


# The power of gibbon songs: Going beyond the research to inform conservation actions

Susan M. Cheyne<sup>1,2</sup>  | Carolyn Thompson<sup>1,3,4</sup> | Alizeé Martin<sup>1</sup> |  
Abdul Aziz K. Aulia<sup>5</sup> | Helene Birot<sup>1</sup> | Eka Cahyaningrum<sup>5</sup> | Joana Aragay<sup>1</sup> |  
Petricia Andini Hutasoit<sup>5</sup> | Jito Sugardjito<sup>6</sup>

<sup>1</sup>Borneo Nature Foundation International, Penryn, UK

<sup>2</sup>Oxford Brookes University, Oxford, UK

<sup>3</sup>University College London, London, UK

<sup>4</sup>Institute of Zoology, Zoological Society of London, London, UK

<sup>5</sup>Yayasan Borneo Nature Foundation, Palangka Raya, Indonesia

<sup>6</sup>Universitas Nasional, Jakarta, Indonesia

## Correspondence

Susan M. Cheyne, Borneo Nature Foundation International, Penryn, UK.  
Email: [s.cheyne@borneonature.org](mailto:s.cheyne@borneonature.org)

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## Abstract

Gibbons (Hylobatidae) are the smallest of the apes, known for their arboreal behavior and stereotyped songs. These species and sex-specific songs are often the subject of detailed studies regarding their evolution, responses to changing environments, involvement in social behavior, and used to design vocalization-based survey techniques to monitor population densities and trends. What is poorly understood is the value and impact of using the science and sound of gibbon vocalization and gibbon stories in education and outreach to complement nongovernmental organizations (NGOs) efforts. We present an example of how Borneo Nature Foundation, a NGOs based in Indonesia, is working to use the recordings of the songs of Bornean white-bearded gibbons (*Hylobates albibarbis*) to inform conservation actions and education efforts. Gibbons in Indonesia are often poorly known or understood by the public compared to orangutans (*Pongo* spp). We showcase how a field of study, namely primate acoustics, is an untapped resource to create digital content to engage with local, national and international communities and can be developed into educational tools in the form of storytelling, mobile apps and games, to highlight the plight of these threatened species and how to conserve them.

## KEYWORDS

communication, conservation, education, function, singing, smoke

## 1 | HISTORICAL INTRODUCTION ON GIBBONS

Darwin in “Descent of Man” (Darwin 1871) described siamangs (*Symphylangus syndactylus*) and gibbons (*Hylobates agilis*) from the island of Sumatra (Indonesia) and discussed their complex singing in detail (Chapters 18 and 19). Gibbon song has also played a big role in

human myths, legends and culture, both in the past (Turvey et al., 2018; van Gulik, 1967) and in the present (Fan, 2017; Supriatna & Ario, 2015). In China, for example, the gibbon has been known as a species distinct from monkeys since at least the Zhou Dynasty (1027–221 B.C.), where gibbons were described as “the aristocrat among apes and monkeys” and whose singing is mentioned frequently in poems and folktales (van Gulik, 1967). Unpublished stories, myths and legends exist across

**Abbreviations:** BNF, Borneo Nature Foundation; IUCN, International Union for the Conservation of Nature.

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all 11 range countries have since been gathered and collated by members of the IUCN Species Survival Commission Section Primate Specialist Group for Small Apes (<https://gibbons.asia/myths-and-legends-of-the-gibbons/>) and highlight the historical and cultural importance of gibbons. Despite the prevalence of records and stories about gibbons throughout history, gibbons are often regarded as the forgotten or overlooked ape (Fan & Bartlett, 2017) compared to the great apes, particularly in Malaysia and Indonesia where gibbon conservation is overshadowed by a focus on orangutans (*Pongo* spp). The number of gibbons recognized gibbon species has increased from 12 in 2002 to now 20 species across 11 countries (Fan, He, et al., 2017) yet it is a species of gibbon which is the most endangered of all the apes, if not all primates (*Nomascus hainanus*) with only an estimated 35 individuals (Liu et al., 2020). Of the 20 species, five are Critically Endangered, 14 are Endangered and one is listed as Vulnerable on the IUCN Red List of Threatened Species (<https://www.iucnredlist.org/>) and therefore there is an urgent need to conserve them.

### 1.1 | Current situation for small apes (threats and population estimates)

The numbers of gibbons living in non-protected forest is a cause for concern as it is almost impossible to extrapolate current population numbers to these areas without detailed habitat and threat assessments. Gibbons occur in many forests where orangutans are absent, meaning they are the largest fully arboreal frugivore present for seed dispersal and maintaining forest dynamics. It is crucial to remember that while these numbers indicate that gibbon populations are thriving, the habitat loss, wildlife trade and estimates of 50-75% of gibbon populations occur in non-protected areas means that all gibbons in Kalimantan are still highly threatened.

Current estimates are of 115,000 (75,000–130,000) *Hylobates albibarbis* individuals living in Kalimantan, of which, at least 50% are found in Tropical Peat-Swamp Forest, not all of which is protected. Gibbons are able to maintain a good density across different habitat types and even in unprotected forest areas providing these forests remain undisturbed and unfragmented and there is no hunting of the gibbons (Cheyne et al., 2016; Hamard et al., 2010). These population estimates are calculated based on density and forest/landscape size, predominantly focused on forests with some level of legal protection at the national level.

### 1.2 | Gibbon songs—behavioral ecology

Gibbons are small, territorial, socially monogamous, arboreal apes with groups consisting of a mated pair and their offspring (Chivers & MacKinnon, 1977; MacKinnon & MacKinnon, 1984). All species of gibbons produce species-specific and sex-specific vocalisations, predominantly consisting of pure tones, which are typically referred to as “songs” (Cowlshaw, 1992, 1996; Marshall & Marshall, 1976). Mated male-and-female gibbon pairs combine their songs in a relatively rigid and

stereotyped pattern to produce coordinated duet songs (Geissmann, 1993; Mitani, 1985b). These melodic calls are produced around dawn by each mated pair, resulting in a chorus of song across the forest (Geissmann & Nijman, 2006; Wanelik, Azis, & Cheyne, 2013). Theories on the function of gibbon songs include mate attraction (Raemaekers & Raemaekers, 1985), mate defense (Cowlshaw, 1992; van Schaik & Dunbar, 1990), territorial defense (Mitani, 1985a; Raemaekers & Raemaekers, 1985), pair-bond formation and maintenance (Brockelman & Srikosamatara, 1984; Geissmann & Orgeldinger, 2000), and pair-bond advertisement (Cowlshaw, 1992; Haimoff 1984c, 1984a, 1984b). These functions likely vary in importance between different species of gibbons (Geissmann & Orgeldinger, 2000).

