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Primate Crop-raiding: A Study of Local Perceptions in Four Villages in North Sumatra, Indonesia

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Abstract: The main threat to the survival of primates in Sumatra is habitat destruction, but there is also an increasing problem of conflict with local people due to crop-raiding. This study characterizes the perceived impacts of primate crop-raiding in four villages in North Sumatra. Ninety-eight semi-structured interviews were conducted to collect data on (i) crop species, (ii) which vertebrates are thought to damage crops, (iii) the perceived extent to which each vertebrate species damages crops, and (iv) the preventive measures taken in the four villages. Farmers reported an average of 16 different crop species; 85.7% had rubber plantations. Crop-raiding by wildlife was reported by 94.9% of the interviewees as the single most important determinant of crop yields. Thirteen vertebrates were reported causing damage to cultivars; most important were squirrels, porcupines, pigs, deer, elephants and primates. However, primates were perceived as damaging crops differently from the other vertebrate species. Long-tailed macaques (*Macaca fascicularis*) and Thomas' leaf monkeys (*Presbytis thomasi*) were considered to be the most destructive crop-raiders in all locations. Contrary to what was expected, only a small proportion of farmers complained about the Sumatran orangutan (*Pongo abelii*). The interviewees reported twenty different crop protection techniques. Shouting was the most common.
Key words: Primates, crop-raiding, Sumatra, human-wildlife conflict

Introduction

The Sumatran landscape is currently dominated by agriculture with isolated patches of rainforest (Kinnaird *et al*. 2003). Oil palm is grown as a monoculture, and provides habitat for 20% or less of the previously resident animals (Laidlaw 1995; Heang and Boo Liat 1998). The remaining forest patches cannot support all the previously resident animals. As a result, primates, for example, are pushed nearer to human settlements and raid crops in farms (Brown and Jacobson 2005).

The province of North Sumatra used to be Indonesia's primary rubber-producing area, but in the 1990s most of the estates were converted to palm oil plantations (Gérard and Ruf 2001). The area covered by oil palm plantations in Indonesia is 3,107,986 ha, and the Indonesian government is planning to expand oil palm plantations by an additional 4 million ha in Sumatra (Brown and Jacobson 2005). Large-scale plantation activities are one of the main causes of the ongoing degradation of primate habitat and food resources, which in turn increases crop-raiding in smaller-scale agricultural plots of local farmers. Indonesian householders plant various species of trees, including durian (*Durio zibethinus*), cempedak (*Artocarpus integer*), jengkol (*Archidendron pauciflorum*), petai (*Parkia speciosa*) and mango (*Mangifera* spp.), as commercial and household crops along the perimeter of their cash crop plantations (rubber and oil palm). Primates eat these fruits, resulting in conflict between wildlife and farmers.

In tropical and subtropical regions, the extension of farming into the forest interior makes wild animals become farm pests, and the degree of tolerance of the damage caused changes over time (Knight 2001). Indeed, many farmers expect a certain amount of loss due to wildlife damage, but tolerance of this declines with the increasing use of pesticides and new technological inputs which promise preventability (Knight 2001). Previous research into human-wildlife conflict has tended to focus on either directly measuring the extent of the losses at sites where damage is occurring or interviewing the victims of the damage about their losses (Conover 2002). It is important to record absolute crop losses experienced at the individual, village and district levels because individual farming households can experience different crop losses even within the same village (Hill 2004). For instance, the distance between the farm and the forest boundaries and the number

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of neighboring farms are highly likely to affect vulnerability to crop-raiding by wildlife (Hill 2000). Additionally, farmers are not equally exposed to human-wildlife conflict situations; age, gender, farm location, ethnicity, cultural rules, crop assemblages, and the behavioral and ecological characteristics of wildlife can all influence vulnerability to crop damage by wildlife (Hill 2004). The extent and intensity of damage may also vary depending on the cropping patterns, wildlife population density and behavior, and food availability in wild habitats (Sekhar 1998). Crop losses to wildlife may have various impacts on farming households. They include high guarding investment, disruption of schooling for children who have to help guard fields, increased risk of injury from wildlife, and increased risk of contracting diseases such as malaria (Hill 2004). Crop-damage depends also on the species that are involved in this activity. Indeed, different species may specialize on different types of crop and different plant parts or development stages (Osborn and Hill 2005). Certain species may cause more damage than others. For instance, primates and elephants can have a significant impact on crop yields due to the extreme agility of many primate species and to the large size and nocturnal/crepuscular activity of elephants (Osborn and Hill 2005). Our knowledge and understanding of the issues surrounding human-primate conflict interactions is based predominantly on research completed at a number of African sites in, for example, Tanzania (Gillingham and Lee 2003), Uganda (Hill 2000, 2004; Naughton-Treves *et al*. 1998; Saj 2001), and Zanzibar (Siex and Struhsaker 1999). In Asia, crop depredation by wild animals has been studied in India (for example, Sekhar 1998; Rao *et al.* 2002; Chhangani and Mohnot 2004), in Indonesia (for example, Nyhus *et al*. 2003; Priston 2005), and in Nepal (for example, Chalise 2005). In India, crop damage is very common along the immediate periphery of wildlife sanctuaries and national parks (Chhangani and Mohnot 2004), as is the case at many other sites in Africa and Asia.

