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Reconciling ecological and phytogeographical spatial boundaries to clarify the limits of the montane and alpine regions of sub-Sahelian Africa

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ABSTRACT

The Afromontane phytochorion is a region delineated on the basis of shared plant species distributions and centres of plant endemism occurring mainly in the high elevation regions of sub-Sahelian Africa. We have provided in this study a synthesis of the various contexts in which the Afromontane concept has been applied in the past, highlighting many complexities, nuances and shortcomings. A complicating factor is that the Afromontane region has both a phytogeographical and ecological context, operating at different spatial scales. We note that use of the Afromontane region as a broad floristic framework is problematic because it incorporates non-montane (alpine) regions above the treeline. Going back to first principles of phytogeography and ecology, we have developed a novel framework to resolve the aforementioned challenges. We argue that the best way to make sense of the Afromontane region is to reconcile the phytogeographical and ecological contexts to a common and unambiguous spatial boundary. We also question the recognition of the Afromontane phytochorion as a floristic region in future. Spanning some 48° of latitude, it is a rather ungainly frame of reference probably immune to detecting the nuances of floristic, physiognomic, elevational, climatic and topographic variability at finer scales, particularly in the species-rich grasslands and plateau margins.

1. Introduction

The 'dark continent' of Africa, second in size only to Asia (Ollier, 1996), is renowned for its vast natural landscapes and rich biodiversity (Burgess et al., 2004). Its mountain landscapes, in particular, occupy an area of 1.2 million km^2 at the highest ruggedness threshold (Körner et al., 2011), and are grouped principally into (1) the 'Saharan' Mountains; (2) the Great Rift Mountains (e.g. Mount Kenya, Mount Kilimanjaro, Ethiopian Highlands); (3) the Albertine Rift Mountains (e.g. Rwenzori Mountains); (4) the highlands of West Africa; and (5) the Great Escarpment of southern Africa, the latter defined by the almost horseshoe-shaped eroded continental margin incorporating the high ground of Angola in the west, to Zimbabwe and Mozambique in the east. Africa's mountains are predominantly moist, but arid exceptions include the Atlas Mountains (north-western Africa), Tibesti Mountains and Ennedi Plateau (northern and north-eastern Chad respectively), Jebel Marra (western Sudan), and the western Great Escarpment (Bussmann, 2006). The Great Rift Mountains combined with the eastern Great Escarpment, in particular, are a prominent signature feature discontinuously spanning two-thirds of the length of sub-Sahelian Africa (Fig. 1; Table 1), akin to what the Rocky Mountains and Andean Cordillera are to North and South America respectively.

Studies relating to the flora and vegetation of sub-Sahelian Africa's mountain regions have largely been viewed through the lens of White's (1978) Afromontane phytochorion. The Afromontane concept, published almost 40 years ago, applies to a large area spanning some 48° of latitude, and is further complicated by having both phytogeographical and ecological contexts that generally operate at different spatial scales. In this paper, we return to the first principles of phytogeography (essentially a description of centres of plant diversity and endemism and an understanding of the historical factors that may have

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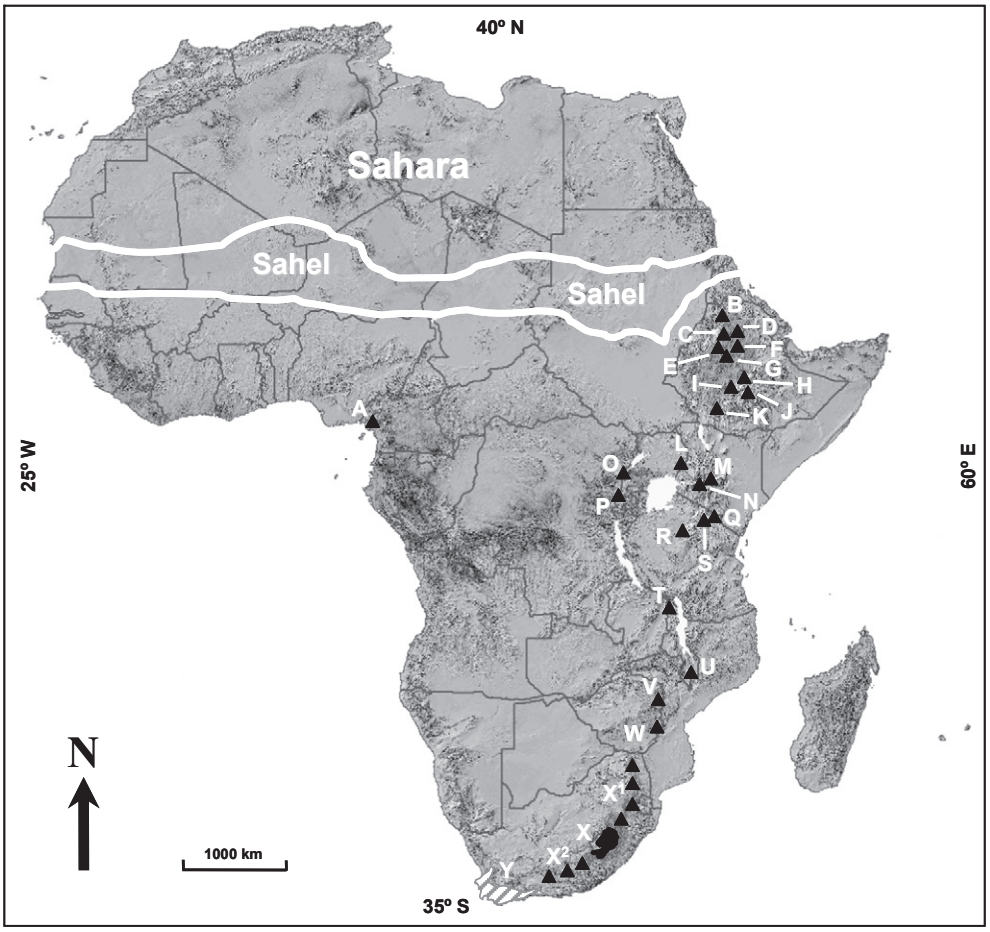

