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A SURVEY OF THE TAXONOMIC STATUS OF CAPTIVE GIBBONS IN TAIWAN

Hou-Chun Chen
Taipei Zoo, 30 Sec. 2 Hsin Kuang Road, Taipei, Taiwan, R.O.C.
Email: chc0316@ms3.hinet.net

Thomas Geissmann
Anthropological Institute, University Zurich-Irchel, Winterthurerstrasse 190, CH-8057 Zurich, Switzerland
Email: thomas.geissmann@aim.unizh.ch

Pao-Chung Chen
Taipei Zoo, 30 Sec. 2 Hsin Kuang Road, Taipei, Taiwan, R.O.C.

***ABSTRACT.* –** The gibbons or small apes (Hylobatidae) of South-east Asia include several highly endangered species. In the 1980s, gibbons were very popular in Taiwan as pets and were imported into the country in high numbers. Their diversity as well as the abnormal presence of captive-bred hybrids frequently causes problems in species identification. Given the importance of taxa identification as a necessary step for conservation, we conducted a survey of the captive gibbon population in Taiwan. We applied morphological analysis, DNA analysis, and vocal identification to identify the numerous gibbon species. Our 2002 survey revealed 83 gibbons of eight species in Taiwan. Our findings correct the original records in zoos and rescue centers and will help to prevent further hybridization. The results of this survey will be useful in establishing breeding programs and for improving ex-situ conservation of gibbon species in Taiwan. Finally, this study provides a template for similar work on captive gibbon identification elsewhere.

***KEY WORDS.* –** Hylobatidae, ex-situ conservation, systematics, species identification.

INTRODUCTION

Most gibbons or small apes (Hylobatidae) are endangered, and this group includes the world's three most critically endangered ape species (Geissmann, 2002a; Geissmann et al., 2000, 2003). Yet gibbons are often overlooked because media and scientists alike tend to focus on the more popular large-bodied apes (e.g., chimpanzees, bonobos, gorillas, and orangutans). With this in mind, gibbon specialists attending the 19th congress of the International Primatological Society in Beijing recently urged top priority to be given to gibbons (Geissmann, 2003) in order to prevent the first ape extinction of the 21st century.

In the early 1980's, many primates, ranging from small monkeys to gibbons and orangutans, were kept in private homes in Taiwan. The primary cause of this was that baby orangutans and gibbons were actively popularized by the media as adorable pets. At that time, primates were not legally protected in Taiwan, and most Taiwanese knew little about the importance of primate conservation. Moreover, primate owners had almost no experience or knowledge of how to feed and care for these animals. Possessing an ape as a pet became a status symbol, and it was easy to find infant gibbons and orangutans, kept in boxes like puppies in Taiwanese pet stores. In 1985, the Taiwanese government began to address conservation issues, and people became more aware of conservation concepts. However, there were no laws protecting endangered animals housed as pets, and because of the lure of big money, the illicit (although not illegal) trade of apes continued unabated. These animals could be bought in certain countries in South-east Asia where they are indigenous, for the equivalent of one hundred New Taiwan dollars, but they could often be resold for more than a hundred times that amount. This tarnished Taiwan's reputation in the eyes of animal right groups and animal loving people all over the world.

In 1989, Taiwan enacted the Wildlife Conservation Act, a law that drastically curbed but did not end, the ape trade. By this time, the owners' 'cute baby monkeys' had grown to adulthood and were no longer adorable pets. Their owners would discard them on the street as if they were trash (Chen & Yang, 1993). Furthermore, due to the strictness of the law, keeping pet apes became so difficult that more and more owners began to discard their pets (Agoramoorthy, 1995). After the Conservation Act was passed, Taiwanese people became increasingly supportive of primate projects. One such

Table 1. Gibbon classification (Geissmann, 2002c).

Genus	Diploid number of chromosomes	Other division names	Species	
Hylobates	44	*Lar* group	*H. agilis* [1]	Agile gibbon
			H. klossii	Kloss's gibbon
			H. lar	White-handed gibbon
			H. moloch	Silvery gibbon
			H. muelleri [2]	Müller's gibbon
			H. pileatus	Pileated gibbon
Bunopithecus	38		*B. hoolock*	Hoolock
Nomascus	52	*Concolor* group, crested gibbons	*N. concolor*	Western black crested gibbon
			N. gabriellae	Yellow-cheeked crested gibbon
			N. leucogenys [3]	White-cheeked crested gibbon
			N. sp. cf. *nasutus*	Eastern black crested gibbon
Symphalangus	50	*S. syndactylus*	Siamang	

[1] including *H. agilis albibarbis*.
[2] including *H. muelleri abbotti* and *H. muelleri funereus*.
[3] including *N. leucogenys siki*.

project, named "Send the orangutan back to Indonesia" was to repatriate orangutan to their natural habitat. During the widely-publicized efforts supporting orangutan conservation, the many ex-pet gibbons appeared to be forgotten.

