

GIBBON POPULATIONS AND THEIR CONSERVATION IN THAILAND

Warren Y. Brockelman¹

SUMMARY

At least three species of gibbons inhabit the broad-leaved evergreen and partly deciduous forests of Thailand:

The white-handed gibbon (*Hylobates lar*) occurs in the South, West, and most of the northern regions. In Thailand, there are about 75,000 sq. km of forest habitat remaining within its geographical range.

The pileated gibbon (*Hylobates pileatus*) occurs in southeastern Thailand and Cambodia west of the Mekong River. In Thailand, it has about 13,500 sq. km of habitat remaining.

The agile gibbon (*Hylobates agilis*) occurs in 2000 to 3000 sq. km of rain forest near the Malaysian border, in Yala and probably also Narathiwat Provinces.

The white-cheeked gibbon (*Nomascus concolor*) is native to countries east of the Mekong River, but a few individuals may exist in northeastern Thailand.

Gibbon species are most easily found and distinguished by their morning territorial vocalizations. The appearance and vocalizations of Thai gibbons are described. All of the species live in small territorial family groups of about four individuals, averaging.

Protected, undisturbed evergreen forests can support one to three groups per square kilometer, on the average, but the density is well below this in most of the forests of Thailand. Gibbons are illegally hunted in most regions for food, the pet market, or for sale to animal dealers who smuggle them abroad. However, the greatest threat to their future survival in the kingdom is probably deforestation, which will reduce all

1. Department of Biology, Faculty of Science, Mahidol University, Rama VI Road, Bangkok, Thailand

populations to small isolated remnants within the parks and sanctuaries that can be adequately protected within about 30 years. In the South and Southeast in particular, the diverse evergreen forests are being cleared away so that they will not regenerate into the original forest type.

Gibbons can be bred in captivity with some success, but their reproductive rate is low. Breeding of captive animals will not significantly help to conserve the species, although it will help zoos and research facilities maintain their colonies. Some tame captive animals, but not all, will readjust to a free-ranging environment and breed, with careful management and ample space for the expression of their territorial behaviour. But the only management strategy that will save adequate populations for the future is vigorous protection of large areas of forest from lumbering and hunting.

Introduction

Loud territorial calls of gibbons are a distinctive feature of the forests of Thailand and most other countries of Southeast Asia. There are approximately nine species, three of which occur in significant numbers in Thailand: the white-handed gibbon, *Hylobates lar* (ชนชรรมาดา); the agile or black-handed gibbon, *Hylobates agilis* (ชนมือดำ); and the pileated or capped gibbon, *Hylobates pileatus* (ชนกระหม่อมดำ หรือ ชนมงกุฎ). The agile gibbon has been considered by some to be conspecific with the white-handed (GROVES, 1972). Although they are closely related, there are distinguishing features in both the colour of the pelage and the voice; regardless of taxonomic status, they merit being considered separate kinds worth conserving. There have been reports of the white-cheeked gibbon, *Hylobates (Nomascus) concolor* (ชนแก้มขาว) in northeastern Thailand, but we have been unable to confirm that it occurs west of the Mekong River (MARSHALL *et al.*, 1972). The siamang *Symphalangus syndactylus*, the largest member of the gibbon family, has been found in Malaysia very close to the border of Narathiwat Province in the South, and may well also occur on the Thai side.

The gibbons of Thailand are extremely important wildlife species. Concern for their welfare is now frequently voiced in local newspapers and by a growing number of conservation organizations, both local and

