American Journal of Primatology 00:1–10 (2012)

RESEARCH ARTICLE

Newly Discovered Bale Monkey Populations in Forest Fragments in Southern Ethiopia: Evidence of Crop Raiding, Hybridization With Grivets, and Other Conservation Threats

ADDISU MEKONNEN[1]*, AFEWORK BEKELE[1], PETER J. FASHING[2], JEAN-MARC LERNOULD[3], ANAGAW ATICKEM[4], AND NILS CHR. STENSETH[4]
[1]*Zoological Sciences Program Unit, Faculty of Life Sciences, Addis Ababa University, Addis Ababa, Ethiopia*
[2]*Department of Anthropology and Environmental Studies Program, California State University Fullerton, Fullerton, California*
[3]*Conservation des Espèces et des Populations Animales (CEPA), Schlierbach, France*
[4]*Centre for Ecological and Evolutionary Synthesis (CEES), Department of Biology, University of Oslo, Blindern, Oslo Norway*

Until recently, the Bale monkey (*Chlorocebus djamdjamensis*), an arboreal primate endemic to the southern Ethiopian highlands, remained virtually unstudied, and its distribution pattern inadequately documented. To broaden our knowledge of the species' distribution and abundance, we carried out interviews with local people and total count surveys for Bale monkeys across 67 fragmented forest sites in human-dominated landscapes in the Oromia and Southern Nations, Nationalities, and People's Regions, Ethiopia. From January 2010 to May 2011, we discovered 26 new Bale monkey populations inhabiting forest fragments at elevations ranging from 2,355 to 3,204 m asl. Across these populations, we recorded 37 groups ranging in size from 9 to 29 individuals (Mean = 19.5, SD = 4.5), for a total of 722 individuals. Black-and-white colobus monkeys (*Colobus guereza*) were sympatric with Bale monkeys at all sites, while grivet monkeys (*Chlorocebus aethiops*) were found only at sites where Bale monkeys did not occur. All of the newly discovered Bale monkey sites once contained bamboo forest, though at 35% of the sites bamboo forest had been eliminated during the past two decades. The persistence of Bale monkeys at fragmented sites lacking bamboo suggests greater habitat flexibility for the species than previously thought, though the long-term viability of populations both with and without bamboo remains uncertain. Human hunting in response to crop raiding, a behavior the monkeys engaged in at all sites, represents a major threat facing the newly discovered Bale monkey populations. Furthermore, despite their current lack of sympatry, apparently hybrid individuals between Bale monkeys and grivets were noted at three sites, posing yet another potential obstacle to Bale monkey conservation. Community conservation programs aimed at (1) protecting remaining habitat fragments, (2) planting bamboo and trees within and between fragments, and (3) reducing crop raiding represent the only hope for survival of the newly discovered Bale monkey populations. Am. J. Primatol. 00:1–10, 2012.

Key words: *Chlorocebus djamdjamensis*; conservation; crop raiding; distribution; forest fragmentation; hybridization

INTRODUCTION

Nonhuman primates face a variety of anthropogenic threats including habitat destruction, hunting, infectious disease, and climate change [Chapman et al., 2006; IUCN, 2010]. The most serious immediate threat to the survival of many primate species is habitat destruction for timber, agricultural land, and human settlement [Isabirye-Basuta & Lwanga, 2008; IUCN, 2010]. Habitat loss has forced many primate populations to live in small fragments isolated from one another by human-dominated landscapes [Marsh, 2003].

Conversion of primate habitats into agricultural land, in particular, creates the potential for conflict between hungry primates and people [Campbell-Smith et al., 2010; Cowlishaw and

Contract grant sponsor: Conservation des Espèces et des Populations Animals (CEPA); contract grant sponsor: Zoologische Gesellschaft für Arten- und Populationsschutz, Germany (ZGAP); contract grant sponsor: Le Conservatoire pour la Protection des Primates; contract grant sponsor: La Vallée des Singes Primate Park.

*Correspondence to: Addisu Mekonnen, Zoological Sciences Program Unit, Faculty of Life Sciences, Addis Ababa University, PO Box 1176, Addis Ababa, Ethiopia. E-mail: addisumk@yahoo.com

Received 25 August 2011; revised 17 November 2011; revision accepted 19 November 2011

DOI 10.1002/ajp.21999
Published online xx XXXX xxxx in Wiley Online Library (wileyonlinelibrary.com).

Dunbar, 2000; Oates, 1996]. Crop raiding is an increasing source of human-wildlife conflict and many primate species living adjacent to agricultural land are known to engage in this behavior [Campbell-Smith et al., 2010; Hill, 1997; Lee & Priston, 2005; Marchal & Hill, 2009; Priston & Underdown, 2009; Warren, 2008]. Local communities are likely to develop negative attitudes towards primate species that crop raid, thereby further endangering primates already at risk because of human encroachment upon their habitat [Campbell-Smith et al., 2010; Hill, 1997].

Habitat disturbance may also result in increased chance of hybridization between taxa. For example, species previously separated by large tracts of forest may encounter one another in agricultural areas once forest has been cleared, leading to hybridization [Chapman & Chapman, 1996; Detwiler et al., 2005]. Unfortunately, the conservation threats posed to primate species by hybridization remain relatively little studied [though see the excellent recent review of what is known on the topic by Detwiler et al., 2005].

