Population size and habitat preference of the Vulnerable Bale monkey *Chlorocebus djamdjamensis* in Odobullu Forest and its distribution across the Bale Mountains, Ethiopia

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Abstract The Bale monkey *Chlorocebus djamdjamensis* is a little-known primate endemic to the south-eastern highlands of Ethiopia. From August 2007 to May 2008 we surveyed to determine the species' habitat preferences and population size in the Odobullu Forest and its range across the Bale Mountains. In Odobullu Forest a total of 136 transects of 1.8–3.0 km were surveyed over a total distance of 280 km. Bale monkey groups were encountered only in bamboo forest, suggesting that the species is a bamboo forest specialist. The density and population size of the Bale monkey in the bamboo forest of Odobullu Forest were estimated to be 121–141 km^{-2} and 1,718–2,002, respectively. At a larger scale, we assessed the distribution of the Bale monkey in 40% of the bamboo forest across the Bale Mountains within the species' altitudinal range of 2,400–3,250 m. We identified the areas to be surveyed using a 200 m digital elevation model and a 10-m resolution satellite image. We found the Bale monkey in five areas, three of which are previously unrecorded locations for the species. The Bale monkey is now categorized as Vulnerable on the IUCN Red List, partly based on the results of our surveys. Although extensive, our surveys did not cover all of the species' potential habitat and further surveys are required across all of the bamboo forest of the Bale Mountains and Sidamo region (the western extension of the Bale Mountains).

Keywords Bale monkey, bamboo, *Chlorocebus djamdjamensis*, distribution, Ethiopia, habitat preference, Odobullu Forest, population size

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Introduction

Savannah monkeys *Chlorocebus* spp. are the most widely distributed non-human primates in Africa, occurring from Senegal to Ethiopia and southwards to South Africa. Although the taxonomy of savannah monkeys has been the subject of debate (Grubb et al., 2003), Groves (2005) divides *Chlorocebus* into six species. The least known and most range-restricted of these is the Bale monkey *Chlorocebus djamdjamensis*, endemic to the southern Ethiopian highlands.

Other savannah monkeys, such as the grivet *Chlorocebus aethiops* and vervet monkey *Chlorocebus pygerythrus* are habitat generalists, inhabiting a wide range of habitat types including savannah, woodland, forest, grassland and riverine and gallery forests (Kingdon, 1997; Zinner et al., 2002; Barrett, 2005). The occurrence of Bale monkeys has been documented in the Bale Mountains National Park, Harenna Forest, Kacha and Rirra areas (Carpaneto & Gippoliti, 1994; Kingdon, 1997; Butynski et al., in press), and in Odobullu Forest (Butynski et al., in press; Mekonnen et al., 2010). In addition, Bale monkeys have been recorded in bamboo forest 23 km north-west of Dodolla and in the Djam-Djam Mountains near Abera, east of Lake Abaya at c. 3,000 m (Carpaneto & Gippoliti, 1994; Butynski et al., in press). However, the distribution of the species has not previously been adequately documented.

The Bale Mountains, which harbour a diverse range of endemic fauna and flora, are part of the Eastern Afromontane Biodiversity Hotspot (Myers et al., 2000). Despite this diversity, however, habitat loss and fragmentation are intensifying because of the increasing human population and associated agricultural expansion (Philip et al., 2001; WWF, 2001). The Bale Mountains National Park, which was established in 1970 to conserve the endemic mammals of the region, currently provides limited protection because of lack of law enforcement. Studies of the distribution patterns and habitat preferences of wildlife in this human-modified landscape are thus crucial to focus conservation efforts in the region.

The Bale monkey is one of Africa's least known primates. At the time of our study it was categorized as Data Deficient on the IUCN Red List but has now been categorized as Vulnerable (Butynski et al., 2008). The

combination of the species' thickly forested mountainous habitat, a tendency to flee rapidly upon encountering humans, and quiet behaviour may explain why no detailed field study of the species has previously been undertaken.