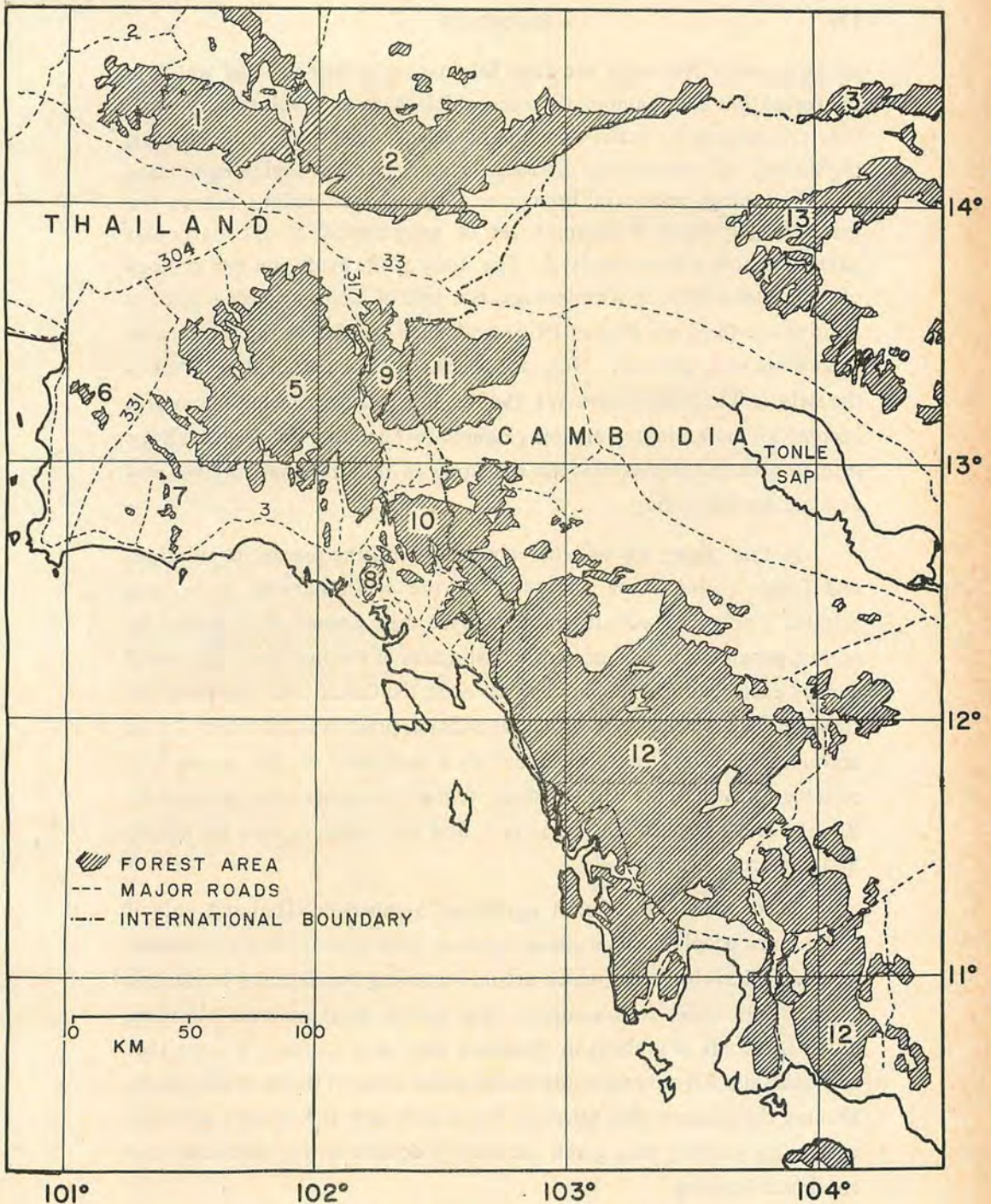


Figure 1. Forest habitat (shaded) in the geographical range of the pileated gibbon. Some forest in Cambodia and eastern Thailand is off the map to the east. See Table 2 for a description northern of the numbered areas. Data from Earth Resources Technology Satellite (LANDSAT-1) images.

international. Not only are they fascinating to listen to and watch in the forest, but being among the apes which share our evolutionary past, they are helping to teach us about ourselves: our evolution, behaviour, physiology and responses to diseases. And we are just beginning to learn how the ecology and social behaviour of these apes, unique among the primates, represent a complex set of adaptations of the particular environment in which they live. The study of the evolution and ecology of social behaviour, or sociobiology, is a field of biology coming into its renaissance (e.g., see WILSON, 1975), and much exciting work still remains to be done with gibbons. Only one species has been studied in detail in the wild in Thailand (CARPENTER, 1940). For these reasons, gibbons will become an increasingly valuable resource to Thailand, but as with all the primates, native populations are declining as international interest and demand are increasing.

In this paper we will be concerned with the present populations and future conservation prospects of the white-handed, agile, and pileated gibbons. I will attempt to analyze their present distributions by region, provide order-of-magnitude estimates of the numbers that could occupy each region, and comment on what the future holds in store for these animals on the basis of present policies, practices and trends. This account based on the most recent data available on the amount of suitable forest habitat still standing, information generously supplied by Royal Forest Department personnel, and field observations by myself and numerous other people.

Gibbons will be saved in significant numbers in Thailand only if many more people become conservation-minded and achieve a spectacular reversal of the forces which are now causing populations to decline rapidly. In order to accomplish this, people must be well informed about the kinds of gibbons in Thailand and their status. I hope that this analysis will stimulate additional active interest in conserving them, because the chances that effective action will save the species diminish with every passing year, given the steady decline in forested area and continued hunting.



Fig. 1. Light phase white-handed gibbon in Ko Klet Kaew colony of SEATO Medical Research Laboratory.



Fig. 2. Dark phase white-handed gibbon on Ko Klet Kaew.



Fig. 1. Female pileated gibbon caged at Khao Khiew Wildlife Sanctuary, Chon Buri Province.



Fig. 2. Young adult male pileated gibbon at Khao Khiew Sanctuary.

The Characteristics of Thai Gibbons

Below is a capsule summary of the natural behaviour and ecology of gibbons and a brief description of the three main species (see MARSHALL *et al.*, 1972, and LEKAGUL and MCNEELY, *in press*, for more information).

The white-handed gibbon is the best known species (CARPENTER, 1940; CHIVERS 1972, 1974; ELLEFSON, 1968, 1974; MCCLURE, 1964). The ecology and behavior of the pileated gibbon has yet to be studied in detail, but preliminary observations suggest that it is not very different from the white-handed gibbon. The agile gibbon has recently been studied in Malaysia near the Thai border (GITTINGS, unpublished), and it is very similar to the white-handed gibbon.

All species of gibbons live in the dense and very diverse evergreen forests, or mixed evergreen-deciduous forests that are not too dry and open, where they feed on a wide variety of fruits, shoots, leaves, and occasional small animals. They very rarely come to the ground, except when the dry season may make it necessary to descend for water; they are completely at home in the middle and upper layers of the forest canopy. Gibbons are sensational acrobats, moving mostly by swinging with their arms (brachiation).

They characteristically live in small groups of a single mated pair and up to four offspring. Average group size is about four individuals. In most species (including those in Thailand) each group ranges within an area of from 15 to over 50 ha from which they chase all intruding individuals. Loud vocalizations are given on most mornings which advertise the occupancy of their territories to individuals in neighbouring groups. Interestingly, males and females make different sounds in all species, and a mated pair usually sings in a duet which can be heard from a distance of a kilometer or more. During these calling sessions, which usually last 10 to 30 min, the female gives an extended vocalization termed the "great call" at intervals of 1 to 3 min, which is accompanied or followed by a distinctive but shorter vocalization by the male. The climax of the female's great call is a moment of intense excitement usually accompanied by vigorous brachiation and shaking of

the branches. The easiest way of finding and distinguishing the species of gibbons in the forest is by these vocalizations, which are remarkably constant in pattern and length within each species.

