The Potential of Sumatran Elephant Feed Plants in Aek Nauli's Special Purpose Forest Region, North Sumatera

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Abstract: One of the problems that needs to be considered in the captive elephants management is the adequacy of feed. This study aims to obtain information on feed plants species, the palatability value and productivity of elephant feed in Aek Nauli's Special Purpose Forest Region. The research method was carried out by observation, focal animal sampling as well as feed productivity by measurements of changes in growth weight, height and diameter trees. The results showed that at the grazing area elephant have been identified at least 41 species of elephant feed, mainly from the Paoceae, Moraceae, Myrtaceae and Euphorbiaceae Families. The part plant species that most consumed is all parts (grass), leaves, plant skin and fruit. The species that have the highest palatability value (frequency and duration of feed) are Ottochloa nodosa, Caryota gigas and Rhodamnia cinerea. The highest leaf productivity has Arthocarpus integler and Litsea sumatrana is the lowest. Plant characteristics that affect feed growth are diameter and total height with equation (dry weight) is Ybk = 0.079 + 0.103 Diameter + 0.052 Total Height with correlation of 65.5%.

1 INTRODUCTION

Your The current wildlife population is thought to be decreasing due to human activities that cause fragmentation and reduced habitats (Villard and Metzger, 2014; Lino *et al*., 2019). Habitat fragmentation has caused wildlife some species on the local extinction because of the lower feed plants, home ranges and decreased genetic flow between populations, such as large mammals (Vetter et al., 2011; Murphy and Romanuk, 2014; Montgelard et al., 2014). Hunting and illegal trade are animals also continue to meet market demands such as traditional medicine, food, sold and pets (Skonhoft, 2013; Angula, 2018).

One animal that currently endangered is the Sumatran elephant (*Elephas maximus sumatranus*). In the Red Book International Union for Conservation of Nature and Natural Resources/IUCN (2017) has listed as endangered species and Convention on International Trade in Endangered Species of Wild Fauna and Flora

(CITES) classified as Appendix 1. Regulation of Environment and Forestry Ministry number : P.20/ MENLHK/Setjen/Kum.1/6/2018 stated that elephant conservation needs as a priority program because the population and its natural habitat continue to decline. The elephant population in 2007 was estimated about 2,400-2,800 individuals, then in 2013 the remaining elephants are 1,970 individuals. During 2012-2016, the population has diminished, at least 150 elephants were killed due to conflict or poaching (Sukumar, 2003; WWF Indonesia, 2017).

Elephant conservation programs have developed by the Government of Indonesia and NGO (non government organization), both in situ and ex situ (Bangun, 2017). One that is being done like a captive elephants on their natural habitat at Aek Nauli's Special Purpose Forest Region (Aek Nauli SPFR). That area was established through the decree of the Minister of Forestry No. 39/Menhut-II/2005, February 7th 2005 with an area of 1,900 Ha. As administrative included Sibaganding Village, Girsang Sipanganbolon District, Simalungun Regency, North Sumatra Province. Aek Nauli SPFR are functions as a catchment area Lake Toba with an altitude around 1,000 - 1,750 meters above sea level. Forest areas are habitat for protected species of plants and wildlife as well es ecotourism (Kuswanda and Pratiara, 2017).

In the Aek Nauli SPFR, the management of captive elephants is intended to support the

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conservation efforts and used as an ecotourism destination. To support the elephants welfare, one of the things to consider is availability of feed. Minimum requirements for elephant feed between 150-200 kg/day must fulfilled so elephant programs can be more successful (Ribai et al., 2013). The potential of natural elephant feed is important to know because highland forests which are estimated have only a few species of elephants feed plants. This information can be a reference for developing elephant feed management at Aek Nauli SPFR and other elephant management units. Therefor, this research was aims to obtain information on feed plant species and elephant palatability level on the vegetation in the Aek Nauli SPFR, North Sumatra.

2 METHOD

2.1 Research Location

Research on palatability and productivity of elephant feed plants was carried out in forest areas in Aek Nauli SPFR during April to October 2018.

