African Forest elephants persist in Guinea-Bissau but require an emergency conservation plan

Luís Palma, Raquel Godinho, Quebá Quecuta, Tomé Mereck, João Mandeck Teli Uri Só, Juan Pablo Cancela and Pedro Beja

Abstract The status of the forest elephant *Loxodonta cyclotis* in Guinea-Bissau has been in doubt since the last assessment in 2006. In 2020–2022 we carried out field surveys to update the species' status. We found elephant signs within an area of c. 1,000 km². Microsatellite genotyping of faeces identified four males. Females could not be individually identified but their presence was confirmed by molecular sex determination. Camera trapping (2,075 camera-trap days) recorded 824 photos in 24 independent sequences, involving three males and two presumed females. The continued presence of elephants in Guinea-Bissau raises hope for the species in the region, but urgent efforts are needed to refine population range and size estimates, increase protected area coverage, and reduce ongoing and impending habitat loss. An emergency conservation action plan is a priority.

Keywords Action plan, camera trapping, conservation status, Guinea-Bissau, *Loxodonta cyclotis*, molecular surveys

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In West Africa, the African forest elephant *Loxodonta cyclotis* is now restricted to small, isolated and threatened populations (Gobush et al., 2021). The species might persist in Guinea-Bissau and adjacent areas in Guinea, but its status was previously unclear (Thouless et al., 2016). Early 20th century writings mentioned the rarity of elephants in Guinea-Bissau (Monard, 1938; Frade et al., 1946) but at the same time (1946–1948) a Portuguese hunter considered the species common (Ferreira, 1973). Later estimates of elephants in the country varied from five (Limoges, 1989) to 10–50 (Thibault, 1993), and c. 35 (Blanc et al., 2003). The first systematic survey was undertaken in 2003–2004 based on interviews in villages in southern Guinea-Bissau and adjacent Guinea (Brugière et al., 2006). Conservatively, this study estimated there were 4–10 elephants resident in Guinea-Bissau but they were present only during the rainy season in Guinea. In the absence of a contemporary assessment, Guinea-Bissau was more recently regarded as potentially lying within the species' range, with an estimated total population of seven (Thouless et al., 2016).

Our study area in southern Guinea-Bissau encompasses the complete presumed elephant range in the country. It lies partly within two National Parks and their linking ecological corridor, but c. 33% of the study area has no legal protection status. The country is generally flat and covered by a mosaic of Upper Guinean dry and sub-humid tropical forest (Sayre et al., 2013), degraded savannah woodland, tall gallery forest, cashew orchards and scattered patches of slash-and-burn agriculture, with small villages throughout the landscape. The study area is crossed by the Corubal River and a dense network of small rivers and streams, and punctuated by temporary freshwater wetlands (*wendus*). The climate is sub-humid tropical (Sayre et al., 2013), monsoonal and markedly seasonal, with a rainy season from June to October and a dry season from November to May.

We examined the status of the forest elephant in Guinea-Bissau through field surveys in areas previously known or suspected to be used by elephants (Brugière et al., 2006), molecular methods and camera trapping. We surveyed for signs of elephant activity (e.g. trails, dung, felled and uprooted trees) during February 2020–January 2022, encompassing three dry seasons and one rainy season. Surveys were made on foot by three teams of two collaborators each, encompassing all of the study area. Teams were generally accompanied by LP. Each team surveyed for 7 days per month. Surveys, dung sampling and setting of camera traps were in areas indicated by local residents, typically hunters, who were also the teams' field guides. Elephant signs were georeferenced and samples taken from 148 fresh and semi-fresh dung piles, stored in tubes with silica gel for later molecular analysis. DNA was extracted in a laboratory dedicated to the analysis of low quality DNA. Individual and sex

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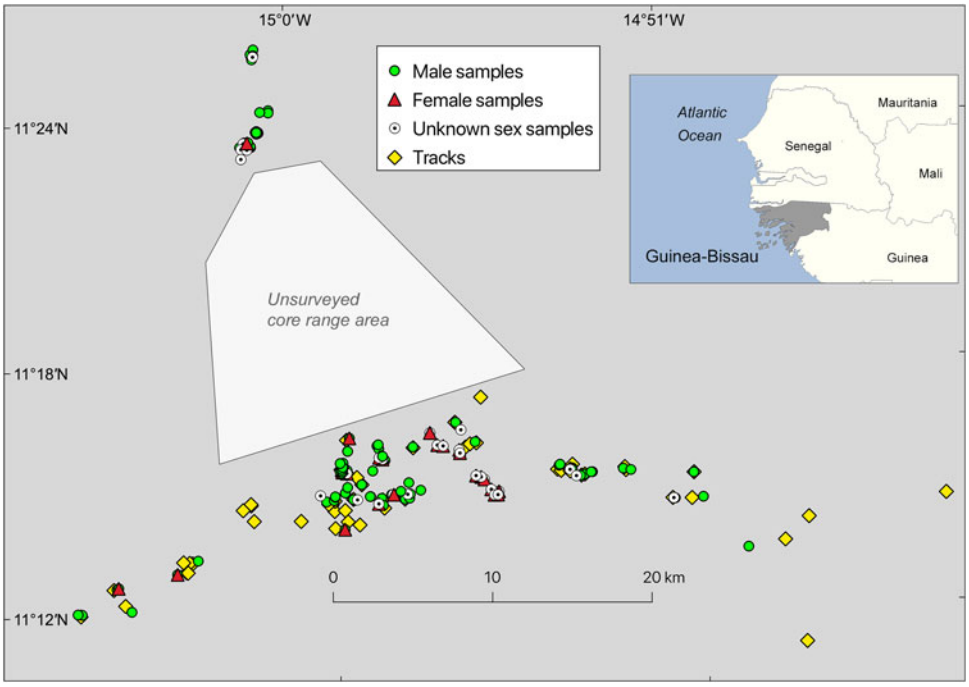