Gibbon songs are species-specific (Cheyne et al., 2007; Goustard & Demars, 1973; Haimoff & Gittins, 1985) and have received a great deal of attention over the past 80 years for identifying species (Geissmann & Nijman, 2006; Geissmann & Orgeldinger, 2000; Terleph et al., 2018), assessing population densities (Brockelman & Srikosamatara, 1993; Chan et al., 2017; Cheyne et al., 2016; Hankinson et al., 2021; Höing et al., 2013; Kamaruzaman et al., 2023; Pang et al., 2022; Phoonjampa et al., 2011; Setiawan et al., 2012), exploring different methods for assessing gibbon population densities (Bryant et al., 2016; Chan et al., 2017; Gilhooly et al., 2015; Kidney et al., 2016; Vu & Tran, 2019), understanding individuality (Clink et al., 2017; Terleph et al., 2015, 2018; Wanelik et al., 2013), assessing habitat preferences (Guan et al., 2018; Hamard et al., 2010; Hankinson et al., 2021; Singh et al., 2018), understanding vocal anatomy (McAngus Todd & Merker, 2004), assessing the function of songs in terms of gibbon behavior (Cowlshaw, 1992; Geissmann & Nijman, 2006; Geissmann, 1986; Ham et al., 2016; Heine & Geissmann, 2000; Keith et al., 2009; Tenaza, 1976), and looking at the development of song production in young gibbons (Cheyne et al., 2007). Gibbon songs are critical to assess gibbon density and monitor population trends as well as assessing the possibility for reintroduction of gibbons back into the wild (Campbell et al., 2015; Cheyne, 2006). Emerging technologies open up the opportunity to survey gibbons in more detail using passive acoustic recorders (Bryant et al., 2016; Vu & Tran, 2019) and drones (Stark et al., 2018).

### 1.3 | Gibbon songs for conservation—the singing, swinging apes

Gibbon songs (videos and recordings) are increasingly making their way into the public sphere of communication. For example, the BBC, published a post about the issues affecting the most endangered of the gibbons, the Hainan gibbon (*Nomascus hainanus*) entitled, ‘Conservation: Glimmer of hope for world’s rarest primate’ (<https://www.bbc.co.uk/news/science-environment-52842550>). The songs of the gibbons are predictable, measurable, quantifiable, can be analyzed, and furthermore, these melodic calls resonate with people, both those who live near gibbons and hear them daily, but also those who are only recently learning about the singing, swinging apes. We showcase that videos of gibbons singing and recordings their songs,

while having been intensively researched, are untapped resources to engage the public with gibbon conservation efforts using examples from our conservation research work in Indonesian Borneo. We use the gibbon's song in three ways: to highlight the impact of anthropogenic disturbance (fires and smoke) on gibbon singing and family units (book and app) and how their singing influences their behavioral ecology (game).

#### 1.4 | Current initiatives and education approaches for gibbon conservation

"Conservation education" and "conservation outreach" are terms often used in grant/project proposals and presentations to showcase how nongovernmental organizations (NGOs) are teaching and enhancing capacity building among local communities regarding options relating to how to use their resources sustainably to advance towards conservation goals (Nekaris et al., 2018). There is a need to evaluate conservation education initiatives with a flexible and culturally appropriate approach (Supriatna & Ario, 2015). The implementation of conservation education programs is led in many cases by a western-mindset approach: the people providing the education theories are foreigners that, although skilled in education techniques, are not always fully aware of the local education system, cultural beliefs, social context or knowledge of local dialects (Kling & Hopkins, 2015). Equally skilled local educators may not know the ecological subject material well for example, behavior of gibbons, conservation issues etc. Of equal importance, and often overlooked, is demonstrating that the education and outreach have a measurable effect; that is, that it is driving the desired behavior change (Rivas & Owens, 1999). Where skilled local educators are employed, there is often a lack of awareness of theory of change analysis and how to evaluate education success (Bonine et al., 2003). Theory of Change defines long-term goals for a given action/activity and then allows practitioners to work to identify actions or other activities to be taken to achieve the long-term goals and to sustain these (Biggs et al., 2017; Rice et al., 2020). Often the pressures of dealing with immediate issues can mean that educational programs are not fully planned out with consideration for short-term, intermediate, and long-term outcomes and how to achieve these (Freund et al., 2020).

Education and awareness programs hold a critically important position in changing public attitude towards conservation efforts for primates, including gibbons, where outreach to the public (national and foreign) reduced the use of gibbons in entertainment (Cheyne, 2009; Nijman, 2006; Nijman et al., 2009, 2017; Osterberg et al., 2015). An improvement in public awareness helps people understand and value the economic and environmental benefits of forest preservation and protection (Trombulak et al., 2004). This awareness motivates the public to act against causes of damage to ape habitats (e.g., forest fires, illegal logging, hunting) and support conservation in general (Schoneveld-de Lange et al., 2016). Gibbons are often overlooked in conservation education in favor of orangutans, yet feature in many myths and legends across Sumatra, Java, Mentawai Islands and

Kalimantan. Thus, there is a need to showcase all nine species of Indonesian gibbons to promote a call to action by local people for gibbon conservation (Hoeing et al., 2015a, 2015b).