The objectives of the study described here were to determine the population size and habitat preferences of the Bale monkey in one of its known strongholds, Odobullu Forest, and to conduct surveys across the Bale Mountains to document further the species' distribution.

Study area

The study of habitat preferences and population size was carried out in the 71 km² Odobullu Forest, south-eastern Ethiopia (Fig. 1). Odobullu Forest is controlled by a private organization, Rift Valley Hunting Safaris. The area is protected from livestock grazing and tree cutting but bamboo harvesting is allowed. Hunting of wildlife is allowed based on quota-managed trophy hunting but hunting of the Bale monkey is not permitted. The topography of the area is mountainous, with cliffs and valleys intersected by streams at altitudes of 2,250–3,022 m. The broader distribution survey was conducted across the Bale Mountains in an area of 5,551 km² over altitudes of 2,400–3,250 m, in the bamboo forest (Fig. 1).

Methods

Habitat classification and vegetation mapping

We classified the vegetation of Odobullu Forest into four types (tree-dominated forest, bamboo forest, bushland and grassland). We used the supervised classification method in *Erdas Imagine v. 8.6* (ERDAS, Norcross, USA) to analyse 10-m resolution Spot images of 160 randomly selected locations (Dean & Smith, 2003; Irwin et al., 2005). To calibrate the image we surveyed vegetation composition within a 4 × 5 m quadrat at each of the 160 points, located with a global positioning system (GPS), recording plant species and their frequency, and canopy cover. Quadrats that contained trees > 30 cm diameter at breast height with dominant canopy cover were classified as tree-dominated forest. Quadrats with > 60% cover of Euphorbiaceae (*Erythrococca* spp.) and/or other shrubs were classified as bushland. Quadrats with > 50% cover of bamboo *Arundinaria alpina* were classified as bamboo forest. Quadrats with primarily grass species were classified as grassland. Following classification, the areas of each of the four habitat types were calculated using the geographical information system (GIS) *ArcGIS v. 9.1* (ESRI, Redlands, USA).

Habitat preference and population estimate

In Odobullu Forest transect sampling (Peres, 1999) was used to determine the habitat preference of the Bale monkey and to estimate the species' population size. Transects were established based on a stratified random sampling approach within each habitat type (Chapman et al., 1988; Plumptre, 2000; Lacher, 2003). A total of nine transects of 1.8–3.0 km in length were censused in bamboo forest, tree-dominated forest and bushland using both existing and newly established trails. We did not survey grassland because we found that it comprises only 7% of the area and is distributed in many discontinuous patches. Each transect was censused 12–16 times in total, during both the

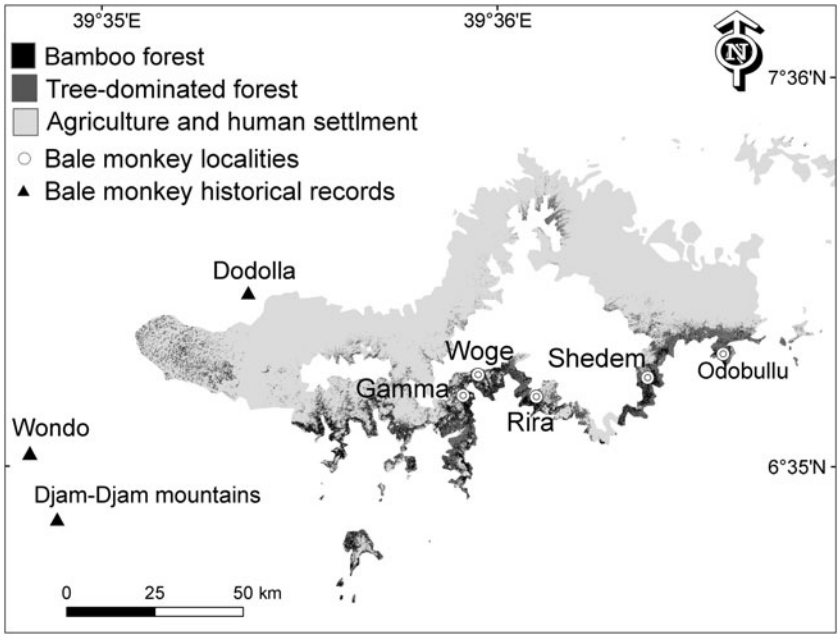

FIG. 1 The study area in the Bale Mountains, with the five areas of bamboo forest in which we located the Bale monkey *Chlorocebus djamdjamensis,* and known historical records of the species.