FIG. 1 Locations of dung samples, indicating molecular sexing, and elephant tracks. The polygon shows an unsurveyed area within the elephant core range. The map is rotated and topographic details are not provided, to avoid exposing the elephants to unnecessary risk. (Readers of the printed journal are referred to the online article for a colour version of this figure.)

identification was assessed using 24 polymorphic microsatellites and two sex-linked loci amplified in six multiplex reactions (Supplementary Table 1). Negative controls were used across the whole process. Alleles were scored using *GeneMapper 4.1* (Applied Biosystems, Waltham, USA). Four PCR replicates were performed per marker. Consensus genotypes for each sample were grouped into individuals.

During one dry season (October 2021–May 2022), 16 cameras were deployed at frequently used elephant trails for a total of 1,704 camera-trap days (mean 106.5 days/camera), and seven cameras were set at remnant water ponds (371 camera-trap days, mean 53 days/camera). Cameras were attached to trees at a height of c. 1.8 m, facing the presumed paths of elephant movement. Photograph sequences of the same individual were considered independent if from different cameras and different days, or on the same day and camera with a minimum interval of 30 min. Photographed elephants were tentatively sexed and individually identified by LP from a combination of characteristics: relative tusk size, length, width and shape; forehead and belly shape; ear notches, tears and holes; bottom wrinkle pattern; and presence of phallic shaft if visible (Bedetti et al., 2020; ElephantVoices, 2023). Unclear cases of individual identification and sexing were checked by a second person (Chris Thouless).

We confirmed elephant activity within an area of c. 1,000 km^2 (Fig. 1). In total, we found 58 elephant tracks, of which four were paired tracks of two individuals. Sex was determined for 111 (75%) of the dung samples, of which 101 (91%) were male (Fig. 1). Individual genotyping was achieved for 55 (55%) male-sexed samples, indicating a total of four individuals (Fig. 2a). No female samples could be genotyped.

Nine (56%) cameras recorded elephants on trails, with 812 elephant photographs corresponding to 23 independent sequences, and one 12-photograph sequence of an elephant from a camera set at a water pool. The majority of photograph sequences were in November (19; 79%). Sixteen (67%) sequences were at night (19.00–6.27) and eight (33%) during the day (7.45–18.03). The photographs were of five different individuals, of which three were males (with a fourth identified by his genotype in dung samples) and two were presumed to be females. One of these was identified as female based on physical characteristics, including no visible phallic shaft, although no mammary glands were visible. Female dung was identified in the vicinity. For the second presumed female only parts of the body were visible in the photographs as the individual was close to the camera, but the single visible tusk did not match the tusk of any of the other photographed individuals. Although sex could not be determined from the photographs, this elephant was photographed at the same camera simultaneously with a male, and female dung was collected from the same area. Two bulls were photographed along 22 km of the border with Guinea, by six cameras on 9 days and by three cameras on 3 days, respectively. A third male was recorded by two cameras and the two presumed females were recorded by only one camera each, in different locations (Fig. 2b). All individuals photographed were adults, all three males appeared to be relatively old and were always alone, with the exception mentioned above. We did not record any infants or calves, although oral records persistently refer to the sighting of adults with young.