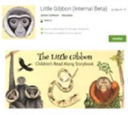



#### 1.5 | Integrating research and practical gibbon conservation action

Borneo Nature Foundation (BNF) is a not-for-profit organization founded in 1999 to protect Bornean rainforests and their biodiversity. Our research projects aim to assess conservation needs and set up community-based projects to maintain and enhance different landscape ecosystems of Central Kalimantan (Cheyne et al., 2016, 2019; Harrison et al., 2020; Struebig et al., 2015). We used data collected from long-term studies on the singing behavior of Bornean white-bearded gibbons (*H. albibarbis*) in a) three distinct habitat types in the Sebangau National Park, Central Kalimantan, Indonesia, since 2005 (Cheyne, 2010; Cheyne et al., 2019; Singh et al., 2018), and b) Rungan Education Forest since 2016 (Buckley et al., 2018; Cheyne et al., 2016). Using these population data we have assessed direct protection of the forests, impacts of reforestation, impacts of forest loss (i.e., from forest fires and illegal logging) and, where possible, hunting of gibbons for the illegal pet trade. This work has helped to form a variety of conservation actions implemented with local government partners, including but not limited to reforestation, habitat protection, community development, scientific research, science outreach, and environmental education.

#### 1.6 | Initiatives about the use of gibbon songs for conservation

Increasing effort is being put to use real-world situations to inform and educate the public about gibbons. This approach, often referred to as "community-based learning," focuses on topics that engage communities with meaningful connections to their surrounding environment (Bennett et al., 2017). Using examples specific to BNF (i.e., books, games and apps, Figure 1), we highlight how these tools can be used as to evaluate engagement and interaction with gibbon behavioral ecology specifically song, before discussing current limitations and areas of future investigation.

In 2015, the IUCN declared this to be the Year of the Gibbon and saw the start of the International Gibbon Day (<https://gibbons.asia/international-gibbon-day/>) held on 24th October annually. To celebrate this, BNF created a children's book in Bahasa Indonesia and English: *The Little Gibbon Who Lost His Song (Owa Kecil Yang Kehilangan Nyanyiannya)* aimed at 7–12 years old and to highlight the issues of forest fires on gibbons. The engagement with this book whereby schools were approaching BNF to come and deliver the activity, led to the development of further bespoke education materials. The "Gibbon Goes to School" program where the BNF education team visits schools and reads the Little Gibbon book accompanied by an interactive slide and puppet show. This activity is

MEDIA	YEAR LAUNCH	FORMAT AND LANGUAGE	\$	CONTENT	DISSEMINATION AND RESOURCE USE(SEPT 2023)
 Little Gibbon Book	2015 6 – 10 yrs.	 	8.90	Storybook	 700 books  6000 people  12 countries
 Wildeverse	2020-2022 10 yrs. - Adult	 	FREE	Interactive game	 19,000 downloads  9 countries
 Little Gibbon App	2021 6 – 10 yrs.	 	FREE	Interactive book	 7,965 downloads

**FIGURE 1** Summary of BNF publicly accessible education content about gibbons. BNF, Borneo Nature Foundation. [Color figure can be viewed at [wileyonlinelibrary.com](https://wileyonlinelibrary.com)]

aimed at young children whose literature skills are not yet well developed. The story of Little Gibbon is presented to children by reading the book to them accompanied by a puppet show. Pictures of the wildlife in the book are projected and forest sounds played to the children. This session is followed by a presentation and games. Copies of the book are donated with the aim that these will be used as an educational tool and to help the school to build up a collection of environmental education resources. As the book is bilingual, the students are also able to practice languages while enjoying the story (<https://www.borneonaturefoundation.org/project/interactive-storytelling/>). The key behavior underlying this book is the fact that gibbons sing, and how they use their song to communicate and what happens when there are forest fires. Gibbon singing behavior is adversely affected by smoke from forest fires (Cheyne et al., 2008).

In 2018, BNF partnered with the Internet of Elephants (<https://www.internetofelephants.com/>) team whose mission is to bring together the skills of wildlife lovers, data heads, gaming geeks and marketers to create massive consumer engagement through digital experiences. By combining behavioral ecological data from gibbons living wild in the Sebangau National Park, along with accurate data about the forest, foods the gibbons eat, ranging, singing behavior and conservation actions being taken by BNF, this was added to a bespoke game called Wildeverse (<https://www.wildeversegame.com/>). A single identified individual gibbon (named Chilli, born in Sebangau National Park and followed by the BNF team since birth) was included as the gibbon which game users are seeking to learn about and protect. Released in October 2018, this game also features an orangutan (*Pongo pygmaeus wurmbii*), a western lowland gorilla (*Gorilla gorilla gorilla*) and a chimpanzee (*Pan troglodytes*)—again all based on real wild individuals. Unfortunately, due to a lack of ability by the developers to update the software for this game, it was discontinued in March 2022. Following the Covid-19 pandemic, and

the impact this had on the in-person education activities of BNF, we collaborated with Jamie's Software to develop the gibbon book into an interactive app ([https://play.google.com/store/apps/details?id=com.jamiessoftware.littlegibbon.book&hl=en\\_GB&gl=US](https://play.google.com/store/apps/details?id=com.jamiessoftware.littlegibbon.book&hl=en_GB&gl=US)) where the books is narrated in Bahasa Indonesia and English and with additional information and available on iPhone and Android launched in June 2020. The countries from where people are accessing these materials at time of writing are UK, USA, Australia, Indonesia, Germany, India, Canada, Malaysia, Vietnam, Cambodia, Thailand and South Africa.

The game and app are free, and the book is donated free to schools within Indonesia. With materials such as this, we are able to gauge the engagement (number of books sold or donated, number of downloads of the app or game, number of children and teachers who participated in the interactive school sessions, online reviews etc.) and to assess the distribution of where people are accessing these materials from. The veracity of unsolicited online reviews is hard to gauge but emerging research suggests that people are less likely to post untrue positive reviews than untrue negative ones (Pooja & Upadhyaya, 2022). Assessing the direct impact of online materials is still an emerging field thus monitoring engagement needs to be the initial step. Given the different media being used, the different target age groups (and language availability), effective evaluation of these tools is ongoing (Figure 2).