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wet (September–October 2007) and dry seasons (December 2007–January 2008). Censuses were conducted on foot by AM and a field assistant, together with villagers who were familiar with the area, from 06.30–06.45 to 10.30–10.45 and 14.00–18.00 (Peres, 1999; Timmuck & Vaughan, 2002) at an average speed of 1 km h^{-1} in forest and 2 km h^{-1} in bushland (Wallace et al., 1998; Peres, 1999; Chapman et al., 2000).

When Bale monkeys were encountered the dominant habitat type was noted (Wallace et al., 1998), along with location (with a GPS), group size, distance from observer and sighting angle (Chiarello, 2000; Fashing & Cords, 2000; Bennet et al., 2001; Anderson et al., 2007). Distance was estimated visually by AM, who previously practiced estimating distance, and sighting angle was measured with a compass.

Encounter rates of groups per km were calculated by habitat type (Wallace et al., 1998; Bobadilla & Ferrari, 2000), and sightings were summarized as the total number of groups and individuals observed in each habitat type (Anderson et al., 2007). We estimated density using the animal–observer distance method to the first animal seen (Chapman et al., 1988; Chapman et al., 2000; Fashing & Cords, 2000; Marshall et al., 2008). We created a histogram of all animal–observer distances, in 10-m interval classes (Müller et al., 2000). The fall-off distance or maximum reliable sighting distance was determined by applying the 50% cut-off rule, i.e. the point at which sighting frequency decreased by at least 50% from the previous sighting class interval (Fashing & Cords, 2000; Chapman & Chapman, 2002; Teelen, 2007; Weghorst, 2007). Group sightings lying beyond the fall-off distance were excluded from density estimation (Twinomugisha & Chapman, 2006).

Group density was calculated as the total number of groups sighted within the fall-off sighting distance divided by the total transect length multiplied by transect width. Population density was estimated by multiplying group density estimates with the observed mean group size (Rosenbaum et al., 1998; Fashing & Cords, 2000). Sightings of solitary individuals were excluded from calculations of group density estimates and encounter rates (Fashing & Cords, 2000; Worman & Chapman, 2006). The total population was estimated by multiplying the average group density estimates by the total area of suitable habitat (Chiarello, 2000).

Distribution across the Bale Mountains

Based on the altitudinal preference of Bale monkeys, (2,400–3,250 m; Mekonnen, 2008), the species' potential range was demarcated using a 200-m digital elevation model in *ArcGIS*. This area was then classified into three habitat types (agriculture and human settlement, tree-dominated forest and bamboo forest) using a 10-m resolution satellite image with *Erdas Imagine* (Rappole et al., 2000; Irwin et al., 2005).

Based on the results of the habitat preference survey, the bamboo forest of the Bale Mountains was then surveyed, from east to west, covering c. 40% of the total area of this forest, during January–April 2008. We surveyed by walking along existing paths, besides rivers and on trails that we cut. When Bale monkeys were sighted we noted the location, with a GPS, group size, altitude and habitat type (Lehman, 2004; Isbell & Chism, 2007). Locations of the species recorded during our surveys and locations obtained from the literature (Butynski et al., in press) were incorporated into *ArcGIS* to create a map of the species' distribution (Baumgarten, 2006). This survey was supplemented with informal interviews (Iwanaga & Ferrari, 2002) of the people who were familiar with, and reside in the vicinity of, the bamboo forest, during which we showed photographs of the Bale monkey.

