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BUKTI SUBMIT ARTIKEL KE LIVESTOCK RESEARCH FOR RURAL DEVELOPMENT (LRRD) DAN ARTIKEL YANG DI SUBMIT (1 FEBRUARI 2022)

Gmail erwan apis <apiserwan@gmail.com>

LRRD

erwan apis <apiserwan@gmail.com> 1 Februari 2022 pukul 13.01
Kepada: Reg Preston <reg.preston@gmail.com>

Dear Professor T R Preston, Ph.D., D.Sc.

Senior Editor in LRRD

in Colombia

Good Afternoon, we hope Prof. T R Preston, Ph.D., D.Sc. is always healthy, happy doing the activity every day. I am Erwan from the Faculty of Animal Science, University of Mataram, Indonesia interest for me and our team to submit a paper with identity as follows:

Title : Improving the productivity of local honeybee (*Apis cerana*) by using feeds coconut sap and sugar palm (sap and pollen) in West Lombok, Indonesia

Authors : Erwan and Agussalim

Affiliation : University of Mataram, Indonesia.

In our study we use coconut sap and sugar palm sap which was added by sugar palm pollen. In addition, in our study we use the bee Apis cerana as the local honeybee in West Lombok, Indonesia. Based on the recent finding showed that the feed from sugar palm sap or coconut sap which was added by sugar palm pollen were increased the brood cells number, honey production, and colony weight of the bee *A. cerana*, but not on nest number and worker hatches weight compared to sugar palm sap or coconut sap without added by sugar palm pollen. The coconut sap or sugar palm sap which are added sugar palm sugar improves the productivity of the bee *A. cerana*. However, coconut sap which is added by sugar palm pollen is recommended as an alternative sustainability feed for the bees. Therefore, also increasing or improving the biodiversity of plants around the beekeeping location and creating a green environment.

We hope our paper can be Accepted and Published in Livestock Research for Rural Development

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Best Regards,

Dr. Ir. Erwan, M.Si.
Faculty of Animal Science, University of Mataram, Indonesia

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ARTIKEL YANG DI SUBMIT KE LIVESTOCK RESEARCH FOR RURAL DEVELOPMENT

Improving the productivity of local honeybee (*Apis cerana*) by using feeds coconut sap and sugar palm (sap and pollen) in West Lombok, Indonesia

Erwan and Agussalim[1]

Faculty of Animal Science, University of Mataram, Jl. Majapahit No. 62, Mataram – 83125, Indonesia
apiserwan@gmail.com
[1]Faculty of Animal Science, Universitas Gadjah Mada, Jl. Fauna 3, Bulaksumur, Yogyakarta – 55281, Indonesia

Abstract

The productivity of the bee *Apis cerana* in the traditional beekeepers in Indonesia is low and one of the problems is feeding limited nectar and pollen when the rain season which is decreased productivity. The purposes of this research were to be improving the productivity of the local honeybee of *A. cerana* by using feeds coconut sap and sugar palm (sap and pollen) in West Lombok, Indonesia. The bee *A. cerana* of 30 colonies were divided into 6 groups consisting of sugar palm sap without added by sugar palm pollen; coconut sap without added by sugar palm pollen; 50% of coconut sap + 50% of sugar palm sap without added by sugar palm pollen; sugar palm sap was added by sugar palm pollen; coconut sap was added by sugar palm pollen; 50% of coconut sap + 50% sugar palm sap was added by sugar palm pollen. The recent finding showed that the feed from sugar palm sap or coconut sap which was added by sugar palm pollen were increased the brood cells number, honey production ($p<0.01$), and colony weight ($p<0.05$) of the bee *A. cerana*, but not on nest number and worker hatches weight compared to sugar palm sap or coconut sap without added by sugar palm pollen. The coconut sap or sugar palm sap which are added sugar palm sugar improves the productivity of the bee *A. cerana*. However, coconut sap which is added by sugar palm pollen is recommended as an alternative sustainability feed for the bees.

Keywords: *Arenga pinnata, bee bread, beekeeping, Cocos nucifera, honey*

Introduction

Apis cerana is included in morhpocluster Indo-Malayan *cerana* which is distributed in several islands in Indonesia consisting of Sumatera, Kalimantan, Java, Bali, Lombok, Sumbawa, Sulawesi, Papua, and Seram (Hepburn and Radloff 2011; Radloff et al 2011). The beekeeping of *A. cerana* has been done by the beekeepers in several origins in Indonesia such as in North Sumatra, Riau, Lampung, Banten, West Java, Central Java, Yogyakarta Region, East Java, Bali, Nusa Penida, and Lombok (Schouten et al 2019). However, the bee hunters are still looking in the plantation and forest areas to harvest honey. In addition, the bee *A. cerana* also produces bee bread where the protein content ranges from 16.92 to 20.58% (Erwan et al 2021). The main role of honeybees is pollinators agent to improve the plants productivity which impacts the improvement of livelihoods (Partap 2011; Pohorecka et al 2014).

To produce honey in sustainability is required the availability of feed sufficient and sustained conditions like nectar and pollen from plant flowers that can be blooming all year. However, the main problem when beekeeping the bees is lacking feed sources especially in the rain season. Furthermore, Schouten et al. (2019) reported some problems when beekeeping of the bee *A. cerana* in several origins in Indonesia especially in Java, Bali, and Sumbawa consists of

queen bees rearing is minimum, absconding of the bees is high, beehives not yet standardized, high moisture of honey. In addition, Theisen-Jones and Bienefeld (2016) reported that Indonesia is one of the Asian countries which is significantly decreased the *A. cerana* population. Erwan et al (2021) have been studying the use of coconut sap which added by sugar palm pollen can increase production of honey cells and bee bread cells of the bee *A. cerana*. However, no studies have been done about the productivity of the bee *A. cerana* from Indonesia like honey production, brood cell numbers, colony weight, nest or comb numbers, and other parameters. Therefore, this study was aimed to improve the productivity of local honeybee *A. cerana* by using feeds of coconut sap and sugar palm sap or pollen.

Material and Methods

Location and study design

This study was performed in the Village of North Duman, Sub-district of Lingsar (West Lombok District, West Nusa Tenggara Province, Indonesia). This study used 30 colonies of the bee *Apis cerana* by using a randomized complete block design with the factorial 3×2 and 5 replications. The first factor was plant sap, which consists of three subfactors: coconut sap (C), sugar palm sap (S), and a mix of 50% coconut sap + 50% sugar palm sap (SC). The second factor was sugar palm pollen consisting of two subfactors added by sugar palm pollen (P) and without sugar palm pollen. The treatment in our study consisted of sugar palm sap without added sugar palm pollen (SP0); coconut sap without added sugar palm pollen (CP0); 50% of coconut sap + 50% of sugar palm sap without added sugar palm pollen (SCP0); sugar palm sap was added by sugar palm pollen (SP1); coconut sap was added by sugar palm pollen (CP1); 50% of coconut sap + 50% sugar palm sap was added by sugar palm pollen (SCP1).

The given technique of plants sap and sugar palm pollen

The technique was used to give coconut and sugar palm saps, and sugar palm pollen according to the previous method reported by Erwan et al (2021). Briefly, the fresh coconut sap (*Cocos nucifera*), sugar palm sap (*Arenga pinnata*), and sugar palm pollen were obtained from North Duman Village, the Sub-district of Lingsar. Afterward, the fresh coconut and sugar palm saps were given to the bees by using plate plastic and split bamboo was supported by 4 to 5 of twigs as a foragers perch and placed at the distance of one meter from the box hives. The sugar palm pollen was hung in the wood at a height of 1.5 m and placed beside the saps.

Bee nests and brood cells numbers

Brood cell numbers were counted from 30 colonies of *A. cerana* from each treatment. Briefly, the covers of the box hives were removed and the frame which contained the bee nest was lifted. Afterward, the brood cell numbers were counted by using a hand counter for all the bee nests. The bee nest numbers were calculated from each treatment after three months of beekeeping from 30 colonies.

Hatches weight of worker bees

The hatches of worker bees were taken five heads for each treatment, then put into a tube and weighed by using a digital scale with 5 replications and each twice measured. This process was performed every third week for about three months of the beekeeping.

Figure 1. The collecting pupae before hatches to measure their hatches weight

Colony weight and honey production

Colony's weights were weighed by using a digital scale for each treatment after three months of beekeeping minus the weight of the empty box hive. Honey production was measured after beekeeping for three months. Briefly, honey was harvested by opening the box hive cover and taking the frame which was contained honey. Afterward, a honeycomb from each treatment was cut and squeezed to separate honey and wax. The clean honey was weighed by a digital scale from 30 colonies and each twice measured.

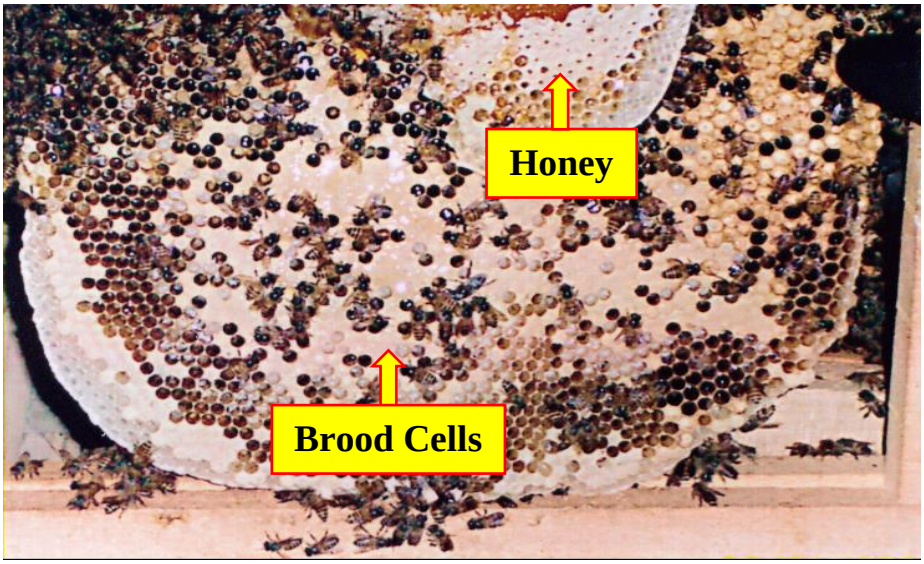

Figure 2. The brood cells and honey from the bee *A. cerana*

Data analysis

The data of brood cell numbers, hatches weight of worker bees, bee nests number, colony weight, and honey production from the bee *A. cerana* were analyzed by using variance analysis and followed by contrast orthogonal test (Steel et al 1997).

