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Source: Primate Conservation, 2010(25) : 27-32

Published By: Conservation International

URL: https://doi.org/10.1896/052.025.0107

Primate Conservation 2010 (25): 27–32

Photographic Maps of the Primates of Kenya and Tanzania: A Tool for Identification and Conservation

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Abstract: The design and implementation of effective conservation measures for primates requires an efficient and accessible resource for the identification of species and subspecies. A total of 487 photographs (June 2010) on five on-line maps, called 'Photographic Maps' (or 'PhotoMaps'), present the phenotypic characters for 15 species and 26 subspecies of primates at 82 sites in Kenya and Tanzania. The PhotoMaps, at <wildsolutions.nl>, provide a 'living' collection of photographs. More photographs will be uploaded as they become available. PhotoMaps are a practical tool for documenting and discussing primate diversity, taxonomy, biogeography, distribution and conservation status and, therefore, for developing and implementing actions for primate conservation. The use of photographs to document phenotypic characters will become increasingly important as the collection of specimens for hands-on assessments becomes ever more difficult.

Key words: Photographic maps, primates, identification, diversity, biogeography, conservation, Kenya, Tanzania

Introduction

The degree of phenotypic variation within a species can vary widely, often being highest in geographically distant populations or those in very dissimilar ecological conditions. Consistent phenotypic differences among populations may provide the foundation for species and subspecies designations (Mayr 1969; Meffe and Carroll 1997). Likewise, phenotypic similarities among populations, or the identification of phenotypic clines, may signal invalid species and subspecies. Species and subspecies are often used as the basis for assessing and comparing levels of biodiversity and for determining priorities for conservation actions. As such, to design adequate measures to conserve biological diversity, sampling geographic variation within and among populations is necessary. This means that efficient and accessible resources for the designation and identification of species and subspecies are required. Many species of primates show considerable morphometric and phenotypic variation (for example, in body size, skin color and pattern, pelage color and pattern), both among and within populations (Groves 2001; Struhsaker 2008). Visual comparisons using photographs can often be used to determine and evaluate phenotypic characters in support of species and subspecies designations.

For centuries naturalists have obtained specimens for museum collections from almost all primate taxa. Museum collections around the world constitute a vital source of natural history information. In time, these collections will become increasingly valuable; museum collections have always been the most important tool for identifying and describing species and subspecies of primates. Nowadays, collecting primates for museums is, however, often considered unethical and/or impractical. Additionally, specimens are not always well-prepared, pelage color changes (fades) with time, skin color often changes drastically after death due to drying and preservation processes, and details of the provenance of specimens are sometimes vague, questionable, or lacking.

Photography and video are valuable means by which to collect visual research data (Nowe and Myers 2003). Advanced digital cameras, computers, and computer software, combined with precise spatial or geographic data, have become increasingly powerful and useful tools for exhibiting variation within and among species, and, thus, for recording and assessing biological diversity. Although photographs cannot replace the value of an adequate museum collection, photographs can be practical means by which field workers and naturalists can collect, store and access descriptive data for primate species and subspecies.

Photographic maps

As part of our program to document and describe primate diversity in Kenya and Tanzania, we designed five online maps (De Jong and Butynski 2010). These maps, called photographic maps (or 'PhotoMaps'), present the phenotypic characters of primate populations over large parts of their geographic ranges in Kenya and Tanzania. In June 2010, these PhotoMaps held 487 photographs of 15 species and 26 subspecies of primates at 82 sites. The photographs were taken during our field surveys (2003 to present) and are divided into five taxonomic groups (Galagonidae, *Papio*, *Cercopithecus mitis*, Colobinae, and *Chlorocebus pygerythrus*). Photographs are uploaded to the PhotoMaps soon after they become available and serve as an online 'living' photographic collection of the primates over our extensive study region. All PhotoMaps have open access on <wildsolutions.nl>.