Results

Tree-dominated forest, bamboo forest and bushland accounted for 56, 20 and 17% of the area of Odobullu Forest, respectively. A total of 136 transect censuses were conducted over a cumulative distance of 280 km in the three habitat types. Bale monkey groups were sighted on 43 occasions, all in bamboo forest (Table 1).

The mean group size of Bale monkeys encountered along the two transects in bamboo forest was 19.1 ± SD 5.43 (range 13–41). The fall-off distance was 40 m and not significantly different between transects (Mann-Whitney *U* test, $P > 0.05$). Of the sightings, 41 were used to estimate density (two were beyond the fall-off distance). The mean group encounter rate was 0.58 ± SD 0.08 km^{-1}, mean group density was 7.0 ± SD 1.3 km^{-2} (range 6.0–7.8) and mean individual density 132 ± SD 14 km^{-2} (range 121–141). Based on the range of mean individual density we estimated that the total population size of the Bale monkey in the bamboo forest of Odobullu is 1,718–2,002.

We sighted the Bale monkey in bamboo forest at five localities across the Bale Mountains (Fig. 1), of which Shedem, Woge and Gamma are newly discovered locations for the species. The highest altitude at which we observed the species was 3,200 m, in the Woge area. The Odobullu and Shedem populations were not in the vicinity of villages but rather surrounded by tree-dominated forest in mountainous terrain, whereas the Woge and Gamma populations were within the vicinity of people. In the Shedem population we observed two groups, of c. 18 and 32 each, but local people estimated that > 10 groups occur in the area. In the Woge and Gamma populations group sizes were 15–30 and we estimate that there are > 300 Bale monkeys in each locality.

Discussion

The results of our study suggest that the Bale monkey exclusively inhabits bamboo forest, irrespective of season,

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TABLE 1 Sightings of Bale monkey *Chlorocebus djamdjamensis* groups along transects in bamboo forest, tree-dominated forest and bushland in Odobullu Forest (Fig. 1).

Transect number	Transect length (km)	No. of censuses	Distance surveyed (km)	Total groups sighted	Encounter rate (groups km^{-1})	Habitat type
1	3.0	16	48.0	25	0.52	Bamboo forest
2	1.8	16	28.8	18	0.63	Bamboo forest
3	2.0	16	32.0	0	0	Tree-dominated forest
4	2.0	16	32.0	0	0	Tree-dominated forest
5	2.0	16	32.0	0	0	Tree-dominated forest
6	2.0	16	32.0	0	0	Tree-dominated forest
7	2.0	16	32.0	0	0	Tree-dominated forest
8	1.8	12	21.6	0	0	Bushland
9	1.8	12	21.6	0	0	Bushland
Total	15.4	136	280.0	43		

and avoids tree-dominated forest and bushland. As with the golden monkey *Cercopithecus mitis kandti* at Mgahinga Gorilla National Park, Uganda (Twinomugisha & Chapman, 2006) the habitat preference of the Bale monkey is almost certainly because of its dietary specialization on bamboo, which accounts for 77% of its diet at Odobullu (Mekonnen, 2008; Mekonnen et al., 2010). The Bale monkey is thus a specialist compared to its close relatives the grivet *C. aethiops* and vervet *C. pygerythrus*, both of which are habitat generalists (Kingdon, 1997; Zinner et al., 2002; Barrett, 2005). Species with a narrow ecological niche are particularly susceptible to extinction because of habitat destruction (Yu & Dobson, 2000; Harcourt, 2006). The legal harvesting of bamboo by local people for commercial purposes could pose a serious future threat to the Bale monkey, and needs to be either discouraged or closely managed. The survival of the species clearly depends on planning and implementing conservation strategies for the management of the bamboo forest.

