18].

Sugar palm fruits eaten and excreted in the form of seeds and droppings by palm civets will germinate and then grow naturally [19]. Palm seed germination assisted by palm civets is better than germination done by the farmers. This is because the outer skin sheel of palm sugar is thick, making the nursery or planting efforts by farmers difficult [20].

The pollination and seed dispersion are key processes that have a mutual relationship and that have a major influence on the success of the spread of plant reproduction. The effectiveness of this mutualism results from a combination of quantitative components,

including the number of visits and the number of pollinated flowers / seed distribution per visit, and the qualitative components, including fertilization, germination, and seed resistance [21].

Recently, there has been a decline in the population of insect pollinators in almost all parts of the world. Data presented by UNEP (2010) show that in the European hemisphere, the decline in honeybee colonies has occurred since 1986 and in 1988 unusual weakening and mortality in honeybee colonies occurred. Additionally, a decrease in bee colonies in America started to happen in 2004, and in the Asian region, including China and Japan, a decline in Apis species also took place. The decline in insect pollinators may occur because of changes in land use, the use of chemicals (insecticides, herbicides, fungicides), environmental contamination caused by heavy metals, nitrogen and light, diseases suffered by insect pollinators, management of insect pollinators, foreign species invasion, climate change, and other threats [22].

Biodiversity loss is a natural process and is bound to occur; however, human activities often accelerate the rate of decline resulting in extinction [23]. In addition, the mutual relations between animals and plants will be reduced because animal-plant mutualism is very sensitive to habitat damage caused by humans [24]. Therefore, conservation of pollination and seed dispersion, including animals providing these services to plants, should be a priority in the global forest conservation efforts [25].

From the afore mentioned backgroud, it can be seen that habitat conditions affect the biodiversity in providing ecosystem services in the palm sugar plants production system. Efforts to conserve the habitat of insect pollinators and palm civets that provide ecosystem services for the palm sugar production system also need to be carried out in order to maintain and increase the production of palm sugar that has high economic value. This study is also needed to be conducted to become a reference for future conservation efforts. Therefore, a research on the types of ecosystem services of the palm sugar production system and management strategies of the palm sugar production system in extreme landscapes in Rongga District, West Bandung Regency was conducted.

Material and Method

The study was conducted on the extreme landscape in Rongga District, West Bandung Regency. The research used a mixed method, and the study design used explanatory sequential design where quantitative data was collected and analyzed in the first stage, followed by a qualitative data collection and analysis [26]. The quantitative method was used to collect ecological data, namely the types of insects, the distribution of palm civets, and the local community's knowledge about the ecosystem services of insect pollinators and palm civets. The qualitative method was used to develop the strategies for managing the service ecosystem of the palm sugar production system.

Insect data is the primary data collected using vial bottles. These insects were then identified, and their pollens were counted in pest laboratory (*laboratorium hama*) at the Faculty of Agriculture, University of Padjadjaran. The number of palm sugar plants sampled was 15 plants in different land uses. Insect data analysis was performed to calculate the Shannon-Wiener diversity index and evenness index.

The palm civet distribution data in this study was the secondary data. Secondary data obtained were then analyzed descriptively to discuss the number of individuals and the distribution of palm civets at the research site. Structured interviews were conducted with respondents who were palm sugar crafters and who were located around the research site with a population of 66 people, while the semi-structured interviews were conducted with *Perum Perhutani* who managed the forest around the research site.

Results and discussion

The existence of palm sugar plants

Sugar palm plants tapped by the local community at the research site were located in the *kebun talun*, forests, and fields. *Kebun talun* is an agricultural land which is planted with various kinds of annual crops such as *petai* (stinky beans), *jengkol*, palm sugar plants, betel nuts, fruits, and timber [27], while fields are defined as lands usually found in areas with land topography dominated by hills or dry land [28]. The percentage of areas where palm sugar plants were tapped by the respondents can be seen in figure 1 below.

