Productivity and feed management strategies of sambar deer (*Rusa unicolor*) at the special purpose forest area (KHDTK) of Aek Nauli

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Abstract. The availability of feed plants is one of the most important components in improving the breeding ability of sambar deer in captivity. Planting program and productivity assessment of feed plants are necessary to ensure the availability of feed plants for deer, including deer management demonstration plot at Aek Nauli KHDTK. This study was aimed to observe the productivity and nutritional contents of sambar deer feed plants in Aek Nauli KHDTK. This study was performed at the deer feed plant plot. Sampling activities were conducted in the 1x1 m² plot (for grass) and 2 x 2 m² (for non-grass such as shrubs and herbs). The results showed that the productivity of 6 feed plants is about 51.56 kg day⁻¹ (fresh weight) or 19.52 kg day⁻¹ (dry weight); indicating that these plants meet the needs of 5 deer which are requiring 38.82 kg feed day⁻¹. The average productivity of feed plants in the dominant dry days was about 33,342.75 kg ha⁻¹ year⁻¹ (fresh weight) or 14,977.17 kg ha⁻¹ year⁻¹ (dry weight). The productivity of feed plants in the dominant rainy days was about 60,687.33 kg ha⁻¹ year⁻¹ (fresh weight) or 20,287.92 kg ha⁻¹ year⁻¹ (dry weight). Nutritional contents of feed plants are water content (56.3-66.0%), protein (0.037-0.156%), ash content (5.891-7.199%), fat content (1.751-10.089%), and carbohydrate (21.597-33.932%). Required feed management strategies are regular weeding, block division, rotational harvesting system, fertilizing, watering (during the dry season), and providing additional feeds and supplements such as *Pennisetum purpureum*, *Calliandra calothyrsus*, *Artocarpus heterophyllus*, and *Manihot utilissima*.

1. Introduction
The utilization of deer in the form of captive breeding in Indonesia is regulated by the Government Regulation of the Republic of Indonesia Number 8 of 1999 on wild flora and fauna exploitation. The Regulation of the Indonesian Ministry of Forestry Number P.19/Menhut-II/2005 of 2005 concerning plants and wildlife conservation then states that captive breeding is a propagation effort through breeding and nurturing by maintaining the purity of the species. According to [1,2], captive breeding programs nurturing wildlife under controlled conditions and human supervision are also a strategy for wildlife conservation. Sambar deer (*Rusa unicolor* Kreb.) nurturing techniques have been developed in several areas of Indonesia.
Sambar deer, along with timor deer, bawean deer, and muncak/kijang, is a native deer species in Indonesia [3]. In Indonesia, sambar deer lives naturally in the islands of Sumatera and Kalimantan. Sambar deer from Indonesia is a subspecies of *Rusa unicolor equinus* that can also be found in the Peninsula of Malaysia and Thailand. Sambar deer are hunted for meat. Consequently, the population of sambar deer in nature is decreasing [4,5]. The International Union for Conservation of Nature (IUCN), categorized sambar deer as vulnerable [6]. Therefore, ex-situ conservation efforts are needed to maintain its sustainability so that the second generation (F2) can be consumed by humans. Deer meat has low cholesterol [7].

The rising public interest in enjoying the beauty and attraction of wildlife has encouraged the development of captive breeding for tourism purposes, as in the special purpose forest area (KHDTK) of Aek Nauli [8]. Sambar deer demonstration plot in Aek Nauli KHDTK is established to support conservation and provide alternative tourist destinations around Toba Lake [9]. Aek Nauli KHDTK is easy to visit, and it has a strategic position as a tourist destination before heading to Toba Lake in Parapat.

The development of sambar deer captive breeding for conservation and ecotourism purposes requires a holistic approach. Management of captive breeding needs to consider the combination of physical and biotic factors in creating an optimal condition for wildlife development [10]. One of the most important components in managing wildlife in captive breeding is the availability of feed plants [11]. To maintain the sustainability of sambar deer in the captive breeding of Aek Nauli KHDTK, management needs to improve the quality of the habitat through the rising productivity of feed plants. This study aims to observe the productivity, nutritional content, and feed management strategy of sambar deer feed plants in Aek Nauli KHDTK. The results of this study are expected to be the reference in managing sambar deer feed plants in Aek Nauli KHDTK.

2. Materials and Method

2.1. Study sites
This study was conducted in Aek Nauli KHDTK, particularly in the demonstration plot of sambar deer research and development (figure 1). Sambar deer plot is geographically located between 2°43'13'' N and 98°56'24'' E. This study was performed from July to November 2018.

2.2. Materials
Materials used in this study are feed plants, balance, oven, measuring tape, ropes, camera, grass cutter, newsprint, 2 kg plastic bags, tally sheet, and stationery.

