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# Preliminary study on premature infant death of Hainan gibbons (*Nomascus hainanus*): implications for conservation

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Hainan gibbon (*Nomascus hainanus*) is China's only endemic gibbon species and among the world's rarest primate species. Documenting infant mortality and investigating their underlying causes are essential for informing evidence-based conservation strategies to support population recovery. From 2010 to 2024, we conducted demographic monitoring and behavioral observations of extant gibbon groups in Bawangling area of Hainan Tropical Rainforest National Park, China, recording four infant mortality cases through *ad libitum* sampling. Among these, three infants (75%) were born to primiparous females, while one (25%) was born to a multiparous female. Notably, we documented for the first time that 4-month-old infants began to move away from their mothers, and infant mortality events coincided temporally with their initial attempts at independent activities. These findings suggest that inadequate parenting experience (primiparity) in females and premature infant independence would be critical determinants of neonatal survival in Hainan gibbons. Specifically, infants born to primiparous mothers, particularly those aged 4–6 months, face elevated risks of accidental mortality. We propose that conservation efforts prioritize enhanced patrols and rescue protocols during this high-vulnerability stage. Long-term monitoring of infant birth-death dynamics, coupled with rigorous investigation of causative factors, is imperative for the conservation and population recovery of this Critically Endangered species.

## KEYWORDS

small ape, infants, premature death, maternal parity, infant independence

## Introduction

Primate infant mortality is a critical demographic parameter influencing population dynamics. Documenting neonatal mortality and elucidating its possible causes are essential for developing targeted conservation strategies for threatened species (Altmann and Alberts, 2005; Hassell et al., 2017). Reported drivers of primate infant mortality include neonatal diseases, maternal parity status and physiological condition, predation by natural enemies, male infanticide, and extreme climatic events (Liu et al., 2016; Ma et al., 2019; Campos et al., 2020). Among these, maternal parity serves as a proxy for reproductive experience and maternal investment, though its species-specific effects remain contentious. For instance, primiparous female baboons (*Papio hamadryas*) exhibit significantly higher offspring mortality compared to multiparous females (Sunderland et al., 2008), whereas no such parity effect has been detected in François' langurs (*Trachypitecus francoisi*) (Yi et al., 2023). From a neonate perspective, beyond pathogen exposure and nutritional stress, the transition to behavioral independence (e.g., maternal separation and locomotor exploration) may elevate mortality risk. However, direct observations of these behaviors are logistically challenging in wild forest-dwelling primates, resulting in limited empirical data. Most existing studies derive from captive populations, with wild primate systems remaining critically understudied (Hassell et al., 2017).

Hainan gibbon (*Nomascus hainanus*) is classified as Critically Endangered (Fan, 2017; IUCN, 2023), with a global population of only 42 individuals distributed across seven groups in the Bawangling area of Hainan Tropical Rainforest National Park, China. To address population recovery challenges, extensive research has been conducted on this species, encompassing long-term population monitoring, behavioral ecology, and habitat suitability assessments (Deng and Zhou, 2015; Zhu et al., 2023). Hainan gibbons live in social groups, typically comprising one adult male, one to two adult females, and their offspring. Infancy generally refers to individuals under three years of age, juvenility to individuals aged between three and eight years, and adulthood to those over eight years of age. Sexual maturity in females occurs at 7–8 years of age, with a typical interbirth interval of 2–3 years (Zhou et al., 2008; Zhong et al., 2025). Maternal care is obligate, and infants remain physically dependent on their mothers until weaning (~2 years), after which they achieve locomotor independence (Zhu et al., 2024). Given that infant survival is a critical determinant of population viability, systematic documentation of birth-death events and identification of mortality drivers are essential for evidence-based conservation.

In this study, we documented cases of premature infant mortality (i.e., death prior to two years of age) through 15 years of continuous field monitoring, while collecting comprehensive individual information. Moreover, particular attention was given to the earliest age at which infants left their mothers, and their associated behaviors. These data were analyzed to elucidate the potential causes of premature death of infant gibbons, with the ultimate goal of informing more effective conservation strategies for this threatened species.

## Methods

The study was conducted in the Bawangling area of Hainan Tropical Rainforest National Park (18°52'–19°12'N, 108°53'–109°20'E), representing one of China's most biologically diverse tropical rainforest ecosystems. The region experiences a tropical monsoon climate, characterized by distinct wet (May–October) and dry (November–April) seasons. The vegetation types in the local forests primarily include tropical cloud forests at elevations above 1200 m, tropical montane rainforests at 800–1200 m, and tropical lowland rainforests at elevations below 800 m (Long et al., 2011).

Hainan gibbon (*Nomascus hainanus*, Hylobatidae) is one of only 20 extant gibbon species with a global population below 100 individuals (IUCN, 2023). This species experienced catastrophic declines due to anthropogenic pressures, including habitat loss from commercial logging, and historical illegal hunting, which reduced the population to just 10 individuals across two groups (Group A and Group B) by 1984 (Liu et al., 1989; He et al., 2023). Four decades of intensive conservation interventions (e.g., anti-poaching enforcement, habitat restoration) have facilitated gradual population recovery, and a new group (Group C) was established in 2011. Groups D, E, F and G were formed successively in 2014, 2020, 2022 and 2024, respectively (Supplementary Table S1). The current population inhabits tropical primary and secondary forests within a predator community that includes avian raptors, presenting ongoing ecological challenges for this Critically Endangered species (Zhang et al., 2024; Meng et al., 2023).

