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Forest Structure at a Primate Natural Habitat Breeding Facility after Fifteen Years of Operation

[STRUKTUR VEGETASI HUTAN DI FASILITAS PENANGKARAN ALAMI PRIMATA SETELAH LIMA BELAS TAHUN BEROPERASI]

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During July-September 2002, a vegetation survey of Tinjil Island was conducted as part of a larger study examining macaque feeding ecology and island carrying capacity. Fourteen quadrats (0.04 ha each) were randomly established at 1000-meter intervals along the northern and southern midline of the island. Trees (N=263) were marked and identified with respect to species, diameter at breast height, height, crown shape/size, and phenological state. Trees were of mid-canopy height across the island with 48% of the stems included in the 0.56 ha sample plot identified as fruit tree species used by the long-tailed macaques. This survey indicates that habitat quality continues to be very high and along with modest provisioning, has yet to limit the long-tailed macaque population.

Keywords: *NHBF, population management, habitat survey, Macaca fascicularis*

Introduction

Indonesia is considered one of the hotspots for primate conservation in Asia. It supports the greatest primate diversity in the region (Rosenbaum *et al.*, 1998), while having an overall human density around five times that of other Asian countries (Population Reference Bureau, 2005). As a result, the primates of Indonesia are at high risk: of the 76 species and subspecies occurring there, 20 are endangered, 7 are considered vulnerable, and 26 have insufficient data (IUCN, 2000). Further, pig-tailed langur (*Simias concolor*), Miller's grizzled surili (*Presbytis hosei canicrus*) and the Sumatran orangutan (*Pongo abelii*), each endemic to Indonesia, are listed on Conservation International's 25 Most Threatened Primates list (Mittermeier *et al.*, 2005). Primatologists in Indonesia face a great challenge in the management of the country's non-human primate populations. As non-human primates continue to be used for biomedical research, new approaches are needed to assure the supply of primates, while insuring the conservation of the natural populations (Kyes *et al.*, 1995).

Natural habitat breeding facilities (NHBF) are excellent alternatives to wild trapping and compound breeding as they ensure maximal health and well being of animals destined for biomedical research (Crockett *et al.*, 1996). With continuing export restrictions, NHBF are unique alternatives to meet the demands of primate supply in a manner that is both economically advantageous and consistent with conservation objectives (Crockett *et al.*, 1996; Kyes *et al.*, 1995). Tinjil Island, Indonesia, provides a NHBF for a free-ranging population of long-tailed macaques (*Macaca fascicularis*). Central to the long-term management and survival of the Tinjil macaque population is the availability of natural food sources. Native food species provide the majority of the diet, while modest provisioning is used as a

management tool to habituate animals, facilitate capture, as well as provide nutritional supplement (Crockett *et al.*, 1996).

The aims of this study were: (1) to evaluate the structure, composition, and diversity of vegetation on Tinjil Island, and (2) to identify natural food resource availability for the macaque population.

Materials and Methods

Field Site

The study was conducted from 19 July through 03 September 2002 at the Tinjil Island Natural Habitat Breeding Facility (NHBF). Tinjil Island is located approximately 16 kilometers off the south coast of West Java, Indonesia (Figure 1) (Kyes, 1993). Kyes (1993) provides a description and history of the Tinjil Island facility.

Primate Population

Between February 1988 and December 1994, 520 adult long-tailed macaques (58 males and 462 females) were released onto Tinjil. A 2001 survey estimated a population of more than 2200 monkeys (Leeson *et al.*, 2004) with approximately two-thirds of the adult population concentrated at the eastern third of the island. Current estimates suggest at least 25 social groups have formed on the island (R. Kyes, unpub. data).

The habituated "M-26" group, was followed and individual feeding records were logged as part of a larger study examining macaque-feeding ecology. When an individual or group of monkeys was observed feeding at a tree, the tree was marked with surveyors' flagging tape and recorded in field notes. Later, the researcher (JAM) returned to the site to take measurements (see habitat survey section, below). A total of 38 feeding trees were marked. Feeding samples were logged *ad libitum* (Altmann, 1974) during island reconnaissance, global positioning system (GPS) mapping, and also during weekly surveys mapping mast fruiting events/locations across the island. Feeding records were used to estimate monkey food source usage, specifically, the proportions of wild food use and consumption and provisioned food source usage.

