

MANAGEMENT OF A NATURAL HABITAT BREEDING COLONY OF LONGTAILED MACAQUES

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ABSTRACT

Tinjil Island, a 600 ha island located off the southern coast of West Java, Indonesia, has been designated a natural habitat breeding facility (NHBF) for simian retrovirus (SRV)-free longtailed macaques (*Macaca fascicularis*). This island breeding facility has been in operation since 1987 and functions as a primate resource and conservation program. The purposes of the Tinjil NHBF are: 1) to provide healthy, SRV-free macaques for important biomedical research (e.g., AIDS-related research) and 2) to contribute to the conservation and management concerns of naturally occurring primate populations. Between February 1988 and December 1994 a total of 520 adult longtailed macaques (58 males and 462 females) were released onto Tinjil Island which previously had been uninhabited by monkeys). Before being released, all animals were screened for SRV and tuberculosis (TB). The Tinjil population has been censused annually since 1990. The most recent census data (1997) indicate the presence of 18-20 social groups located throughout the island. Estimates of reproduction suggest an annual birth rate of about 60%. The current population size on Tinjil Island is estimated to be 1550 macaques. A critical management activity of the NHBF is the periodic harvesting of offspring for use in biomedical research. During 13 harvest operations between 1991 and 1997, 707 offspring (396 males and 311 females), mostly 1 to 3 years old, have been removed from the island. Each animal captured is (re)screened for SRV and TB and given a numeric tattoo for identification. All offspring screened thus far have tested negative for SRV and TB, thus assuring the integrity of the SRV-free breeding population. The successful operation of the Tinjil Island NHBF demonstrates that natural habitat breeding is a useful approach to managing primate populations as sustainable resources capable of satisfying the needs of important biomedical research in a manner that is conservationally sound.

Key Words: *Macaca fascicularis*, Indonesia, management, breeding, conservation

Received: 22 March 1997; Accepted: 16 May 1998

INTRODUCTION

Ensuring the availability of nonhuman primates for use in important biomedical research presents a difficult challenge for the next century. Although research demand remains constant, the available sources of primate supply continue to diminish. Increasing concern for the preservation of natural populations has prompted many habitat countries to place strict limitations or

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a complete ban on the export of wild-caught primates. The financial obligations associated with traditional captive breeding facilities are becoming too costly for many institutions to manage. Natural-habitat breeding of primates in the country of origin represents a unique approach to meeting the continuing demands of primate supply in a manner that is both conservationally sound and economically efficient (Bowden & Smith, 1992; Kyes *et al.*, 1995).

The concept of natural habitat breeding originated, in part, in response to a 1981 World Health Organization (WHO) meeting convened to address the feasibility of establishing, in habitat countries, national programs designed to manage primate populations as sustainable (or "renewable") resources so as to ensure the permanent conservation of the various species and maintain the supply of primates for essential biomedical research (MacKinnon, 1983). That same year, the Ecosystems Conservation Group (of the International Union for Conservation of Nature) and WHO submitted a joint recommendation that only primates known to be "common" (e.g., longtailed macaques, see Crockett & Wilson, 1980; Supriatna, *et al.*, 1996) should be used for biomedical research and that "wild caught primates be used primarily for the establishment of self-sustaining breeding colonies, the eventual goal of which should be to captive breed most or all primates used in research" (p. 1, cited in MacKinnon, 1983). The following year, consultants, sponsored by WHO, met with the Indonesian government to explore the possibility of establishing a national primate breeding program in Indonesia (Hiddleston & Smith, 1982). Their recommendation focused on Natural Habitat Breeding Facilities (NHBF) as the most feasible approach to a sustainable resource capable of satisfying the needs of primate supply and conservation (Bowden & Smith, 1992). In 1987, the Tinjil Island NHBF was established. The facility, dedicated to the breeding of simian retrovirus (SRV)-free longtailed macaques (*Macaca fascicularis*), represents one of the first sizeable attempts to establish, in a habitat country, a primate resource and conservation program in accordance with the 1981 joint recommendation of the Ecosystems Conservation Group and WHO.

