SHORT COMMUNICATIONS

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DECLINE OF THE GOLDEN EAGLE (*AQUILA CHRYSAETOS*) IN ETHIOPIA

MICHEL CLOUET AND CLAUDE BARRAU
AROMP Museum d'Histoire Naturelle, 35 Allées Jules Guesde, 31000 Toulouse, France

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Ethiopia harbors a small and isolated population of Golden Eagles located in the Bale Mountains, southern highlands, east of the Rift valley, the only known population in tropical Africa (Clouet and Barrau 1993, Ash and Atkins 2009; Fig. 1). The Ethiopian highlands, where the Afro-alpine community is the largest on the continent, are remarkable for their endemic and range-restricted flora and fauna. The Bale Mountains National Park (BMNP) was created to protect part of this Afro-alpine ecosystem and initially to safeguard their two charismatic mammals, the mountain nyala (*Tragelaphus buxtoni*) and the Ethiopian wolf (*Canis simensis*; Brown 1969, Hillman 1986).

We previously studied a sample of this population of Golden Eagles over 5 yr from 1993 to 1997 in the BMNP, reporting a number of unusual characteristics: relatively small home range, low diet diversity, low productivity, and strong interspecific interactions with Verreaux's Eagles (*Aquila verreauxii*; Clouet et al. 1999). This sample, which numbered seven occupied territories, possibly represented the entire population of Golden Eagles of the BMNP and even of Ethiopia (Ash and Atkins 2009).

Since the 1990s, the BMNP has been under increasing pressure from an ever-growing human population, resulting in a strong negative effect on the habitats and the fauna (Stephens et al. 2001, Gower et al. 2013). In this context, we thus revisited this population of Golden Eagles, and we here report on its status two decades later.

METHODS

Study Area. The study was conducted in the upper Web valley between 3200 and 4000 masl, and focused on the same seven sites, in an area of 200 km^2, as previously investigated in the 1993–1997 study. The upper Web valley, which is the only known breeding range of the Golden Eagle in tropical Africa, represents the typical Afro-alpine steppe, with its endemic rodent community (mainly the giant mole rat [*Tachyoryctes macrocephalus*] and two species of murine rodents [*Arvicanthis blicki* and *Lophumoris melanonyx*]), which make up the majority of the prey of the Ethiopian wolf (Sillero-Zubiri and Gottelli 1995) and of a rich raptor assemblage (Clouet et al. 2000). The upper Web valley harbors the highest biomass of rodents of any area studied within the BMNP (Sillero-Zubiri et al. 1995, Tallents et al. 2012) and formerly held a high density of the endemic Starck's hare (*Lepus starcki*), the main prey of the Golden Eagles (Clouet et al. 1999).

Survey Method. Our study was conducted during the breeding season of 2014 (22 February–4 March). Observers (one to four) walked the same standardized transects in the Web valley as in our previous study (2–6 km in length; $n = 21$, three surveys in each eagle territory) through known territories of Golden Eagles, recording presence and activities of the birds. Transects were supplemented by periods of continuous observations of 2–5 hr (for a total observation time of 52 hr), during which all bird sightings were recorded. We also conducted complementary transects in the Web valley ($n = 6$) and on the Sanetti plateau ($n = 6$), the other large region of Afro-alpine habitat in the BMNP, to search for other sites occupied by Golden Eagles.

On all transects ($n = 33$), we recorded other raptor species and hares (as potential prey for the eagles). Data on presence of livestock (species, number) and settlements were also collected during the survey.

RESULTS

Among the seven territories monitored in 1993–1997, only three, located in the uppermost part of the valley, were occupied by pairs of adult Golden Eagles in 2014 (i.e., birds perching, soaring, and displaying with undulating flights). Except for an immature female near one of these occupied territories, no other eagles were observed in the Web valley nor on the Sanetti plateau.

Conversely, other raptor species did not show any decrease in numbers compared to the results of our previous study (Clouet et al. 2000; Table 1). All seven of the Verreaux's Eagles' territories previously found within the sampling area and contiguous with those of Golden Eagles were occupied by breeding pairs (Fig. 2). These Verreaux's Eagles now moved through the vacant nesting areas of Golden Eagles. Breeding Augur Buzzards (*Buteo augur*) numbered three pairs in each of the vacant Golden Eagle nesting areas, where previously there were none when the sites were occupied by the eagles. Numbers of