Results and Discussion

Brood cells number

The recent finding showed that the feed of sugar palm sap or coconut sap, which was added by sugar palm pollen, increased the brood cells number ($p<0.01$) (Table 1). The brood cells number of the bee *A. cerana* was highest found in the treatment SP1 was 21,349 cells/colony, followed by CP1 was 18,271 cells/colony, then followed by the other treatments (SCP1, CP0, and SCP0), and the lowest was found in treatment SP0 was 7,142 cells/colony. Generally, the number of brood cells were higher found in the treatments of coconut and sugar palm saps which were added by sugar palm pollen compared to brood cells number at treatments of coconut and sugar palm saps without added by sugar palm pollen (Table 1).

Table 1. The brood cells number, hatches weight of worker bees, and nests number of the bee *A. cerana*

Parameters	Treatments						SEM	*p*
	SP0	CP0	SCP0	SP1	CP1	SCP1		
Brood cells number (cells/colony)	7,142[e]	10,129[d]	9,334[d]	21,349[a]	18,271[b]	14,223[c]	982	0.007
Worker hatches weight (g/head)	0.0628	0.0621	0.0627	0.0622	0.0620	0.0626	0.0002	0.869
Nest number (nest/colony)	5.60	6.20	6.00	7.00	7.80	7.00	0.170	0.537

[a,b,c,d,e] *Different superscripts within rows indicate differences at p<0.05. Abbreviations: SP0 = sugar palm sap without added by sugar palm pollen; CP0 = coconut sap without added by sugar palm pollen; SCP0 = 50% of coconut sap + 50% of sugar palm sap without added by sugar palm pollen; SP1 = sugar palm sap was added by sugar palm pollen; CP1 = coconut sap was added by sugar palm pollen; SCP1 = 50% of coconut sap + 50% sugar palm sap was added by sugar palm pollen.*

The difference in brood cell number formed by the worker bees is related to feed availability namely nectar and pollen from the plant flowers. In our study, it was found that the bee *A. cerana* required both nectar and pollen for their feed to increase the brood cells number. In addition, in our study, the nectar was supplied by saps from sugar palm and coconut, while pollen was supplied by sugar palm flowers. To produce eggs maximally, the queen bee needed to be fed in sufficient quantity and quality. The availability of pollen from sugar palm continuously with high protein content was 27.12% (Erwan et al 2021) maybe can provide the essential and non-essential amino acids which was required by the queen bee to produce more eggs. The addition of sugar palm pollen as a protein source to produce the higher of brood cells number ranging 226 to 339 cells/day compared to without added by sugar palm pollen was produce brood cells number ranging 113 to 148 cells/day. Shuel (1992) explained that pollen collected by the bees contains high nutrients such as nineteen amino acids and contains the B-complex vitamins. In addition, most of the pollen was rich in proline amino acids. The queen bee was given royal jelly by the young worker bees in the nest continuously. The royal jelly was produced by the young worker bees at the age of 5 to 10 days old and the royal jelly feed was related to egg production from the queen bee, where the higher egg production was supported by the higher royal jelly consumption or otherwise.

In addition, Paray et al (2021) explained that pollen is the main protein source for the development of the colony, brood rearing, adult worker bees longevity, and as the raw material

to make royal jelly. Winston et al (1983) reported that each feeding period by one of the worker bees, the queen bee, can produce eggs ranging 2 to 26 eggs/day, where the feeding was given by 1 to 5 worker bees. Furthermore, Shah and Shah (1980) reported that the queen bee of *A. cerana* produces eggs ranging from 300 to 500 eggs/day if they are given the feed with good nutrition. The lack of pollen on the bee colony can be decreased the brood number, abnormal growth, and reduce the lifespan of the worker bees (Winston et al 1983). The bee colony can't carry and rearing the broods without the presence of pollen in sufficient quantities in the nest, so decrease the growth and development of the colonies. Gary (1992) explained that the queen bee can't produce an egg much more if the availability of pollen in small quantity and which was impacted on the low of eggs can be produced by the queen bee and decreasing the number of queen cells can be formed.

Hatches weight of worker bees

The recent finding showed that the difference of sugar palm sap, coconut sap, and sugar palm pollen in each treatment was similar on the hatches weight of worker bees ($p>0.05$). The hatches weight of worker bees from our study ranged from 0.0621 to 0.0628 g/head (Table 1). The hatches weight of the bee depends on the availability of food reserves like honey and pollen (bee bread) in the nest to fulfill the requirement for the growth of the bee brood. Honey and bee bread are very necessary for the development of larvae and pupae in the brood cells of the bees. The growth and development of the bees have started since the queen bee lays eggs into brood cells until they become larvae and pupae, where their requirements are protein, carbohydrate, fat, vitamins, and minerals in sufficient amounts and quality. The larvae of the bee that are less than 3 days old were given food of royal jelly to rapidly their growth and development (Winston 1987). In addition, the larvae which were produced by the worker bees as the candidate of new queen bee was fed royal jelly by the worker bees that rapidly of their growth and development (Abrol 2011; Abrol et al 2005; Paray et al 2021; Wongsiri et al 1990).

Pupae is the final period before the bees hatch which is characterized by the formation of the head, eyes, antennae, chest, legs, and abdomen, but the wings have not yet developed. Generally, the total time from the egg to hatches was 16 days for queen bees, 21 days for worker bees, and 24 days for drones. However this period varied, ranging from 14 to 17 days for queen bees, 14 to 16 days for worker bees, and 20 to 28 days for drones (Winston 1987). This variation was caused by environment and food factors. The lower temperature under the normal temperature (35^{o}C) can inhibit the bees hatches and inhibit the larvae development. The larvae in the comb site require a longer time than larvae in the center of the comb. This condition is related to the temperature and humidity stabilities from each location around the nest or comb. In addition, the hatches weight of the worker bees was affected by the availability of nectar and pollen, brood cells size, the population of worker bees, disease or pest, and season. Lack of feed which had stunted growth, lower hatches weight, and higher rate mortality. Furthermore, Subandrio et al (1997) reported that the installation of the pollen trap continuously did not affect the hatches weight of the worker bees because the food reserve in the nest can fulfill the nutrients requirement for larvae or pupae.

Nest number

The recent finding showed that the nest number from each treatment sugar palm sap, coconut sap, and sugar palm pollen each treatment was similar ranging from 5.60 to 7.80 nest/colony ($p>0.05$) (Table 1). The nest was used by the bees to store honey and bee bread and as the location to queen bee lays. The large nest number in the hive was caused by the increase of the

honey cells, pollen cells, and larvae or pupae numbers. The coconut sap and sugar palm pollen are taken by the bees as food to stimulate worker bees to make the new nest or comb. The nest or comb was made from the wax produced or secreted by four glands located in the abdomen of the worker bees. Furthermore, was mixed by using saliva until it becomes solid with high elasticity to make it easy to be shaping. A thick layer of wax is placed in the base of the nest, then cells are slowly made by lengthening and thinning the wax so that it is made into cell walls. The worker bees will be built the brood cells simultaneously and start at the top horizontally (Winston 1987). This condition may be useful for preventing the honey from spilling from the honey cells. The worker bees will be increasing their activity to make the comb if supported by higher food flow, so increasing the eggs produced by the queen bee. In addition, the high queen bee producing eggs must be supported by the higher pollen availability. The formation of pollen and honey cells and brood cells will be stimulating the bees to increase the number of nests. The nest or comb number in our study (Table 1) was lower compared to reported by Schouten et al (2019) that the comb can be produced by the bee *A. cerana* from three origins in Indonesia (Java, Bali, and Sumbawa) ranging from 10 to 12 combs from traditional keeping by beekeepers. The nest numbers of the bee *A. cerana* in our study (Table 1) are in line with the reported by Hikmah et al (2021) that the Asiatic honey bee of *A. cerana* ranging from 5 to 10 nest combs/colony.

Table 2. The colony weight and honey production of the bee *A. cerana*

Parameters	Treatments						SEM	*p*
	SP0	CP0	SCP0	SP1	CP1	SCP1		
Colony weight (kg/colony)	3.14^{d}	3.57^{c}	3.53^{c}	5.36^{a}	5.57^{a}	4.43^{b}	0.211	0.043
Honey production (g/colony)	288.21^{e}	574.04^{c}	454.84^{d}	714.53^{b}	931.65^{a}	543.50^{c}	38.85	0.000

^{a,b,c,d,e} *Different superscripts within rows indicate differences at p<0.05. Abbreviations: SP0 = sugar palm sap without added by sugar palm pollen; CP0 = coconut sap without added by sugar palm pollen; SCP0 = 50% of coconut sap + 50% of sugar palm sap without added by sugar palm pollen; SP1 = sugar palm sap was added by sugar palm pollen; CP1 = coconut sap was added by sugar palm pollen; SCP1 = 50% of coconut sap + 50% sugar palm sap was added by sugar palm pollen.*

Colony weight

The recent finding showed that the difference of sugar palm sap, coconut sap, and sugar palm pollen in each treatment was significant on the colony weight of the bee *A. cerana* (*p<0.05*) (Table 2). The highest colony weight was found in treatment CP1 was 5.57 kg/colony, which was similar to the colony weight from the treatment SP1 was 5.36 kg/colony. Furthermore, followed by the treatment SCP1 with the colony weight was 4.43 kg/colony and the lowest of colony weights were found in treatment SCP0, CP0, and SP0, 3.53 g/colony, 3.57 g/colony, and 3.14 g/colony, respectively. These findings indicate that both nectar and pollen from the plants were needed by the bee *A. cerana* to support their colony development like colony weight. In addition, our study also showed that the bee *A. cerana* was fed only nectar to decrease the colony weight. Generally, the colonies were treated by sugar palm sap or coconut sap which was added by sugar palm pollen which resulted in a higher colony weight compared to sugar palm sap or coconut sap without the addition of the sugar palm pollen. The colony weight was higher in the treatment sugar palm sap or coconut sap which was added by sugar palm pollen was supported by the much more of brood cells number which was shown in Table

1. The colony weight of the bee *A. cerana* in our study was higher compared to reported by Widowati et al (2020) that the bee *A. cerana* which was fed by pollen substituted (made from soybean dregs, skim milk, and bread yeast) resulted in the colony weight of the bee *A. cerana* ranging from 0.30 to 1.52 kg/colony for seven weeks of the beekeeping. The difference in colony weight was affected by the difference of the pollen source, the colony's health, and the environmental condition (temperature and humidity).

