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Distribution and conservation status of Boutourlini's blue monkey

(*Cercopithecus mitis boutourlinii*), a Vulnerable subspecies endemic to

western Ethiopia

Addisu Mekonnen[1*], Peter J. Fashing[1,2], Afework Bekele[3] and Nils Chr. Stenseth[1,3]

[1] Centre for Ecological and Evolutionary Synthesis (CEES), Department of Biosciences,

University of Oslo, P.O. Box 1066, Blindern, N-0316, Oslo, Norway

[2] Department of Anthropology and Environmental Studies Program, California State

University Fullerton, Fullerton, CA 92834, USA

[3] Department of Zoological Sciences, College of Natural Sciences, Addis Ababa University,

Addis Ababa, Ethiopia

[*]Corresponding author: Addisu Mekonnen, Centre for Ecological and Evolutionary Synthesis

(CEES), Department of Biosciences, University of Oslo, P.O. Box 1066, Blindern, N-0316,

Oslo, Norway. Tel: +4793987362

E-mail: addisumekonnen@gmail.com

Abstract

Reliable data on the distribution and threats facing primate species are crucial to identifying priority sites for conservation and designing effective management plans. Boutourlini's blue monkey (*Cercopithecus mitis boutourlinii*) is a little-known arboreal primate endemic to the forests of western Ethiopia. This subspecies is categorized as Vulnerable on the IUCN Red list and the distribution of extant populations is largely unknown. To increase our knowledge of the spatial distribution and conservation status of Boutourlini's blue monkey, we carried out intensive reconnaissance surveys from January 2010 to May 2011 across ~40% of its potential range and conducted interviews with local people at each of the survey locations. We carried out geospatial analyses and mapped the distribution of Boutourlini's blue monkey localities with respect to elevation, protected area status, and changes in forest cover over time using ArcGIS 10.4.0. Through our surveys, we discovered 30 previously unknown Boutourlini's blue monkey populations in three administrative regions of western Ethiopia (Amhara, Oromia, and Southern Nations, Nationalities and People's Regions). A total of 34 different groups were sighted and counted at the survey sites, averaging 14.7 members (range: 8-23) per group. There are now 32 Boutourlini's blue monkeys populations of recently confirmed occurrence at altitudes ranging from 1039 - 2780 m asl, seven in forests of >50 km^2. Crop feeding by Boutourlini's blue monkeys was reported by people at seven sites and confirmed through direct observation at three of these sites. None of the known extant populations of Boutourlini's blue monkeys occur within a strictly protected area (e.g., National Park) where exploitative human activities are outlawed. A complete reassessment of the distribution and conservation status of Boutourlini's blue monkeys will require further surveys across the remaining ~60% of its potential range.

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Introduction

Deforestation is currently the biggest threat to biodiversity in the tropics (Hansen et al. 2013; Morris 2010; Newbold et al. 2015). Among mammals, primates are particularly vulnerable to forest loss and degradation because most species depend on forests for survival (Almeida-Rocha et al. 2017; Estrada et al. 2017; Estrada et al. 2018). Populations of many primate species now exist in small, isolated forest fragments surrounded by agriculture and other human-dominated landscapes (Estrada et al. 2017; Marsh 2003). Most primates in such fragments experience reduced habitat quality and food availability and/or increased conflict with local humans, which can lead to population decline and local extirpation (Arroyo-Rodríguez et al. 2007; Campbell-Smith et al. 2010; Fahrig 2003; Hilario et al. 2017; Mekonnen et al. 2012).

Given the rapid rates of habitat fragmentation and degradation in much of the tropics (Hansen et al. 2013; Lewis et al. 2015), studies on the spatial distribution of primates are increasingly useful to deciding where to pursue conservation action most effectively and identifying priority sites for further research (Bersacola et al. 2018; Funk and Fa 2010; Ravetta and Ferrari 2009). In particular, endemic species are important targets of global conservation efforts because endemics generally have more restricted distributions, smaller populations, fewer potential sites for conservation intervention, and overall greater susceptibility to extirpation and extinction than non-endemics (Brooks et al. 2006; Lamoreux et al. 2006).

Many studies have shown that protected areas are more effective at conserving biodiversity than unprotected areas (Geldmann et al. 2013; Laurance et al. 2012; Laurance et al. 2014; Vačkář et al. 2016). Further, studies have also shown that strictly protected areas (IUCN category I–IV), where all or nearly all human activities are prohibited, are more effective at protecting wildlife than multiple-use reserves (IUCN category V and VI), where human activities are not prohibited (Bruner et al. 2001; Pringle 2017). Moreover, identifying where the

geographic ranges of primates and protected areas overlap, particularly for threatened and endemic species or subspecies, is essential to determining the most promising areas for primate conservation (Estrada et al. 2018).

Owing to its topographic and altitudinal variation, Ethiopia is home to at least six endemic primate species or subspecies (Butynski and Gippoliti 2008; Fashing and Oates 2019; Fashing et al. 2019; Gippoliti et al. 2019; Yalden and Largen 1992; Zinner et al. 2018). Similar to endemic primates elsewhere (Estrada et al. 2017; Herrera 2017), many Ethiopian endemics are threatened with extinction due to deforestation and other forms of habitat loss, especially in its biodiversity rich highlands (Mekonnen et al. 2018c; Zinner et al. 2018). One of the endemic primates affected by this deforestation is Boutourlini's blue monkey (*Cercopithecus mitis boutourlinii*) which occurs in the highland forests west of the Rift Valley in Ethiopia (Butynski and Gippoliti 2008).