[1] Email address: michel.p.clouet@gmail.com

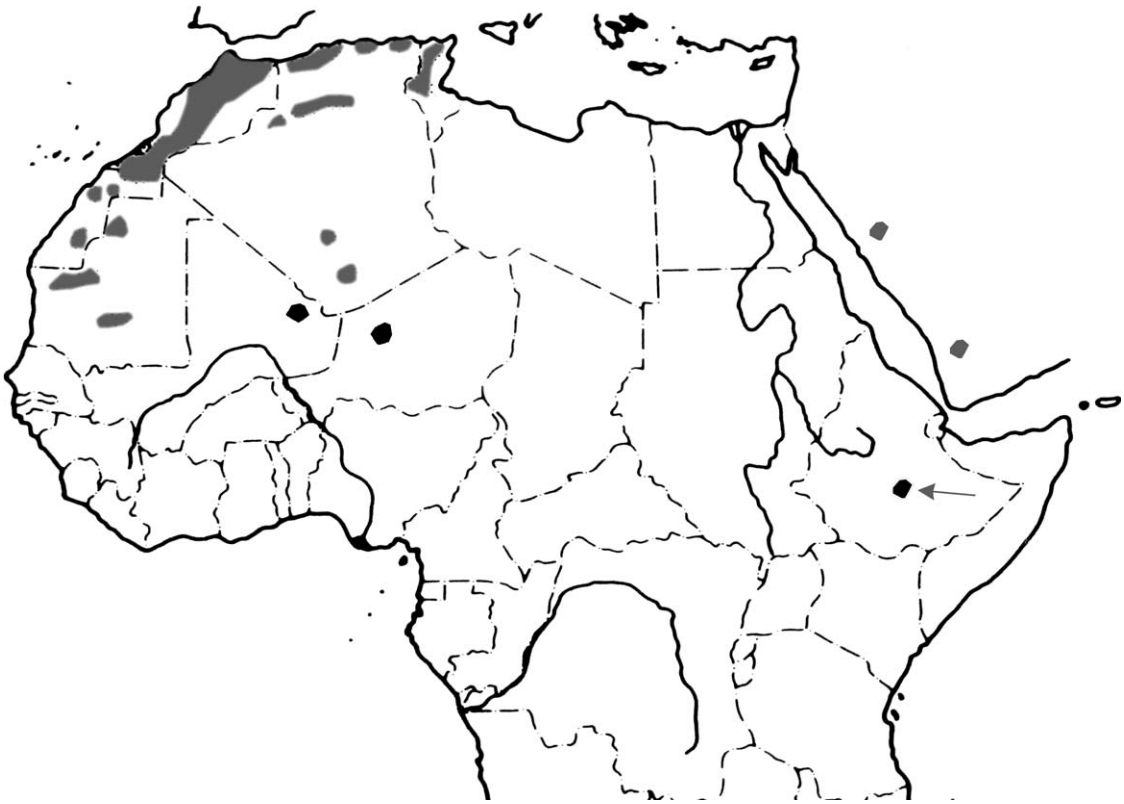

Figure 1. Range of the Golden Eagle in Africa and Western Arabia (after Brown et al. 1982). Black plots (Mali and Niger) after Clouet and Goar 2006, and Clouet and Barrau 1993. Arrow indicates the Bale Mountains of Ethiopia.

breeding Bearded Vultures (*Gypaetus barbatus*), Lanner Falcons (*Falco biarmicus*) and Eurasian Kestrels (*F. tinnunculus*) remained stable, as did counts of migrating Steppe Eagles (*Aquila nipalensis*) and Tawny Eagles (*A. rapax*).

The numbers of hares observed along our transects had decreased by 50% from the numbers seen in the surveys in the 1990s. The 2014 mean was = 4 hares / km, compared to 8 hares / km in the 1990s.

Table 1. Number of territorial pairs of raptors in the upper Web valley study area (taken from Clouet et al. 2000).

	Study Date	
Species	1990s	2014
Bearded Vulture (*Gypaetus barbatus*)	4	4
Augur Buzzard (*Buteo augur*)	44	51
Golden Eagle (*Aquila chrysaetos*)	7	3
Verreaux's Eagle (*Aquila verreauxii*)	7	7
Eurasian Kestrel (*Falco tinnunculus*)	9	5
Lanner Falcon (*Falco biarmicus*)	15	14
Peregrine Falcon (*Falco peregrinus*)	0	1

Habitat Changes. In the four vacant Golden Eagle territories, we recorded domestic stock, dogs, and humans at a distance of 50–500 m from the base of the former nesting cliff. Small livestock (goats and sheep) numbered 30–300 and cattle 20–40 in each site. In two of the three occupied territories, new human settlements had been built (within 50–500 m of the nest cliff) and in one of them, the 2014 Golden Eagle breeding site had shifted 600 m downhill to other side of the valley. Only one occupied territory remained free of settlements or permanent cattle grazing in 2014 (Fig. 2).