To date, comparatively little information has been published about crop raiding by primates in Indonesia, and information is largely limited to unpublished reports and anecdotes. In addition, the literature focuses on orangutans (*Pongo abelii*) and very little is known about conflicts involving other non-human primates. When their habitat is lost, orangutans stay within the area even to the extent of risking starvation (Singleton *et al.* 2002). Under such circumstances, this renders them even more likely to raid householders' gardens. Householders are reported to respond to crop-raiding by shooting the apes (I. Singleton pers. comm.). However, while conflicts between farmers and orangutans are being reported, there are no systematic records and no centralized database, so little verified information is available in order to examine exactly what is happening. This study provides baseline data on human-primate conflicts in areas where non-human primates, including orangutans, and farmers co-exist.

Methods

Study sites

The study took place in four locations in the Langkat district of Sumatra: Sampan Getek, Tangkahan, Bukit Lawang, and Telaga Said (see Fig. 1). The village of Sampan Getek is located at 3°43'35"N, 98°11'26"E. Singleton *et al.* (2002) identified eight orangutans in this area, which appears to be completely isolated from the forests of the Leuser Ecosystem. The area in which these animals roam is less than 1,000 ha

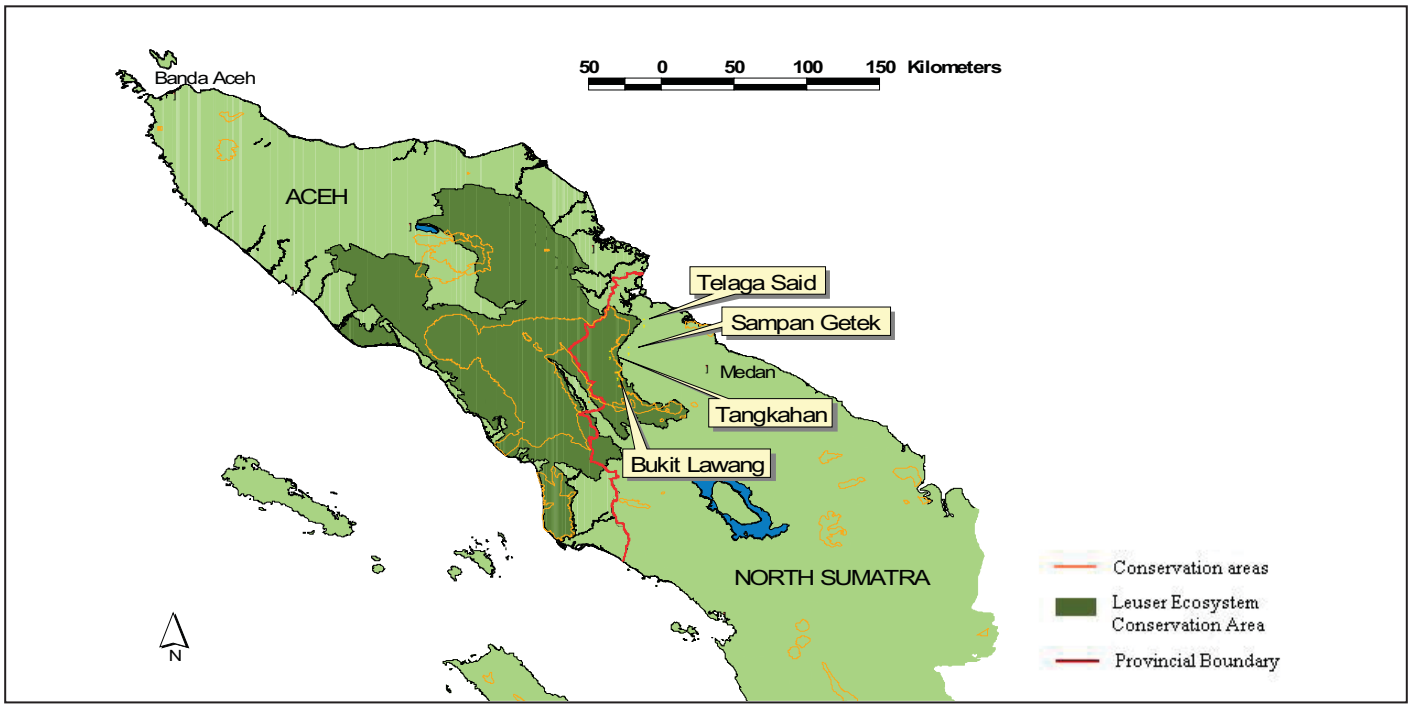


Figure 1. Location of the study sites in North Sumatra. Map by Ian Singleton©.