Fig. 1. The most prominent high elevation areas of the Afromontane region in sub-Sahelian Africa (A–X) as well as the location of the Cape Floristic Region (Y). Adapted from Hedberg (1994), Carbutt and Edwards (2001) and Wesche et al. (2008). The Great Rift is represented by B–N, Q–U; the Albertine Rift is represented by O and P; and the Great Escarpment is represented by V–X. Key to abbreviations: A, Mount Cameroon, Cameroon (4040 m); B–K, Ethiopian Highlands (north-east Africa, Ethiopia); B, Simen Mountains (4543 m); C, Mount Guna (4225 m); D, Mount Abuna Yosef (4260 m); E, Mount Choqa (4113 m); F, Mount Abuye Meda (4012 m); G, Mangestu Mountains (4072 m); H, Mount Bada (4036 m); I, Mount Kaka (4200 m); J, Bale Mountains (4377 m); K, Mount Guge (4203 m); L, Mount Elgon, Kenya/Uganda (4315 m); M, Mount Kenya, Kenya (5199 m); N, Aberdare Mountains, Kenya (3994 m); O, Rwenzori Mountains, Democratic Republic of Congo/Uganda (5109 m); P, Virunga Mountains, Democratic Republic of Congo/Rwanda/Uganda (4507 m); Q, Mount Kilimanjaro, Tanzania (5895 m); R, Mount Hanang, Tanzania (3417 m); S, Mount Meru, Tanzania (4565 m); T, Nyika Plateau, Malawi (2605 m); U, Mount Mulanje, Malawi (3002 m); V, Mount Nyangani, Zimbabwe (2592 m); W, Chimanimani Mountains, Mozambique/Zimbabwe (2440 m); X, Drakensberg Alpine Centre, Lesotho/South Africa (3482 m) bisecting the north-eastern escarpment (X^1) and the south-eastern escarpment (X^2); Y, Cape Floristic Region.

shaped the distribution of a flora) and plant ecology (essentially detailing vegetation structure and how it may be partitioned in the landscape by the local abiotic environment).

Our aims are to (1) produce a synthesis of the vast literature relating to the Afromontane phytochorion that spans almost four decades within a framework that refers to its various contexts, paying particular attention to its complexities, nuances and misapplied terminologies; (2) critically assess how well the Afromontane framework supports each context, making relevant amendments and suggestions; and (3) begin interrogating the relevance of the Afromontane phytochorion as a floristic region into the future. We therefore aim to extend the synthesis into a framework that clarifies and re-defines the Afromontane region by addressing the host of misapplications made in the past. This novel approach is simple and pragmatic in its execution — the underpinning principle is to ensure that the ecological and phytogeographical contexts are congruent and fully reconciled to a common and unambiguous spatial boundary.

Other than a cursory reference to its outliers, we do not include an explicit review of the high elevation flora and vegetation of the Cape Fold Mountains (Linder et al., 1993) in the Cape Floristic Region. Its subalpine flora and vegetation are not sharply distinct from the lowland flora and vegetation due to the strong influence of nutrient-poor soils, summer drought, fire and southern temperate latitudes, hence the pervasive occurrence of xeromorphic vegetation across elevational gradients (Marloth, 1902; Linder et al., 1992, 1993; McDonald et al., 1993).

2. Afromontane region: a broad framework of various contexts

2.1. Background and overview

White (1978, 1981, 1983, 1993) mapped the broad floristic units of Africa into phytochoria and regional centres of endemism based on patterns of species richness and endemism. One of these phytochoria, the Afromontane region (Fig. 1), encompasses the disjunct highlands of sub-Sahelian Africa and comprised six units of vegetation: Afromontane forest, Afromontane bamboo, Afromontane evergreen bushland and thicket, Afromontane and Afroalpine shrubland, Afromontane and Afroalpine grassland, and mixed Afroalpine plant communities (White, 1983). Chapman and White (1970) had earlier applied the Afromontane concept, still under development at the time, to include the forests of the Cape region in South Africa, rendered 'Afromontane' by southern latitudes. This expanded Afromontane region, spanning a large latitudinal range of 48°, thereby incorporates a suite of floras and vegetation types at various spatial scales, viz. the montane and alpine floras and vegetation of tropical Africa (Fig. 2), south-central Africa, southern Africa (Fig. 3), and the Cape forests.