Species with limited distributions and narrow ecological niches are especially susceptible to extinction caused by habitat disturbance [Yu & Dobson, 2000; Harcourt, 2006]. For example, the Bale monkey (*Chlorocebus djamdjamensis*), an arboreal primate endemic to the southern Ethiopian highlands, is at risk of extinction (IUCN classification: Vulnerable) because of rapid clearance of its bamboo forest habitat [Butynski et al., 2008; Mekonnen et al., 2010a]. While the full extent of the Bale monkey's distribution remains unknown, its apparent dietary specialization on bamboo [Mekonnen et al., 2010a] suggests the species may lack the ecological flexibility to cope with disturbance to its habitat. Furthermore, Kingdon [1997] suggested that hybridization of Bale monkeys (*C. djamdjamensis*) with other more widespread and adaptable *Chlorocebus* spp. [e.g., grivets (*Chlorocebus aethiops*) or vervets (*C. pygerythrus*)] represents a potential threat facing the species as its habitat is cleared for agricultural purposes. While the Bale monkey is unique among *Chlorocebus* spp. in its specialization on bamboo and mostly arboreal lifestyle [Mekonnen et al., 2010a], destruction of its habitat for agriculture could lead to crop raiding and spatial overlap and hybridization with other more terrestrial *Chlorocebus* taxa. Indeed, J.-M. Lernould [pers. obs.] (who kept a tame young male Bale monkey at home in Goba, Ethiopia at a time when the species was only known from the holotype) noted possible Bale monkey × grivet hybrids in Sidamo Province in 1969 though never published these observations.

As for other primates, many of the anthropogenic threats faced by Bale monkeys can be linked to the high rate of human population growth in the country where they occur. According to Ethiopia's Central Statistical Agency [2008], the population of Ethiopia nearly doubled between 1984 and 2007, from 40 million to 74 million. The resulting increasing human demand for natural resources in Ethiopia has led to an alarming rate of deforestation. While initially possessing 40% forest cover, the most recent estimates suggest that only 2.4% of Ethiopia remains forested today [FDRE, 1998; Waktola, 1999]. Most of this forest clearance has been carried out to facilitate shifting agriculture, fuel wood collection, and livestock production [FDRE, 1998; Waktola, 1999].

From January 2010 to May 2011, we carried out surveys to (1) improve our knowledge of the distribution and abundance of Bale monkeys across the southern Ethiopian highlands and (2) document the conservation threats the species faces because of the degradation and loss of its habitat. Prior to our surveys, Bale monkeys were known primarily from several sites in and around Bale Mountains National Park in the Bale Mountains, Oromia Region (Fig. 1). Here, we report the presence of newly discovered Bale monkey populations at 26 localities consisting of forest fragments far to the W and SW of most previously known populations. At all 26 localities, Bale monkeys were directly observed or reported by local people to engage in crop raiding. Furthermore, at three additional localities we recorded the presence of likely hybrids between Bale monkeys (*C. djamdjamensis*) and grivet monkeys (*C. aethiops*). We suggest strategies for conserving fragmented Bale monkey populations and expect that the new information on Bale monkey distribution, abundance, and conservation threats presented here will prove helpful in updating the categorization of the species on the IUCN Red List.

METHODS

From January to June 2010 and December 2010 to May 2011, Addisu Mekonnen and a team of trained field assistants carried out surveys in 67 forest fragments separated from one another by at least 1 km of cultivated land and human settlement in two neighboring administrative regions, Oromia Region (West Arsi and Guji Zones) and Southern Nations, Nationalities, and People's (SNNP) Region (Sidama and Gedeo Zones) (Fig. 1). We identified areas to survey as those presently (or until recently) containing at least some bamboo and occurring at elevations ranging from 2,000 to 3,300 m asl (i.e., the approximate range of elevations at which Bale monkeys are known to occur). These areas generally consisted of some combination of bamboo-dominated forest, tree-dominated forest, cultivated land, and human settlement (Table I). The primary forms of human disturbance in these areas included bamboo harvesting and forest clearance for cattle ranching, cereal cultivation, and enset plantations [*Ensete ventricosum (Musaceae)*, the most important root crop and staple food for the Sidama people; Brandt et al., 1997].

During our surveys, we covered more than 4,300 km by vehicle, motor bike, or horse to access the

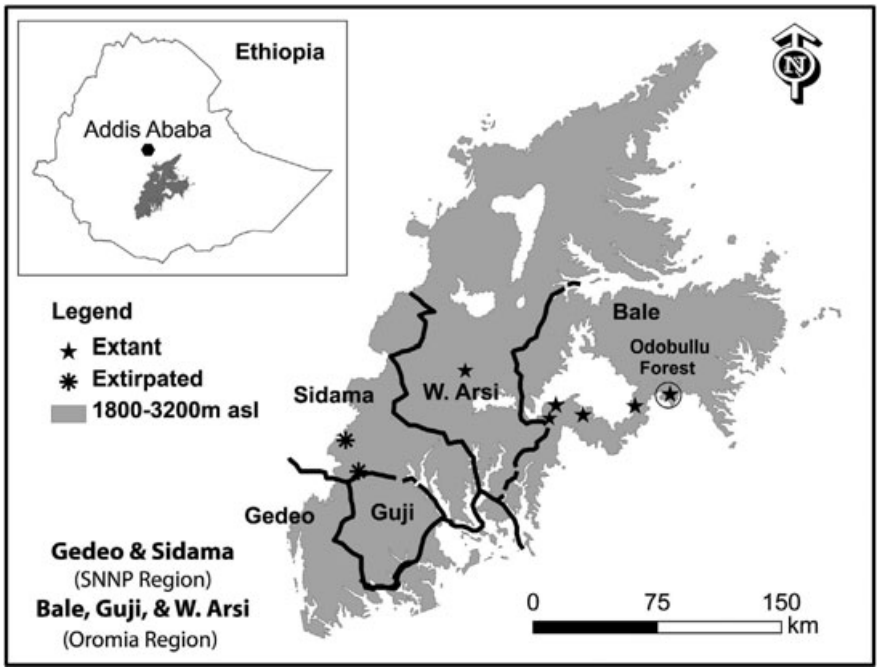

Fig. 1. Map depicting portions of the Oromia Region (Bale, Guji, and West Arsi Zones) and SNNP Region (Gedeo and Sidama Zones), including the locations where Bale monkeys had been reported prior to our surveys (stars = extant populations; asterisks = extirpated populations).