2.2 Research Method

2.2.1 Title

Observation of species and natural feed palatability was using by focal animal sampling method (Santosa et al., 2011; Munita et al., 2016). The feed plants is deformed by following the elephant when grazing in the forest area. The location of the observations was carried out on three land covers, namely mixed pine forest, secondary forest, and open land. Palatability data was done by observing the frequency and duration of eaten plant species for 30 days during two hours every day, starting at 10.00-12.00 when the elephants are in the pasture.

2.2.2 Subtitle

Production value can carried out by measuring the percentage of growth or weight a part feed plants difference in a given time (YMR, 2002; Santosa et al., 2011). The feed plant species are selected 10 spesies that dominant in Aek Nauli SPFR, both ont the saplings and seedlings level (Kuswanda et al., 2017). Calculation of growth was done in the interval of 2-3 months. Weighing and drying are carried out on each sample plant. To determine the characteristics of feed plants is measured diameter, total height, height and crown width of each sample feed tree.

2.3 Data Analysis

The species and feed palatability is known by observing and recording a natural feed that is consumed by elephants during observation. The palatability value was analyzed based on the frequency and duration percentages of each species for all feed consumed by elephants. Frequency was calculated based on the number a species is consumed and the duration from length of time a species is eaten during the observation time. Analysis to determine the value of elephant feed productivity by the difference in weight of part of the plant feed samples (leaves and twigs) in a certain time (YMR, 2002; Santosa *et al*., 2011)

Analysis of sample plant characteristics are using by descriptive statistics with SPSS 21.0 for Windows. Effect of plant characteristics on feed productivity values was analyzed with multiple linear regression analysis. In the stages of regression analysis, the normality test was carried out based on the Kolmogorov-Smirnov test and multicollinearity test to detect the correlation between the independent variables (x). The basic equation is used refers to Chapman (2000); Alkarkhi and Low (2012); Alkarkhi et al., (2019) as follows:

$$Y = a + b\,D\,bh + c\,T\,tot + d\,T\,bc + e\,Dtj + \varepsilon$$

Where,

Y = production (kg /m2 per day)
D = diameter of tree (cm)
Ttot = total height of tree (m)
Ttaj = height of crown (m)
Tbc = branch free height (m)
Ltaj = diameter of canopy (m)

Data analysis were processed using program of SPSS 21.0 for Windows with the backward method. Regression model will be used if the probability (p) of the ANOVA test results is below 0.05 (Sig, <0.05).

3 RESULT AND DISCUSSION

Sumatran elephants are browser animals, folivores, frugivores, seed eaters, and the other parts of plants. These animals are consume more than 400 species of plants. The study results of the Sitompul (2011) in Kerinci Seblat National Park showed that Sumatran elephants consume at least 273 plant species. Every

day elephants need 50 to 95 plant species (Joshi and Singh, 2008; Meytasari, et al., 2014). Elephants are very selective in choosing their feed and have a high feeding rate according to body size, age, sex, weather and ecosystem types (Berliani, 2017). Results of research on elephant feed was done at Aek Nauli SPFR as follows:

3.1 Natural Food Species

The elephants' natural feed found in the Aek Nauli SPFR has identified of 41 species, both in trees, shrubs, lianas and grasses. The species of feed plants are as shown in Table 1.

Table 1: Species of elephant natural food plants at the Aek Nauli SPFR.