Here are the features which distinguish the species of Thai gibbons.

Hylobates lar: This species, widely distributed in Thailand except in the eastern regions and some areas near the Malaysian border, is the most commonly seen species in zoos or as pets. It occurs in two colour phases: buff or light brown, and very dark brown to black. Colour is unrelated to age or sex. Both phases have whitish hands and feet and a white ring of fur around the face (Plate I, Figures 1 and 2).

The great call of the female, 15-20 sec in duration, consists of a few soft low introductory notes (not audible at a distance) immediately followed by a series of six to eight extended hoots or loud wails, generally rising in pitch and volume to a screaming climax, with the last few notes descending again in pitch and volume. This performance is followed by more rapid hoots from the male. Males often answer one another early in the morning (sometimes before dawn) with series of similar rapid hoots. The first hoots rise in pitch but the last one or two usually rise and quaver downward at the end, somewhat plaintively.

Hylobates agilis: Occurs in West Malaysia sandwiched between the Perak and Mudah Rivers, but reaches over the border into Thailand in this region. It is similar to *H. lar* in colouration, except for the absence of white fur on hands and feet. Thai individuals are all or nearly all dark phase, dark chocolate brown or black, with white eyebrows and (especially in the male) white cheek whiskers.

The female's great call is the same as that of *H. lar*, although often slightly faster in tempo. The male's call is different: a "whoo-haah", with the second syllable accented and higher, but slightly descending, in pitch.

Hylobates pileatus: This species, which is considered to be endangered by extinction by the International Union for the Conservation of Nature, is confined to southeastern Thailand and the highlands of

Cambodia west of the Mekong River. Sexes are different in coloration as adults. Both are buff coloured when young, and develop black patches on the cap of the head and on the breast. Near maturity, the males turn nearly all black, except for (1) white eyebrows, the white extending backward around the the cap and fading into brownish or black, with some white also extending down the sides of the face; and (2) a white tuft of pubic hair covering the genitals. The adult female retains the buff juvenile colouration with black cap and V-shaped "vest" extending from the neck region to the groin. Both sexes have hairs parted or flattened on the top of the head and extending out over the ears in tufts, or (especially in the female) down along the sides of the face. This species also tends to have white hands and feet (Plate II, Figures 1 and 2).

The territorial calls of the pileated gibbon are quite different from those of the above species, but equally spectacular. The great call of the female consists of a series of hoots, each rising steeply in pitch, which begin slowly but steadily become faster and grade in to a long bubbly trill. The male's vocalization, given several times during or after the female's, consists of alternating notes, "Oh-Ah", the second nearly an octave higher than the first, frequently followed by a short low bubbly trill. A typical sequence by the male may be: "Oh-Ah'-Oh-Ah'-Oh-Ah'-Bubububububububub".

Practices and policies affecting gibbon populations

The future of gibbon populations in Thailand unfortunately depends on the following three factors:

- (1) The exploitation of forests for lumber and new land for farming.
- (2) Hunting practices.
- (3) Demand for gibbons for pets and research, etc., including the international trade.

I believe that the first factor listed is the most critical one effecting the decline of populations, because gibbons require intact natural forests for their survival. Furthermore, lumbering operations,

besides destroying the habitat, bring gibbons into increased contact with lumberers, settlers, and professional hunters who shoot them, creating a double threat. Most forests of commercial value in the kingdom have been designated as "reserved", from which concessions are allocated for lumbering and other purposes. Other forests have been included in national parks and wildlife sanctuaries to be completely preserved. Many of these preserves have been designated only recently, so there has been insufficient time to survey them or carry out adequate protective measures. There is tremendous difficulty in controlling lumbering activities, however, and virtually all forests, regardless of status, are shrinking in area by several percent per year.

This problem is particularly critical in the Southeast, in the range of the pileated gibbon. The expanses of forest still standing there (Figure 1, Areas 2, 5, 9, 10) are shrinking from all sides where they are accessible and clearcut patches up to 1 km across are speckled through the peripheral parts of these areas on the Earth Resources Technology Satellite (ERTS) images. New highways built through the region in recent years have greatly increased accessibility to lumberers and squatters. The settlers typically come from more highly populated areas such as the Northeast or from other cut-over areas whose soils have been depleted, and settle in just a few kilometers behind the lumbering operations. They gradually cut what the lumberers have left, and forest regeneration does not usually occur except on slopes or mountains too isolated or otherwise unsuitable for permanent settlement.

In the mountainous North, regular slash-and-burn agriculture by hill tribes continues to be a difficult problem to solve, and gibbons have disappeared or become rare in many regions. In the far North, increasing human populations have caused the cycle of cutting to be speeded up beyond the rate of regeneration.

Forest Department personnel have estimated that the forested area has shrunk by approximately 30% during the last decade in all regions of the country. The amount of forest effectively protected from clearing within parks and wildlife sanctuaries will be crucial to the survival of gibbon populations. The extent of such areas will be evaluated below along with the estimates of total gibbon habitat.

The hunting and sale of gibbons has been illegal since 1960 (Wild Animals Reservation and Protection Act B.E. 2503), but it is unrealistic to believe that this regulation can be widely enforced, given the existing finite manpower and budgets. To attempt enforcement where forests are being destroyed in any event would be a futile waste of manpower, and attention is justifiably directed more toward protecting the more vital parks and wildlife sanctuaries. The sale of baby gibbons continues to some extent even in the largest pet markets, although it is less conspicuous now because of the threat of arrest. Young gibbons are frequently seen chained as pets in rural villages as well as in Bangkok, in homes, stores, near hotels, and at other places frequented by tourists. The number of such pets probably runs in the thousands, although I have not tried to make a serious estimate.