Discussion

Because Golden Eagles were highly territorial yearround and used well known perches and roosts that we had previously recorded, we assumed that the number of transects and periods of observation in the present survey were adequate for a reliable comparison with previous data. It remains possible that the eagles had relocated to areas we did not survey However, we believe that the observed decline may be attributable to one or both of two

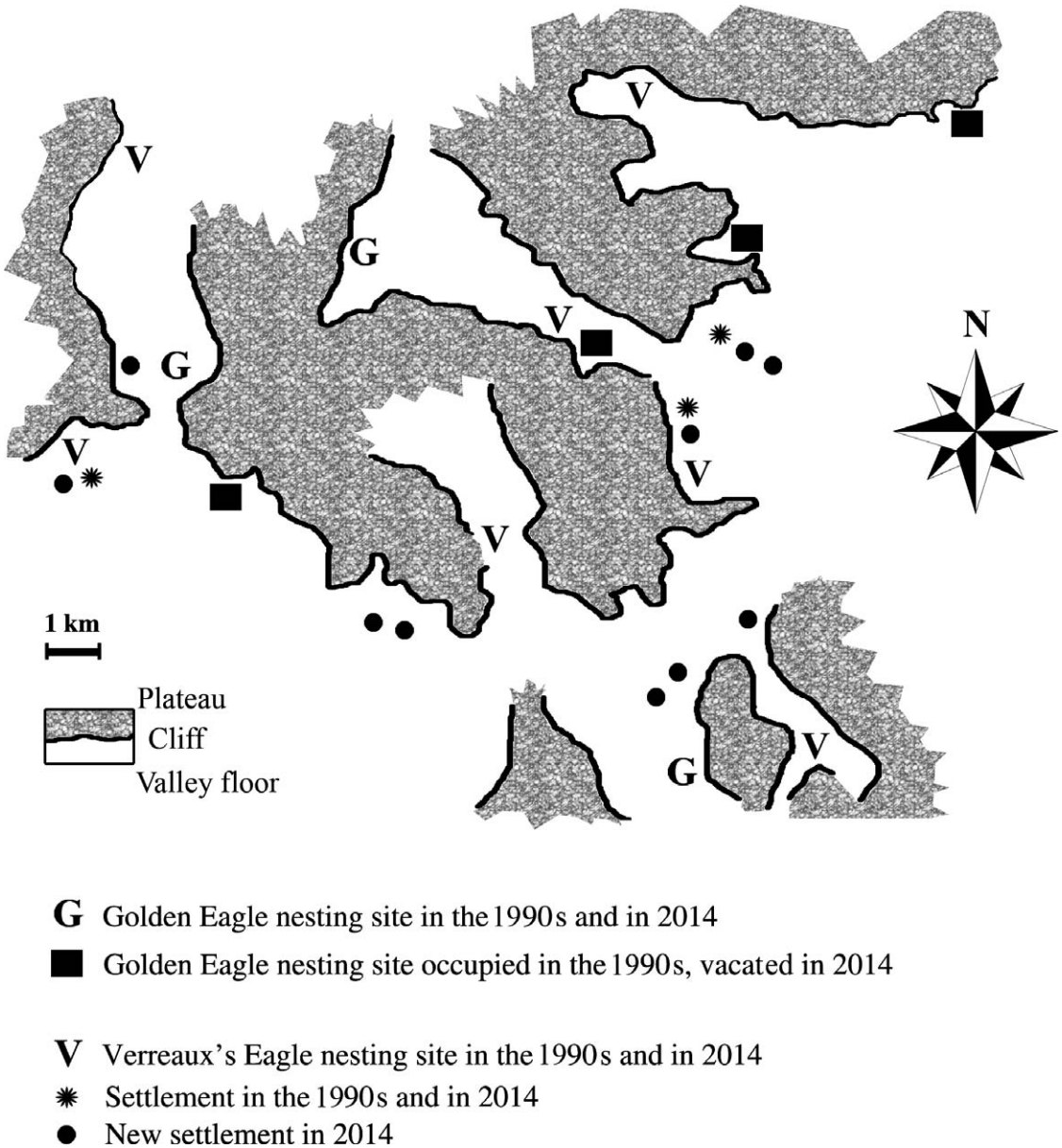

Figure 2. Distribution of the nesting sites of Golden Eagles, Verreaux's Eagles and of human settlements in the study area.

non-exclusive factors: (1) a negative effect of human activity on territory quality and (2) a demographic constraint.