Habitat Survey

Fourteen (N=14) quadrats (0.04 hectare each; 20 m x 20 m) were randomly established along existing transects at 1000-meter intervals

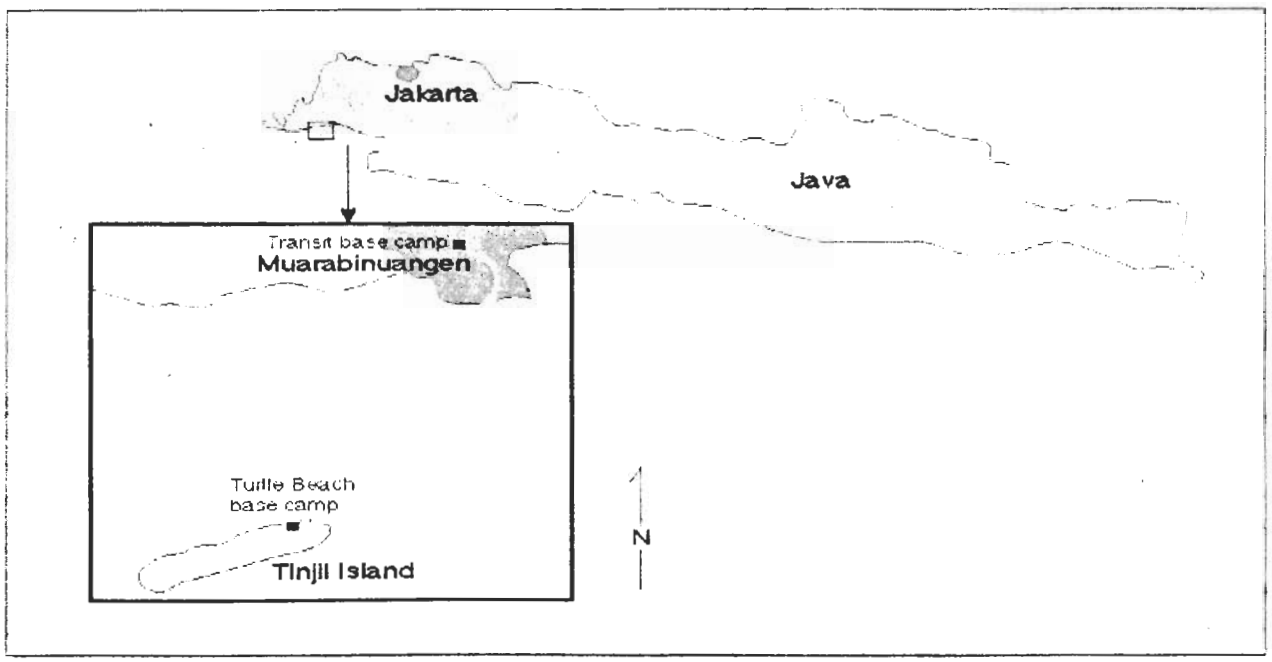

Figure 1. The location of Tinjil Island Natural Habitat Breeding Facility, Indonesia.

