Optimizing the habitat of the Javan rhinoceros (*Rhinoceros sondaicus*) in Ujung Kulon National Park by reducing the invasive palm *Arenga obtusifolia*

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Abstract

The dominance of the arenga palm had been identified as a potential limiting factor in the distribution of Javan rhinos because it prevented the growth of food plant species, thus created a nutrition-poor area in which rhinos roamed. Palm dominance was reduced in an area consisting of four 1-ha plots (assigned as plots A–D) that was selected on the basis of various ecological criteria such as number of palm trees (shading) and potential for connecting home ranges of several rhinos. The research was carried in two phases—palm control and monitoring—to study the impact of palm control on the growth of food plants and, consequently, on the area's accessibility by rhinos. Palm control resulted in increasing abundance and diversity of food plants for rhinos, and increasing visitation by rhinos. Results from this research show that controlling palm and other invasive plant species can potentially be used to improve the Javan rhinoceros's accessibility to certain areas within the habitat.

Résumé

La domination du palmier Arenga avait été identifié come un facteur limitatif potentiel dans la distribution des rhinocéros de Java, car il empêche la croissance des espèces de plantes alimentaires et crée une zone « pauvre en nurition » pour les rhinocéros. La réduction de la domination du palmier s'est effectuée dans une zone composée de quatre parcelles d'un ha sélectionées sur base de divers critères écologiques tels que le nombre de palmiers (ombrage) et le potentiel de relier les habitats vitaux de plusieurs rhinocéros. La recherche a été effectuée en deux phases—le contrôle de palmier Arenga a entraîné une augmentation de l'abondance et de la diversité des plantes alimentaires pour les rhinocéros ainsi qu'une augmentaiton de la fréquentation par les rhinocéros. Le résultat de cette recherche montre que le contrôle du palmier et des autres espèces de plantes envahissantes pourrait être utilisé pour améliorer l'accessibilité des rhinocéros à certaines zones au sein de leur habitat.

Introduction

After enduring a period of a very small population with only 25 animals in 1967, the Javan rhinoceros (*Rhinoceros sondaicus*) reached a population of 58 in 1980, but unfortunately there has not been a significant increase in population size since then (Setiawan et al. 2002; Groves & Leslie 2011). Many studies have been conducted in Ujung Kulon National Park (NP) to determine the limiting factors causing the population to stagnate. The factor suspected to be the major setback is habitat conditions that reduce the park's carrying capacity. The carrying capacity of habitats for herbivores such as the Javan rhinoceros is determined by many factors, such as rainfall and soil quality, which eventually influence the abundance and diversity of food plants (Fritz & Duncan 1994) as well as their nutritional quality (Hobbs & Swift 1985). Low food quality is a threat that should be avoided when managing wild herbivore populations as it may result in mortality during the first six months of an animal's life due to lack of nutrition in the food supply (Freeland & Choquenot 1990). It is also important to note that in the context of large herbivores, access to food sources such as feeding ground plays an important role in determining the limit of the habitat's carrying capacity (Boone & Hobbs 2004). Previous studies done by Bogor Agricultural University indicate that the dominance of arenga palm, *Arenga obtusifolia,* a rapidly spreading palm species, poses a threat by reducing the availability of food plants for rhinos. Therefore, in addressing the issue of availability of food plants, it is important to reduce the dominance of this invasive palm in certain areas within Ujung Kulon peninsula to allow the growth of other plant species with high palatability for Javan rhinos (Putro 1997).

Arenga palm is classified under the Arecaceae (or Palmae) family (Sastrapradja 1978) that relies on both root extension and seed for spread and dispersal. The arenga palm was not recorded in Ujung Kulon NP in the 1980s (Hommel 1987), but it is now found in most places within the park. Ripe fruits are normally consumed by palm civets (*Paradoxurus hermaphroditus*) and the long-tailed macaque (*Macaca fascicularis*) that help in seed dispersal by expelling palm seeds through faeces or by dropping seeds after consuming the fruit (Lucas & Corlett 1992; Putro 1997). Besides seed dispersal, the arenga palm can also spread and sprout using its extensive subterraneous roots that also restrict the growth of other plant species (Supriatin 2000). These dispersal methods make the arenga palm superior over other species in the course of vegetation succession in Ujung Kulon. As its mode of expansion and dispersal is known, it is important to ensure that the palm's fruits and roots are removed completely or destroyed to minimize the probability of it regrowing. This can be done by removing it manually or by using chemicals such as isopropyl ammonium glyphosate, an active ingredient of common weed killer, that has no negative effects on the natural flora (Carlson & Gorchov 2004) even after a prolonged five-year use (Hochstedler et al. 2007). Unfortunately, despite the potential of isopropyl ammonium glyphosate to effectively and efficiently eradicate the invasive arenga palm, the relevant authorities have note approved its use inside Ujung Kulon NP and all efforts to control the arenga palm must resort to manual interventions.

