BIODIVERSITAS
Volume 13, Number 2, April 2012
Pages: 79-85

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d130205

Determination of long-tailed macaque's (*Macaca fascicularis*) harvesting quotas based on demographic parameters

YANTO SANTOSA[1], KUSMARDIASTUTI[2], AGUS PRIYONO KARTONO[1], DEDE AULIA RAHMAN[1,♥]
[1]Wildlife Ecology Laboratory, Department of Forest Resource Conservation and Ecotourism, Faculty of Forestry, Bogor Agricultural University, IPB Campus at Darmaga, Bogor 16680, P.O. BOX 168, West Java, Indonesia, Tel. +62-251-8629150, Fax. +62-251-8629150, ♥email: dede_fahutanipb@mail.com
[2]Department of Forestry, Natural Resources Conservation Center of Central Java, Semarang, Central Java, Indonesia.

Manuscript received: 15 November 2011. Revision accepted: 28 March 2012.

ABSTRACT

Santosa Y, Kusmardiastuti, Kartono AP, Rahman DA. 2012. Determination of long-tailed macaque's (Macaca fascicularis) harvesting quotas based on demographic parameters. Biodiversitas 13: 79-85. Harvesting quota of long-tailed macaques for breeding purpose should be set up based on demographic parameters. The objectives of this research were to determine demographic parameters affecting the set up of harvesting quota and the sustainable harvesting quotas of long-tailed macaque in Indonesia. This study was expected to provide useful information for consideration of setting up harvesting quotas for long-tailed macaque in Indonesia. This study was conducted in November 2009-Januari 2010 using the equation of Q = Nt-MVP. The results showed varied harvesting quotas for different age classes of long-tailed macaque with an average number of 5 for infant males, 3 for infant females, 5 for juvenile males, 4 for juvenile females, 6 for sub-adult males, 8 for sub-adult females and 2 for adult males. The dominant variable determining quota was survival rate.

Key words: fecundity, harvesting quota, long-tailed macaque, survival.

INTRODUCTION

Indonesia is one of the largest exporters of long- tailed macaques in the world, besides Malaysia and the Philippines (MacKinnon 1983). The demands of the species are growing due to the development of technology and products used by humans, where long-tailed macaque has significant role as animal model for biomedical research (Eudey 2008). While most wildlife is traded locally and the majority nationally (that is within the political borders of a country or state), long tailed-macaque is also traded internationally (Stoett 2002; Blundell and Mascia 2005; Schlaepfer et al. 2005; Nijman and Shepherd 2007). Long-tailed macaques may be taken from the wild to meet the needs of domestic market, while export demands should come from captive breeding. This is in line with the Decree No.26/Kpts-II/94 concerning the utilization of long-tailed macaque (*Macaca fascicularis*) and southern pig-tailed monkey (*Macaca nemestrina*) for export, that exported animals must come from captive breeding. To ensure the sustainable population of long-tailed macaque, harvesting quota was used. The number of long-tailed macaques captured from the wild should follow the catch quotas issued by the Director General of Forest Protection and Nature Conservation (PHKA), Ministry of Forestry as the Management Authority in accordance to the recommendation from the Indonesian Institute of Sciences (LIPI) as the Scientific Authority. For example the number of harvesting quota for long-tailed monkeys from the wild in 2006 was 2,000, which increases to 4,100 in 2007, 5,100 in 2008, 15,100 in 2009 but dropped to 5,000 in 2010 (Ditjen PHKA 2011).

Special Province of Yogyakarta (DIY) is one of the locations where long-tailed macaques were harvested. Until 2009, long-tailed macaques were captured from Paliyan Wildlife Sanctuary and Kaliurang Recreation Forest. The harvesting quotas for long-tailed macaque in these areas were 200 animals in 2006 and 2007, zero in 2008 and 1200 animals in 2009 (BKSDA Yogyakarta 2007-2010). Previously, based on the export statistics compiled by the Directorate of Protection and Nature Conservation (BKSDA Yogyakarta 2002), a total of more than 86,332 long-tailed macaques were exported between the periods of 1992-1997. Currently, the harvest quotas issued by PHKA contain only the figures for allowable catch, and have not considered detailed classification of the species's sex and age classes. This has raised a concern that such quotas will threaten the sustainability of the macaque's population (Santosa and Desi 2010).

