THE RAFFLES BULLETIN OF ZOOLOGY 2004 **52**(1): 271-280

CONSERVATION OF THE JAVAN GIBBON *HYLOBATES MOLOCH*: POPULATION ESTIMATES, LOCAL EXTINCTIONS, AND CONSERVATION PRIORITIES

Vincent Nijman
Institute for Biodiversity and Ecosystem Dynamics, Zoological Museum, University of Amsterdam, P.O. Box 94766, 1090 GT Amsterdam, The Netherlands
Email: nijman@science.uva.nl

ABSTRACT. – The Javan gibbon is one of the rarest species of gibbons, restricted as it is to the western half of the densely populated island of Java, Indonesia. Based on a study from 1994-2002 it was found that the Javan gibbon has a larger distribution range than previously assumed. It is not restricted to the forests of the province of West Java and significant populations occur in the central part of the island. To establish the presence of gibbons in an area focused research is needed and in the past certain populations were missed in rapid presence-absence surveys. Javan gibbons occur at population densities of c. 2.6 groups km^{-2} (8-9 individuals km^{-2}) in lowland and hill forest <1000 m asl and less than one group km^{-2} (1.5 individuals km^{-2}) in montane forest between 1000-1750 m asl. Based on the extent of remaining habitat in 15 of the largest populations of Javan gibbons, a conservative density estimate of one group km^{-2}, and exclusion of floaters (sub-adults that have not yet established a territory), it is estimated that some 4000-4500 Javan gibbons remain in the wild. This conservative estimate is considerable higher than assumed by conservation authorities. Given that large-scale deforestation on Java (the main threat to the survival of the species) dates back more than a century and has slowed down over the last decades, this suggests that the present IUCN status of Critically Endangered seems untenable. Following IUCN guidelines the species should therefore be down-listed to Endangered. As still considerable populations remain in unprotected areas of natural forest it is argued that, in order to effectively protect the species and in an attempt to increase its survival prospects, increased protection of these forest areas is the key to the survival of the species. It is recommended not to resort to expensive and intrusive captive-breeding programmes and reintroduction initiatives as this will inevitably divert the attention away from in-situ conservation. Any programme that costs a great deal of money over the years will inevitably seek to portray itself as necessary and relevant, and if caution is needed it is in the evaluation of current management options, based on the best possible information irrespective of previous investments.

KEY WORDS. – census methods, Hylobatidae, Indonesia, Java, primate, Silvery gibbon, trade.

INTRODUCTION

The island of Java, Indonesia's political and industrial centre, is one of the most densely populated areas in the world. The very fertile soils which lend themselves to terracing for irrigated rice, sustain about 121 million inhabitants, at an average population density of 914 people km^{-2} (data from 2000: BPS, 2004). Java is largely deforested and most of the remaining forest fragments cover (parts of) the numerous volcanoes on the island. The remainder is essentially a mosaic of rice fields, cities and villages.

Java has a long history of cultivation and deforestation that already started ca. 1000 AD, but really took off in 1830 when the Dutch colonial government imposed the so-called 'cultuurstelsel'. To support this agro-economic system, farmers were forced to grow export crops on communal grounds, which was often forest (Whitten et al., 1996). By the end of the 19th century the natural forest was severely fragmented, and at the beginning of the last century the remaining forest, especially in West and Central Java, showed a fragmentation pattern very similar to that seen today. At present, less than 10% of the original forest remains, including 54% of the montane forest (>1000 m asl), 19% of the hill forest (500-1000 m asl), and only 2% of the lowland forest (<500 m asl); over the last few decades, the decrease in forest area has been slow (Smiet, 1990).

In the remaining forest patches in the western part of the island, one of Indonesia's rarest primate remains, the Javan or silvery gibbon *Hylobates moloch*. It is confined to floristically rich patches of relatively undisturbed lowland to lower montane rain forest mostly below 1600 m asl (Kappeler, 1981) but occasionally up to 2000-2400 m asl (Docters van Leeuwen, 1926; R. Sözer, pers. comm.). Most populations can be found in the western province (Kappeler, 1984), but a few remain in Central Java (Nijman, 1995; Nijman & Sözer, 1995).

Population estimates of this species differ greatly. Chivers (1977) firstly attempted to assess the population size of the species. Based on outdated vegetation maps he calculated that some 20000 gibbons may remain noting however that '... we would be advised to apply the formula that [ ] gibbons may occur] in only one-third of the total forest area' (Chivers, 1977: 574). This then would suggest a population of some 7000 gibbons on Java, although in the same paper, Chivers (1977: 586), stated that the species seems to be represented by hundreds of animals rather than the thousands estimated from figures of available forest. In 1978, Kappeler (1981) carried out a two-month survey visiting a large number of forest areas in West and Central Java and, extrapolating on the basis of the geographic area inhabited and density at different altitudinal zones, estimated the total population between 2400 and 7900 animals. MacKinnon (1986a, b) estimated the total remaining population at 4824 animals. Asquith et al. (1995) re-surveyed most of the forest patches where Kappeler (1984) reported their presence, and, again on the basis of geographic area inhabited and density at different altitudinal zones, estimated the total population at some 2700 animals (Asquith et al., 1995: 4). In their estimate, Asquith et al. (1995) did not include thirteen areas with an estimated population of less than 100 individuals each or areas that were highly disturbed. Including those areas, the total population was estimated at some 3000 individuals (Asquith et al., 1995: 4). More recently, Supriatna & Wahyono (2000) estimated that some 2000-4000 gibbons remained in the wild.

Whereas the estimates mentioned above all are in the same order of magnitude, a Population Habitat Viability Analysis (Supriatna et al., 1994) came to very different conclusions. On the basis of the number of individuals actually observed in a few areas, the total population was estimated at 386 individuals. An estimate of the total population of Javan gibbons based on a comparable methodology as those used by Kappeler (1984) and Asquith et al. (1995) gave a number of 1957 individuals, but this number was considered 'too large to be realistic as the method implied complete habitat saturation [sic], which was not substantiated by field observations…' (Supriatna et al., 1994: 2). Consensually, it was decided that the lower estimate of about 400 gibbons approximated the real status of the wild Java gibbons (Supriatna et al., 1994; Ellis, 1996/1997). I assume that the inferred decline of 2400-7900 gibbons in 1978 to 400 gibbons in 1994 was the main reason for altering the species conservation status from Endangered to Critically Endangered (Eudey, 1996/1997; IUCN, 2001).