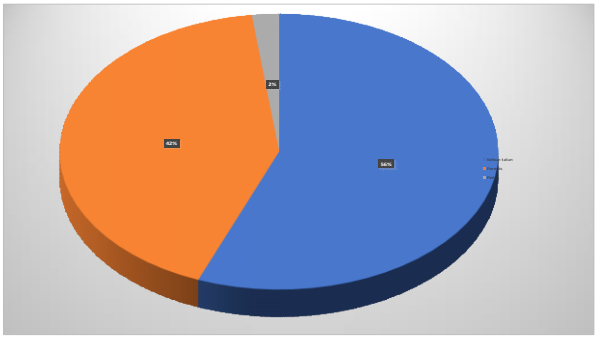

Fig. 1. The percentage of areas where palm sugar plants were tapped

From figure 1 it can be seen that the palm sugar plants tapped by the local community were mostly located in the land use of *kebun talun* (56%), followed by forests (42%) and fields (2%). Palm sugar plants existing at the research site grew naturally with the help of palm civets. There were no palm sugar crafters cultivating palm sugar plants, thus, the plants grew at an intermittent distance [29].

Plants existing around the tapped palm sugar plants were diverse, ranging from annual crops to seasonal crops, as seen in Table 1 below.

Table 1. Types of plants existing around the sugar palm plants in *kebun talun*

No	Name of plants	Local names	Latin names
1.	Pine	Pinus	*Pinusmerkusii*
2.	Albasiah	Albasiah	*Albiziachinensis*
3.	Bamboo	Awi	*Bambusa sp.*
4.	Kaliandra	Kaliandra	*Calliandra sp.*
5.	Durian	Kadu	*Duriozibenthinus*
6.	Langsat	Pisitan	*Lansiumdomesticum*
7.	Jackfruit	Nangka	*Artocarpusheterophyllus*
8.	Coconut	Kalapa	*Cocos nucifera*
9.	Cassava	Sampeu	*Manihotesculenta*
10.	Stinky beans	Peuteuy	*Parkiaspeciose*
11.	Jengkol	Jengkol	*Archidendronpauciflorum*
12.	Banana	Cau	*Musa paradisiacal*
13.	Coffee	Kopi	*Coffea sp.*
14.	Surian	Suren	*Toonasureni*
15.	Papaya	Gedang	*Carica papaya*
16.	Guava	Jambu	*Psidiumguajava*
17.	Pineapple	Ganas	*Ananascomusus*
18.	Avocado	Alpuket	*Persea Americana*
19.	Rice	Pare	*Oryza sativa*
20.	Alangalang	Jukut	*Imperata sp.*

From Table 1 it can be seen that the types of plants around the palm sugar plants varied depending on the location of the palm sugar plants tapped by the respondents. Plants they could find existing around their palm sugar plants were pine, sengon, albasiah, bamboo, kaliandra, durian, pisitan, jackfruit, coconut, cassava, stinky beans, jengkol, bananas, coffee, suren, papaya, guava, pineapple, avocado, rice, and weeds.

Most of palm sugar producers used plants existing around them for consumption and for firewood. They usually ate fruits existing in the surrounding of the palm sugar plants they tapped such as bananas, durians, avocados, jackfruits, papayas, and guavas for daily use, and only rarely did the respondents sell the crops existing around the palm sugar plants they owned (only about 3.03% of respondents did this). Some of the plants that they sold were bananas and bird's eye chillis, whereas woody plants are used as firewood to fuel the production of palm sugar, by using their twigs or using old woody plants. Additionally, some repondents sold the pine sap to those needing it.

The research site in the extreme landscapes in Rongga District was still pristine. The matrix landscape of this area was mostly forests. This was evidenced by the dominating areas of this region (1250ha or around 61.89% of the total research areas were forests). The highest number of respondents in the research site was in Dusun Cibaros and Dusun Cimarel. However, according to one of the informants, the palm sugar resouces in Dusun Hanjawar and Sukawargi continued to decrease. One of the factors leading to this decrease in palm sugar resources was the palm flour crafters. Palm flour was produced from the palm sugar plant trunks, thus, to produce it, one palm sugar plant had to be cut down. According to [30], the logging of palm sugar plants for the production of palm flour was the main factor in the decrease of palm sugar plants' population.

Types of Insect pollinators

Palm sugar plants did not bloom throughout the year. According to one of the informants, the male flowers of palm sugar plants were cut before blooming. This was done for the benefits of the palm sugar tappers. The arm of the palm sugar plants consisting of male flowers was first struck with the tool. This activity was called "*ditinggur*". The tappers did this for 15 minutes, for about 15 days. The purpose of this activity was to collect the sap at the end of the arm. After that, this arm was swung for around 30 times, then the tapper started to do the activity called "*pemagasan*" which was the cutting of the palm sugar plants' arm. A container made of bamboo called *lodong* was placed at the point where *pemagasan* was done to contain the sap.