Although the taxonomy of blue monkeys (*Cercopithecus mitis*) is the subject of debate, Boutourlini's blue monkey (*C. mitis boutourlinii)* is typically classified as a subspecies of *C. mitis* (Groves 2005; Grubb et al. 2003; Lawes et al. 2013). Some subspecies of blue monkeys are relatively well-studied and widely distributed throughout central and eastern Africa where they inhabit a variety of habitat types including moist, semideciduous, evergreen forests and tropical montane forests (Butynski 1990; Cords 1986; Cords 2012; Jaffe and Isbell 2011; Kaplin 2001). However, because of its geographic isolation and, until recently, a general dearth of research on Ethiopian forest primates, Boutourlini's blue monkey remains one of the least-known *C. mitis* subspecies with only one detailed study of its ecology having been completed at a single site, Jibat Forest (Tesfaye et al. 2013). Boutourlini's blue monkey is categorized as Vulnerable by the IUCN because its population is assumed to be declining due to the extensive deforestation in its estimated range (Butynski and Gippoliti 2008; Yalden et al. 1977). Although historical records of sightings of Boutourlini's blue monkeys during the first three-quarters of

the 20th century exist for several areas, including along the Omo River near Lake Turkana, and in the Jimma, Wollega and Gojjam areas (reviewed in Yalden et al. (1977)), our knowledge of the geographic distribution for the subspecies and its total area of occupancy is fragmentary at best (Butynski and Gippoliti 2008).

Systematic methods such as line-transect surveys and occupancy models are well-established techniques to assess distribution patterns as they can provide detailed quantitative data and be replicated for long-term monitoring (Baker et al. 2011; Chapman et al. 2018; Fashing et al. 2012; Keane et al. 2012). In regions where little or no preliminary research has been carried out, however, reconnaissance surveys can provide a vital initial step by documenting the presence or absence of a particular species within its potential range, the habitats it occupies, and the conservation threats it faces, important steps for identifying suitable locations for long-term studies, designing conservation management plans, and providing data for IUCN assessments (Bersacola et al. 2018; Mekonnen et al. 2012; Plumptre 2000; Plumptre et al. 2002). Given the limited knowledge about Boutourlini's blue monkey and the forests it inhabits, the main objectives of the present study were therefore to carry out reconnaissance surveys in the highland forests west of the Rift Valley in Ethiopia to (1) determine the presence of Boutourlini's blue monkey at each forest site, (2) assess its altitudinal distribution, (3) determine the conservation threats that the subspecies faces, and (4) identify potential suitable habitats for future conservation and research activities.

Methods

Study area

Our survey research on the geographic distribution of Boutourlini's blue monkey was carried out in 45 highland forests west of the Ethiopian Rift Valley. These surveys took place in three administrative regions, Southern Nations, Nationalities and People's (SNNP) Region, Oromia

Region, and Amhara Region (Fig. 1). The study area is part of the Eastern Afromontane

Biodiversity Hotspot which extends from Mozambique and Zimbabwe in the south to Ethiopia

and Yemen in the north and contains many tropical forest ecosystems characterized by high

species richness and endemism (Mittermeier et al. 2011). Many of these forests, including those

in the regions of western Ethiopia that we surveyed, are also under intense pressure from various

forms of human disturbance, including deforestation, agricultural land expansion, selective

logging, and grazing (Mittermeier et al., 2011).

Distribution surveys

We identified areas of possible occupancy by Boutourlini's blue monkey for our surveys based

on Google Earth and other satellite images of tropical highland forests or riverine forests

occurring west of the Ethiopian Rift Valley (Mekonnen et al. 2012). We then carried out surveys

in 45 of these forests from January 2010 to May 2011. Although our surveys covered at least

40% of Boutourlini's blue monkey likely range, we were unable to cover all areas of potential

occupancy including the Gambella and Benishangul-Gumuz Regions as well as parts of Amhara,

Oromia and Southern Nations, Nationalities and People's Regions (Fig. 1) due to insufficient

funding.

AM and two well-trained research assistants accessed each survey site (locality) by

vehicle, horse, and/or on foot. Once we arrived at a new forest site, we carried out informal

interviews with at least 5 local people regarding whether primates were present or absent

(Davenport et al. 2008; Mekonnen et al. 2012). As part of these interviews, we showed

interviewees photographs of possible primates in the region, including Boutourlini's blue

monkey, de Brazza's monkey (*Cercopithecus neglectus*), grivet monkey (*Chlorocebus*

aethiops), black and white colobus monkey (*Colobus guereza ssp. guereza*) and olive baboon

(*Papio anubis*), and asked them which, if any, were present.

146   If local people confirmed the existence of *Cercopithecus* spp. in a forest, the forest was

147   then surveyed for up to three days by walking along existing paths and newly cut trails to

148   directly identify the *Cercopithecus* spp. and other primates present there (Baker and Olubode

149   2008; Davenport et al. 2008). We walked in the forest until we saw one or two groups of

150   Boutourlini's blue monkeys (i.e., enough to confirm their presence), then moved on to the next

151   locality. Survey walks were conducted at an average speed of 1.5 to 2.0 km per hour early in

152   the morning (7:00 to 11:00) and late in the afternoon (14:00-17:30) when most primates are

153   likeliest to be active (Iwanaga and Ferrari 2001; Mekonnen et al. 2012). When Boutourlini's

154   blue monkeys and/or other primate species were sighted, we recorded the GPS location, altitude,

155   group size, and habitat type(s) where the group was spotted (Lehman 2004; Mekonnen et al.