During 1994-2002, as part of a study on the conservation and ecology of endemic primates of Java, I found significant populations of Javan gibbons in areas outside the assumed range of the species, and gibbons were found present in areas from where they had been reported to have recently become extinct. It was found that census methods used by previous researchers to establish whether or not gibbons are present in an area did not take into account the behavioural changes that occur as a result of disturbance, and that some of the assumptions on which previous estimates were based were invalid. Thus, the aim of the present paper is to present new data on the geographical distribution, population densities and population numbers of the Javan gibbon, and to critically review the evidence for the assumed critically endangered status of the species.

METHODS

***Survey data.* –** Between 1994 and 2002, Javan gibbons were studied in Gede-Pangrango National Park and surroundings in West Java and in the Dieng mountains in Central Java. Additionally, I surveyed numerous forest areas in West, Central and East Java, with a total survey effort of some 340 days inside forest areas. Gibbons are territorial and live in monogamous family groups consisting of an adult pair with none to four offspring. Gibbons are completely arboreal. Paired groups give loud morning calls which can be heard over several kilometres (Dahlmann & Geissmann, 2001; Nijman, 2001b).

Gibbons can be difficult to observe in the dense rain forest, and during surveys their presence is normally established by listening for their songs. The presence of gibbons was established by fixed-point counts, i.e. listening for their far-carrying songs from vantage-points above the forest, and by transect walks in the forest. Additional affirmative information was requested from officers of the local wildlife department (PHKA, KSDA), the forestry service (Perum Perhutani), and local villagers.

***Testing survey methodologies.* –** Behavioural changes in Javan gibbons brought about due to habitat disturbance and its effect on density estimation was studied by collecting data in disturbed and undisturbed forest areas (Nijman, 2001a). Undisturbed and disturbed study sites were selected either in close proximity and were similar in climate, original vegetation type, altitude and topography (Gede-Pangrango), or a forest area was sampled before (1995-1998) and during logging (1999) during the same months of the year (Dieng mountains). Given the close proximity and similarity of the forest areas, it is anticipated that the behaviour of the gibbons prior to the commencement of disturbance did not differ significantly. In order to explore the relation between gibbon density, calling frequency and likelihood of recording the presence of gibbons in an area, data were collected on the calling behaviour in a low-density (Telaga Warna Nature Reserve and surroundings, Sept. 1999) and a high-density (Linggo Asri, Dieng mountains, Sept. 1998) population. For both areas, the number of female call bouts heard after sunrise over an 11-day period was recorded. In Javan gibbons female calls are almost exclusively emitted after sunrise and make up >90% of the calls heard during day-time; male calling is rare (Geissmann & Nijman, 1999, 2001).

RESULTS

***Geographical distribution.* –** Limited effort has been put in accurately assessing the distribution of the Javan gibbon. Kappeler (1984) found the species to be present in 22 areas;

Table 1. Densities of Javan gibbons as obtained by various techniques.

Technique	Area	Altitude	Density [a]		Source[b]
			Groups km^{-2}	Individuals km^{-2}	
Range mapping	Ujung Kulon	0-50	6.3	22	1
	Ujung Kulon	50-185	1.9	8.2	2
	Ujung Kulon	15-30	2.3	10.7	2
	Mt Gede	1080	[0.5]	1.6	3
Line transects	Ujung Kulon	0-100	[2.7]	9	1
	Ujung Kulon	0-100	2.9	8.3	4
	Mts Halimun	600-1200	5.6	9.9	5
	Mts Halimun	1200-1750	0.8	1.5	5
	Mts Halimun	700-1075	2.6	[8.9]	6
Fixed-point counts	11 lowland sites	0-500	[1.2-3.9]	4-13	1
	9 hill sites	500-1000	[0.6-2.1]	2-7	1
	8 montane sites	1000-1500	[0.3-0.9]	1-3	1
	Mts Halimun	700-1075	2.5	[8.3]	6
	Mt. Pangrango	900-1050	4.2	[13.8]	7
	Telaga Warna	1300-1400	1.1-2.1	[3.3-6.3]	8
	Mts Dieng	300-1300	0.9-1.1	[3.0-3.6]	9
	Mts Dieng	450-650	1.9-3.7	6.7-13.1	10

[a] Number between brackets are derived from the adjacent estimate, assuming an average group size of 3.3 individuals (Kappeler, 1981).
[b] 1. Kappeler, 1981; 2. Rinaldi, 1999; 3. Suranto, 1994; 4. Gurmaya et al., 1995; 5. Sugarjito et al., 1997; 6. Kool, 1992; 7. V. Nijman, unpubl. data; 8. present study; 9. Nijman & van Balen, 1998; 10. Geissmann & Nijman, 2001.

i.e. 20 in the West Javan province and two in the Central Javan province. Asquith et al. (1995) recorded the species in 14 of 21 areas where Kappeler reported the species to be present (one area in Central Java was not re-surveyed), and additionally found it to be present in three areas where Kappeler reported gibbons to be absent or where he did not survey. Andayani et al. (2001) reported the possible presence of Javan gibbons on Mt Sawal and Mt Ciremai, both situated in the eastern part of West Java.

During the present study, Javan gibbons were found to be additionally present in one small forest area in West Java (Takokak) and in three significantly-large forest areas, viz. the southern slopes of Mt Segara (Pembarisan mountains), the southern slopes of Mt Slamet and the Dieng mountains, all in Central Java. Smaller and isolated populations in Central Java occur on three adjacent forests, i.e. Mt Lawet (Kappeler, 1984), Mt Cupu-Simembut (M. Linsley, pers. comm.) and Mt Jaran (pers. observ.). Fig 1 gives the current distribution of the Javan gibbon.