Our density estimates depend on the encounter rates and group size, and the method used to estimate transect width (Shah, 2003; Weghorst, 2007). To reduce errors in group size estimation, group sizes were always recounted by the accompanying assistants during transect walks. The maximum reliable sighting distance was used for estimation of transect width, a technique that has proven effective for density estimation in many forested sites (Chapman et al., 1988; Chapman et al., 2000; Fashing & Cords, 2000; Shah, 2003; Irwin et al., 2005; Marshall et al., 2008). We therefore believe that our estimate of the total population size of the Bale monkey in the bamboo forest of Odobullu is reasonably accurate.

The density and biomass of many primates are primarily related to food quality and availability (Chapman & Chapman, 2002; Fashing et al., 2007). The relatively high density of Bale monkeys in Odobullu Forest may be related to the high abundance and productivity of their main food source, bamboo (Mekonnen, 2008). It is likely, however, that other features, such as soil quality, climate, forest history, competition, predation and disease (Oates et al., 1990) also influence the density of the Bale monkey at Odobullu.

Surveys in c. 40% of the bamboo forest in the Bale Mountains located the Bale monkey in three new localities. These discoveries suggest that the range of the species is broader than suggested in previous reports (Carpaneto & Gippoliti, 1994; Kingdon, 1997; Butynski et al., in press). The Bale monkey is now categorized as Vulnerable on the IUCN Red List (Butynski et al., 2008), partly based on the results of our surveys. This is the first time the species has received a designation other than Data Deficient. Although extensive, our surveys did not cover all of the species' potential habitat and therefore the Vulnerable categorization should remain, pending the results of further surveys, which we plan to conduct, across all the bamboo forest of the Bale Mountains and Sidamo region (the western extension of the Bale Mountains).

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References

ANDERSON, J., ROWCLIFFE, J.M. & COWLISHAW, G. (2007) The Angola black-and-white colobus (*Colobus angolensis palliatus*) in Kenya: historical range contraction and current conservation status. *American Journal of Primatology*, 69, 664–680.

Barrett, A.S. (2005) *Foraging ecology of the vervet monkey* (Chlorocebus aethiops) *in mixed lowveld bushveld and sour lowveld bushveld of the Blydeberg Conservancy, Northern Province, South Africa*. PhD thesis, University of South Africa, Pretoria, South Africa.

Baumgarten, A. (2006) *Distribution and biogeography of central American howling monkey (*Alouatta pigra *and* A. palliata*)*. MSc thesis, Louisiana State University, Baton Rouge, USA.

Bennet, C.L., Leonard, S. & Carter, S. (2001) Abundance, diversity and patterns of distributions of primates on the Tapiche River in Amazonian Peru. *American Journal of Primatology*, 54, 119–126.

Bobadilla, U.L. & Ferrari, S.F. (2000) Habitat use by *Chiropotes satanas utahicki* and syntopic Platyrrhines in Eastern Amazonia. *American Journal of Primatology*, 50, 215–224.

Butynski, T.M., Atickem, A. & De Jong, Y.A. (in press) Bale monkey (*Chlorocebus djamdjamensis*). In *The Mammals of Africa. Vol. 2. Primates* (eds T.M. Butynski, J.S. Kingdon & J. Kalina). Academic Press, Amsterdam, The Netherlands.

Butynski, T.M., Gippoliti, S., Kingdon, J. & De Jong, Y. (2008) *Chlorocebus djamdjamensis*. In *IUCN Red List of Threatened Species v. 2009.1*. Http://www.iucnredlist.org [accessed 19 September 2009].

Carpaneto, G.M. & Gippoliti, S. (1994) Primates of the Harenna Forest, Ethiopia. *Primate Conservation*, 11, 12–14.

Chapman, C.A. & Chapman, L.J. (2002) Foraging challenges of red colobus monkeys: influence of nutrients and secondary compounds. *Comparative Biochemistry and Physiology*, 133, 861–875.

Chapman, C.A., Fedigan, L.M. & Fedigan, L. (1988) A comparison of transect methods of estimating population densities of Costa Rican primates. *Brenesia*, 30, 67–80.