No	Local name	Scientific name	Family	Parts consumed
1	Anggrek pohon	*Bulbophyllum macranthum*	Orchida-ceae	All parts of the plant
2	Aren	*Arenga pinnata*	Arecaceae	Leaves, midrib
3	Attaro-don	*Arthocarpus integler*	Moraceae	Leaves, fruit
4	Balik angina	*Aglaia argentea*	Meliaceae	Leaves, plant skin
5	Bambu	*Bambusa sp*	Poaceae	Leaves
6	Cempedak hutan	*Arthocarpus integer*	Moraceae	Leaves, fruit, plant skin
7	Harimo-tting	*Rhodamnia cinerea*	Myrtaceae	Leaves, fruit
8	Horing	*Lithocarpus daphnoideus*	Fagaceae	Leaves
9	Hoting	*Quercus gemelliflora*	Fagaceae	Leaves
10	Ilalang	*Imperata cylindrica*	Poaceae	All parts of the plant
11	Jambu batu	*Syzygium sp.*	Myrtaceae	Leaves, fruit
12	Jambu biji	*Psidium guajava*	Myrtaceae	Fruit
13	Jambu-jambu	*Eugenia fastigiata*	Myrtaceae	Leaves, fruit
14	Jungjung buit	*Actinodaphne glabra*	Lauraceae	Leaves
15	Kaliandra	*Calliandra calothyrsus*	Fabaceae	Leaves, plant skin
16	Kirinyuh	*Chromolaena ordorata*	Asteraceae	All parts of the plant
17	Laos hutan	*Zingiber aquosum*	Zingibera-ceae	Tuber
18	Liana	*Epipremnum aureum*	Araceae	All parts of the plant
19	Manggis hutan	*Garcinia celebica*	Guttiferae	Leaves, fruit, plant skin
20	Medang kertas	*Litsea sumatrana*	Lauraceae	Leaves
21	Medang sabal	*Cinnamomum cuspidatum*	Lauraceae	Leaves
22	Motung	*Ficus toxicaria*	Moraceae	Leaves
23	Nangka	*Artocarpus heterophyllus*	Moraceae	Leaves, fruit
24	Paku	*Mesophlebion chlamydophorum*	Thelypteridaceae	All parts of the plant
25	Palem saray	*Caryota gigas*	Arecaceae	Leaves
26	Pandan	*Pandanus atrocarpus*	Pandanaceae	Leaves
27	Putri malu	*Mimosa pudica*	Fabaceae	All parts of the plant
28	Rambutan hutan	*Cryptocarya nitens*	Lauraceae	Leaves, fruit
29	Rotan	*Daemonorops hirsuta* Blume	Arecaceae	All parts of the plant
30	Rumput bambu	*Ottochloa nodosa*	Poaceae	All parts of the plant
31	Rumput belulang	*Eleusine indica*	Poaceae	All parts of the plant
32	Rumput emprit	*Cyrtococcum patens*	Poaceae	All parts of the plant
33	Rumput gajah	*Pennisetum purpureum*	Poaceae	All parts of the plant
34	Rumput jukut	*Cyperus kyllingia*	Poaceae	All parts of the plant
35	Rumput kerbau	*Centotheca lappacea*	Cyperaceae	All parts of the plant
36	Rumput palem	*Setaria megaphylla*	Poaceae	All parts of the plant
37	Sendok sendok	*Endospermum diadenum*	Euphorbiaceae	Leaves, plant skin
38	Sintrong	*Crassocephalum crepidioides*	Asteraceae	All parts of the plant
39	Sitarak	*Macaranga lowii*	Euphorbiaceae	Leaves, plant skin
40	Sukun	*Artocarpus altilis*	Moraceae	Leaves, fruit
41	Tumbuhan c	*Neosortechia kingii*	Euphorbiaceae	Root

All parts of the plant from the Poaceae Family are eaten by elephants while species of other families are only leaves and skin, leaves and stems/twigs or roots. Samansiri and Weerakon (2007); Santosa *et al*.,(2011) states that the food of Sumatran elephants is dominated by the Poaceae. The Poaceae is favored by Sumatran elephants because it has a soft morphological texture, stature

in the form of shrubs or bushes so that it is easier to reach than leaves on trees. The Foaceae family is mostly plant species in the form of grasses and herbs. The grasses selection are also caused by carbohydrates (Abaye, 2019).

The elephants eat all parts of the tree if they are still saplings and eat the palm cabbage by opening the trunk mainly palm plants was large (Sukumar, 2003). The portion of fruit eaten in open land comes from the *Psidium guajava*. The root part was eaten for *Neosortechia kingii* found in secondary forests and dominant pine forests. *Crassocephalum crepidioides* is consumed on the leaves and stems. The leaf part was chosen because contains a lot of protein. Whereas the species eaten by the tubers was only found in *Zingiber aquosum*. Elephants also consume plant skin to meet the shortcomings of essential fatty acids in their food and certain minerals such as manganese (Mn), iron (Fe) and copper (Cu) was contained in the plant skin as *Endospermum diadenum* (Zahrah 2002; Mrambaa, 2019).