Population densities. **–** The three most commonly used methods of estimating gibbon densities in tropical rain forests are range mapping, line-transects and fixed-point counts (Brockelman & Srikosamatara, 1993; Nijman & Menken, in press). Table 1 lists reported densities of Javan gibbons as obtained by various techniques. Taking into account the effect of altitude, we can conclude that these densities generally vary little between different studies, with the exception of Kappeler's (1981) range mapping estimate for Ujung Kulon. The highest densities originate from the range-mapping method, whereas line-transects and fixed-point counts give more similar results. Giving equal weight to each study, the median density is some 2.7 groups km^{-2} or 9.0 individuals km^{-2} in lowland forest (<500 m asl), 2.6 groups km^{-2} or 8.6 individuals km^{-2} for hill forest (500-1000 m asl), and 0.6 groups km^{-2} or 1.5 individuals km^{-2} for lower montane forest (1000-1750 m asl).

Population numbers. **–** Table 2 lists the number of gibbons present on Java, broken down to 15 forest areas that are inhabited by more than 50-100 gibbons. These areas harbour a population of 4000-4400 Javan gibbons. In addition to these areas, the species is known from at least 14 other (mostly small and sometimes fragmented) forest areas from which few data on forest size or number of gibbons present are currently available. These smaller forests include Rawa

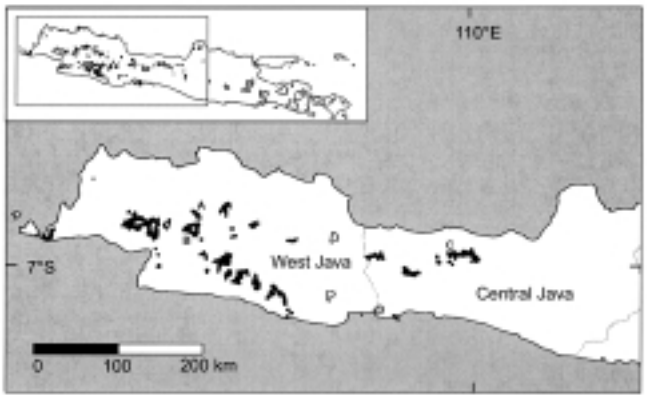

Fig. 1. Current distribution of the Javan gibbon *Hylobates moloch*. Based on Kappeler, 1984, Asquith et al., 1995, Nijman 2001b, and present study. All areas where the species' presence has been confirmed are indicated in black; areas where the species' possible presence was reported by Andayani et al. (1999) are indicated in white. The three main study areas are: A, Telaga Warna Nature Reserve; B, Gunung Gede Pangrango National Park; C, Dieng mountains. The insert shows Java with all remaining forest patches on the island.

Table 2. Estimated number of Javan gibbons in the 15 largest remaining populations in Java.

Area	Longitude (E) - Latitude (S)	Status [a]	Altitudinal range forest	Forest area [b]	Survey effort [c]	Total population	Number of adults [d]	Source [e]
Ujung Kulon (Honje - Tereleng)	105°20', 6°45'	NP	0-480	85	2	560	339	1, 2
Mts Halimun	106°30', 6°40'	NP	400-1929	270	2	850-1320	515-800	1, 2, 3, 4
Mt Salak	106°45', 6°45'	unp.	800-2210	70	3	140	85	1, 2
Telaga Warna - Megamendung	107°00', 6°40'	NR / unp.	500-1600	30	3	>50?	>30?	1
Gede Pangrango	107°00', 6°45'	NP	500-3019	50	3	100	61	1, 5
Sanggabuana	107°15', 6°35'	unp.	250-1280	50	—	100	61	1, 2
Mt Burangrang / Tangkuban Perahu	107°35', 6°45'	NR / unp.	900-2081	40	1	>50?	>30?	1, 6
Mt Simpang	107°25', 7°15'	NR	400-1816	140	—	600	364	2
Mt Tilu	107°30', 7°10'	NR	900-2434	30	—	100	61	1, 2
Mt Papandayan	107°45', 7°20'	NR	700-2622	120	—	250	152	2
Mt Wayang	107°50', 7°25'	unp.	500-1830	85	—	300	182	2
Mts Pembarisan	108°48', 7°07'	unp.	300-1351	120	1	>50?	>30?	1, 7
Mt Slamet	109°13', 7°19'	unp.	700-3428	40	3	100?	61?	1, 7
Mt Lawet / Cupu-Simembut / Jaran	109°30', 7°15'	unp.	700-1100	20-30	2	>50?	>30?	1
Mts Dieng	109°37', 7°05'	unp.	300-2565	120-135	3	519-577	315-350	1, 8
Total			0-3428	1270-1295	340 days	4019-4397	2436-2665	

[a] Status: NP= national park (taman nasional); NR= strict nature reserve (cagar alam); unp. = not protected as conservation forest: smaller sections might be protected as strict nature reserve.
[b] Habitat is the approximate available habitat that is inhabited by gibbons. Forest above 1500 m a.s.l. is not included.
[c] Survey effort refers to present study only: 1 = < 4 days; 2 = 4-10 days; 3 = > 10 days.
[d] Number of adults is based on an average group size of 3.3 individuals, of which two are adult; floaters are not included in any of the above estimates.
[e] 1. Present study; 2. Asquith et al., 1995; 3. Kool, 1992; 4. Sugarjito et al., 1997; 5. Harris, 1996; 6. Juniarto 1999; 7. Nijman, 1995; 8. Nijman & van Balen, 1998.

