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Title

Death of a one-armed blackback male due to severe injuries in a group of wild western lowland gorillas (*Gorilla gorilla gorilla*) in Moukalaba-Doudou National Park, Gabon

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Abstract

The survival of limb-disabled primates in the wild has been widely reported. Nevertheless, their ultimate fate is little documented. It is important to understand the influence of limb disability on primate survival from a conservation perspective, as many African great apes suffer from limb injuries caused by entrapment in snares. Here, we report the death of a one-armed blackback male in a large one-male group of wild western lowland gorillas. The subject was a blackback male (14 years old) named *Dodo*, who lost his right forearm in August 2008. On December 8, 2019, *Dodo* was found to have suffered serious bleeding injuries to the front of his body, including large lacerations and puncture wounds. On December 14, his corpse was found in the forest. We provide evidence to suggest that his injuries were more likely caused by intraspecific aggression, though a predatory attack by a leopard could not be completely ruled out. His one-armed disability could have made him more vulnerable to either a gorilla's or leopard's attack and led to his fatal injury. This report shows that a gorilla who had previously overcome a disability in one arm in childhood may die prematurely in part due to this disability in young adulthood.

Keywords

African great apes, death, injury, limb disability, snare trap, western lowland gorilla

Introduction

The survival of primates with limb disabilities has been widely reported in captive, free-ranging, and wild conditions. A range of topics have been studied in these animals, identifying their activity patterns (e.g., Turner et al. 2012), behavioral flexibility and innovation (e.g., Byrne and Stokes 2002), and the behavioral responses of other group members (e.g., Herrera and Heymann 2004). Despite numerous studies, however, little work has been done on the ultimate fate of these animals.

While it is challenging to observe such a fate, obtaining this information can provide important insights for primate conservation. This is because limb injuries from snare entrapment continue to be a great concern for primates (Kasozi et al. 2023), especially for endangered African great apes (*Pan troglodytes*: Quiatt et al. 2002, *Pan paniscus*: Kano 1984, *Gorilla beringei*: Haggblade et al. 2019). At some study sites, veterinary interventions have successfully assisted apes that are victims of snares (Haggblade et al. 2019; McLennan et al. 2012). However, to date, little information is available regarding the long-term life history costs of great apes with limb injuries following survival of snare entrapment (Kasozi et al. 2023).

Several mortality factors are reported and suspected in wild African great apes, such as intraspecific aggression (Harcourt & Stewart 2007; Wilson et al. 2014), predation by leopards (*Panthera pardus*) (Klailova et al. 2012), and disease (Leendertz et al. 2006). Because limb injuries reduce animal movement and cause physiological and psychological stress, limb-disabled great apes are expected to be more vulnerable to such threats than uninjured ones (Kasozi et al. 2023).

Here, we provide the first record of the death of a one-armed young male wild

western lowland gorilla (*G. gorilla gorilla*) due to severe injuries. No reports have been published on disabled individuals of this subspecies. In this report, we aimed to discuss the possible cause of his fatal injuries, i.e., leopard predation or intraspecific aggression, and to discuss whether his one-armed disability affected his premature death.

Methods

This study was carried out in the Moukalaba-Doudou National Park, Gabon. At this site, the long-term socio-ecological studies of wild western lowland gorillas started in 2001 with the beginning of the habituation of Gentil Group in 2004. This site harbors leopards (Nakashima 2015), a potential predator of gorillas (Klailova et al. 2012). For further general description of the site, see Takenoshita et al. (2008). In this report, the age classes of gorillas are defined as in Breuer et al. (2009).

The subject blackback male, named *Dodo*, was born in 2005 in the one-male Gentil Group that had been fully habituated by 2008 (Ando et al. 2008). In August 2008, 3-year-old *Dodo* and his mother disappeared from the group. A few days later, *Dodo* returned to the group alone, without the mother. He also missed his right forearm for unknown reasons (Ando and Nguema 2010, Fig. 1a). Despite this serious injury and the absence of his mother, he grew into a blackback male in his natal group (Fig. 1b).