Numerous studies have concluded that regulation of wildlife trade laws within Asia, be it in relation to international or domestic trade, are insufficient (Davies 2005; Lee et al. 2005; Giles et al. 2006; Nijman 2006; Nekaris and Nijman 2007; Shepherd and Nijman 2007a, b; Eudey 2008; Zhang et al. 2008; Chen et al. 2009), furthermore, wildlife in Southeast Asia such as a long tailed-macaque is under attack due to habitat loss and degradation, global climate change, commercial hunting and competition with introduced species (McNeely et al. 2009; Sodhi et al. 2004). Therefore, there is an urgent need for a more effective wildlife trading regulatory mechanisms, particularly in Indonesia.

Santosa (1996) says that harvesting quota is determined by demographic parameters including birth rates, mortality, sex ratio and size of population. These parameters are important components for the development of wildlife population. Thus, the planning and determination of harvesting quotas requires information on demographic parameters of the population in question (Santosa 1993). Based on the above, research on the determination of long-tailed macaque harvesting quotas based on demographic parameters was conducted in order to determine the harvest quota of long-tailed macaques based on number and sex ratio, in Paliyan Wildlife Sanctuary and Kaliurang Recreation Forest, both in Yogyakarta, Indonesia. It is expected that such results would become a model for the determination of long-tailed macaques harvesting quotas in other places and identification of variables that affect the demographic parameters of quotas.

MATERIALS AND METHODS

Time and location

The study was conducted from November 2009 to January 2010 in Yogyakarta Special Province, precisely in Paliyan Wildlife Sanctuary of Gunungkidul District which is a karts region with an area of 434.60 hectares and in Kaliurang Recreation Forest of Sleman District which is a montane forest.

Data collection

Data on demographic parameters of long-tailed macaque (*Macaca fascicularis*) were collected using concentration count method based on preliminary information. Observations were carried out twice daily, in the morning (6-9 a.m) and afternoon (3-6 p.m). Data recorded include number of individuals in each group, number of individuals based on sex, age and class. The numbers of individuals were recorded based on the encountered/directly observed individuals within the observation trail. Individuals were classified based on age as infants, juvenile, sub-adult and adults after Napier and Napier (1967), i.e. infant (0-18 months/ still breast feeding), juvenile (18 months-4 years old), sub-adult (4-9 years old), and adult (9-21 years). Classification of age classes based on Napier and Napier (1967) was more likely to be applied in a study in nature, related to the difficulty to distinguish individual age classes if age is classified into infant, weaning, juvenile, sub-adult and sexual maturity (male and female) by Rowe (1996) which further allows for a controlled study such as in captivity.

Data analysis

Demographic parameters

Numbers of individuals in each group, as well as numbers of individuals based on sex and age classes were used to calculate the crude birth rate / fecundity, and survival rate for each age class. The formula used to calculate fecundity is as follows:

$$f = \frac{\sum Xi}{\sum Bi}$$

f = crude birth rate/fecundity
Xi = number of infants in ith group
Bi = number of reproductive adult females in i-group
Px = $\underline{L_{x+1}}$
L_x = 1 -Mortality
Lx +1 = number of individuals in $_{X+1}$age class
Lx = number of individuals in age class

Population growth

To determine the population growth (Nt +1) in each group was used a modified of matrix Leslie not adrift density (Priyono 1998) where only the female part of the populations would be considered, while the male populations were determined using sex ratio. The calculation was made using Powersim 2.0. The matrix formula for the calculation was:

$M \times N_t = N_{t+1}$

$$M = \begin{vmatrix} \delta_0 & 0 & F_m & F_d \\ P_1 & \delta_1 & 0 & 0 \\ 0 & P_2 & \delta_2 & 0 \\ 0 & 0 & P_2 & \delta_3 \end{vmatrix} \quad Nt = \begin{vmatrix} N_{0,t} \\ N_{1,t} \\ N_{2,t} \\ N_{3,t} \end{vmatrix}$$

Fxm = sub-adult fecundity
Fxd = adult fecundity
Xd = adult age class
δ0 = proportion of infant age class
P1 = probability of infant survival
δ1 = proportion of juvenile age class
P2 = probability of juvenile survival
δ2 = proportion of sub-adult age class
P2 = probability of sub-adult survival
δ3 = proportion of adult age class

Minimum Viable Population (MVP)

Minimum viable population (MVP) is the smallest population size that will ensure a species survival in the long term (Shaffer 1981). MVP is important when decisions are made which can alter the available habitat, and consequently the species population and risk of catastrophic extinction (Harcourt 2002). Similar to the population growth, MVP was also calculated for each age class and sex based on females' population only, whereas males' populations were obtained based on sex ratio. The analysis used two algebraic equations, *i.e*. B = D and Nt, where the intersection value between the two equations determined the MVP value. The formula used was:

B = D

B = birth (birth)
D = death (mortality)

Further described by the following equation:

Fxm. Xm + Fxd. Xd = mb. Xb + ma. Xa + mm. Xm + δmd.Xd. .....(i)

Fxm = sub-adult fecundity
Xm = number of individuals of sub-adult age class
Fxd = adult fecundity
Xd = number of individuals of adults age class with maximum breeding age of 12 years
mb = infant mortality
Xb = number of individuals of infant age class
ma = juvenile mortality
Xa = number of individuals of juvenile age class
mm = sub-adult mortality
Xm = number of individuals of sub-adult age class
δmd = proportion of adult mortality
Xd = number of individuals of adult age class

Nt value used N1 value as constant for Powersim, thus if translated in algebraic form became:

Nt = (Xm + Fxd Fxm.. Xd + δb. Xb) + (XB + δa Pxb.. Xa) + (Xa + δm Pxa.. Xm) + (Xm + δd Pxm.. Xd) .... (ii)

Nt = population size in year-t
Fxm = sub-adult fecundity
Xm = number of individuals of sub-adult age class
Fxd = adult fecundity
Xd = number of individuals adult age class with maximum breeding age of 12 years
δb = proportion of infants
Xb = number of individuals of infant age class
Pxb = infant survival rate
δa = proportion of juvenile
Xa = number of individuals of juvenile age class
PXA = juvenile survival rate
δm = proportion of sub-adult
Xm = number of individual of sub-adult age class
Pxm = sub-adult survival rate
δd = proportion of adult
Xd = number of individual of adult

The two equations above were combined to produce the following intersection:

Fxm. Xm + Fxd. Xd-mb. Xb + ma. Xa + mm. Xm + δmd.Xd = Nt-Fxm. Xm + Fxd. Xd + δb. Xb) + (XB + δa Pxb.. Xa) + (Xa + δm Pxa.. Xm) + (Xm + δd Pxm.. Xd).........(iii)

Nt = population size in year-t
Fxm = sub-adult fecundity
Xm = number of individuals of sub-adult age class
Fxd = adult fecundity
Xd = number of individuals of adult age class with maximum breeding age of 12 years
mb = infant mortality
Xb = number of individual of infant age class
ma = juvenile mortality
Xa = the number of individuals of juvenile age class
mm = sub-adult mortality
Xm = number of individuals of sub-adult age class
δmd = proportion of adult mortality
Xd = number of individuals of adult age class
δb = proportion of infants
Pxb = infant survival rate
δa = proportion of juvenile
PXA = juvenile survival rate
δm = proportion of sub-adult
Pxm = sub-adult survival rate
δd = proportion of adult

Value of harvesting quota

Value of harvesting quota represented the difference between the numbers of existing individuals with the minimum viable population (MVP). The harvesting quota was calculated for each age class and sex, using the following formula:

Qij = Ntij-MVPi

Qi = harvesting quota of i-age class to j-sex
Ntij = number of individuals of i-age class with j-sex on year-t
MVPij = minimum viable population of i-age class with j-sex

Analysis of demographic variables that determine quota

Based on the matrix equation of population growth and MVP, the variables affecting demographic parameters were survival quota (Px) and fecundity. To determine the dominant variables affecting the quotas, a regression test was done using the following equation:

Y = b1X1 + b2X2 + ε

b1 = regression coefficient
1 = average fecundity
X2 = average survival rate

Sensitivity analysis of dominant quota determinant variables

Sensitivity test was conducted for the dominant variables determining the quota, which was done by addition and subtraction of 10% to 30% of the dominant variables to observe the extent of the impacts on the value of the quota.

RESULTS AND DISCUSSION

Long-tailed macaque group characteristics

During the observation periods, three groups of long-tailed macaques were encountered in Paliyan Wildlife Sanctuary and four groups in Kaliurang forest. Although Paliyan Wildlife Sanctuary has been disturbed by human activities, nevertheless the number of individuals within each group was higher than those in Kaliurang forest. Group size referred to the number of individuals contained in a group (Priyono 1998). In Kaliurang forest, the group size ranged from 20-45 animals, whereas in Paliyan Wildlife Sanctuary it ranged between 48-68 animals (Table 1). This was in line with Bismark's (1986) finding where formation and size of groups varies according to habitat types. In primary forest, one group of long-tailed macaque comprised of 10 individuals, in mangrove forest about 15 individuals, and more than 40 individuals in disturbed forest.