The description of hunting practices in Thailand by BERKSON *et al.* (1971) continues to be valid; shooting the adults for food and selling any surviving dependent young for pets is still the common practice. Recent observations in southeastern Thailand reveal that loggers partly depend on the pileated gibbon for food. Ten freshly-taken skins were seen in one camp hut, but pileated gibbons were still heard calling in the forest nearby (in Area 5, Table 2).

Permission to export gibbons must be specifically obtained from the Ministry of Agriculture and Cooperatives, and is not granted in ordinary cases. Exportation through normal channels is thus controlled with some vigour, although instances of smuggling and deceptive labelling of shipments through the airport still come to light (International Primate Protection League, 1974). Smuggling may also occur regularly via roadway or ship from southern Thailand to Singapore, a country which condones the international trade in protected and endangered species by its animal dealers (e.g., Bangkok Post, July 24, 1975, p. 5). The magnitude of smuggling operations is difficult, if not impossible, to evaluate, and it probably represents a sacrifice of at least several hundred wild gibbons per year. Its importance to conservation will increase as natural populations become smaller.

Habitat area and population abundance

The number of gibbons remaining in Thailand depends on (1) the geographical area of suitable forest still standing, (2) the density of gibbons that such forests could support, and (3) the effects of hunting and other disturbance on that density. The area of forest standing is known, and we can also obtain a reasonable approximation for (2). But the third factor, as implied above, is extremely difficult to evaluate. Actual censuses or samples of population density have not been made in most areas because most remaining forest is relatively inaccessible, lies over difficult terrain, or is politically insecure. Furthermore, there is no consensus among the most knowledgeable people as to the quantitative effect of hunting on the density of gibbons in Thailand, but there is unanimous agreement that the density is now below the carrying capacity in virtually all areas, and perhaps far below. Gibbons appear to be at their maximum density in much of Khao Yai National Park, and may also be in the central portions of the larger forested areas infrequently visited by humans. But where forests are accessible by road or trail, gibbons are increasingly hard to find, and their calls cannot be heard any longer in many suitable forests throughout the kingdom. I will therefore not presume to estimate the actual number of gibbons remaining in Thailand, but the number that the remaining forests could support in the absence of hunting. These figures will therefore represent upper limits to the numbers in Thailand. They may still be useful in understanding the problems and possibilities for conserving gibbons.

The estimates of remaining forest come from several sources. For peninsular and southeastern Thailand, they are taken from the Earth Resources Technology Satellite (LANDSAT-1) images, band MSS 5, taken by NASA, United States Government, in 1972 and 1973. For the West, North and Northeast, I rely mostly on the Royal Forest Department's estimates of forest areas derived from aerial photographs taken during 1961 and 1967. Although the southern and southeastern forests are mostly evergreen and suitable as gibbon habitat, the more northern regions are a complex mosaic of forest types designated as evergreen, mixed deciduous, dry dipterocarp, pine, teak plantation, etc.,

which are not readily distinguishable on ERTS images. I also provide an estimate of the amount of pileated gibbon habitat in neighbouring Cambodia from LANDSAT-1 images interpreted with the aid of a vegetation map with elevation and climatic data (LEGRIS and BLASCO, 1972), based on arial photography and ground studies.

The Forest Department estimates that the amount of forest destroyed since their surveys ranges from 28 to 33%, depending on the region. For our purposes, these percentages may be too conservative. My estimates of forest still standing tend to be lower, mainly because I include only relatively intact and solid areas of forest in which at least 75% of the tree cover is still standing (estimated by eye). The peripheral areas that are eliminated in this process are about 10 to 20% of the intact forest area. This was done because such peripheral areas are subjected to heavier hunting pressure, and because the LANDSAT-1 images are already 2 to 3 years old. Such areas will be nearly completely felled by now.

One gibbon group per square kilometer is a reasonable approximation of the average density of gibbons in undisturbed areas of forest, free of hunting. Estimates of territorial size of the white-handed gibbon range from 16 to somewhat over 50 ha (CARPENTER, 1940; ELLEFSON, 1974; CHIVERS, 1972) and groups have been found living in isolated stands of trees of 4-6 ha (BERKSON *et al.*, 1971), but the average amount of forested area per group has usually been found to be closer to 100 ha (1 sq. km) (CARPENTER, 1940; ELLEFSON, 1974). This may be due to the limited distribution of water in the dry season, availability of food during poor seasons or years, terrain unsuitability for tall forest growth, or other reasons. CHIVERS (1974), who has done the most detailed analysis, has found densities of the white-handed gibbon in his survey areas in West Malaysia to range from 0.70 to 3.54 groups per sq. km, with most regions having between 1 and 2 groups per sq. km. In well protected areas of Khao Yai National Park, I have found the average density to be 2 to 3 groups per sq. km.

Mountainous terrain makes estimation of gibbon habitat especially difficult, because many rocky hills and bluffs are covered with only scrub

forest, and the larger ranges typically have rather moist forests of reduced stature and tree diversity covering their cooler, higher elevations. I have eliminated significant areas over 1000 m in elevation, as gibbons are not generally found above this level.

The white-handed gibbon has been found in partly deciduous forests (BERKSON *et al.*, 1971; MARSHALL *et al.*, 1972) which are widespread in northern Thailand. I know of no estimates of density in this type of forest, but it probably does not reach one group per sq. km.

Observations so far indicate that the pileated gibbon has a territory size and density similar to those of the white-handed gibbon. In Khao Yai National Park, two pileated groups have been found inhabiting somewhat less than 1 sq. km, and in another area of 4-6 sq. km, I heard five white-handed and four pileated gibbon groups. Their territories do not appear to overlap.

The point of all this discussion is that, even in the best of natural conditions, gibbons are not very crowded. We will now evaluate the distributional area of each species.