The purpose of this paper is to summarize the natural habitat breeding operation on Tinjil Island, focusing on management practices. Several papers about Tinjil Island and the NHBF have already been published (Bowden & Smith, 1992; Crockett *et al.*, 1996; Hernowo *et al.*, 1989; Iskandar *et al.*, 1996; Kyes, 1993; Kyes *et al.*, 1995; Morton *et al.*, 1995; Pamungkas *et al.*, 1994) and provide greater technical description of topics related to this paper.

Tinjil Island Natural Habitat Breeding Facility

Location and Habitat

Tinjil Island is located about 16 km off the south coast of West Java at 6°56'97"S, 105°48'70"E (GPS position fix: island base camp, see Fig. 1). The island is about 600 ha in size (6 km long and 1 km wide) and consists primarily of lowland, secondary tropical rain forest and coastal/beach vegetation. More than 75 species of plants have been identified on the island, 28 of which produce fruits or foliage known to be eaten by the monkeys. Island fauna includes numerous species of insects, crustacea, reptiles, and birds. The only native mammal species are rats and bats (see Hernowo *et al.*, 1989 for a detailed review of the island ecology). At least two natural fresh water sources exist on the island. Before the longtailed macaques were introduced in 1988, the island was uninhabited by human beings or nonhuman primates.

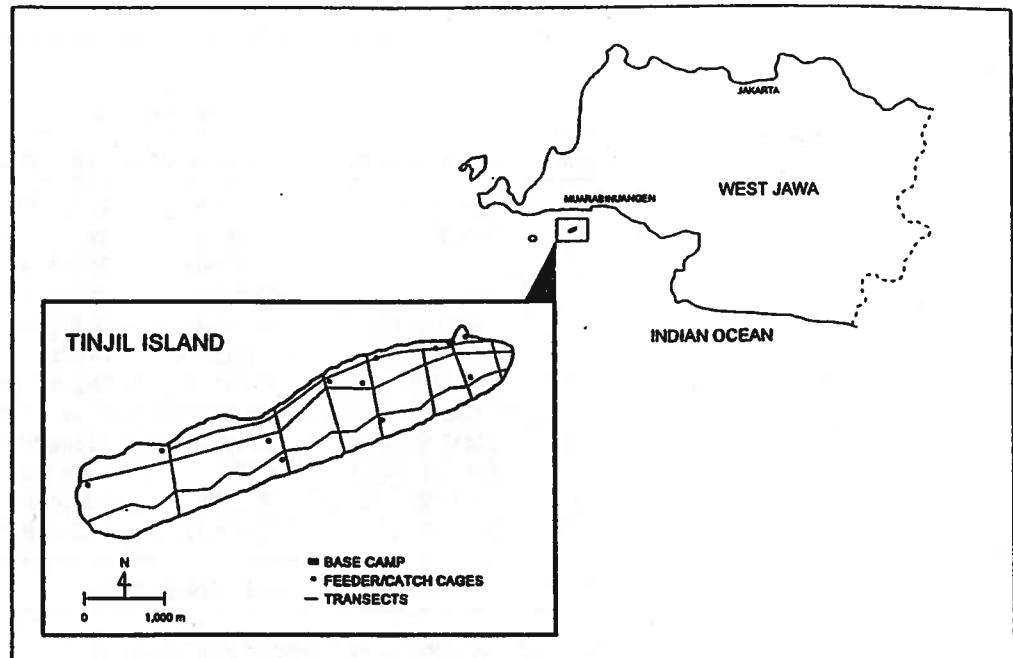


Figure 1. Location of the Tinjil Island Natural Habitat Breeding Facility.

Facilities and Logistical Support

The base of operation is located near the eastern end of the island and consists of several permanent buildings and huts that provide living accommodations and office space for resident staff (5-8 individuals), visiting scientists, and students. There are also storage facilities for support equipment (i.e., electric generator, all-terrain vehicle) and supplemental food provisions for the monkeys (including bananas, corn, and sweet potatoes); a communications room with a two-way radio system; and a temporary holding cage (12m x 3m x 2.5m, partitioned into four rooms) for housing animals prior to removal from the island.