Table 1. Long-tailed macaques groups characteristics

Group	Infant	Juvenile		Sub-adult		Adult		Total
		M	F	M	F	M	F	
Paliyan Wildlife Sanctuary								
1.	12	7	11	8	16	3	11	68
2.	10	6	8	8	17	3	5	57
3.	9	4	9	6	9	4	7	48
Kaliurang Forest								
1.	6	3	5	5	9	3	5	36
2.	9	4	7	5	9	4	7	45
3.	5	2	5	4	7	3	4	30
4.	4	3	3	2	3	2	3	20

Note: M = male, F = female

There were four groups of long-tailed macaque groups observed in Kaliurang forest with a total of 131 individuals, which indicated an increased from previous research results. Ningrum finds as many as 63 individuals in 2002, which later developed into 2 sub-groups with 80 individuals (Fallah 2005) and again into 3 sub-groups in 2009 (Raharjo 2009).

Demographic parameters

Age structure and sex ratio

Age structure is the ratio of individuals of a population in each age class. Table 2 showed the age structure of long-tailed macaques in Paliyan Wildlife Sanctuary and Kaliurang forest based on age classification by Napier and Napier (1967).

Table 2. Age structure of long tailed macaque group

Group	Group size (individuals)	Number of individuals Infant: juvenile: sub-adult: adult
Paliyan Wildlife Sanctuary		
1	68	12: 18: 24: 14
2	57	10: 14: 25: 8
3	48	9: 13: 15: 11
Kaliurang Forest		
1	36	6: 8: 14: 8
2	45	9: 13: 14: 11
3	30	5: 7: 11: 7
4	20	4: 6: 5: 5

In almost all groups, the highest number of individuals was found within the sub-adult age class and the lowest within the infant age class. These results were similar to those found in PT. Musi Hutan Persada Forest Concession (Priyono 1998). The weakness of a qualitative grouping is that time interval between age classes was not the same and that there would be accumulation of individuals in particular age class. Priyono (1998) states that this condition would result in the emergence of a declining population structure (regressive population). The development of population in such age structure would continue to decline if the environmental conditions stayed the same, which after some time, would result in the extinction of the population (Peres 2001).

To overcome the inequality of age interval of age class, a population structure was developed within the same age class by dividing the population into age-class intervals. This was done to obtain an increased age structure where the infant age class would be higher than other age classes (progressive populations). Figure 1 showed the graph for group size of each age class with its range of class.

Age structure can be used to measure the success of wildlife development and hence to assess its sustainability prospects. Figure 1 indicated sustainable populations of each group of long-tailed macaque in both Paliyan Wildlife Sanctuary and Kaliurang forest shown by the greater number of infants as compared to adults, thus possible future regeneration could occur properly.

Sex ratio is the ratio of males to females. Sex ratio of each group of long-tailed macaques in Paliyan Wildlife Sanctuary and Kaliurang forest were given in Table 3. In general, the long-tailed macaque groups in both Paliyan Wildlife Sanctuary and Kaliurang forest had a sex ratio of 1: 2 (Table 3), which was similar to research results by Sularso (2004) in Alas Purwo National Park and by Triprajawan (2007) in Pangandaran Forest Recreation Park.

Table 3 Sex ratio of each group of long-tailed macaque

Group	Number of males	Number of females	Sex ratio
Paliyan Wildlife Sanctuary			
1	18	38	1: 2.11
2	17	30	1: 1.76
3	14	25	1: 1.79
Kaliurang Forest			
1	11	19	1: 1.73
2	13	23	1: 1.77
3	9	16	1: 1.78
4	7	9	1: 1.29