Hylobates lar populations

The estimated areas of evergreen and mixed deciduous forest in the range of the white-handed gibbon are shown in Table 1, which also gives the area included in national parks and wildlife sanctuaries.

In the 14 southern provinces forests are now largely confined to mountain ranges, of which three major divisions may be recognized. The most extensive forests cover the range extending from the Thai-Burmese border south into Phang-nga and Phuket Provinces. The largest intact forest area, in Ranong, Phang-nga and western Surat Thani Provinces, contains more than 5000 sq. km, and is one of the largest relatively undisturbed pieces of gibbon habitat left in the kingdom. Two roads have been recently built through the southern end, however, which are already accompanied by strips of deforestation up to 5 km wide. The western range contains a sanctuary of 480 sq. km (Khlong Nakha) in Ranong Province and another of 1084 sq. km. (Khlong Sang) in Surat Thani. The second range extends from northern Nakhon Si Thammarat

south to Satun Province at the Malaysian border, with about 4630 sq. km, but is severed by roads in at least four places. It contains a wildlife sanctuary (Khao Ban That) of 1288 sq. km near the south end and a national park (Khao Luang) of 1056 sq. km in the North. Much logging by clearcutting up the steep slopes can be seen from the railway on the west side, in Surat Thani Province.

Between these two ranges lie about seven isolated forest areas including an estimated 1644 sq. km of intact forest. They are rapidly being destroyed.

The third area of forested mountains lies on the Malaysian border. The parts not occupied by the agile gibbon, in Songkhla and in some ranges in eastern Narathiwat Province, include about 1270 sq. km, but this is tentative, as the exact distribution of the agile gibbon in Thailand has not been definitely established.

The southern total of 16,440 sq. km probably represents the richest area of habitat of the white-handed gibbon in the kingdom. The forests in the West, North and Northeast could probably support at least 40,000 groups (assuming that deciduous forests could support half as many gibbons as evergreen forest), which gives a carrying capacity of about 55,000 groups (220,000 individuals) of this species for the entire kingdom, if the forests were adequately protected. Of the total forested area, 12,234 sq. km is now included in wildlife sanctuaries and 5,490 sq. km in national parks. If adequately protected, these areas could hold 10,000 to 20,000 groups, but an unknown proportion of several of the parks and sanctuaries consists of deciduous, bamboo, or previously logged forest.

In former times, there must have been about 10 times as much gibbon habitat in Thailand as there is today, and perhaps 20 to 50 times as many white-handed gibbons. Although parks and sanctuaries being developed or planned on the peninsula could save significant remnants of the former population from extinction, none of these areas can be fully protected yet from either logging or hunting.

Hylobates agilis populations

The agile gibbon occurs in Thailand in forests along the Malaysian border from approximately the Songkhla-Yala border east to about the

Sai Buri River, which I suspect limits it geographically in the East. Although the border areas have not been accurately established, it is known that the agile gibbon occurs in the Pattani River drainage. Areas of interspecies contact may occur in the highlands, where rivers are no separating barrier.

The total habitat of this species is an estimated 2000 to 3000 sq. km. (The Pattani River Dam Project planned for Yala Province would inundate only 10 to 15 sq. km of undisturbed habitat, mostly on the tributary Khlong Ha Ra.)

Hylobates pileatus: Interaction with *Hylobates lar*

The pileated gibbon is second in abundance to the white-handed gibbon in Thailand, with which it is largely allopatric. An area of overlap in distribution between the two species occurs in Khao Yai National Park, which is the northwestern extremity of the range of the pileated gibbon (Figure 1, Area 1). The area of overlap in the park is at least in the tens of square kilometers. The white-handed gibbon occurs in the western one-fourth of the park area, about 550 sq. km, which includes most of the valley area developed for visitors. Although MARSHALL *et al.* (1972) reported little segregation of the area by species, we have since found areas near Khao Khieo and Khao Rom (the long mountain which the paved road ascends), at the eastern side of the valley, where the pileated gibbon becomes prevalent, and about a dozen groups have been seen or heard. The sections of the park to the east have not been adequately explored for gibbons, but only the pileated gibbon (has been seen in the far eastern part of the park, and I believe that the pileated gibbon predominates, perhaps exclusively, in the intervening region. It is possible that the zone of contact is not very old in the phylogeny of the species, and that it is the result of the extension of the range of the white-handed gibbon southward or eastward into that of the pileated gibbon.

The interaction between the two species at the ecological and behavioural levels could bear importantly on the future of the rarer species. Observations thus far indicate that (1) there are no obvious differences in habitat preference or food habits between the species, and

(2) there is behavioural interaction between them, some of it aggressive. It is possible that one species will displace the other, given a long enough period of time, but it will require much further study to determine this.

Hylobates pileatus populations

Table 2 lists all significant intact areas of forest within the range of the pileated gibbon. I exclude *fouillé dense* from the evergreen forest of the Cardamom and Elephant Mountains (as shown on the French vegetation map) which occurs mostly at high elevations.

Area 1, in Khao Yai National Park, has perhaps 1000 or more pileated groups if this species is as prevalent as my limited observations indicate in the eastern region. Areas 2, 5, 9, and 10 comprise the bulk of the species' range in Thailand. I have reports of gibbons near both ends of Area 5 and in Areas 2 and 9. Unfortunately, these areas are faced with nearly complete destruction in the near future, judging from present trends, and the number of gibbons in them at present is probably of interest only for future historical record. Within the next three decades, or by the year 2000 A.D., I expect no habitat for the pileated gibbon to remain outside of the parks and sanctuaries that are successfully brought under protection. The only significant refuge areas at present are Khao Yai Park, and the combined Khao Soi Dao Sanctuary-Khao Khitchakut National Park area, each containing on the order of 1000 sq. km of habitat. Other areas to be reserved, Khao Khieo Sanctuary (Chon Buri), Khao Sabap Park (Chanthaburi), and the proposed Khao Chamao Park (eastern Rayong) of about 60 sq. km, are probably too small to guarantee significant populations of gibbons and other large mammals for the distant future, and gibbons are already scarce in these areas.