Materials and methods

An area measuring 4 ha was selected in the peninsula of Ujung Kulon NP (6°43′14.8″–6°43′17.3″ S and 105°19′12.3″–105°19′12.3″ E) based on criteria that included known presence of rhinos in the vicinity of the plot based on previous observation and census data; presence of other determinants for rhinos such as wallow holes, feeding ground, etc.; high palm density of more than 700 palm trees/ha (causes shading that prevents the growth of other plant species); and potential viability as a corridor to connect rhino home ranges in the peninsula of Ujung Kulon NP. The habitat was manipulated for 17 months from February 2008 until June 2009. The work schedule consisted of: phase 1, *clearing* between February and April 2008, phase 2, *treating* in May–November 2008, and phase 3, *monitoring* from December 2008 to June 2009. Specific activities included systematic clearing of a palm-infested plot, monitoring the growth of food plants important to the Javan rhinoceros, and monitoring rhino visitation to the treated plot. The 4-ha area designated as the study area was divided into four plots each measuring 1 ha. Each of the four plots (plots A to D) was further divided into smaller subplots of 20 m x 20 m containing smaller grids—2 m x 2 m, 5 m x 5 m, and 10 m x 10 m—to allow vegetation analysis of four classes of growth stages: sapling, hedge, young tree, and full-grown tree. Each subplot was used to calculate the density of full-grown tree densities, the 10 m x 10 m grids were used to calculate density of the young trees, the 5 m x 5 m grids were used for shrubs, and the 2 m x 2 m grids were used to calculate sapling densities in each subplot (Fig. 1). Palms were cleared within the first five months of the study by a team of 10 persons: two persons each operating a Motoyama 24-inch chainsaw, and eight persons removing the fallen palms out of the optimization plot to prevent them regrowing through seed dispersal. Next, palm roots and stubs were removed from the plot using shovels and hatchets to prevent arenga palm regrowing from roots. The effect after treatment on food plants important to rhinos was reflected in the diversity of food plants (numbers of plant genera) and abundance (quantity of food plants available).

To study the nutritional value of the new food plants growing on the plot, proximate analyses were conducted with gravimetric, acid-base extraction, bomb calorimeter, auto analysis destruction, Atomic Absorbance Spectrophotometry, and conventional spectrophotometry, specifically water, fat, ash, rough fibres, energy, protein content, calcium, and phosphate-tannin. All food plant samples were sun dried for 8 hours and oven dried at 60 ºC until they reached constant weight before the proximate analysis.

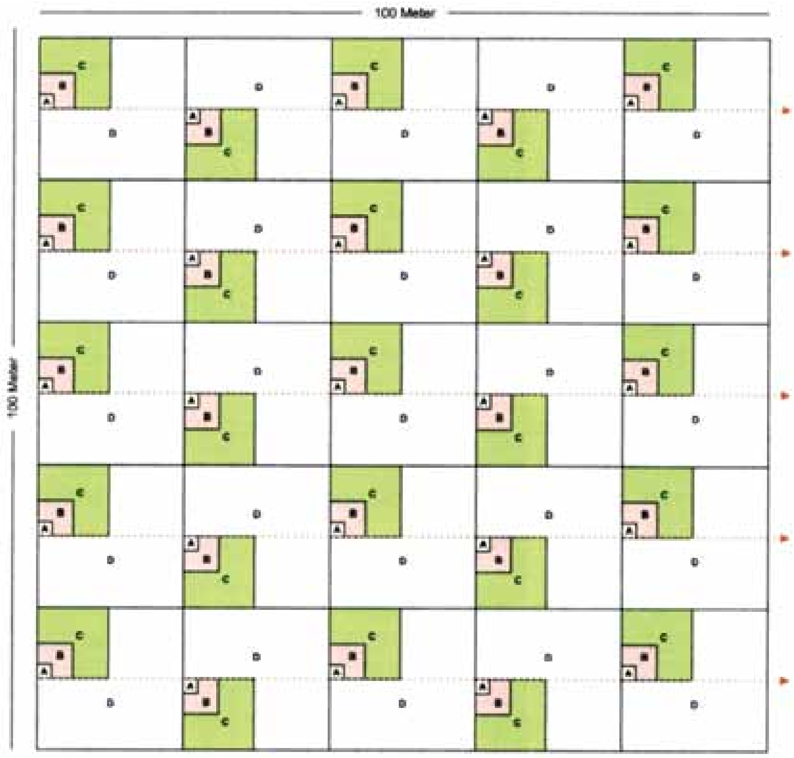

Figure 1. The plot layout for vegetation measurements on the 4-ha study area, an area of 1 ha (100 m x 100 m) divided into smaller grids of 2 m x 2 m (A), 5 m x 5 m (B), 10 m x 10 m (C), and 20 m x 20 m (D) to properly assess various stages of vegetation consisting of seedling, hedge, young tree, and full-grown tree.