TABLE I. Description of Habitat Types in Southern Ethiopia

Habitat type	Description
Tree-dominated forest	Habitat type composed primarily of indigenous trees
Degraded tree-dominated forest	Habitat type composed of mostly indigenous trees though at reduced densities because of deforestation by humans
Bamboo forest	Habitat type dominated by indigenous bamboo, *A. alpina* (Poaceae), interspersed with relatively few trees and shrubs
Degraded bamboo forest	Habitat type dominated by indigenous bamboo and some trees though at reduced densities because of harvesting by humans
Bushland	Habitat type dominated by woody shrubs and herbaceous plant species
Human settlement	Habitat type dominated by human settlement areas like villages
Cultivated land	Cultivated areas including agricultural fields and land being prepared for raising crops
Protected habitat	A legally protected area where cattle grazing and tree and bamboo harvesting are prohibited by the local government

67 survey sites. Upon arriving in a new area, we carried out informal interviews with local people [e.g., Baker & Olubode, 2007; Davenport et al., 2008], asking them if bamboo forest currently (or previously) occurred nearby and showing them photographs of the three *Chlorocebus* spp. that occur in Ethiopia: Bale monkeys, grivets, and vervets. During these interviews, we also asked whether Bale monkeys at a site (1) engaged in crop raiding, (2) were hunted, or (3) had been extirpated by humans.

If people reported the existence of *Chlorocebus* in an area, we then surveyed nearby forested sites by walking along existing paths or newly cut trails. We conducted surveys in the early morning or late afternoon, when monkeys were most likely to be active [Struhsaker, 1981], at an average speed of 1.5–2.0 km/hr. Upon sighting Bale monkeys or other *Chlorocebus* spp., we stopped to record Global Positioning System (GPS) location (using a Garmin GPS 12), altitude, habitat type(s) occupied, group size, instances of crop raiding, and morphological evidence of hybridization with other *Chlorocebus* spp. We also noted the presence of additional diurnal primate species, eastern black-and-white colobus monkeys (*Colobus guereza*), and baboons (*Papio anubis*), in forest fragments containing Bale monkeys.

We recorded habitat types as bamboo-dominated forest, tree-dominated forest, bushland, cultivated land, or human settlements (see Table I for definitions of habitat types). We also noted when forested sites were heavily disturbed. We identified possible hybrid individuals based on phenotypic features, including coat color, facial hair (including moustache) pattern, and tail length and color that appeared to

be intermediate between *C. djamdjamensis* and *C. aethiops* [Aguiar et al., 2007; Bicca-Marques et al., 2008; Detwiler et al., 2005].

Because forest patches surveyed were small (estimated fragment sizes ranged from <1 to 10 km^2), we attempted to identify and count all Bale monkey groups inhabiting them. This total count method [Davenport et al., 2008; Plumptre & Cox, 2006] was used to estimate the population size of Bale monkeys in each forest patch. Most monkey populations were partially habituated to human observers given the fragmented and human-dominated habitats they occupied. Multiple individuals (Addisu Mekonnen and local assistants) simultaneously counted the number of individuals in the groups encountered, though we acknowledge that some group sizes may have been at least slightly underestimated. We can be confident, though, that we are reporting at least minimum group sizes.

Furthermore, though we treated each forest fragment containing Bale monkeys as a separate population in this study, we should note that the distance Bale monkeys are capable of dispersing between fragments through a matrix of human settlements and croplands is unknown. Despite our ignorance about the dispersal capabilities of Bale monkeys, it seems possible, or even likely, that some of the populations found in this study belong to a larger metapopulation given that some fragments containing Bale monkeys were located as little as 1 km apart [e.g., Swart and Lawes, 1996; Anderson et al., 2007a].

We incorporated GPS locations of Bale monkey populations recorded during the current surveys, along with the locations of previously known populations [Butynski et al., in press; Mekonnen et al., 2010b], into geographic information system (ArcMap v. 9.1) to create a distribution map for Bale monkeys.

The research described here complied with the ASP Principles for the Ethical Treatment of Nonhuman Primates and adhered to the legal requirements of Ethiopia.

RESULTS

Distribution and Population Status

Bale monkeys were observed at 26 of the 67 sites surveyed (Table II; Fig. 2). Local people reported the existence of Bale monkeys at an additional five sites where their presence was not confirmed through direct observation. At sites where they were observed, Bale monkey populations occurred at elevations ranging from 2,355 to 3,204 m asl. A total of 37 Bale monkey groups containing 722 individuals were recorded with groups ranging in size from 9 to 29 individuals (Mean = 19.5, SD = 4.5).

Black-and-white colobus monkeys were observed at all sites where Bale monkeys occurred and baboons were present at three of these sites as well (Table II). Grivet monkeys were never found in sympatry with Bale monkeys, but were observed at 13 sites to the N and W of Bale monkey populations (Fig. 2). Most (85%) grivet monkey populations occurred below the minimum elevation for Bale monkeys (2,300 m asl), though at two localities (Arsi Negele and Bowicha) they were found at ~2,500 m asl.

All 26 new Bale monkey sites consisted of fragmented forest in human-dominated landscapes outside officially protected areas (Table II). At most sites where Bale monkeys occurred, the bamboo forest had either been degraded or, in several cases, eliminated and converted into human use areas for settlement, agriculture, or livestock grazing. Most sites containing Bale monkeys occurred on public lands (e.g., Bodie Mountain, Felada Mountain, Geramba Mountain, and Sucha Mountain), though several of the sites with the best protected remaining bamboo (and Bale monkeys) occurred on privately owned land (e.g., Guticha, Womma Shella).

During our surveys, local people reported the recent extinction of Bale monkeys at two sites near Hagere Selam (H.S.) town—Abera (10 km SW of H.S.) and Selassie Church (2 km N of H.S.)—in Sidama Zone (Table II). Indeed, the past presence of Bale monkeys at Abera can be confirmed from published reports stating that the species occurred at this site 40 years ago [Carpaneto & Gippoliti, 1994; Dandelot & Prévost, 1972]. The extinctions at Abera and Selassie Church were reputedly because of a combination of habitat loss and hunting in response to crop raiding [Mulushewa Belachew, pers. comm.].

Crop Raiding

Across the newly discovered populations of Bale monkeys, conflict with humans was widespread. Local people reported that Bale monkeys were crop pests at all 26 sites. We were able to confirm these reports at five sites where we directly observed Bale monkeys engaging in crop raiding. Local people reported using dogs, spears, or traps to kill Bale monkeys at many sites.