Currently, four genera of gibbons are recognized (Geissmann et al., 2000; Roos & Geissmann, 2001). They differ in, among other features, in their diploid chromosome number: *Bunopithecus* (2n=38), *Hylobates* (2n=44), *Nomascus* (2n=52), and *Symphalangus* (2n=50). These four genera are classified into 12 species (Table 1).

Because of their high taxonomic diversity, their high intra-specific variability in fur coloration (including sexual dichromatism, polychromatism and multiple ontogenetic colour changes) and the relatively small amount of research and publications on this ape group, the identification of gibbons in zoos can be problematic. Usually, no information on the origin of zoo gibbons is available, making identification more difficult. Based on fur coloration characteristics alone, it is particularly easy to confound *Hylobates moloch* with *H. muelleri abbotti*, *H. muelleri muelleri* with *H. agilis albibarbis*, male *Bunopithecus hoolock* with dark *H. agilis*, and female *Nomascus leucogenys* with *N. gabriellae*. Many non-specialists are even unsure whether dark gibbons without light face markings are *N. concolor*, *H. klossii*, *H. agilis* or *Symphalangus syndactylus*. Identification of gibbon species based on vocal characteristics is more reliable, but only relatively few specialists are familiar with the method and call variability. Identification based on DNA sequences is a little-tested option which, in addition, is expensive. As a result, incorrectly identfied gibbons are common in zoos worldwide (TG, pers. observ.).

In order to set up a captive breeding program in Taiwan with zoo gibbons of unknown origin and taxonomic status, we made special efforts to identify all individuals. The research plan for the present study was presented, and published as an abstract, at the 10th Conference of the South-East Asian Zoos Association (SEAZA) (Chang et al., 2002). We describe here our approach at resolving the identification problem and our results.

MATERIALS AND METHODS

Because gibbons can be difficult to identify, particularly when hybridization had occurred, we used three methods to identify the gibbons observed in our survey.

***Morphological analysis.* –** This method is based largely on fur coloration, but other external features such as body weight, the presence or absence of a throat sac, the extent of inter-digital webbing, or the size of the male genital tuft may also be considered. To make a general identification, we followed Geissmann's (1995) identification key, along with photographic updates from his web archives (available at www.gibbons.de) to make a general identification. We used Rowe's (1996) pictorial guide to living primates as a supplementary reference. In addition, Alan Mootnick, director of the International Center Gibbon for Studies (USA), assisted in 2000 in identifying individuals. Fur coloration of all 83 gibbons of this studied were examined directly by one of us (HCC).

***DNA analysis.* –** Forty-two hair follicles or blood samples were collected for mitochondrial DNA extraction and identification. The extracted and purified mitochondrial DNA were amplified by polymerase chain reaction (PCR) and subjected to DNA sequencing. We used published mitochondrial DNA sequence data as a comparison to our sequences, including those of Garza & Woodruff (1992) for

Table 2. Captive gibbons of surveyed zoos and institutions in Taiwan. Commas separate (from left to right) males, females, and unsexed individuals, respectively.

Species	Taipei Zoo	Hsin Chu Zoo	Kaoshiung Zoo	Lefoo Zoo	Leopard World	Pingtung Rescue Center	Private hand	Total
H. agilis	2,1	1,1	3,0	3,0	3,1	2,0	0,1	14,4
H. klossii								0
H. lar	8,7		1,1	2,2	2,2	1,3		14,15
H. moloch		1,0 [a]						1,0 [a]
H. muelleri	3,1	1,2		1,2	1,1	2,1	2,0	10,7
H. pileatus							0,1	0,1
B. hoolock								0
N. concolor								0
N. gabriellae	2,1		1,0				0,1	2,2
N. leucogenys	1,0			0,1			0,1	1,2
N. sp. cf. *nasutus*								0
S. syndactylus	2,2			1,0				3,2
Hybrid	0,1			1,1 [b]	0,0,1 [c]			1,2,1
Total	18,13	3,3	5,1	8,6	6,4,1	5,4	2,4	47,35,1

[a] Unconfirmed, identification based on fur coloration only.
[b] *H. agilis* x *H. muelleri*, based on identification of parents.
[c] *H. muelleri* x *H. lar*, based on identification of parents.

Table 3. The number of gibbon identifications tested, the number of originally misidentified individuals discovered, and the number of gibbons that we were unable to identify reliably with each of three methods.