2.3. Method
A total of 6 feed plants comprising 3 understorey and 3 grass species were observed during this study. The observed understorey was *Diplazium proliferum* (pakis), *Crassocephalum crepidioides* (sintrong), and *Chromolaena odorata* (putihan/kirinyuh), while grass species consisted of *Cyrtococcum patens* (omak-omak), *Paspalum* sp. (*rumput manisan*), and *Panicum brevifolium* (*rumput humbil*). These feed plants were planted in a 0.4 ha plot (Figure 2). A total of 6 subplots (18 x 32 m² in size) were installed inside the main plot. Inside these subplots, other sub subplots (1 x 1 m² for grass and 2 x 2 m² for understorey) were added. The distance between these sub subplots was about 5 m. The grass and understorey were planted inside these sub subplots with the line spacing about 40 x 40 cm².

To measure the biomass of feed plants, understorey and grass were cut and weighed for their fresh weight. The remaining part of feed plants was left and allowed to grow for 30 to 40 days. After 40 days, understorey and grass were cut back and weighed for their fresh weight. These activities were performed for 4 months [12,13]. About 300 gr of green samples were selected for dry weight and water content assessment. All samples were dried at a temperature of 70°C for 48 hours [12].
Figure 1. The location of sambar deer plot in Aek Nauli KHDTK. The position of sambar deer plot on the map is the triangle in the top R&D utilization zone
2.4. Data analysis

2.4.1. The productivity of fresh feed
Biomass and productivity of grass and non-grass were calculated using equation 1 [11]:

\[
P = \frac{\bar{p}}{\bar{l}}
\]

Where, \(P\): biomass/production of fresh grass and non-grass in subplots (kg); \(L\): the size of subplots (ha); \(p\): biomass/production of fresh grass and non-grass in sub subplots (kg); \(l\): the size of sub subplots (ha). The productivity of grass and understorey was calculated by dividing the average fresh feed plants per day with the time difference in grass and understorey harvesting.

2.4.2. Nutrition analysis
Feed plant nutrition analysis was performed in the Food Chemistry Analysis Laboratory of Faculty of Agriculture, University of North Sumatera. Through proximate tests, feed plants were analyzed for their protein content, water content, fat, crude fiber, ash content, and carbohydrate.

3. Results and Discussion

3.1. Feed plant biomass
Feed plant biomass measurement (Table 1) showed that there was a difference in biomass content among feed plants where \(P.\ brevifolium\) had the highest biomass and \(D.\ proliferum\) had the lowest biomass. This condition indicated that biomass was varied among feed plants, depending on the vegetation type. Overall, the average biomass for feed plants was about 4,505.55 kg (fresh weight) or 857.69 kg (dry weight).
Table 1. Biomass of feed plants in Aek Nauli KHDTK

| No | Feed plants | Biomass (gr m⁻²) | Biomass (kg ha⁻¹) |
|----|-------------|-----------------|------------------|
|    |             | FW   | DW   | FW   | DW   |
| 1  | C. patens   | 289.29 | 83.23 | 2,892.86 | 832.33 |
| 2  | P. brevifolium | 1,166.30 | 123.61 | 11,662.96 | 1,236.10 |
| 3  | C. crepidioides | 499.36 | 99.06 | 4,993.58 | 990.60 |
| 4  | C. odorata   | 371.64 | 71.42 | 3,716.40 | 714.23 |
| 5  | D. proliferum | 127.40 | 52.79 | 1,273.95 | 527.90 |
| 6  | Paspalum sp. | 249.35 | 84.50 | 2,493.53 | 844.98 |
|    | Total       | 2,703.34 | 514.61 | 27,033.28 | 5,146.14 |
|    | Average     | 450.56 | 85.77 | 4,505.55 | 857.69 |

FW: Fresh weight; DW: dry weight.

3.2. Feed plants productivity

The productivity of feed plants can be defined as the value of natural growth of grass and non-grass in a certain period (days) and a certain unit area. The measurement of feed plant production was conducted after feed plants were 2 months old (plants grow normally). Feed plants in the plot were cut and harvested again in 30-40 days. The productivity of feed plants in the dominant dry days and dominant rainy days are presented in Table 2 and 3.