Hybridization With Grivets

Throughout the areas surveyed for Bale monkeys, we found no evidence of current sympatry with grivets, though populations of the two species were found separated by as little as 12 km. Despite their apparent lack of sympatry, we observed putative hybrid populations of *C. djamdjamensis* × *C. aethiops* at three localities in Oromia Region: Ekuma Mountain, Kulla Mountain, Wotiye. Monkeys at these sites were morphologically different from Bale monkeys elsewhere (Fig. 3). In particular, all monkeys observed exhibited coat colors, tail

TABLE II. Description of Survey Localities Where Populations of Bale Monkeys (*C. djamdjamensis*) or Bale Monkey–Grivet (*C. djamdjamensis* × *C. aethiops*) Hybrids Were Sighted (1–29), Were Reported to Occur by Local People (30–34), or Had Recently Gone Extinct (35–36) in Southern Ethiopia

No.	Name of locality	Location Woreda/zone/ region	Bale monkey	GPS location X	GPS location Y	Altitude, m	Method of detection	Number of groups observed	Number of individuals per group	Habitat type(s)	Crop raiding (yes/no)	Other primates present
1	Woge Abeyu	Kofele/West Arsi/Oromia	Present	0469957	0765101	2,664	Sighting	2	18, 24	Degraded TDF, BF, HS	Yes	CM
2	Gata Forest	Kokossa/West Arsi/Oromia	Present	0485508	0744400	2,716	Sighting	1	18	Degraded BF	Yes	CM, AB
3	Kokossa Forest	Kokossa/West Arsi Oromia	Present	0478173	0774996	2,643	Sighting	1	26	Degraded TDF, bushland	Yes	CM, AB
4	Ekuma Mountain	Kokossa/ West Arsi/Oromia	Hybrid[a]	0467688	0750962	2,754	Sighting	2	31, 38	Degraded TDF, no bamboo	Yes	CM
5	Kulla Mountain	Kokossa/ West Arsi/ Oromia	Hybrid[a]	0464613	0750144	2,900	Sighting	2	25, 34	Degraded TDF, no bamboo	Yes	CM
6	Shambel Kedir	Nenesebo /West Arsi/Oromia	Present	0506032	0736328	2,723	Sighting	1	24	Degraded BF, CL	Yes	CM
7	Ashena Forest	Dodola/West Arsi/Oromia	Present	0517175	0747695	2,790	Sighting	2	23, 17	BF & TDF	Yes	CM, AB
8	Gorte Forest	Kokosa/West Arsi/Oromia	Present	0480669	0752252	2,740	Sighting	1	18	Degraded TDF and BF	Yes	CM
9	Ududa	Gorche/Sidama/SNNPR	Present	0460530	0753015	2,833	Sighting	1	16	Degraded TDF, HS	Yes	CM
10	Afursa Mountain	Arbegona/Sidama/SNNPR	Present	0468685	0741162	2,681	Sighting	1	21	Protected TDF	Yes	CM
11	Geramba Mountain	Arbegona/Sidama/SNNPR	Present	0461412	0745412	3,204	Sighting	2	23, 18	Protected BF, BL, TDF	Yes	CM
12	Bodie Mountain	Bensa/Sidama/SNNPR	Present	0491434	0724153	2,773	Sighting	2	20, 25	BF and TDF	Yes	CM
13	Sadisa Kedado Forest	Chire/Sidama/SNNPR	Present	0497602	0719694	2,620	Sighting	2	29, 21	BF and TDF	Yes	CM
14	Felada Mountain	Chire/Sidama/SNNPR	Present	0497610	0717408	2,805	Sighting	2	24,14	BF and TDF	Yes	CM
15	Sucha Mountain	Chire/Sidama/SNNPR	Present	0503277	0726091	2,637	Sighting	2	13,19	BF and TDF	Yes	CM
16	Melke Dintu	Aroressa/Sidama/SNNPR	Present	0493681	0700793	2,355	Sighting	1	15	Degraded TDF and HS	Yes	CM
17	Kankicha	Hula/Sidama/SNNPR	Present	0452199	0718249	2,676	Sighting	1	23	Degraded BF and TDF, HS	Yes	CM
18	Keransa Village	Bore/Guji/Oromia	Present	0459413	0704868	2,670	Sighting	1	9	HS	Yes	CM
19	Abaye Kutre Village	Bore/Guji/Oromia	Present	0460635	0702232	2,674	Sighting	1	11	HS	Yes	CM
20	Loga Forest	Ana Sora/Guji/Oromia	Present	0470580	0681652	2,390	Sighting	1	18	HS and TDF	Yes	CM
21	Gelesho Forest	Ana Sora/Guji/Oromia	Present	0467327	0691184	2,693	Sighting	1	21	TDF	Yes	CM
22	Womma Shella village	Ana Sora/Guji/Oromia	Present	0464434	0694705	2,628	Sighting	2	17, 23	Private BF and HS	Yes	CM
23	Wotiye	Ana Sora/Guji/Oromia	Hybrid[a]	0465236	0694038	2,632	Sighting	1	16	Degraded TDF, HS	Yes	CM
24	Bubie Kersa	Ana Sora/Guji/Oromia	Present	0471293	0678239	2,360	Sighting	1	19	Degraded TDF, HS	Yes	CM
25	Guticha Area	Damma/Guji/Oromia	Present	0448519	0698350	2,775	Sighting	2	18, 23	Private BF and HS	Yes	CM
26	Heto Dadi	Damma/Guji/Oromia	Present	0444845	0693351	2,846	Sighting	1	13	Degraded BF, HS	Yes	CM
27	Bondie Forest	Uraga/Guji/Oromia	Present	0443001	0689863	2,835	Sighting	1	16	Degraded BF	Yes	CM
28	Wolena Forest	Uraga/Guji/Oromia	Present	0444081	0686949	2,711	Sighting	2	27, 19	Private BF	Yes	CM
29	Kedida Forest	Uraga/Guji/Oromia	Present	0449431	0681745	2,563	Sighting	2	16, 23	Degraded BF, TDF HS	Yes	CM
30	Gerbicho Kila	Aleta Wondo/Sidama/SNNPR	Not confirmed	0443184	0727080	2,468	Local people	?	?	BF and HS	Yes	CM
31	Edume Forest	Hula /Sidama/SNNPR	Not confirmed	0441434	0721820	2,628	Local people	?	?	TDF and degraded BF	Yes	CM
32	Buke Forest	Gorche/Sidama/SNNPR	Not confirmed	0450475	0754630	2,407	Local people	?	?	TDF	Yes	CM, AB
33	Siba Forest	Bule/Sidama/SNNPR	Not confirmed	0433547	0687789	2,987	Local people	?	?	Degraded BF	Yes	CM
34	Sakaro village	Ana Sora/Guji/Oromia	Not confirmed	0488673	0661329	2,205	Local people	?	?	Degraded TDF, HS	Yes	CM
35	Abera	Hula/Sidama/SNNPR	Extinct	0441508	0712177	2,890	Sighting	0	0	CL	Yes	CM
36	Selassie Church, Abela	Hula/Sidama/SNNPR	Extinct	0447542	0718587	2,693	Sighting	0	0	BF and HS	Yes	CM