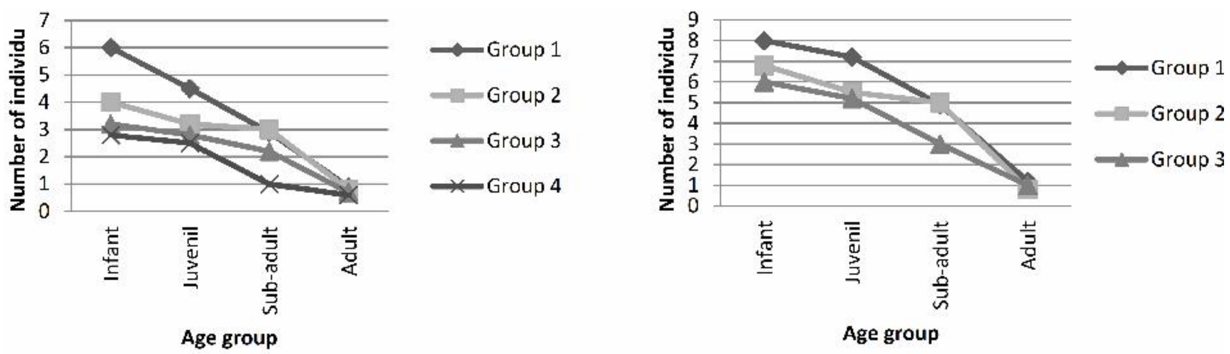

Figure 1. Age structure of long-tailed macaque group in (A) Paliyan Wildlife Sanctuary and (B) Kaliurang recreation forest

Natality and mortality

Natality is the ratio between the number of infants with the number of productive females in sub-adult and adult age classes. The natality of all groups in both study sites showed similar values, i.e., between 0.44-0.67. These suggested that on the average, half of the productive females were able to produce offspring under the assumption that the number of birth is 1 individual (Lavieren 1982).

Mortality or death rate is an important determinant of wildlife preservation. High mortality would threaten the wildlife sustainability. Estimation of population mortality rate of long-tailed macaques in the wild was based on the survival rate of each age class. The survival rate of each age class and birth rate of each long-tailed macaque groups in the study sites were tabulated in Table 4.

Table 4. Natality and survival rates of each long-tailed macaque's group

Group	Natality	Pxb_a	Pxa_m	Pxm_d
Paliyan Wildlife Sanctuary				
1.	0.44	0.90	0.67	0.24
2.	0.45	0.84	0.89	0.13
3.	0.56	0.87	0.58	0.31
Kaliurang Forest				
1.	0.43	0.80	0.87	0.24
2.	0.56	0.73	0.64	0.33
3.	0.45	0.84	0.79	0.27
4.	0.67	0.90	0.42	0.32

Note: Pxb_a: survival rate of infant to juvenile age class; Pxa_m: survival rate of juvenile to sub-adult age class; Pxm_d: survival rate of sub-adult to adult age class

The lowest survival rate was found in sub-adult and adult age classes. The assumption made was based on the presence of competitions for social status that caused the release of individual adult male resulting in fewer numbers of adult males. Meanwhile, infant deaths were usually caused by accidents or eaten by predators (Priyono 1998). However, in general, natural death of long-tailed macaque was very rare. Death was often caused by hunting, capturing to meet quotas and killing by local people as long-tailed macaques are considered as pests in some areas (Thoisy et al. 2000).

Population growth

The results of analysis using Powersim 2.0 on population growth showed that each long-tailed macaque group experienced an average increase of 20-30% annually. Group 1 in Paliyan Wildlife Sanctuary had an initial number of 68 individuals, and during year 1 increased to 89 and in year 2 to 108 individuals; group 2 initially had 57 individuals, then increased to 71 in year 1 and to 89 in year 2; group 3 with initial total individuals of 48 and increased to 72 in year 1 and to 69 in year 2. Analysis on population growth in Kaliurang forest resulted the following figures: group 1 with an initial total number of 36 individuals, increased to 44 in year 1 and to 53 in year 2; group 2 with an initial number of 45 individuals, increased to 57 in year 1 and 69 in years 2; group 3 started with 30 individuals, became 36 in year 1 and 44 in year 2; group 4 with starting number of 20, increased to 23 in year 1 and 29 in year 2.

Minimum Viable Population (MVP)

The results showed that the MVP values varied between each long-tailed macaque groups. The highest MVP was found in group 1 of Paliyan Wildlife Sanctuary with 86 individuals and the lowest was found in group 3 of Kaliurang forest with 37 individuals (Table 5) .

Table 5. The MVP values of each group of long-tailed macaque.

Group	Infant		Juvenile		Sub-adult		Adult		Total
	M	F	M	F	M	F	M	F	
Paliyan Wildlife Sanctuary									
1.	10	19	7	14	5	10	7	14	86
2.	7	14	9	17	3	5	6	12	73
3.	8	3	3	6	16	6	6	11	59
Kaliurang Forest									
1.	4	8	5	9	2	4	4	7	43
2.	5	10	4	8	4	8	5	10	54
3.	3	6	2	4	3	5	5	9	37
4.	6	6	4	4	5	5	9	9	48

Harvest quota

Analysis of both, population growth and MVP values suggested that MVP for each group should be obtained in year 1 so that harvesting could be done in year 2. The harvest quota itself was calculated for each age class and sex to avoid over-exploitation of certain sex and age class that could threaten group's sustainability. The value of the harvest quota was determined based on consideration of sex ratio, where a male can mate with more than 2 females, even up to 1:7 for the purpose of reproduction (Rowe 1996).