## 2 | DISCUSSION

### 2.1 | Impact evaluation

Evaluating the impact of education and outreach activities is one of the most difficult aspects for a conservation NGO (Bonine et al., 2003; Breuer et al., 2017; Franquesa-Soler & Serio-Silva, 2017). Behavior





**FIGURE 2** Children in Indonesia reading the Little Gibbon Book. [Color figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

change takes time (years) to filter through and be measured, thus we sought to focus initially on engagement with the resources and knowledge gain. Using a combination of books, mobile phone apps and mobile phone games, BNF is working to reach a wide audience both in Indonesia and around the world to engage people with the plight of gibbons and to inform positive conservation actions. The traditional medium of a physical book complemented by an enhanced supporting app as well as an augmented reality mobile phone game allows users to experience gibbon conservation and actions in a variety of accessible formats. At the heart of these tools are the song of the gibbons—using the spectacular acoustics of these species to engage the general public through science and sharing the work of BNF as well as promoting the science, conservation and traditional local stories, myths and legends of gibbons to a new audience. Thus, we propose the idea that using the science and stories of gibbon vocalizations can enhance the NGO communication efforts.

While a complete evaluation and analysis of these tools has not yet been completed, based on feedback online (unsolicited where people leave reviews online) the book and app are proving very popular (high engagement and high star ratings on Google Play and iOS).

Examples of reviews for the Little Gibbon App: posted May 22, 2022 “the app is a fantastic tool to help read the book with my kids, love the sounds and drawings.” Posted October 17, 2022 “the animal sounds are wonderful, the story is so engaging, my kids loved it and so did I, am planning to buy the book.” Reviews for Wildeverse: posted May 17, 2020 “This app is educational and a lot of fun! The augmented reality is well done. There's the occasional glitch (like it briefly hangs when I point up too fast), but it all goes well with the premise that you

are using experimental equipment. So far I have learned a fair bit about what orangutans eat (I'm glad the poo is virtual!). I'm looking forward to exploring all the levels. I also hope they add more species and researchers in the future!” Posted January 14, 2021 “I discovered the game through #NatGeoStorySummit 2021. This is treasure learning tool to inspire and empower the young generation about wildlife conservation. Being an English teacher, I always try to find new ways to get my learners engaged. Can't wait to share it with my NatGeo Teen Learners in our next session. The game is beautifully set up, interactive, fun and exciting!!! Highly recommend!!!”

The book remains a popular item for supporters to buy to help support BNF. Further evaluation of the book, app and game are pending and will inform future actions and activities. Given the five components of a theory of change (Rice et al., 2020), BNF has achieved three of these: (1) inputs—clear, accurate scientific information, the BNF approach is always to use the best science to inform our conservation activities and our education and outreach activities, (2) activities—development of the book, app and game, (3) outputs—launching of the book, app and game. The final components (4) outcomes and (5) impact, require further evaluation and investigation, which has been somewhat hampered by the Covid-19 pandemic.

## 2.2 | Engaging local people

Dissemination of materials is done via the weekly children's clubs (all age groups), to schools as part of the formal classes, to mosques and churches and online. Sometimes a species-specific narrative is not

always appropriate for engaging the support and cooperation of local people with direct forest connections. Local perceptions of gibbons are that they are a part of the forest ecosystem, no more or less important than the many other species dependent on these forests. Sharing information about these animals, not only ecological or behavioral but making the links between conservation and people underpins the development of these tools. Furthermore, generally speaking, political decisions are and always will be acts of compromise, with ecological/conservation considerations often “competing” against other motivations; and successful implementation of political decisions/laws will be constrained by availability of will, resources and expertise. Failure to consider these realities is likely to lead to failure to achieve gibbon conservation goals. In this context and faced with these realities encountered in the field, the problem changes from being primarily ecological to social-political-economic in nature while urgently needing the support of people, both close to the forests and those who live further away. This has led to calls for conservationists to “think outside the box,” working across disciplines, with industry, plus local government and communities to promote conservation, while maintaining and strengthening protected area networks and legislation (Cooney et al., 2017; Phelps et al., 2021).

### 2.3 | Technology and conservation education

The conservation research and the face-to-face education and outreach through the apps and games are continuing and the work of BNF is expanding to reach more children in Central Kalimantan and to evaluate the impact of these educational tools. All these data need to be shared to highlight the importance of public outreach for science communication including online sessions, magazines, social media, children's clubs, school visits, public events etc.

We recognize that developing books, apps and games are time-consuming and can be expensive and that accessibility to online tools in remote areas can be difficult. BNF was fortunate to receive funding to develop the game with Internet of Elephants, the app was developed as a donation and the book was self-published and all were advertised through BNF social media and at in-person events in Indonesia and the UK. Increasingly we do recommend that conservation organizations continue to develop innovative ways to communicate with the general public. For the next steps we will assess engagement with online educational resources through downloads as well as reaching out to users to evaluate their engagement with the book, game and app. We highlight how unique aspects of different species can help conservationists to create engaging outreach materials to help support conservation engagement.

### 2.4 | Additional Information

The research adhered to the Code of Best Practice for Field Primatology including ethical obligations to the study species (Riley et al., 2014).

### AUTHOR CONTRIBUTIONS

**Susan M. Cheyne:** Conceptualization (lead); data curation (lead); writing—original draft (lead); writing—review and editing (lead). **Carolyn Thompson:** Formal analysis (equal); Writing—review and editing (equal). **Alizé Martin:** Project administration (equal); resources (equal); writing—original draft (equal). **K. Abdulaziz:** Data curation (supporting); investigation (equal). **Helene Birot:** Investigation (equal); methodology (equal); project administration (equal). **Eka Cahyaningrum:** Data curation (equal); investigation (equal); methodology (equal); project administration (equal). **Joana Aragay:** Conceptualization (equal); formal analysis (equal); funding acquisition (equal). **Petricia Andini Hutasoit:** Conceptualization (equal); funding acquisition (equal); methodology (equal); project administration (equal). **Jito Sugardjito:** Resources (equal); supervision (equal); writing—original draft (equal).

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### CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

### DATA AVAILABILITY STATEMENT

All data are available upon request from the corresponding author.