The increasing human pressure that was observed in our survey area has been reported elsewhere in the BMNP (Stephens et al. 2001). Although some human settlements and livestock had been consistently present in the upper Web valley, the number of houses and people in each settlement had considerably increased: 13 new houses were built in 2009–2010 (EWCP 2010) and cattle and small livestock now regularly graze in areas where they were not recorded during our survey in the 1990s. (We did not observe any indications of direct human persecution in the Web valley.) Livestock density, as determined in a dynamic trophic modelling study, was 195 Tropical Livestock Units (TLU) in the Web valley, whereas the maximum sustainable livestock density predicted by the models was

32–117 TLU (Vial et al. 2011). Previous studies suggested that cattle compete with rodents and that rodent biomass declines as livestock density increases along a grazing gradient (Vial et al. 2011), limiting prey availability for predators. Grazing pressure by domestic livestock and the presence of humans and dogs may also restrict predator access to good foraging habitat and disturb prey (i.e., hares and rodents, which accounted for 50% and 42% of Golden Eagle prey items, respectively [Clouet et al. 1999]). The high density of these prey species and the Golden Eagle's diet specificity were likely important factors influencing the occupancy of the Bale Mountains by eagles. Lower prey availability, small home ranges, and intense interspecific interactions with neighboring Verreaux's Eagles (Clouet et al. 1999) may have resulted in Golden Eagles vacating the lower quality territories. This is consistent with the model stating that territory occupancy is related to territory quality and that occupancy is a reliable estimate of territory quality (Sergio and Newton 2003).

Phylogenetic reconstruction suggests that the Ethiopian Golden Eagle clusters in the western Palearctic clade (*A. c. chrysaetos* and *A. c. homeyeri*) and is clearly individualized, indicating that isolation could have occurred about 200 000–300 000 yr B.P. (Wink et al. 2004). The present population persistent in this Afro-alpine enclave is probably a relict of an ancient and larger one dating from the time when the Afro-alpine habitat was geographically much more extensive during the Pleistocene glaciations (Messerli et al. 1977, Hamilton 1982), allowing the emergence of a community of species adapted to high altitude with high level of endemism (e.g., rodents, wolf) and also easily colonized by Palearctic species (e.g., hare, eagle). In the case of the present small and isolated population, demographic traits may represent potential agents of decline. The reported fledging rate of 0.28 young per occupied territory per year (Clouet et al. 1999) is one of the lowest reported for the Golden Eagle (reviewed in Watson 2010). The lack of surplus birds (floaters) and the absence of proximal sources of potential new colonizers prevent replacement of disappearing adults and any gene flow. To our knowledge, no other records of breeding Golden Eagles have been reported elsewhere in the northern or central highlands of Ethiopia, nor in the BMNP (Ash and Atkins 2009; M. Clouet and C. Barrau unpubl. data). Such a restricted distribution underscores the potential importance of the Web valley for the preservation of this population.

This relict population, which may be smaller than the minimum abundance threshold (Shaffer 1981), seems to be highly vulnerable and in a critical situation. Changes in the environment, such as increasing human impact, and especially the lower availability of prey, are likely to exacerbate the negative effects on its viability and increase the risk of extirpation.

The report of this decline highlights the need for further observations, and a more detailed study is needed to understand the ecology and demography of this flagship species, which contributes to the biodiversity of the Afro-alpine ecosystem and to genetic diversity in Golden Eagles.

Although the BMNP is the most important conservation area in Ethiopia and a BirdLife International Important Bird Area, Golden Eagles could become a charismatic victim of increasing human pressure on the environment. As suggested for other taxa (Frankfurt Zoological Society 2007, IUCN/ SSC Canid Specialist Group 2011, Gower et al. 2013), the primary conservation action that would protect these birds is the limitation of human encroachment.

DECLIVE POBLACIONAL DE *AQUILA CHRYSAETOS* EN ETIOPÍA

RESUMEN.—Etiopía alberga una pequeña población aislada de *Aquila chrysaetos*, la única conocida en el África tropical, encontrada y seguida por primera vez hace 20 años. Durante la estación reproductora de 2014 se llevóda cabo un segundo censo en la misma zona en que se había realizado un estudio previo en el valle Web en el Parque Nacional Bale Mountains. De los siete territorios seguidos durante el periodo 1993–1997, sólo tres estuvieron ocupados por parejas de individuos adultos de *A chrysaetos* en 2014. Este declive puede ser atribuido a los crecientes impactos antrópicos y a posibles problemas demográficos. Esta población relicta de *A. chrysaetos* que contribuye a la biodiversidad del ecosistema afro-alpino y a la diversidad genética en la especie, parece ser altamente vulnerable y encontrarse en una situación crítica.

[Traducción del equipo editorial]

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