156   2012). We recorded habitat types as continuous tropical montane rainforest, degraded forest,

157   fragmented forest, bushland, human settlement, coffee plantation, natural coffee forest, and/or

158   cultivated land (see Table 1 for definitions). We recorded the administrative areas of each site

159   as locality, District (Woreda), Zone and Region. We defined and recorded forest size as small

160   forest fragment (<1 km^2), large forest fragment (1-10 km^2), small continuous forest (11-50 km^2),

161   and large continuous forest (>50 km^2) (Table 2). Further, we recorded the protected area (PA)

162   designation of each forest site as a National Park, Wildlife Reserve, Controlled Hunting Area,

163   UNESCO Biosphere Reserve, Forest Priority Area or Unprotected Area (see Table 2 for the

164   definitions). The total number of individuals in each group encountered was counted by the

165   observer, assistants and local guides (for a period of up to 3 hrs) to determine group size as

166   reliably as possible given the time constraints inherent in carrying out surveys. Because blue

167   monkeys belonging to a group are known to often spread out widely (Cords 1987), we

168   considered clusters of individuals to be separate groups only if they were at least 500 m apart.

169   Once we confirmed the presence of Boutourlini's blue monkey at each survey site, we

170   also asked the local people whether the monkeys engaged in crop feeding there. Reports of crop

feeding were considered reliable if at least 5 adults independently described the occurrence of crop feeding by Boutourlini's blue monkey at a site (Mekonnen et al. 2012). In two areas where we failed to obtain direct evidence ourselves, the presence of Boutourlini's blue monkey was recorded because at least 5 local adults correctly identified pictures of Boutourlini's blue monkey among our set of Ethiopian primate pictures, described its physical features, and provided a local name uniquely used to designate the blue monkey. The local name for Boutourlini's blue monkey is "Chano" in Oromia Region, "Bojo" in Kaffa Zone of SNNP Region, "Bazu" in Bench Zone of SNNP Region and "Baradle" in Awi Zone of Amhara Region. Conversely, the local name for the sometimes sympatric de Brazza monkey is "Wonna" in Illuababora Zone of Oromia Region and "Suku" in Bench Zone of SNNP Region.

We also carried out a search of available databases to find the scant published scientific literature containing information on the distribution of Boutourlini's blue monkeys (Yalden et al., 1977, Tesfaye et al., 2013; Geleta & Bekele, 2016). We divided this literature into recent (since 2000, effectively post-2012) and historical (2000 and before, effectively pre-1978), and consider locations of Boutourlini's blue monkey from the recent literature along with the locations where the species was found during our surveys to be places where the subspecies still occurs. Historical sites where Boutourlini's blue monkeys were reported to occur before 1978 are also plotted on maps in this paper (Figs. 1, 2, and S1) but are given a unique symbol to denote that it is unclear whether the subspecies still remains at these sites today.

Environmental variables

We obtained a Digital Elevation Model (DEM) of Ethiopia with a 30 m resolution from the United States Geological Survey database (https://earthexplorer.usgs.gov). Protected area data for Ethiopia were obtained from the World Database on Protected Areas (UNEP-WCMC 2019). Land use cover change data for Ethiopia were obtained from the Global Forest Watch database

196 (Global Forest Watch 2014). Global Forest Watch is an open-source web application used to

197 monitor patterns of forest loss (i.e., loss of canopy cover) and forest gain (i.e., gain of canopy

198 cover) around the world (Global Forest Watch 2014). In this study, we focused our efforts on

199 assessing forest loss which we defined as the loss of >30% of the tree canopy cover over a

200 period of time (Estrada et al. 2018; Estrada et al. 2019; Global Forest Watch 2014).

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Data analysis

203 We summarized our occurrence data from current and recent localities recorded to assess

204 Boutourlini's blue monkey's regional distribution pattern, altitudinal preferences, forest size,

205 and protected area designation. Because of the lack of recent evidence that the populations still

206 exist, we did not include historical (pre-1978) sites (Yalden et al. 1977) in these analyses. To

207 map the current spatial and altitudinal distribution of Boutourlini's blue monkey in the highland

208 forests west of the Rift Valley, we overlaid the GPS locations recorded on the 30 m resolution

209 DEM in ArcGIS v. 10.4.0 (ESRI 2016). To assess the distribution of protected areas within the

210 likely range of Boutourlini's blue monkeys, we also overlaid the points of occurrence of the

211 monkeys onto a protected area map of the region in ArcGIS v. 10.4.0 (Estrada et al. 2018). To

212 evaluate the extent of recent forest loss in the likely range of Boutourlini's blue monkey, we

213 extracted land use change information from Global Forest Watch (e.g., Estrada et al. 2018) for

214 the periods between 2001-2011 (the decade leading up to and including our surveys) and

215 between 2012-2018.

Results

Distribution surveys

218 Boutourlini's blue monkeys were observed at 28 of the 45 sites surveyed (Table 3; Fig. 1).

219 Local people reported the existence of Boutourlini's blue monkeys at an additional two sites

where their presence was not confirmed through direct observation, bringing the total of new sites identified in our surveys to 30. There are also reports from the recent literature of Boutourlini's blue monkeys at two additional sites that we did not survey (Geleta and Bekele 2016; Tesfaye et al. 2013). Thus, there are currently 32 known sites of occurrence for Boutourlini's blue monkey which we have plotted on Fig. 1 (and included in Table 3). SNNP and Oromia Regions account for 41% and 56% of known Boutourlini's blue monkey sites, respectively, while, Amhara Region accounts for only 3% (i.e., one isolated locality). This isolated site is in NW Ethiopia where the majority of the forest cover has already been lost with the exception of small and isolated forest fragments in an otherwise human-dominated landscape (Hurni et al. 2005). This northern population is located ~185 km from the nearest southern population. The mean distance between Boutoroulini's blue monkey localities is 145 km (SD ± 91, range 3 - 495 km).