The worker bees are usually taking the feed with the location was closer to the nest, therefore the much more of the availability of feed with the closer distance was rapidly the deposit of honey and bee bread as the reserve food in the nest. The addition of sugar palm pollen resulted in higher brood cells namely 280 cells/day compared to without the addition of sugar palm pollen was 141 cells/day. The high number of brood cells formed by the worker bees will increase the population of worker bees. A few hours after hatching, the young bee directly consumes pollen (bee bread) which is used for the development of their body organs. The consumption of this bee bread continued to be increased until the age of worker bees 5 to 6 days old and bee bread as the main source of protein and amino acids which was required by the bees for their growth and development. Furthermore, the protein requirement will be decreased when the age of worker bees is 10 to 14 days old. Zaytoon et al (1988) reported that the pollen in the bee *Apis mellifera* will increase the development of the hypopharyngeal gland and the laying capacity of the queen bee. The deficiency of pollen will inhibit colony development, brood cells production will decrease and reduce the lifespan of worker bees (Winston et al 1983). The addition of coconut sap or sugar palm sap which was added by the sugar palm pollen can fulfill the nutrient requirement like protein, carbohydrates, fat, vitamins, and minerals which were needed for the growth and development of the bee *A. cerana*. In addition, the excess of the food will be deposited or stored into honey cells and pollen cells (bee bread cells) so can stimulate the worker bees to create a new comb which was impacted by the increase of the colony weight. Furthermore, Kuntadi (2002) explained that much more food availability in the nest will be stimulating the worker bees to create a new comb that was used to store honey and bee bread as the food reserve and was produced by the queen bee.

Honey production

Honey was produced by the worker bees by using nectar as raw material and stored in the honeycomb for the bee in the Apis genus. The recent finding showed that the difference of sugar palm sap, coconut sap, and sugar palm pollen in each treatment was highly significant on honey production of the bee *Apis cerana* (Table 2) ($p<0.01$). The highest amount of honey production was found in treatment CP1 was 931.65 g/colony, followed by the treatment SP1 was 714.53 g/colony, CP0 was 574.04 g/colony was similar with the treatment SCP1 was 543.50 g/colony and the lowest of honey production was found in the treatment SCP0 and SP0 were 454.84 g/colony and 288.21 g/colony, respectively (Table 2). In our study was in line with the study by Erwan et al (2021) that the combination of coconut sap or sugar palm sap, which were added by sugar palm pollen increased the production of honey and bee bread cells which impacted on the increasing of honey production.

Honeybees are a requirement of feed that contain complete nutrients like carbohydrates, protein, vitamins, minerals, and other nutrients for their life such as for colony development, queen bee care, to increase eggs production by the queen bee and increase honey production (Abrol 2011; Paray et al 2021). The carbohydrates source is mostly obtained from nectar and honeydew and is the main material to produce honey, while protein source is obtained from pollen. Therefore, to produce honey in big quantities must be supported by the availability of

nectar and pollen continuously. The high of honey production was caused by the much more of saps amount was taken by the bees and the slow change of coconut sap from fresh to sour taste was longer compared to sugar palm sap and they are mixed. Therefore, was impacted on the higher of sap amount can be collected by the worker bees, so was increased the honey production. The coconut sap has been collected by the worker bees, stored in the honey stomach, and then was transported to the young worker bees for processing into honey which was added by the invertase enzyme. The mature honey was stored by the worker bees in the honeycomb or honey cells at the top of the nest or comb. The main process in honey production was the decomposition of sucrose nectar into glucose and fructose and then water evaporation. The sugar content was also one of the factors that were influencing the increase of honey production and higher sugar content of coconut sap will be faster in honey maturation. Souza et al (2002) reported that the larger corbiculae can be stored in pollen and transported to the hive which was used to increase honey production.

Production of honey in Table 2 was higher compared to reported by Supeno et al (2021) for the bee *A. cerana* which was beekeeping in the coffee plantation (nectar main source) in Central Lombok (Indonesia) was 301.35 g/hive/5 months. Schouten et al (2019) reported production of honey from the bee *A. cerana* in Indonesia ranges from 0.5 to 5 kg/hive. Furthermore, Widowati et al (2020) reported production of honey from the bee *A. cerana* which was fed by pollen substituted (made from soybean dregs, skim milk, and bread yeast) ranging from 210 to 1,010 mL/colony for seven weeks of the beekeeping. The difference in honey production was affected by the different of the bee feed (nectar and pollen), the condition of the bees (health, growth, and development), the population of the worker bees, environmental condition (climatic, season, temperature, humidity), and the activity level of the worker bees. In addition, Hikmah et al (2021) reported that the bee *A. cerana* produce honey was 250.58 g/colony which is beekeeping in the protected forest in Enrekang Regency (South Sulawesi), Indonesia.

Conclusion

- The combination of coconut sap or sugar palm sap which are added by sugar palm pollen increases the brood cells number, colony weight, and honey production of the bee *A. cerana* than the treatment of coconut sap or sugar palm sap without added by sugar palm pollen.
- The coconut sap is recommended as an alternative to sustainability feed for the bee *A. cerana* or other bee species because it has slowly fermented compared to sugar palm sap.

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KOMENTAR DARI REVIEWER TERHADAP ARTIKEL
(7 FEBRUARI 2022)

Gmail erwan apis <apiserwan@gmail.com>

220125apise

Reg Preston <reg.preston@gmail.com> 7 Februari 2022 pukul 07.08
Kepada: erwan apis <apiserwan@gmail.com>

220125apise concept to LRRD

1. The evaluated work presents an investigation on the native bee (*Apis cerana*) and the effect of supplementary feeding with a combination of energy sources: sap from two palms(*Arenga pinnata* and *Cocus nucifera*) and protein sources (palm pollen).

2. The study of local tropical agroforestry resources and the sustainable management of sustainable livestock production systems, in this case native bees, are two lines of greatest interest to LRRD, therefore the work is eligible for publication.

3. The research has an obvious connection to another work published in LRRD in 2021 (**Erwan, Muhsinin M and Agussalim 2021** Enhancing honey and bee bread cells number from Indonesian honeybee *Apis cerana* by feeding modification. *Livestock Research for Rural Development. Volume 33, Article #121*. Retrieved February 4, 2022, from http://www.lrrd.org/lrrd33;/10/33121apist.htm)and can be understood as a line of research over time on the same resources. The new experiment with its results is a logical continuation and does not duplicate the previous post.

4. The research presents a clear design of comparable treatments that seek a better combination between the sap of the palms and their pollen. The results are very clear and the authors give a reasonable explanation of them using appropriate and current bibliographic sources.

5. The contribution of new scientific knowledge and its possible immediate application by the producers warrants recommending the work for publication with a mention of congratulations to the authors. We need more healthy bees, more natural products based on tropical biodiversity that provide opportunities for food, employment and income for local people. These are principles shared by LRRD.

6. I only have two simple suggestions to the text for publication:

a. Expand information (hopefully with photographs) on the procedure for extracting the sap of *Arenga pinnata* and *Cocus nucifera*. This is for the thousands of readers from around the world who do not know this resource and these traditional uses.

b. Further describe in the Materials and Methods section how bees in each colonie are guaranteed to use each supplementation treatment and there are no errors because they feed on another treatment.

Thanks.
Professor T R Preston, PhD, DSc

Investigador Emérito
Centro para la Investigación en Sistemas Sostenibles
de Producción Agropecuaria (CIPAV),
Carrera 25 No 6-62 Cali, Colombia

Senior Editor, Livestock Research for Rural Development
http://www.lrrd.org (The international on-line journal on sustainable livestock-based agriculture)

Tropical Animal Production

http://www.cipav.org.co/TAP/tapindex.htm

Matching Ruminant Production Systems with Available Resources in the Tropics and Sub-Tropics
http://www.cipav.org.co/PandL/Preston_Leng.htm

El sitio Web sobre Producción Tropical Sostenible (Universidad de los Llanos, Colombia)
www.produccion tropicalsostenible.info

Web site (old) of MEKARN I

http://hostcambodia.com/mekarn/indexold.htm

On Tue, Feb 1, 2022 at 1:01 AM erwan apis <apiserwan@gmail.com> wrote:

> Dear Professor T R Preston, Ph.D., D.Sc.
>
> Senior Editor in LRRD
>
> in Colombia
>
> Good Afternoon, we hope Prof. T R Preston, Ph.D., D.Sc. is always healthy, happy doing the activity every day. I am Erwan from the Faculty of Animal Science, University of Mataram, Indonesia interest for me and our team to submit a paper with identity as follows:
>
> Title : Improving the productivity of local honeybee (*Apis cerana*) by using feeds coconut sap and sugar palm (sap and pollen) in West Lombok, Indonesia
>
> Authors : Erwan and Agussalim
>
> Affiliation : University of Mataram, Indonesia.
>
> In our study we use coconut sap and sugar palm sap which was added by sugar palm pollen. In addition, in our study we use the bee Apis cerana as the local honeybee in West Lombok, Indonesia. Based on the recent finding showed that the feed from sugar palm sap or coconut sap which was added by sugar palm pollen were increased the brood cells number, honey production, and colony weight of the bee *A. cerana*, but not on nest number and worker hatches weight compared to sugar palm sap or coconut sap without added by sugar palm pollen. The coconut sap or sugar palm sap which are added sugar palm sugar improves the productivity of the bee *A. cerana*. However, coconut sap which is added by sugar palm pollen is recommended as an alternative sustainability feed for the bees. Therefore, also increasing or improving the biodiversity of plants around the beekeeping location and creating a green environment.
>
> We hope our paper can be Accepted and Published in Livestock Research for Rural Development
>
> --
> Best Regards,
>
> Dr. Ir. Erwan, M.Si.
> Faculty of Animal Science, University of Mataram, Indonesia

Gmail erwan apis <apiserwan@gmail.com>

220125apise

erwan apis <apiserwan@gmail.com> 7 Februari 2022 pukul 09.09
Kepada: Reg Preston <reg.preston@gmail.com>

Dear Professor T R Preston, Ph.D., D.Sc.