The informant added that the falling male flowers normally bloomed in the place where they fell, thus, many insects visited the bunch of flowers. However, generally these clusters of male flowers were used by farmers to feed their, or their neighbour's, goat herd. This situation led to the difficulties in finding the nectar / pollen from palm sugar plants, making the potential of pollination by insects low.

In this study, the flowering palm sugar plants were needed so that the insects around these flowers can be found and captured, thus, the plants that were sought were untapped palm sugar plants. This type of plant was difficult to obtain as there were quite a lot of palm sugar tappers in this research site. These flowering palm plants could be found in forests that were rarely touched by public. The ecosystem of this type of forest contained several plants having the potential to become the source of nectar and pollen for insect pollinators.

The method of capturing insect pollinators on the palm sugar plants using vial bottles had its. However, in this study this method was used because the palm plants had an average height of more than 15-20m and the palm sugar flowers were located at the top of the palm plant. Therefore, someone who was an expert at climbing palm trees was needed to catch the insects around them. Another determing factor at choosing this method was that the palm sugar plants were positioned on steep slopes, making palm trees that were chosen to be samples

difficult to reach. From the abovementioned reasons, this method was chosen, as other methods of catching insects were not deemed sufficient.

The types of palm sugar insect pollinators that were captured and identified are presented in Table 2 below.

Table 2. Types of insect pollinators and number of palm sugar pollen

No	Order	Family	Species	Number of individuals	Average number of pollen
1	Hymenoptera	Apidae	*Apiscerana*	23	3.282
			Apisdorsata	2	5.131
			Trigonasp	4	6.302
		Vespidae	*Vespa velutina*	7	3,15
2	Coleoptera	Cerambycidae	*Pelagoderusbipunctus*	1	1070
		Scarabidae	*Apogoniasp*	2	20
		Dystiscidae	*Aciliussp*	1	25
3	Diptera	Drosophilidae	*Drosophila sp*	7	8,4
4	Heteroptera	Pyrrhocoridae	*Dindymusbifurcarus*	3	4

From table 2 it can be seen that the obtained 50 individuals of palm sugar insect pollinators consisted of 4 orders, 7 families, and 9 species. The number of pollens in the Hymenoptera order, especially in theApidae family, was much higher compared to the insects of other orders. This happens because insects in the Apidae family have *corbiculla*– or pollen pocket or pollen basket – located in both their hind legs [31]. According to [32], corbicula in bees can carry up to 10-20mg of pollen. In addition, bees' abdomen hairs also carry pollen to the bees' hives [33]. Thus, insect pollinators from the Apidae family are essential for the pollination of plants [34-36] and they are considered as efficient insect pollinators [36]. Insect pollinators are divided into two kinds: efficient insect pollinators – insects which most often pollinate annual plants and perennial plants, including bees and wasps – and less efficient insect pollinators –insects which are less active in visiting flowers to eat the nectar and pollen, including insects from the Coleoptera, Lepidoptera, and Diptera orders [37].

An ecosystem is affected by various human activities that change the natural landscape. Changes in the landscape can be in the form of destruction, fragmentation, and loss of habitat [38]. The research site was one of the locations for the mega project *Upper Cisokan Pumped Storage*, so a large scale of habitat fragmentation could not be avoided. Similarly, the practice of agriculture land clearing could not be avoided because the forests in the research site were production forests. The decrease in the natural and semi-natural habitat because of farming activities in a landscape can led to a decrease in the diversity and population of pollinationg insects [39]. The changes in land use to become commercial and agricultural lands in a large scale will lower the biodiversity and the fertility of the soil and will cause soil erosion in the agriculture landscape in the Southeast Asian region [40].

The destruction of the insects' habitat can cause a drop in the number of insects due to the loss of insects' feed and nesting place. It can even affect plants' level of density because of the failure in the pollination process. Protecting, improving, or providing habitat is the best way to conserve native insect pollinators and to provide pollen and nectar that support the insect pollinators [41]. Hence, the protection of the insects' habitat is one of the insect conservation strategies because both the diversity and population of insect pollinators are dependent on the quality of a habitat, such as the number and diversity of sources of feed in the form of flowering plants and the availability of flowers throughout the year [42].