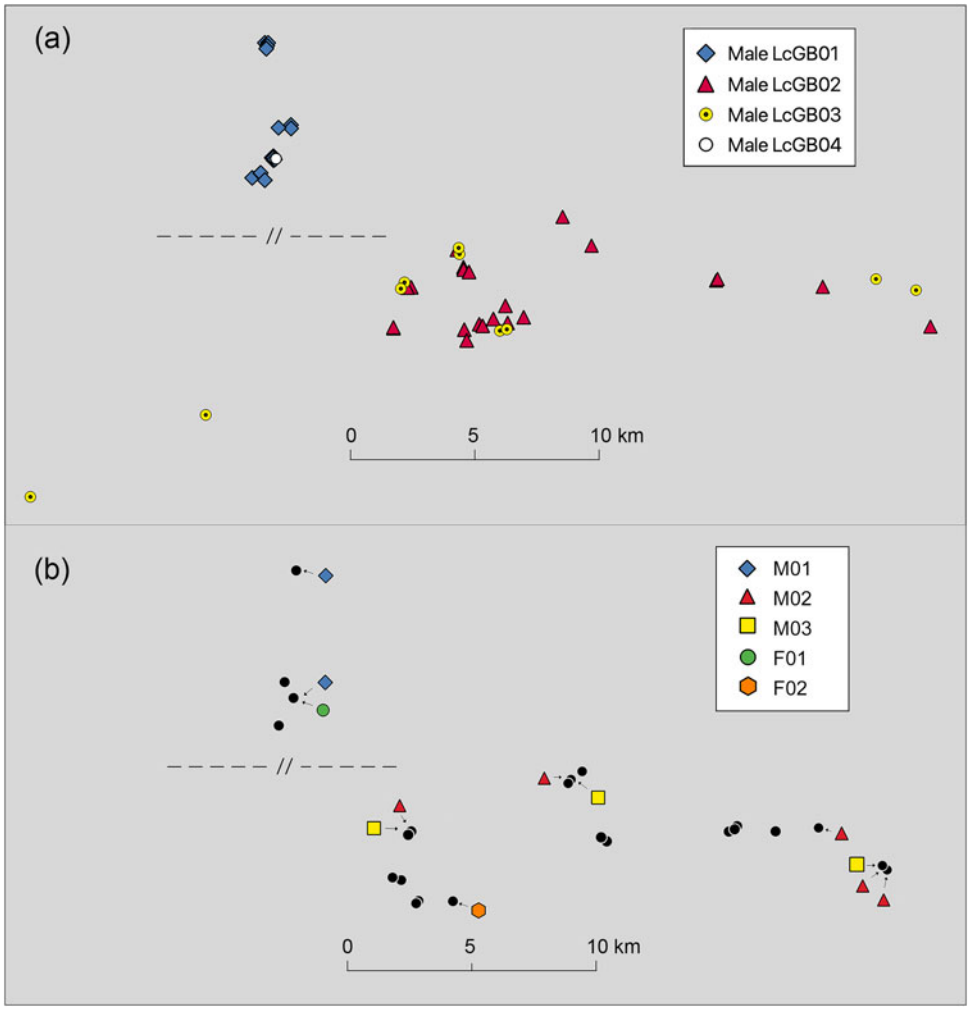

FIG. 2 (a) Distribution of the individually discriminated samples of the four genotyped males, and (b) distribution of the camera traps (black dots) and where each elephant was photographed (M = males; F = females). The maps are truncated (dashed line) at the unsurveyed area (Fig. 1), rotated, and topographic details are not provided, to avoid exposing the elephants to unnecessary risk. (Readers of the printed journal are referred to the online article for a colour version of this figure.)

Our findings confirm that a forest elephant population persists within a limited area of Guinea-Bissau, although the actual elephant range could potentially be greater as we could not survey some of the areas for which there are unconfirmed records. We did not survey the potential species range documented by Brugière et al. (2006) in neighbouring Guinea. It is possible there are other individuals in areas we were unable to survey, and the low number of females that we recorded suggests we may not have surveyed their main areas of occurrence. As we do not know what proportion of the population we surveyed, we cannot estimate the total size. However, it appears to be a small population, and the total of six individuals so far identified lies within the most recent estimates and guesses (Brugière et al., 2006; Thouless et al., 2016).

Elephants in Guinea-Bissau appear to be severely threatened. About one-third of the potential elephant range lies outside protected areas, and the adjacent Kogon River region in Guinea is unprotected, despite being identified by Brugière & Kormos (2009) as a key biodiversity area. Moreover, habitat degradation as a result of human encroachment, expanding cashew orchards, charcoal production, fires set by hunters, road development, and overexploitation of the fan palm *Borassus aethiopum*, an important elephant food resource, are ongoing (authors' pers. obs.). The elephant population is isolated following the near extinction of the species in neighbouring Senegal (Drouilly, 2021) and in most of Guinea (Thouless et al., 2016; Gobush et al., 2021), making it vulnerable to demographic stochasticity, inbreeding and loss of genetic diversity. For the above reasons, even though there are no records of elephants being killed recently (the last known cases were in 1977 and 1982), we have not provided details of elephant distribution in the text or figures. Short-term conservation efforts should include an improved estimate of the population range and size, together with enhancing protected areas coverage and preventing further habitat loss within critical areas. We continue to study this population, to identify any additional individuals and their range and gather additional information on movements, seasonality and any threats, both in Guinea-Bissau and adjacent areas of Guinea. An emergency conservation plan

is urgently needed for this elephant population, to address critical threats and ensure its long-term conservation.

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Author contributions Study design, data analysis: LP, RG; fieldwork coordination: LP; institutional/logistic support: QQ, TM, JM, TUS; map conception and design: JPC, LP; supervision: PB; writing: LP, RG, PB; revision: all authors.

Conflicts of interest None.

Ethical standards This research abided by the *Oryx* guidelines on ethical standards. Fieldwork was conducted with full permission of the Boards of the Research Centre in Biodiversity and Genetic Resources and Institute of Biodiversity and Protected Areas. Fieldwork was developed in partnership with the Institute of Biodiversity and Protected Areas and with its permission, including within protected areas.

Data availability To protect this small population of elephants, we do not provide public access to details of the data and survey area.

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