Senior Editor in LRRD

in Colombia

Thanks very much for the information and some comments for our manuscript will be revise according to your suggestions and some pictures about the processing of coconut and sugar palm saps will be added in our manuscript

BUKTI SUBMIT PERBAIKAN/REVISI ARTIKEL DAN ARTIKEL HASIL PERBAIKAN
(10 FEBRUARI 2022)

Gmail erwan apis <apiserwan@gmail.com>

220125apise

erwan apis <apiserwan@gmail.com> 10 Februari 2022 pukul 20.47
Kepada: Reg Preston <reg.preston@gmail.com>

Dear Professor T R Preston, Ph.D., D.Sc.

Senior Editor in LRRD

in Colombia

We send a revise of our manuscript which is completed by the pictures of coconut sap and sugar palm sap (processing when it harvest and the sap). In addition, we inform to you that we also add one of author to manuscript because it include our team when this research conducted. Furthermore, for the comment Further describe in the Materials and Methods section how bees in each colonies are guaranteed to use each supplementation treatment and there are no errors because they feed on another treatment. We has been add the explanation that the colonies (box hives) were placed at distance of 600 meters. Finally, please find attached file of the revise our manuscript.

Thanks very much.

Best Regards,

Dr. Ir. Erwan, M.Si.
Faculty of Animal Science, University of Mataram, Indonesia

[Kutipan teks disembunyikan]

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ARTIKEL HASIL PERBAIKAN
(10 FEBRUARI 2022)

Improving the productivity of local honeybee (*Apis cerana*) by using feeds coconut sap and sugar palm (sap and pollen) in West Lombok, Indonesia

Erwan, Bambang Supeno[1] and Agussalim[2]

Faculty of Animal Science, University of Mataram, Jl. Majapahit No. 62, Mataram – 83125, Indonesia
apiserwan@gmail.com
[1]Faculty of Agriculture, University of Mataram, Jl. Majapahit No. 62, Mataram – 83125, Indonesia
[2]Faculty of Animal Science, Universitas Gadjah Mada, Jl. Fauna 3, Bulaksumur, Yogyakarta – 55281, Indonesia

Abstract

The productivity of the bee *Apis cerana* in the traditional beekeepers in Indonesia is low and one of the problems is feeding limited nectar and pollen when the rain season which is decreased productivity. The purposes of this research were to be improving the productivity of the local honeybee of *A. cerana* by using feeds coconut sap and sugar palm (sap and pollen) in West Lombok, Indonesia. The bee *A. cerana* of 30 colonies were divided into 6 groups consisting of sugar palm sap without added by sugar palm pollen; coconut sap without added by sugar palm pollen; 50% of coconut sap + 50% of sugar palm sap without added by sugar palm pollen; sugar palm sap was added by sugar palm pollen; coconut sap was added by sugar palm pollen; 50% of coconut sap + 50% sugar palm sap was added by sugar palm pollen. The recent finding showed that the feed from sugar palm sap or coconut sap which was added by sugar palm pollen were increased the brood cells number, honey production ($p<0.01$), and colony weight ($p<0.05$) of the bee *A. cerana*, but not on nest number and worker hatches weight compared to sugar palm sap or coconut sap without added by sugar palm pollen. The coconut sap or sugar palm sap which are added sugar palm pollen improves the productivity of the bee *A. cerana*. However, coconut sap which is added by sugar palm pollen is recommended as an alternative sustainability feed for the bees.

Keywords: *Arenga pinnata, bee bread, beekeeping, Cocos nucifera, honey*

Introduction

Apis cerana is included in morhpocluster Indo-Malayan *cerana* which is distributed in several islands in Indonesia consisting of Sumatera, Kalimantan, Java, Bali, Lombok, Sumbawa, Sulawesi, Papua, and Seram (Hepburn and Radloff 2011; Radloff et al 2011). The beekeeping of *A. cerana* to produce honey has been done by the beekeepers in several origins in Indonesia such as in North Sumatra, Riau, Lampung, Banten, West Java, Central Java, Yogyakarta Region, East Java, Bali, Nusa Penida, and Lombok (Schouten et al 2019). However, the bee hunters are still looking in the plantation and forest areas to harvest honey. In addition, the bee *A. cerana* also produce bee bread where the protein content ranges from 16.92 to 20.58% (Erwan et al 2021). The main role of honeybees is pollinators agent to improve the plants productivity which impacts the improvement of livelihoods (Partap 2011; Pohorecka et al 2014).

To produce honey in sustainability is required the availability of feed sufficient and sustained conditions like nectar and pollen from plant flowers that can be blooming all year. However,

the main problem when beekeeping the bees is lacking feed sources especially in the rain season. Furthermore, Schouten et al. (2019) reported some problems when beekeeping of the bee *A. cerana* in several origins in Indonesia especially in Java, Bali, and Sumbawa consists of queen bees rearing is minimum, absconding of the bees is high, beehives not yet standardized, high moisture of honey. In addition, Theisen-Jones and Bienefeld (2016) reported that Indonesia is one of the Asian countries which is significantly decreased the *A. cerana* population. Erwan et al (2021) have been studying the use of coconut sap which added by sugar palm pollen can increase production of honey cells and bee bread cells of the bee *A. cerana*. However, no studies have been done about the productivity of the bee *A. cerana* from Indonesia like honey production, brood cells number, colony weight, nest or comb numbers, and other parameters. Therefore, this study was aimed to improve the productivity of local honeybee *A. cerana* by using feeds of coconut sap and sugar palm sap or pollen.

Material and Methods

Location and study design

This study was performed in the Village of North Duman, Sub-district of Lingsar (West Lombok District, West Nusa Tenggara Province, Indonesia). This study used 30 colonies of the bee *A. cerana* by using a randomized complete block design with the factorial 3×2 and 5 replications. The first factor was plant sap, which consists of three subfactors were coconut sap (C) (Photo 1), sugar palm sap (S) (Photo 2), and a mix of 50% coconut sap + 50% sugar palm sap (SC). The second factor was sugar palm pollen consisting of two subfactors were added by sugar palm pollen (P) and without sugar palm pollen. The treatment in our study consisted of sugar palm sap without added by sugar palm pollen (SP0); coconut sap without added by sugar palm pollen (CP0); 50% of coconut sap + 50% of sugar palm sap without added by sugar palm pollen (SCP0); sugar palm sap was added by sugar palm pollen (SP1); coconut sap was added by sugar palm pollen (CP1); 50% of coconut sap + 50% sugar palm sap was added by sugar palm pollen (SCP1).

Photo 1. Coconut sap during the harvest process (A) and the sap was stored in the plastic bottles (B)

The given technique of plants sap and sugar palm pollen

The technique was used to give coconut sap, sugar palm sap, and sugar palm pollen according to the previous method reported by Erwan et al (2021). Briefly, the fresh coconut sap (*Cocos nucifera*), sugar palm sap (*Arenga pinnata*), and sugar palm pollen were obtained from North Duman Village, the Sub-district of Lingsar. Afterward, the fresh coconut and sugar palm saps were given to the bees by using plate plastic and split bamboo was supported by 4 to 5 of twigs as a foragers perch and placed at the distance of one meter from the box hives. The sugar palm pollen was hung in the wood at a height of 1.5 meters and placed besided the saps. To avoid the bees were collect sap and pollen from the other treatment, the box hives were placed at distance of 600 meters.

Photo 2. Sugar palm sap during the harvest process (A) and the sap was stored in the plastic glass (B)

Bee nests and brood cells numbers

Brood cells number were counted from 30 colonies of *A. cerana* from each treatment. Briefly, the covers of the box hives were removed and the frame which was contained the bee nest was lifted. Afterward, the brood cells number (Photo 3) were counted by using a hand counter for all the bee nests. The bee nest numbers were calculated from each treatment after three months of beekeeping from 30 colonies.

Colony weight and honey production

Colony's weights were weighed by using a digital scale for each treatment after three months of beekeeping minus by the weight of the empty box hive. Honey production was measured after beekeeping for three months. Briefly, honey (Photo 3) was harvested by opening the box hive cover and taking the frame which was contained honey. Afterward, a honeycomb from

each treatment was cut and squeezed to separate honey and wax. The clean honey was weighed by a digital scale from 30 colonies and each twice measured.

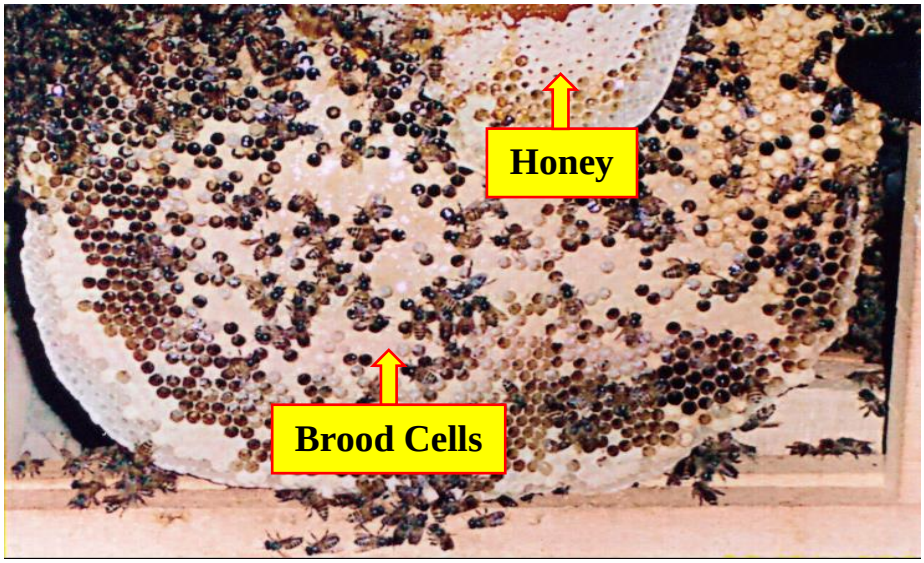

Photo 3. The brood cells and honey from the bee *A. cerana*

Hatches weight of worker bees

The hatches of worker bees were taken five heads (replications) for each treatment (Photo 4), then put into a tube and weighed by using a digital scale and each twice measured. This process was performed every third week for about three months of the beekeeping.