The 32 known populations of Boutourlini's blue monkeys occur at elevations ranging from 1039 m asl (at Bebeka Cultivated Coffee Forest) to 2780 m asl (at Jibat Forest) (Mean ± S.E. = 1876 ± 66 m asl) (Table 3; Fig. 2). Seven of the populations occur in large continuous forests, 14 in small continuous forests, seven in large forest fragments, and four in small forest fragments (Table 3). None of the populations occur in strictly protected areas (i.e., National Parks), but 19 (59%) are found in multiple use reserves (e.g., Biosphere Reserves and Forest Priority Areas) where there are some constraints on human activities (Table 3; Fig. S1).

Thirty-four Boutourlini's blue monkey groups were spotted and counted during our surveys, ranging in size from 8 to 23 individuals (Mean = 14.7, SD = 3.9) and totaling 499 individuals. Both grivet monkeys (*Chlorocebus aethiops*) and black-and-white colobus monkeys (*Colobus guereza ssp. guereza*) were found at all 32 sites where Boutourlini's blue monkeys occurred and olive baboons (*Papio anubis*) were found at 29 of these sites. In contrast,

244   de Brazza's monkeys (*Cercopithecus neglectus*) were observed at only three of these sites

245   (Table 3).

246   **Crop feeding**

247   Local people reported that Boutourlini's blue monkeys engaged in crop feeding at seven sites

248   (Table 3). We were able to confirm these reports at three sites (Gubie Muleta, Kochi and

249   Hamuma) where we directly observed Boutourlini's blue monkeys feeding on crops, including

250   cereals (seeds) and coffee berries (*Coffea arabica* Rubiaceae).

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252   **Forest loss in the range of Boutourlimi's blue monkeys (2001-2011 and 2012-2018)**

253   Between 2001 and 2011, 84,800 ha of forest was lost in the estimated range of Boutourlini's

254   blue monkeys, equivalent to a 1.2% decrease in tree cover (Fig. S2). Forest loss over this period

255   occurred fairly evenly throughout the subspecies' range (Fig. S2). Over the 7-year period

256   following our surveys, rate of forest loss in the area increased with a loss of 114,500 ha,

257   equivalent to a 1.7% decrease in tree cover (Fig. S3).

258

259   # Discussion

260   This study reports the discovery of 30 new Boutourlini's blue monkey localities in the highland

261   forests west of the Rift Valley in three Administrative Regions of Ethiopia. Our surveys, which

262   covered ~40% of the likely geographic range of Boutourlini's blue monkey, greatly expand

263   knowledge of this Ethiopian endemic primate's geographic distribution, the forests it occupies,

264   and the conservation threats it faces, setting the stage for more in-depth research and

265   conservation activities. Through our surveys, we also identified the presence of at least four

266   other primate species that occur sympatrically with Boutourlini's blue monkeys in western

267   Ethiopia.

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Distribution of Boutourlini's blue monkeys and protection of the forests they occupy

We found that Boutourlini's blue monkeys occur in tropical montane forest habitats west of the Ethiopian Rift Valley at elevations ranging from 1039 - 2780 m asl, suggesting that conservation of these habitats is essential for the long-term persistence of this subspecies. It is a significant concern that none of the 32 known populations of Boutourlini's blue monkeys [30 from our surveys (Table 3), two from recent publications by Tesfaye et al. (2013) and Geleta and Bekele (2016)] occur in a strictly protected area (i.e., National Park) where human exploitation is forbidden and laws are successfully enforced. However, 19 of the populations are afforded partial protection because they occur in Forest Priority Areas or Biosphere Reserves. These multiple-use reserves are often ineffective at protecting wildlife from hunting or at preventing selective logging, cattle grazing, and fuel wood collection, but are generally successful at preventing large-scale deforestation (Laurance et al. 2012; Naughton-Treves et al. 2011). Therefore, upgrading one or more of the existing 19 multiple-use reserves to National Park status would help to ensure the long-term survival of Boutourlini's blue monkeys and the other threatened wildlife that share their habitats (Pringle 2017). We suggest Yayu Forest Biosphere Reserve, Belete-Gera Forest Priority Area and Jibat Forest Priority Area as prime candidates for upgrading to National Parks because of their extensive sizes (2302 km^2, 1523 km^2 and 367 km^2, respectively) (Table 3) and relatively undisturbed montane forest habitats. Yayu is also notable for its extensive understorey of wild coffee (*Coffea arabica*) plants and the presence of DeBrazza's monkeys in parts of the reserve (Amare 2012).

Though our study explicitly documented the spatial distribution of Boutourlini's blue monkeys over ~40% of their estimated current range, similar survey work is still needed in the other ~60% of their range. Within those areas we were unable to include in our surveys, there are 16 sites reported in the literature from the first ¾ of the 20th century where blue monkeys

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293 once occurred (reviewed in Yalden et al., 1977; Fig. 1). These sites, covering an elevation range

294 of 1000-2800 m asl, must be considered priorities for revisitation during future surveys.