Results of this research showed that harvests for sub-adult age class were found greater in group 2 of Paliyan Wildlife Sanctuary, which comprised of 11 sub-adult males and 18 sub-adult females, while the lowest was found in group 4 of Kaliurang forest that comprised of only 2 sub-adult males and 1 sub-adult female. For infant age class, the largest harvesting quota was found in group 2 of Paliyan Wildlife Sanctuary and Kaliurang forest, while the largest harvesting quota for juvenile age class was found in group 3 of Paliyan Wildlife Sanctuary. On the other hand, the largest harvesting quota for adult age class was found in group 1 of Paliyan Wildlife Sanctuary. The average harvest quotas for the seven groups in year-2 comprised of 5 infant males, 3 infant females, 5 juvenile males, 4 juvenile females, 6 sub-adult males, 8 sub-adult females and 2 for adult males. The harvesting quotas for each age class and sex in each group studied were tabulated in Table 6.

Based on the calculation, for the next 11 year, harvesting quotas for each age class and sex would experienced annual increase with an average of 20% per year, as shown in Figure 2. This figure showed the increase in harvest quotas for female infant age class. The calculation was made based on population growth data without harvesting quota. With the increasing number of population, the harvest quota would also increase.

Table 6. Harvesting quotas for each long-tailed macaque group

Group	Infant		Juvenile		Sub-adult		Adult	
	M	F	M	F	M	F	M	F
Paliyan Wildlife Sanctuary								
1.								
Size	11	22	9	18	11	21	6	11
MVP	3	19	2	14	2	10	2	14
Quota	8	3	7	4	9	11	4	0
2.								
Size	10	19	6	12	12	23	3	5
MVP	2	14	3	17	1	5	2	12
Quota	7	5	3	0	11	18	1	0
3.								
Size	7	13	8	15	6	12	4	7
MVP	3	16	1	6	1	6	2	11
Quota	4	0	7	9	5	6	2	0
Kaliurang Forest								
1.								
Size	6	11	4	7	6	12	3	5
MVP	2	8	2	9	1	4	1	7
Quota	4	3	2	0	5	8	2	0
2.								
Size	8	16	6	12	6	12	4	7
MVP	2	10	2	8	2	8	2	10
Quota	6	6	4	4	4	4	2	0
3.								
Size	4	7	4	8	5	9	2	4
MVP	1	6	1	4	1	5	2	9
Quota	3	1	3	4	4	7	0	0
4.								
Size	4	8	6	11	3	6	2	3
MVP	1	6	1	4	1	5	2	9
Quota	3	2	5	7	2	1	0	0
Average	5	3	5	4	6	8	2	0

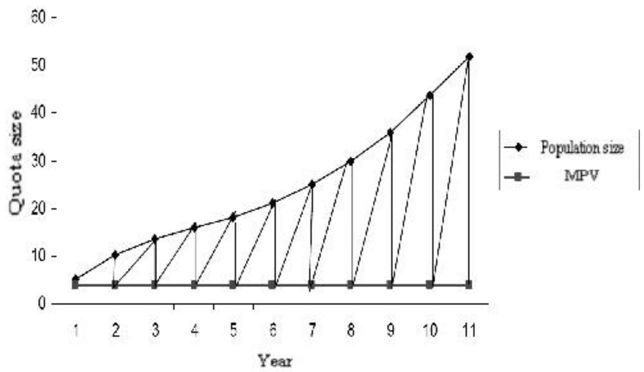

Figure 2. The size of harvest quota for infant females up to year-11

Harvesting is one of strategy in maintaining a natural balance. According to Bailey (1984), populations that are not harvested rarely showed increased in population, thus harvest increased the population growth.

Analysis of demographic variables determining quota

The survival rate and fecundity were analyzed using linear regression. The average value of survival rate was found to be 0.60, while the average fecundity was 0.16. Regression results showed that the dominant survival variable determining the harvest quotas was the equation Y = 0.0885 X + 0.7873, meaning that independent variables (X) significantly affected dependent variables (Y). This was indicated by the analysis of variance regression equation, which had a value of R2 = 0.8174, which signified that overall, all independent variables (X) were significantly affecting dependent variables (Y) and more than 81% of the quota frequency was described by the existing variables. Harvesting quota would increase with the increased value of survival rate.