### ORCID

Susan M. Cheyne  <http://orcid.org/0000-0002-9180-3356>

### REFERENCES

- Adilah Suhailin Kamaruzaman, K., Mohd Rameli, N. I. A., Lappan, S., Bartlett, T. Q., Nik Fadzly, N. R., Shahrul Anuar, M. S., & Ruppert, N. (2023). Group densities of endangered small apes (Hylobatidae) in two adjacent forest reserves in Merapoh, Pahang, Malaysia. *Journal of Threatened Taxa*, 15(8), 23631–23640. <https://doi.org/10.11609/jott.8562.15.8.23631-23640>
- Bennett, N. J., Roth, R., Klain, S. C., Chan, K., Christie, P., Clark, D. A., Cullman, G., Curran, D., Durbin, T. J., Epstein, G., Greenberg, A.,

- Nelson, M. P., Sandlos, J., Stedman, R., Teel, T. L., Thomas, R., Verissimo, D., & Wyborn, C. (2017). Conservation social science: Understanding and integrating human dimensions to improve conservation. *Biological Conservation*, 205, 93–108. <https://doi.org/10.1016/j.biocon.2016.10.006>
- Biggs, D., Cooney, R., Roe, D., Dublin, H. T., Allan, J. R., Challender, D. W., & Skinner, D. (2017). Developing a theory of change for a community-based response to illegal wildlife trade. *Conservation Biology*, 31(1), 5–12. <https://doi.org/10.1111/cobi.12796>
- Bonine, K., Reid, J., & Dalzen, R. (2003). Training and education for tropical conservation. *Conservation Biology*, 17, 1209–1218. <https://doi.org/10.1046/j.1523-1739.2003.01754.x>
- Breuer, T., Mavinga, F. B., Evans, R., & Lukas, K. E. (2017). Using video and theater to increase knowledge and change attitudes—Why are gorillas important to the world and to Congo? *American Journal of Primatology*, 79(10), e22692. <https://doi.org/10.1002/ajp.22692>
- Brockelman, W. Y., & Srikosamatara, S. (1984). Maintenance and evolution of social structure in gibbons. In H. Preuschoft, D. J. Chivers, W. Y. Brockelman & N. Creel (Eds.), *The Lesser Apes: Evolutionary and Behavioural Biology* (pp. 298–323). Edinburgh University Press.
- Brockelman, W. Y., & Srikosamatara, S. (1993). Estimation of density of gibbon groups by use of loud songs. *American Journal of Primatology*, 29(1), 93–108.
- Bryant, J. V., Brulé, A., Wong, M. H. G., Hong, X., Zhou, Z., Han, W., Jeffree, T. E., & Turvey, S. T. (2016). Detection of a new hainan gibbon (*Nomascus hainanus*) group using acoustic call playback. *International Journal of Primatology*, 37(4–5), 534–547.
- Buckley, B. J. W., Capilla, B. R., Maimunah, S., Adul, A., Boyd, N., & Harrison, M. E. (2018). *Biodiversity, Forest Structure & Conservation Importance of the Mungku Baru Education Forest, Rungan, Central Kalimantan, Indonesia*. Palangka Raya.
- Campbell, C. O., Cheyne, S. M., & Rawson, B. (2015). *Best Practice Guidelines for the Rehabilitation and Translocation of Gibbons*. Gland.
- Chan, B. P. L., Mak, C. F., Yang, J. H., & Huang, X. Y. (2017). Population, distribution, vocalization and conservation of the gaoligong hoolock gibbon (*Hoolock tianxing*) in the Tengchong section of the gaoligongshan national nature reserve, China. *Primate Conservation*, 31(1), 107–113.
- Cheyne, S., Gilhooly, L., Hamard, M., Höing, A., Houlihan, P., Kursani, L., Loken, B., Phillips, A., Rayadin, Y., Ripoll Capilla, B., Rowland, D., Sastramidjaja, W., Spehar, S., Thompson, C., & Zrust, M. (2016). Population mapping of gibbons in Kalimantan, Indonesia: Correlates of gibbon density and vegetation across the species' range. *Endangered Species Research*, 30(1), 133–143. <https://doi.org/10.3354/esr00734>
- Cheyne, S. M. (2006). Wildlife reintroduction: Considerations of habitat quality at the release site. *BMC Ecology*, 6(1), 5. <https://doi.org/10.1186/1472-6785-6-5>
- Cheyne, S. M., Chivers, D. J., & Sugardjito, J. (2007). Covariation in the great calls of rehabilitant and wild gibbons *Hylobates agilis albibarbis*. *Raffles Bulletin of Zoology*, 55(1), 201–207.
- Cheyne, S. M., Thompson, C. J. H., Phillips, A. C., Hill, R. M. C., & Limin, S. H. (2008). Density and population estimate of gibbons (*Hylobates albibarbis*) in the sabangau catchment, central kalimantan, Indonesia. *Primates*, 49(1), 50–56. <https://doi.org/10.1007/s10329-007-0063-0>
- Cheyne, S. M. (2009). Challenges and Opportunities of Primate Rehabilitation—Gibbons as a Case Study. In K. A. I. Nekaris, V. Nijman, M. Bruford, J. Fa & B. Godley (Eds.), *Endangered Species Research* (9, pp. 159–165). Endangered Species Research. <https://doi.org/10.3354/esr00216>