Table 2. The productivity of feed plants in the dominant dry days.

| Feed plants | 1st Repetition (gr m⁻² day⁻¹) | 2nd Repetition (gr m⁻² day⁻¹) | Average (gr m⁻² day⁻¹) |
|-------------|--------------------------------|--------------------------------|------------------------|
|             | FW   | DW   | FW   | DW   | FW   | DW   |
|             | n = 36 days | n = 40 days | n = 38 days |
| C. patens  | 5.71 | 2.05 | 5.46 | 1.87 | 5.59 | 1.96 |
| P. brevifolium | 18.08 | 5.21 | 11.39 | 2.73 | 14.74 | 3.97 |
| C. crepidioides | 16.27 | 6.24 | 12.54 | 4.85 | 14.41 | 12.05 |
| C. odorata  | 8.38 | 1.75 | 13.46 | 2.39 | 10.92 | 2.07 |
| D. proliferum | 2.23 | 0.87 | 4.44 | 2.22 | 3.33 | 1.55 |
| Paspalum sp. | 7.05 | 3.70 | 4.59 | 2.34 | 5.82 | 3.02 |

Table 3. The productivity of feed plants in the dominant rainy days.

| Feed plants | 1st Repetition (gr m⁻² day⁻¹) | 2nd Repetition (gr m⁻² day⁻¹) | Average (gr m⁻² day⁻¹) |
|-------------|--------------------------------|--------------------------------|------------------------|
|             | FW   | DW   | FW   | DW   | FW   | DW   |
|             | n = 40 days | n = 34 days | n = 37 days |
| C. patens  | 14.80 | 3.32 | 9.18 | 1.53 | 11.99 | 2.42 |
| P. brevifolium | 40.76 | 13.73 | 27.33 | 9.55 | 34.05 | 11.64 |
| C. crepidioides | 33.76 | 16.08 | 22.91 | 7.94 | 28.34 | 12.01 |
| C. odorata  | 11.84 | 1.74 | 7.36 | 1.69 | 9.60 | 1.72 |
| D. proliferum | 6.25 | 1.92 | 4.89 | 0.42 | 5.57 | 1.17 |
| Paspalum sp. | 14.01 | 5.44 | 6.41 | 3.34 | 10.21 | 4.39 |
The results showed that the productivity of feed plants in the dominant rainy days was higher than that of dominant dry days. The average productivity of 6 feed plants in the dominant dry days was about 9.14 gr m\(^{-2}\) day\(^{-1}\) (FW) or 4.10 gr m\(^{-2}\) day\(^{-1}\) (DW). In the meantime, the productivity of feed plants on the dominant rainy days was about 16.63 gr m\(^{-2}\) day\(^{-1}\) (FW) or 5.56 gr m\(^{-2}\) day\(^{-1}\) (DW). The dominant rainy days caused the soil tends to be moist and suitable for the growth of grass and understorey.

Conversion to ha (table 4) was performed to observe the productivity of feed plants on a broader scale. The productivity of feed plants per year in the dominant dry days was about 33,342.75 kg ha\(^{-1}\) year\(^{-1}\) (FW) or 14,977.17 kg ha\(^{-1}\) year\(^{-1}\) (DW). In the dominant rainy days, the productivity of feed plants was about 60,687.33 kg ha\(^{-1}\) year\(^{-1}\) (FW) or 20,287.92 kg ha\(^{-1}\) year\(^{-1}\) (DW). The productivity of feed plants in Aek Nauli KHDTK is higher than that of Aras Senapal elephant management unit (FW: 44,024.59 kg ha\(^{-1}\) year\(^{-1}\) and DW: 11,894.13 kg ha\(^{-1}\) year\(^{-1}\)) [15]. High productivity of feed plants this study is affected by the characteristic of feed plants where \(P.\) \textit{brevifolium} and \(C.\) \textit{crepidioides} have greater weight.

### Table 4. The productivity of feed plants in the dominant dry days and dominant rainy days on a broader scale.

| Feed plants | dominant dry days | dominant rainy days |
|-------------|-------------------|---------------------|
|              | FW (kg ha\(^{-1}\) year\(^{-1}\)) | DW (kg ha\(^{-1}\) year\(^{-1}\)) | FW (kg ha\(^{-1}\) year\(^{-1}\)) | DW (kg ha\(^{-1}\) year\(^{-1}\)) |
| \(C.\) \textit{patens} | 20,403.50 | 7,154.00 | 43,763.50 | 8,833.00 |
| \(P.\) \textit{brevifolium} | 53,801.00 | 14,490.50 | 124,282.50 | 42,486.00 |
| \(C.\) \textit{crepidioides} | 52,596.50 | 43,982.50 | 103,441.00 | 43,836.50 |
| \(C.\) \textit{odorata} | 39,858.00 | 7,555.50 | 35,040.00 | 6,278.00 |
| \(D.\) \textit{proliferum} | 12,154.50 | 5,657.50 | 20,330.50 | 4,270.00 |
| \(Paspalum\) \textit{sp.} | 21,243.00 | 11,023.00 | 37,266.50 | 16,026.50 |
| Average | 33,342.75 | 14,977.17 | 60,687.33 | 20,287.92 |