Photo 4. The collecting pupae before hatches to measure their hatches weight

Data analysis

The data of brood cells number, hatches weight of worker bees, bee nests number, colony weight, and honey production from the bee *A. cerana* were analyzed by using variance analysis and followed by contrast orthogonal test (Steel et al 1997).

Results and Discussion

Brood cells number

The recent finding showed that the feed of sugar palm sap or coconut sap, which were added by sugar palm pollen, increased the brood cells number ($p<0.01$) (Table 1). The brood cells number of the bee *A. cerana* was highest found in the treatment SP1 was 21,349 cells/colony, followed by CP1 was 18,271 cells/colony, then followed by the other treatments (SCP1, CP0, and SCP0), and the lowest was found in treatment SP0 was 7,142 cells/colony. Generally, the number of brood cells were higher found in the treatments of coconut and sugar palm saps which were added by sugar palm pollen compared to brood cells number at treatments of coconut and sugar palm saps without added by sugar palm pollen (Table 1).

Table 1. The brood cells number, hatches weight of worker bees, and nests number of the bee *A. cerana*

Parameters	Treatments						SEM	*p*
	SP0	CP0	SCP0	SP1	CP1	SCP1		
Brood cells number (cells/colony)	7,142[e]	10,129[d]	9,334[d]	21,349[a]	18,271[b]	14,223[c]	982	0.007
Worker hatches weight (g/head)	0.0628	0.0621	0.0627	0.0622	0.0620	0.0626	0.0002	0.869
Nest number (nest/colony)	5.60	6.20	6.00	7.00	7.80	7.00	0.170	0.537

[a,b,c,d,e] *Different superscripts within rows indicate differences at p<0.05. Abbreviations: SP0 = sugar palm sap without added by sugar palm pollen; CP0 = coconut sap without added by sugar palm pollen; SCP0 = 50% of coconut sap + 50% of sugar palm sap without added by sugar palm pollen; SP1 = sugar palm sap was added by sugar palm pollen; CP1 = coconut sap was added by sugar palm pollen; SCP1 = 50% of coconut sap + 50% sugar palm sap was added by sugar palm pollen.*

The difference in brood cells number were formed by the worker bees is related to feed availability namely nectar and pollen from the plant flowers. In our study, it was found that the bee *A. cerana* required both nectar and pollen for their feed to increase the brood cells number. In addition, in our study, the nectar was supplied by saps from sugar palm and coconut, while pollen was supplied by sugar palm flowers. To produce eggs maximally, the queen bee needed to be fed in sufficient quantity and quality. The availability of pollen from sugar palm continuously with high protein content was 27.12% (Erwan et al 2021) maybe can provide the essential and non-essential amino acids which was required by the queen bee to produce more eggs. The addition of sugar palm pollen as a protein source to produce the higher of brood cells number ranging 226 to 339 cells/day compared to without added by sugar palm pollen was produce brood cells number ranging 113 to 148 cells/day. Shuel (1992) explained that pollen collected by the bees contains high nutrients such as nineteen amino acids and contains the B-complex vitamins. In addition, most of the pollen was rich in proline amino acids. The queen bee was given royal jelly by the young worker bees in the nest continuously. The royal jelly was produced by the young worker bees at the age of 5 to 10 days old and the royal jelly feed was related to egg production from the queen bee, where the higher egg production was supported by the higher royal jelly consumption or otherwise.

In addition, Paray et al (2021) explained that pollen is the main protein source for the development of the colony, brood rearing, adult worker bees longevity, and as the raw material

to make royal jelly. Winston et al (1983) reported that each feeding period by one of the worker bees, the queen bee, can produce eggs ranging 2 to 26 eggs/day, where the feeding was given by 1 to 5 worker bees. Furthermore, Shah and Shah (1980) reported that the queen bee of *A. cerana* produces eggs ranging from 300 to 500 eggs/day if they are given the feed with good nutrition. The lack of pollen on the bee colony can be decreased the brood number, abnormal growth, and reduce the lifespan of the worker bees (Winston et al 1983). The bee colony can't carry and rearing the broods without the presence of pollen in sufficient quantities in the nest, so decrease the growth and development of the colonies. Gary (1992) explained that the queen bee can't produce an egg much more if the availability of pollen in small quantity and which was impacted on the low of eggs can be produced by the queen bee and decreasing the number of queen cells can be formed.

Hatches weight of worker bees

The recent finding showed that the difference of sugar palm sap, coconut sap, and sugar palm pollen in each treatment was similar on the hatches weight of worker bees ($p>0.05$). The hatches weight of worker bees from our study ranged from 0.0620 to 0.0628 g/head (Table 1). The hatches weight of the bee depends on the availability of food reserves like honey and pollen (bee bread) in the nest to fulfill the requirement for the growth of the bee brood. Honey and bee bread are very necessary for the development of larvae and pupae in the brood cells of the bees. The growth and development of the bees have started since the queen bee lays eggs into brood cells until they become larvae and pupae, where their requirements are protein, carbohydrate, fat, vitamins, and minerals in sufficient amounts and quality. The larvae of the bee that are less than 3 days old were given food of royal jelly to rapidly their growth and development (Winston 1987). In addition, the larvae which were nursed by the worker bees as the candidate of new queen bee was fed royal jelly to rapidly of their growth and development (Abrol 2011; Abrol et al 2005; Paray et al 2021; Wongsiri et al 1990).

Pupae is the final period before the bees hatches which is characterized by the formation of the head, eyes, antennae, chest, legs, and abdomen, but the wings have not yet developed. Generally, the total time from the egg to hatches was 16 days for queen bees, 21 days for worker bees, and 24 days for drones. However this period varied, ranging from 14 to 17 days for queen bees, 14 to 16 days for worker bees, and 20 to 28 days for drones (Winston 1987). This variation was caused by environment and food factors. The lower temperature under the normal temperature (35^{o}C) can inhibit the bees hatches and inhibit the larvae development. The larvae in the comb site require a longer time than larvae in the center of the comb. This condition is related to the temperature and humidity stabilities from each location around the nest or comb. In addition, the hatches weight of the worker bees was affected by the availability of nectar and pollen, brood cells size, the population of worker bees, disease or pest, and season. The lack of feed which had stunted growth, lower hatches weight, and higher rate mortality. Furthermore, Subandrio et al (1997) reported that the installation of the pollen trap continuously did not affect the hatches weight of the worker bees because the food reserve in the nest can fulfill the nutrients requirement for larvae or pupae.

Nest number

The recent finding showed that the nest number from each treatment sugar palm sap, coconut sap, and sugar palm pollen each treatment was similar ranging from 5.60 to 7.80 nest/colony ($p>0.05$) (Table 1). The nest was used by the bees to storage honey and bee bread and as the location to queen bee lays. The large nest number in the hive was caused by the increase of the

honey cells, pollen cells, and larvae or pupae numbers. The coconut sap and sugar palm pollen are taken by the bees as food to stimulate worker bees to make the new nest or comb. The nest or comb was made from the wax produced or secreted by four glands located in the abdomen of the worker bees. Furthermore, was mixed by using saliva until it becomes solid with high elasticity to make it easy to be shaping. A thick layer of wax is placed in the base of the nest, then cells are slowly made by lengthening and thinning the wax so that it is made into cell walls. The worker bees will be built the brood cells simultaneously and start at the top horizontally (Winston 1987). This condition may be useful for preventing the honey from spilling from the honey cells. The worker bees will be increasing their activity to make the comb if supported by higher food flow, so increasing the eggs produced by the queen bee. In addition, the high queen bee producing eggs must be supported by the higher pollen availability. The formation of pollen and honey cells and brood cells will be stimulating the bees to increase the number of nests. The nest or comb number in our study (Table 1) was lower compared to reported by Schouten et al (2019) that the comb can be produced by the bee *A. cerana* from three origins in Indonesia (Java, Bali, and Sumbawa) ranging from 10 to 12 combs from traditional beekeeping. The nests number of the bee *A. cerana* in our study (Table 1) are in line with the reported by Hikmah et al (2021) that the Asiatic honey bee of *A. cerana* ranging from 5 to 10 nests/colony.

Table 2. The colony weight and honey production of the bee *A. cerana*

Parameters	Treatments						SEM	*p*
	SP0	CP0	SCP0	SP1	CP1	SCP1		
Colony weight (kg/colony)	3.14^{d}	3.57^{c}	3.53^{c}	5.36^{a}	5.57^{a}	4.43^{b}	0.211	0.043
Honey production (g/colony)	288.21^{e}	574.04^{c}	454.84^{d}	714.53^{b}	931.65^{a}	543.50^{c}	38.85	0.000

^{a,b,c,d,e} *Different superscripts within rows indicate differences at $p<0.05$. Abbreviations: SP0 = sugar palm sap without added by sugar palm pollen; CP0 = coconut sap without added by sugar palm pollen; SCP0 = 50% of coconut sap + 50% of sugar palm sap without added by sugar palm pollen; SP1 = sugar palm sap was added by sugar palm pollen; CP1 = coconut sap was added by sugar palm pollen; SCP1 = 50% of coconut sap + 50% sugar palm sap was added by sugar palm pollen.*

Colony weight

The recent finding showed that the difference of sugar palm sap, coconut sap, and sugar palm pollen in each treatment was significant on the colony weight of the bee *A. cerana* (*$p<0.05$*) (Table 2). The highest colony weight was found in treatment CP1 was 5.57 kg/colony, which was similar to the colony weight from the treatment SP1 was 5.36 kg/colony. Furthermore, followed by the treatment SCP1 with the colony weight was 4.43 kg/colony and the lowest of colony weights were found in treatments SCP0, CP0, and SP0, 3.53 kg/colony, 3.57 kg/colony, and 3.14 kg/colony, respectively. These findings indicate that both nectar and pollen from the plants were needed by the bee *A. cerana* to support their colony development like colony weight. In addition, our study also showed that the bee *A. cerana* was fed only nectar to decrease the colony weight. Generally, the colonies were treated by sugar palm sap or coconut sap which was added by sugar palm pollen which resulted in a higher colony weight compared to sugar palm sap or coconut sap without the addition of the sugar palm pollen. The colony weight was higher in the treatment sugar palm sap or coconut sap which was added by sugar palm pollen was supported by the much more of brood cells number which was shown in Table

1. The colony weight of the bee *A. cerana* in our study was higher compared to reported by Widowati et al (2020) that the bee *A. cerana* which was fed by pollen substituted (made from soybean dregs, skim milk, and bread yeast) resulted in the colony weight ranging from 0.30 to 1.52 kg/colony for seven weeks of the beekeeping. The difference in colony weight was affected by the difference of the feed availability (pollen and nectar), the colony's health, and the environmental condition (temperature and humidity).