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and is surrounded by mature palm oil plantations. It is thought that the orangutans survive by 'hiding' in the more scrubby valleys, eating what fruits are available there and avoiding encounters with humans as much as they can (Singleton *et al*. 2002). Tangkahan is located in Padang Tualang sub-district, at 3°41'9"N, 98°4'31"E. The village is on the border of the Gunung Leuser National Park, but is otherwise surrounded by palm oil plantations. The village of Bukit Lawang is located in Bohorok sub-district, at 3°32'58"N, 98°7'33"E. Until 1995, Bukit Lawang was the site of an orangutan rehabilitation center that released ex-captive orangutans into the Gunung Leuser National Park. The center was closed in 1995, due mainly to new regulations governing species' reintroduction that disallowed the release of the orangutans into areas already containing existing wild populations (Orangutan Reintroduction and Protection Workshop 2001; IUCN/SSC Re-introduction Specialist Group 1995). In addition, the site has become a mass-tourism destination that is not compatible with a re-introduction programme. Nevertheless, semi-wild orangutans still live in the area surrounding the center and are fed on platforms twice a day in order to give tourists an opportunity to view them (Rijksen and Meijaard 1999). In this village householders consider that orangutan raids on gardens are particularly problematic. The village of Telaga Said is located at 3°37'47"N, 98°16'45"E; an area of about 1,000 ha surrounded by palm oil plantations and completely isolated from the forests of the Gunung Leuser National Park. Orangutan habitat in this location is restricted to about 10 ha, bordered by a river on one side and by palm oil plantations on the other. Conflicts between orangutans and farmers are reported in this village, especially during the durian fruiting season.

Data collection

Semi-structured interviews were used to investigate the farmers' perceptions of the crop-raiding issue. The framework for interviews was adapted from Gillingham and Lee (2003) (see Table 1). The interviews were conducted in Bahasa Indonesia with the help of a local translator. These semi-structured interviews were conducted with either the household head or the household head's wife. The local population was advised of the aims of the study, how the results would be used and who was funding it, following the Oxford Brookes University Code of Practice on Ethical Standards. Each interviewee was informed that sensitive information and personal characteristics would not be included in any reports or publications, against his/her wishes (Christensen 1992). Each interview took approximately 20–30 minutes to complete, and focused on farming strategies and experiences of crop-damage by vertebrates (following Hill 1997). Notes were taken during the interview, including information about the informant's manner, number of interruptions, and physical surroundings.

Study sample

Ninety-eight interviews were completed between 17 May and 24 June 2005. In each site, we conducted an average of eight interviews a day. We reviewed the daily interviews every evening. The reported age of respondents ranged from 18 to 113 years, with a mean of 41.9. Two thirds of the respondents were men. The majority originated from North Sumatran ethnic groups (62% of respondents were Karo and 6% were Melayu people), others were ethnically from the islands of Java (29%) or Borneo (3%). Sixty-seven percent identified themselves as Christian and 33% as Muslim. The majority of respondents (61%) reported that they had lived in the study site for more than 25 years (24% between 26 and 35 years and 37% for longer than 36 years).

Data analysis

The data collected from the interviews are presented as the percentage frequency of respondents giving each response in the case of multi-response questions. SPSS for Windows (version 11) was used to analyse all data. Weighted ranks

Table 1. Framework of the semi-structured interview.

The number of the interview, date, location (name of the village), time at which the interview was completed and the sex of the interviewee were first recorded. The interviewee was then asked the following questions:	
1.	How old are you?
2.	What is your ethnicity?
3.	What is your religion?
4.	How long have you been in this village?
5.	What is your position in the household?
6.	How far is your garden from your home?
7.	Which types of crops do you cultivate in your garden?
8.	Do you sell your harvest, or is it solely for household consumption?
9.	Does anything limit your crop yields? • Respondents who answered "yes" to this question were then asked: "Which of kind of problems limit crop yields in your gardens?" Respondents were asked to rank the problems in order of importance. • If respondents listed wild animals as one of the problems, they were asked "Which animals are problematic for you?" They were asked to rank the four species that cause the most damage in order of importance. • Respondents who reported primates as causing crop-damage were then asked: "When was the last time that a primate caused crop-damage to your garden?" and "Which species of primate did you see crop raiding in your garden?"
10.	Which methods do you use do protect your crops?
11.	Have you ever seen/heard someone shooting/trapping a crop raider? • Respondents who answered "yes" to this question were then asked: "Did this person kill the animal or injure it?"

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were calculated from the ranks farmers assigned to different wildlife species to indicate how species compared with each other with respect to the crop damage they caused. To calculate the weighted rank, each individual rank given by the interviewees was assigned a score: rank 1 = 1, rank 2 = 2, rank 3 = 3, and rank 4 = 4, and the formula below was used to calculate weighted rank for each species.

$$\text{Overall ranking} = \Sigma\,(\text{score} \times n)/N$$

n = number of respondents ranking the species
N = total number of respondents in the sample

The Kendall Coefficient of Concordance was used to assess degree of concordance in farmer rankings across the four village sites (Siegel and Castellan 1988).