Danau, Mt Jayanti-Tangkuban Perahu, Lengkong, Mt Porang, Cisolok, Mt Pongkor, Takokak, Bojongpicung, Pasir Susuru, Mt Malang, Mt Halu, Leuweung Sancang, Mt Masegit-Kareumbi, and Mt Manglayang (Kappeler, 1981; Supriatna et al., 1994; Asquith et al., 1995; Indrawan et al., 1996; Bolton, 2002; present study). The available data suggest that these areas combined hold at least another 100-120 gibbons. If Javan gibbons are indeed present in the forests of Mt Sawal (c. 50 km^2 of forest between 600-1764 m asl) and Mt Ciremai (c. 120 km^2 of forest largely above 1000 m asl), as suggested by Andayani et al. (2001), these additionally may hold populations of tens to hundreds of gibbons. Hence, the total number of Javan gibbons remaining in the wild total some 4000-4500, and possibly more.

Calling frequencies and local extinctions. – Asquith et al. (1995) reported the apparent extinction of nine local gibbon populations, mostly due to loss of habitat. Asquith et al. (1995) checked the presence of gibbons by seeking information from local forestry officers and/or by surveying the forest for one or two days. Kappeler (1981: 14) did not explicitly mention the number of days he spent in each of the forest areas he surveyed in order to assess the presence of gibbons throughout Java. However, based on the duration of his survey, i.e. two months (Kappeler, 1981: 14, or four months: Kappeler, 1984: 19), the number of forest patches visited (64), some of which were visited several times, the shortest overland distance between forest patches (>3000 km), the difficulties of reaching forest areas in remote places, and the fact that gibbons almost exclusively call in the early hours of the day, the average survey duration in each forest patch must have been a few hours at most, and several patches must have been surveyed on the same morning. More importantly, it seems unlikely that Kappeler (1981) spent an additional day in any of the 19 patches where he did not record the presence of gibbons on the first day.

In forest areas that are disturbed by logging, frequent collection of forest products and encroachment or hunting, gibbons may alter their behaviour in response to disturbance. Calling frequencies may be depressed for considerable period (Johns, 1985; Nijman, 2001a). This makes it less likely that gibbons are detected, and may lead to an under-estimation of the presence of gibbons.

Calling frequency in gibbons is dependent on, amongst others, the density of gibbons (Chivers, 1974). Thus, not only are there less gibbons to record in low density populations, but those present are less likely to be recorded. This may explain why gibbons were recorded during the present study from two of nine forest areas, where Asquith et al. (1995) reported the species to have become extinct between 1978 and 1994 (Mt Tangkuban Perahu and the adjacent Mt Burangrang, and Telaga Warna Nature Reserve). In Telaga Warna and the

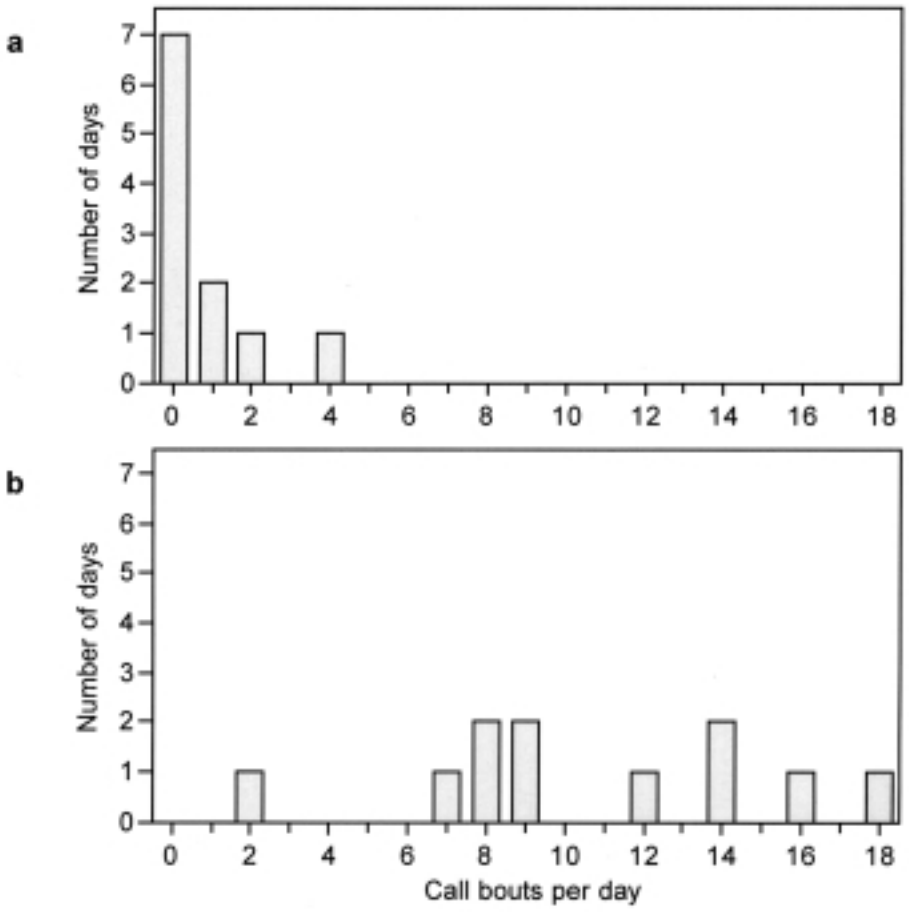

Fig. 2. Relation between number of groups calling per day and number of census days in the Telaga Warna Nature Reserve (Sept 1999) and Lingo Asri, Dieng mountains (Sept 1998).

adjacent forest to the north, Javan gibbons were recorded at different sites, suggesting multiple groups. Assuming calls were audible over a 1.0-1.4 km distance (cf. Geissmann & Nijman, 2001) a population density of 1.1-2.1 groups km^{-2} was reached. Calling frequencies were depressed, however, and on occasions, gibbons were not heard for several days in a row. On other days, up to four groups were heard calling from the reserve. The median number of call bouts recorded was 0 day^{-1} (Fig. 2a). In Linggo Asri, where gibbons occur at a density of 1.9-3.7 groups km^{-2} (Geissmann & Nijman, 2001), the median number of call bouts recorded was 9 day^{-1}. On none of the days were no gibbons heard, and the lowest number of call bouts recorded was 2 day^{-1} (Fig. 2b). If these findings are representative for other gibbon populations, the implication for gibbon censusing is that in low density populations there is a high likelihood of not recording the species' presence. On 36% of the days (4/11) groups were heard calling in Telaga Warna, and the calling frequency for individual groups is 0.18 day^{-1}. With the methods of Asquith et al. (1995), and under the assumption that groups are calling independently, to establish the presence of gibbons over a two-day period, there is a 20% chance of not recording a single group in this area $[((1-0.18)^4)^2 = 0.20]$. Alternatively, under the more realistic assumption that groups are not calling independently, and using the data from Fig. 2a, the chances of not recording a single group over a two-day period whereas in fact four groups are present are twice as high $[(1-0.36)^2 = 0.40]$. The chances of not recording the presence of gibbons in low-density populations, or populations in disturbed forest, during rapid presence-absence surveys seems high indeed.

