Molecular phylogeny of the hawk-eagles (genus *Spizaetus*)

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The systematic relationships between genera of Accipitridae are only incompletely known, especially between tropical taxa such as the *Spizaetus* hawk-eagles. This genus includes, besides the genus *Aquila*, the greatest number of taxa within the "booted eagles" (eagles with feathered tarsi). Current taxonomy is based on morphology and plumage patterns, but the cladogenesis of the currently distinguished 11 pantropical hawk-eagles is still unclear. Common characters shared by all taxa are similar proportions and slender appearance, especially short rounded wings, a long tail, and long feathered legs. Although variation in plumage coloration is high, some characters of adult plumage such as barring on belly, tights and under tail coverts are found in all species. Moreover, the juvenile plumage is strikingly different from that of adults. Most representatives of this agile raptor genus are medium-sized but some species are small or rather large. Two species, *S. ornatus* (Daudin, 1800) and *S. tyrannus* (Wied, 1820) occur in Central and South America, one, *S. africanus* (Cassin, 1865) inhabits West and Central Africa and eight species live in South-east Asia (*S. nipalensis* (Hodgson, 1836), *S. alboniger* (Blyth, 1845), *S. bartelsi* Stresemann, 1924, *S. nanus* Wallace, 1868, *S. lanceolatus* Temminck & Schlegel, 1844, *S. philippensis* Gould, 1863, *S. pinskeri* Preleuthner & Gamauf, 1998, *S. cirrhatus* (Gmelin, 1788).

To clarify the phylogeny within the genus *Spizaetus* and the relationships to other tropical "eagles" we sequenced two mitochondrial marker genes: sections of the control region (CR) and the cytochrome *b* gene (cyt *b*). Samples of all valid species and subspecies of the genus *Spizaetus* were investigated, together with members of 12 other "booted" and "non-booted" Neotropical, Eurasian, Afrotropical and Australasiatic genera (*Oroaetus, Spizastur, Harpia, Morphnus, Lophaetus, Stephanoaetus, Hieraaetus, Aquila, Ictinaetus, Pithecophaga, Spilornis* and *Harpyopsis*). The trees based on these two mitochondrial sequences show that the hawk eagles fall into three clearly distinct clades and that this genus represents a paraphyletic group.

1. The South American species *S. ornatus* forms a cluster with *Oroaetus isidori* (Des Murs, 1845) in both the CR and the cyt *b* tree. The other South American species *S. tyrannus* belongs to this clade only in the CR tree. It should be emphasized that in both markers the genetic distance between the two subspecies of *S. ornatus* (*ornatus*, *vicarius* Friedmann, 1935) is considerably high and lies in the range usually found among valid species.
2. *S. africanus* belongs to another clade, which also includes various species of the genera *Hieraaetus* (*fasciatus* (Vieillot, 1822), *ayresii* (Gurney, 1862), *pennatus* (Gmelin,

1788)) and *Aquila*. However, low bootstrap values indicate that the relationships among these taxa are not clearly resolved.

3. The remaining species of the genus *Spizaetus* represent a third monophyletic group comprising all taxa from South-east Asia. This clade is divided into two subgroups: (I) *S. nipalensis* (four subspecies), *S. alboniger, S. bartelsi* and *S. nanus*; (II) *S. lanceolatus, S. philippensis, S. pinskeri* and *S. cirrhatus* (six subspecies). The position of *S. nanus*, the smallest of the South-east Asian hawk-eagles, remains unclear. In the cyt *b* tree it is found at the base of the two subgroups, whereas in the CR tree and in the combined tree it belongs to the *nipalensis*-cluster.

The basal branches of our trees are not resolved unambiguously, especially in the cyt *b* tree branch support is rather low. Nevertheless, the data clearly show that the genus *Spizaetus* as defined so far represents a paraphyletic assemblage of more or less similar species.

Based on the molecular data a taxonomic revision of the genus *Spizaetus* and some other taxa appears appropriate. Therefore, we suggest a new assignment of the taxa to the following genera: *Spizaetus* (*S. ornatus*), *Oroaetus* (*O. isidori*), *Ptenura* (*P. tyrannus*) for Central and South America, and *Nisaetus* (*N. nipalensis, alboniger, bartelsi, nanus, lanceolatus, pinskeri, philippensis* and *cirrhatus*) for the South-east to East Asian clade. The African taxon may be included into the genus *Hieraaetus* (*H. africanus*), but further studies have to clarify first the relationships between *Hieraaetus* and *Aquila*.

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