The insects' diversity value shown by the Shanon- Wiener index was 1.69, indicating that the diversity of insect pollinators was in the category of medium. For the evenness, the value obtained was 0.43 indicating that the evenness of the insects was in the category of

medium. This meant that the abundance of individuals in each species was uneven, and it had an unstable community. This was evidenced by the dominance of a species whose abundance differed greatly from other species: the number of *Apiscerana* species was higher compared to other species (Table 1). The dominance of a species at the research site might occur due to the influence of its environment. The dominance of insects in a habitat is influenced by the environment that is suitable for supporting their life [43].

The survey results obtained through structured interviews showed that 97% of all respondents knew the presence of insect pollinators' hives in the tress in the forests, 1.52% of respondents said that the presence of insect pollinator hives was on the roof of the house, and the remaining 1.52% did not know. The statement saying that the habitat of insect pollinators was the forest was in accordance with the reference. Forests provide several materials for making hives, with the most important for a good quality habitat for the insect pollinators being the abundant variety of flower plants [44]. Other materials include the places / hives and their materials, areas with vegetation cover, and a landscape free of substances that can be harmful for insect pollinators such as pesticides [45].

Palm Civets Distribution

Palm civets live in a variety of habitats from the wilderness to around human settlements, and they seek shelter on wooden roofs of houses [46]. Research in Sukaresmi Village shows that palm civets are found more abundantly in land uses having more dense covers and high food availability [9]. This is proven from the direct meetings with as many as 28 palm civet individuals in 15 different locations. At the time of the meetings, palm civets are often found walking around human settlements and shrubs. As a nocturnal animal, palm civets are active at night, so the researchers of [9] assume that the palm civets are looking for food. As a nocturnal animal, palm civets are active at night, so it was assumed that the palm civets were looking for food. This is consistent with [47] stating that the palm civets look for food at night. As an arboreal animal, they spend most of their life on branches of trees where they eat their food. Usually these palm civets take fruits carefully and store them as supplies [48].

In addition to direct observations, the presence of palm civets can also be detected using the sign survey method. According to [49], sign survey is a method that is used to search for the existence of animals from the signs of the presence they leave. The results of the sign survey from [9] research shows 153 traces in the form of footprints, droppings, food scraps, and nests (Table 2). The traces of palm civets' droppings contain the skins of seeds or hard fruits, for example palm sugar and coffee [50]. The droppings most found are the droppings in the form of palm sugar seeds, compared with droppings from other seeds such as jackfruit, guava, *takokak*, *kayu afrika*, and soursop [9].

Table 2. Palm civets' traces found through sign surveys

No.	Types of traces	Amount
1.	Footprints	1
2.	Droppings	153
3.	Food scraps	7
4.	Nests	35
	Total	196

Source Parikesit, 2019

Research results in the same location show 35 palm civets' nests consisting of active and inactive nests scattered around the extreme landscapes, with 9 of them being active nests on trees [9]. Trees used as nests most often are trees whose fruits are palm civets' food. Most nests found in the research sire were on plants such as jackfruit (Artocarpusheterophyllus), *puspa*

(Schimawallichi), passion fruit (Passifloraligularis), rasamala (Eltingiaexcelsa), palm sugar plants (Arengapinnata), *kapuk randu* (Ceibapetandra), *kayu afrika* (Maesopsiseminii), and bamboo (Bambusa sp.). This is in accordance with [50] statement that palm civets choose to live in habitats having food availability and resting places such as tree holes, rock crevices, or dense foliage.

Survey of the respondents' knowledge through interviews showed that 95% of them mentioned palm civets' nests to be on trees. The remaining 3.03% mentioned that the palm civets' nests were located on the ground, and 1.92% of respondents said that the palm civets' nests were located both on trees and on the ground. This was in accordance with the references because palm civets are noctunal, arboreal and solitary animals, but they can live in groups of 5-8 individuals [46].

Relationship of Insects and Palm civets in the Palm Sugar Production System

One of the ecosystem services that needs to be maintained is the aspect of pollinators and the seeds dispersion that are regulating services (services obtained from the control or essential ecological process in an ecosystem) [51]. One of the efforts that need to be done is to protect the natural habitat of such organism. This is in line with [52] claim that that there are several factors that can cause a decrease in the diversity and abundance of insect pollinators, such as the destruction of habitat, the loss of the natural habitat that can directly cause a reduction in the sources of feed, the loss of nesting place, and the mismatch in the microclimate.