Chapman, C.A., Gillespie, T.R., Skorupa, J.P. & Struhsaker, T.T. (2000) Long term effect of logging on African primate communities: a 28-year comparison from Kibale National Park, Uganda. *Conservation Biology*, 14, 208–216.

Chiarello, A.G. (2000) Density and population size of mammals in remnants of Brazilian Atlantic Forest. *Conservation Biology*, 14, 1649–1657.

Dean, A.M. & Smith, G.M. (2003) An evaluation of per-parcel land cover mapping using maximum likelihood class probabilities. *International Journal of Remote Sensing*, 24, 2905–2920.

Fashing, P.J. & Cords, M. (2000) Diurnal primate densities and biomass in the Kakamega Forest: an evaluation of census methods and a comparison with other forests. *American Journal of Primatology*, 50, 139–152.

Fashing, P.J., Dierenfeld, E.S. & Mowry, C.B. (2007) Influence of plant and soil chemistry on food selection, ranging patterns and biomass of *Colobus guereza* in Kakamega Forest, Kenya. *International Journal of Primatology*, 28, 673–703.

Groves, C.P. (2005) Order Primates. In *Mammal Species of the World. A Taxonomic and Geographic Reference*, 3rd edition (eds D.E. Wilson & D.M. Reeder), pp. 111–184. Johns Hopkins University Press, Baltimore, USA.

Grubb, P., Butynski, T.M., Oates, J.F., Bearder, S.K., Disotell, T.R., Groves, C.P. & Struhsaker, T.T. (2003) Assessment of the diversity of African primates. *International Journal of Primatology*, 24, 1301–1357.

Harcourt, A.H. (2006) Rarity in the tropics: biogeography and macroecology of the primates. *Journal of Biogeography*, 33, 2077–2087.

Irwin, M.T., Johnson, S.E. & Wright, P.C. (2005) The state of lemur conservation in south-eastern Madagascar: population and habitat assessments for diurnal and cathemeral lemurs using surveys, satellite imagery and GIS. *Oryx*, 39, 204–218.

Isbell, L.A. & Chism, J. (2007) Distribution and abundance of patas monkeys (*Erythrocebus patas*) in Laikipia, Kenya, 1979–2004. *American Journal of Primatology*, 69, 1223–1235.

Iwanaga, S. & Ferrari, S.F. (2002) Geographic distribution and abundance of woolly (*Lagothrix cana*) and spider (*Ateles chamek*) monkeys in southwestern Brazilian Amazonia. *American Journal of Primatology*, 56, 57–64.

Kingdon, J. (1997) *The Kingdon Field Guide to African Mammals*. Academic Press, London, UK.

Lacher, T.E. (2003) *Tropical Ecology, Assessment and Monitoring (TEAM) Initiative: Primate Monitoring Protocol*. Unpublished Report to the Center for Applied Biodiversity Science, Conservation International, Washington, DC, USA.

Lehman, S.M. (2004) Distribution and diversity of primates in Guyana: species-area relationships and riverine barriers. *International Journal of Primatology*, 25, 73–95.

Marshall, A.R., Lovett, J.C. & White, P.C.L. (2008) Selection of line-transect method for estimating the density of group-living animals: lessons from the primates. *American Journal of Primatology*, 70, 1–11.

Mekonnen, A. (2008) *Distribution of the Bale monkey* (Chlorocebus djamdjamensis) *in the Bale Mountains and its ecology in the Odobullu Forest, Ethiopia—a study of habitat preference, population size, feeding behaviour, activity and ranging patterns*. MSc thesis, Addis Ababa University, Addis Ababa, Ethiopia.

Mekonnen, A., Bekele, A., Fashing, P.J., Hemson, G. & Atickem, A. (2010) Diet, activity patterns, and ranging ecology of the Bale monkey (*Chlorocebus djamdjamensis*) in Odobullu Forest, Ethiopia. *International Journal of Primatology*, 31, 339–362.