Methods

When possible, photographs were taken by both authors of all primate groups and individuals encountered during field surveys over large parts of Kenya and Tanzania. The authors used digital Nikon or Canon SLR cameras fitted with 100–300 or 80–400 mm lenses. When primate groups were encountered, the following data were collected: date, time, GPS coordinates (Garmin GPSmap 60Cx), altitude (by GPS or altimeter), primate species/subspecies, habitat type, and tree density (by visual assessment). The primary aims during each primate encounter were to (1) obtain a detailed description of as many individuals of the group as possible and (2) take photographs of as many individuals of the group as possible.

Photographs, usually shot in 'RAW' or 'JPEG' format, were 'geotagged' (the process of adding geographical identification metadata to digital media such as photographs, video, websites; Wikipedia 2009). The associated coordinates were either obtained automatically with a phototracker GPS (Gisteq PhotoTrackr), or by hand-held GPS with the aid of Picasa software (Version 2.7 and higher; Google Inc.) and Google Earth software (version 4.3 and higher). Photographs were automatically plotted onto a Google map by uploading them to a Picasa Web Album using Picasa software. The proposed subspecies, locality, altitude, habitat type, date and any notes/comments were linked to all photographs.

How to use the PhotoMaps

To access the PhotoMaps, go to <wildsolutions.nl> and click on the name of the taxonomic group you want to view. What opens is an overview of thumbnails of all the photographs included on that PhotoMap (Fig. 1). To view the map that gives an overview of all the localities at which photographs were taken, click 'View Map' on the lower right corner. Scroll with the mouse over the map and the photographs will enlarge when you reach them (Fig. 2). To adapt the PhotoMap to your own preferences, you can select a 'road', 'terrain', or a 'satellite' map and then zoom in or out on specific areas. Photographs can be enlarged and viewed separately on a detailed map. Viewers can change from 'View Map' to 'Album View' which brings you back to the overview of all photographs present on the PhotoMap.

Visitors to a PhotoMap can read comments given with photographs by the authors or by visitors. Anyone logged in with a Google or Gmail account can add their own comments concerning a specific photograph.

Who could make use of the PhotoMaps

PhotoMaps might be used by anyone interested in the biogeography, diversity, taxonomy, or conservation of the primates of Kenya and Tanzania. More specifically, the PhotoMaps are useful to those who want to:

- identify primate species/subspecies;
- know which primate species/subspecies occur in which areas;
- obtain primate species/subspecies photographs; and
- describe variation within a species/subspecies, especially as it relates to geographic distribution.

Example 1: Phenotypic diversity within the Zanzibar Sykes's monkey *Cercopithecus mitis albogularis* Sykes, 1831

The Zanzibar Sykes's monkey *Cercopithecus mitis albogularis* is a medium-size, arboreal, forest or woodland guenon. The taxonomy and geographic range of this taxon have been debated for many years and remain unresolved. According to Kingdon *et al*. (2008a) and Lawes *et al*. (in press), this subspecies occurs from Gedi Ruins (central coast of Kenya), southwards along the coast to northern Tanzania (including Unguja Island [Zanzibar] and Mafia Island), and west to Mt. Kilimanjaro and Mt. Meru in north-eastern Tanzania. Hill (1966), Kingdon (1971), Dandelot (1974) and Groves (2001), however, restrict *C. m. albogularis* to Unguja Island. They accept *C. m. kibonotensis* as the mainland subspecies, for which Groves (2001) gives the geographic range as from Kilifi Creek (just north of Mombasa) and the Taita Hills in south-eastern Kenya to the coast of northern Tanzania inland to Mt. Kilimanjaro and Mt. Meru.

Booth (1968) opposes the above designations and argues that the only subspecies of *C. mitis* east of the Eastern (Gregory) Rift Valley is *albogularis* and that phenotypic differences within this subspecies occur as a cline that runs from the Kenya Highlands to the coast of Kenya and north-western Tanzania to Unguja Island.