In summary, there are about 13,500 sq. km of pileated gibbon habitat remaining in Thailand, of which 2632 sq. km are to be protected, and about 28,790 sq. km in Cambodia, the fate of which remains uncertain. Approximately 43% of the Cambodian forest consists of semideciduous forest covering low or moderate elevations in the North that is being increasingly disturbed and eliminated (most of this is off the map in Figure 1 to the east). The areas of evergreen forest around

the Elephant Mountains (southeasternmost part of Area 12) show much clearcutting near main roads, similar to that occurring in Thailand. I have no recent records of gibbons from Cambodia, nor do I know anything about forest reserves or land policies. Such information should be sought as soon as political conditions permit.

In Thailand as many as 10,000 of this species might be supported in the larger areas to be protected, a small remnant of the 2 to 3 million pileated gibbons that probably occurred in Thailand before deforestation began.

Discussion

The uncertain fate of Thai gibbons

Although, on the whole, there are still many thousands of square kilometers of gibbon habitat left in Thailand, and no doubt thousands of gibbons, there is ample reason to be extremely worried about the future of Thai gibbon populations. The continuing forest destruction everywhere and largely uncontrollable hunting are virtually certain to wipe out nearly all gibbon populations in the kingdom. The remnants remaining will not be able to sustain any significant exploitation or hunting for export—certainly not at the level that is occurring today. I see no objective evidence that present trends will slow down or stop; if I am to be proven wrong, it will have to be fairly soon. It does not seem worthwhile arguing whether it take 20, 30, or 50 years to finish off the evergreen forests.

However, the species of gibbons are not now (this moment) equally endangered. The white-handed gibbon is still widespread in Thailand, and will be the last to be reduced to critical numbers. The pileated gibbon is rapidly being reduced by the uncontrolled deforestation and hunting in the Southeast, and soon will be confined to a few relatively small areas. This species will then be largely confined to Cambodia. The agile gibbon at the Malaysian border may also soon become threatened, as there is no area to be protected within its range.

The white-cheeked gibbon may no longer occur naturally in Thailand, if it once did. This is unfortunate, because the entire range of this

species now lies within Laos, Vietman, eastern Cambodia, and the Peoples Republic of China, inaccessible to most of the world's scientists and naturalists. This species is quite different from all other gibbons, and is believed to have been the first to diverge from the rest of the Family Hylobatidae (GROVES, 1972). Its natural behaviour and ecology have never been studied. White-cheeked gibbons occur as pets in the Northeast, but it is difficult to ascertain whether they were captured in Thailand or Laos. The presence of this species in Thailand would mean that Thailand has more gibbon species than any other country.

General management possibilities

Gibbons cannot be perpetuated in significant numbers artificially, despite attempts to do so. Their maximum reproductive rate is low (about one offspring per pair every 1-2 years), and many individuals will not reproduce in captivity. Even if captive populations could replace themselves (some zoos have had good success), any margin of increase would be extremely low and unsteady.

The SEATO Medical Research Laboratory (SMRL) in Bangkok has since about 1965 maintained a large captive colony of gibbons for medical research, and has attempted to propagate them artificially. This has involved both breeding them in pairs in large cages, and establishing a free-ranging colony on a 24-ha island in the Gulf of Thailand (BERKSON *et al.*, 1971; BROCKELMAN *et al.*, 1973, 1974). In the breeding cages, 16 adults have produced a total of 26 young. In the island study, carried out from 1965 to 1970, ten pairs were introduced in all, but only four mated pairs remained established at the end (the others either dying or being returned to the laboratory because of failure to adjust to the free-ranging environment), each producing one offspring.

Captive animals show great variations in behaviour and many are never able to successfully mature and form a normal pair bond for breeding. Most were captured while very young for the pet market and were deprived of their normal family life and the natural environment, which are necessary for normal social development. Those individuals that are successful in breeding in captivity, however, may produce many offspring.

Breeding gibbons in a free-ranging environment also requires, in addition to careful management, a relatively large, isolated area of habitat. Unlike the naturally more sociable macaques, baboons, and chimpanzees, gibbons will not tolerate crowding. Each family unit requires a large area of forest to itself, or else fighting and deaths or emigration will lower the density. This behavioural intolerance to crowding among adults of the same sex (but not immature animals) is part of the genetic heritage of the species and is relatively inflexible.

BERKSON *et al.* (1971) have argued that gibbons may be successfully managed without much effort in small isolated patches of forest of about 5 ha. This is supported by observations of family groups naturally persisting in such places. The restocking of such patches could well be a useful management technique where gibbons are to be exploited in some way for entertainment, research, or breeding, and where security and supporting facilities are available. But such isolates could not guarantee the long term survival of the species. Security will always be a problem, and emigration and new group formation will be hindered at best. Large expanses of forest capable of supporting at least thousands of individuals are necessary to maintain a sufficiently large and continuous gene pool and as a buffer against man's capricious and unstable policies, practices and politics.

We should strive to conserve any desirable species or natural community for at least as long as we ourselves would like to persist as a species: for thousands, hundreds of thousands, or (with extreme optimism) millions of years. Sanctuaries containing less than about 1000 sq. km may not be able to insure stable populations on these time scales. Recent ecological research, concerned mostly with the biogeography of animal communities occurring naturally on islands, has yielded findings that appear relevant to the problem of conserving biological species (MACARTHUR and WILSON, 1968; MACARTHUR, 1974; DIAMOND, 1973; TERBORGH, 1974). Indirect evidence indicates that the probability of extinction of a vertebrate species within, say, 1000 years increases markedly as the area of an island or other isolated piece of habitat is reduced below about 1000 sq. km. A few large protected areas are a

much better guarantee of long term survival than a larger number of smaller, isolated areas.