Numbers of gibbons	Type of data		
	Fur characteristics	DNA sequences	Vocal characteristics
tested with method	83	43	58
found incorrectly identified	12	11	17
not reliably identifiable with method	6	2	0

cytochrome *b*, and Hayashi et al. (1995) for ND4 and ND5. We used our mtDNA sequences were used to construct phylogenetic trees in order to identify the gibbon by species (Hu et al, 2000).

***Vocal identification.* –** All gibbon species produce long and loud morning song bouts that include species- and sex-specific characteristics (Geissmann, 1995, 2000, 2002 b, c). We tape-recorded the songs of fifty-six individuals that are over four yeas old, and used Thomas Geissmann's gibbon sound gallery (available on the internet at www.gibbons.de) as a reference for species identification. Our sound equipment consisted of a directional microphone (Sennheiser K6+ME67) and a cassette recorder (Sony TCM 5000EV, Type II). We generated sonagrams using the computer programs STX and Syrinx.

RESULTS

We found 83 gibbons of represent eight species in Taiwan (Table 2). Most gibbons were probably imported to Taiwan from Thailand (*H. lar*, n = 29), Indonesia and Malaysia (*H. agilis* n = 18, *H. muelleri* n = 16, *S. syndactylus* n = 5), but some also came from Indochinese countries (species of the genus *Nomascus*, n = 7). Highly endangered taxa (such as *H. moloch*, *H. klossii*, *N. concolor, and N.* sp. cf. *nastutus*) and taxa distributed in areas that are geographically furthest remote from Taiwan (*Bunopithecus*) are rare or completely absent.

Table 3 lists the number of gibbon identifications we carried tested, the number of inccorrectly identified individuals we found among these gibbons, and the number of gibbons which

remained not reliably identified with each of three methods we used (i.e. based on fur characteristics, DNA sequences and vocal characteristics, respectively).

DISCUSSION

Our survey has helped to verify gibbon species numbers held in captivity in Taiwan. Our results have at least two critical and long-term consequences for ex-situ conservation. First, they allow zoos personnel in Taiwan to update and correct collection records. During our survey, we discovered that zoo staff members often found it difficult or impossible to accurately identify gibbon species. For example, we found 15 gibbons which were incorrectly identified as *H. agilis*, *H. muelleri*, or *B. hoolock*. Misidentification has several undesirable consequences. Incorrect labels on cages mislead visitors and undermine zoos' conservation education efforts. Keeper may also inadvertently create breeding pairs of mixed species that results in hybridization. Zoos personnel can avoid both of these situations in the future by using our newly corrected information.

Second, accurate species identification information is necessary for maintaining a stable ex-situ population. Wild gibbon populations are threatened by the loss, fragmentation, and degradation of their habitat, hunting pressure (for food, medicine, and sport) and the illegal wildlife trade (pets and medicine) (Geissmann, 2003). In addition to efforts directed at improving in-situ conservation, it is also important to establish viable breeding programs in safe environment. Because gibbons live in small, monogamous family groups, they require more independent exhibits in which to breed than polygamous species such as chimpanzees or gorillas, which can be kept in large groups including more breeding individuals than just one pair. Correct information on identification and optimal captive management of all taxa becomes crucial in this case to avoid wastage of valuable exhibit space.

In 2002, the Taipei Zoo developed a three point strategy to improve ex-situ conservation of gibbons. Two gibbon species, *N. gabriellae* and *N. leucogenys*, were chosen as the conservation breeding species. At the time of the writing this paper, additional special exhibits are being built on zoo property, and all *N. gabriellae* and *N. leucogeny* individuals living in Taiwan will be collected and brought to this site for inclusion in the breeding project. Two other gibbon species, *H. lar* and *S. symphalangus*, will also be on display. The Taipei zoo's remaining gibbon species will be exchanged with other zoos. Gibbon education programs will be created to educate the public on the importance of the survival of gibbons in the wild. In addition, the websites will be developed to make knowledge about gibbons more easily available to Chinese speaking people.

Our future objectives include a wider survey of captive gibbons in the South-east Asian Zoos Association (SEAZA) collection in this region. In cooperation with zoos in Indonesia, Malaysia, Singapore, and Thailand, we will tape-record song bouts of zoo gibbons. Staff at Taipei Zoo will establish a comprehensive database of the captive gibbon populations in South-east Asia including molecular data, vocal data and fur coloration data. This database will serve as an important tool for ex-situ gibbon conservation. In addition, the Taipei Zoo is planning several fund-raising events and programs to help support gibbon research and in-situ conservation in South-east Asia.

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