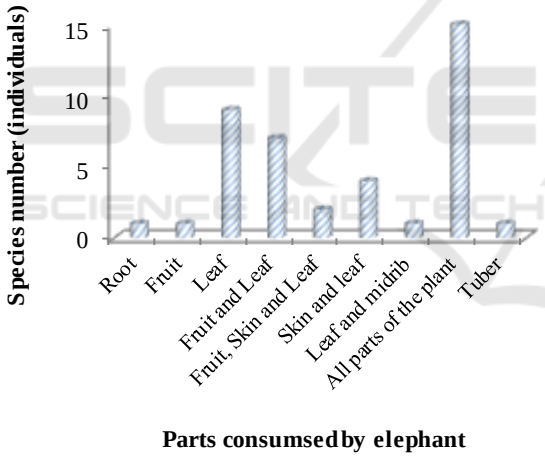

Figure 1: The part of plant consumed by elephant.

Parts of plants that are consumed by elephants are leaves. Elephants consume only leaves especially is classified as trees, such as from Moraceae, Euphorbiaceae and Myrtaceae. The results of this study indicate that elephants are herbivorous animals that consume all parts of plants, both leaves, twigs, midribs or whole. Variations in elephant feed usually depend on the season which affects the availability of feed in its natural habitat. In addition to grass, elephants also need other types of food such as leaves from higher plants, shrubs, and tree trunks (Sitompul, 2011; Archie and Chiyo, 2012)

The variation of feed consumed by elephants depends on the season because it affects the food availability in its natural habitat. The grass and shrubs are usually consumed during on the rainy season because the availability of quite abundant whereas in the dry season elephants prefer fresher leaves because the grass dries. In natural habitat, in the dry season elephants also reduce their movement, which may be caused by factors other than energy saving, such as caring for calves and avoidance of predation or high temperature (Sukumar, 2003; Owen-Smith and Chafota, 2012; Shrestha et al., 2014).

3.2 Palatability of Feed Species

The frequency of eating Sumatran elephants is influenced by three factors, namely the availability of feed in nature, conditions of elephant health and weather (Riba'i, 2013). Sumatran elephants have a high frequency or food intensity if the preferred feed species is available in grazing areas. Based on the results of observations in the area 'ngangon' at Aek Nauli SPFR by following 4 elephants in three land cover types (mixed pine forest, secondary forest and open land) was obtained plants that has palatability value by duration and the highest frequency is *Ottochloa nodosa, Caryota gigas* and *Rhodamnia cinerea*.

Table 2: Palatability values of 6 species the highest elephant feed.

No	*Species*	Frequency (%)	No	Species	Duration (%)
1	*Ottochloa nodosa*	32.471	1	*Ottochloa nodosa*	28.654
2	*Calliandra calothyrsus*	6.118	2	*Caryota gigas*	15.999
3	*Daemonorops hirsuta*	6.118	3	*Rhodamnia cinerea*	9.925
4	*Centotheca lappacea*	6.118	4	*Centotheca lappacea*	8.798
5	*Pandanus atrocarpus*	5.176	5	*Neosortechia kingii*	5.141
6	*Zingiber aquosum*	4.941	6	*Calliandra calothyrsus*	4.494

From Table 2, it can be seen that the *Ottochloa nodosa* is the species that has the frequency and highest percentage duration which indicates the favor of the Sumatran elephant. This species is grass that generally grows and dominates in the grazing area. The high frequency of the type *Ottochloa*

nodosa in each land cover shows the same palatability level in each location. High frequencies can be caused by the *Ottochloa nodosa* availability of uniform distributed and very favored. The intensity of sunlight to the forest floor, especially in open land, is very sufficient so causes under stories and grass to feed elephants to grow rapidly.

In other types it shows that the frequent consumption does not necessarily have a long consumption time, such as in *Calliandra calothyrsus* or vice versa in *Caryota gigas*. The need for elephant consumption is strongly influenced by the characteristics of the feed type itself. For example, to consume trees, elephants generally knock down tree trunks to get young leaves. Likewise for hard-skinned plant species, elephants first peel the tree's skin to take parts that can be consumed so that the time taken is relatively longer than the time to spend the grass.