- Cheyne, S. M. (2010). Behavioural ecology and socio-biology of gibbons (*Hylobates albibarbis*) in a degraded peat-swamp forest. In J. Supriatna & S. L. Gursky (Eds.), *Indonesian Primates* (pp. 121–156). Springer. <http://www.springerlink.com/content/t1735521717773lh/>.
- Cheyne, S. M., Capilla B. R., Abdulaziz, K., Supiansyah, Adul, Cahyaningrum, E., & Smith, D. E. (2019). Home range variation and site fidelity of bornean Southern gibbons (*Hylobates albibarbis*) from 2010–2018. *PLoS One*, 14(7), e0217784. <https://doi.org/10.1371/journal.pone.0217784>
- Chivers, D. J., & MacKinnon, J. (1977). On the behaviour of siamang after playback of their calls. *Primates*, 18(4), 943–948.
- Clink, D. J., Bernard, H., Crofoot, M. C., & Marshall, A. J. (2017). Investigating individual vocal signatures and Small-Scale patterns of geographic variation in female bornean gibbon (*Hylobates muelleri*) great calls. *International Journal of Primatology*, 38(4), 656–671. <https://doi.org/10.1007/s10764-017-9972-y>
- Cooney, R., Roe, D., Dublin, H., Phelps, J., Wilkie, D., Keane, A., Travers, H., Skinner, D., Challender, D. W. S., Allan, J. R., & Biggs, D. (2017). From poachers to protectors: engaging local communities in solutions to illegal wildlife trade. *Conservation Letters*, 10(3), 367–374. <https://doi.org/10.1111/conl.12294>
- Cowlshaw, G. (1992). Song function in gibbons. *Behaviour*, 121(1–2), 131–153.
- Cowlshaw, G. (1996). Sexual selection and information content in Gibbon song bouts. *Ethology*, 102(4), 272–284.
- Darwin, C. (1871). The descent of man, and selection in relation to sex, Vol. 1. John Murray. <https://doi.org/10.1037/12293-000>
- Fan, P. (2017). The past, present, and future of gibbons in China. *Biological Conservation*, 210, 29–39. <https://doi.org/10.1016/j.biocon.2016.02.024>
- Fan, P., & Bartlett, T. Q. (2017). Overlooked small apes need more attention. *American Journal of Primatology*, 79(6), e22658. <https://doi.org/10.1002/ajp.22658>
- Fan, P. F., He, K., Chen, X., Ortiz, A., Zhang, B., Zhao, C., Li, Y. Q., Zhang, H. B., Kimock, C., Wang, W. Z., Groves, C., Turvey, S. T., Roos, C., Helgen, K. M., & Jiang, X. L. (2017). Description of a new species of Hoolock gibbon (Primates: Hylobatidae) based on integrative taxonomy. *American Journal of Primatology*, 79(5), e22631. <https://doi.org/10.1002/ajp.22631>
- Franquesa-Soler, M., & Serio-Silva, J. C. (2017). Through the eyes of children: Drawings as an evaluation tool for children's understanding about endangered Mexican primates. *American Journal of Primatology*, 79(12), e22723. <https://doi.org/10.1002/ajp.22723>
- Freund, C. A., Achmad, M., Kanisius, P., Naruri, R., Tang, E., & Knott, C. D. (2020). Conserving orangutans one classroom at a time: Evaluating the effectiveness of a wildlife education program for school-aged children in Indonesia. *Animal Conservation*, 23, 18–27. <https://doi.org/10.1111/acv.12513>
- Geissmann, T. (1986). Mate change enhances duetting activity in the siamang gibbon (*Hylobates syndactylus*). *Behaviour*, 96(1–2), 17–27.
- Geissmann, T. (1993). *Evolution of communication in gibbons (Hylobatidae)*. Anthropological Institute, Philosoh. Faculty II. Zürich University.
- Geissmann, T., & Nijman, V. (2006). Calling in wild silvery gibbons (*Hylobates moloch*) in Java (Indonesia): Behavior, phylogeny, and conservation. *American Journal of Primatology*, 68(1), 1–19. <https://doi.org/10.1002/ajp.20203>
- Geissmann, T., & Orgeldinger, M. (2000). The relationship between duet songs and pair bonds in siamangs, *Hylobates syndactylus*. *Animal Behaviour*, 60, 805–809.
- Gilhooly, L. J., Rayadin, Y., & Cheyne, S. M. (2015). A comparison of hylobatid survey methods using triangulation on müller's gibbon (*Hylobates muelleri*) in sungai wain protection forest, east kalimantan, Indonesia. *International Journal of Primatology*, 36(3), 567–582. <https://doi.org/10.1007/s10764-015-9845-1>
- Goustard, M., & Demars, C. (1973). Structure and form of the segments of the great call of the gibbon *Hylobates concolor*. *Bulletin Biologique de la France et de la Belgique*, 107(2), 171–187.