The worker bees are usually taking the feed with the location was closer to the nest, therefore the much more of the availability of feed with the closer distance was rapidly the deposit of honey and bee bread as the reserve food in the nest. The addition of sugar palm pollen resulted in higher brood cells namely 280 cells/day compared to without the addition of sugar palm pollen was 141 cells/day. The high number of brood cells formed by the worker bees will increase the population of worker bees. A few hours after hatching, the young bee directly consumes pollen (bee bread) which is used for the development of their body organs. The consumption of this bee bread continued to be increased until the age of worker bees 5 to 6 days old and bee bread as the main source of protein and amino acids which was required by the bees for their growth and development. Furthermore, the protein requirement will be decreased when the age of worker bees is 10 to 14 days old. Zaytoon et al (1988) reported that the pollen in the bee *A. mellifera* will increase the development of the hypopharyngeal gland and the laying capacity of the queen bee. The deficiency of pollen will inhibit colony development, brood cells production will decrease and reduce the lifespan of worker bees (Winston et al 1983). The addition of coconut sap or sugar palm sap which was added by the sugar palm pollen can fulfill the nutrient requirement like protein, carbohydrates, fat, vitamins, and minerals which were needed for the growth and development of the bee *A. cerana*. In addition, the excess of the food will be deposited or stored into honey cells and pollen cells (bee bread cells) so can stimulate the worker bees to create a new comb which was impacted by the increase of the colony weight. Furthermore, Kuntadi (2002) explained that much more food availability in the nest will be stimulating the worker bees to create a new comb that was used to storage honey and bee bread as the food reserve and was produced by the queen bee.

Honey production

Honey was produced by the worker bees by a using nectar as the raw material and stored in the honeycomb for the bee in the *Apis* genus. The recent finding showed that the difference of sugar palm sap, coconut sap, and sugar palm pollen in each treatment was highly significant on honey production of the bee *A. cerana* (Table 2) ($p<0.01$). The highest amount of honey production was found in treatment CP1 was 931.65 g/colony, followed by the treatment SP1 was 714.53 g/colony, CP0 was 574.04 g/colony was similar with the treatment SCP1 was 543.50 g/colony and the lowest of honey production was found in the treatment SCP0 and SP0 were 454.84 g/colony and 288.21 g/colony, respectively (Table 2). In our study was in line with the study by Erwan et al (2021) that the combination of coconut sap or sugar palm sap, which were added by sugar palm pollen increased the production of honey and bee bread cells which impacted on the increasing of honey production.

Honeybees are requirement of feed that contain complete nutrients like carbohydrates, protein, vitamins, minerals, and other nutrients for their life such as for colony development, queen bee care, to increase eggs production by the queen bee and increase honey production (Abrol 2011; Paray et al 2021). The carbohydrates source is mostly obtained from nectar and honeydew and is the main material to produce honey, while protein source is obtained from pollen. Therefore, to produce honey in big quantities must be supported by the availability of nectar and pollen

continuously. The high of honey production was caused by the much more of saps amount was taken by the bees and the slow change of coconut sap from fresh to sour taste was longer compared to sugar palm sap and they are mixed. Therefore, was impacted on the higher of coconut sap amount can be collected by the worker bees, so was increased the honey production. The coconut sap has been collected by the worker bees, stored in the honey stomach, and then was transported to the young worker bees for processing into honey which was added by the invertase enzyme. The mature honey was stored by the worker bees in the honeycomb or honey cells at the top of the nest or comb. The main process in honey production was the decomposition of sucrose nectar into glucose and fructose and then water evaporation. The sugar content was also one of the factors that were influencing the increase of honey production and higher sugar content of coconut sap will be faster in honey maturation. Souza et al (2002) reported that the larger corbiculae can be stored in pollen and transported to the hive which was used to increase honey production.

Production of honey in Table 2 was higher compared to reported by Supeno et al (2021) for the bee *A. cerana* which was beekeeping in the coffee plantation (nectar main source) in Central Lombok (Indonesia) was 301.35 g/hive/5 months. Schouten et al (2019) reported production of honey from the bee *A. cerana* in Indonesia ranges from 0.5 to 5 kg/hive. Furthermore, Widowati et al (2020) reported production of honey from the bee *A. cerana* which was fed by pollen substituted (made from soybean dregs, skim milk, and bread yeast) ranging from 210 to 1,010 mL/colony for seven weeks of the beekeeping. The difference in honey production was affected by the different of the bee feed (nectar and pollen), the condition of the bees (health, growth, and development), the population of the worker bees, environmental condition (climatic, season, temperature, humidity), and the activity level of the worker bees. In addition, Hikmah et al (2021) reported that the bee *A. cerana* produce honey was 250.58 g/colony which was beekeeping in the protected forest in Enrekang Regency (South Sulawesi), Indonesia.

Conclusion

- The combination of coconut sap or sugar palm sap which are added by sugar palm pollen increases the brood cells number, colony weight, and honey production of the bee *A. cerana* than the treatment of coconut sap or sugar palm sap without added by sugar palm pollen.
- The coconut sap is recommended as an alternative to sustainability feed for the bee *A. cerana* or other bee species because it has slowly fermented compared to sugar palm sap.

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Investigador Emérito
Centro para la Investigación en Sistemas Sostenibles
de Producción Agropecuaria (CIPAV),
Carrera 25 No 6-62 Cali, Colombia

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(19 MARET 2022)

Improving the productivity of local honeybee (*Apis cerana*) by using feeds coconut sap and sugar palm (sap and pollen) in West Lombok, Indonesia

Erwan, Bambang Supeno[1] and Agussalim[2]

Faculty of Animal Science, University of Mataram, Jl. Majapahit No. 62, taram – 83125, Indonesia
apiserwan@gmail.com
[1]Faculty of Agriculture,University of Mataram, Jl. Majapahit No. 62, Mataram – 3125, Indonesia
[2]Faculty of Animal Science, Universitas Gadjah Mada, Jl. Fauna 3, Bulaksumur, Yogyakarta – 55281, Indonesia

Abstract

The productivity of the bee *Apis cerana* in the traditional beekeepers in Indonesia is low and one of the problems is feeding limited nectar and pollen when the rain season which is decreased productivity. The purposes of this research were to be improving the productivity of the local honeybee of *A. cerana* by using feeds coconut sap and sugar palm (sap and pollen) in West Lombok, Indonesia. The bee *A. cerana* of 30 colonies were divided into 6 groups consisting of sugar palm sap without added by sugar palm pollen; coconut sap without added by sugar palm pollen; 50% of coconut sap + 50% of sugar palm sap without added by sugar palm pollen; sugar palm sap was added by sugar palm pollen; coconut sap was added by sugar palm pollen; 50% of coconut sap + 50% sugar palm sap was added by sugar palm pollen. The recent finding showed that the feed from sugar palm sap or coconut sap which was added by sugar palm pollen were increased the brood cells number, honey production ($p<0.01$), and colony weight ($p<0.05$) of the bee *A. cerana*, but not on nest number and worker hatches weight compared to sugar palm sap or coconut sap without added by sugar palm pollen. The coconut sap or sugar palm sap which are added sugar palm pollen improves the productivity of the bee *A. cerana*. However, coconut sap which is added by sugar palm pollen is recommended as an alternative sustainability feed for the bees.

Keywords: *Arenga pinnata, bee bread, beekeeping, Cocos nucifera, honey*

Introduction

Apis cerana is included in morhpocluster Indo-Malayan *cerana* which is distributed in several islands in Indonesia consisting of Sumatera, Kalimantan, Java, Bali, Lombok, Sumbawa, Sulawesi, Papua, and Seram (Hepburn and Radloff 2011; Radloff et al 2011). The beekeeping of *A. cerana* to produce honey has been done by the beekeepers in several origins in Indonesia such as in North Sumatra, Riau, Lampung, Banten, West Java, Central Java, Yogyakarta Region, East Java, Bali, Nusa Penida, and Lombok (Schouten et al 2019). However, the bee hunters are still looking in the plantation and forest areas to harvest honey. In addition, the bee *A. cerana* also produce bee bread where the protein content ranges from 16.92 to 20.58% (Erwan et al 2021). The main role of honeybees is pollinators agent to improve the plants productivity which impacts the improvement of livelihoods (Partap 2011; Pohorecka et al 2014).

To produce honey in sustainability is required the availability of feed sufficient and sustained conditions like nectar and pollen from plant flowers that can be blooming all year. However, the main problem when beekeeping the bees is lacking feed sources especially in the rain season. Furthermore, Schouten et al. (2019) reported some problems when beekeeping of the bee *A. cerana* in several origins in Indonesia especially in Java, Bali, and Sumbawa consists of queen bees rearing is minimum, absconding of the bees is high, beehives not yet standardized, high moisture of honey. In addition, Theisen-Jones and Bienefeld (2016) reported that Indonesia is one of the Asian countries which is significantly decreased the *A. cerana* population. Erwan et al (2021) have been studying the use of coconut sap which added by sugar palm pollen can increase production of honey cells and bee bread cells of the bee *A. cerana*. However, no studies have been done about the productivity of the bee *A. cerana* from Indonesia like honey production, brood cells number, colony weight, nest or comb numbers, and other parameters. Therefore, this study was aimed to improve the productivity of local honeybee *A. cerana* by using feeds of coconut sap and sugar palm sap or pollen.

Material and methods

Location and study design

This study was performed in the Village of North Duman, Sub-district of Lingsar (West Lombok District, West Nusa Tenggara Province, Indonesia). This study used 30 colonies of the bee *A. cerana* by using a randomized complete block design with the factorial 3×2 and 5 replications. The first factor was plant sap, which consists of three subfactors were coconut sap (C) (Photo 1), sugar palm sap (S) (Photo 2), and a mix of 50% coconut sap + 50% sugar palm sap (SC). The second factor was sugar palm pollen consisting of two subfactors were added by sugar palm pollen (P) and without sugar palm pollen. The treatment in our study consisted of sugar palm sap without added by sugar palm pollen (SP0); coconut sap without added by sugar palm pollen (CP0); 50% of coconut sap + 50% of sugar palm sap without added by sugar palm pollen (SCP0); sugar palm sap was added by sugar palm pollen (SP1); coconut sap was added by sugar palm pollen (CP1); 50% of coconut sap + 50% sugar palm sap was added by sugar palm pollen (SCP1).