An average of three random observation points was set up monthly within the 4-ha study area to observe rhino presence from 0800 h to 1730 h in the period between 19 August 2008 and 17 July 2009. The frequency of rhino visits to the 4-ha plot was calculated as the number of observation periods with rhino presence divided by total number of observation periods of rhino visits in the treated plots. This information was compiled to analyse how rhinos used the treated areas every month during the monitoring phase of this study. Rhinos were identified by the footprint size and visually using a DVREye automatic video camera (Pix Controller, Inc., 1056 Corporate Lane Murry Corporate Park Export, PA. USA), while plots, subplots and rhino presence were marked using a Garmin 12 XL global positioning device (GPS) to obtain all coordinates. Data from vegetation analyses and rhino visitations were compiled using spreadsheet software Microsoft Excel (Microsoft Inc.), and statistical analyses were done using biostat software (Analystsoft). One-way analysis of variance (ANOVA) was used to test the null hypotheses that there would be no significant differences in the numbers and diversity of sapling presence before and after treatment.

Results

Systematic clearing of the area dominated by the arenga palm resulted in an increase in the number of saplings (Fig. 2). ANOVA rejected the null hypothesis and indicated significant differences between the number of saplings before clearing between February and April and after clearing phases in May–November (df = 1; Fcrit = 5.9874; F = 21.8474), but not between clearing in May–November and monitoring phases in December–June (df = 1; Fcrit = 5.9874; F = 4.2505). ANOVA also rejected the null hypothesis and suggested that the diversity of newly growing saplings differs significantly between February–April and May–November phases (df = 1; Fcrit = 5.9874; F = 93.0258) as well as between May–November and December–June phases (df = 1; Fcrit = 5.9874; F = 14.2274). Descriptive analysis showed that, unlike the numbers of saplings growing in the plot area, the diversity of saplings (indicated by the numbers of different plant species) continued to increase significantly throughout these periods. In the initial period, vegetation analysis showed an average of 42.5 plant species per plot, while the later period showed an average of 65 plant species per plot. Table 1 gives the plant species found in the palm control plots, Table 2 the nutritional values of some of the rhino food plant species growing in this area. Rhino visitation data showed a trend of increasing occurrence throughout the year (Fig. 2), and at least two different rhinos were identified through the automatic video camera installed in the combined 4-ha study area. Frequency

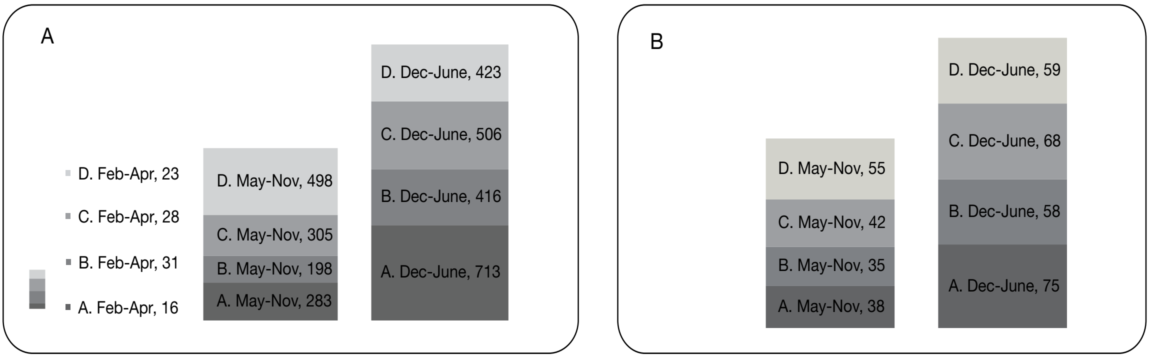

Figure 2. Bar graph indicates the numbers of seedlings (A) and the diversity of seedling species (B) growing in the areas before palm clearing (February–April), after clearing (May–November), and at maintenance period (December–June). The data show information from all four plots (plots A–D) combined; no data were collected for seedling diversity during the February–April period.

of rhino visitation indicated no visitation in August and September 2008 (treated phase), and showed steady visitation by two individuals (footprint size 25–26 cm and 27–28 cm) in treated and monitoring phases between November 2008 and July 2009 with most occurrences (100% rhino findings in every observation occasion) in the monitoring phase between December 2008 and February 2009 and in April 2009.

Table 1. Plant species known to be food plants for Javan rhinos found growing as seedlings in the cleared area.