Results

Only 21.4% of respondents had two gardens and 3.1% had three. Most smallholders (85.7%) reported they cultivated rubber; all the farmers interviewed in Telaga Said grew this crop (Table 2). Interviewees reported planting various species of trees at the margin of their cash crop plantations (rubber and oil palm). Durian trees were grown by the majority of interviewees (62.3%). In Tangkahan, the large majority of the farmers interviewed (85.7%) were growing this crop. Approximately half the interviewees cultivated cempedak, jengkol and petai (55.1%, 51.2% and 49.2%, respectively). Of the 30.6% of interviewees who reported they cultivated oil palm, the largest proportion (48.6%) was found in Tangkahan.

The number of different crops grown on each farm varied greatly (mean standard variation = 30.73; n = 98). The majority grown were sold in local markets, where people bought food mainly for their households (see Table 3). All the villagers interviewed were fully dependent on the proceeds of their gardens for their livelihood needs. The average area of rubber and oil palm fields was about 2 ha (1.9 ha and 2.2 ha, respectively; see Table 3). The annual incomes generated from the main cash crops (durian, rubber and oil palm) were very variable, depending on the quality of the production and the price at the local market. Nevertheless, the mean income generated by rubber plantations was reported to be about two times higher than the mean income from an oil palm plantation.

Most farmers (94.9%) reported that crop-raiding by wildlife was the single most important limit to their yields. Other reported constraints on agricultural productivity were insect pests and fungi. There is a small degree of variation in the farmers' ranking of crop raiding species across the 4 village sites but analysis using the Kendall Coefficient of Concordance indicates that there is a significant degree of concordance between farmer rankings of problem species across the four villages ($W = 0.556$, $N = 8$, $p < 0.05$). Locally, primates were considered more problematic than any other wildlife species; long-tailed macaques ranked first as the most severe crop-raiding species in terms of raid frequency and economic impact, and the next four were Thomas' leaf monkey, pig-tailed macaque, Griffith's silver langur, and orangutan, respectively (see Table 4). Thomas' leaf monkeys were reported damaging fruits of 11 crop species (see Table 5). They were also reported eating the flowers of durian and petai trees (53.1% and 37% responses, respectively). Long-tailed macaques were reported to cause damage to 14 crop species (Table 6). Even though they damaged fruits crops the most often, they also damaged flowers of petai, durian and banana trees. Sumatran orangutans were reported causing damage to only six species of fruit tree (Table 6); only a small proportion of respondents claimed that they damage banana, jengkol and mango trees.

Squirrels were indicated as the most destructive to the oil palm plantations, with 76% of oil palm growers reporting

Table 2. Distribution of the most common crop species in each study site (percentage of interviewees).

Crop species	Sampan Getek (n = 39)	Tangkahan (n = 35)	Bukit Lawang (n = 10)	Telaga Said (n = 14)	Mean (N = 98)
Rubber (*Hevea brasiliensis*)	84.6	80.1	90	100	85.7
Durian (*Durio zibethinus*)	48.8	85.7	60	42.9	62.3
Cempedak (*Artocarpus integer*)	66.7	34.4	50	85.8	55.1
Jengkol (*Archidendron pauciflorum*)	28.3	59.9	60	86.2	51.2
Petai (*Parkia speciosa*)	48.9	43.1	60	57.8	49.2
Mango (*Mangifera* spp.)	15.4	51.6	40	36.4	33.8
Oil palm (*Elaeis guineensis*)	23.1	48.6	10	21.4	30.6
Banana (*Musa* spp.)	12.8	34.3	30	36.1	25.6
Rambutan (*Nephelium lappaceum*)	10.2	34.3	10	64.1	26.5
Cocoa (*Theobroma cacao*)	10.2	31.5	10	0	16.3
Mangosteen (*Garcinia mangostana*)	5.2	2.9	20	14.4	11.3
Pineapple (*Ananas* spp.)	5.2	14.4	20	0	5.1
Maize (*Zea mays*)	2.5	5.6	0	0	3
Papaya (*Carica papaya*)	0	5.6	0	7.7	3

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Table 3. Area, number of trees grown and destination of the crops per species cultivated. The values in parentheses are the standard deviation.

			Destination of crops (% responses; N = 98)		
	Mean area (ha)	Mean number of trees	Household consumption	Sale	Both
Banana	N/A	18.4 (10.3)	12	60	28
Cempedak	N/A	19.5 (10.6)	16.4	78.2	5.5
Cocoa	N/A	128 (90.8)	0	100	0
Corn	0.06 (0.04)	N/A	0	100	0
Durian	N/A	15.2 (8.6)	7.8	89.1	3.1
Jengkol	N/A	10.1 (5.6)	5.9	84.3	9.8
Mango	N/A	4.3 (3.5)	41.7	41.7	16.7
Mangosteen	N/A	3.9 (2.6)	18.2	81.8	0
Oil palm	2.2 (0.8)	116.7 (63.1)	0	100	0
Papaya	N/A	6.3 (3.2)	33.3	33.3	33.3
Petai	N/A	5.9 (3.1)	10.9	89.1	0
Pineapple	N/A	131 (49.9)	0	100	0
Rambutan	N/A	6.5 (3.6)	19.2	65.4	15.4
Rubber	1.9 (1.1)	237.1 (144.9)	0	100	0

Table 4. Wildlife species reported to damage crops at each of the four villages. In **bold** are the percentages of farmers reporting crop-raiding of each species (per study site and the mean for the four study sites). The values in parentheses are the rankings of the farmers for each species reported to damage crops: the first value is the farmer's overall ranking of the crop raiders; numbers after the semi-colon are the weighted ranking scores of the various species. N/A = Not assessed.