Several feeder/catch cages (12m x 6m x 2.5m) distributed around the island (Fig. 1) function as provisioning sites and trapping facilities for the periodic capture of monkeys for health assessment and harvest. To date, only cages located throughout the eastern and central thirds of the island (9 cages) have been used for routine provisioning and trapping. The primary purpose of the supplemental provisioning is to attract the monkeys to the cages to help facilitate the captures. Fresh water wells have been dug next to most of the cages to provide additional water sources for the monkeys.

A network of 10 transects (Fig. 1) provides access to most of the island. The trails are numbered at 25 m intervals to aid in identifying the locations of groups encountered during routine population survey/census. The trails also provide convenient access to the feeder cages for food provisioning with the use of an all-terrain vehicle.

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Table 1. Summary of Macaques Screened and Released onto Tinjil Island

Group*	No. Screened	No. Released	Date of Release
	(males/females)	(males/females)	
1.	204 (9/195)	51 (1/50)	21 Feb 1988
2.	206 (33/173)	15 (5/10)	29 Apr 1988
3.	**	58 (7/51)	26 Jun 1988
4.	**	13 (2/11)	10 Jul 1988
5.	198 (21/177)	10 (0/10)	28 Sep 1988
6.	**	66 (13/53)	14 Mar 1989
7.	**	48 (1/47)	26 Apr 1989
8.	182 (39/143)	125 (29/96)	21 Oct 1989
9.	224 (0/224)	89 (0/89)	26 Jun 1990
10.	101 (0/101)	3 (0/3)	4 Jun 1991
11.	23 (1/22)	20 (1/19)	5 Sep 1994
12.	34 (0/34)	23 (0/23)	16 Dec 1994
Total	1172 (103/1069)	521 (59/462)	

Note: All macaques released were of adult status.

* Exception, infant male born during screening and released with its mother.

*Release groups - do not represent established social groups.

** Macaques that required additional screening, held over from previous groups.

Logistical support for the Tinjil facility originates at the Bogor Agricultural University (Institut Pertanian Bogor, IPB) transit base camp located in Muarabinuangen, a small fishing village on the south coast of West Java, about 18 km from Tinjil (Fig. 1). The transit facility consists of a large two-story building that provides ample accommodations for staff and visitors; office space, and a meeting room. Adjoining buildings offer equipment storage, laboratory space, and a temporary holding facility for monkeys. The transit base camp also has a floating dock and covered dry dock for boat maintenance. Two inboard diesel engine boats are available to ferry equipment, supplies, personnel, and monkeys between the island and Java as needed.

Founderstock

Between February 1988 and December 1994, a total of 520 adult long-tailed macaques (58 males and 462 females) were released onto Tinjil Island to establish a permanent breeding population (Table 1). The monkeys had been captured at locations in West Java and in the provinces of Lampung and Southern Sumatra. Each monkey released onto Tinjil underwent a thorough quarantine and viral screening process including physical examination, age determination (via dental eruption), tuberculin skin test (animals with a positive reaction were removed from the screening process) and treatment for intestinal parasites as required. Each animal also received a chest tattoo for identification purposes. To assure genetic diversity in the population, plans include periodic introduction of new breeder males.

A unique aspect of the Tinjil primate population is its simian retrovirus (SRV)-free status. Since some of the offspring bred on Tinjil are intended for use in AIDS research at the University of Washington, it is imperative that the breeding population be free of immunodeficiency viruses. Therefore, before being cleared for release onto the island, each monkey was tested for SRV by the use of ELISA, virus isolation, and immunoblot assay (for more detail on the virus screening protocol, see Pamungkas *et al.*, 1994; Morton *et al.*, 1995). The entire quarantine/screening process normally lasted 3 to 5 months.

Population Monitoring

A thorough and current knowledge of population characteristics is an essential component of a successful management program. Regular monitoring of demographic variables provides the best means of assessing the status of a population and the effectiveness of the management strategy. A survey/census of the macaque population on Tinjil Island has been conducted annually since 1990 (see Kyes, 1993 for a description of the census methods). Census data on demographic parameters such as birth rate and survivorship play a critical role in guiding the management of this breeding colony.

