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Growth characteristics and casava (*Samia cynthia ricini*) caterpillar's ability to digest leaf *Manihot esculenta* Crantz

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Abstract
Cassava caterpillars (*Samia cynthia ricini*) are a type of silk-producing caterpillar that consumes castor bean leaves, cassava leaves, and papaya leaves. A study was conducted to determine the growth characteristics of casava caterpillars (*Samia cynthia ricini*) fed with elephant cassava (*Manihot esculenta* Crantz) leaves. A total of 200 head *Samia* caterpillars are maintained by feeding them in the form of elephant cassava leaves. The parameters observed include body weight gain, body length, feed consumption and feed convertion ratio and feed digestibility coefficient. The results showed that the cultivation of *Samia* caterpillar by feeding elephant cassava leaves requires 21 days of cultivation time to form a cocoon. *Samia* caterpillars have a body length of 51.67 mm and a final body weight of 3.211 gram/head with an average body weight gain of 0.512 grams/head/day. Feed consumption of 0.168 grams/head/day with a FCR value of 1.344. *Samia* Caterpillar has 77.23% dry matter digestibility, 96.48% organic matter, 96.82% crude protein, 95.18% ether extract and 2.48% crude fiber. It can be concluded that the *Samia* caterpillars fed elephant cassava leaves have good growth and digestibility of nutrients, so it is very suitable to be used as an alternative feed for *Samia cynthia ricini* caterpillars.

Keywords: *Cassava* leaves, digestibility, *Samia cynthia ricini* caterpillars, silks

Introduction
Increasing the added value of a cultivation business can be done by maximizing the overall product produced by a commodity including its waste. The cassava cultivation business has so far only been oriented to tuber production and only a few have utilized its leaf production. One effort to increase the added value of cassava cultivation is to use the leaves as cassava caterpillar feed. Cassava caterpillars (*Samia cynthia ricini*) are a type of silk-producing caterpillar that consumes castor bean leaves, cassava leaves, and papaya leaves (Neelu *et al*., 2000) [1]. Sakthivel (2012) [2] reported that the administration of cassava leaves is very suitable for the cultivation of *Samia* caterpillars to produce silk on a large scale. Giving a portion of cassava leaves (25-40%) to maintain the silkworm *Samia* will provide additional income and has no effect on tuber yield and starch content.

Indonesia is the 5th largest cassava producer country in the world, with a harvest area of more than 1.11 million hectares. The average cassava production in Indonesia from 2011-2015 was 22.82 million tons (Widaningsih, 2016) [3]. So far, the use of cassava leaves for consumption has not been utilized to the full. Through the integration of cassava cultivation with casava caterpillar farming, farmers are expected to gain added value from silk yarn production so that it will increase their income. Aside from producing silk threads, there are still opportunities for the use of caterpillar larvae or pupae to serve as alternative sources of animal feed. Pupae caterpillar *Samia* has 54.8% protein content, 25% fat, 1923 kj/100g energy and 3.62% crude fiber (Longvah *et al.*, 2011) [4]. Some researchers report that pupae from *Samia* caterpillars can be used as cosmetics, medicines and sources of animal protein (Debaraj *et al*., 2003) [5].

Efforts to increase the productivity of cassava have been carried out by introducing superior types of cassava namely elephant varieties (*Manihot esculenta* Crantz). Cassava has higher tuber and leaf production compared to local types of cassava. Purchasing 10 kg of organic fertilizer/tree will be able to produce tubers of 20 kg/tree at the age of 9 months (Amarullah, 2015) [6]. The average cassava produced 118 leaves weighing 1.498 kg (Dinata *et al*., 2016) [7]. This high cassava leaf production is very potential to be utilized for the cultivation of *Samia*

caterpillars. The difference in cassava varieties will affect the nutrient content contained in cassava leaves which will have an impact on the growth of Cassava (*Samia*) caterpillars. Therefore it is necessary to conduct a study to determine the growth and digestibility characteristics of *Samia* caterpillar feed fed with cassava leaves of elephants.

Material and Methods

Experimental design, animals, housing and diets

The study was conducted at the BPTP-Bali office, Ngurah Rai Pesanggaran Street Bypass Denpasar, Bali. The *Samia* caterpillar used in this study was a white type, where fertile caterpillar eggs were obtained from Solo Batik University. Maintenance of eggs to be cocoon of 200 caterpillars were carried out in a plastic box equipped with a lid. Maintenance from cocoons to hatching into butterflies were carried out on glass boxes. The plastic box inside was coated with greaseproof paper to make it easier to clean up dirt and leftovers. Before maintaining the caterpillars carried out disinfection in the maintenance box using 2% formalin. Formalin was dissolved in water and then sprayed 2-3 days before the caterpillar maintenance was done. The eggs are placed in a plastic box and then covered with cassava leaves so that when the eggs hatch they will immediately be provided with food.