DISCUSSION

Population numbers and density. – Asquith et al. (1995) acknowledged that part of the differences between their estimate and Kappeler's (1984) was due to inaccurate interpretation of the extent of forest inhabited by gibbons in 1978 by Kappeler (1984). Hence some of the populations were not as large as inferred, and hence the decline not as severe as the numbers suggested. The apparent increase in the number of gibbons between the present study and those of Asquith et al. (1995) derives largely from the addition of a significant population in Central Java, and reinterpretation of data.

A better way of judging the decline of Javan gibbons is by comparing the amount of available habitat between different studies (Table 4). Kappeler (1984) did not find gibbons in a number of areas where they were found present during later studies. Instead of inferring range extensions of gibbons, it appears reasonable to assume that he missed some populations or, by his own admission, did not visit all areas. Under this assumption, the total available habitat in 1978 was *c*. 1515-1700 km^2, although Asquith et al. (1995) found some of Kappeler's forest patches to be mature pine plantations, suggesting that Kappeler probably over-estimated the available habitat. If we compare this with the present estimate of 1270-1295 km^2, and add a conservative 50 km^2 for the 14 forest areas not included in this estimate, this suggests a reduction of the available habitat by some 20% over two decades.

The present study found the total number of wild gibbons in Java to be in the order of 4000-4500 individuals, i.e. an order of magnitude larger than estimated by Supriatna et al. (1994). This new estimate is unlikely to be an over-estimate for at least two reasons: (1) conservative overall densities and (2) exclusion of floaters (sub-adults that have left their natal territory but have not yet established a territory for themselves).

Overall, a conservative population density of about one gibbon group km^{-2} has been used. This is in line with most other studies (Table 3). Both Asquith et al. (1995) and MacKinnon (1986b), however, explicitly made clear that in their estimates this was a conservative working density. Most studies listed in Table 2 found population densities to be considerably larger than one group km^{-2}, and in fact the median density of all studies combined is some 2.7 groups km^{-2}, i.e. almost three times higher. Compared to previous studies and the available data, the average density used by Supriatna et al. (1994), i.e. 0.2 groups km^{-2}, seems to be very conservative. It is a factor six lower than those used in other studies, and a factor seventeen lower than the median density mentioned above. This difference in part derives from the fact that Supriatna et al. (1994) assumed that Javan gibbons did not inhabit the first kilometre of edge forest, an assumption that is invalid (Nijman & van Balen, 1998; present study).

Floaters receive severe aggression from mated territorial adults (Mitani, 1988), and are generally more difficult to detect than paired individuals as they occur singly, behave inconspicuously to avoid detection by resident pairs, and call less. Limited information is available on the density of non-territorial floaters (cf. Cowlishaw, 1992), and normally, they are excluded from density estimates (although a proportion of them may be included in some of the range mapping and line-transect studies). Cowlishaw (1992) calculated the floater density of one population of Javan gibbons to be 9%, and estimated that in gibbons floater densities are, on average, between 3% and 10% of the mated adult density. Thus, including floaters in the above estimate will add some 100 to 400 individuals to the total number of wild gibbons.

The Javan gibbon as a critically endangered species. – For a long time, Javan gibbons were listed as Endangered according to the IUCN threat criteria. Shortly after the results of the PHVA-workshop were published (Supriatna et al., 1994), the species' status was changed to Critically Endangered (Eudey, 1996/1997; IUCN 2001). Currently, the species is listed Critically Endangered based on the 1994-criteria A1(cd) and C2(a) (IUCN 2001), where A1(cd) stands for 'a reduction of at least 80% over the last three generations (corresponding to some 40-odd years) based on a decline in area of occupancy, extent of occurrence and / or quality of habitat', and C2(a) stands for 'a population estimated to number less than 250 mature individuals and a continuing decline, observed, projected, or inferred, in numbers of mature

Table 3. Summary of previous estimates of the total number of Javan gibbons.

#	Reference	Data collection	Habitat (km^2)	Total population	Density	
					Individuals km^{-2}	Groups km^{-2}
1.	Chivers (1977)	1973[a]	9340	20000	2.1[b]	—
2.	Kappeler (1984)	1978	1425	2400-7900	1.7-5.5	0.5-1.7
3.	MacKinnon (1986ab)	<1982	1608	4824	3	0.9
4.	Asquith (1995)	1994	770[c]	2700-3000	3.5	1.1
5.	Supriatna et al. (1994)	1994	793-811[d]	400	0.5	0.2
6.	Supriatna & Wahyono (2000)	—	1608	2000-4000	1.2-2.5	—
7.	Present study	2000	1270-1295[e]	4000-4400	3.1-3.5	0.9-1.1

[a] Based on modified forest data collected in 1929.
[b] Average density of 2.5 individuals km^{-2} in text (Chivers, 1977: 575-576).
[c] Based on the six largest populations. No data on forest area is given for an additional 13 areas inhabited by gibbons.
[d] The first *lower* figure is derived from the available habitat in 23 areas (Supriatna et al., 1994: 21), whereas the second *higher* estimate is derived from only seven areas (Supriatna et al., 1994: 22).
[e] Includes some 100-285 km^2 habitat in central Java not included in studies 2-6.

individuals and severely fragmented population structure (i.e. no sub-population estimated to contain more than 50 mature individuals)'.