Recent census data (Kyes, 1997) indicate that the monkeys are distributed throughout the island, with a disproportionate concentration in the eastern third of the island near the release site. These findings have remained constant since 1990. Unlike those located elsewhere on the island, monkeys ranging in the western third are not habituated to humans and are difficult to observe. Approximately 18-20 groups have formed on the island, 12 of which can be reliably identified by tattoos and/or physical features of group members.

Group size, composition, and reproduction estimates have been obtained from 4 of the 12 identified groups. These "sample" groups frequent the feeder cages, permitting the most complete counts of group members. Mean group size (1994-97) for the sample groups has varied around 49 members (range: 22-77) with an average of 5 adult males and 23 adult females per group. The number of offspring in these groups, although increasing, fluctuates considerably as a result of the periodic harvest of offspring which began in 1991.

Estimates of reproduction (1990-1997) suggest a mean annual birth rate of 60% (yearly averages have ranged between 56-68%). Births occur during all 12 months of the year, a finding consistent with other studies of *M. fascicularis* (Kavanagh & Laursen, 1984; Lindburg, 1987; van Schaik & van Noordwijk, 1985; van Noordwijk, pers. l. commun., cited in Crockett *et al.*, 1996). On the basis of population modeling (described below), the population on Tinjil Island at year end 1997 was estimated to be about 1550 monkeys (assuming an average birth rate of 60% and intermediate survivorship values; see Crockett *et al.*, 1996). This translates to a population density of 258 individuals per sq km, at the high end of densities reported for lightly provisioned free-ranging macaques (summarized in Crockett *et al.*, 1996).

We caution that the estimates of group size, composition, and reproduction from the sample of identified groups that frequent the feeder cages may not be representative of the remaining population (a portion of which has not received provisioning). Primate groups that receive supplementary feeding can have higher birth rates than unprovisioned groups (Loy, 1988; Lyles & Dobson, 1988; Mori, 1979). Provisioning may also support an increase in group size.

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Table 2. Summary of Offspring Harvests on Tinjil Island

	Number of Monkeys (Male/Female) by harvest period													TOTAL
	1	2	3	4	5	6	7	8	9	10	11	12	13	
Category	Jun91	Dec91	Jul92	May93	Dec93	Jun94	Dec94	Jun95	Nov95	Apr96	Dec96	Sep97	Dec97	
Captured	56	56	65	59	64	130	63	62	55	56	57	106	32	861
Died during Holding	0	0	2	3	1	1	4	11	0	0	0	0	0	22*
Released back	6	6	18	5	9	9	6	34	5	20	3	6	5	132
Removed from Island	50	50	45	51	54	120	53	17	50	36	54	100	27	707
	(28/22)	(24/26)	(22/23)	(27/24)	(29/25)	(76/44)	(28/25)	(13/4)	(21/29)	(22/14)	(29/25)	(60/40)	(17/10)	(396/311)

*Deaths that resulted from pythons that gained access to the temporary holding cage or apparent exposure (while in the holding cage) during unusually severe and extended periods of stormy weather. No deaths have occurred during actual capture.

In addition to facilitating the harvest of offspring, the captures allow facility staff to perform routine health assessment on the animals captured (including the original adult breeders). Once captured, all offspring and randomly selected adult breeders are held in the temporary holding cage at the island base camp. Each animal is sedated and then given a physical exam, (re)tattooed, and tested for tuberculosis. A blood sample is collected for SRV screening. The information is then entered into a population monitoring data base. Original breeders and offspring judged to be too young or too old for removal from the island are returned to their social groups following assessment. All animal (re)screened thus far have tested negative for tuberculosis and SRV, thus assuring the integrity of the SRV-free natural habitat breeding colony on Tinjil.

DISCUSSION

Natural habitat breeding of primates in the country of origin represents a viable approach to meeting the conflicting demands of primate supply and conservation. The success of the Tinjil Island natural habitat breeding program has prompted the Indonesian government and state forestry company, Perum Perhutani, to consider designating other islands as breeding sites, modeled after the Tinjil facility.