Plant diversity is essential for insect pollinators' habitats. This is because flowers as a source of feed for insect pollinators can be available throughout the year. Flowers provide food for insects in the form of pollen and nectar located near their sexual organs. The number of insect pollinator' visits and the color of the flowers become a determinant factor to the success of the fruit production which is the precursor of the sustainability of the plant.

Similarly, palm civets' natural habitat is forests. Palm civets choose to live where there is an availability of food and where there is a presence of areas they could occupy. Although palm civets have the characteristics of being adaptive, being highly distributed and having a high number of populations, if hunting activities and habitat fragmentation continue to occur, the decline in their populationsis inevitable. Pollination conservation and seeds dispersion, including for animals providing this service to plants, should be a priority in forest conservation efforts in a global scale [53].

Seed dispersion is an essential process in the regeneration of plants, and in turn, plant regeneration is essential in maintaining the biodiversity and the function of forest ecosystems which are globally threatened by human disturbance [53]. According to [54], palm civets may facilitate or provide ecosystem services by spreading some important types of plants, including palm sugar (Arenga pinnata Merr.), arabica coffee (Coffea arabica L.), and fig (Ficus variegate Blume). The service of seed dispersion in the palm sugar production system is carried out by palm civets. Palm civets play a role in plant nurseries, affecting plant compositions, genetic diversity, and plant heterogeneity in an ecosystem. This service determines the regeneration of palm sugar plants because palm sugar nursery aided by humans is seldom conducted. Therefore, the population of palm civets must be taken seriously, as the decline both in civets' populations as seed dispersion agents and in insects' population as pollinating agents will cause a decrease in the production of palm sugar plants and this can affect the welfare of palm sugar producers.

Palm civets eat the fruit of palm sugar plants and excrete the seeds of plants with their droppings. The seeds of plants, along with the droppings, are discovered in relatively open places [55, 56]. The range of distance between palm civets make them potential agents for dispersing seeds in far distances although the time trajectory of palm civets' intestines lasted several hours prior [57]. According to [57], palm civets have the potential to disperse seeds regularly, including on the banks of the streams, the path where the rain flows, the path which

they pass, and the gaps between trees characterized by the density of the low branches and canopy cover.

As the agent of seed dispersion, palm civets have an indirect relationship with insect pollinators in the reproduction of plants. The pollination service in palm sugar production system is carried out by insects. This is becausepalm sugar plants are monoecious unisexual plants where both the male and female flowers are located in the same individual, but not in the same cluster. In addition, the flowering time between these flowers is also different. Thus, the existence of insect pollinators needs to be taken seriously for their essential role in the palm sugar production system. The process of biotic pollination and the dispersion of seeds are significant in the ecological processes of the plant reproduction. Insect pollinators help plants carry out the pollination process, where pollen is sent or touches the stigma which ensures the right balance in the genetic make up of species. After that, a fusion between the core sperm and the core egg cell occurs, and this is called fertilization, with the final outcome of fruits. This is the fruit that becomes the food for palm civets.

Palm Sugar Crafters' Knowledge of Ecosystem Services in the Palm Sugar Production System

The results of this study indicated that not all respondents knew that there were beneficial insects. Of the 66 respondents surveyed, 72.72% knew there were beneficial insects, and the remaining 27.28% did not. Respondents who were aware of beneficial insects stated that insects were beneficial to pollinate plants (79.17%), to produce honey (14.58%), and the remaining 6.25% stated that insects were beneficial both as pollinators and as honey producers. Respondents were then given more specific questions about the beneficial insects in terms of insect pollinators and the results can be seen in Table 3.

Table 3. Respondents' knowledge of the type of insect pollinators

No	Species	Percentage of respondents who are knowledgable of insect pollinators
1	*Apiscerana*	71,74
2	*Apisdorsata*	50
3	*Trigonasp*	10,87
4	*Vespa velutina*	19,57

Source: Primary Data 2019

From Table 3 it can be seen that the palm sugar tappers who knew about insect pollinators often saw insects belonging in the Hymenoptera order. [58], stating that the most important insect pollinators are the group of bees, either social or solitary bees, belonging in the Hymenoptera order. The Hymenoptera is the most important order of insects because it gives value for agriculture, ecology, and economics [59].