[a]Putative hybrid between *C. djamdjamensis* and *C. aethiops*.
Habitat type: BF, bamboo forest; BL, bushland; CL, cultivated land, HS, human settlement; TDF, tree-dominated forest.
Other primates seen: AB, Anubis baboons: *Papio anubis*; CM, Eastern black-and-white colobus monkeys: *C. guereza*.

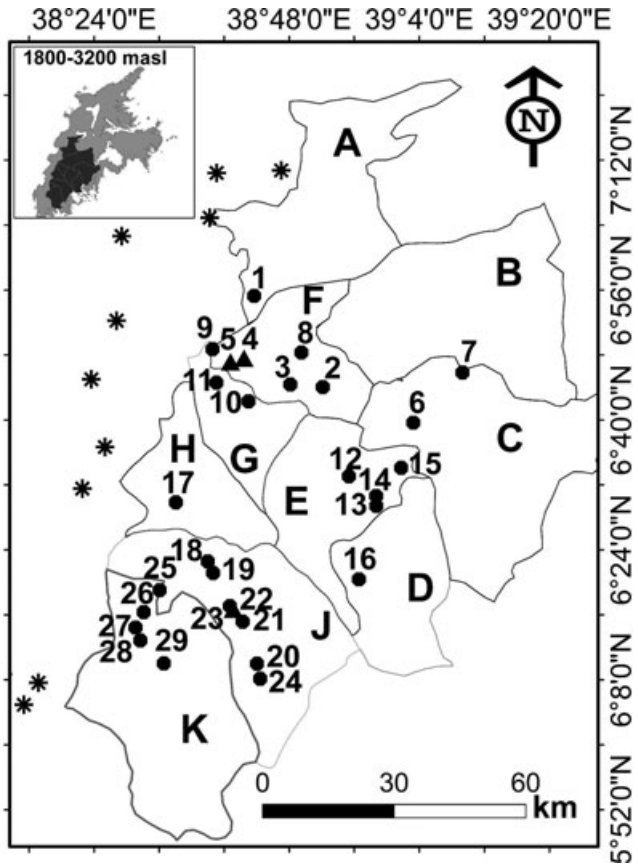

Fig. 2. Map of Bale monkey and grivet monkey localities in southern Ethiopia discovered during our current research, including localities of presumed hybridization. Letters A-–K represent different Woredas (administrative districts): A, Kofele; B, Dodola; C, Nenesebo; D, Aroresa; E, Bensa; F, Kokosa; G, Arebegona; H, Hula; J, Bore and K, Uraga. Asterisks indicate grivet monkey localities, circles indicate Bale monkey localities, and triangles indicate possible hybrid populations.

lengths, and whisker lengths that were intermediate between Bale and grivet monkeys. Furthermore, the putative hybrids had white tail tips and white browbands that are larger in grivets and absent in Bale monkeys. Photos of examples of putative hybrids from Wotiye and Ekuma Mountains are provided in Figure 3c and d, respectively, along with examples of pure Bale monkeys (Fig. 3a,b) and grivets (Fig. 3e,f) from other sites for comparative purposes. Curiously, none of the three sites with putative hybrids contained bamboo forest, yet group sizes of hybrids were larger on average (Mean = 28.8; n = 5 groups) than those of pure Bale monkeys at other sites (Mean = 19.5; n = 37 groups).

DISCUSSION

Our study extends the distribution of the Bale monkey (*C. djamdjamensis*) to Guji and West Arsi Zones of Oromia Region and to Sidama Zone of SNNP Region in the southern Ethiopian highlands. In total, we discovered 722 Bale monkeys belonging to 37 groups distributed across 26 new fragmented forest sites, all occurring outside protected areas. Bale monkeys in the Oromia and SNNP Regions face major conservation challenges because of (1) degradation of their habitats, (2) backlash against their crop raiding behavior, and, at some sites, (3) apparent hybridization with the more widespread and adaptable grivet monkey (*C aethiops*). We hope that by having identified new Bale monkey populations and the threats they face, we have helped to further clarify the distribution and conservation status of Bale monkeys in southern Ethiopia.

Bale Monkey Distribution and Abundance

Despite substantially widening the known distribution of Bale monkeys (Fig. 2), our study failed to identify any populations that are large in size. Indeed, the largest population we found contained only 50 individuals. Even if the total counts conducted during our preliminary surveys slightly underestimated the number of individuals in these populations [Baker et al., 2009; Plumptre & Cox, 2006], the sizes of these populations still fall far below the theoretical threshold for population viability [Harcourt, 2002]. Although dispersal between at least some of the forest fragments is probably possible [e.g., Anderson et al., 2007b], the long-term prognosis for the small Bale monkey populations in these fragments is poor, even without considering the other conservation threats facing these monkeys (see below).