We encountered 149 groups of *C. mitis* in Kenya and Tanzania; 52 of them within the range of *C. m. albogularis* as described by Kingdon *et al*. (2008a) and Lawes *et al*. (in press). As of June 2010, the '*C. mitis* PhotoMap' held 62 photographs, of which 43 were taken within the range of

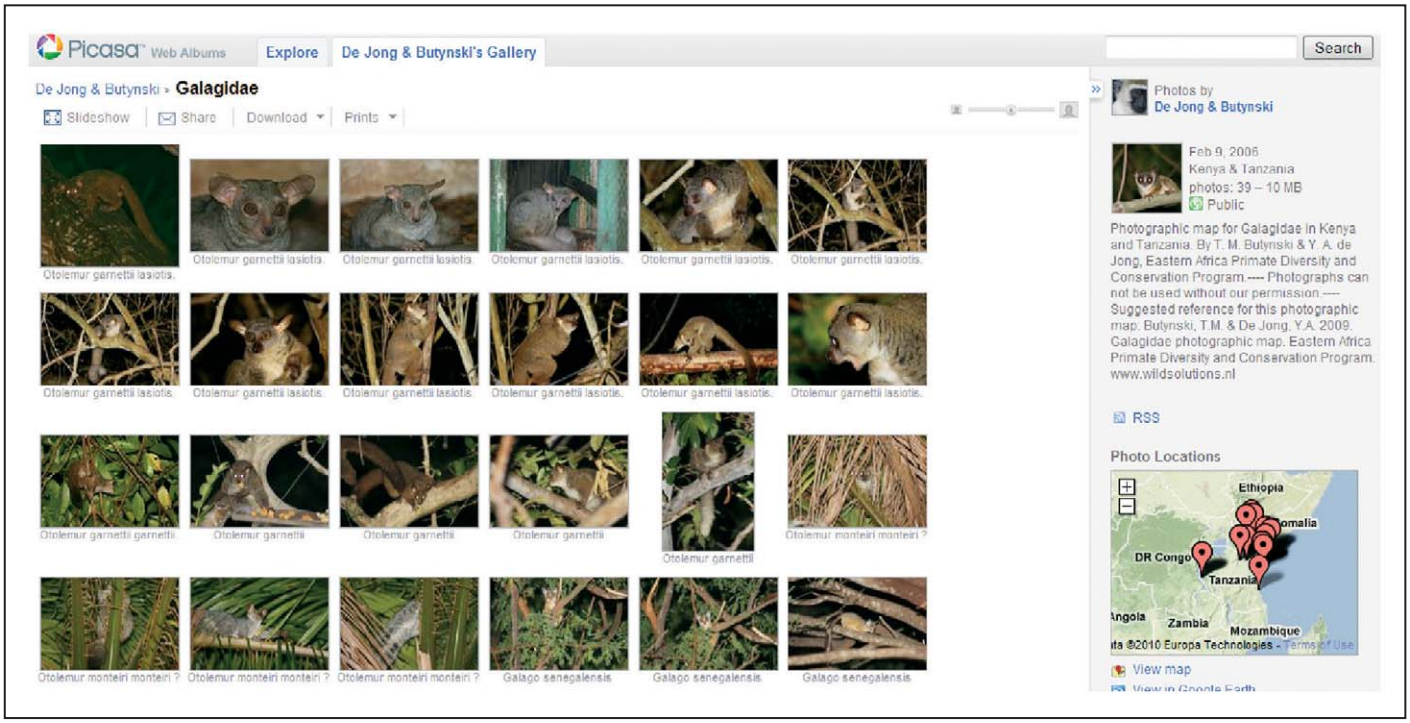

Figure 1. Screenshot of the 'Album View' of the 'Galagidae PhotoMap'. The bar at the top right enlarges the thumbnails. The 'View Map' button below the thumbnail map enlarges the map and shows all photographs that are plotted on the interactive Google map.