As already mentioned in the introduction, unlike many other tropical countries, Java has a long history of deforestation. The greatest loss of forest occurred in the period 1830-1940. In 1830, the Dutch administration imposed the 'cultuurstelsel' which forced farmers to grow export crops on communal grounds, which were often forests (Whitten et al., 1996). Until World War II this led to a sharp decrease in the amount of forest. Between Indonesia gaining independence after World War II and present, however, the decrease in forest area on Java has been generally slow (Smiet, 1990; Whitten et al., 1996). Hence, there seems to be no ground to infer a decline of 80% in the area of occupancy, extent of occurrence, and / or the quality of the habitat, over the last four decades. Comparing data on the change in habitat for Javan gibbons over the last two decades suggests a decline of some 20%.

The total number of mature individuals is considerably higher than 250. In all likelihood, it is a factor ten larger, i.e. some 2500 mature individuals. Likewise, the notion that no sub-population is larger than 50 mature individuals is wrong. There seem to be at least 11 forest areas with an estimated population of a hundred gibbons (corresponding to at least 60 mature individuals) or more, and four areas with over 500 gibbons each. The population estimate of 400 gibbons as made at the PHVA-workshop (Supriatna et al., 1994) has been questioned (Asquith et al., 1995; Asquith, 2001), and given the results of the present study does not seem to be tenable. Interestingly, the senior author of the PHVA-workshop proceedings recently estimated the total population of Javan gibbons in the wild at 2000-4000 individuals (Supriatna & Wahyono, 2000).

Trade in gibbons is widespread in Indonesia, and indeed Javan gibbons are occasionally encountered at wildlife markets. A study in 2003 yielded <100 wild-caught individuals being kept at eight Wildlife Rescue Centres and eleven zoological gardens throughout Java and Bali (Nijman, in press). Javan gibbons in international zoos (only few of which have been derived directly from the wild) number a few dozen at the most (Bolton, 2002; Nijman, unpubl. data). However, too few data are available on numbers of Javan gibbons that are being extracted from the wild annually to make meaningful statements on the severity of this threat.

In conclusion, listing the Javan gibbon as Critically Endangered according to the IUCN threat criteria as indicated above is invalid. Those who wish to consider critically endangered on purely personal or subjective criteria are free so to do, but if we wish to apply threat-criteria consistently and unambiguously, and if the conservation community wants to be taken seriously, while still maintaining the precautionary principle, I recommend adjusting the species status to Endangered (2001-criteria A2(c): An estimated population size reduction of 50% over the last three generations, where the reduction or its causes may not have ceased or may not be understood or may not be reversible, based on a decline in area of occupancy, extent of occurrence and/or quality of habitat).

Prioritising conservation strategies. – The uncritical acceptance of the critically endangered status of the Javan gibbon will crucially influence the way conservationist will respond to the species' needs. A situation where only 400 individuals of a species remain in a large number of forest fragments tends to reinforce the view that ex-situ management and intrusive management is vital to the Javan gibbon. Recently, Asquith (2001) stressed the dichotomy between strategies for Javan gibbon conservation suggested by geneticists, zoo biologists and captive-breeding specialist on the one hand and field biologists on the other. The first group focused largely on active management of small populations (including genetic supplementation, demographic management, and for small populations, rapid habitat expansion, translocation, and captive propagation; Supriatna et al. 1994; see also Supriatna & Manullang, 1999), whereas the second group has repeatedly argued that expansion of the protected area network, improved protection and further research and monitoring are the most urgent actions required (Kool, 1992; Nijman & Sözer, 1995; Nijman & van Balen, 1998; Asquith, 1995, 2001; Asquith et al., 1995). Andayani

et al. (2001) found evidence of two genetically-differentiated lineages in Javan gibbons, and assumed that these correspond with two subspecies (cf. IUCN, 2001). Reanalysis of the same data by Geissmann et al. (2002), as well as a cladistic analysis of morphological and vocal data, however, did not find support for this two-clade model (T. Geissmann, pers. comm.; cf. Supriatna et al., 1999). Andayani et al. (2001), on the assumption of small population size of one of their two purported lineages, proposed translocation of individuals as a means of genetic and demographic management. On the basis of small population size, Gates (2002) has expressed a similar need for intervention. In the face of extreme fragmentation, Andayani et al. (2001) recommended immediate experimentation with translocating silvery gibbons as a preclude to direct metapopulation management and proposed immediate efforts to determine how to best translocate gibbons among Javan forest patches. Apart from the notion that translocation is not the first logical step in the improvement of the conservation of the Javan gibbon, it needs to be stressed that the 'smaller and more isolated populations' that comprise this lineage, in fact make up over half of the total number of Javan gibbons (i.e. >2000 individuals).

Proposals have already been put forward to increase the number of gibbons in the wild through the reintroduction of gibbons that have been kept as pets, whereas subsequent generations of rehabilitated animals might be released to other suitable areas (Gates & Baker, 2001). As of 2003, less than two dozen Javan gibbons are being housed in one of seven operative wildlife rescue-centres (Nijman, in press). Many of these suffer from tuberculosis or have severe behavioural problems (unpubl. data), and even when successfully released in the wild, in all, these individuals will contribute little to the survival of the species. Rehabilitation and release of confiscated gibbons in isolated forest areas without a resident wild gibbon population may be a way to solve the dilemma of what to do with gibbons held in captivity, but should not be used as a conservation strategy. Initiatives to improve the lives of captive Javan gibbons and programmes that enable the Indonesian conservation authorities to house confiscated gibbons properly are to be applauded, but will contribute little for the increase of survival chances of gibbons in the remaining forests on Java (cf. Asquith, 1995). A large number of the forest areas listed in Table 1 are not included in the conservation area network. Some of these forests (e.g., Mt Wayang and the Dieng mountains) harbour some of the largest remaining populations of the Javan gibbon. As such these populations face an unnecessary large threat of their forest being converted into plantations, rice fields or other forms of land use incompatible with the survival of gibbons.