In November 2016, Gentil Group disintegrated due to the death of the silverback (*Dodo's* father). Then, in March 2018, *Dodo* and some other remnants immigrated into the neighboring one-male Nidai Group. This group was led by the silverback *Nidai*, who was unrelated to *Dodo* (unpublished data). After the immigration event, we decided to monitor and habituate Nidai Group. Even though Nidai Group was not habituated, we

were immediately able to conduct all-day group follows, as most of the other group members were already habituated because they came from Gentil Group. Thus, Nidai Group has been monitored by researchers and field assistants on a daily basis since March 2018.

The current case was observed during a 6-month study period from July to December 2019. During this study period, we conducted all-day group follows on a daily basis; the total observation time was 749 hours over 121 days. At the time, the group consisted of 19 individuals in total, including the silverback, three blackbacks (including *Dodo*), five adult females, three subadults, three juveniles, and four infants. All of the members of the group were individually identified and we were able to observe them as close as 7 m.

All data were recorded ad libitum using direct observations and a video camera (SX710 HS, Canon). In addition, a trap camera, installed in the study area for a research project on sympatric forest elephants (*Loxodonta africana*), happened to capture Nidai Group, including the seriously injured *Dodo*; we used that video footage as well.

Results

Finding *Dodo*'s serious injuries on December 8, 2019

At 9:30, we located Nidai Group in the forest. We observed that *Dodo* had serious injuries on the front of his body (Fig. 2) that had not been present during the last observation on December 6. Two parallel lacerations were seen on the upper right of *Dodo*'s chest. The lacerations were wide but not deep, and no bleeding was seen. One small non-bleeding laceration was left on his left chest. Two puncture wounds with

bleeding were seen on the upper abdomen. Further, *Dodo* appeared to be breathing heavily (ESM_1). We did not see any other injuries on his body.

We confirmed the presence of all other group members on this day. In addition to *Dodo*'s wounds, we found mild abrasions on the right cheek and mouth of the silverback (Fig. 3) and on the right ear of another blackback. All wounds appeared to be fresh.

On this day, group members fed on food on the ground and on trees, as usual, but *Dodo* was not observed to feed. During the resting period, many group members of all age-sex classes remained within 5 m of *Dodo* (this is an unusual situation in Nidai Group). Once the group began to move, however, *Dodo* seemed to have difficulty keeping up with the pace of travel, and he moved alone at the back of the group. On two occasions, one group member stopped at the rear of the group during travel, and they resumed moving with *Dodo*. Nevertheless, shortly afterward, *Dodo* was again alone at the tail end of the group. We ended the observation early at 14:30 on this day, taking account of *Dodo*'s severe physical condition (see ESM_2 for a detailed description of observations).

Following our departure, a trap camera located in the savanna area captured Nidai Group at 17:03, filming the silverback, one blackback, one subadult female, and *Dodo* (see ESM_3 for the video footage). In this video, *Dodo* seemed to follow the tail end of the group.

Days after finding the seriously injured *Dodo*

On December 9, we did not find the study group. We found it on December 10 and followed it from December 10 to 14 for more than six hours each day. On all five

days, we confirmed the presence of all other group members but never saw *Dodo*.

On the evening of December 14, after the field survey, local villagers working on another gorilla project informed us that they had found *Dodo* in the forest on December 13. They reported that *Dodo* seemed to be still alive but alone and immobile, and flies had begun to cover his body. From the GPS information provided, *Dodo* was still within the home range of Nidai Group.

Finding *Dodo*'s corpse on December 15, 2019

We visited the location where *Dodo* had been found using the GPS information. At 08:28, we found a corpse of a gorilla in the forest. Because the corpse was lacking its right forearm, we determined that this was in fact *Dodo*. His corpse had begun to decay and was maggot-infested (Fig. 4).

Discussion

We judged *Dodo*'s death to be caused by the observed severe injuries, as he had been in a healthy condition until December 6. Here, we consider two possible causes for his injury: a predatory attack by a leopard or intraspecific aggression.