Sympatry With Other Primates

We found that throughout the southern range of Bale monkeys, the species lives in sympatry with eastern black-and-white colobus monkeys (*C. guereza*). Indeed, the two species were often observed in proximity to one another during our surveys [Addisu Mekonnen, pers. obs.], a phenomenon warranting further study. These apparent associations may arise because of the small sizes of the forest fragments they occupy, dietary overlap among fellow folivores [Fashing, 2001; Mekonnen et al., 2010a], or predator avoidance benefits [e.g., Bshary & Noë, 1997] resulting from colobus monkeys appearing to prefer the top canopy and Bale monkeys the middle and lower canopies [Addisu Mekonnen, pers. obs.].

On the other hand, we found no evidence for current sympatry between Bale monkeys and grivets or vervets in the areas surveyed. This lack of overlap appears to result from differences in altitudinal range and habitat preferences between Bale monkeys and their congeners. While grivets and vervets tend to prefer lower elevations and drier woodland habitats [Jaffe & Isbell, 2011; Zinner et al., 2002], Bale monkeys tend to occupy high elevation sites

COLOUR ONLINE, B&W IN PRINT

Fig. 3. Comparison of appearance of pure *C. djamdjamensis*, *C. aethiops*, and their putative hybrids. (a, b) Adult male pure *C. djamdjamensis* from Odobullu Forest. Note that the pelage is relatively brown, a white browband is absent, the whiskers are short, and the tail is short with no tuft. (c) Adult male putative hybrid *C. djamdjamensis* × *C. aethiops* at Wotiye, Ana Sora Woreda possessing an intermediate coat color that is grayer than that of a pure Bale monkey but less gray than that of a pure grivet. The animal possesses a white browband, though it is smaller than that of a pure grivet. (d) Subadult male putative hybrid *C. djamdjamensis* × *C. aethiops* at Ekuma Mountain, Kokossa Woreda exhibiting a coat color intermediate between that of a Bale monkey and a grivet, a tail of intermediate length, a very small white tail tuft, and a small white browband and moustache. Pure adult grivet monkeys from Awash National Park (e) and Wondo Genet (f) with grayish-gold fur, thick white browbands, long, white, and slightly curved whiskers, black faces with white moustaches, and long tails whose bases contain tufts of white hairs on both sides.

containing some bamboo forest [Mekonnen et al., 2010a,b; this study].

Evidence of Habitat Flexibility

Previous surveys across the Bale Mountains area (in Bale Zone, Oromia Region; Fig. 1) suggested that Bale monkeys occurred only in bamboo forest [Mekonnen et al., 2010b]. Indeed, a detailed ecological study of Bale monkeys undertaken at Odobullu Forest (Fig. 1) in Bale Zone found that 77% of their diet consisted of a single species of bamboo, *Arundinaria alpina* (Poaceae) [Mekonnen et al., 2010a]. We were therefore surprised to find Bale monkeys living in forests lacking bamboo during our recent surveys in Oromia and SNNP Regions. Of the 26 new localities where Bale monkeys were discovered, only 17 contained bamboo. It should be noted, however, that the nine sites lacking bamboo held the species until recently (i.e., within the past ~20 years) according to local people. At most of these sites, humans are presumed to have eliminated the bamboo through overexploitation, though at Kulla and Ekuma Mountains (Kokossa area) people reported that bamboo disappeared naturally after last producing seeds ~20 years ago.

The persistence of populations of Bale monkeys for over a decade in heavily disturbed forest fragments lacking bamboo suggests the species is capable of greater habitat flexibility than previously

believed [e.g., Mekonnen et al., 2010a,b]. Unlike extreme bamboo specialists such as bamboo lemurs (*Hapalemur* spp.) [Tan, 1999], for example, Bale monkeys are able to subsist on other food sources in bamboo-less forest fragments. More intensive study is needed, however, to determine exactly how Bale monkeys manage to survive in suboptimal habitat. Incidentally, the captive Bale monkey kept by J.-M. Lernould [pers. obs.] in Goba in 1969 subsisted on grass and insects as well as a variety of provisioned fruits and vegetables though the long-term ability of captive Bale monkeys to survive on such unnatural diets is unknown.

Conservation Threats

While the evidence for ecological lability uncovered by our study is encouraging, the long-term prospects for the small Bale monkey populations in fragments both with and without bamboo remain grim. As for many primates [Chapman et al., 2006; IUCN, 2010], habitat loss is the greatest threat facing Bale monkeys in southern Ethiopia. All 26 forest fragments where Bale monkeys were found during our surveys occurred amidst a matrix of human settlements and cultivation and were undergoing extensive habitat modification. Unfortunately, a recent study of a far more flexible species, *C. guereza* in small, heavily disturbed Ugandan forest fragments found that their numbers declined by 55% over just an 8-year period during which they experienced extensive habitat degradation and loss of the sort reported in our study of Bale monkeys [Chapman et al., 2007].

Another threat placing the newly discovered Bale monkey populations in Oromia and SNNP Regions at risk of extirpation is hunting by local people in response to crop raiding by the monkeys. Bale monkeys were observed or reported to be crop raiders at all sites where they were found during our surveys. At Felada Mountain and Melke Dintu, for example, we watched Bale monkeys feeding on barley planted near the edge of the forest [Mekonnen, pers. obs.]. Elsewhere, they entered agricultural areas to feed on other cereals, vegetables, fruits, and enset. Like other crop raiding primates [Campbell-Smith et al., 2010; Hill, 1997; Lee & Priston, 2005; Marchal & Hill, 2009; Warren, 2008], having lost their primary food item (bamboo) to human disturbance, Bale monkeys have extended their diet to include agricultural products, resulting in conflict with nearby human populations [Cowlishaw & Dunbar, 2000]. In response, humans have turned to hunting Bale monkeys as crop pests, though taboos prevent local people from consuming the monkeys after killing them [Mekonnen, pers. obs.]. As long as the monkeys continue to intensively raid crops, efforts to convince local people to conserve them are probably doomed to fail.