	Villages in which farmers lived									
	Sampan Getek (n = 39)		Tangkahan (n = 35)		Bukit Lawang (n = 10)		Telaga Said (n = 14)		Mean (n = 98)	
Species										
Civet (*Viverricula* spp.)	**5%**		**18.5%**		**20%**		**0%**		**10.6%**	
Common long-tailed macaque (*Macaca fascicularis*)	**85%**	(1.64 ; 1)	**91%**	(1.31 ; 1)	**90%**	(1.43 ; 1)	**92%**	(1.27 ; 1)	**88.6%**	(1.46; 1)
Fruit bat (Pteropodidae)	**1.5%**		**4.5%**		**10%**		**8%**		**4.4%**	
Griffith's silver langur (*Trachypithecus villosus villosus*)*	**12%**	(2.60 ; 3)	**9%**	(3.33 ; 6)	**20%**	(3.50 ; 6)	**92%**	(2.60 ; 5)	**23.2%**	(2.65 ; 4)
Pig (*Sus scrofa*)	**26%**	(3.44 ; 7)	**48%**	(4.00 ; 8)	**0%**	(N/A ; 7)	**15%**	(2.00 ; 2)	**29.6%**	(3.25 ; 6)
Pig-tailed macaque (*Macaca nemestrina*)	**1.5%**	(N/A ; 8)	**42%**	(2.61 ; 3)	**80%**	(2.67 ; 4)	**42%**	(2.39 ;4)	**29.8%**	(2.48 ; 3)
Plantain squirrel (*Callosciurus notatus*)	**47%**	(2.81; 4)	**78%**	(2.72; 4)	**70%**	(2.67; 4)	**100%**	(3.77; 6)	**68.0%**	(3.77; 7)
Porcupine (*Hystrix brachyura*)	**12%**	(3.20 ; 6)	**18%**	(3.20 ; 5)	**0%**	(N/A ; 7)	**0%**	(N/A ; 8)	**11.2%**	(N/A ; 8)
Sumatran elephant (*Elephas maximus sumatrensis*)	**0**		**15%**		**0%**		**0%**		**5.3%**	
Sumatran orang-utan (*Pongo abelii*)	**58%**	(2.85; 5)	**49%**	(3.60; 7)	**80%**	(2.12; 2)	**21%**	(4.00; 7)	**51.7%**	(2.95; 5)
Sun bear (*Helarctos malayanus*)	**0%**		**11%**		**10%**		**0%**		**4.9%**	
Thomas' leaf monkey (*Presbytis thomasi*)	**81%**	(1.78; 2)	**85%**	(2.17; 2)	**90%**	(2.50; 3)	**92%**	(2.27; 3)	**84.9%**	(2.06; 2)

**sensu* Brandon-Jones et al. (2004)

Table 5. Damage caused by the Thomas' leaf monkey and the Griffith's silver langur to each fruit tree species.

	Thomas' leaf monkey				Griffith's silver langur			
	No damage	Fruits	Fruits+ flowers	Fruits+ flowers+ leaves	No damage	Fruits	Fruits+ flowers	Fruits+ flowers+ leaves
Banana (N=25)	20	72	4	4	72	28	0	0
Cempedak (N=55)	27.3	69.1	0	3.6	78.2	21.8	0	0
Cocoa (N=17)	88.2	11.8	0	0	100	0	0	0
Corn (N=3)	66.7	33.3	0	0	66.7	33.3	0	0
Durian (N=64)	32.8	7.8	53.1	6.3	90.6	1.6	7.8	0
Jengkol (N=51)	37.3	54.9	2	5.9	78.4	19.6	0	2
Mango (N=36)	47.2	44.4	2.8	5.6	88.9	8.3	0	2.8
Mangosteen (N=11)	72.7	27.3	0	0	90.9	9.1	0	0
Papaya (N=3)	66.7	33.3	0	0	66.7	33.3	0	0
Petai (N=46)	30.4	26.1	37	6.5	78.3	13	8.7	0
Pineapple (N=5)	100	0	0	0	100	0	0	0
Rambutan (N=26)	38.5	57.7	0	3.8	76.9	23.1	0	0

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that they attacked the fruits. Almost 45% of crop growers reported that long-tailed macaques raided the fruits. Pigs, porcupines and elephants were reported damaging the roots of the oil palm trees. About 64% of rubber growers claimed that Thomas' leaf monkeys damaged the leaves. According to 8.3% of the growers, orangutans were responsible for damage to the bark of the rubber trees.