The respondents' answers about the reasons why insect pollinators perch on flowers varied, for example because of the flower's source of pollen, the flowers' fragrance, or the flowers' colors. From the 46 (or 69.7%) respondents who had the knowledge of the insect pollinators, the majority knew that the reason for the insects to perch on flowers was because of flowers' fragrance and nectar. The interest of insect pollinators to certain flowers is influenced by several factors, including the size of the flowers, the color of the flowers, the number of flowers, and the availability of nectar and pollen on those flowers [60, 58]. The statement is in accordance with the knowledge of farmers about the reasons why insect pollinators perch on flowers. The availability of pollen and nectar is an important factor for attracting insects to flowers because insects visit the flowers to get food [61].

Another question about the intensity and time of visit of insect pollinators to the palm sugar flowers were asked to the respondents. They almost had the same answers: in the mornings and in the evenings. This was because respondents conducted activities at the same

time, that is to tap the plants in the mornings and evenings. The results showed that mostly palm sugar tappers saw insects visiting or being around the palm flowers everyday in the mornings and evenings. This is in accordance with references stating that insect pollinator activities can be influenced by certain factors. For instance, daily activities of *Apis cerana* worker bees have several activity patterns with different intensity which are influenced by physical factors such as solar radiation, temperature and wind speed. The activity of carrying pollen is generally done in the mornings and evenings and stops at 12.00-15.00. Insect activity in visiting flowers depends on extrinsic and intrinstic factors. Extrinsic factors include abiotic parameters (environmental temperature, wind speed, and solar radiation) and biotics parameters (predation and competition among flowers), while intristic factors include taxonomic affiliation to physiological attributes such as thermoregulation ability [62].

Similar to sightings of insects, almost all respondents (96.97%) had seen palm civets either around their homes or close to the palm trees they tapped. Each respondent had a different intensity on the sightings of the palm civets. The results showed that every respondent who had seen palm civets had seen them at least once every month, and there was even a respondent who said that he saw a palm civet every night on a tree in his yard. This proves that as arboreal animals, palm civets can be found on trees.

The results showed that most of the palm sugar tappers (71% of respondents) knew that palm civets ate palm fruits. Other respondents knew that palm civets eat other fruits and poultry. As a frugivorous animal, it was certain that palm civets ate fruits - including palm fruit and other fruits. Additionally, as carnivorous animals, palm civets ate other animals, including chickens, so some respondents who had chickens mentioned that palm civets were pests.

The survey results also showed that 87.88% of the respondents stated that palm civets were beneficial for them. The reason mentioned was that palm civets were agents for spreading palm sugar plants' seeds. Thus far, palm sugar plants, whose benefits these repondents harvested, existed because of the services of palm civets which grew sugar palm plants by eating the seeds. Palm sugar seeds that come out with the palm civets' droppings then grew into new palm sugar plants.

Conversely, 12.12% of the total respondents stated that palm civets did not provide benefits for them. The reason was because palm civets interfered with the *lodong* which they kept as containers for *nira*, in that palm civets living on trees overturned the *lodong*, making them unable to store *nira*. In addition, these respondents also mentioned that palm civets oftentimes disturbed their poultry.

The Government's Response Regarding the Conservation of Ecosystem Services in the Palm Sugar Production System

Seedbed seedlings are created by *Perum Perhutani* in the Central Java region. In natural conditions new palm seeds can germinate in 6-24 months after sowing [63]. This is because the palm sugar plants seeds have a hard and thick seed shell, so dormancy breakage needs to be done to accelarate the germination process. Therefore, efforts are made to scrape the seeds shell by using sandpaper, soaking it with a chemical solution of H_2SO_4, and storing it in an incubator at a temperature of 40°C. These efforts can shorten the dormant period to 2-6 months. *Perum Perhutani* in Gunung Halu region, especially in the extreme landscape of Rongga District, concentrates on developing pine (*Pinus merkusii*) commodity. However, this focus does not necessarily neglect other commodities, including palm sugar plants. Unfortunately, these palm nurseries attempted by Perum Perhutani until now have not been successful.