This is not to say that smaller protected areas cannot play a useful role in primate conservation, however. Public education is one important function that could be served by protecting gibbons or other animals in smaller reserves near cities or towns. Others are experimentation with various management techniques such as rehabilitation of captive animals, recolonization, controlled harvesting, or studies of the suitability of altered habitats.

The rehabilitation and release of captive animals into the wild may often be preferable to letting them weaken and languish uselessly on chains or in cages. The SMRL's island project demonstrated that this feasible, and the Royal Forest Department has also carried out pilot rehabilitation studies. Rehabilitation procedure should involve (1) inclosure of adult pairs together in large cages to insure compatibility, (2) habituation to a more natural diet of wild fruits and leaves, (3) carefully watched release into the wild, away from human settlements, and (4) continued observation to insure that the animals successfully adjust to the forest environment. Experience thus far indicates that not all captive individuals are strong and adaptable enough to make the transition, and that some mortality is to be expected. Nevertheless, many people will agree that one successful release into the wild is worth more to conservation than many in the cage.

Conservation and land use

As important as gibbons may be, why save Thailand's forests just for them? When the human population in the kingdom expands within the 100-200 million range within two more generations, the supply of land and resources will become more critical. Few people would advocate that saving the gibbons (or any other wildlife species) justifies depriving the people of their forests—but the issue is not correctly stated. Natural forest ecosystems serve a variety of functions in the total human ecosystem, only one of which is to provide a place for game animals and other useful species. The idea that our expanding population justifies the clearing of forests to obtain more resources and land no longer makes

any sense, either economically or ecologically, in the long run. Although there is no space here for full supporting arguments, I outline some general reasons.

- (1) Forests, with the hundreds of products of commercial value they provide, are in theory renewable, but they are being utilized in an uncontrolled and nonrenewable fashion in all tropical regions of the earth. When clearcut over wide areas, broad-leaved evergreen forests, with their thousands of species of plants and animals, many of yet unknown utility to man, do not return to their original stature and diversity on any reasonable time scale. Regeneration into a more manageable monoculture tree plantation is not feasible or advisable in many types of tropical forest environments with their high rates of leaching of soil nutrients, erosion, and often unmanageable insect and weed pest problems.
- (2) Forests over important watersheds are now being recognized for their value in stabilizing water flow to lowland areas and controlling sediment load.
- (3) The upland slopes to which forests are now largely confined are very poor for sustained farming, in general. It is difficult or impossible to apply the methods of modern technological agriculture in the mountains. Slash-and-burn agriculture is very low in productivity on a total area basis, and alternative methods of subsistence must be found if people are to continue to live in these forested areas. Bare subsistence and continued poverty are the rule to which I have never seen exception among such farmers. Increased agricultural modernization and land reform in the more fertile lowlands are the key to increasing per capita productivity, not clearing of more evergreen forest area.

Of course, I should not underestimate the difficulty of solving these forest and land use problems. I review them because it is important for conservationists to understand the full difficulty and complexity of the problem of conserving gibbons or other species which depend on these forests for their continued survival, and the magnitude of the problem facing us.

Acknowledgments

This synthesis of information was made possible by the generous cooperation of many people. A constant source of information and companionship in the Field have been Dr. Joe and Mrs. Elsie Marshall. I also thank Mr. Pong Leng-Ee, Chief, Wildlife Conservation Division, Royal Forest Dept., and Mr. Phairot Suwanakorn, Chief, National Park Division, for providing much useful information concerning parks, sanctuaries and wildlife. Dr. Sathi Chaiyapechara kindly provided information concerning forests. The National Research Council of Thailand was especially cooperative in providing the satellite images. Ms. Ardith Eudey, Dr. Tem Smitinand, Mr. Peter Rand, Mr. John Paxton and Mr. Wirachai Na Nakorn gave me the benefit of their field observations, and Dr. Shirley McGreal provided information on international trade. The following people helped by reading and criticising the manuscript: Dr. C. P. Groves, Dr. J.T. Marshall, Mr. Pong Leng-Ee, Mr. J. F. Maxwell and Mr. J. A. McNeely.

REFERENCES

- BERKSON, G., B.A. ROSS and S. JATINANDANA, 1971. The social behavior of gibbons in relation to a conservation program, pp. 225-255. In (L.A. ROSENBLUM, ed.) Primate behavior: developments in field and laboratory research. Academic Press, New York.
- BROCKELMAN, W. Y., B. A. ROSS and S. PANTUWATANA, 1973. Social correlates of reproductive success in the gibbon colony on Ko Klet Kaeo, Thailand. Amer. J. Phys. Anthropol. 38: 637-640.
- BROCKELMAN, W. Y., B. A. ROSS and S. PANTUWATANA, 1974. Social interactions of adult gibbons (*Hylobates lar*) in an experimental colony, pp. 137-156. In (D. M. RUMBAUGH, ed.) Gibbon and siamang, Vol. 3. S. Karger, Basel.
- CARPENTER, C. R. 1940. A field study in Siam of the behavior and social relations of the gibbon (*Hylobates lar*). Comp. Psychol. Monogr. 16 (5): 1-212.
- CHIVERS, D. J. 1972. The siamang and the gibbon in the Malay Peninsula, pp. 103-134. In (D. M. RUMBAUGH, ed.) Gibbon and siamang, Vol. 1. S. Karger, Basel.
- CHIVERS, D. J. 1974. The siamang in Malaya: a field study of a primate in tropical rain forest. Contr. Primatology, Vol. 4, S. Karger, Basel.