Small islands, representative of a species' native environment, are especially suitable for establishing NHBFs. Using the natural boundary provided by an island, an introduced population of primates can be managed as a self-sustaining population and a certain percentage of offspring can be harvested for use in biomedical research. Provided the population is maintained within the island's carrying capacity, the island's natural vegetation and water sources provide a convenient and economical alternative to the intensive provisioning normally required outside of a species' natural range. Further, animals bred in their native surroundings experience the beneficial effects of their environment (e.g., natural food sources, natural stress levels), and should therefore be healthier research animals. One concern with

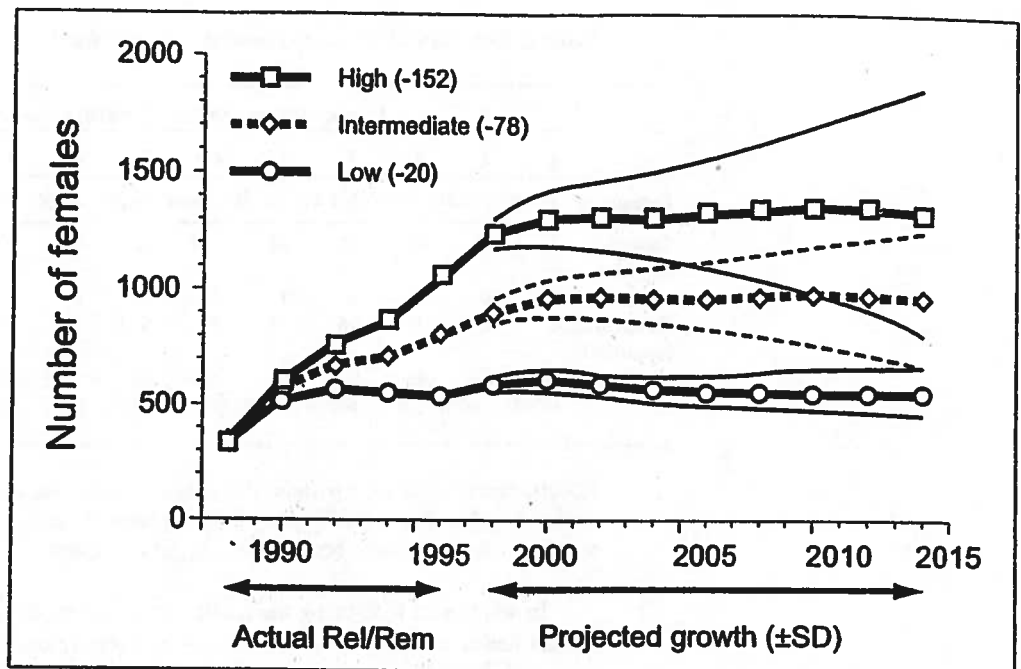


Figure 2. Mean (\pm SD) number of females of all ages over years of expected facility operation assuming three natality and survival schedules (High-70% birth rate; Intermediate-60% birth rate; Low-50% birth rate). Actual Rel/Rem: modeling actual number of females released and removed (through year end 1995). Projected growth (\pm SD): population size over time with annual harvest at threshold harvest rate, which varies for natality-survival schedules: High (152 female offspring harvested/yr), Intermediate (78 female offspring harvested/yr), and Low (20 female offspring harvested/yr). Figure reprinted from Crockett *et al.*, 1996.

All 13 harvests were conducted at the feeder/catch cages in the eastern and central thirds of the island, the sites of routine provisioning. Individual cage traps with automatic locking door were used around the base camp on a few occasions with limited success. During the harvest period, provisioning is provided each morning by the staff while another staff member hides in a blind about 50 m from the cage. After several offspring have entered the cage, the worker pulls a string which releases a spring-loaded cage door, thus trapping the monkeys. Early capture operations lasted up to 6 weeks to trap 50-60 offspring. Recently, the capture process has become more efficient through modification of the capture schedule and improvements in the trapping techniques. Two harvest periods are scheduled per year (during April/May and October/November) each lasting about 4 weeks. Trapping takes place at two or three different cages each day with at least 4 days between trapping at any one cage. An offspring harvest quota, generated from the census data and computer modeling, is set at the beginning of each year to ensure a self-sustaining population.