Injury patterns (i.e., wound type and location) of *Dodo* may be informative in inferring their cause. The most recent article provides a useful reference for distinct injury patterns of victim animals attacked by mountain gorillas and leopards (Potel et al. 2024). One of the major wound types of *Dodo* was the puncture wounds, which were seemingly due to biting with the canines. Potel et al. (2024) showed that attacks with canines by leopards caused small and deeply penetrating wounds, while those by gorillas caused

large tears. *Dodo*'s puncture wounds may be similar to the former. The other major wound type of *Dodo* was the parallel lacerations. Although lacerations can occur both in gorilla and leopard attacks (Potel et al. 2024), the long parallel pattern on *Dodo* appeared to indicate the strike of a leopard's claws (Nakazawa et al. 2013). Thus, judging solely from his wound type, the perpetrator appears to be a leopard.

The location of *Dodo*'s wounds, however, might be inconsistent with the possibility of leopard predation. Potel et al. (2024) reported that all leopard victims primarily had wounds on the head, especially around the neck. On the other hand, physical combat between gorillas leads to injuries over the entire body (Potel et al. 2024), and commonly results in wounds to the front of the body (Leeds et al. 2021; Rosenbaum et al. 2016). In this case, *Dodo*'s wounds were found only on the front of the body. Furthermore, we also found mild abrasions on the face of the silverback and the ear of the blackback. Thus, the wound locations of the three males could be interpreted as indicative of the possibility of intraspecific aggression.

It may be worth recalling that *Dodo* lived in a large one-male group consisting of 19 individuals. Because groups can increase their capacity to defend themselves (Potel et al. 2024), leopards are more likely to attack solitary gorillas (Parnell 2002). Moreover, the presence of the leading silverback could be an additional deterrence against predation, as group silverbacks invest more time in vigilance to protect their mates and offspring (Klailova et al. 2012). Consistently, the previous two reports of leopard predation attempts involved a silverback and a blackback (Fay et al. 1995) and a lone silverback (Watson 1999–2000). However, we should note that a suspected leopard predatory attack on a group silverback leading seven individuals was also reported by Cipolletta (2003).

The fact that *Dodo* survived for several days after receiving severe injuries may be another clue. Previous papers have reported leopards persistently pursuing gorillas for several kilometers following the failure of predatory attacks (Fay et al. 1995; Watson 1999–2000). In this case, the presence of other group members concerned about the injured *Dodo* could deter further predation attempts by a leopard. However, he frequently remained alone at the tail end of the group and was eventually left completely. This should have made predation easier for any predator. Nevertheless, we observed no indications of subsequent predations or the presence of leopards, implying that leopards were not involved in this event. However, it is possible that a leopard immediately gave up pursuing *Dodo* because the predator failed to kill him due to counterattacks by the silverback and the blackback. Altogether, comprehensively evaluating the injury patterns, the social environment surrounding *Dodo*, and survival time with the severe injuries, intraspecific aggression seems a plausible cause of his injuries. However, in the absence of observational evidence, the possibility of a predatory attack by a leopard cannot be completely ruled out. We repeatedly urge that our interpretation of the cause of *Dodo*'s injuries must be made with caution.

In this case, to what extent did *Dodo*'s limb disability affect his receiving the fatal injury? Blackback gorillas can suffer injuries by intraspecific aggressions as they sometimes participate in agonistic inter-unit encounters (Magliocca and Gautier-Hion 2004). However, their injuries are usually non-fatal because they are thought to intervene only when the risk of injury is likely to be low (Rosenbaum et al. 2016). Within-group aggression by the leading silverback could also cause blackbacks' injuries in the case of Nidai Group because they are unrelated each other. The author, GWE, observed that the

silverback, *Nidai*, attacked and lacerated an immigrant blackback when the blackback approached a group female in estrus (*personal observation*). Nevertheless, we have never observed healthy blackbacks suffer fatal injuries on the front of their body resulting from within-group aggressions. Thus, in general, blackback gorillas without disabilities might be unlikely to suffer fatal injuries by intraspecific aggression, either internal or external fight. If the perpetrator was a leopard, it is difficult to determine whether the limb disability affected receiving a fatal predation attack because of the lack of available documents about leopard predation on gorillas. To our knowledge, however, there have been no reports of blackback gorillas dying from severe injuries to the front of the body regardless of the cause. Further, *Dodo*'s premature death could be interpreted as a deviation from the lower mortality rate of the blackback age class (Robbins et al. 2009). Thus, it can be suggested that *Dodo*'s one-armed disability might have made him more vulnerable to external threats (i.e., gorillas and leopards), which could have resulted in the fatal injury.