- DIAMOND, J. M., 1973. Distributional ecology of New Guinea birds. *Science* **179** : 759-769.
- ELLEFSON, J. O., 1968. Territorial behavior in the common white-handed gibbon, *Hylobates lar* Linn., p. 180-199. In (P. C. JAY, ed.) *Primates : studies in adaptation and variability*. Holt, Rinehart and Winston, New York.
- ELLEFSON, J. O., 1974. A natural history of gibbons on the Malay Peninsula, pp. 1-136. In (D. M. RUMBAUGH, ed.) *Gibbon and siamang*, Vol. 3. S. Karger, Basel.
- GROVES, C. P., 1972. Systematics and phylogeny of gibbons, p. 1-89. In (D. M. RUMBAUGH, ed.) *Gibbon and siamang*, Vol. 1. S. Karger, Basel.
- International Primate Protection League, 1974. Illegal traffic in gibbons. *Newsletter*, Vol. **12** : 5-6.
- LEGRIS, P. and F. BLASCO, 1972. Carte internationale du tapis végétal et des conditions écologiques : Cambodge. Extrait des travaux de la section scientifique et technique de l'Institut Français de Pondichéry. Hors. Série No. 11.
- LEKAGUL, B. and J. A. MCNEELY. *Mammals of Thailand. (in press)*.
- MACARTHUR, R. H. 1972. *Geographical ecology : patterns in the distribution of species*. Harper and Row, New York. 269 p.
- MACARTHUR, R. H. and E. O. WILSON, 1968. *The theory of island biogeography*. Princeton Univ., Princeton. 203 p.
- MCCLURE, H. E., 1964. Some observations of primates in climax dipterocarp forest near Kuala Lumpur, Malaya. *Primates* **5** : 39-58.
- MARSHALL, J. T., B. A. ROSS and S. CHANTHAROJVONG, 1972. The species of gibbons in Thailand. *J. Mammal.* **53** : 479-486.
- TERBORGH, J., 1974. Preservation of natural diversity : the problem of extinction prone species. *BioScience* **24** : 715-722.
- WILSON, E. O., 1975. *Sociobiology : The new synthesis*. Belknap Press, Harvard Univ., Cambridge. 697 p.

Table 1. Estimated areas of habitat of the white-handed gibbon in different regions of Thailand in sq. km. Data for North, Northeast, and West courtesy of Royal Thai Forest Department. These areas have been discounted by percentages estimated to have been destroyed since the surveys. Data for South from LANDSAT-1 images.

Region	Total area	Evergreen forest	Mixed deciduous forest	Wildlife sanctuaries area and no.	National parks : area and no.
North	171,186	12,529	29,375	2,825 (2)	2,771 (5)
Northeast ¹	170,226	3,742	2,292	2,261 (2)	550 (1)
Central	24,465	0	0	0	0
West	42,675	9,170	3,180	4,296 (2) ²	1,000 (1)
South	69,964	16,440	0	2,852 (3)	1,169 (2)
Total	478,516 ³	41,881	34,847	12,234	5,490

1) Known present *Hylobates lar* range includes only forests in Loei, Khon Kaen, and Chaiyaphum Provinces, and about 550 sq. km of Khao Yai National Park in Nakhon Ratchasima, Saraburi and Nakhon Nayok Provinces, which is included.

2) Includes sanctuary partially in southern Tak Province.

3) Total area of Thailand is 514,910 sq. km.

Table 2. Estimated areas of remaining habitat of the pileated gibbon in southeastern Thailand, Cambodia and Laos. See map in Figure 1 for location of areas.

Area No.	Province(s)	Description of area	Sq. km
Thailand :			
1	Prachinburi, Nakhon Ratchasima, Nakhon Nayok	Khao Yai National Park east of about 101°25' E.	1,300
2	Nakhon Ratchasima, Prachinburi, Buriram, Surin	Western parts of Dong Rek Range.	4,250
3	Si Saket	Middle of Dong Rek Range.	669
4	Ubon Rachathani	Forested highlands in easternmost part of Dong Rek Range in Thailand.	706
5	Chon Buri, Rayong, Chanthaburi, Chachoengsao	Large expanse of forest, much of it lowland, between 12°50' and 13°45' N, southwest of Highways 33 and 317. Includes about 922 sq. km of forest in Khao Soi Dao Wildlife Sanctuary and 100 sq. km in Khao Khitchakhut National Park in the southeasternmost part.	4,644
6	Chon Buri	Khao Khieo Wildlife Sanctuary. Population now small.	82
7	Rayong	Scattered isolated mountains. Gibbons probably extinct in these small areas.	86
8	Chanthaburi	Khao Sabap National Park. Relatively isolated range with few gibbons remaining.	120

9	Prachinburi, Chanthaburi	East of Highway 317 to Cambodia, north of 13° N.	663
10	Chanthaburi, Trat	Southeasternmost parts of Thailand, bordering Area 12 in Cambodia.	1,244
Cambodia :			
11		Eastward extension of Area 9, north of Mongkol River.	1,625
12		Evergreen forest south of Mongkol River covering Elephant and Cardamom Ranges.	14,754
13		Semideciduous forest, undisturbed or little disturbed, in northern Cambodia west of Mekong River.	12,412
Laos :			
14		Semideciduous forest in southwestern corner of Laos. Presence of gibbons here not confirmed, but once continuous with other pileated gibbon areas.	844
<hr/>			
		Grand total	43,193
		Total, Cambodia	28,791
		Total, Thailand	13,558
		Sanctuaries and parks known to contain gibbons, Thailand.	2,632
<hr/>			