The duration value can be influenced by the habitat of feed species and like it. The food that liked almost all parts are eaten by elephants, while the less preferred only part is consumed. For example, the *Centotheca lappacea* has a long duration because the elephants spend this species. Sukumar (2003); Archie and Chiyo (2012) stated that Sumatran elephants always walked to look for feed but not all feed is consumed. Howover, they will stop and consume food when finding species is very preferred.

3.3 Food Production

Measurements of elephant feed tree productivity were grouped at seedling and sapling levels. The average production value of feed at seedling level is 0.78 grams/day per tree (wet weight) or 0.25 gram/day per tree (dry weight) and sapling level of 2.93 grams/day per tree (wet weight) or 0.8425 gram/day per tree (dry weight). The types that have the highest production are *Arthocarpus integer* (sapling) and *Syzygium* sp. (seedling). The results of this study are similar to those of Santosa *et al*., (2011) on some types of elephant feed at the Elephant Training Center, North Bengkulu, which are between 0.03 - 5.10 gram /day/tree with the highest species is *Leea indica* and *Piper aduncum*. The results of a descriptive statistical of 20 samples feed plants are presented in Table 3.

Table 3: Results of descriptive statistics on the characteristics of elephant's feed.

Descriptive Statistics						
	N	Min.	Max.	Mean	Std. Deviation	Variance
Dbh	20	0.80	9.80	2.922	1.984	3.934
Ttot	20	1.36	7.55	3.218	1.767	3.124
Ttaj	20	0.32	3.75	1.595	0.931	0.867
Tbc	20	0.59	3.80	1.623	0.941	0.885
Ltaj	20	0.16	16.76	2.693	3.638	13.237
Ybb	20	0.10	7.15	1.851	1.770	3.133
Ybk	20	0.04	1.66	0.548	0.444	0.197
Valid N	20					

The characteristics of elephant feed plants in Aek Nauli SPFR are showed an average diameter of 2.922 cm, total height of 3.218 meter, branch-free height about 1.623 m, canopy height of 1.595 m and canopy area about 2,693 m^2. The species have the largest diameter and highest is the *Garcinia celebica* and the smallest is *Aglaia argentea*. These results indicate that elephants are still able to reach food with a height of 6 m above the land. In a tall and preferred tree, the elephant usually sticks out its trunk and then pulls the tree limb until it breaks or collapses. The characteristics of these feed plants are then used as independent variables (X) to predict elephant feed production.

3.4 Compilation of Equations

The analysis results to obtain plant characteristics factors is related to the feed production value, i.e. :

3.4.1 Normal distribution test

The results of normality data analysis with the Kolmogorov-Smirnov (KS) Statistical Test was indicate that the KS values for all X and Y variables appear to have a probability value above $\alpha = 0.05$ ($p > 0.05$), which means that it can be concluded that all variables x have normal distribution (Ghozali, 2009). For example, the KS value for the tree diameter is 0.824 with a Sig value=0.506 and above $\alpha = 0.05$, it can be concluded is normally distributed. For the other variables all have Sig> 0.05, it's the

data can suitable for analysis using multiple linear regression.

Table 4: Results of the Kolmogorov-Smirnov test for characteristics of elephant feed plants.

One-Sample Kolmogorov-Smirnov Test								
Normal distribution test		D	Ttot	Ttaj	Tbc	Ltaj	Ybb	Ybk
N		20	20	20	20	20	20	20
Normal Parameters[a.b]	Mean	2.922	3.218	1.595	1.623	2.693	1.851	0.548
	Std. Deviation	1.984	1.767	0.931	0.941	3.638	1.770	0.444
Most Extreme Differences	Absolute	0.184	0.173	0.166	0.200	0.243	0.200	0.208
	Positive	0.184	0.173	0.166	0.200	0.215	0.200	0.208
	Negative	-0.172	-0.147	-0.085	-0.136	-0.243	-0.162	-0.125
Kolmogorov-Smirnov Z		0.824	0.775	0.743	0.894	1.085	0.893	0.932
Asymp. Sig. (2-tailed)		0.506	0.585	0.639	0.401	0.189	0.403	0.351

a. Test distribution is Normal.
b. Calculated from data.
c. Ybb (wet weight) and Ybk (dry weight)

3.4.2 Multicollinearity Test

The results of the SPSS output from the multicollinearity test of variable X (feed plant characteristics) on Y are presented in Table 5.