From a conservation perspective, such reports on the ultimate fate of limb disabled primates lead to a further understanding of the long-term life history costs of snare survivors. So far, fatal or near-fatal accidents, presumably due to snare-related disabilities, have been reported in wild chimpanzees (Cibot et al. 2019) and bonobos (Tokuyama 2019). Likewise, this case indicates that even if a gorilla has overcome a one-armed disability in childhood, he/she may prematurely die in part due to the disability in young adulthood. Accumulating information such as was done in this study will help properly evaluating the ongoing risk of limb injury and develop management programs for deformed animals (Tokuyama 2019). This is especially desirable for long-lived and

slow-reproducing species of conservation concern where every individual is important for population persistence, such as the great apes (Kasozi et al. 2023).

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Declarations

Conflict of interest: The authors declare that they have no conflicts of interest.

Ethics approval: All data collection reported in this paper was observational and adhered

to the International Primatological Society's Code of Best Practice for Field Primatology.

We conducted this research respecting the laws of the Gabonese Republic.

Authors' contributions: All authors contributed to the field survey and data collection.

The first draft of the manuscript was written by MT and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Data availability: All data are available upon reasonable request.

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Figure captions

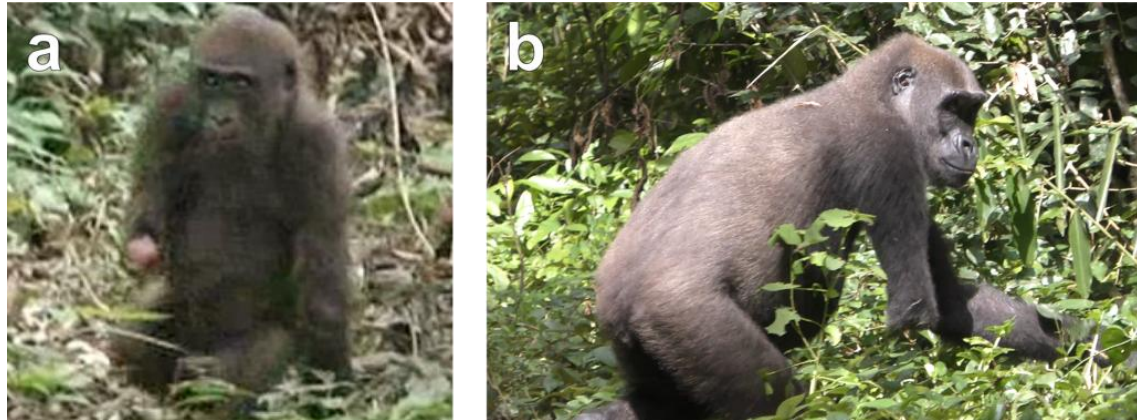


Fig. 1 Victim, *Dodo*, as a) a 3-year-old in 2008 (photograph provided by C. Ando) and b) a 13-year-old in 2018. In both pictures, his missing right forearm is visible.



339 **Fig. 2** Seriously injured *Dodo* on December 8, 2019.



340 **Fig. 3** Abrasions on the right cheek and around the mouth of the silverback found on
341 December 8, 2019. The white arrows point to the wounds.



342 **Fig. 4** *Dodo*'s corpse, found on December 14, 2019.

Online supplemental materials

ESM_1 Video footage of the severely injured *Dodo* on December 8, 2019.

ESM_2 Detailed description of the group observation from 09:30 to 14:30 on December 8, 2019.

ESM_3 Video footage from the trap camera installed in the savanna area that captured the silverback, a blackback, a subadult female, and *Dodo* at 17:03 on December 8, 2019 (video provided by M. Nomoto).