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Released back	6	6	18	5	9	9	6	34	5	20	3	6	5	132
Removed from														
Island	50	50	45	51	54	120	53	17	50	36	54	100	27	707
	(28/22)	(24/26)	(22/23)	(27/24)	(29/25)	(76/44)	(28/25)	(13/4)	(21/29)	(22/14)	(29/25)	(60/40)	(17/10)	(396/311)

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Small islands, representative of a species' native environment, are especially suitable for establishing NHBFs. Using the natural boundary provided by an island, an introduced population of primates can be managed as a self-sustaining population and a certain percentage of offspring can be harvested for use in biomedical research. Provided the population is maintained within the island's carrying capacity, the island's natural vegetation and water sources provide a convenient and economical alternative to the intensive provisioning normally required outside of a species' natural range. Further, animals bred in their native surroundings experience the beneficial effects of their environment (e.g., natural food sources, natural stress levels), and should therefore be healthier research animals. One concern with

an introduced population, however, is the potential for ecological damage to the island's ecosystem. Routine monitoring of the flora and fauna on Tinjil Island suggests that the macaque population has had no significant adverse impact on island's biodiversity. Finally, if the island can support a population representative of those naturally occurring, it could function as a "demonstration plot" in which to evaluate various conservation and population management techniques (e.g., sustained-yield harvest strategies) that could later be applied to wild populations.

Primate population management and conservation are goals that are central to the operation of NHBFs. The Tinjil facility, as originally conceived, provided conservation protection to wild populations by reducing the number of wild macaques captured and exported for biomedical research. This contribution to conservation diminished a bit when the Indonesian government banned the export of wild-caught primates beginning in April 1994 (although the facility's purpose as a primate resource program assumed a sense of urgency in light of this new legislation). The facility's role in conserving the natural populations, however, remains a significant contribution as macaques are now being used for biomedical research in Indonesia. The export ban does not restrict the use of wild-caught macaques (e.g., *M. fascicularis*) within Indonesia.

The Tinjil NHBF may assume an even more critical role in demonstrating the need for population management programs with naturally occurring populations. The export ban, although imposed in the interest of preserving natural populations, may produce unwanted results particularly if population densities increase in areas where monkey-human conflict is already a problem. If macaque populations in high-density areas are left unmanaged (i.e., no controlled harvesting), a far greater number of animals could be lost to poisoning, shooting, etc. by farmers frustrated with crop-raiding macaques. Or simply, an expanding population could suddenly decline as a consequence of increased disease, starvation, or aggression levels experienced as its size exceeds the resource capacity of a habitat restricted by deforestation. The Tinjil NHBF provides a representative population in which to test and demonstrate the effectiveness of management strategies that must be applied to naturally occurring primate populations to ensure their future.

In addition to its function as a primate breeding facility, the Tinjil NHBF has become an active field station that offers excellent opportunities for primate research and field training. Over the past eight years, more than 150 students from Indonesia, Japan, and the United States have conducted research projects on Tinjil Island on topics including primate biology and behavior, ecology, management and conservation. A number of students have also studied native birds, reptiles, plants, and marine life thus extending the assessment of the island's biological diversity. An annual field course in primate behavior and ecology has been conducted since 1991 (Kyes *et al.*, 1995). Training activities such as these play an important role in promoting a greater understanding of primatology, an appreciation of biodiversity, and an awareness of the need for effective conservation and management practices.

Natural-habitat breeding will undoubtedly become one of the primary resource options for maintaining the availability of high-quality, bred-for-purpose primates for use in important biomedical research around the world. The facility established on Tinjil Island should serve as a useful model for future primate resource and conservation programs

ACKNOWLEDGEMENTS

We express our appreciation to the Indonesian Ministry of Environment, Indonesian Ministry of Forestry, The Directorate General of Forest Protection and Nature Conservation, Perum Perhutani, and all other contributing individuals and organizations for their support and commitment to the natural habitat breeding program on Tinjil Island. The Tinjil NHBF is supported in part by NIH Grant RR00166 to the University of Washington and funds from the Primate Research Center at Bogor Agricultural University.

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