The strength a correlation is high (statistically significant) if the correlation coefficient value (r) ≥ 0.70, modest between 0.40 - 0.69 and low whit r <0.39 (Fowler *et al*., 1998). In this study, the limitation of correlation used to detect multicolonity problems about 0.7. From the table above it can be seen that the diameter (D) has a very high correlation with canopy area (Ltaj) is equal to 83.4%. From this result, the Ltaj variable is not included in the preparation of the regression equation because it can already be represented by the D variable.

Table 5: Test results for multicollinearity characteristics of feed plants.

Coefficient Correlations						
Model			Ltaj	Tbc	Ttaj	D
1	Correlations	Ltaj	1.000	0.385	0.159	-0.834
		Tbc	0.385	1.000	-0.151	-0.561
		Ttaj	0.159	-0.151	1.000	-0.479
		D	-0.834	-0.561	-0.479	1.000
a. Dependent Variable: Ybb						

4 MODELING

The analysis results on the SPSS output in the summary model using the backward method showed Y (wet weight) in the third step (best model) with predictions of tree diameter (D) and crown height (Ttaj) show the correlation value (r) of 62.0%. This means that variations in leaf production in wet weight (Ybb) of elephant feed plants can be explained by variations in D and Ttaj of 62.0% and the remainder may be explained or influenced by other factors outside the model. Likewise for Ybk can be seen in the second step, showing that the value of r is 65.5%. These results indicate that the correlation of feed plant characteristics is better with production in dry weight (Ybk).

The F values by ANOVA test obtained for wet weight (second step) of 3.334 and for dry weight (fourth step) 6.384 with probability (p) below 0.05 (Sig. <0.05), so that the regression model can be used or fit model to predict plant production based on variable X. Furthermore, to interpret the coefficients of the X to be included in the regression model can be seen from the value of unstandardized beta coefficients as in Table 6.

Table 6: Value of the estimated coefficient of leaf production in the forest.

Model Ybb		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.617	0.728		0.847	0.409
	D	0.521	0.403	0.583	1.293	0.214
	Ttaj	-2.334	1.140	-1.228	-2.046	0.058
	Ttot	1.067	0.673	1.066	1.586	0.132

a. Dependent Variable : Ybb

Model Ybk		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
2	(Constant)	0.079	0.171		0.462	0.650
	D	0.103	0.093	0.463	1.111	0.282
	Ttot	0.052	0.105	0.207	0.497	0.626

a. Dependent Variable : Ybk

Then the equation for estimating the plant production for elephant feed is compiled as follows:

a. Based on BB : Ybb = 0.617 + 0.521 D - 2.333 Ttaj + 1.067 Ttot
b. Based on BK : Ybk = 0.079 + 0.103 D + 0.052 Ttot

The above equation can then be a reference to predict the production of elephant feed plants, especially from 41 species that have identified at Aek Nauli SPFR. This information is very useful for developing elephant feed fulfillment programs that reach consumption values of between 150-200 kg per day for each elephant (Sukumar, 2003).

5 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

1. In the grazing area in Aek Nauli SPFR at least 41 species of elephant feed plants have been identified, mainly from the Paoceae, Moraceae, Myrtaceae and Euphorbiaceae. Parts of the feed plants that are often consumed are leaves, plant skin and all parts for grass. The species that elephants has a high palatability is Ottochloa nodosa.
2. The value of feed production at seedling is 0.78 grams/day per tree (wet weight) or 0.25 gram/day per tree (dry weight) and sapling of 2.93 grams/day per tree (wet weight) or 0.8425 gram/day per tree (dry weight). The type that has the highest production is Arthocarpus integer.
3. The equation for estimating the production of elephant feed plants as follows:
   a. Based on wet weight : Ybb = 0.617 + 0.521D - 2.333 Ttaj + 1.067 Ttot
   b. Based on dry weight : Ybk = 0.079 + 0.103D + 0.052 Ttot

5.2 Recommendation

1. The enrichment of feed plants in grazing areas, especially in pine dominant forests, needs are done to enrich the diversity of elephant feed plants. The choice of tree species planted is often eaten by elephants.
2. It is necessary to immediately the rotation regulate of the grazing area so that the former grazing area of elephants is not degraded.

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