A third threat to Bale monkeys for which we found evidence is hybridization with other more widespread and adaptable *Chlorocebus* species [Kingdon, 1997]. Since the three sites (Ekuma Mountain, Kulla Mountain, and Wotiye) at which probable hybrids were found are at elevations well above where grivets occurred in our surveys, and even adult individuals at the three sites appeared to be hybrids, the hybridization must have occurred long ago. As Detwiler et al. [2005] noted, hybridization between closely related taxa is often facilitated by anthropogenic habitat modification. Given the differences in habitat preferences between grivets and Bale monkeys [Mekonnen et al., 2010a,b; Jaffe & Isbell, 2011; Zinner et al., 2002], it seems probable that past (and potentially future) zones of contact were in agricultural areas to which the two taxa were attracted for crop raiding. Further research on the population genetics and molecular phylogeny of the "phenotypically hybrid" monkeys observed in our surveys is recommended to confirm that the presumed hybridization hypothesized in our study did indeed occur. Because the remaining numbers of Bale monkeys appear to be small [Mekonnen et al., 2010b; this study], we concur with previous suggestions that the potential for genetic swamping by the more abundant grivet must be considered a real long-term risk for Bale monkeys [Kingdon, 1997; Detwiler et al., 2005].

Conservation Status and Recommendations

Bale monkey populations in southern Ethiopia are under immense anthropogenic pressure because of rapid habitat loss and hunting, and may also be threatened via hybridization with grivets. Considering these threats along with their narrow geographic distribution and generally small remaining population sizes, Bale monkeys appear to face a high risk of extinction. We fear that most extant Bale monkey populations will not be sustainable over the long-term without immediate conservation action. As a result, we suggest that the species be given serious consideration by IUCN for elevation to "Endangered" status from their current designation of "Vulnerable" [Butynski et al., 2008]. In the meantime, further surveys are needed to determine the remaining numbers of Bale monkeys in the Bale Mountains range as well as the conservation threats the monkeys face in that area [Mekonnen et al., 2010b].

The newly discovered Bale monkey populations occurring outside formally protected areas in the Oromia and SNNP Regions of southern Ethiopia provide opportunities for community-based conservation. Indeed, sustainable resource management projects were recently initiated by the Agriculture Offices of the Chire, Kokossa, and Arbegona Woredas (i.e., administrative districts). These projects may in the future generate income by attracting ecotourism

which would provide funds for the local community [Wearing & Neil, 2009]. These activities would, in turn, presumably help promote conservation of the monkeys and their habitats [Wearing & Neil, 2009]. In addition to the protection of existing habitats, restoration of bamboo forest within and between forest fragments must be a primary goal of Bale monkey conservation efforts. Lastly, solutions must be found to reduce crop raiding which will help to increase support for Bale monkey conservation efforts among the local community and may even help to prevent future hybridization between Bale monkeys and grivets.

ACKNOWLEDGMENTS

We would like to thank Wildlife Conservation and Environmental Development Association (WildCODE) for facilitating the financing of this project and World Association of Zoos and Aquariums (WAZA) for branding this project. We also thank the Zoological Sciences Program Unit of the Faculty of Life Sciences at Addis Ababa University for logistical support. Government officials in the Federal Ethiopian Wildlife Conservation Authority, and West Arsi, Guji, Sidama, and Gedeo Zones kindly offered their permissions to conduct this research. We would also like to thank Mulushewa Belachew, a respected local farmer at Hagere Selam, for his information about the extirpation of Bale monkeys in this area. We are grateful to the local assistants, guides, camp attendants, and residents in the survey areas for the valuable support and information they provided.

REFERENCES

Aguiar LM, Mellek DM, Abreu KC, Boscarato TG, Bernardi IP, Miranda JMD, Passos FC. 2007. Sympatry between *Alouatta caraya* and *Alouatta clamitans* and the rediscovery of free-ranging potential hybrids in Southern Brazil. Primates 48:245–248.

Anderson J, Cowlishaw G, Rowcliffe JM. 2007a. Effects of forest fragmentation on the abundance of *Colobus angolensis palliatus* in Kenya's coastal forests. Int J Primatol 28:637–655.

Anderson J, Rowcliffe JM, Cowlishaw G. 2007b. Does the matrix matter? A forest primate complex agricultural landscape. Biol Conserv 135:212–222.

Baker LR, Olubode OS. 2007. Correlates with the distribution and abundance of endangered Sclater's monkeys (*Cercopithecus sclateri*) in southern Nigeria. Afr J Ecol 46:365–373.

Baker LR, Tanimola AA, Olubode OS, Garshelis DL. 2009. Distribution and abundance of sacred monkeys in Igboland, southern Nigeria. Am J Primatol 71:574–586.

Bicca-Marques JC, Prates HM, de Aguiar FRC, Jones CB. 2008. Survey of *Alouatta caraya*, the black-and-gold howler monkey, and *Alouatta guariba clamitans*, the brown howler monkey, in a contact zone, State of Rio Grande do Sul, Brazil: evidence for hybridization. Primates 49:246–252.

Brandt SA, Spring A, Hiebsch C, McCabe JT, Taboje E, Diro M, Wolde-Michel G, Yntiso G, Shigeta M, Tesfaye S. 1997. The "tree against hunger": enset-based agricultural systems in Ethiopia. Report to the American Association for the Advancement of Science, Awassa Agricultural Research Center, Kyoto University Center for African Area studies, and University of Florida. 56 p.

Bshary R, Noë R. 1997. Red colobus and diana monkeys provide mutual protection against predators. Anim Behav 54:1461–1474.

Butynski TM, Atickem A, De Jong YA. In press. Bale monkey (Chlorocebus djamdjamensis). In: Butynski TM, Kingdon JS, Kalina J, editors. The mammals of Africa. *Vol.* 2. Amsterdam, The Netherlands: Primates Academic Press.

Butynski TM, Gippoliti S, Kingdon J, De Jong Y. 2008. *Chlorocebus djamdjamensis*. In: IUCN Red List of Threatened Species Version 2010.4. <www.iucnredlist.org>. Accessed May 15, 2011.

Campbell-Smith G, Simanjorang HVP, Leader-Williams N, Linkie M. 2010. Local attitudes and perceptions toward crop-raiding by orangutans (*Pongo abelii*) and other nonhuman primates in northern Sumatra, Indonesia. Am J Primatol 71:1–11.