Feed given is elephant cassava leaves. Feed has been given every day on an *ad libitum* basis adjusted to the development phase of the caterpillar. The remaining feed was taken out of the maintenance box and then replaced with fresher leaves every day. In addition, every day the maintenance box must be cleaned of caterpillar dirt. In the phase from egg to 1 week old cassava leaves are selected which are still young and chopped with a small size (5-10 mm). The next phase was from the age of 8 days to the cooking phase (21-22 days) given whole cassava leaves in fresh form. In the cooking phase no feed was given. This phase was characterized by a change in the color of the caterpillar's skin from white to transparent yellow.

The parameters observed included body weight gain, body length, feed consumption and feed convertion ratio (FCR) and feed digestibility coefficient. The data obtained were tabulated then analyzed the mean and diversity descriptively. To find out body weight is done by initial weighing and every week until the age of 21 days. Body length measurements are also carried out from the hatch and every week until the age of 21 days. Sampling of given feed and caterpillar droppings was carried out at the age of 14-21 days. Composite samples, dried and then taken to the laboratory for analysis of nutritional content. The feed content of elephant cassava leaves is as follows: 24.39% dry matter, 83.40% organic matter, crude protein 26.57%, crude fat 3.82% and crude fiber 11.20%.

Weight gain is known by calculating the difference between the weight of the weighing body once every 1 month. Daily body weight gain was obtained from the results of the reduction in final body weight with initial body weight divided by the length of the study. Feed consumption is calculated based on the consumption of dry matter (g/head/day) using the formula: Consumption of dry matter feed = Amount of feed given (g/DM) - Remaining feed (g/DM). For the determination of the feed conversion ratio (FCR) is calculated by dividing the amount of feed consumption/day with additional body weight/head/day obtained during the study. Feed digestibility is known by calculating the difference between the amount of feed (g/DM) eaten and the amount of feed released through feces (g/DM). Nutrient digestibility can be calculated by the following equation:

$$C = \frac{K - F}{K} x\ 100\%$$

Note:
C = digestibility coefficient
K = nutrient consumed
F = nutrient in excreta

Results And Discussion

Body Weight and Body Length

Casava (*Samia*) caterpillar cultivation up to the cooking process requires 21 days. This cultivation period is longer than the results of the study (Tungjitwitayakul and Tatun, 2017) [8] which obtained the maintenance period of *Samia* caterpillars fed cassava leaves takes 19.26 days to enter the cooking phase. At the time of hatching the average body weight of the caterpillar was 0.021 gram (Figure 1). Until the age of 2 weeks there was only a slight increase in body weight gains. Starting from the age of 14 days the United Nations has only rapidly occurred to reach an average of 3,211 grams/head at the age of 21 days. The final body weight obtained from the results of this study is smaller than the study (Setiyawan and Fitasari, 2018) [9] which obtained a caterpillar final body weight of 3.283 grams/head. The data on the development of *Samia* caterpillar body weight can be seen in Figure 2.

Fig 1: Comparison of the Performance of *Samia* Caterpillars Age 1 Day and 21 Days

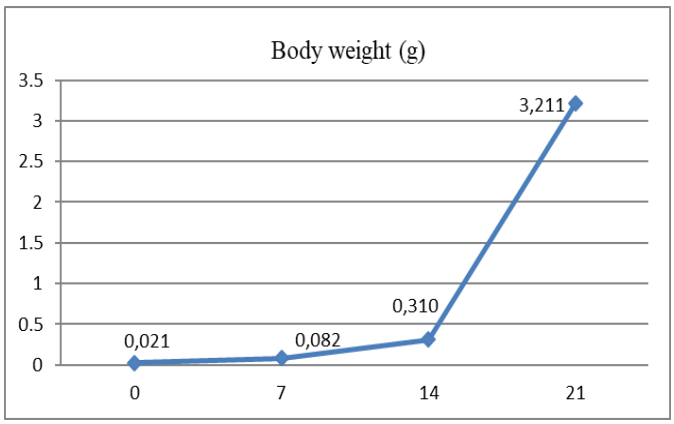

Fig 2: Curve development of the weight of the *Samia* Caterpillar (*Samia cynthia ricini*)

In contrast to maintenance in sub-tropical regions which are the origin of these *Samia* caterpillars, the body weight of caterpillars fed with cassava leaves can reach 5.10-6.87 grams/head, especially during spring (Deka *et al*., 2011) [10]. The results of the study (Kumar and Gangwar, 2010) [11] obtained maximum body weight of *Samia* caterpillars fed cassava leaves 6.8-6.82 grams/head.