Perhutani admits that there has not been any special attention given to palm sugar commodities if compared to other commodities. However, *Perum Perhutani* of Gunung Halu Region states that efforts to cultivate palm sugar plants in the extreme landscape of Rongga District had been made. 9,000 palm tree seedlings have been planted in the Upper Cisokan

stream beds. However, this program was not successful because most of the seedlings planted were damaged by pests including monkeys. Thus, the planting of palm sugar plants currently still relies on the services of a palm civets.

Palm civet's protection by the *Perum Perhutani* has not been specifically done. *Perum Perhutani* will act only if there are reports from the local community about the disturbance in the biodiversity preservation. Up to the present, Perhutani has never received a report about the threat of palm civets' lives in Perhutani Gunung Halu management areas, especially in the research site. This is different from the statement of one of the informants stating that at the time of the research there had been palm civets hunting activity in the research site.

In terms of insect pollinators, *Perum Perhutani* Gunung Halu admits that they have not carried out specific preservation effort for these insects. However, regulations explaining efforts to maintain the balance of ecosystems in the forest areas managed by Perum Pehutani include the preservation of insect pollinators as the ecosystem services. This is in accordance with one of the three *Perum Perhutani* missions: " (i) To manage forest resources with the principle of sustainable forest management based on regional characteristics and the supporting capacity of the watersheds, (ii) to increase the benefits of forest, timber and non-timber products, ecotourism, environmental services, and agroforestry, and (iii) to ensure the company growth on an ongoing basis."

Currently, *Perhutani KPH Bogor* is managing the insect pollinators, including bees, so that their honey can be used. The type of honey produced is the result of the introduction of *Apis melifera* bees to the agricultural lands having the plant commodities that are in accordance with the source of nectar. *Perhutani Gunung Halu* usually empowers the local honey producers and sends LMDH representatives to trainings in *Pusat Perlebahan Nasional Bogor* (Bogor National Beekeeping Center) to improve the bee farmers' skills and the quality of honey produced.

In addition, *PerumPerhutani* facilitates the cooperation between LMDH and parties related to the land management, including the Department of Agriculture. One of the programs carried out includes workshops about the cultivation of plants in the forest areas. These are done so that any cultivation activities done still pay attention to the ecological, economical, and social aspects.

Management Strategies of Palm Sugar Production System

In this research, the biodiversity conservation strategies in palm sugar production system refered to Indonesia Biodiversity Strategy and Action Plan (IBSAP) and Intergovernmental Science-Policy Platform Biodiversity and Ecosystem Services (IPBES). Both documents provided guidance in terms of the preservation of biodiversity by effectively utilizing thediversity for the benefits and welfare of human beings, as well as by participating in the preservation of biodiversity covering the entire components of society, so that policy makers can formulate preservation strategies that are beneficial to humans and are based on science and knowledge.

Based on the abovementioned reasons, the proposed strategies for managing the palm sugar production system are as follows:

a. The management of biodiversity habitats (including those of insect pollinators' and palm civets') to maintain their presence in the extreme landscape of Rongga District.
b. The development of paticipative cooperation system in managing the biodiversity among the government, the local community, and the stakeholdersto monitor, to manage, and to ensure a responsible biodiversity management.
c. The development of biodiversity protection policy in the practice of palm civets hunting,

d. The implementation of the biodiversity monitoring and management system to ensure a responsible biodiversity management,
e. The education and exchange of knowledge among the palm sugar producers, the local communities, the researchers, the industry, the government, and the stakeholders in the Rongga District
f. The proper and continuous communication among the supervisors, the stakeholders, and the local communities in the Rongga District
g. The monitoring and the responsible management of biodiversity to prevent the extinction of biodiversity.

Conclusions

There are several findings from this research: (i) the ecosystem services that supported the production system of palm sugar plants (*Arenga pinnata*) are pollinator insects and palm civets, (ii) 4 orders, 7 families, and 9 species of pollinator insects were found at the research site, and (iii) palm civets were distributed in many types of land cover such as *talun*, forest, ladang and shrubs. To maintain the sustainability of the palm sugar production system in the extreme landscape, several strategies that are in line with the national policies need to be implemented, such as strategies and action plans for Indonesia Biodiversity Strategy and Action Plan (IBSAP) and Intergovernmental Science-Policy Platform Biodiversity and Ecosystem Services (IPBES).

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