Müller, P., Velo, A., Raheliarisoa, E., Zaramody, A. & Curtis, D.J. (2000) Surveys of sympatric lemurs at Anjamena, north-west Madagascar. *African Journal of Ecology*, 38, 248–257.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., Fonseca, da G.A.B. & Kent, J. (2000) Biodiversity hotspots for conservation priorities. *Nature*, 403, 853–858.

Oates, J.F., Whitesides, G.H., Davies, A.G. & Mole, S. (1990) Determinants of variation in tropical forest primate biomass: new evidence from West Africa. *Ecology*, 71, 328–343.

Peres, C.A. (1999) General guidelines for standardizing line-transect surveys of tropical forest primates. *Neotropical Primates*, 7, 11–16.

Plumptre, A.J. (2000) Monitoring mammal populations with line transect techniques in African forests. *Journal of Applied Ecology*, 37, 356–368.

Rappole, J.H., King, D.I. & Leimgruber, P. (2000) Winter habitat and distribution of the endangered golden-cheeked warbler (*Dendroica chrysoparia*). *Animal Conservation*, 2, 45–59.

Rosenbaum, B., O'Brien, T.G., Kinnaird, M. & Supriatna, J. (1998) Population densities of Sulawesi crested black macaques (*Macaca nigra*) on Bacan and Sulawesi, Indonesia: effects of habitat disturbance and hunting. *American Journal of Primatology*, 44, 89–106.

Shah, N.F. (2003) *Foraging strategies in the two sympatric mangabey species (*Cercocebus agilis *and* Lophocebus albigena*)*. PhD thesis, Stony Brook University, Stony Brook, USA.

Stephens, P.A., Candy, A. d'Sa, Sillero-Zubiri, C. & Leader-Williams, N. (2001) Impact of livestock and settlement on the large mammalian wildlife on Bale Mountains National Park, southern Ethiopia. *Biological Conservation*, 100, 307–322.

Teelen, S. (2007) Primate abundance along five transect lines at Ngogo, Kibale National Park, Uganda. *American Journal of Primatology*, 69, 1030–1044.

Timmuck, J. & Vaughan, C. (2002) A census of mammal populations in Punta Leona Private Wildlife Refuge, Costa Rica. *Revista de Biologia Tropical*, 50, 1–12.

Twinomugisha, D. & Chapman, C.A. (2006) Golden monkey populations decline despite improved protection in Mgahinga Gorilla National Park, Uganda. *African Journal of Ecology*, 45, 220–224.

Weghorst, J.A. (2007) High population density of black-handed spider monkeys (*Ateles geoffroyi*) in Costa Rican lowland wet forest. *Primates*, 48, 108–116.

Worman, C.O. & Chapman, C.A. (2006) Densities of two frugivorous primates with respect to forest and fragment tree species composition and fruit availability. *International Journal of Primatology*, 27, 203–225.

WWF (2001) *Ethiopian Montane Grasslands and Woodlands*. Http://www.worldwildlife.org/wildworld/profiles/terrestrial/at/at1007_full.html [accessed 4 June 2008].

Yu, J. & Dobson, F. (2000) Seven forms of rarity in mammals. *Journal of Biogeography*, 27, 131–139.

Zinner, D., Pelaez, F. & Torkler, F. (2002) Distribution and habitat of grivet monkeys (*Cercopithecus aethiops aethiops*) in eastern and central Eritrea. *African Journal of Ecology*, 40, 151–158.

Biographical sketches

Addisu Mekonnen's research interests include the ecology, conservation and taxonomy of the Bale monkey and other primates and large mammals. Afework Bekele is working on a wide range of wildlife species in Ethiopia in collaboration with students, in particular in the general area of mammal ecology. Eyob Teshome is working on land-use cover change in the Bale Mountains in relation to wildlife conservation and is also interested in GIS and remote sensing. Graham Hemson is working on the conservation of the Ethiopian wolf and is also interested in the conservation and ecology of carnivores and other wildlife. Anagaw Atickem is working on the ecological genetics of mountain nyala and Bale monkey and is interested in GIS-based ecological studies and the use of population genetics in wildlife research.

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