295   Because reconnaissance surveys emphasize surveying for primates across large distances

296 rather than carrying out repeated counts of individual groups, they are thought to typically result

297 in underestimates of actual group size (Plumptre and Cox 2006). Mean group sizes from our

298 survey work (Mean = 14.7 individuals; n = 34 groups) proved to be only slightly smaller than

299 those reported in a recent intensive behavioral and ecological study of Boutourlini's blue

300 monkeys in Jibat Forest (Mean = 16.0 individuals; n = 2 groups; Tesfaye et al. 2013). No other

301 comparative data exist for Boutourlini's blue monkeys, though group sizes of other more-

302 studied blue monkey subspecies elsewhere tend to be larger (Jaffe and Isbell 2011). In addition,

303 because we terminated surveys at each site after only one or two group sightings, we are

304 confident that our total of 499 Boutourlini's blue monkeys counted represents only a fraction of

305 the number that actually exist across the forests we surveyed. Though time and labor intensive,

306 repeated line-transect surveys will be necessary to determine the population density and overall

307 population size in each forest (Campbell et al. 2016).

308

309 **Occurrence of other primates in the range of Boutourlini's blue monkeys**

310 We found that grivet monkeys (*Chlorocebus aethiops*), black-and-white colobus monkeys

311 (*Colobus guereza*) and olive baboons (*Papio anubis*) were typically sympatric with

312 Boutourlini's blue monkeys in the forests that we surveyed (Table 3). On the other hand, De

313 Brazza's monkeys (*Cercopithecus neglectus*) were recorded in only three of the forests. De

314 Brazza's monkeys tend to be more cryptic as well as more ecologically specialized than the

315 other four monkeys, making them less likely to be spotted and more likely to occur primarily

316 in riverine forest areas (Amare 2012; Wahome et al. 1993). In fact, DeBrazza's monkeys are

317 known to be unusual among *Cercopithecus* species in their tendency to avoid forming

polyspecific associations with other primates (Wahome et al. 1993). Though for now we must conclude that De Brazza's monkeys are probably less widely distributed in western Ethiopia than Boutourlini's blue monkeys, grivet monkeys, black-and-white colobus monkeys, and olive baboons, we suggest that surveys tailored specifically to searching for De Brazza's monkeys might yet reveal a wider distribution than reported in our study.

Deforestation, crop feeding and conservation of Boutourlini's blue monkeys

As for most other primates (Chapman et al. 2006; Estrada et al. 2017), deforestation is the major ongoing threat to Boutourlini's blue monkeys. Though the impact of deforestation differs from species to species, it tends to have a consistently negative effect on forest-dwelling primates, which depend on trees to meet their needs for food, refugia, movement and sleeping sites (Almeida-Rocha et al. 2017; Mekonnen et al. 2018a; Mekonnen et al. 2018b; Pozo-Montuy et al. 2011). With the increasing rate of deforestation in the range of Boutourlini's blue monkeys (Fig S2 and Fig S3), the long-term survival of blue monkey populations in degraded and fragmented forests will depend on their behavioural and ecological flexibility. Conservation management strategies must be implemented to protect remaining intact forest habitats and limit further deforestation in disturbed areas. Fortunately, the central portion of the range of Boutourlini's blue monkey still contains several large intact forest habitats with a high potential for the future conservation of the study species if the current rate of deforestation in the region can be curtailed.

Agricultural expansion by a growing human population has resulted in conflict between wildlife and humans throughout Ethiopia, Africa's second most populous country (Dixon et al. 2009; Mekonnen et al. 2012; Mekonnen et al. 2020). Further, it is expected that the competition for cultivated foods between wildlife and local people will become more intense in the coming decades (Crist et al. 2017; Laurance et al. 2014). Studies have shown that consumption of

343   cultivated foods by wildlife often results in conflict between the crop feeding wildlife and local

344   people due to real or perceived economic losses, which can lead to retaliatory killing

345   (Campbell-Smith et al. 2010; Chapman et al. 2016; Hill 2018). Thus, hunting may become a

346   more common threat to Boutourlini's blue monkeys, which were reported by local people to

347   engage in crop feeding at seven sites and were directly observed feeding on cereals and coffee

348   berries at three of these sites. In Tesfaye et al.'s (2013) dietary study at Jibat, Boutourlini's blue

349   monkeys in forest fragments ventured onto farms to eat barley (*Hordeum vulgare* Poaceae) and

350   wheat (*Triteum aestivum* Poaceae) seeds while those in nearby continuous forest did not. The

351   challenge of ensuring the coexistence of crop feeding wildlife and local people in Ethiopia's

352   human-dominated landscapes will be crucial to the conservation of many taxa, including

353   Boutourlini's blue monkeys (Hill and Wallace 2012; Mekonnen et al. 2020; Strum 2010).

354   In sum, our surveys revealed the existence of 30 new Boutourlini's blue monkey

355   populations and the conservation threats they face in the highland forests west of the Ethiopian

356   Rift Valley. Although we covered large areas amounting to ~40% of Boutourlini's blue

357   monkey's suspected range area during the present study, further surveys are still needed to the

358   south (Southern Nations, Nationalities and People's), west (Gambella), northwest (Oromia and

359   Benshangul-Gumuz), north (Awi, Amhara), and east (Oromia) of the localities described in this

360   study (Fig 1). Although at least 32 populations are currently known to exist, seven in forests of

361   >50 km^2, the fact that none of these populations occur in strictly protected areas where human

362   disturbance is outlawed suggests that the Vulnerable status of Boutourlini's blue monkey on

363   the current IUCN's Red List of Threatened Species (Butynski and Gippoliti 2008) continues to

364   be warranted, pending the results of future survey and censusing research.