Sensitivity analysis of dominant variables affecting quotas

Sensitivity analysis (Table 7) of survival probability showed that an increase and a decrease by 10% would affect the size of quotas, by an increase and decrease of ± 15%.

Table 7. Sensitivity analysis survival chance on quota.

No.	Scenarios	Average quota (individuals)
1	Early survival rate	26
2	Survival rate decreased by 10 %	22
3	Survival rate decreased by 20 %	19
4	Survival rate decreased by 30 %	16
5	Survival rate increased by 10 %	30
6	Survival rate increased by 20 %	35
7	Survival rate increased by 30 %	39

Table 7 signified that increasing survival rate would increase the harvest quotas. One effort to increase survival rate was through population management such as harvesting (Novaro et al. 2000) apart from habitat management through planting of dietary vegetation, cover and providing sufficient space. This will facilitate protection of primates and provide opportunities for improving the sustainable use of other forest species (Thoisy et al. 2005).

CONCLUSION AND RECOMENDATIONS

The size of harvesting quotas for each long-tailed macaque group varied depending on the survival rate and fecundity. The average harvest quotas for the seven groups studied in year 2 composed of 2 infant males, 3 infant females, 2 juvenile males, 4 juvenile females, 4 sub-adult males and 8 sub-adult females. The determinant dominant variable of the harvesting quota was survival rate.

As a scientific study, results of this research can be used for considerations in setting up quota in Indonesia, specifically within the Special Region of Yogyakarta. To balance the growth in demands for long-tailed macaques, it is necessary to establish intensive ex-situ breeding program to reduce the pressure of wild-caught animals.

REFERENCES

Bismark M. 1986. Habitat and behavioural studies of proboscis monkey in Kutai National Park , East Kalimantan. Buletin Penelitian Hutan 474: 67-79.

BKSDA Yogyakarta. 2002. Report on monitoring of potentials and problems of long-tailed macaque. Natural Resource Conservation Agency, D.I.Yogyakarta, Yogyakarta.

BKSDA Yogyakarta. 2007-2010. Statistical Report of Forestry in BKSDA Yogyakarta. Unit of Natural Resource Conservation D.I.Yogyakarta, Yogyakarta.

Blundell AG, Mascia MB. 2005. Discrepancies in reported levels of international wildlife trade. Conserv Biol 19: 2020-2025.

Chen TH, Chang HC, Lue KY. 2009. Unregulated trade in turtle shells for Chinese Traditional Medicine in East and Southeast Asia: the case of Taiwan. Chelonian Conserv Biol 8: 11-18.

Davies B. 2005. Black market: inside the endangered species trade in Asia. Earth Aware Editions, San Rafael, USA.

Ditjen PHKA. 2011. Harvesting quota of long-tailed macaque from natural habitat in 2006-2010. Ditjen PHKA-Ministry of Forestry, Jakarta.

Eudey AA. 2008. The crab-eating macaque (*Macaca fascicularis*): widespread and rapidly declining. Primate Conserv 23: 129-132.

Fallah M. 2005. Density and structure population of long-tailed macaque (*Macaca fascicularis*) in Plawangan Turgo recreation forest, Kaliurang recreation area. [Hon. Thesis]. Faculty of Forestry, Gadjah Mada University, Yogyakarta.

Giles BG, Truong SK, Do HH, Vincent ACJ. 2006. The catch and trade of seahorses in Vietnam. Biodiv Conserv 15: 2497-2513

Harcourt AH. 2002. Empirical estimates of minimum viable population sizes for primates;tens to tens of thousand? Anim Conserv 5: 237-244

Lavieren V. 1982. Management of conservation areas. School of Environmental Conservation Management. Ciawi, Bogor.

Lee RJ, Gorog AJ, Dwiyahreni A et al. 2005. Wildlife trade and implications for law enforcement in Indonesia: a case study from North Sulawesi. Biol Conserv 123: 477-488.

MacKinnon K. 1983. WHO Primate Resources Programme, feasibility study. Phase II. Bogor.

McNeely JA, Kapoor-Vijay P, Zhi L et al. 2009. Conservation biology in Asia: the major policy challenges. Conserv Biol 23: 805-810.

Napier JR, Napier PH. 1967. A handbook of living primates: morphology, ecology, and behaviour of non human primates. Academic Press, New York.

Nekaris KAI, Nijman V. 2007. CITES proposal highlights rarity of Asian nocturnal primates (Lorisidae: Nycticebus). Folia Primatol 78 (3): 211-214.