3.3. Nutrition analysis

The nutritional content of feed plants (Table 5) is varied among the species. \(C.\) \textit{crepidioides} has the highest protein and ash contents. \(P.\) \textit{brevifolium} has the highest fiber and fat content, and the lowest fiber and fat content is \(C.\) \textit{odorata}. The highest carbohydrate content is \(C.\) \textit{patens}, while the lowest carbohydrate content is \(C.\) \textit{crepidioides}. For optimal growth, a deer needs protein, calcium, and phosphorous about 13-16%, 0.45%, and 0.35% respectively [16]. Therefore, the diversity of feed plants either from the combination of feed plants or additional supplements (concentrate and vitamin) are needed. The concentrate is rich in protein or carbohydrates. The quality of concentrate affects the growth of deer. Low-quality concentrate will interfere with digestion and affect physical appearance (the hair is not bright and shiny, hair loss, and the deer looks small and thin) [17].

Table 5 also shows that feed plants generally low in protein content. To meet protein requirements, the deer needs additional supplements. Protein is a complex organic material made from many amino acids. The excess of protein consumed by deer will be overhauled and stored in liver tissue and used as a source of energy [18]. The nutritional content of feed plants is affected by the growth phase, soil fertility, fertilization, and climate. The quality and quantity of feed plants varied among sex, age, physiological status, and season [19].
Table 5. The nutritional content of feed plants.

| Feed plants | Water content (%) | Protein (%) | Ash content (%) | Fat content (%) | Fiber content (%) | Carbohydrate (%) |
|-------------|-------------------|------------|----------------|----------------|------------------|------------------|
| C. patens   | 56.312            | 0.037      | 5.891          | 3.829          | 8.993            | 33.932           |
| P. brevifolium | 60.911       | 0.091      | 6.044          | 10.089         | 11.196           | 22.865           |
| C. crepidioides | 66.032       | 0.156      | 7.199          | 5.016          | 11.188           | 21.597           |
| C. odorata  | 63.887            | 0.104      | 6.507          | 1.751          | 6.414            | 27.752           |
| D. proliferum | 58.610      | 0.082      | 7.199          | 4.694          | 6.470            | 25.922           |
| Paspalum sp. | 60.677            | 0.047      | 6.436          | 4.212          | 6.670            | 31.689           |

3.4. Feed management strategy
Table 2 and 3 show that the average productivity of feed plants for both dominant dry days and dominant rainy days is about 12.89 gr m⁻² day⁻¹. These results indicate that a 0.4 ha of feed plants demonstration plot in Aek Nauli KHDTHK can provide 51.56 kg of feed day⁻¹. If consumption level of deer is about 7,764 kg individual⁻¹ day⁻¹, feed plant requirement for 5 deer in Aek Nauli KHDTHK is about 38,82 kg day⁻¹ [20]; indicating that the demonstration plot meets feed requirement of 5 deer in Aek Nauli KHDTHK. These feed plants are expected to improve the welfare of deer.

Even though feed plants are adequate, plot management strategies are needed to minimize the decrease or the death of feed plants in the dry season. The required strategies for feed plants are:
1. Regular weeding to remove other plants in the plot (twice to thrice a week).
2. Block division, road construction (subplot spacing), and implementing rotational harvesting system for each plant.
3. Post-harvest fertilizing to improve feed productivity (a week after harvesting).
4. Watering the feed plants (twice to thrice a day during the dry season).
5. Providing other feed plants such as Pennisetum purpureum, Calliandra callothyrsus, Artocarpus heterophyllus, and Manihot utilissima to increase the diversity of feed plants, and to meet the nutritional needs of deer.
6. Additional feed/ supplements such as bran, pellets, and fruits (minimum once a week) to increase production, reproduction, and the basic needs of deer.

4. Conclusions
The productivity of feed plants in Aek Nauli KHDTHK is about 51.56 kg day⁻¹. The productivity of feed plants in the dominant dry days is about 33,342.75 kg ha⁻¹ year⁻¹ (FW) or 14,977.17 kg ha⁻¹ year⁻¹ (DW). The productivity of feed plants in the dominant rainy days is about 60,687.33 kg ha⁻¹ year⁻¹ (FW) or 20,287.92 kg ha⁻¹ year⁻¹ (DW). The nutritional contents of feed plants vary among the species. Nutritional content of feed plants is water content (56.3-66.0%), protein (0.037-0.156%), ash content (5.891-7.199%), fat content (1.751-10.089%), and carbohydrate (21.597-33.932%). The type of feed given to the deer should contain a lot of protein. Recommended feed management strategies are regular weeding, block division, rotational harvesting system, fertilizing, watering (during the dry season), and providing additional feeds and supplements such as Pennisetum purpureum, Calliandra callothyrsus, Artocarpus heterophyllus, and Manihot utilissima.

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