365

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Table 1 Description of habitat types in the highlands west of the Ethiopian Rift Valley where

our surveys were carried out

Habitat type	Description
Continuous tropical montane rainforest	A natural forest that occurs at elevations between 1000-3000 m asl and with a mostly intact canopy composed of large primarily indigenous trees.
Degraded forest	Habitat type composed of mostly indigenous trees though with a more open canopy and evidence of disturbance due to logging and other signs of anthropogenic influence regardless of elevation.
Fragmented forest	A forest of <10 km^2 surrounded by human settlement, grazing land and/or cultivated land.
Bushland	Habitat type dominated by woody shrubs and herbaceous plant species.
Human settlement	Habitat type dominated by human villages and other settlements.
Coffee plantation	Plantation of coffee (*Coffea arabica*) consisting of planted coffee with indigenous trees or planted trees in the overstorey.
Cultivated land	Cultivated areas including agricultural fields and land under preparation for growing crops.

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591   **Table 2** Definitions of protected area (PA) designations and IUCN PA management categories

Protected Area Designation	IUCN PA Category	Description
National Park	II	A large, mostly untouched area of land permanently reserved for the conservation of wildlife and their habitats, that is strictly protected by law.
Wildlife Reserve	IV	A protected area designed to protect a particular wildlife species where tree cutting and cattle grazing are illegal.
Controlled Hunting Area	VI	A legally protected area where sustainable sport hunting of wildlife is permitted.
UNESCO Biosphere Reserve	Not Applicable	A legally protected area where sustainable use of natural resources is permitted.
National Forest Priority Area	Not Reported	A legally protected habitat where sustainable use of resources is permitted and the primarily focus is on the conservation of forested habitat.
Unprotected area	None	A habitat that has no designated legal protection.

592   Definitions for IUCN PA management categories adapted from IUCN (2016).

593   **Table 3** List of known Boutourlini's blue monkey localities in the highland forests west of the Rift Valley, including information on administrative

594   area, GPS location, elevation, method of detection, group size, habitat type, forest area, protected area status, crop feeding, and sympatric primates.

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Locality No.	Name of locality	District	Zone	Region	Latitude	Longitude	Elevation (m asl)	Detection	Group size	Habitat type(s) (*)	Forest size (km²)	PA Designation	Crop feeding	Other primate present
1	Gombera Forest	Bonga/	Kafa	SNNP	7.197119	36.287121	1638	Sighting	14	TMF, DF	SCF	BR	No	CM, GM, OB,
2	Dadiben Forest	Gimbo	Kafa	SNNP	7.44546	36.17957	1778	Sighting	15, 23	TMF, DF	LCF	BR	No	CM, GM, OB
3	Saja Forest	Gewata	Kafa	SNNP	7.509034	36.114695	2125	Sighting	13	TMF, DF	SCF	BR	No	CM, GM, OB
4	Boginda Foresrt	Gewata	Kafa	SNNP	7.516339	36.057026	1907	Sighting	16,13	TMF, DF	SCF	BR	No	CM, GM, OB
5	460 Forest	Bonga	Kafa	SNNP	7.305007	36.092505	1990	Sighting	14	TMF, DF	LFF	BR	No	CM, GM, OB
6	Angesha Forest	Bonga	Kafa	SNNP	7.308176	36.072669	1912	Sighting	9	TMF, DF	SCF	None	No	CM, GM, OB
7	Chosa Forest	Shebench	Bench-Maji	SNNP	7.018079	35.753205	2505	Sighting	14	TMF	LFF	None	No	CM, GM, OB
8	Bebeka Coffee Forest	South Benchi	Bench-Maji	SNNP	6.889179	35.418555	1039	Sighting	17	TMF, CP	LFF	None	No	CM, GM, OB
9	Shimi Forest	Sheka	Sheka	SNNP	7.042467	35.440899	1605	Sighting	12	TMF, FF	SCF	None	No	CM, GM, OB
10	Yemechech Forest	Andracha	Sheka	SNNP	7.412457	35.396511	2343	Sighting	16	TMF	SCF	None	No	CM, GM, OB
11	Andracha Forest	Andracha	Sheka	SNNP	7.559279	35.403328	2035	Sighting	13	TMF	SCF	None	No	CM, GM, OB
12	Sele Andracha Forest	Masha	Sheka	SNNP	7.677274	35.497742	2294	Interview	?	TMF, DF	SCF	None	No	CM, GM, OB
13	Gura Farda Forest	Gura Farda	Benchi-Maji	SNNP	6.763242	35.203607	1234	Sighting	9	TMF	LFF	None	Rep, DO	CM, GM, OB
14	Kecho/Gera Forest	Gera	Jimma	Oromia	7.784377	36.330641	2048	Sighting	14	TMF	LCF	FPA	No	CM, GM, OB
15	Gera Forest/ Geranasu	Gera	Jimma	Oromia	7.679688	36.239618	1970	Sighting	11	TMF	LCF	FPA	No	CM, GM, OB
16	Gubie Muleta Village	Mena	Jimma	Oromia	7.734612	36.758598	2023	Sighting	9	CL, FF	SFF	None	Rep, DO	CM, GM
17	Belete Forest	Shebie-Sembo	Jimma	Oromia	7.532305	36.56477	2017	Sighting	17	TMF	LCF	FPA	No	CM, GM, OB
18	Botor Bacho Forest	Chora Botor	Jimma	Oromia	8.498868	37.307431	1579	Sighting	13	TMF	SCF	FPA	No	CM, GM, OB
19	Choche	Goma	Jimma	Oromia	7.894378	36.668317	1507	Sighting	13	TMF	LFF	None	No	CM, GM, OB
20	Kochi Village	Didu Lalo	Illuababora	Oromia	7.912341	35.507222	1868	Sighting	16	TMF, CP	SFF	None	Rep, DO	CM, GM, DM
21	Hamuma Forest	Alu	Illuababora	Oromia	8.156761	35.399657	1639	Sighting	13, 11	TMF, CP	LFF	None	Rep, DO	CM, GM, OB, DM