Food plant species	No. of stems found in plot
Spondias pinnata	115
Lagerstroemia speciosa	24
Mikania cordata	17
Musa sp.	15
Unclassified 1	11
Mallotus floribundus	9
Unclassified 2	8
Cordia dichotoma	8
Zanthoxylum rhetsa	7
Eupatorium odoratum	7
Lantana camara	6
Unclassified 3	5
Tetrastigma lanceolarium	4
Solanum sp.	3
Unclassified 4	3
Donax canniformis	2
Glochidion rubrum	2
Amomum sp.	2
Unclassified 5	2
Trema orientalis	2
Solanum torvum	1
Anthocephalus chinensis	1
Dillenia obovata	1
Pterocymbium tinctorium	1
Lepidagathis javanica	1

Discussion

Statistical analysis confirmed that the number of arenga palms in all four plots (plots A–D) was significantly reduced and was followed by the growth of non-palm saplings that included rhino food plant species. The pattern of sapling growth in the palm control plot showed similarity with a succession where a period of growth was followed by a period of growth stagnancy, indicating that the optimum capacity of growth was reached. Furthermore, the composition of plant species found in the area showed a trend of increasing diversity (increasing numbers of species) throughout the observation periods. These facts suggest a direct correlation between the decreasing palm populations with the increasing growth of other plant species. The plant species were dominated by *Spondias pinnata*, a relatively good source of water and calcium for the rhinos but a poor source of energy (lower calorie content than that of other food plant species). The plants showed lower water content than they normally would in natural state due to the drying processes; therefore the water content from proximate analysis was suitable for indicating the water content that could be retained by these plant species.

Increased growth of plants known to be food sources for Javan rhinos seemed to influence the rhinos' use of the treated plots. This can be inferred from the data showing the increase in rhino visitation (percentage of rhino occurrences in the area) at

Table 2. Proximate analysis of various plant species

Plant species	Calorie kcal/kg	Grams per 100 grams							
		Water	Protein	Fat	Rough fibre	Ash	C	P	Tannin
Spondias pinnata	3.005	9.42	9.16	2.62	15.57	20.16	4.70	0.19	0.02
Mallotus floribundus	3.521	7.89	15.71	4.45	25.93	11.42	2.42	0.30	0.91
Amomum sp.	4.151	9.58	10.24	1.63	33.79	8.69	0.67	0.23	0.18
Lantana camara	4.004	8.37	7.67	4.11	15.96	9.99	2.04	0.16	0.05

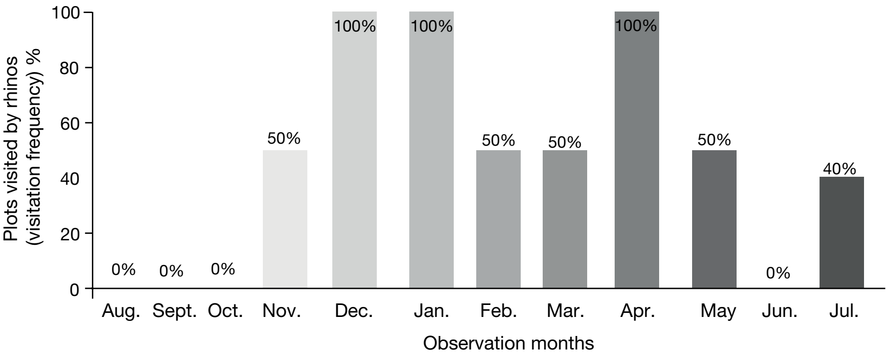

Figure 3. Occurrence of rhino visitation (%) in three observation points in all cleared plots (combined) from August 2008 to July 2009.

approximately the same time as the increase in growth of food plants. Rhinos were first identified by their footprints; the footprint sizes suggested two animals were entering this study area. Further observation using video trap revealed that the two rhinos were a mother travelling with her calf (Fig. 4). Results from field observations were supported by video clip records of the rhinos showing them using these plots as a new path as well as new feeding ground. Since no rhino presence had been recorded previously in this particular area, it can be concluded that the palm control area provided a new access for certain rhinos. Therefore, habitat optimization by reducing the amount of invasive palm (or any other plant) species could be used by park managers as a tool to increase access and probability of joining the isolated rhinos for breeding purposes and for improving the quality of rhino home ranges.

In addition to manually removing the arenga palm, there are options for using chemical as well as biological agents to control its spread. The use of biological agents (insects) has been implemented and evaluated for controlling *Lantana camara* in Australia (Day et al. 2003), and a similar concept may be applied to control the arenga palm. Potentially invasive plant species that could affect the

Figure 4. Rhino mother and calf using the study area as the new feeding ground.

habitat quality of the Indonesian rhinoceros included vine (*Merremia peltata*) and wild bamboo species such as *Schizostachyum zollingeri* and *Bambusa* sp., as well as *Lantana camara.*

Acknowledgements

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