Photo 1. Coconut sap during the harvest process (A) and the sap was stored in the plastic bottles (B)

The technique was used to give coconut sap, sugar palm sap, and sugar palm pollen according to the previous method reported by Erwan et al (2021). Briefly, the fresh coconut sap (*Cocos nucifera*), sugar palm sap (*Arenga pinnata*), and sugar palm pollen were obtained from North Duman Village, the Sub-district of Lingsar. Afterward, the fresh coconut and sugar palm saps were given to the bees by using plate plastic and split bamboo was supported by 4 to 5 of twigs as a foragers perch and placed at the distance of one meter from the box hives. The sugar palm pollen was hung in the wood at a height of 1.5 meters and placed besided the saps. To avoid the bees were collect sap and pollen from the other treatment, the box hives were placed at distance of 600 meters.

Photo 2. Sugar palm sap during the harvest process (A) and the sap was stored in the plastic glass (B)

Bee nests and brood cells numbers

Brood cells number were counted from 30 colonies of *A. cerana* from each treatment. Briefly, the covers of the box hives were removed and the frame which was contained the bee nest was lifted. Afterward, the brood cells number (Photo 3) were counted by using a hand counter for all the bee nests. The bee nest numbers were calculated from each treatment after three months of beekeeping from 30 colonies.

Colony weight and honey production

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Colony's weights were weighed by using a digital scale for each treatment after three months of beekeeping minus by the weight of the empty box hive. Honey production was measured after beekeeping for three months. Briefly, honey (Photo 3) was harvested by opening the box hive cover and taking the frame which was contained honey. Afterward, a honeycomb from each treatment was cut and squeezed to separate honey and wax. The clean honey was weighed by a digital scale from 30 colonies and each twice measured.

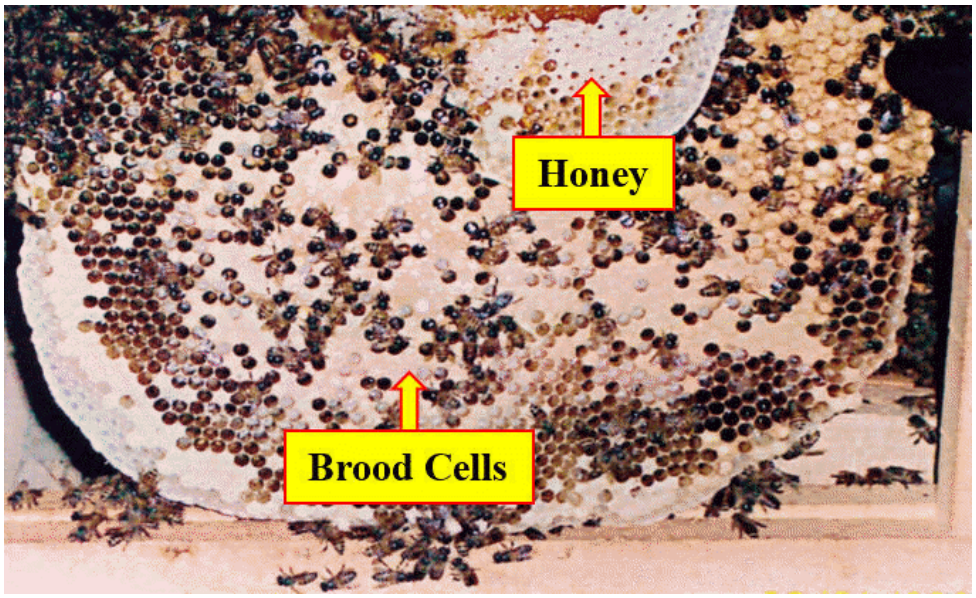

Photo 3. The brood cells and honey from the bee *A. cerana*

Hatches weight of worker bees

The hatches of worker bees were taken five heads (replications) for each treatment (Photo 4), then put into a tube and weighed by using a digital scale and each twice measured. This process was performed every third week for about three months of the beekeeping.

Photo 4. The collecting pupae before hatches to measure their hatches weight

Data analysis

The data of brood cells number, hatches weight of worker bees, bee nests number, colony weight, and honey production from the bee *A. cerana* were analyzed by using variance analysis and followed by contrast orthogonal test (Steel et al 1997).

Results and Discussion

Brood cells number

The recent finding showed that the feed of sugar palm sap or coconut sap, which were added by sugar palm pollen, increased the brood cells number ($p<0.01$) (Table 1). The brood cells number of the bee *A. cerana* was highest found in the treatment SP1 was 21,349 cells/colony, followed by CP1 was 18,271 cells/colony, then followed by the other treatments (SCP1, CP0, and SCP0), and the lowest was found in treatment SP0 was 7,142 cells/colony. Generally, the number of brood cells were higher found in the treatments of coconut and

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sugar palm saps which were added by sugar palm pollen compared to brood cells number at treatments of coconut and sugar palm saps without added by sugar palm pollen (Table 1).

Table 1. The brood cells number, hatches weight of worker bees, and nests number of the bee *A. cerana*

Parameters	Treatments						SEM	*p*
	SP0	CP0	SCP0	SP1	CP1	SCP1		
Brood cells number (cells/colony)	7,142^{e}	10,129^{d}	9,334^{d}	21,349^{a}	18,271^{b}	14,223^{c}	982	0.007
Worker hatches weight (g/head)	0.0628	0.0621	0.0627	0.0622	0.0620	0.0626	0.0002	0.869
Nest number (nest/colony)	5.60	6.20	6.00	7.00	7.80	7.00	0.170	0.537

^{a,b,c,d,e} *Different superscripts within rows indicate differences at p<0.05. Abbreviations: SP0 = sugar palm sap without added by sugar palm pollen; CP0 = coconut sap without added by sugar palm pollen; SCP0 = 50% of coconut sap + 50% of sugar palm sap without added by sugar palm pollen; SP1 = sugar palm sap was added by sugar palm pollen; CP1 = coconut sap was added by sugar palm pollen; SCP1 = 50% of coconut sap + 50% sugar palm sap was added by sugar palm pollen*

The difference in brood cells number were formed by the worker bees is related to feed availability namely nectar and pollen from the plant flowers. In our study, it was found that the bee *A. cerana* required both nectar and pollen for their feed to increase the brood cells number. In addition, in our study, the nectar was supplied by saps from sugar palm and coconut, while pollen was supplied by sugar palm flowers. To produce eggs maximally, the queen bee needed to be fed in sufficient quantity and quality. The availability of pollen from sugar palm continuously with high protein content was 27.12% (Erwan et al 2021) maybe can provide the essential and non-essential amino acids which was required by the queen bee to produce more eggs. The addition of sugar palm pollen as a protein source to produce the higher of brood cells number ranging 226 to 339 cells/day compared to without added by sugar palm pollen was produce brood cells number ranging 113 to 148 cells/day. Shuel (1992) explained that pollen collected by the bees contains high nutrients such as nineteen amino acids and contains the B-complex vitamins. In addition, most of the pollen was rich in proline amino acids. The queen bee was given royal jelly by the young worker bees in the nest continuously. The royal jelly was produced by the young worker bees at the age of 5 to 10 days old and the royal jelly feed was related to egg production from the queen bee, where the higher egg production was supported by the higher royal jelly consumption or otherwise.

In addition, Paray et al (2021) explained that pollen is the main protein source for the development of the colony, brood rearing, adult worker bees longevity, and as the raw material to make royal jelly. Winston et al (1983) reported that each feeding period by one of the worker bees, the queen bee, can produce eggs ranging 2 to 26 eggs/day, where the feeding was given by 1 to 5 worker bees. Furthermore, Shah and Shah (1980) reported that the queen bee of *A. cerana* produces eggs ranging from 300 to 500 eggs/day if they are given the feed with good nutrition. The lack of pollen on the bee colony can be decreased the brood number, abnormal growth, and reduce the lifespan of the worker bees (Winston et al 1983). The bee colony can't carry and rearing the broods without the presence of pollen in sufficient quantities in the nest, so decrease the growth and development of the colonies. Gary (1992) explained that the queen bee can't produce an egg much more if the availability of pollen in small quantity and which was impacted on the low of eggs can be produced by the queen bee and decreasing the number of queen cells can be formed.

Hatches weight of worker bees

The recent finding showed that the difference of sugar palm sap, coconut sap, and sugar palm pollen in each treatment was similar on the hatches weight of worker bees ($p>0.05$). The hatches weight of worker bees from our study ranged from 0.0620 to 0.0628 g/head (Table 1). The hatches weight of the bee depends on the availability of food reserves like honey and pollen (bee bread) in the nest to fulfill the requirement for the growth of the bee brood. Honey and bee bread are very necessary for the development of larvae and pupae in the brood cells of the bees. The growth and development of the bees have started since the queen bee lays eggs into brood cells until they become larvae and pupae, where their requirements are protein, carbohydrate, fat, vitamins, and minerals in sufficient amounts and quality. The larvae of the bee that are less than 3 days old were given food of royal jelly to rapidly their growth and development (Winston 1987). In addition, the larvae which were nursed by the worker bees as the candidate of new queen bee was fed royal jelly to rapidly of their growth and development (Abrol 2011; Abrol et al 2005; Paray et al 2021; Wongsiri et al 1990).

Pupae is the final period before the bees hatches which is characterized by the formation of the head, eyes, antennae, chest, legs, and abdomen, but the wings have not yet developed. Generally, the total time from the egg to hatches was 16 days for queen bees, 21 days for worker bees, and 24 days for drones. However this period varied, ranging from 14 to 17 days for queen bees, 14 to 16 days for worker bees, and 20 to 28 days for drones (Winston 1987). This variation was caused by environment and food factors. The lower temperature under the normal temperature (35^{o}C) can inhibit the bees hatches and inhibit the larvae development. The larvae in the comb site require a longer time than larvae in the center of the comb. This condition is related to the temperature and humidity stabilities from each location around the nest or comb. In addition, the hatches weight of the worker bees was affected by the availability of nectar and pollen, brood cells size, the population of worker bees, disease or pest, and season. The lack of feed which had stunted growth, lower hatches weight, and higher rate mortality. Furthermore, Subandrio et al (1997) reported that the installation of the pollen trap continuously did not affect the hatches weight of the worker bees because the food reserve in the nest can fulfill the nutrients requirement for larvae or pupae.