By stressing the need for captive-breeding, translocations, and reintroductions the point is missed that, despite the widespread believe that Java is completely deforested, significant forest areas remain intact on Java, and that a large proportion of the Javan gibbon population has survived outside the protected area network in poorly protected forests. It is the increased protection of these remaining forest patches that is badly needed as its successful protection will make the greatest contribution for the survival of the Javan gibbon.

Even though a holistic approach to captive-breeding including habitat management, limiting factors management, field research and public education has been proposed by advocates of captive-breeding, apart from the most extreme cases in which only a very small number of individuals remains, captive-breeding should not be viewed as a complete solution (Ellis, 1996/1997). A futher great risk of implementing a captive-breeding programme or an intrusive management programme that includes translocation, will be that any programme that costs a great deal of money over the years will inevitably seek to portray itself as necessary and relevant, and if caution is needed it is in the evaluation of current management options, based on the best possible information irrespective of previous investments.

ACKNOWLEDGEMENTS

The study was conducted under sponsorship of the Indonesian Institute of Sciences (LIPI) and the Directorate General for Forest Protection and Conservation (PHKA), and stems from an agreement between the zoological museums of Bogor and Amsterdam. In this the help of Dr Dewi M. Prawiradilaga and Prof dr Steph B.J. Menken is kindly acknowledged. Financial support came from the Netherlands Foundation for International Nature Protection, Society for the Advancement of Research in the Tropics, and Stichting het Kronendak. Dr Thomas Geissmann (Universität Zürich) is thanked for comments and for data on calling behaviour. Two reviewers are thanked for comments and suggestions.

LITERATURE CITED

Andayani, N., J. C. Morales, M. R. J. Forstner, J. Supriatna & D. J. Melnick, 2001. Genetic variability in mtDNA of the silvery gibbon: implications for the conservation of a critically endangered species. *Conservation Biology,* **15**(3): 770-775.

Asquith, N. M., 1995. Javan gibbon conservation: why habitat protection is crucial. *Tropical Biodiversity,* **3**(3): 63-65.

Asquith, N. M., 2001. Misdirections in conservation biology. *Conservation Biology,* **15**(2): 345-352.

Asquith, N. M., Martarinza & R. Sinaga, 1995. The Javan gibbon (*Hylobates moloch*): status and conservation recommendations. *Tropical Biodiversity,* **3**(3): 1-14.

Bolton, W. A., 2002. *Silvery gibbon in Java*. Silvery Gibbon Information Page, Chipping Norton, UK. Pp 1-11.

BPS (Badan Pusat Statistik), 2004. Population statistics. [http://www.bps.go.id/sector/population, accessed 11 March 2004]

Brockelman, W. Y. & S. Srikosamatara, 1993. Estimation of density of gibbon groups by use of loud calls. *American Journal Primatology,* **29**(2): 93-108.

Chivers, D. J., 1974. The Siamang in Malaysia: a field study of a primate in tropical rain forest. *Contributions to Primatology,* **4**. Karger, Basel.

Chivers, D. J., 1977. The lesser apes. In: H.S.H. Prince Rainier III of Monaco & G. H. Bourne (eds), *Primate conservation*. Academic Press, New York. Pp 539-598.

Cowlishaw, G., 1992. Song function in gibbons. *Behaviour,* **121**(1-2):131-153.

Dahlmann, R. & T. Geissmann, 2001. Individuality in the female songs of wild Silvery gibbons (*Hylobates moloch*) on Java, Indonesia. *Contributions to Zoology*, **70**(1): 41-50.

Docters van Leeuwen, W., 1926. Uit het leven van planten en dieren op de top van de Pangrango. IIIa De dieren. *Tropische Natuur*, **15**: 57-65. (In Dutch).

Ellis, S., 1996/1997. Primate conservation and the IUCN/SSC Conservation Breeding Specialist Group: tools, models and processes. *Primate Conservation*, **17**: 41-45.

Eudey, A. A., 1996/1997. Asian primate conservation – The species and the IUCN/SSC primate specialist network. *Primate Conservation*, **17**:101-110.

Gates, D., 2002. Javan gibbon rescue and rehabilitation center. *Asian Primates*, **8**: 23.

Gates, D. & C. Baker, 2001. *Javan gibbon rescue and rehabilitation centre: a project report.* Perth Zoo, Australia. Pp 1-7.

Geissmann, T., R. Dallmann & J. Pastorini, 2002: The Javan silvery gibbon (*Hylobates moloch*): Are there several subspecies? In: *Caring for primates*. Abstracts of the XIXth congress of the International Primatological Society, Beijing, China. Pp. 120-121

Geissmann, T. & V. Nijman, 1999. Do male Javan gibbons have anything to say? *Folia Primatologica*, **71**: 225.

Geissmann, T. & V. Nijman, 2001. Calling behaviour of wild Javan gibbons *Hylobates moloch* in Java, Indonesia. In: Nijman, V., *Forest and primates: conservation and ecology of the endemic primates of Java and Borneo*. Tropenbos Kalimantan Series 5. Tropenbos, Wageningen. Pp 43-59

Gurmaya K. J., I. M. W. Adiputra, A. B. Saryatiman, S. M. Danardono & T. T. H. Sibuea, 1995. *Primate survey, population and ecology: Gunung Honje range Ujung Kulon National Park.* Departemen Kehutanan and New Zealand Ministry of Foreign Affairs and Trade, Jakarta. Pp. 1-86.

Harris, K., 1996. *Mt Gede Pangrango National Park*. Information Book Series 2. Gede-Pangrango National Park, Cipanas-Cianjur. Pp. i-iii, 1-106.

Indrawan, M., D. Supriyadi, J. Supriatna & N. Andayani, 1996. Javan gibbon surviving at a mined forest in Gunung Pongkor, Mount Halimun National Park, West Java: considerable tolerance to disturbances? *Asian Primates*, **6**: 11-13.