For display the average body of a newborn caterpillar is 3 mm/head (Figure 3). Up to the age of 21 days the average length of a *Samia* caterpillar is 51.67 mm. *Samia* caterpillars on average increase in length by 2.32 mm/head/day with the highest increase in body length occurs at the age of 14-21 days which is equal to 3.61 mm/head/day.

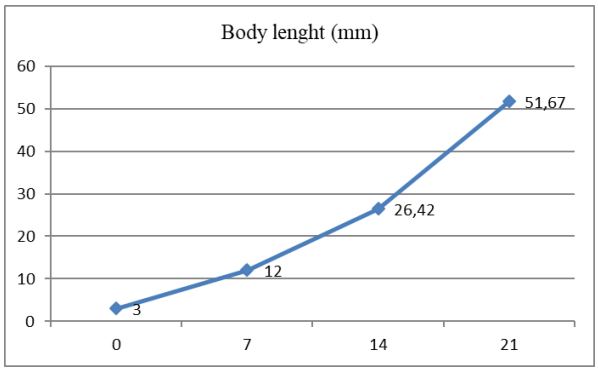

Fig 3: *Samia* Caterpillar Body Length (*Samia cynthia ricini*)

After 21 days the *Samia* caterpillar begins to enter the cocoon phase (cocon) which is characterized by the formation of a membrane covering the body of the caterpillar (Figure 4). To get silk thread, harvesting should be done 1-3 days after forming cocon. After harvesting the sun is dried for 12 hours (Oduor *et al*., 2016) [12]. If kept for nursery cocon must be moved to the marriage cage and allowed to morph into a butterfly (Figure 5). This phase takes between 13-15 days (Tungjitwitayakul and Tatun, 2017) [8].

Fig 4: Cocon of *Samia* caterpillars

Fig 5: Mature Butterflies

Samia caterpillars have body weight gains of 0.512 g/head/day. The average *Samia* caterpillar consumed feed in the form of fresh cassava leaves by 0.688 g/head/day or by 0.168 g/head/day in the form of dry matter. From these data obtained the value of Feed Convertion Ratio (FCR) of 1.344. This means that each feeding of 1.344 grams dry will result in body weight gain of 1 gram.

Table 1: Productivity of the *Samia* Caterpillar

No	Variables	Score
1	Body weight gain (g/day)	0.512
2	Feed consumption	
	- As feed (g/day)	0.688
	- Dry matter (g DM/day)	0.168
3	FCR	1.344

Feed Digestibility

Nutrients contained in the feed are not entirely available to the body of livestock, most will be released again through feces because it is not digested in the digestive tract. From the average consumption of dry matter caterpillars by 0.654 g/head/day there was excretion of *Samia* caterpillar droppings by 0.149 g/head/day so as to obtain the digestibility coefficient of caterpillar dry matter by 77.23% (Table 2). This digestibility coefficient is higher compared to the administration of jatropha leaves which is only 43,84-53.70% (Shifa *et al*., 2014) [13]. Other results found that the digestibility of *Jatropha Jatropha* leaf feed on instar 5 was 84.66-92.39% in dry weight (DW) basis [14].

Table 2: Nutrient digestibility

No	Variables	Feed consumption (g)	Excreation (g)	Digestibility (g)	Digestibility (%)
1	Dry matter	0.654	0.149	0.505	77.23
2	Organic matter	0.545	0.019	0.526	96.48
3	Crude protein (CP)	0.174	0.006	0.168	96.82
4	Ether extract	0.025	0.001	0.024	95.18
5	Crude fibre	0.073	0.071	0.002	2.48

Samia silkworms have the digestive coefficient of organic nutrients, crude protein and very high crude fat. This is closely related to the need for growth. High nutrient content in cassava dun will affect the level of nutrient digestibility.

This nutrient digestibility will affect the growth which is characterized by the lower period of maintenance of *Samia* caterpillar (Sakthivel and Qadri, 2017) [15] The quality parameters of cassava leaves such as crude protein, nitrogen, phosphorus, potassium and total minerals are positively related to the economic properties of *Samia* caterpillar (Sakthivel, 2016) [16]. However, the digestibility coefficient of crude fiber is very low at only 2.48%. This indicates that the *Samia* caterpillar is unable to digest crude fiber.

Conclusion

We conclude that *Samia cynthia ricini* caterpillar cultivation by feeding elephant cassava leaves requires 21 days of cultivation time to form a cocoon. *Samia cynthia ricini* caterpillars have a high digestibility of the nutritional content found in elephant cassava leaves, except for coarse fiber.

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Conflict of Interest Declaration

We certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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