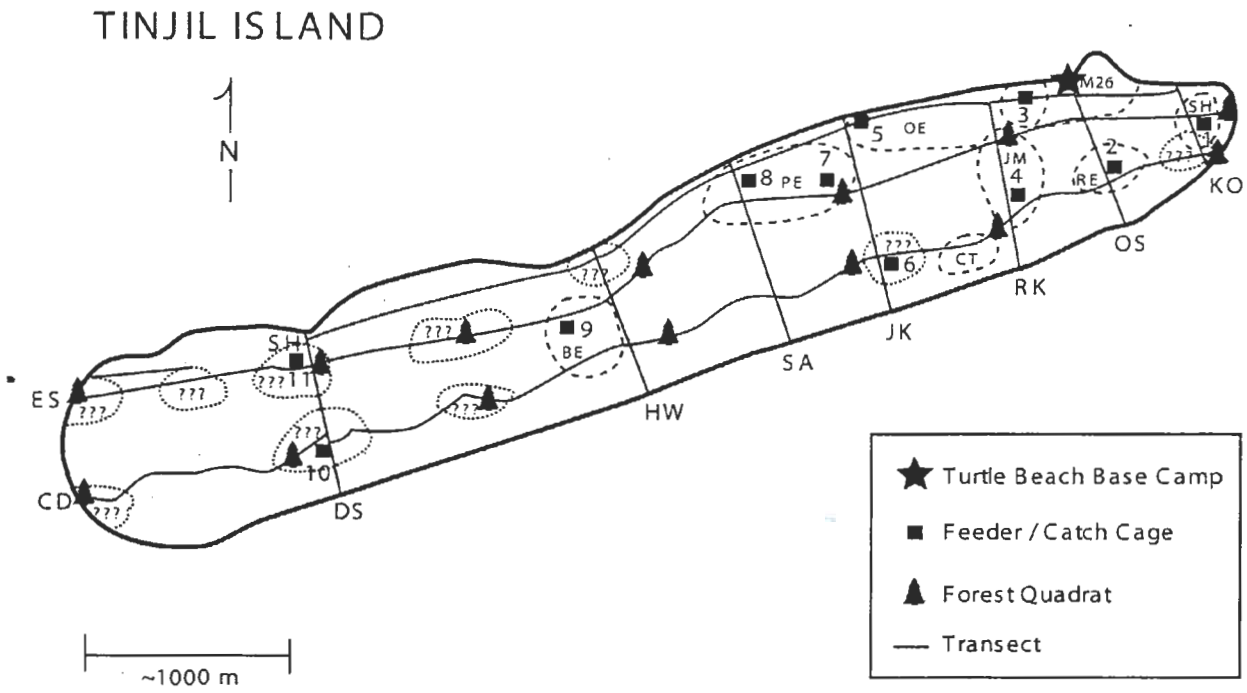

Figure 2. Long-tailed macaque group distribution, approximate home ranges, and forest quadrat (0.04 ha each) locations (adopted from Kyes, 1993). Dotted lines are estimated home ranges for observed groups, letters indicate group names, and "???" indicate that a group has been reliably observed but has yet to be clearly identified.

along the northern and southern midline of the island (Figure 2) to study the composition, diversity, and structure of available habitat. All plots fell within the home ranges of troops of monkeys. A total of 263 trees of 36 species were included in this 0.56 ha total sample area. Each tree with $\geq$ 10 cm diameter-at-breast height (DBH) was marked with surveyors' flagging tape, assigned a unique identification number, and was identified with respect to species, DBH, estimated height, crown shape/size, and phenological state (e.g., presence/absence young leaves, ripe or unripe fruit and flowers).

Results and Discussion

Forest Composition and Structure

Measures of forest composition and structure for individual quadrats are shown in Table 1. On Tinjil Island, 263 trees ($\geq$ 10 cm DBH) were enumerated in 0.56 ha of forest, representing 36 species. Of these, 125 trees (48%) representing 17 species were identified as fruit tree species used by the long-tailed macaques. The dominant tree species on the island was *Erioglossom rubiginosum* (10.1% of sampled trees) and the dominant fruiting species was *Gnetum gnemon* (6.4% of sampled trees). The macaques favored *Ficus benjamina* and *F. ampelas* species, accounting for 0.5% and 1.6% of sampled trees, respectively, as indicated from ad libitum feeding observations ($\chi^2 = 94.788$, $df = 35$, $p < 0.001$).

Number of Stems

The number of stems ($\geq$ 10 cm DBH) within each forest quadrat ranged between 7 and 35, with an average of 18.79 (Table I), and differs significantly by quadrat ($\chi^2 = 42.817$, $df = 13$, $p < 0.001$). The northern half of the island did not differ from the south ($t = 0.876$, $df = 261$, $p = 0.381$). The number of stems was not different ($F = 3.982$, $df = 2$, $p = 0.221$) between the three geographic regions.

Average DBH

The average DBH of trees of all forest quadrats ranged between 18.74 and 42.14 cm (average = 27.60 cm) indicating that most trees

were of mid-canopy height across the island (Perry 1994; Rosenbaum *et al.* 1998). The DBH of trees in the North did not differ significantly from the DBH of trees in the South ($t = 0.876$, $df = 261$, $p = 0.381$). Further, the average DBH was not significant between the three geographic regions ($F = 0.396$, $df = 2$, $p = 0.673$) or between the six geographic regions ($F = 0.413$, $df = 5$, $p = 0.840$).