- Guan, Z. H., Ma, C. Y., Fei, H. L., Huang, B., Ning, W. H., Ni, Q. Y., Jiang, X. L., Fan, P. F., Guan, Z. H., Ma, C. Y., Fei, H. L., Huang, B., Ning, W. H., Ni, Q. Y., Jiang, X. L., & Fan, P. F. (2018). Ecology and social system of Northern gibbons living in cold seasonal forests. *动物学研究*, 39, 255–265. <https://doi.org/10.24272/j.issn.2095-8137.2018.045>
- van Gulik, R. H. (1967). *The Gibbon in China: an essay in Chinese animal lore*. E.J. Brill.
- Haimoff, E. H. (1984a). Acoustic and organisational features of gibbon song. In H. Preuschoft, D. J. Chivers, W. Y. Brockelman & N. Creel (Eds.), *The Lesser Apes: Evolutionary and Behavioural Biology* (pp. 333–353). University of Edinburgh Press.
- Haimoff, E. H. (1984b). The organization of song in the agile gibbon (*Hylobates agilis*). *Folia Primatologica*, 42, 42–61.
- Haimoff, E. H. (1984c). The organization of song in the Hainan black gibbon (*Hylobates concolor hainansus*). *Primates*, 25, 225–235.
- Haimoff, E. H., & Gittins, S. P. (1985). Individuality in the songs of wild agile gibbons (*Hylobates agilis*) of peninsular Malaysia. *American Journal of Primatology*, 8, 239–247.
- Ham, S., Hedwig, D., Lappan, S., & Choe, J. C. (2016). Song functions in nonduetting gibbons: Evidence from playback experiments on javan gibbons (*Hylobates moloch*). *International Journal of Primatology*, 37(2), 225–240. <https://doi.org/10.1007/s10764-016-9897-x>
- Hamard, M., Cheyne, S. M., & Nijman, V. (2010). Vegetation correlates of gibbon density in the peat-swamp forest of the sabangau catchment, central Kalimantan, Indonesia. *American Journal of Primatology*, 72(7), 607–616. <https://doi.org/10.1002/ajp.20815>
- Hankinson, E. L., Hill, R. A., Marsh, C. D., Nowak, M. G., Abdullah, A., Pasaribu, N., Supriadi, A. H., Nijman, V., Cheyne, S. M., & Korstjens, A. H. (2021). Influences of forest structure on the density and habitat preference of two sympatric gibbons (*Symphalangus syndactylus* and *Hylobates lar*). *International Journal of Primatology*, 42, 237–261. <https://doi.org/10.1007/s10764-021-00199-2>
- Harrison, M. E., Wijedasa, L. S., Cole, L. E. S., Cheyne, S. M., Choiruzzad, S. A. B., Chua, L., Dargie, G. C., Ewango, C. E. N., Honorio Coronado, E. N., Ifo, S. A., Imron, M. A., Kopansky, D., Lestaris, T., O'Reilly, P. J., Van Offelen, J., Refisch, J., Roucoux, K., Sugardjito, J., Thornton, S. A., ... Page, S. (2020). Tropical peatlands and their conservation are important in the context of COVID-19 and potential future (zoonotic) disease pandemics. *PeerJ*, 8, e10283. <https://doi.org/10.7717/peerj.10283>
- Heine, A., & Geissmann, T. (2000). Gibbon ethograms: what makes the difference? *Folia Primatologica*, 71, 228.
- Hoeing, A., Suncoko, A., Rowland, D., Murray, E., Sabahudin, I., & Cheyne, S. M. (2015a). How nature is used and valued by villagers in two villages in Uut Murung. *Journal of Indonesian Natural History*, 3(1), 8–18.
- Hoeing, A., Suncoko, A., Rowland, D., Murray, E., Sabahudin, I., & Cheyne, S. M. (2015b). Perceptions towards companies and forest conservation in two villages of Uut Murung, Central Kalimantan, Indonesia. *Journal of Indonesian Natural History*, 3(1), 19–30.
- Höing, A., Quinten, M. C., Indrawati, Y. M., Cheyne, S. M., & Waltert, M. (2013). Line transect and triangulation surveys provide reliable estimates of the density of kloss' gibbons (*Hylobates klossii*) on siberut island, Indonesia. *International Journal of Primatology*, 34(1), 148–156. <https://doi.org/10.1007/s10764-012-9655-7>
- Keith, S. A., Waller, M. S., & Geissmann, T. (2009). Vocal diversity of Klossis gibbons (*Hylobates klossii*) in the Mentawai Islands, Indonesia. In S. M. Lappan & D. Whittacker (Eds.), *The gibbons: New perspectives on small ape socioecology and population biology* (pp. 51–71). Springer.
- Kidney, D., Rawson, B. M., Borchers, D. L., Stevenson, B. C., Marques, T. A., & Thomas, L. (2016). An efficient acoustic density estimation method with human detectors applied to gibbons in Cambodia. *PLoS One*, 11(5), e0155066. <https://doi.org/10.1371/journal.pone.0155066>
- Kling, K. J., & Hopkins, M. E. (2015). Are we making the grade? Practices and reported efficacy measures of primate conservation education programs. *American Journal of Primatology*, 77(4), 434–448. <https://doi.org/10.1002/ajp.22359>
- Liu, H., Ma, H., Cheyne, S. M., & Turvey, S. T. (2020). Recovery hopes for the world's rarest primate. *Science*, 368(6495), 1074. <https://doi.org/10.1126/science.abc1402>
- MacKinnon, J., & MacKinnon, K. (1984). Territory, monogamy and song in gibbons and tarsiers. In H. Preuschoft, D. J. Chivers, W. Y. Brockelman & N. Creel (Eds.), *The Lesser Apes: Evolutionary and Behavioural Biology* (pp. 291–297). Edinburgh University Press.
- Marshall, J. T., & Marshall, E. R. (1976). Gibbons and their territorial songs. *Science*, 193, 235–237.
- McAngus Todd, N. P., & Merker, B. (2004). Siamang gibbons exceed the saccular threshold: Intensity of the song of *Hylobates syndactylus*. *The Journal of the Acoustical Society of America*, 115(2), 3077–3080.
- Mitani, J. C. (1985a). Gibbon song duets and interspacing behaviour. *Behaviour*, 92, 59–96.
- Mitani, J. C. (1985b). Responses of gibbons (*H. muelleri*) to self, neighbour and stranger song duets. *International Journal of Primatology*, 6(2), 193–200.
- Nekaris, K. A. I., McCabe, S., Spaan, D., Ali, M. I., & Nijman, V. (2018). A novel application of cultural consensus models to evaluate conservation education programs. *Conservation Biology*, 32(2), 466–476. <https://doi.org/10.1111/cobi.13023>
- Nijman, V. (2006). In-Situ and Ex-Situ status of the Javan Gibbon and the role of zoos in conservation of the species. *Contributions to Zoology*, 75, 161–168.
- Nijman, V., Spaan, D., Rode-Margono, E. J., Wirdateti, I., & Nekaris, K. A. I. (2017). Changes in the primate trade in Indonesian wildlife markets over a 25-year period: Fewer apes and langurs, more macaques, and slow lorises. *American Journal of Primatology*, 79(3/4), 161–168. <https://doi.org/10.1002/ajp.22517>
- Nijman, V., Yang Martinez, C., & Shepherd, C. R. (2009). Saved from trade: donated and confiscated gibbons in zoos and rescue centres in Indonesia. *Endangered Species Research*, 9, 151–157.
- Osterberg, P., Samphanthamit, P., Maprang, O., Punnadee, S., & Brockelman, W. Y. (2015). Gibbon (*Hylobates lar*) reintroduction success in Phuket, Thailand, and its conservation benefits. *American Journal of Primatology*, 77(5), 492–501. <https://doi.org/10.1002/ajp.22367>
- Pang, Y. H., Lappan, S., Bartlett, T. Q., Mohd Sah, S. A., N. Rosely, N. F., & Ruppert, N. (2022). Population densities of *Hylobates agilis* in forests with different disturbance histories in Ulu Muda Forest Reserve, Malaysia. *American Journal of Primatology*, 84, e23388. <https://doi.org/10.1002/ajp.23388>
- Phelps, J., Aravind, S., Cheyne, S., Dabrowski Pedrini, I., Fajrini, R., Jones, C. A., Lees, A. C., Mance, A., Nagara, G., Nugraha, T. P., Pendergrass, J., Purnamasari, U., Rodriguez, M., Saputra, R., Sharp, S. P., Sokolowki, A., & Webb, E. L. (2021). Environmental liability litigation could remedy biodiversity loss. *Conservation Letters*, 14, e12821. <https://doi.org/10.1111/conl.12821>
- Phoonjampa, R., Koenig, A., Brockelman, W. Y., Borries, C., Gale, G. A., Carroll, J. P., & Savini, T. (2011). Pileated gibbon density in relation to habitat characteristics and Post-Logging forest recovery. *Biotropica*, 43(2), 619–627.
- Pooja, K., & Upadhyaya, P. (2022). What makes an online review credible? A systematic review of the literature and future research directions. *Management Review Quarterly*. <https://doi.org/10.1007/s11301-022-00312-6>
- Raemaekers, J. J., & Raemaekers, P. M. (1985). Field playback of loud calls to gibbons (*Hylobates lar*): territorial, sex-specific and species-specific responses. *Animal Behaviour*, 33, 481–493.
- Rice, W. S., Sowman, M. R., & Bavinck, M. (2020). Using theory of change to improve post-2020 conservation: A proposed framework and