Nijman V, Shepherd CR. 2007. Trade in non-native, CITES-listed, wildlife in Asia, as exemplified by the trade in freshwater turtles and tortoises (Chelonidae) in Thailand. Contrib Zool 76 (3): 207-211. Novaro AJ, Redford KH.Bodmer RE.. 2000. Effects of hunting in source-sink systems in the Neotropics. Conserv Biol 14: 73-721.

Nijman V. 2006. In situ and ex-situ status of the Javan gibbon and the role of zoos in conservation of the species. Contrib Zool 75 (3-4): 161-168

Ningrum WNW. 2002. Behavioral Long Tailed Macaques (*Macaca fascicularis*) in. Recreation Forest of Kaliurang. [Hon. Thesis]. Faculty of Forestry, Gadjah Mada University, Yogyakarta.

Novaro AJ, Redford KH, Bodmer RE. 2000. Effect of hunting in source-sink systems in the neotropics. Conserv Biol 14: 713-721.

Peres CA. 2001. Synergetic effects of subsistence hunting and habitat fragmentation on Amazonian forest vertebrates. Conserv Biol 15: 1490-1505.

Priyono A. 1998. Determination of optimum population number of long-tailed macaque (*Macaca fascicularis* Raffles) in captivity with breeding system at natural habitat: Case study in PT. Musi Hutan Persada. [Thesis]. Graduate Program, Bogor Agricultural University, Bogor.

Raharjo A. 2009. Habitat selection by long-tailed macaque (*Macaca fascicularis*) in use zone Plawangan Turgo recreation forest, Kaliurang recreation area, Gunung Merapi National Park. [Hon. Thesis]. Faculty of Forestry, Gadjah Mada University, Yogyakarta.

Rowe N. 1996. The pictorial guide to living primates. Proc R Soc London. B 271: 1135-1141.

Santosa Y, Desi I. 2010. Policy evaluation for setting up quota for long-tailed macaque (*Macaca fascicularis*) in Indonesia. Media Konservasi Special edition 2010. Faculty of Forestry, Bogor Agricultural University, Bogor

Santosa Y. 1993. The final report of quantitative strategies for estimating some demographic parameters and population of wildlife harvesting quotas based approach of behavioural ecology: a case study of long-tailed macaque populations (*Macaca fascicularis*) on the island Tinjil. Faculty of Forest, Bogor Agricultural University, Bogor.

Santosa Y. 1996. Significant bio-ecological importance in long-tailed macaque (*Macaca fascicularis*) business. Media Konservasi 5 (1): 25-29.

Schlaepfer MA, Hoover C, Dodd CK. 2005. Challenges in evaluating the impact of the trade in amphibians and reptiles on wild populations. BioScience 55: 256-264

Shaffer M.L. 1981. Minimum population sizes for species conservation. BioScience 31: 131-134.

Shepherd CR, Nijman V. 2007a. An overview of the regulation of the freshwater turtle and tortoise pet trade in Jakarta, Indonesia. TRAFFIC Southeast Asia, Kuala Lumpur

Shepherd CR, Nijman V. 2007b. An assessment of wildlife trade at Mong La market on the Myanmar-China border. TRAFFIC Bull 21: 85-88

Sodhi NS, Koh LP, Brook BW, Ng PKL. 2004. Southeast Asian biodiversity: an impending disaster. Trends Ecol Evol 19: 654-660

Stoett P. 2002. The international regulation of trade in wildlife: institutional and normative considerations. Int Environ Agreem Pol Law Econ 2: 195-210

Sularso E. 2004. Population study of long-tailed macaque (*Macaca fascicularis*) and the constituent habitat vegetation structure at the Resort Rowobendo Alas Purwo National Park, Banyuwangi, East Java. [Hon. Thesis]. Faculty of Forestry, Gadjah Mada University, Yogyakarta.

Thoisy B. de, Francois R,Catherine J. 2005. Hunting in northern French Guiana and its impact on primate communities. Oryx 39 (2): 149-157.

Thoisy B. de, Massemin D, Dewynter M. 2000. Hunting impact on a neotropical primate community: a preliminary case study in French Guiana. Neotropical Primates 8: 141-144.

Triprajawan, T. 2007. Population size and Home Range of Long Tailed Macaques (*Macaca fascicularis*) in TWA Pangandaran, Ciamis District, West Java. [Hon. Thesis]. Faculty of Forestry, Gadjah Mada University, Yogyakarta.

Zhang L, Ning H, Sun S. 2008. Wildlife trade, consumption and conservation awareness in southwest China. Biodiv Conserv 17: 1493-1516.