Diversity

Tree species diversity was high on Tinjil Island ($H' = 1.913$, $D = 7.042$). While the majority of tree species were present in all geographic regions on the Island, there were large differences in their abundances within each quadrat, as evident in the range of values for the diversity indices (Table I). The diversity of trees, however, is not significant between the North and South ($t = 2.179$, $df = 12$, $p = 0.626$), the Western, Central, and Eastern geographic regions ($F = 1.694$, $df = 2$, $p = 0.23$), or the six-geographic regions ($F = 0.563$, $df = 5$, $p = 0.73$).

Discussion

The results from this project confirm that there is considerable variation in the habitat structure across Tinjil Island (Table I.) however, these data do not suggest any specific source of variation. Based on local reports and the observation of stumps and decomposing felled logs, logging occurred during the 1940s or 1950s. The extent of the logging, however, is undocumented. During the early stages of stand development, competition among seedlings is not severe enough to cause mortality, and as a result, the average seedling size increases with no corresponding decrease in stock density (Perry, 1994). The observed stem size and counts in the north central region is consistent with this idea, however, it is reported that many trees that colonize after a disturbance attain a girth of $\geq$ 30 cm DBH after 5-6 years (Johns, 1988). If the observed stem density and size were absolutely a result of the known logging, then we would expect to find little to no variation in stem size or density, since the logging disturbance occurred over 50 years ago.

Previous research has shown that in wild, total primate biomass (a variable used to determine carrying capacity) in Indonesia and Malaysia rarely exceeds 1000 kg/km^2 (Crockett *et al.*, 1996). *M. fascicularis* has an average weight of 3 kg across both age and sex classes (Crockett *et al.*, 1996), which translates to about 333 individuals/km^2. The population density on Tinjil in 2001 was estimated to be as high as 403.2 individuals/km^2 (Leeson *et al.*, 2004), which exceeds estimates for this species.

Carrying capacity of a given area, however, can be increased by provisioning (Lyles and Dobson, 1988). Provisioning has not substantionally altered the dietary patterns of the Tinjil macaques: over 85% of all observed feeding was of natural food sources. Dietary proportions of foods eaten are similar to published diets of nonprovisioned troops of *M. fascicularis* (Fooden, 1995). Further, the Tinjil macaque time budgets reflect activity patterns characteristic of wild populations for feeding and travel activities and are characteristic of introduced populations for all other daily activities (Fooden, 1995). This survey indicates that Tinjil Island includes a diverse habitat and that natural food sources, along with modest provisioning, are sufficient to support the current population density. Further, the introduced macaques could certainly be having a positive impact on the forest via increased seed dispersal, thus helping to counteract any possible negative impact of an increased population. Habitat quality continues to be very high and, along with modest provisioning, has yet to limit the long-tailed macaque population.

Although there is high confidence in the consistency and reliability of the data collected for this report, several shortcomings of this research must be addressed. First, the sample size for this research is rather low, as clearly evident from the small forest sample: 0.56 ha versus the suggested 30-60 ha (National Research Council, 1981). Moreover, rainfall patterns may help explain the species diversity and tree density at a given site, as well as soil patterns (Gupta and Chivers, 1999). There has been no weather monitoring, nor any formal soil analysis. Lastly, the strength and reliability of ecological studies is vastly increased when data come from all months and seasons of the year (Gupta and Chivers, 1999; Strier, 1989; Sugardjito *et al.*, 1989; Yeager, 1996). The seven weeks during which this study took place was only a snapshot in time of the seasonal variation of the site. These results, however, suggest that an

adequate supply of fruits and other items are available to the macaques even during this time period, which is the dry season. There is a need for long-term assessment and monitoring to provide additional insight into long-tailed macaque habitat use.

Conclusion

This survey indicates that there is considerable variation in the habitat structure across Tinjil Island. A diverse habitat, an ample supply of natural food sources, and modest provisioning are sufficient to support the current population density without adversely effecting the habitat sturcture or the activity patterns of the macaque population.

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