22	Yayu Forest	Yayu	Illuababora	Oromia	8.366282	35.800849	1480	Sighting	23, 18, 14	TMF	LCF	BR	Rep	CM, GM, OB, DM
23	Geba Forest	Chora	Illuababora	Oromia	8.358653	36.048318	1568	Sighting	8	TMF, CP	SCF	BR	No	CM, GM, OB
24	Mute Mountain	Bedele	Illuababora	Oromia	8.472846	36.340803	2080	Sighting	11	TMF, BL	SFF	FPA	No	CM, GM, OB
25	Komto Forest	Wayu tuka	East Wolega	Oromia	9.313056	36.782774	1603	Literature	?	TMF	LCF	FPA	No	CM, GM, OB
26	Dedessa River	Arjo	East Wolega	Oromia	8.685366	36.410956	1295	Interview	?	FF, BL	SFF	None	Rep	CM, GM, OB
27	Metu Abo	Nono	West Shewa	Oromia	8.664747	37.366247	2150	Sighting	18	TMF	SCF	FPA	No	CM, GM, OB
28	Bilo Abo	Nono	West Shewa	Oromia	8.645384	37.375816	2038	Sighting	14	TMF	SCF	FPA	No	CM, GM, OB
29	Bildimo Forest	Seyo	West Shewa	Oromia	8.690406	37.357703	2206	Sighting	18	TMF, DF	SCF	FPA	No	CM, GM, OB
30	Botora Forest	Seyo	West Shewa	Oromia	8.730382	37.266871	1810	Sighting	14, 21	TMF, DF	SCF	FPA	No	CM, GM, OB
31	Jibat Forest	Jibat	West Shewa	Oromia	8.764744	37.475725	2780	Literature	-	TMF	LCF	FPA	Rep	CM, GM, OB
32	Dukima & Apini Forests	Banja	Awi	Amhara	10.986892	36.666661	1980	Sighting	16, 22	TMF, DF	LFF	FPA	No	CM, GM, OB

596 **Detection method for Boutourlini's blue monkeys' presence:** sighting, interview, or recent literature [locality 25 = Geleta and Bekele (2016); locality 31 =
597 Tesfaye et al. (2013)]
598 **Habitat Types**: Continuous Tropical Montane Rainforest (TMF), Degraded Forest (DF), Fragmented Forest (FF), Bushland (BL), Human Settlement (HS), Coffee Plantation
599 (CP), Cultivated Land (CL)
600 **Forest size in km^2**: Forest size as small forest fragment, SFF (<1 km^2), large forest fragment, LFF (1-10 km^2), small continuous forest, SCF (11-50 km^2), and large continuous
601 forest, LCF (>50 km^2)
602 **Protected Area (PA) status of the habitat:** Biosphere Reserve (BR), Forest Priority Area (FPA), and 'None'. [Note: none of the populations were found in areas with any of
603 the following PA designations: National Park (NP), Wildlife Reserve (WR), Controlled Hunting Area (CHA).]
604 **Presence of crop raiding by Boutourlini's blue monkeys:** DO = direct observation; Rep = Reported by interviewees; None = No
605 **Other primates present** Black-and-white colobus monkey (CM), Grivet monkey (GM), Olive baboon (OB), De Brazza's monkey (DM)
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Figure Legends