Carpaneto GM, Gippoliti S. 1994. Primates of the Harenna Forest, Ethiopia. Primate Conserv 11:12–14.

Central Statistical Agency. 2008. Ethiopian Census, first draft. Addis Ababa, Ethiopia: Ethiopian Central Statistical Agency.

Chapman CA, Chapman LJ. 1996. Mid-elevation forests: a history of disturbance and regeneration. In: McClanahan TR, Young TP, editors. East African ecosystems and their conservation. Oxford: Oxford University Press. p 385–400.

Chapman CA, Lawes MJ, Eeley HAC. 2006. What hope for African primate diversity? Afr J Ecol 44:116–133.

Chapman CA, Naughton-Treves L, Lawes MJ, Wasserman MD, Gillespie TR. 2007. Population declines of colobus in western Uganda and conservation value of forest fragments. Int J Primatol 28:513–528.

Cowlishaw G, Dunbar R. 2000. Primate conservation biology. Chicago: The University of Chicago Press. 498 p.

Dandelot P, Prévost J. 1972. Contribution à l'étude des primates d'Ethiopie (Simiens). Mammalia 36:607–633.

Davenport TRB, De Luca DW, Jones T, Mpunga NE, Machaga SJ, Kitegile A, Phillipps GP. 2008. The critically endangered kipunji *Rungwecebus kipunji* of southern Tanzania: first census and conservation status assessment. Oryx 42:352–359.

Detwiler KM, Burrell AS, Jolly CJ. 2005. Conservation implications of hybridization in African Cercopithecine monkeys. Int J Primatol 26:661–684.

Fashing PJ. 2001. Feeding ecology of guerezas in the Kakamega Forest, Kenya: the importance of Moraceae fruit in their diet. Int J Primatol 22:579–609.

Federal Democratic Republic of Ethiopia (FDRE). 1998. National Action Programme to Combat Desertification. Addis Ababa, Ethiopia: Environmental Protection Authority.

Harcourt AH. 2002. Empirical estimates of minimum viable population sizes for primates: tens to tens of thousands? Anim Conserv 5:237–244.

Harcourt AH. 2006. Rarity in the tropics: biogeography and macroecology of the primates. J Biogeog 33:2077–2087.

Hill CM. 1997. Crop-raiding by wild vertebrates: the farmer's perspective in an agricultural community in western Uganda. Int J Pest Manag 43:77–84.

Isabirye-Basuta GM, Lwanga JS. 2008. Primate populations and their interactions with changing habitats. Int J Primatol 29:35–48.

IUCN. 2010. IUCN Red List of Threatened Species. Version 2010.4. <www.iucnredlist.org>. Accessed June 4, 2011.

Jaffe KE, Isbell LA. 2011. The guenons: polyspecific associations in socioecological perspective. In: Campbell CJ, Fuentes A, MacKinnon KC, Panger M, Bearder SK. editors. Primates in perspective. Oxford: Oxford University Press. p 277–300.

Kingdon J. 1997. The Kingdon Field Guide to African Mammals. London, UK: Academic Press.

Lee PC, Priston NEC. 2005. Perception of pests: human attitudes to primates, conflict and consequences for conservation. In: Paterson JD, Wallis J, editors. Commensalism and conflict: the human-primate interface. Norman, Oklahama: Am Soc Primatol. p 1–23.

Marchal V, Hill CM. 2009. Primate crop-raiding: a study of local perceptions in four villages in North Sumatra, Indonesia. Primate Conserv 24:107–116.

Marsh LK. 2003. Primates in fragments: ecology in conservation. New York: Kluwer Academic/Plenum Press. 404 p.

Mekonnen A, Bekele A, Fashing PJ, Hemson G, Atickem A. 2010a. Diet, activity patterns, and ranging ecology of the Bale monkey *Chlorocebus djamdjamensis*) in Odobullu Forest, Ethiopia. Int J Primatol 31:339–362.

Mekonnen A, Bekele A, Hemson G, Teshome E, Atickem A. 2010b. Population size and habitat preference of the Vulnerable Bale monkey (*Chlorocebus djamdjamensis*) in Odobullu Forest and its distribution across the Bale Mountains, Ethiopia. Oryx 44:558–563.

Oates JF. 1996. Habitat alterations, hunting and the conservation of folivorous primates in the African forests. Aust J Ecol 21:1–19.

Plumptre AJ, Cox D. 2006. Counting primates for conservation: primate surveys in Uganda. Primates 47:65–73.

Priston NEC, Underdown SJ. 2009. A simple method for calculating the likelihood of crop damage by primates: an epidemiological approach. Int J Pest Manag 55:51–56.

Struhsaker TT. 1981. Census methods for estimating densities. In: Anonymous, editor. Techniques for the study of primate population ecology. Washington: National Academy Press. p 36–80.

Swart J, Lawes MJ. 1996. The effect of habitat patch connectivity on samango monkey (*Cercopithecus mitis*) metapopulation persistence. Ecol Model 93:57–74.

Tan CL. 1999. Group composition, home range size, and diet of three sympatric bamboo lemur species (genus *Hapalemur*) in Ranomafana National Park, Madagascar. Int J Primatol 20:547–566.

Waktola, A. 1999. Exploratory study of two regions in Ethiopia to identify target areas and partners for intervention. Drylands Coordination Group, NORAGRIC, Report No. 6, Aas, Norway.

Warren Y. 2008. Crop-raiding baboons (*Papio anubis*) and defensive farmers: a West African perspective. West Afr J Appl Ecol 14:33–46.

Wearing S, Neil, J. 2009. Ecotourism: Impacts, potentials, and possibilities. New York: Elsevier/Butterworth-Heinemann.

Yu J, Dobson F. 2000. Seven forms of rarity in mammals. J Biogeogr 27:131–139.

Zinner D, Pelaez F, Torkler F. 2002. Distribution and habitat of grivet monkeys (*Cercopithecus aethiops aethiops*) in eastern and central Eritrea. Afr J Ecol 40:151–158.