Most tree crops are reported to be most vulnerable to damage by wildlife during their annual fruiting season (for example, durian, mango, cempedak; see Table 7). However, some crops (rubber, oil palm, banana, cocoa, coconut, papaya, pineapple) were reportedly damaged throughout the year. All farmers said that primates and squirrels were diurnal crop raiders. The other vertebrates (pigs, porcupines and elephants) were nocturnal crop raiders.

Seventeen crop protection techniques were reported being used to respond to crop-raiding by wildlife (see Table 8). About half of the farmers interviewed reported that they shouted to prevent crop raiding. Shouting was the most commonly used protection in Sampan Getek, Tangkahan and Bukit Lawang (respectively 41%, 66% and 50%). In Telaga Said, the percentage of farmers using guns to injure or kill wildlife was higher than in the other villages (57.1% in Telaga Said, 2.6% in Sampan Getek, 8.6% in Tangkahan and 10% in Bukit Lawang).

Thirty-nine percent of interviewees claimed that they had never done any harm to a primate, and that they had never seen others doing so either (Table 9). More interviewees reported the occurrence of farmers killing primates in Telaga Said than in other locations, and they were mostly long-tailed macaques.

Discussion

Crop losses due to excess rainfall or lack of fertilizer and pesticide, though a common claim in developing countries (Rao *et al*. 2002), were not mentioned by the farmers interviewed. The survey data presented here revealed that villagers consider wildlife crop-damage as the most significant limitation to their agricultural production. Some fruit trees were reported damaged every month (for example, banana and papaya trees) because they have no definite fruiting season (Soemarwoto *et al*. 1985). However, most cultivated fruit tree species (cempedak, jengkol, durian and petai trees) were reported to be most vulnerable during the peak of fruiting (May to August). As a result, it is highly likely that conflicts were exacerbated during those four months. Data collection occurred during this time, and the probability that the incidence of crop-raiding was just then particularly high may have influenced the perceptions and responses of the interviewees. Damage to the two main cash crops (oil palm and rubber) was reported to be a problem year round; a situation which makes the control of damage by wildlife on those two species even more difficult.

Fruits were the plant parts most often reported damaged by primates. However, although primates caused damage to the fruits and leaves of rubber trees, farmers did not perceive this as a problem because it does not affect latex production, which is all they exploit. Squirrels raid fruits of all the crop species, but according to the interviewees, squirrels are less of a problem because they eat much less than the primates. A similar situation was reported from Uganda by Saj *et al*. (2001). Another important aspect that may influence people's perceptions is the size of the animal. Bell (1984), for example, found that larger animals attracted greater attention from the farmers because farmers assume that small animals eat fewer fruits and therefore cause less damage than do the larger species. Small species, however, usually have a larger population (for example, insect pests) and consequently can cause significant damage when they raid gardens.

Damage to oil palm fruits was mainly attributed to squirrels and long-tailed macaques. Only a small proportion of oil palm growers complained about the other primate species; a situation which is surprising when compared with the oil palm raiding issue in Malaysia. Indeed, orangutan raids in oil palm plantations are commonplace in the lower Kinabatagan, Malaysia (Brown and Jacobson 2005). Nevertheless, it seems that orangutans do not like oil palm fruits and they raid plantations only when there is little alternative (M. Ancrenaz pers. comm. 2005). In Sabah, there are a number of places where

Table 6. Damage caused by the long-tailed macaque, the pig-tailed macaque and the Sumatran orangutan to each fruit tree species.

	Long-tailed macaque			Pig-tailed macaque			Sumatran orangutan				
Crop species	No damage	Fruits	Fruits+ flowers	No damage	Fruits	Fruits+ flowers	No damage	Fruits	Bark	Fruits+ bark	Nest
Banana (n = 25)	28	64	8	84	16	0	92	8	0	0	0
Cempedak (n = 55)	25.5	74.5	0	85.5	14.5	0	67.3	16.4	7.3	9.1	0
Cocoa (n = 17)	52.9	47.1	0	94.1	5.9	0	100	0	0	0	0
Corn (n = 3)	0	100	0	66.7	33.3	0	100	0	0	0	0
Durian (n = 64)	34.4	53.1	9.4	81.3	17.2	1.6	39.1	34.4	0	10.9	15.6
Jengkol (n = 51)	21.6	78.4	0	78.4	21.6	0	84.3	9.8	2	3.9	0
Mango (n = 36)	22.2	77.8	0	83.3	16.7	0	97.2	2.8	0	0	0
Mangosteen (n = 11)	27.3	72.7	0	72.7	27.3	0	100	0	0	0	0
Papaya (n = 3)	33.3	66.7	0	0	100	0	100	0	0	0	0
Petai (n = 46)	32.6	52.2	15.2	80.4	17.4	2.2	69.6	30.4	0	0	0
Pineapple (n = 5)	40	60	0	80	20	0	100	0	0	0	0

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small forest patches have been surrounded by oil palms and then further encroached upon. Any orangutans remaining in these isolated patches are often crowded together and forced to eat oil palms to survive. In Sumatra to date, there are few or no reports of orangutans eating palm oil, although that is not to say that they never do, nor that it will not happen in the future as more and more of their forest is lost (I. Singleton pers. comm. 2005). Damage to the bark caused by pigs, porcupines and elephants does not have a direct impact on the oil palm fruit harvests, but if severe it may kill the palm. These three nocturnal species (pig, porcupine, elephant) should also, therefore, be considered as of some threat to oil palms.