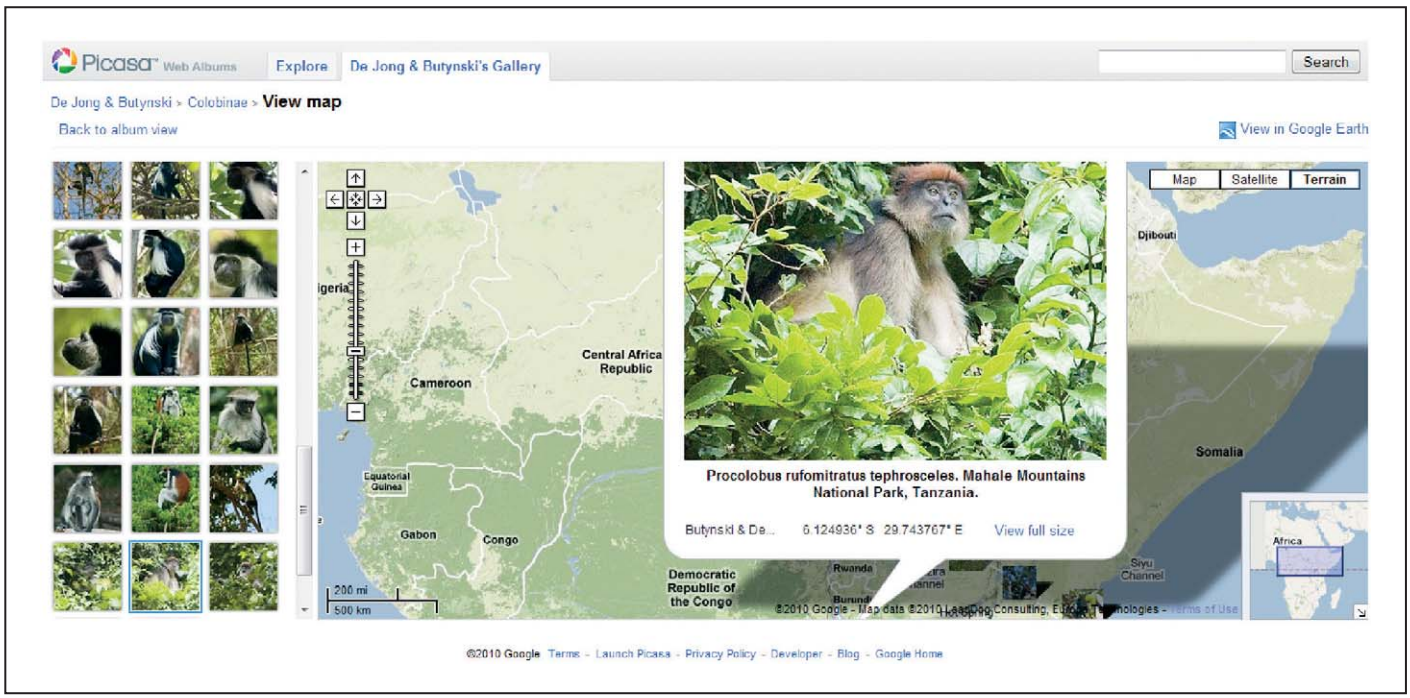

Figure 2. Screenshot of the 'View Map' of the 'Colobinae PhotoMap'. The buttons at the top right activate either the 'Map', 'Satellite', or Terrain' Google map. Clicking on the photographs enlarges them and details appear, accompanied by the discussion section.