- recommendations for use. *Conservation Science and Practice*, 2(12), e301. <https://doi.org/10.1111/csp2.301>
- Riley, E. P., Mackinnon, K. C., Fernandez-duque, E., Setchell, J. M., & Garber, P. A. (2014). *Code of best practices for field primatology*.
- Rivas, J. A., & Owens, R. Y. (1999). Teaching conservation effectively: A lesson from life-history strategies. *Conservation Biology*, 13, 453–454. <https://doi.org/10.1046/j.1523-1739.1999.013002453.x>
- van Schaik, C. P., & Dunbar, R. I. M. (1990). The evolution of monogamy in large primates: A new hypothesis and some crucial tests. *Behaviour*, 115, 30–61.
- Schoneveld-de Lange, N., Meijaard, E., & Löhr, A. (2016). South to south learning in great ape conservation. *American Journal of Primatology*, 78, 669–678. <https://doi.org/10.1002/ajp.22531>
- Setiawan, A., Nugroho, T. S., Wibisono, Y., Ikawati, V., & Sugardjito, J. (2012). Population density and distribution of Javan gibbon (*Hylobates moloch*) in Central Java, Indonesia. *Biodiversitas*, 13(1), 23–32.
- Singh, M., Cheyne, S. M., & Ehlers Smith, D. A. (2018). How conspecific primates use their habitats: Surviving in an anthropogenically-disturbed forest in Central Kalimantan, Indonesia. *Ecological Indicators*, 87, 167–177. <https://doi.org/10.1016/j.ecolind.2017.12.041>
- Stark, D. J., Vaughan, I. P., Evans, L. J., Kler, H., & Goossens, B. (2018). Combining drones and satellite tracking as an effective tool for informing policy change in riparian habitats: A proboscis monkey case study. *Remote Sensing in Ecology and Conservation*, 4(1), 44–52. <https://doi.org/10.1002/rse2.51>
- Struebig, M. J., Wilting, A., Gaveau, D. L. A., Meijaard, E., Smith, R. J., Fischer, M., Metcalfe, K., Kramer-Schadt, S., Abdullah, T., Abram, N., Alfred, R., Ancrenaz, M., Augeri, D. M., Belant, J. L., Bernard, H., Bezuijen, M., Boonman, A., Boonratana, R., Boorsma, T., ... Wong, A. (2015). Targeted conservation to safeguard a biodiversity hotspot from climate and Land-Cover change. *Current Biology*, 25(3), 372–378. <https://doi.org/10.1016/j.cub.2014.11.067>
- Supriatna, J., & Ario, A. (2015). Primates as flagships for conserving biodiversity and parks in Indonesia: lessons learned from west java and north sumatra. *Primate Conservation*, 29(1), 123–131. <https://doi.org/10.1896/052.029.0109>
- Tenaza, R. R. (1976). Songs, choruses and countersinging of Kloss' gibbons (*Hylobates klossii*) in Siberut Island, Indonesia. *Zeitschrift für Tierpsychologie*, 40(1), 37–52.
- Terleph, T. A., Malaivijitnond, S., & Reichard, U. H. (2015). Lar gibbon (*Hylobates lar*) great call reveals individual caller identity. *American Journal of Primatology*, 77, 811–821. <https://doi.org/10.1002/ajp.22406>
- Terleph, T. A., Malaivijitnond, S., & Reichard, U. H. (2018). An analysis of White-handed gibbon male song reveals speech-like phrases. *American Journal of Physical Anthropology*, 166(3, SI), 649–660. <https://doi.org/10.1002/ajpa.23451>
- Trombulak, S. C., Omland, K. S., Robinson, J. A., Lusk, J. J., Fleischner, T. L., Brown, G., & Domroese, M. (2004). Principles of conservation biology: Recommended guidelines for conservation literacy from the education committee of the society for conservation biology. *Conservation Biology*, 18, 1180–1190. <https://doi.org/10.1111/j.1523-1739.2004.01851.x>
- Turvey, S. T., Bruun, K., Ortiz, A., Hansford, J., Hu, S., Ding, Y., Zhang, T., & Chatterjee, H. J. (2018). New genus of extinct holocene gibbon associated with humans in imperial China. *Science*, 360(6395), 1346–1349. <https://doi.org/10.1126/science.aao4903>
- Vu, T. T., & Tran, L. M. (2019). An application of autonomous recorders for gibbon monitoring. *International Journal of Primatology*, 40(2), 169–186. <https://doi.org/10.1007/s10764-018-0073-3>
- Wanelik, K. M., Azis, A., & Cheyne, S. M. (2013). Note-, phrase- and song-specific acoustic variables contributing to the individuality of Male duet song in the bornean Southern gibbon (*Hylobates albibarbis*). *Primates*, 54(2), 159–170. <https://doi.org/10.1007/s10329-012-0338-y>

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