IUCN, 2001. *IUCN Red List of Threatened Species. 2001 Categories & Criteria (version 3.1).* IUCN, Gland. [https://www.redlist.org/info/categories_criteria2001.html, accessed 13 January 2004]

Johns, A. D., 1985. Differential detectability of primates between primary and selectively logged habitats and implications for population surveys. *American Journal of Primatology*, **8**: 31-36.

Juniarto, A. I., 1999. *Studi habitat di sekitar sarang Elang Jawa (*Spizaetus bartelsi *Stresemann 1924) di cagar alam Gunung Tangkuban Perahu dan cagar alam Gunung Simpang, Jawa Barat.* Unp. B.S.c. Thesis, Universitas Padjadjaran, Bandung. (In Bahasa Indonesia).

Kappeler, M., 1981. *The Javan silvery gibbon (*Hylobates lar moloch*).* Ph.D. thesis, Universität Basel. Pp. 1-40, 1-121.

Kappeler, M., 1984. The gibbon in Java. In: Preuschoft, H., D. J. Chivers, W.Y. Brockelman & N. Creel (eds.), *The Lesser Apes: evolutionary and behavioural biology*. Edinburgh University Press, Edinburgh. Pp 19-31

Kool, K. M., 1992. The status of endangered primates in Gunung Halimun reserve, Indonesia. *Oryx*, **26**(1): 29-33.

MacKinnon, K., 1986a. The conservation status of nonhuman primates in Indonesia. In: Benirschke, K. (ed.), *Primates, the road to self-sustaining populations*. Springer Verlag, New York. Pp 99-126.

MacKinnon, K., 1986b. Conservation status of Indonesian primates. *Primate Eye*, **29**: 30-35.

Mitani, J. C., 1988. Male gibbon (*Hylobates agilis*) singing behavior: natural history, song variations and function. *Ethology*, **79**(3): 177-194.

Nijman, V., 1995. Remarks on the occurrence of gibbons in Central Java. *Primate Conservation*, **16**: 66-67.

Nijman, V., 2001a. Effects of behavioural changes due to habitat disturbance on density estimation of rainforest vertebrates as illustrated by gibbons (Hylobatidae). In: Hillegers, P. J. M. & H. H. de Iongh (eds.), *The balance between biodiversity conservation and the sustainable use of tropical rainforests*. Tropenbos Foundation, Wageningen. Pp 217-225.

Nijman, V., 2001b. *Forest (and) primates: conservation and ecology of the endemic primates of Java and Borneo*. Tropenbos Kalimantan Series 5. Tropenbos, Wageningen. Pp. i-xii, 1-232.

Nijman, V., in press. *An assessment of the trade in gibbons and orangutans on Java and Bali, Indonesia*. TRAFFIC South-east Asia, Kuala Lumpur (in press).

Nijman, V. & S. van Balen, 1998. A faunal survey of the Dieng mountains, Central Java, Indonesia: status and distribution of endemic primate taxa. *Oryx*, **32**(2): 145-156.

Nijman, V. & S. B. J. Menken, in press. Assessment of census techniques for estimating density and biomass of gibbons (Primates: Hylobatidae) in Borneo. *Contributions to Zoology*.

Nijman, V. & R. Sözer, 1995. Recent observations of the grizzled leaf monkey (*Presbytis comata*) and an extension of the range of the Javan gibbon (*Hylobates moloch*) in Central Jawa. *Tropical Biodiversity*, **3**(3): 45-48.

Rinaldi, D., 1999. *Food preferences and habitat utilization of Java gibbon (*Hylobates moloch *Audebert) in Ujung Kulon National Park, West Java, Indonesia*. M.Sc. thesis Universität Georg-August, Göttingen, Germany. Pp. i-viii, 1-91.

Smiet, A. C., 1990. Forest ecology on Java: conversion and usage in a historical perspective. *Journal of Tropical Forest Science*, **2**: 286-302.

Sugarjito, J., M. H. Sinaga & M. Yoneda, 1997. Survey of the distribution and density of primates in Gn Halimun National Park West Java, Indonesia. In: *The inventory of national resources in Gunung Halimun National Park. Vol II*. LIPI, JICA, PHPA, Bogor. Pp 56-62.

Supriatna, J., N. Andayani, M. Forestner & D. J. Melnick, 1999. A molecular approach to the conservation of the Javan gibbon. In: Supriatna, J. & B. O. Manullang (eds.), *Proceeding of the International Workshop on Javan gibbon (*Hylobates moloch*): rescue and rehabilitation.* Conservation International Indonesia Program and Center for Biodiversity and Conservation Studies, Jakarta. Pp 25-31.

Supriatna, J. & B. O. Manullang, 1999. *Proceeding of the International Workshop on Javan gibbon (*Hylobates moloch*): rescue and rehabilitation.* Conservation International Indonesia Program and Center for Biodiversity and Conservation Studies, Jakarta. Pp. i-iii, 1-60.

Supriatna, J., R. Tilson, K. J. Gurmaya, J. Manansang, W. Wardojo, A. Sriyanto, A. Teare, K. Castle & U. Seal (eds.), 1994. *Javan gibbon and Javan langur: Population and habitat viability analysis report*. IUCN/SSC Conservation Breeding Specialist Group, Apple Valley, Minnesota. Pp. 1-102.

Supriatna, J. & E. H. Wahyono, 2000. *Panduan lapangan primata Indonesia*. Yayasan Obor Indonesia, Jakarta. Pp. i-xxii, 1-332. (In Bahasa Indonesia).

Suranto, M. T., 1994. A conservation study of the Javan gibbon (*Hylobates moloch*) in Situ Gunung tourist park, West Java, Indonesia. In: *Handbook of Abstracts* XVth Congress of the International Primatological Society. Bali. p. 119.

Whitten, A. J., R. E. Soeriaatmadja & S. A. Afiff, 1996. *The ecology of Java and Bali, the ecology of Indonesia series Vol II*. Periplus Editions, Singapore. Pp. i-xxiv, 1-969, Pls. 1-30.