C. m. albogularis as described by Kingdon *et al*. (2008a) and Lawes *et al*. (in press). Figure 3 presents six photographs of *C. m. albogularis* from six groups selected from the '*C. mitis* PhotoMap'. We have yet to analyze, in detail, the phenotypic differences among these individuals. There is, however, obvious phenotypic variation among them. The colour of the ventrum, inner arms, and inner legs, ranges from pale grey on animals on the northern coast of Kenya to blackish or dark grey on the animals of north-eastern Tanzania and Unguja Island. The cheek-ruffs on the Kenya animals are more slender than those of the Tanzania animals. The white collar on the Kenya animals is *ca*. 60–80% complete and *ca*. 55–60% complete on the Tanzania animals. Compared to the Tanzania animals, the collar on the Kenya animals is more sharpely demarcated, runs through the line of the jaw, and lies closer to the ears. Unlike the Tanzanian animals, those in Kenya have a distinct reddish wash on the back of the upper hind legs (De Jong and Butynski 2009).

Of the 149 groups of *C. mitis* encountered, seven were on Unguja Island. As stated above, Hill (1966), Kingdon (1971), Dandelot (1974) and Groves (2001) restricted *C. m. albogularis* to Unguja Island and took *C. m. kibonotensis* as the mainland subspecies. The '*C. mitis* PhotoMap' shows some of the similarities and differences between an adult male *C. mitis* from Unguja Island and a sub-adult male *C. mitis* male in Saadani National Park on the north-eastern coast of mainland Tanzania. These two animals are separated by a 43-km-wide ocean channel. Groves (2001) accepts *C. m. kibonotensis* but acknowledges that it is 'hardly different' from *C. m. albogularis* from Unguja Island. The PhotoMap shows that the extent of the white collar of the Saadani male is substantially less than for the Unguja male. The differences between *C. mitis* on Unguja and at Saadani, however, are less than, for instance, the difference between *C. mitis* at Usa River (southern slope of Mt. Meru) and Ndarakwai (west of Mt. Kilimanjaro) (Fig. 3 and '*C. mitis* PhotoMap'). Usa River and Ndarakwai are only about 40 km apart and an obvious natural boundary between the two sites is absent.

It appears that the '*C. mitis* PhotoMap' can serve as a tool in answering some of the many questions related to the taxonomy of *C. mitis* over the region where the 149 groups were encountered.

Example 2: Phenotypic diversity within Hilgert's vervet monkey *Chlorocebus pygerythrus hilgerti* (Neumann, 1902)

Hilgert's vervet monkey *Chlorocebus pygerythrus hilgerti* is a medium-size, semi-terrestrial, woodland guenon. The geographic range of this taxon is said to extend from southern Sudan, southern Ethiopia (east of the Eastern Rift Valley) and eastern Uganda, through Kenya into northern Tanzania (Groves 2001; Kingdon *et al*. 2008b). Throughout its range, *C. pygerythrus* is patchily distributed but often locally abundant.

We encountered 156 groups of *C. pygerythrus*, of which 136 were within the geographic range described above for *C. p. hilgerti.* The '*C. pygerythrus* PhotoMap' holds 145 photographs, of which 133 were taken within the above-described range for *C. p. hilgerti*. Figure 4 presents six *C. p. hilgerti* photographs selected from the '*C. pygerythrus* PhotoMap'. During our primate surveys we found (surprisingly) little phenotypic variation for *C. p. 'hilgerti'*.

Some geographic variation among adult and subadult male *C. p. 'hilgerti'* is, however, present, particularly in (1) the intensity of pelage color, (2) the length of the whiskers,

Figure 3. *Cercopithecus mitis 'albogularis'* adult/subadult males over the geographic range in Kenya and Tanzania surveyed during this study. **Top row**, left to right: Gedi Ruins, central coast of Kenya; Saadani National Park, northern coast of Tanzania; Mrima Hill, southern coast of Kenya. **Bottom row**, left to right: Usa River, northeastern Tanzania; Unguja Island, eastern Tanzania; Ndarakwai, northeastern Tanzania.