Table 7. Months when crops are the most vulnerable.

Crop species	Month
Banana	Every month (depending on when the tree was planted)
Cempedak	May–August
Cocoa	Every month
Coconut	Every month
Corn	Depends on when the tree was planted
Durian	July–August
Jengkol	February, June–July
Kemiri	February
Lemon	March, May, September
Mango	April–May
Mangosteen	July–August
Oil palm	Every month
Orange	March, June, December
Papaya	Every month
Petai	February, June–July
Pineapple	Every month
Rambutan	August, October
Rubber	Every month

The long-tailed macaque was considered to be the most destructive crop-raiding species in all the four villages. It was reported raiding fruits of all crop species grown. The reasons why it is such a successful pest are probably its omnivorous diet and its behavioral adaptability to changing habitat (Aldrich-Blake 1980; Altmann and Muruthi 1988).

Thomas' leaf monkey was most often perceived as the second most destructive crop-raiding species. It was reported to damage fruits at all stages of maturation, and also flowers and leaves, and is therefore believed to damage crops year round. A small number of farmers complained about the Sumatran orangutan, citing especially damage to cempedak, durian and petai yields. Contrary to what we expected, less than half of the durian growers reported damage to their crops from orangutans. They did complain, however, that the damage was always considerable because of the orangutan's large size.

Active deterrence methods to guard crops against diurnal crop-raiding species were used by a majority of the farmers. Guarding oil palm and rubber plantations by night would perhaps contribute to the reduction in the damage caused by pigs, porcupines, deer and elephants. However, guarding fields results in increased risks of being injured by wild animals or contracting malaria (Hill 2004), and is very time consuming. Alternatively farmers can cooperate in a system of rotating "guard duty" (Osborn and Parker 2003), which would help reduce costs to individuals. In the longer term, conserving large blocks of forest and reducing forest-edge habitat should be a management priority (Naughton-Treves *et al*. 1998). Unfortunately, current trends in encroachment and fragmentation tend to make forest boundaries much longer than would be preferable. In Tangkahan, where some farmers own fields along the edge of the Gunung Leuser National Park, the

Table 8. Percentage of farmers reporting which method they use to prevent crop damage.

Animal species targeted by the protection method	Protection methods	Sampan Getek (n=39)	Tangkahan (n=35)	Bukit Lawang (n=10)	Telaga Said (n=14)	Mean (n=98)
	Passive deterrence methods					
Primate	▪ Using scarecrow	7.7	2.9	0	14.2	5.6
Primate	▪ Making fires	7.7	5.7	0	0	5.1
Orangutan	▪ Putting metal around trees	2.6	5.7	20	0	5.1
Primate; squirrel	▪ Suspending cans	2.6	5.7	0	0	3.1
Primate; civet cat	▪ Hiding fruits	5.1	2.9	0	0	3
Porcupine	▪ Spreading tar on the bark	2.6	2.9	0	0	2.1
Porcupine	▪ Spreading sulphur around trees	0	0	0	7.1	1
Pig; deer; elephant	▪ Fencing	7.7	0	0	0	3.1
Primate	▪ Cutting neighbouring trees	0	0	10	0	1
	Active deterrence methods that do not cause harm to wildlife					
Primate	▪ Guarding	10.3	5.7	0	0	6.1
Primate	▪ Shouting	41	65.7	50	14.3	46.9
Primate; squirrel	▪ Throwing stones/ wood	39.5	25.7	30	21.4	31
Primate	▪ Using guns as warning	15.4	11.4	20	7.1	13.2
	Active deterrence methods that can injure/kill wildlife					
Primate	▪ Chasing with dogs	7.7	37.1	0	14.3	18.4
Primate	▪ Shooting	2.6	8.6	10	57.1	13.3
Primate	▪ Trapping	2.6	2.9	0	14.2	4.1

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Table 9. Percentage of interviewees reporting the occurrence of farmers harming primates at each study site (* LTM = long-tailed macaque; PTM = pig-tailed macaque; TLM = Thomas' leaf monkey; GSL = Griffith's silver langur; OU = orangutan).