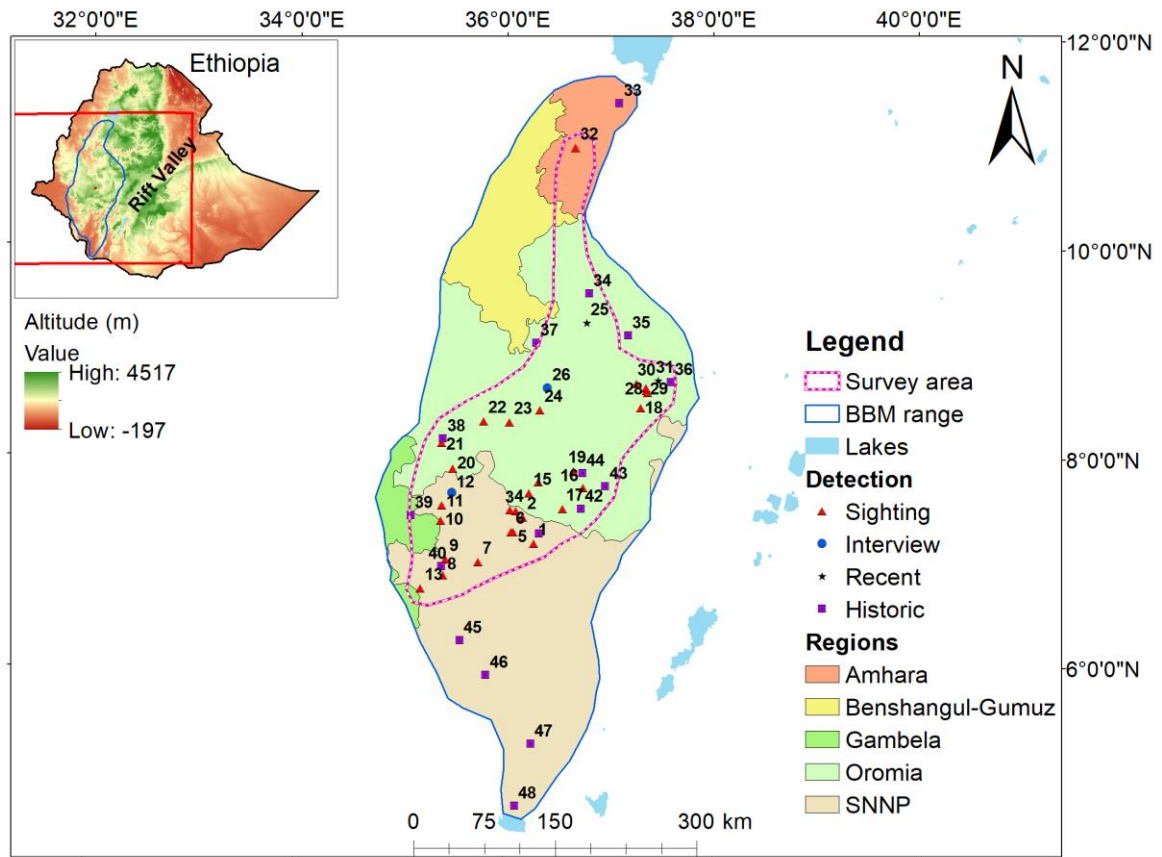**Fig.** 1 Map of the study area, newly discovered and historical Boutourlini's blue monkey localities in administrative regions west of the Rift Valley in Ethiopia

Fig. 2 Map showing the distribution of Boutourlini's blue monkey at different elevational ranges in the highland forests west of the Rift Valley in Ethiopia. Detection method for Boutourlini's blue monkeys' presence: sighting, interview, recent literature and historic literature.
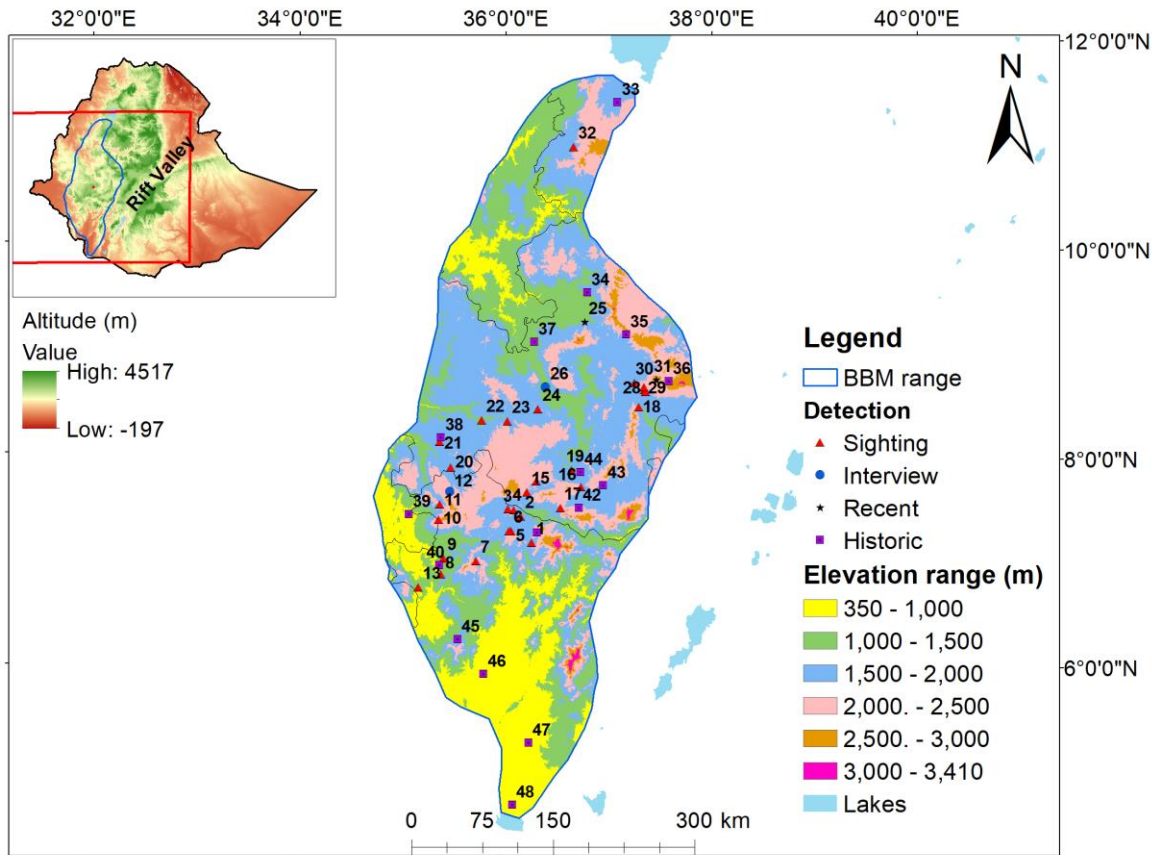
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