(3) the expression of the whitish lateral stripe, and (4) the presence or absence of a red patch under the base of the tail. Of the *C. pygerythrus* encountered, the most distinctive (by far) were those in the one group observed at Lake Naivasha, south-central Kenya (Fig. 4). The adult male of this group appeared smaller yet more robust with a shorter neck, rounder face, longer hair, and a cap and dorsum that are more rufous-grey. Hollister (1912) described and named *Lasiopyga pygerythra callida* from a specimen collected at Lake Naivasha. Although Hill (1966) accepted the validity of *callida*, Kingdon (1971), Groves (2001, 2005) and Grubb *et al*. (2003) placed *callida* as a synonym of *C. p. hilgerti*. Hill (1966) gives the distribution of *callida* as Lake Naivasha west to the eastern shore of Lake Victoria, north to Mt. Elgon, and south to Ikoma and the Wembere Steppe, north-western Tanzania. *Chlorocebus pygerythrus* at Lake Naivasha occurs at about 2,000 m above sea level, the highest altitude reported for this species (De Jong and Butynski unpubl. data). This population spends 20% of the time on the ground (Rose 1974) compared to 60% for *C. p. hilgerti* on Segera Ranch, Laikipia, central Kenya (Enstam and Isbell 2002). Additionally, *C. pygerythrus* occurs in single-male/multi-female groups at Lake Naivasha, but in multi-male/multi-female groups elsewhere (Isbell and Enstam Jaffe in press). In this case, the '*C. pygerythrus* PhotoMap' allowed for recognition of the substantial phenotypic difference of *C. pygerythrus* at Lake Naivasha relative to the minor phenotypic diversity found throughout the supposed range of *C. p. hilgerti.* This, in turn, led to a preliminary review of the literature on the taxonomy, ecology and behaviour of *C. pygerythrus* at Lake Naivasha, and to the review of photographs taken by others of *C. pygerythrus* from this area (which corroborate the phenotypic differences that we mention above). The question raised by these enquiries is whether *callida* might, after all, be a valid subspecies. Further investigations are now warranted and will be undertaken.

Discussion

To design adequate conservation action plans, an accessible source is often required for the identification of species and subspecies. Although photographs cannot replace an adequate museum collection as a resource for assessing species variation, geotagged photographs presented in PhotoMaps are a fast, inexpensive, convenient, and unobtrusive means for detecting and assessing phenotypic variation within primate taxa over large areas. In their current state the PhotoMaps are, however, far from complete. We expect to expand the PhotoMap collection (1) by including other primate taxonomic groups, (2) by increasing the geographic coverage, and (3) by including a large number of geotagged photographs taken by others.

Acknowledgments

We are grateful to Primate Conservation Inc., the Margot Marsh Biodiversity Foundation, the Primate Action Fund, and the Critical Ecosystem Partnership Fund at Conservation International for financial support. We acknowledge the Kenya Ministry of Education, Science & Technology (permit 13/001/33C 283) and the Tanzania Commission for Science

Figure 4. *Chlorocebus pygerythrus 'hilgerti'* adult males over the geographic range in Kenya and Tanzania surveyed during this study. **Top row**, left to right: Malindi, northern coast of Kenya; Majengo, north of Mombasa, southern coast of Kenya; Tanga, northern coast of Tanzania. **Bottom row**, left to right: South Horr, north-central Kenya; Lake Naivasha, south-central Kenya; Lake Manyara, north-central Tanzania.

and Technology (permit 2005-342-CC-2005-109) for permission to conduct field work in Kenya and Tanzania. We thank Zoo Atlanta, the Kenya Institute of Primate Research, the National Museums of Kenya, the Kenya Wildlife Service, Oxford Brookes University, the Colobus Trust, Nomad Tanzania, the Ol Pejeta Conservancy, the King Khalid Wildlife Research Center, and Jean-Pierre Dekker for various kinds of assistance and support.

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Received for publication: 9 May 2010
Revised: 24 May 2010