	Sampan Getek (n = 39)	Tangkahan (n = 35)	Bukit Lawang (n = 10)	Telaga Said (n = 14)	Mean (n = 98)
Never seen/done anything	71.8	28.3	4	0	39.1
Saw someone killing a LTM* to eat it	5.1	11.2	0	0	6.0
Saw someone killing a TLM* to eat it	0	5.7	0	14.3	4.1
Saw someone killing a LTM* and discarding the carcass	2.6	2.9	0	0	2.1
Saw someone injuring a LTM*	2.6	5.7	0	0	3.1
Saw someone catching a LTM* to keep it as pet	8.1	14.3	1	0	8.4
Saw someone catching a TLM* to keep it as pet	2.6	5.7	0	0	3.1
Saw someone catching a PTM* to keep it as pet	2.6	0	0	0	1.0
Saw someone catching an OU* to keep it as pet	2.6	2.9	0	0	2.1
Killed a LTM* and discarded the carcass	0	0	0	35.8	5.1
Killed a TLM* and discarded the carcass	0	0	1	14.3	2.1
Killed a GSL* and discarded the carcass	0	0	0	21.4	3.1
Killed an OU* and discarded the carcass	0	0	1	0	0.1
Injured an OU*	0	2.9	1	7.1	2.1
Caught a LTM* and kept it as a pet	0	8.9	0	7.1	4.2

creation of a non-agricultural buffer zone might not be possible. Consequently, a monoculture of unattractive crops (for example tea or coffee; Naughton-Treves *et al*. 1998) might act as a buffer to discourage primate crop-raiding. Alternative buffer crops could also be medicinal plants not raided by wildlife (Rao *et al*. 2002). Deliberate preservation of wild food species (for example *Ficus* spp.) could also reduce primate crop-raiding in some seasons (Naughton-Treves *et al*. 1998). In all circumstances, highly palatable crops should not be cultivated on the edge of primate habitat (Naughton-Treves *et al*. 1998). However, some crop species (for example, rambutan, cempedak and cocoa) thrive in conditions that mimic their natural habitat, i.e., in the cool and shady understorey of the rainforest (Cobley 1976; Rice *et al*. 1991). Young durian trees also must be shaded. Yaacob and Subhadrabadhu (1995) recommended (i) inter-planting durian trees with banana or papaya trees to provide shade and (ii) not cultivating durian in the forest.

Many farmers considered that shooting or trapping primates was the most successful preventative measure, although shooting them was not the most commonly reported method used except in Telaga Said. Islam forbids the consumption of primate meat, but Muslim farmers in Telaga Said reported killing primates and then either discarding the carcass or giving it to Christian neighbours. The small number of farmers using guns in Tangkahan and Bukit Lawang may be attributed to the proximity of the Gunung Leuser National Park and the presence of wildlife tourism facilities. In Tangkahan, the village community agreed in 2001 to turn the site into an environmentally-oriented tourist destination (Jakarta Post 2003). The Gunung Leuser National Park Office entrusted local people in a small concession area within the Park with the management of ecotourism, and local youths were trained as tourist guides (Jakarta Post 2003). The direct involvement of the local community in ecotourism may prevent the use of guns as a protection method at this particular site. In Sampan Getek, surveys of orangutans have been done since late 2001 (Singleton *et al*. 2002a), and it is possible that the occasional presence of biologists and conservationists in this area might be preventing the use of guns as a preventative measure against primates. The figures presented here about primate shooting are probably not, however, a true picture of the exact frequency of gun use. Interviewees may have considered that confessing to using guns would get them into trouble because they were aware that some primates are officially protected.

The large proportion of interviewees reporting they had never harmed or seen another individual harming primates may reflect a fear of being punished for such acts. Consequently it is very possible that farmers under-reported the incidence of using lethal methods to deter wildlife from damaging their crops. Only a small proportion of farmers complained about the Sumatran orang-utan, but conservationists should be vigilant. Given the Critically Endangered status of the Sumatran orangutan, one might suggest relocating problem animals. However, this procedure is very expensive and risky, and is not guaranteed to be successful (Singleton *et al*. 2002a). We suggest that orangutans should be removed only in extreme cases, after detailed study, and only if suitable alternative habitat is available elsewhere. However, it is important to be aware that eradication of all crop-raiding primates from an area, though perceived by farmers as the most effective protection method, is usually only a short-term solution, as other primate groups may quickly invade the newly available home range (Strum 1987; Osborn and Hill 2005).

Conclusion

Wild vertebrates, and especially primates, were believed to inflict substantial losses on crops in the four villages surveyed. The perceived impacts of primate crop-damage on local people are of great importance for conservationists, because if local people attach a negative value to wildlife they will not support its continued existence in the region (Gillingham and Lee 2003; Hill 2004). Primates are considered

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to be particularly successful crop-raiders because they can cross fences with ease (Newmark *et al*. 1994; Hill 2002) and often wait for the farmers to leave before raiding their gardens (Kavanagh 1980). As a result, farmers may be only marginally successful in preventing their crop-damage (Saj *et al*. 2001). An immediate concern, therefore, is the development of effective, non-lethal, humane methods to mitigate human-primate conflict.

The study presented here provides a snapshot of the primate crop-raiding issue in four villages of North Sumatra. More extensive fieldwork is needed to examine more fully some of the issues we have outlined, and could contribute to the creation of a centralized database on the human-wildlife conflict issue in North Sumatra. There is a need for further studies to cover a much larger area. Successful measures to protect primates using agricultural areas in Indonesia will be a central issue as increasing amounts of the remaining natural forests are put under cultivation. Lowland wildlife species are likely to be even more at risk than other animals because they live on the edge of the remaining forest; exactly where local people live.

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