Nest number

The recent finding showed that the nest number from each treatment sugar palm sap, coconut sap, and sugar palm pollen each treatment was similar ranging from 5.60 to 7.80 nest/colony ($p>0.05$) (Table 1). The nest was used by the bees to storage honey and bee bread and as the location to queen bee lays. The large nest number in the hive was caused by the increase of the honey cells, pollen cells, and larvae or pupae numbers. The coconut sap and sugar palm pollen are taken by the bees as food to stimulate worker bees to make the new nest or comb. The nest or comb was made from the wax produced or secreted by four glands located in the abdomen of the worker bees. Furthermore, was mixed by using saliva until it becomes solid with high elasticity to make it easy to be shaping. A thick layer of wax is placed in the base of the nest, then cells are slowly made by lengthening and thinning the wax so that it is made into cell walls. The worker bees will be built the brood cells simultaneously and start at the top horizontally (Winston 1987). This condition may be useful for preventing the honey from spilling from the honey cells. The worker bees will be increasing their activity to make the comb if supported by higher food flow, so increasing the eggs produced by the queen bee. In addition, the high queen bee producing eggs must be supported by the higher pollen availability. The formation of pollen and honey cells and brood cells will be stimulating the bees to increase the

number of nests. The nest or comb number in our study (Table 1) was lower compared to reported by Schouten et al (2019) that the comb can be produced by the bee *A. cerana* from three origins in Indonesia (Java, Bali, and Sumbawa) ranging from 10 to 12 combs from traditional beekeeping. The nests number of the bee *A. cerana* in our study (Table 1) are in line with the reported by Hikmah et al (2021) that the Asiatic honey bee of *A. cerana* ranging from 5 to 10 nests/colony.

Table 2. The colony weight and honey production of the bee *A. cerana*

Parameters	Treatments						SEM	*p*
	SP0	CP0	SCP0	SP1	CP1	SCP1		
Colony weight (kg/colony)	3.14^{d}	3.57^{c}	3.53^{c}	5.36^{a}	5.57^{a}	4.43^{b}	0.211	0.043
Honey production (g/colony)	288.21^{e}	574.04^{c}	454.84^{d}	714.53^{b}	931.65^{a}	543.50^{c}	38.85	0.000

^{a,b,c,d,e} *Different superscripts within rows indicate differences at p<0.05. Abbreviations: SP0 = sugar palm sap without added by sugar palm pollen; CP0 = coconut sap without added by sugar palm pollen; SCP0 = 50% of coconut sap + 50% of sugar palm sap without added by sugar palm pollen; SP1 = sugar palm sap was added by sugar palm pollen; CP1 = coconut sap was added by sugar palm pollen; SCP1 = 50% of coconut sap + 50% sugar palm sap was added by sugar palm pollen*

Colony weight

The recent finding showed that the difference of sugar palm sap, coconut sap, and sugar palm pollen in each treatment was significant on the colony weight of the bee *A. cerana* (*p<0.05*) (Table 2). The highest colony weight was found in treatment CP1 was 5.57 kg/colony, which was similar to the colony weight from the treatment SP1 was 5.36 kg/colony. Furthermore, followed by the treatment SCP1 with the colony weight was 4.43 kg/colony and the lowest of colony weights were found in treatments SCP0, CP0, and SP0, 3.53 kg/colony, 3.57 kg/colony, and 3.14 kg/colony, respectively. These findings indicate that both nectar and pollen from the plants were needed by the bee *A. cerana* to support their colony development like colony weight. In addition, our study also showed that the bee *A. cerana* was fed only nectar to decrease the colony weight. Generally, the colonies were treated by sugar palm sap or coconut sap which was added by sugar palm pollen which resulted in a higher colony weight compared to sugar palm sap or coconut sap without the addition of the sugar palm pollen. The colony weight was higher in the treatment sugar palm sap or coconut sap which was added by sugar palm pollen was supported by the much more of brood cells number which was shown in Table 1. The colony weight of the bee *A. cerana* in our study was higher compared to reported by Widowati et al (2020) that the bee *A. cerana* which was fed by pollen substituted (made from soybean dregs, skim milk, and bread yeast) resulted in the colony weight ranging from 0.30 to 1.52 kg/colony for seven weeks of the beekeeping. The difference in colony weight was affected by the difference of the feed availability (pollen and nectar), the colony's health, and the environmental condition (temperature and humidity).

The worker bees are usually taking the feed with the location was closer to the nest, therefore the much more of the availability of feed with the closer distance was rapidly the deposit of honey and bee bread as the reserve food in the nest. The addition of sugar palm pollen resulted in higher brood cells namely 280 cells/day compared to without the addition of sugar palm pollen was 141 cells/day. The high number of brood cells formed by the worker bees will increase the population of worker bees. A few hours after hatching, the young bee directly consumes pollen (bee bread) which is used for the development of their body organs. The consumption of this bee bread continued to be increased until the age of worker bees 5 to 6 days old and bee bread as the main source of protein and amino acids which was required by the bees for their growth and development. Furthermore, the protein requirement will be decreased when the age of worker bees is 10 to 14 days old. Zaytoon et al (1988) reported that the pollen in the bee *A. mellifera* will increase the development of the hypopharyngeal gland and the laying capacity of the queen bee. The deficiency of pollen will inhibit colony development, brood cells production will decrease and reduce the lifespan of worker bees (Winston et al 1983). The addition of coconut sap or sugar palm sap which was added by the sugar palm pollen can fulfill the nutrient requirement like protein, carbohydrates, fat, vitamins, and minerals which were needed for the growth and development of the bee *A. cerana*. In addition, the excess of the food will be deposited or stored into honey cells and pollen cells (bee bread cells) so can stimulate the worker bees to create a new comb which was impacted by the increase of the colony weight. Furthermore, Kuntadi (2002) explained that much more food availability in the nest will be stimulating the worker bees to create a new comb that was used to storage honey and bee bread as the food reserve and was produced by the queen bee.

Honey production

Honey was produced by the worker bees by a using nectar as the raw material and stored in the honeycomb for the bee in the *Apis* genus. The recent finding showed that the difference of sugar palm sap, coconut sap, and sugar palm pollen in each treatment was highly significant on honey production of the bee *A. cerana* (Table 2) (*p<0.01*). The highest amount of honey production was found in treatment CP1 was 931.65 g/colony, followed by the treatment SP1 was 714.53 g/colony, CP0 was 574.04 g/colony was similar with the treatment SCP1 was 543.50 g/colony and the lowest of honey production was found in the treatment SCP0 and SP0 were 454.84 g/colony and 288.21 g/colony, respectively (Table 2). In our study was in line with the study by Erwan et al (2021) that the combination of coconut sap or sugar palm sap, which were added by sugar palm pollen increased the production of honey and bee bread cells which impacted on the increasing of honey production.

Honeybees are requirement of feed that contain complete nutrients like carbohydrates, protein, vitamins, minerals, and other nutrients for their life such as for colony development, queen bee care, to increase eggs production by the queen bee and increase honey production (Abrol 2011; Paray et al 2021). The carbohydrates source is mostly obtained from nectar and honeydew and is the main material to produce honey, while protein source is obtained from pollen. Therefore, to produce honey in big quantities must be supported by the availability of nectar and pollen continuously. The high of honey production was caused by the much more of saps amount was taken by the bees and the slow change of coconut sap from fresh to sour taste was longer compared to sugar palm sap and they are mixed. Therefore, was impacted on the higher of coconut sap amount can be collected by the worker bees, so was increased the honey production. The coconut sap has been collected by the worker bees, stored in the honey stomach, and then was transported to the young worker bees for processing into honey which was added by the invertase enzyme. The mature honey was stored by the worker bees in the honeycomb or honey cells at the top of the nest or comb. The main process in honey production was the decomposition of sucrose nectar into glucose and fructose and then water evaporation. The sugar content was also one of the factors that were influencing the increase of honey production and higher sugar content of coconut sap will be faster in honey maturation. Souza et al (2002) reported that the larger corbiculae can be stored in pollen and transported to the hive which was used to increase honey production.

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Production of honey in Table 2 was higher compared to reported by Supeno et al (2021) for the bee *A. cerana* which was beekeeping in the coffee plantation (nectar main source) in Central Lombok (Indonesia) was 301.35 g/hive/5 months. Schouten et al (2019) reported production of honey from the bee *A. cerana* in Indonesia ranges from 0.5 to 5 kg/hive. Furthermore, Widowati et al (2020) reported production of honey from the bee *A. cerana* which was fed by pollen substituted (made from soybean dregs, skim milk, and bread yeast) ranging from 210 to 1,010 mL/colony for seven weeks of the beekeeping. The difference in honey production was affected by the different of the bee feed (nectar and pollen), the condition of the bees (health, growth, and development), the population of the worker bees, environmental condition (climatic, season, temperature, humidity), and the activity level of the worker bees. In addition, Hikmah et al (2021) reported that the bee *A. cerana* produce honey was 250.58 g/colony which was beekeeping in the protected forest in Enrekang Regency (South Sulawesi), Indonesia.

Conclusion

- The combination of coconut sap or sugar palm sap which are added by sugar palm pollen increases the brood cells number, colony weight, and honey production of the bee *A. cerana* than the treatment of coconut sap or sugar palm sap without added by sugar palm pollen.
- The coconut sap is recommended as an alternative to sustainability feed for the bee *A. cerana* or other bee species because it has slowly fermented compared to sugar palm sap.

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Location and study design

Second paragraph

(*Arenga pinnata*) (*Arenga pinnata*)

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Results and discussion

Nest number

First paragraph

First sentence

nest/colony nests/colony

Colony weight

Second paragraph

Last sentence

and was produced by the queen bee and increase the brood cells number.

References

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Best Regards,

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Faculty of Animal Science, University of Mataram, Indonesia

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Faculty of Animal Science, University of Mataram, Indonesia

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