From 2010 to 2024, we conducted population-level monitoring of gibbon groups for approximately 5 days per month, with the primary objective of verifying the presence and location of the target groups. Population demography, including changes in the number of individual gibbons within each group, was recorded using *ad libitum* sampling (Campbell et al., 2011). When an infant gibbon was born, we documented the date and the mother's identifying information through direct observations. Infant death was defined as the absence of the infant from its mother's arms in two consecutive observations, given that infant gibbons in early stages cannot survive without maternal care. During 2019–2023, we focused on mother-infant interactions among Hainan gibbons in these groups. Using a combination of focal animal sampling and all-occurrence recording methods (Altmann, 1974), we documented the behaviors of infant gibbons that left their mothers at an early age, as well as their mothers' restraining behaviors during this period.

## Results

### Infant deaths

A total of four cases of infant gibbon mortality have been documented in the wild (Table 1). Two females (code-named CF1 and CF2) from Group C gave birth to single infants in January and September 2012, respectively, with both infants dying at 6 months of age. Similarly, in early January 2023, a female from Group F

TABLE 1 Summary of four cases of infant death in Hainan gibbons (*Nomascus hainanus*) between 2010 and 2024 in Hainan Island, China.

Date	Mother	Group	Parity	Age at infant death	Group background
June 2012	CF1	GC	Primiparous	Six months	Newly-formed group
February 2013	CF2	GC	Primiparous	Six months	Newly-formed group
May 2022	DF2	GD	Multiparous	Two months	Mature group
April 2023	FF1	GF	Primiparous	Four months	Newly-formed group

Newly-formed group, females and males form family groups for the first time; Mature group, after establishing a family, females and males reproduce at least once.



FIGURE 1 Morphology and behavior of infant Hainan gibbons at four months old (A) and six months old (B) when the infants left their mothers in Hainan Island, China.

(FF1) gave birth to an infant, and which also died prematurely at 4 months of age. All three females in these cases were primiparous. Additionally, one recorded case involved an infant that was not the mother’s first offspring: in March 2022, a female from Group D (DF2) gave birth to an infant. This one was DF2’s third offspring, and died 2 months later. Overall, primiparous female gibbons accounted for a higher proportion of infant deaths (75%) compared to multiparous females (25%).

Infant independence

Infant gibbons (<3 years old) exhibit obligate maternal dependence, requiring continuous care during their early development. Initial separation from the mother occurs at 4–6 months of age, marking the onset of gradual behavioral independence. On March 18, 2019, a 4-month-old infant with incompletely darkened fur from Group C was observed grasping a horizontal trunk with one hand and attempting to pluck fruits from the tree with the other (Figure 1A). However, the infant was unable to move independently due to insufficient forearm strength, and could only hang from the trunk and sway. The mother was 0.5 m away, feeding on a mature fruit of *Ficus subpisocarpa*. After

approximately 10 seconds, the mother quickly drew the infant toward her with her legs and gathered it into her arms with one hand. Born in November 2018, this represents the first recorded instance of a 4-month-old infant initiating movement away from its mother. Additionally, On July 10, 2023, a 6-month-old infant in Group F exhibited relatively agile activities: it could sustain its body with one hand and pluck fruits with the other (Figure 1B). When the mother was feeding or resting, the infant could move within a range of approximately 1 m from her; during potential danger or group movements, the mother would retrieve the infant into her arms.

Discussion

For the first time, we have documented infant mortality events in wild Hainan gibbons. All four cases occurred between regular monitoring sessions, though no carcasses were recovered. Notably, three cases shared consistent characteristics: the infants were born to primiparous females (approximately 8 years old) that had recently established new social groups. This pattern suggests that inadequate maternal experience in infant restraint and protection behaviors may contribute to infant mortality. Our behavioral

observations demonstrated that infant gibbons initiate independent locomotion at 4–6 months of age, and this developmental stage temporally matching the age of the four deceased infants. In cases of inadequate maternal lactation, infants may be driven to prematurely seek external food sources. Furthermore, infants at this stage exhibit limited behavioral competence in threat avoidance, remaining critically dependent on timely maternal retrieval when encountering hazards such as slippery branches, raptors, or human disturbances, these factors collectively represent probable mortality risks.

This study reveals that primiparous female Hainan gibbons exhibit high infant mortality, supporting the important influence of primate parity status on infant survival (Roof et al., 2005; Sunderland et al., 2008). As Zhou (2008) documented, Hainan gibbons require maternal protection when their infants face raptor attacks. One of the probable causes of infant mortality in gibbons appears to be females' inadequate experience in parenting and infants' early independent activities at 4–6 months of age. Therefore, we recommend that the conservation managers prioritize monitoring of 4–6 month-old infants with primiparous mothers, and minimize non-essential anthropogenic disturbances. We further suggest enhancing daily patrols and rescue capabilities, including assigning 1–2 experienced staff per group to enable rapid response to emergencies like infant falls. Although additional factors (e.g., genetic bottleneck, male infanticide, behavioral stressors, and extreme weather) require further investigation (Ma et al., 2019; Campos et al., 2020), these findings provide valuable insights for understanding wild primate population dynamics and informing conservation strategies for threatened species.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Ethics statement

The animal study was approved by Hainan University Institutional Animal Use and Care Committee. The study was conducted in accordance with the local legislation and institutional requirements.

## Author contributions

PL: Funding acquisition, Methodology, Writing – original draft. ZZ: Investigation, Writing – review & editing. WL: Investigation, Writing – review & editing. YC: Conceptualization, Funding acquisition, Writing – review & editing. XQ: Conceptualization, Supervision, Writing – review & editing.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fcosc.2025.1652155/full#supplementary-material>

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